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The Archaeoacoustics of San Vitale, Ravenna

by

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ABSTRACT
SCHOOL OF HUMANITIES
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This research tests and assesses whether sixth-century social and cultural dynamics can be archaeologically identified by including the study of acoustics in the context of extant Late Antique Christian architecture, namely the centrally planned domed octagonal church of San Vitale at Ravenna. Implementing a holistic archaeological research strategy that includes human sensory perception of acoustical phenomena is the best approach to unravelling the complexities of social and cultural mechanisms operating in the sixth-century Mediterranean basin. The methods and issues of Archaeoacoustics are critiqued and developed in order to comment on the intentionality of acoustic attributes in sixth-century ecclesiastical architecture.

The space syntax of San Vitale has been considered for isovists at key locations during the liturgical procession and sequence of the Mass celebration. These are compared with mapped areas of perceiving the acoustic characteristics of Clarity and Reverberation Time. Combining the visual and acoustic analysis of San Vitale, with a better understanding of its date and construction phases, the physical geometry and temporal logic of the church are discussed in relation to the reflexive exchange of influence between Ravenna, Milan and Constantinople. It is posited that liturgical and musical time and tempo is materially expressed in the evident and conceptual substance of San Vitale, a suggestion that offers a springboard for future study and debate.

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DECLARATION OF AUTHORSHIP

I, David J. Knight, declare that the thesis entitled "The Archaeoacoustics of San Vitale, Ravenna" and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University;

- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

- Where I have consulted the published work of others, this is always clearly attributed;

- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

- I have acknowledged all main sources of help;

- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

- Some preliminary results of the research presented in this work have been published as:

Tronchin, L., Knight, D.J., Durvilli, I., and Tarabusi, V. 2007. Sound Perception of Choral Music in San Vitale, Ravenna, Italy. *International Symposium on Musical Acoustics (ISMA), 19th International Congress on Acoustics*; Barcelona, Spain 2007.

Tronchin, L., and Knight, D.J. 2008. The Acoustical Survival of San Vitale, Ravenna, Italy Through Two Millennia. *2008 Proceedings of the Institute of Acoustics, Auditorium Acoustics*; Oslo, Norway.

Signed: ………………………………………………………….
Date: …………………………………………………………

Acknowledgements

This research is dedicated to my parents

Daniel Joseph Knight and Audrey Elizabeth Knight (née Croucher)

And to the memory of my grandparents

Thomas Alfred Knight (1892-1954) & Margaret Hartnett (1896-1950)

And

Frank Austin Croucher (1901-1989) & Eva Fripp (1906-1993)

And to the memory of my sister

Tracy Knight (1960-1960)

Foreword

I embarked on this research immediately following the submission of my MA Dissertation[1] with encouragement and confidence that I would obtain AHRB funding. I was unsuccessful in this and further applied in 2003 and 2004, the rules of the new AHRC were then changed, making it clear I was no longer eligible to apply for future funding. Therefore I have remained a self-funded part time post-graduate student and from 2004 I have been a resident sub-warden in several University of Southampton Small Halls[2].

From the outset it was clear that my research was multidisciplinary, and having chosen to investigate San Vitale in Ravenna, it was necessary to initiate an acoustic survey performed by professional acousticians. In 2006 I was fortunate in gaining the interest and abilities of Professor Lamberto Tronchin (University of Bologna), and his team of doctoral acoustics students.

Therefore, on April 30th 2006 Professor Tronchin and I met at San Vitale (having obtained permissions[3] from the following: Monsignor Guido Marchetti (Opera di Religione of the Diocese of Ravenna), Professor Maria Grazia Maioli (Soprintendenza per i Beni Archeologici dell'Emilia-Romagna), Dr. Anna Maria Iannucci (Soprintendenza per i Beni Ambientali e Architettonici di Ravenna), and the Ravenna architect Emilio Agostinelli. Professor Tronchin brought his colleagues and the necessary equipment for performing the acoustical survey[4]. Dr. Maddalena Roversi (University of Bologna Music Department) also arrived to sing *Lux de luce* with me.

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[1] Knight 2002.

[2] 2B Archers Road and 27 Carleton Road on our former New College campus, Gateley Hall and Bencraft Court.

[3] Thank you to my supervisor Professor Simon Keay (University of Southampton) for issuing a quick succession of letters and faxes to the appropriate authorities, and to Professor Donatella Restani (University of Bologna Music Department) for taking immediate interest and kindly acting as local liaise, 'runner' and interpreter for me before my trip; due to her quick communications and interest in my topic, the entire research trip to Ravenna was fully organised and ready within two short weeks!

[4] Professor Angelo Farina (University of Parma) allowed us to borrow the dummy head from his department at the University of Parma.

Professor Tronchin and myself jointly published and presented the findings of the acoustic survey to the international acoustic community[5].

Having completed the acoustical survey of San Vitale, On April 30th of 2007 I sang and recorded *Lux de luce* in an anechoic chamber at the Institute of Sound and Vibration (ISVR) at the University of Southampton[6].

With the success of having gathered acoustic data from San Vitale and completing the analysis and calculations of the acoustic characteristics, it was apparent that a full virtual model of the church was required. After discussions with Dr. Graeme Earle the topic of creating a 3-dimensional virtual model of San Vitale was given as an option in the curriculum for the Archaeological Computing, Virtual Pasts MSc degree. In May of 2007 this topic was chosen by Ioanna Giannakopoulou, who was interested in understanding the effects of natural light within the church.

From May until September of 2007, when Ioanna Giannakopoulou submitted her MSc Dissertation, I made myself available on a regular basis in order to assist the creation of an accurate Auto Cad and 3DS Max model.

Concurrent with this work, Professor Tronchin had his doctoral students[7] create another virtual photo-realistic model of San Vitale with virtual acoustic materials. The resultant acoustic model was rendered and a virtual camera was recorded moving through the church. A series of short films were created in which I gave advice regarding the movement of the camera. My virtual voice was included into this photo-realistic model and at the Arlecchino Listening Room at the University of Bologna one can experience being inside San Vitale and listening to me singing *Lux de luce*.

By early 2008 it was possible to compare the natural lighting and acoustics within San Vitale by means of two newly created virtual models.

In order to finance my self-funded research and accommodation in Southampton I have been employed on several archaeological projects and have taught several courses. Concurrent with these positions I actively involved myself in the Archaeology department of the University of Southampton.

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[5] Tronchin, L., Knight, D.J., Durvilli, I., and Tarabusi, V. 2007. Tronchin, L. and Knight, D.J. 2008.
[6] With permission and assistance from Dr. Matthew Wright.
[7] Nori, Durvilli and Garagnani.

I am an archaeologist and have relied on the expertise of acousticians and computing archaeologists to create the appropriate virtual models, hence much of the work I have initiated and been an intimate part of cannot be presented as solely my own work. With this in mind the data, models and recordings created by anyone other than myself are expressly referenced, labelled and included within the Appendices. The ideas, analysis and interpretations of *Lux de luce*, acoustic data, geometry and sight-line demonstrations in the text of this thesis are my own work.

Introduction

In the expression of Christian practice in the Western and Eastern Empire we can identify by the sixth-century an architectural difference in congregational churches; the traditional preference in the West for the longitudinal basilica type and in the East for the centrally planned domed church, a phenomenon usually associated with Justinian's initiative to unify East and West. However, his difference has not yet been adequately assessed or explained but rather assumed to be a result of the Eastern development of the centrally planned church and Justinian's popularisation of its form in his attempts to re-unify the Western empire with Constantinople. However, can this difference, which extends into later periods, be understood from contemporary developments in the knowledge of acoustics and, if so, can the remains of this Late Antique knowledge be archaeologically identified by using Acoustical methods, recent developments in 3-D modelling and visibility analysis? If the areas within the interior space of ecclesiastical architecture can be identified as having meaningful physical relationships between areas of perceptibly clear and obscured visibility and listening, can this inform our understanding of the social organisation and choreographed movement through those ecclesiastical spaces and why a certain architectural form superseded the popularity of another?

The present research centres on whether sixth-century social and cultural dynamics can be archaeologically identified by including the study of acoustics in the context of extant Late Antique Christian architecture. The complexities of social and cultural mechanisms at work in the sixth-century Mediterranean basin may be best unravelled by implementing a holistic archaeological research strategy that includes human sensory perception of acoustical phenomena as intentionally designed and expressed through acoustic architecture. More broadly, 'looking' at sound is hoped to help refigure our understanding of past human *sensoria*[1], how architecture was sensorially experienced in Late Antiquity and, by extension, more adequately identify social aspects based on perceptions that operated in the historic past.

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[1] *Sensoria* is the plural form of *sensorium*.

For this research, the sixth-century centrally planned, octagonal domed church of San Vitale, in Ravenna, the capital of the Western Empire, has been analysed in order to test if and how Late Antique theoretical and practical acoustic knowledge may have left an identifiable physical and material trace in its design and construction. A preliminary assessment will be offered regarding the similarities and differences in the visible and acoustic "vistas" afforded by the architecture and their relationship to the temporal and spatial movement and distribution of the organised congregation, as well as developments in Ravennate chant. Further proposed amendments to and clarifications of several details concerning this church's date, geometry, measurement, patterning, and relevance within the context of the broader building scheme of Bishop Ecclesius are offered throughout Chapters Two and Three.

An attempt is made here to understand if there was sixth-century intentional acoustic experimentation and development and if so, whether it is identifiable as a corollary of geometric, symmetrical architectural design and the theological symbolic ordering of time and space.

Additionally, this research posits a corollary between the spatial organisation of male and female members of the congregation in San Vitale and the broader social organisation of Ravenna's urban occupants. The revelations of the particular case are suggested to be active strategies in the broader urban context. To check and balance these suggestions care is taken, for the special attributes of San Vitale, the only centrally planned congregational church of Ravenna, and that city's unique status as capital of the Western Empire, together warn of the danger in over-extending what this church in this city can tell us of wider issues in northern Ostrogothic Italy. In this sense, perhaps the only sure comparisons that can be offered are between this capital of the West and the capital of the East, Constantinople. For this reason, some attention is given in Chapter Eight and Appendix B in reassessing the relationship so often reiterated between San Vitale and SS Sergius & Bacchus.

This research therefore brings together the disciplines of archaeology and acoustical studies in order to test whether we can specifically improve our understanding of how and why the development of the centrally planned domed church became prevalent in the East, so characteristic of what has been labelled the 'Byzantine' East,

while the Roman longitudinal basilica remained favoured in the West. Did expressions of new and 'other' architectural forms fuel Constantinople's ascendant identity over old Rome, Milan and Ravenna, or were more complexly polysemic and reflexive exchanges operating between West and East not generally acknowledged? This research challenges what is meant by 'Byzantine' while dealing specifically with the cultural exchanges between different Christianities (Orthodox, Monophysite, Arian), communities (Roman, Ostrogothic, Greek) and cities (Rome, Milan, Ravenna, Constantinople, Arles) in the development of ecclesiastical acoustic architecture in the sixth-century.

Accordingly, this research gives consideration to the concept of Italian developments in centrally planned domed ecclesiastical architecture, used for various liturgical functions including baptism (baptisteries), the Eucharistic celebration (the Mass in congregational churches such as San Vitale and SS Cosmas & Damian at Canosa), and burial (*martyria*). Contrary to the generally accepted view that San Vitale is evidence of Justinianic influence at Ravenna, the present work opens the question and considers whether the opposite may be more correct; Constantinople substantially influenced by Ravenna. This work therefore challenges the established belief in the extensive influence of the Eastern Empire over the Gothic West, suggesting a re-evaluation of this assumption.

The archaeological investigation of the social landscapes[2] in the Eastern and Western Empires between the fourth and sixth centuries has revealed the prominence of the city[3] (Rome, Milan, Ravenna and Constantinople) and the central importance of urban churches and, therefore, by implication, the sees of the bishops. At a time when bishops were assuming the legal and civic administrative roles traditionally held by secular officials the city churches became a defining factor in the creation of identity and place[4]. I focus on Late Antique ecclesiastical urban communities to discover how their choices of architectural design and expression were intended to shape how people sensorially attended to and perceived the city, other communities, the world and the

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[2] Significant work on sixth-century rural settlement, not directly dealt with in the present work, has recently been investigated by Wickham 2002 and Bowden *et al* 2004.

[3] For example, evidence from the Verona Valley showing decline in large villa sites and rural settlement through the fifth-century and the first half of the sixth-century (Saggioro 2004:527) has been investigated and may indicate some shift in population away from the countryside and into the cities.

[4] Smith 1991, Brown 1992:89 and Kelly 2001:185.

hereafter. How might such a coordination of all the human senses (sight, hearing, touch, smell, taste) have been embedded in the contemporary ecclesiastic architecture and can this be identified by complementing archaeological studies of visibility with that of acoustics and auralisation? If liturgical ritual, accessing all the human senses, structured civic and sacred congregational and private space through the temporal calibration of the liturgical calendar (Sunday Mass, Saints' Feast Days, Christmas, Easter), how was this materially expressed in contemporary architectural design? Conversely did architectural developments feed back into and reshape communal temporal expressions like music? By investigating the 'sensual technology' of Late Antique churches, how these designed sacred spaces were engaged with visually and acoustically, I believe new archaeological interpretations can be reached regarding the social and cultural landscape that at present remain hidden and silent or, at best, blurred and muffled in the evidence of the dramatic turmoil of sixth-century Italy.

In other words was the perception of socially symbolic and sacred space in the sixth-century augmented and enhanced by ecclesiastical centrally planned architecture in ways not achieved by longitudinal basilica churches and if so, what significance has this for our understanding of the social role and importance of Late Antique churches in general? In these ecclesiastical interiors were there specified paths of movement directing and choreographing congregations of people toward intended locations where their visual and aural sensibilities were best enhanced? Were these movements temporally cued and signalled by acoustic musical events? What then are the relationships between the best locations for the production of sound (speech and music), the reception of sound and acoustical effects such as long reverberation times, echo, and the visual focal areas such as the altar and ancillary decorative schemes (mosaic, sculptural, architectural)? If there were intended relationships and corollaries between the spatial foci of visual and acoustic reception, can this inform us of Late Antique communities, in particular the social and cultural relationships between Orthodox Christianity under the Ostrogothic hegemony based at Ravenna and the Orthodoxy of Episcopal leaders in the same city and also imperial Constantinople?

In order to answer these research questions I aim to follow on from the concept of sacred urban topography developed by McManners[5] and investigate whether the sixth-century northern Italian cityscape was intentionally and strategically organised to crystallise select social attitudes as part of a broader attempt to stabilise times of religious-political upheaval. If there was a concerted effort to provide a sense of unification and inclusion during the contestations between Ostrogothic Italy and the Constantinopolitan East[6], did this scheme exacerbate an already complex and volatile situation that culminated in the Gothic War and Belisarius' capture of Ravenna in 540?

This research therefore makes an important contribution to our overall understanding of Late Antique society by asking whether structured movements of people through the resonant[7] space of a centrally planned church was a social way of communicating symbolic and cultural meaning to unified, divided and rival communities. How were the visible and acoustic properties inherent within the architecture involved in this choreography of social perceptions and expressions of culture? Why, in particular, did the characteristically Eastern centralised domed church supersede the longitudinal basilica favoured in the West? Was this simply to do with changes and differences between Eastern and Western ecclesiastical ritual or are there also identifiable social and cultural factors, sited and embedded in all the senses, at work in these preferences?

My interdisciplinary combination of archaeological visibility studies and acoustic analysis adds to the growing academic interest in a methodology that brings immaterial sound and the aural experience together into the praxis of archaeology and balances its material and visual biases. The concept of Empathic Content advances new ways of discussing the non-material past in such a way whereby Archaeological theory is made practical and, conversely, new interdisciplinary methods feed back into and help develop archaeological concepts.

I will suggest that the shift from the horizontal division in conventional basilica design of male and female members of the congregation into *pars virorum* and *pars mulierum* respectively, to the vertical division in centrally planned two storey churches

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[5] McManners 2001:80.
[6] Smith (1991) has described the process by which Byzantine architectural and cultural influences were imported into Italy as a 'mechanism of influence transferral from the East to the West in this time period' (*ibid*).
[7] Forsyth 1985:9.

such as San Vitale, was instituted for reasons of both noise reduction and also acoustic and musical enhancement and augmentation in temporally ordered successions during different celebrations of the contemporary Ravenna Rite. To support this suggestion I will identify the locations within San Vitale that afford the clearest and most obscured visibility to and from the altar, and the most and least acoustically reverberant ("wettest" and "driest") and suggest whether these correlations were intentional or merely epi-phenomenal.

Chapter content description

The research is presented in eight chapters, some with several parts. Chapter One (Archaeoacoustics) begins (Part 1.1) with a discussion of previous research in acoustic archaeology and how it has been developed and applied predominantly by those studying prehistory. Part 1.2 is a summary of the important implications for historic archaeology made by the acoustical renovation of Hagia Sophia by the CAHRISMA Project of 2000-2003. Advances to the CAHRISMA Project's remit of conservation and renovation of presently carpeted mosques are proposed by initiating a programme of archaeological inquiry to restore and reconstruct acoustical spaces of the historic past, namely the sixth-century church of San Vitale at Ravenna. Reasons will be provided why San Vitale is the most appropriate site for scrutiny, mentioning alterations, restorations and the church's current state of preservation. Part 1.4 discusses the knowledge and theories of sound propagation relevant to the context of those who designed and built this church. Related to this discussion is Appendix A: Acoustic Theories Relevant to Late Antiquity.

Chapter Two (Social/Christian Ritual) explores San Vitale's historical context, the architectural examples it references and develops from and examines the social and cultural linkages operating in Late Antique Ravenna, mediated by the pivotal Episcopal station of the city's bishop[8]. Related to this is Appendix B: Late Antique Centrally Planned Baptisteries.

Chapter Three (Constructing San Vitale) highlights and discusses the original process of surveying and constructing San Vitale (Part 3.1), revealing new insights into the relationship and context of this structure with the other churches of Bishop Ecclesius'

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[8] For the role of the bishops in late Roman Italy, see Azzara 2002:85-101.

building scheme, demonstrating the calculation and positioning of the octagonal geometry and its symbolic sacred significance in relation to the intentional transformation of the sacred urban topography of Ravenna, and their relevance to the process of acoustical and visibility mapping. Part 3.2 revisits the mosaic scheme in relation to spatial location and their context within other contemporary Ravennate decoration.

Chapter Four (The Content of San Vitale) discusses how the logic and geometry of the design is also echoed in the temporal choice of dedication date (Part 4.1) according to the liturgical calendar. Part 4.2 is a series of demonstrated isovists[9], following the recreated clerical and congregational procession into San Vitale, revealing the spatial organisation of the congregation on two floors. Accordingly, I review the literature on Late Antique Christian practice relevant to Ravenna, focusing on textual (e.g. Agnellus) and material evidence for the social organisation of congregations. For the purposes of understanding San Vitale's acoustical character Part 4.3 identifies the Ravennate chant *Lux de luce Deus tenebris illuxit Averni* [10] as an arguably closer contemporary to San Vitale and therefore an appropriate vocal sound-source.

Chapter Five (The Acoustic Measurement of San Vitale) begins (Part 5.1) with the processes of creating a virtual 3-dimensional model of San Vitale. Part 5.2 details the methodological stages and steps of preparing *Lux de luce* for rehearsal and live performance Part 5.3 describes the 2006 acoustical survey of San Vitale by Tronchin and highlights the calculated results of Clarity and Reverberation Time. Appendix C provides the raw acoustic data from the 2006 survey, a series of Excel database charts and Power-point slides of the analysis, and wav files[11] of the vocal recordings of *Lux de luce*. Part 5.4 describes the further vocal recording of *Lux de luce* in an anechoic chamber and how my vocalisation of *Lux de luce* was then convolved into the acoustic model. Part 5.5 discusses the results of the acoustic characteristics of San Vitale in comparison with those of SS Sergius & Bacchus and Hagia Sophia. To supplement this Chapter, Appendix D highlights selected key architectural elements of San Vitale (e.g. windows, glass, tapestries) and also provides three sets of data, the metric measurements of San Vitale

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[9] An isovist is the volume of space visible from a given point in space. See Wheatley & Gillings 2000 *et al*. Also Batty 2001, Turner *et al*, Clark 2007, Paliou 2008.
[10] Levy 1971:48.
[11] WAV = Waveform Audio File Format.

and their conversion into contemporary measurements[12], all acoustic raw data from the acoustic survey of April 30th 2006, and the 3D model of San Vitale by Giannakopoulou and also Durvilli *et al*. Appendix E provides an extensive image bank of photographs, plans, sections, renderings from the virtual models and walk-through videos.

Chapter Six (Summary) summarises the results of studying San Vitale's architecture afresh, including revelations made by both the interior isovists and acoustical character and how these together communicate a cohesive set of messages.

Chapter Seven (Discussion) is a closing discussion of the researches' contribution to archaeological studies of Late Antiquity.

Chapter Eight (Suggestions for the Archaeoacoustic Future) is a series of suggestions for further research, both specifically to the case of San Vitale and also to the general field of applying Archaeoacoustics to the historic past.

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[12] The Roman and Late Antique units have been used, namely the *uncia*, *pes*, and *actus* provided by Campbell 2000:482, Appendix 8. Significant measurements and proportions have been collated in Appendix D.4. Also see Table 5.1.1 on page 163.

CHAPTER ONE

Archaeoacoustical Background

Listening is at the centre of the complex relationship between the individual and the environment[1].

This interdisciplinary research investigates concepts of movement through space and the experience of such movement through the phenomena of spatial experience[2] in relation to sacred place. Feld's[3] *acoustemology* of place, implicitly reliant on Smith's *akoumenology*, the phenomenology of sound[4], extends ideas of movement whereby sense and sensation and the experience and knowledge of place 'proceeds through a complex interplay of the auditory and the visual, as well as through other inter-sensory perceptual processes'[5]. Following on from this concept I ask if the sensual content of space, the combinations of visual and aural stimuli, motivates social empathic responses and to what extent these responses assist in the cognitive creation of 'place'. The sensorial content of a space and how it affords a range of elicited behavioural responses in creating place is named here the *empathic content*. As such, is the *empathic content* of a church as much an intentional feature of the architecture as is the plan and material structure and, if so, can this be archaeologically identified? These concepts and questions provide a theoretical framework for my interdisciplinary methodology.

Visibility based approaches to past landscapes, settlements and transhumance have matured[6] and the interdisciplinary and combined study of visibility and acoustics can now be applied to the ancient historic period. Despite these recent developments it has often been acknowledged that archaeology has favoured the visual and tactile senses[7] that the phrase "material culture" implies. For instance, Roman and Late Antique discourses on music[8] and pictorial representations and objects of music-making[9] have

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[1] Truax 1995.
[2] Ingold 2000a; Ingold 2000b; Parker Pearson & Richards 1994.
[3] Cf. Feld 1996.
[4] Smith 1979:234.
[5] Feld 1996:98.
[6] Wheatley and Gillings 2000:1-27.
[7] Cf. Ingold 2000.
[8] Cf. Restani 2004.

been assumed to be as close to the contemporary musical cultures as we can get. The present absence of sources containing notated Roman (Latin) chant surviving earlier than the mid ninth-century has steered the attention of historical musicologists[10] towards extant Greek notation and later documented periods. Since Roman, or sixth-century notated sources in Latin rather than Greek do not survive, and the earliest examples do not seem to predate the *neumatic* notation of Gregorian chant in the mid ninth-century[11], interior built spaces used for musical performance prior to this have been bypassed by archaeological and architectural studies because the exact nature of the music is not known. It is not my aim to provide a rendition of sixth-century chant that would be wholly acceptable to chant studies and musicologists[12], rather, an appropriate and intelligible vocal musical sound source. Acousticians studying the historic period have tended to concentrate on the Medieval and Renaissance when the performed music is well documented although some Greek and Roman theatres are now being studied[13]. Consequently an immense lacuna exists in the pre-Gregorian musical past. By identifying visual and aural foci within San Vitale I hope to offer important new data that will help to fill the 'silence' in the literature on the Late Antique and provide a holistic study that balances the current visual-centric bias of Archaeology.

Part 1.1: Research Background and Critique

Archaeological interest in acoustical investigation has been a recent phenomenon and several lines of research have produced their own descriptive labels, including Music Archaeology, Archaeology of Sound, Archaeo-musicology, and Archaeoacoustics. All these ultimately stem from the recognition of the importance of the phenomenological sensory impact on past experience. In 1994 Tilley, in his *A Phenomenology of*

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[9] Cf. Maioli 1997.

[10] Cf. Wellesz 1947.

[11] Known as *cheironomic* or *in campo aperto*, these *neumes* were written without a staff. They indicated changes in pitch and duration within each syllable, but did not attempt to specify the pitches of individual notes, the intervals between pitches within a *neume*, nor the relative starting pitches of different syllables' neumes. Levy, K. *Plainchant*, Grove Music Online, ed. Macy, L.; Hiley, D. Chant. *Performance Practice: Music before 1600*, pg. 44; Apel, W. Gregorian Chant, pg. 127; Mahrt, W.P. Chant. *A Performers Guide to Medieval Music*, pg. 18.

[12] Chant studies and scholarship appear to have no over-arching sobriquet or label such as chantology or chantography.

[13] Cf. Shankland 1973; Vassilantonopoulos and Mourjopoulos 2003; Gade, Lisa, Lynge and Rindel 2004; Lisa, Rindel and Gade 2005; Gugliermetti, Bisegna and Monaco 2007.

Landscape[14], expressed space as a series of socially produced spaces, each 'a medium rather than a container for action'[15] and that they combine 'the cognitive, the physical and emotional into something that may be reproduced but is always open to transformation and change'. However, space, on earth, is not a vacuum but rather filled with air and therefore it is essential to consider all air-borne phenomena (namely sound and scent) as investing space (human and non-human) with more inherent possibility and effect than Tilley allows for. He defined space as deriving its meanings from particular places[16] and that 'the meaning of place is grounded in existential or lived consciousness of it' while 'it follows that the limits of place are grounded in the limits of human consciousness'[17]. What appears to be lacking in this argument is that space also derives meaning from, and is constituted of, the sensed phenomena carried by air and/or air pressure. Therefore, space may also derive its meanings from the medium and specific attributes of air contained within a place. Three examples may suffice; echo, the howling wind, and a waft of incense may together or independently substantially contribute to the 'atmosphere' of space, assisting in the subjective psychological, ideological, and symbolic construction of place.

The limits of place may be equally bounded and expanded by a particular capability of human consciousness, the periodic requirement to suspend disbelief, in an interior or exterior space, and therefore affecting what is perceived by sight and listening. In other words, belief and consciousness integrated together should be considered as acting in tandem upon how biographies and social relationships are intimately related to spaces and essential to the creation of meaningful places[18]. Related to this is the criticism that the essential components of human behaviour such as conscience, intentionality, uncertainty, historicity, emotions, irrationality, belief, and spiritual experience 'are not reducible to schematizations or to mechanistic systematizations'[19].

Current archaeological debate has entered something of a gnarled impasse constituting two main issues. Firstly, archaeological investigation has been criticised with

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[14] Tilley 1994.
[15] Tilley 1994:10.
[16] Tilley 1994:15.
[17] Tilley 1994:15. Parker Pearson and Richards *et al* 1994.
[18] Tilley (1994:11) has: 'Spaces are intimately related to the formation of biographies and social relationships'.
[19] Gardin 1988:224.

increased frequency since the 1990's that it has become an ostensibly visual and tactile endeavour belying the full scope that the word *archaeology* denotes: *knowledge of the past*. However, a full understanding of the past cannot be attempted without involving disciplines and methods of studying the other human exteroceptive[20] senses of hearing, smell and taste, understanding them to act in synesthesial union. Archaeological theory[21] has developed some discursive tools with which to address the immense lacuna in archaeological practice where these three senses are left untouched and unseen. Of particular interest here is how the immaterial "object of sound" can be brought into, or, to use Frieman & Gillings' word, "blended"[22] into the overtly material emphasis of Archaeology. At the present stage in technological development sound can be digitally visualised and, therefore current capabilities within the disciplines of Acoustics and archaeology afford an exciting opportunity for new, interdisciplinary integrated research methods that include more of the human sensual experience to bear upon our understanding of the past.

Archaeology remains ostensibly a study of the past, and as such, has traditionally given emphasis to material artefacts, their spatial and temporal relationships to each other, distribution patterning and typological advancement. In other words, the immaterial (non-material), impermanent and momentary have been left out of the equation, in part due to the lack of sophisticated analytical tools with which to bring them into the practical methodology of archaeology. Ephemera, such as aurality[23], are relinquished to Archaeological theory and the habit of archaeology as a whole to artificially partition the sensorial immersion of human experience in favour only of the exteroceptive visual and haptic sense registers is understandable but no longer defensible.

Secondly, since the material artefact is defined by visual and haptic (tactile) measurable parameters, and since the other sensory registers of olfaction (smell), gustation (taste), and audition (hearing) are immaterial, ephemeral and vanish relatively quickly leaving no material trace, as they are based on chemical signatures and

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[20] Gibson also refers to Exterospecific as 'information about a world that surrounds a point of observation implies information about the point of observation that is surrounded by a world', calling the former Exterospecific information and the latter Propriospecific information (Gibson 1986:75 and 111).

[21] Shanks and Tilley 1987, Seremetakis 1994, Ingold 2000, Hamilakis 2002.

[22] Frieman & Gillings 2007.

[23] Aurality is however a well developed concept in current commentaries on the sonic arts, as in Kahn 2001:3 and Toop 2004, 1999, 1995.

momentary airwaves, they have remained outside the practical archaeological methodologies employed on site and in the laboratory. The adage "archaeology is the study of the material past" has become a sacrosanct cornerstone to the discipline. However, the tools and methods employed by archaeology have advanced in sophistication in the last two decades (namely involving virtual modelling, GIS, movement, landscape and visibility studies) to such a degree that archaeology now more resembles a network with other disciplines, rendering the embedded emphasis on the *material* past a constrictive and non-inclusive entrenched blinkered hang-over from the days when digging up the past meant discovering tangible treasure. One current definition of archaeology is:

> Archaeology is the science that studies human cultures through the recovery, documentation, analysis, and interpretation of material remains and environmental data, including architecture, artefacts, features, biofacts, and landscapes. Because archaeology's aim is to understand humankind, it is a humanistic endeavour. Furthermore, due to its analysis of human cultures, it is therefore a subset of anthropology…Given the broad scope of the discipline there is a great deal of cross-disciplinary research in archaeology. It draws upon anthropology, history, art history, classics, ethnology, geography, geology, linguistics, physics, information sciences, chemistry, statistics, paleoecology, paleontology, paleozoology, paleoethnobotany, and paleobotany.[24]

The emphasis on material remains is central, and from this archaeology can claim to be an objective science. But, as is well known, many of the interpretations advanced are fundamentally subjective and qualitative, maintaining a vital thread of the discipline firmly rooted in the Humanities. This straddling between objective quantitative analysis and subjective qualitative interpretation makes archaeology attractive but it also invites two extremes: a highly philosophical discourse (theory) endemically difficult to apply, and a highly scientific set of methodologies in which theory is at best introduced as an interpretive function, paying lip-service to the current fashionable theoretical trends. The "gnarled impasse" is created by the age-old collision between objectivity and subjectivity, quantification and qualification, empiricism and epistemology, and bounded by the entrenched reliance on the defining term "material".

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[24] Renfrew & Bahn (1991). Acoustics should now be included in the list of what Archaeology draws upon.

Before suggesting a way through this impasse, it is important to remember the intellectual context of any meaningful "Archaeology of the Senses". The term *senses* is defined as the physiological methods of perception. In the highly developed vocabulary and methodological musculature of neuroscience, ecological psychology[25] and philosophy of perception, three particular modalities of perception are significant for discussions of sensory archaeology. Interoception is how we perceive the expansion and contraction of our internal organs[26]. Proprioception is the sense of the relative position of neighbouring parts of the body, indicating whether the body is moving with required effort[27]. Exteroception is how we sense the external world by use of the sensory registers of sight, taste, smell, touch, hearing and balance[28]. It is only one-third of this latter perceptual modality with which archaeology has traditionally been concerned. And yet, it is artificial to apply parity to the integration and functional inseparability of these and other perceptual modalities, as they work together in union providing the foundations of the classic philosophical problem concerning the epistemology of perception: how can we gain knowledge through perception? An answer comes from inductive methodology, the scientific quantification and statistical analysis of observable phenomena.

However, an earlier answer, and more relevant to Late Antiquity, was offered by Natural Philosophy, whereby similarities and differences of observations were collated, substantiating an over-arching belief in natural laws and rules[29]. The sublime, profound and harmonic Divine architecture, geometry, mathematics and the *numerositas* of Creation and its mysteries were interpreted through analogy[30].

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[25] Gibson 1966 and 1986 *et al*; Beaumont 1998 *et al*.

[26] An Interoceptor is 'any sense receptor which receives stimuli arising within the body' Oxford English Dictionary: http://dictionary.oed.com/cgi/entry/50119438

[27] A Proprioceptor is 'a sensory receptor which responds to stimuli arising within the body', specifically 'one located within a muscle, tendon, or joint capsule that responds to position or movement of a part of the body' Oxford English Dictionary: http://dictionary.oed.com/cgi/entry/50190331

[28] An Exteroceptor is 'a sense organ which receives external stimuli' Oxford English Dictionary: http://dictionary.oed.com/cgi/entry/50080919

[29] Aristotle's Natural Philosophy incorporates a wide range of enquiry of natural phenomena to describe the domain of natural entities (Stanford Encyclopedia of Philosophy: http://plato.stanford.edu/entries/aristotle-natphil/).

[30] *Numerositas* is a concept returned to in Chapter Three, Part 3.1. For analogies of acoustical phenomena refer to Appendix A.

The dichotomy between the observable (knowable) and unobservable (believed) is at the ancient heart of Western philosophy[31], and need only be mentioned here in relation to the impasse in which archaeology is situated. On the one hand archaeology is practiced as an inductive scientific quantification, classification and statistical analysis of past behaviour. On the other hand archaeology is discursively theorised as a Natural Philosophy applied to past behaviour. The current desire to mix ("blend") the two methods is problematic and exciting; within the same department of either Humanities (as at the University of Southampton) or Science (as in anthropology departments of North America), archaeology (the *softest* of sciences / the *hardest* of the arts) strives to be sensible about cross-fertilising inductive methods with discursive theory to research the sensory past. Whether emphatic theorem-like conclusions can be drawn by any "Archaeology of the Senses" (more accurately, albeit ungainly, "Archaeology of Interoception, Exteroception and Proprioception") is not important, but the holistic engagement of all three sensory modalities surely enriches our understanding of past receptive experience. Jones & MacGregor put it succinctly:

> We need to consider not only our subjective engagement with the lived world, but how that world comes to have significance.[32]

For the purpose of specifically encouraging the development of Archaeoacoustics, at least two possible solutions can be suggested. They may not solve the impasse but they may help to redefine the traditional terms under which Archaeology has petrified:

1:       Redefine "material" to include the "immaterial"

2:       Involve disciplines outside Archaeology that *do* measure and analyse other sensorial phenomena.

A wealth of knowledge goes overlooked and unheard by adhering to former concepts of the material artefact and implied relations to the materiality of culture. Chemical signatures (smell/olfaction) and acoustical phenomena have therefore been mentioned with increased frequency but not much has been done about them. For

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[31] Cf. Aristotle *et al*.
[32] Jones & MacGregor 2002:9.

example, the technology for reading the chemical signature (the *trace*) of smell exists, albeit predominantly confined to NASA for military application by the United States military, although sections of the perfume industry have access to this technology[33]. Some excellent commentary of the problem has appeared in recent years, the most important and current being Ingold's *Stop, Look, Listen*[34] and Freiman & Gillings' *Seeing is Perceiving?*[35]. But, for all the verbiage expended on sensory discourse within archaeological theory, it largely remains for actions to speak louder than words, and so accordingly the emphasis of this present work is placed firmly upon making the archaeoacoustic investigation a practical matter with an acknowledged unavoidable yet controlled use of an 'archaeological imagination'[36]. As a test, Archaeoacoustics will be applied to the historic past, to a specific case from Late Antiquity in order to understand whether it can contribute to solving a long-standing question: despite their appearance in the Western Empire, why does centrally planned domed ecclesiastical architecture become popular in the Eastern Empire, leaving the longitudinal basilica as the traditional form in the West?

By the 1990's seminal experimental investigations were performed in prehistoric chamber tombs in France and the UK by Jahn, Devereux and Watson[37]. By 2001 Devereux presented a documentary for Channel Four and an accompanying book entitled *Stone Age Soundtracks*[38]. At the very least the subject of sound in the past was made popular. Aaron Watson applied acoustic measurement techniques to Stonehenge and thus the study of past acoustics was firmly grounded in prehistoric research.

Then, in June of 2003, a workshop was held in Cambridge at the McDonald Institute to 'advocate the establishment of what might be called "cognitive archaeoacoustics"[39]. From this meeting, an important monograph entitled

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[33] See the wonderful little book by Luca Turin, 2006: *The Secret of Scent: Adventures in Perfume and the Science of Smell*. London: Faber & Faber.
[34] Ingold 2000b (2002 reprint).
[35] Frieman & Gillings 2007.
[36] Thomas 1993:74.
[37] Jahn *et al* 1996. Also Devereux & Jahn 1996, Watson 2006, 1999, and Watson & Keating 2000. Also see Lawson, Scarre, Cross & Hills (1998).
[38] Devereux 2001.
[39] Scarre & Lawson 2006: viii.

Archaeoacoustics was published by the Institute in 2006, edited by Scarre and Lawson. Of the thirteen monograph contributors, eight are archaeologists (Blake, D'Errico, Lawson, Morley, Scarre, and Zubrow) and two are musicologists (Cross and Rocconi). All the papers (chapters) are dominated by an emphasis on prehistory. This group and the 2006 monograph have identified two main principles for application to Archaeoacoustical studies: patterned repetition and closeness of fit[40]. Patterned repetition implies a potential indication of intentionality and design. Closeness-of-fit is also known as best-fit, part of the vocabulary and method of statistical prediction.

Of equal importance is the 'incidental feature'[41], the unintended, accidental, and epi-phenomenal qualities and results that are by their very nature not meaningfully understood by statistical analysis. Scarre notes the fundamental problem is that 'any structure, space or artefact, along with any natural feature or setting, will have acoustical properties'[42]. The idea that 'symbolically-structured sound has an especially important role in human behaviour, in the form both of language and music' can be extended and rephrased: symbolically *framed* sound has an especially important role in human *intention*, in the form of *creations of architectural and environmental place*. Scarre goes on to identify the particular problem of applying archaeoacoustics to prehistory:

> …the very intentional acoustics of specially-designed structures such as Romanesque churches and Graeco-Roman theatres…All of these have the potential for either natural ambient sounds or special humanly-produced sounds to have played a significant part in any human practices associated with them. That is perhaps very clear in the case of structures such as theatres and (to a lesser extent) churches; but becomes progressively less clear as our evidence for the activities carried out in those locations becomes less secure, because more remote from our own experience.[43]

However, archaeoacoustics applied to the historic past, namely the present work on Late Antique churches, is not as straightforward as is implied. Scarre's three possible interpretations of the presence of specific acoustical effects in built structures are as follows (and in Flowchart 1.1.1 below):

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[40] Scarre & Lawson 2006:1.
[41] Scarre & Lawson 2006:2.
[42] Scarre & Lawson 2006:2.
[43] Scarre & Lawson 2006:2.

A   (specific acoustical effects) '…were an integral part of the design, intended from the very outset.'

B   (specific acoustical effects) '…were an accidental by-product of the design, but were recognised and exploited to enhance rituals and ceremonies.'

C   (specific acoustical effects) '…were an accidental by-product of the design, and were never used in an intentional way.'[44]

Scarre's first possible interpretation (A) can be expanded to include further complexities regarding the intentionality of experiments to create a specific acoustical effect (B).

A

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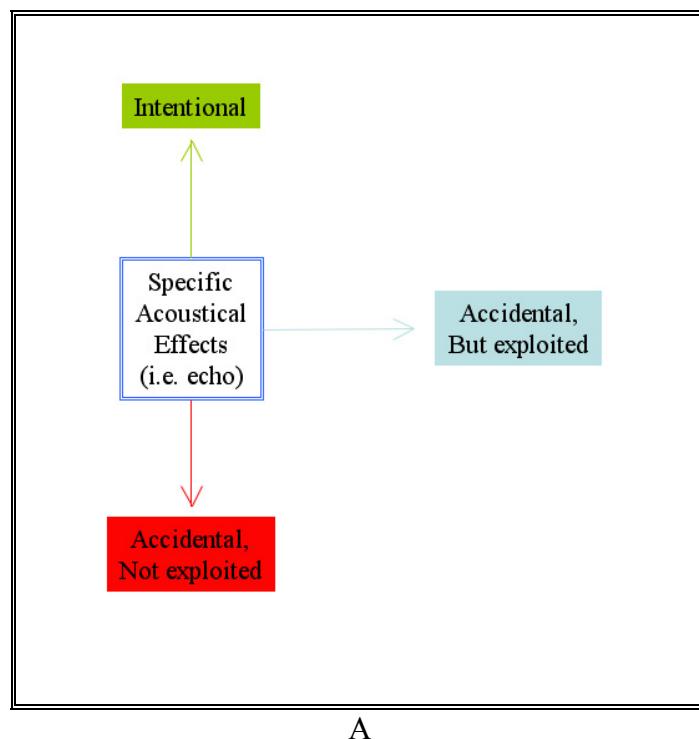
[44] Scarre & Lawson 2006:6.

B
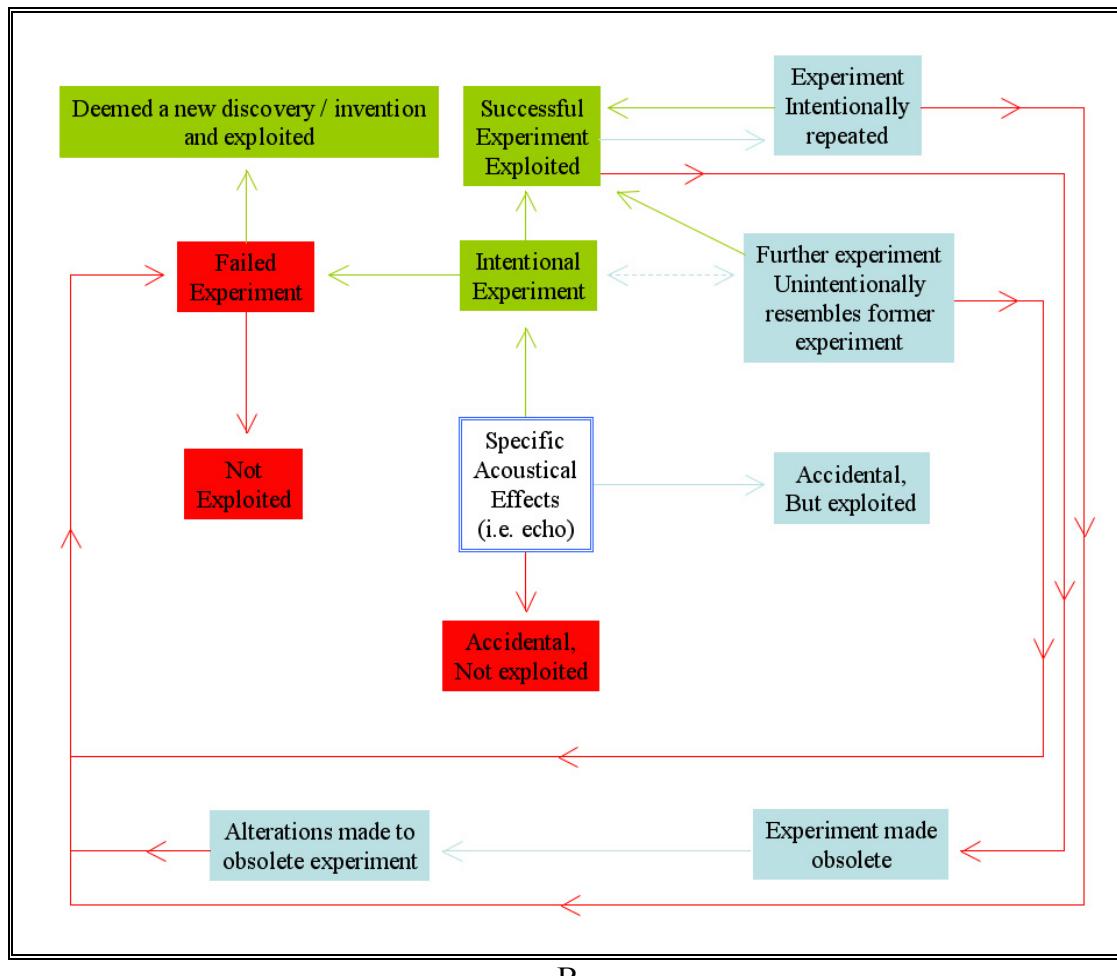
Flowchart 1.1.1: (A) Scarre's three alternative interpretations of specific acoustical effects (After Scarre 2006:6). (B) Further interpretations (Knight 2009).

Additional to the second chart are those instances when the knowledge base of a successful intentional architectural acoustical experiment is not shared (withheld methodology due to its cultural power), lost or forgotten. There are numerous cases of lost technology throughout history and for instance, if sixth-century acoustical experiments were performed in the design and execution of public and/or private architecture, the precise methods and tools used for this specific facility of enclosed space have long since been lost. Therefore, Archaeoacoustics applied to the historic past needs to be aware of all the permutations of whether an acoustical effect like reverberation length and echo were intended or not. Of the many scenarios outlined in Flowchart 1.1.1 B, the task of identifying which particular set of circumstances operated, without being sure of the exact methodological rules and subjective preferences at work, is so complex

as to suggest there cannot be a quantitative, absolute conclusion about ancient acoustical experimentation. However depressing this may sound, a comparison of all associated aspects of a given architecture and an understanding of the ceremonies that utilise the interior acoustics may provide clues of whether those acoustical effects were designed or not. Unfortunately, prehistorians seem to have jumped in at the deepest end, as the details of ceremonies cannot be fully understood. It would arguably be better to apply archaeoacoustics to a historic period in which we are much more certain of the ritual needs and expressions operating in a given space[45]. Hence, the present work focuses on sixth-century Christian liturgical expression, as we have examples of the notated source of sound in the way of chant. Without this identified sound source, the conclusions of archaeoacoustics would remain suspect.

Another problem facing Archaeoacoustics is that endemic to most Western thinking is a deep-seated reticence to holistically include sound (environmental and manufactured), acoustics and listening within an ostensibly musical experience. However, deciding what and how to listen to sounds is as much a part of musical culture as notated scores performed in concert halls. With advances in western musical tradition as of the Italian Futurists, John Cage and continuing on with Brian Eno's Ambient and Generative Musics, it is no longer tenable to exclusively associate intentional shaping of the listening experience with a framed, programmatic musical experience. Refreshingly, the experience of music is becoming understood to be frameless, or at least capable without necessarily being framed by the traditional confines of tempo, polyphony and harmonics. Cage was arguably correct when he identified music as an act of intention toward what and how to listen to sound[46]. Listening (audience) is the organising principal and, as such, inclusive of all sonic phenomena. This position is beneficial not only for musicology but also for any investigation into past listening experience.

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[45] The archaeoacoustics of Late Antique and medieval subjects has come under scrutiny by Lawson (2008) and Lawson in Scarre & Lawson (2006).

[46] In some instances no 'music' at all as in his notorious 4'33" (premiered by David Tudor in 1952), pianist poised at piano, opening and closing the lid, fingers never touching the keys. The piece is popularly remembered as Cage's silent piece but more accurately, he was reinforcing his concept that silence does not exist. Audience reaction and the pianist's body shifting on the piano bench are the sonic 'musical' events of 4'33".

The present work takes as a starting point the premise that past architecture is a technology of sensorial engagement, as we are sensorially immersed in the world[47], so a reflexive and symbiotic relationship is generated with acoustic phenomena and epiphenomena; where immersion in an acoustic space affords listening experiences and musicality, either singing a melody or listening to the pigeons cooing outside on the windowsills. An architecturally enclosed space (leaving the prehistoric utilisation of caves aside) is bivalent in that it also creates a particular definable place in which the bounded column of air is re-figured as meaningful content engaged with sensorially, intellectually, conceptually, emotionally, and symbolically according to beliefs, expectations and familiarity, something that might be called Empathic Content. Even empty ancient enclosed space has Empathic Content and as any column of air is a medium of sound the relationship between context and content in Archaeology can be investigated as past situated and lived places where the human *sensorium* is intrinsic to the architectural vocabulary and invited to act and react through performances.

Working from Cage's argument that the listener's intention creates music and from Eno's experiments with creating unframed sonic landscapes, Archaeology can now approach past methods of shaping the listening experience where music making is one element in the Empathic Content of ancient places. The present research investigates the extent to which we can identify former intentions in shaping the acoustic sonic aspects of Empathic Content and whether acoustic attributes such as Reverberation Time and the spatially located perceptibility of speech and singing (Clarity) are intended phenomena or happy epiphenomena.

The present investigation intends to counter these identified shortcomings in previous investigations of acoustics in the past by integrating acoustical survey with isovist analysis[48] to an historical context.

The 'soundscape' of the aural world relates directly to the concept as put forward by Acoustic Ecology[49] and intrinsic to 'taskscape' as developed by Ingold[50]. It is situated

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[47] Related to the historical phenomenology of the experience of space (Thomas 1993:75), it seems more appropriate and accurate to rephrase the concept of 'Being-in-the-world' as 'Being sensorially immersed in the world'.

[48] Wheatley & Gillings 2000 *et al*. Also Batty 2001, Turner *et al*, Clark 2007, Paliou 2008.

in current debates on sensual archaeology[51] and the emergent term 'sensescape'[52]. Bregman[53] reiterated the distinction usually made between 'perceptual and ecological questions about audition'[54], where the perceptual question asks 'how our auditory systems could build a picture of the world around us through their sensitivity to sound'[55] and the ecological question asks 'how our environment tends to create and shape the sound around us'[56]. Such a distinction echoes the subject / object, human / nature dichotomy that Ingold successfully rejects, for '…in a landscape, each component enfolds within its essence the totality of its relations with each and every other'[57]. Bregman states that anything written regarding perception before 1965 merely discussed 'basic auditory qualities as loudness and pitch'[58]. In response to this over-simplistic conclusion I shall illustrate in Appendix A (Acoustic Theories Relevant to Late Antiquity) just how complex Roman analogous ideas and descriptions of sound were.

Oddly enough, Hofstadter constructs a problematic analogy when he says:

> …trying to develop a theory of analogy making while bypassing both gist extraction and the nature of concepts is as utterly misguided as trying to develop a theory of musical aesthetics while omitting all mention of both melody and harmony[59].

It is the contention of the present work that a musical aesthetic is not necessarily inextricably bound to melody, harmony, or rhythm, but rather to qualities within the vertical colour of sound and its psycho-acoustic fluidity through space and time. In other words, the aesthetic (*aisthesis*), or perception of sound by methods of listening, *creates* music. This is not to imply that the exclusion of gist extraction and the nature of concepts from a theory of analogy making is warranted, but simply that the analogy Hofstadter makes between a theory of analogy and musical aesthetics reiterates a commonly-held

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[49] Schafer 1977, 1985 and Truax 1995, 1999.
[50] Ingold 2000a and b.
[51] Seremetakis 1994, Hamilakis 2002.
[52] Gamble 2003.
[53] Bregman 1990.
[54] Bregman 1990:1.
[55] Bregman 1990:1.
[56] Bregman 1990:1.
[57] Ingold 2002a:191.
[58] Bregman 1990:1.
[59] Hofstadter 1995:78.

problematic definition of music and the musical experience. The inextricable interplay between the perception of acoustical phenomena and musical development is accepted in this work. The acoustical character of an ecclesiastical structure will be shown to be a vital element in the architectural vocabulary of the sixth-century, and specifically, the liturgical music of Ravenna. The relationship between acoustics and developments in choral music will be returned to in more detail, within the context of Late Antique Ravenna, in Chapter Two, Part 2.5, Chapter Three, Part 3.1, and Chapter Four, Part 4.1.

Archaeoacoustics applied to the historic past, specifically the Late Antique, is at the moment a rather rarefied if not recherché endeavour. It is hoped the present work will at the very least demonstrate the potential and broad scope of such a study for the historic past. Accordingly, suggestions are made of ways in which former methods of gathering acoustical data in an Archaeological context can be advanced and applied to the historic past. Prehistorians have coined the term Acoustic Archaeology and have made some headway in measuring the acoustic properties of chamber tombs and megalithic monuments such as Stonehenge[60]. Tschan *et al* suggested in 1999 that perception based on indirect engagement (seeing, hearing and smelling):

> …could be subject to spatial analysis using already existing technology/methods such as the line-of-sight algorithms. The key is to understand that all three (senses) are subject to distance as a process and based on this fact there is no reason why viewshed analysis parameters for visibility could not be adopted to also identify sound, odour or cumulative combinations[61].

Gouk's statement that 'Acustica was the sister discipline of Optica, which has received far more attention in histories of early science'[62] also still holds true within the discipline of archaeology. The virtual modelling and interest in visibility in historic archaeological research does not pragmatically address aurality and acoustics. Simulations and reconstructions are so often artificially silent. This has long imposed a skewed way of studying the past, especially the musical past devoid of extant musical notation.

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[60] Devereux and Jahn 1996; Watson and Keating 1999; Devereux 2001, 2006.
[61] Tschan *et al* 2000:45.
[62] Gouk 1982:156.

If, for the moment, it is agreed that sound is conceptually somewhat interchangeable with colour, then the work of Jones & MacGregor (2002) is of interest, specifically:

> One of the strengths of an art historical approach to colour is the interweaving of the technological, social and ideational aspects of the phenomenon of colour. For instance Gage (1999:76-82), in a wider work on colour and meaning, describes the method of staggering coloured *tesserae* on wall surfaces in the execution of Byzantine mosaics. Such a technique was meant to convey softness and depth to the mosaic viewed from a distance…while we cannot be certain that the artisans and the designers who directed them were not aware of Ptolemy's *Optics*, it does suggest a shared set of beliefs about the nature of vision and colour.[63]

Since Ptolemy's *Optics* only survives because of an Arabic translation and subsequent retranslation into Latin by Eugene of Palermo in c.1154[64], it cannot be proved the work was widely known outside Alexandria or used at any time in the West between the second and twelfth-century. Focusing on the inconclusive whereabouts and influence of the *Optics* belies the scientific influence of Alexandria, Ptolemy's contemporary fame, and other related concepts of optical phenomena. That the interest in optical effects, as demonstrated by the "Byzantine" mosaicists, was forefront in Late Antiquity cannot be denied. Related to this is Ptolemy's *Harmonics* and more broadly, the interest in and experimentation with acoustical phenomena. Light and sound were together understood to be mathematically based on geometric ratio (see Appendix A) and, when investigating sixth-century acoustics or colour (artificial lighting from candles and hanging lamps, windows, polished reflective architectural materials such as marble from Proconnesus) the attempts to visually mimic nature, *trompe l'oeil*, should also be understood to include the comparable attempts to acoustically mimic nature, *trompe l'oreille*. The 'impressionism' implied by Gage in "Byzantine" mosaics may also be an identifiable quality in Late Antique ecclesiastic architectural acoustics, where long reverberation times and echo could have been present; the intentionality of these acoustical characteristics will be returned to in greater detail in Chapters Two (Part 2.5) and Four (Part 4.1).

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[63] Jones & MacGregor 2002:15.
[64] Eugenius' works discussed by Norwich 1970.

But, whereas colour (paint, dye, stains) may leave a material trace, sound (*viz* music and language) are yet more difficult:

> …music may be represented only through the remains of musical instruments (Buisson 1990; Holmes 1986), or the acoustic properties of particular spaces (Lawson *et al*. 1998; Watson and Keating 1999), and languages perhaps not at all…[65]

Art and Architectural Historians[66] have tended to focus on the purely visual and documentary evidence of classical musical culture. Archaeologists have been eager to find methods of applying theories of phenomenological experience to the material record. Thankfully, in the second decade of the 21st Century we now have the technology to begin methodically addressing a more holistic understanding of the past that includes both visibility and aurality. An important starting point for the consideration of acoustics in the historic past has already been provided by the CAHRISMA Project in 2000, detailed in the following Part 1.2.

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[65] Scarre 2002:227.
[66] Cf Elsner 1995, 1998, and 2004; Lassus 1967; Krautheimer 1965 (1986); Mango 1974 and 1990.

Part 1.2: CAHRISMA 2000-2003

Parallel to the archaeoacoustical investigation of prehistoric tombs and monuments mentioned in Part 1.1, there has also recently been an important acoustic renovation project conducted in some of the major sixth-century churches of Constantinople, CAHRISMA[1], the Conservation of the Acoustical Heritage by the Revival and Identification of the Sinan's Mosques Acoustics[2]. The aim was part of a broader goal to identify, revive and conserve visual and acoustical architectural heritages[3]. The primary objective was to 'innovate and implement the concept of Hybrid Architectural Heritage in the field of conservation and restoration'[4], whereby acoustical and visual peculiarities are identified. Further, the Project intended to combine virtual acoustical and visual environments 'to enable users to have more realistic perceptions' with the purpose of designing and creating a novel Hybrid (acoustical and visual) Architectural Heritage System[5]. Karabiber[6] has usefully summarised the seven 'scientific and technological goals' of the Project as follows:

1. Identification of the recent and initial acoustical peculiarities of the Sinan's mosques and Byzantine churches, by acoustical measurements and computer aided modelling tools.
2. Evaluation of psycho-acoustical and subjective characteristics of these worship spaces.
3. Integration of acoustical and visual virtual environments into an interactive 3D real-time system.
4. Creation of an integrated real-time system for CD-ROM of 3D architectural models with realistic virtual humans.
5. Comparison of the mosques and churches acoustics and review of the acoustical influence of Byzantine churches on Sinan's mosques.

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[1] http://vrlab.epfl.ch/Projects/cahrisma.html. The Project was supported by the European Commission, within the "Confirming of International Role of Community Research – INCO MED", a specific programme of the Fifth Framework.
[2] Weitze *et al* 2001.
[3] Karabiber 2000.
[4] http://vrlab.epfl.ch/Projects/cahrisma.html
[5] These goals are collaboratively worked on, by the Yildiz Teknik University (YTU), Turkey (http://www.yildiz.edu.tr/), the University of Ferrara (UNIFE), Italy (http://www.unife.it/), the Institut National De Recherche sur les Transports et leur Sécurité (INRETS), France (http://www.inrets.fr/), the Danmarks Tekniske Universitet (DTU), Denmark (http://www.dtu.dk/), the University of Malta (UOM), Malta (http://www.um.edu.mt/), the University of Geneva MIRALab (http://www.miralab.unige.ch/), and the EPFL-Vrlab, Lausanne, Switzerland (http://vrlab.epfl.ch/).
[6] Karabiber 2000.

6. Determination of the optimum acoustical conditions for mosques by the comparison of subjective parameters obtained from psycho-acoustical surveys with the objective parameters obtained from measurements and calculations.
7. Conservation and restoration of the selected monuments architectural heritage (acoustical and visual) in a virtual environment.[7]

The study focus of the project was Istanbul and included the three mosques (*masjid*) of Sokullu, Selimiye, and Süleymaniye, as well as three Byzantine churches (Hagia Sophia, Saint Irene, and SS Sergius & Bacchus) also at present mosques. Accordingly, the current acoustical characteristics of these structures were scrutinised. Following the Ottoman Turkish sack of Constantinople in 1453, the Christian churches were converted into mosques. Therefore, due to the Islamic use of the structures, and the architectural alterations to the former Christian churches (namely the addition of the *qiblah* wall, the *mihrab* niche indicating the direction of Mecca, and the *minbar* raised pulpit), a pre-recorded Islamic intonation *Iç Ezan Allahüekber, Allahüekber*[8] was chosen as an appropriate vocal sound source. The Imam, a male, performs the intonation, while female vocalisation was not included as it is inappropriate to Islamic worship within the mosque. Additionally, the absorption coefficient of the extensive floor carpeting (*sajjada*)[9], characteristic of the mosque interior prayer hall (*musalla*), was modelled in the reverberation chamber of the company *Modulo Uno*, Turin[10], identifying a predicted acoustic absorption in the medium-high frequency range [11].

CAHRISMA methodology

At key positions throughout the spaces, 'in the usual positions of the leader of the congregation'[12] a Lookline dodecahedron loudspeaker produced a test signal consisting of an exponential sine sweep from 80Hz to 18000Hz of 20 seconds duration[13]. The sweep was recorded using two different types of microphone (Binaural probe Neumann KU100

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[7] http://www.eng.um.edu.mt/~pjmica/research/cahrisma/cahrisma.htm
[8] Meaning *Dieu est grand* (God is Great); recorded in an anechoic chamber at the University of Ferrara, the intonation is voiced by the Imam as part of the Turco-Islamic Friday Service: http://server.oersted.dtu.dk/www/oldat/cahrisma/MosqueAndChurchSound.htm#Sergius%20Bacchus%20mosque
[9] The small portable prayer mat is the *sajjada* in Arabic (thanks to Soukeyna Boye for clarification).
[10] http://www.modulouno.it/
[11] Marsilio *et al* 2001:1. Also Pirn 1999:67.
[12] Prodi *et al* 2001:1.
[13] The following methodology details are substantially from Fausti *et al* 2003:2.

and a B-format probe Soundfield ST250), positioned throughout the space, and 'digitally stored on magnetic tape from a 20bit digital recorder' (Tascam DA38). Subsequent processing and calculations were conducted according to the specific technical standard ISO3382, 1997. The calculation of acoustical parameters (using Cooledit with an Aurora package) was based on the omni-directional signal enclosed in the B-format coding (called W). From the recorded Impulse Response several acoustical parameters were calculated including Reverberation Time (RT) and Clarity. Reverberation Time was reported between 125 and 2000 Hertz (see Chart 1.2.1 below) for T_{20}, calculated from the decay range between –5 and –25 decibels[14]. The perceptible clarity (*Klarheitsmass*) of speech (C_{50}) and music (C_{80}) are calculations[15] that aid in identifying areas within the space where best to stand in order to clearly hear speech and singing.
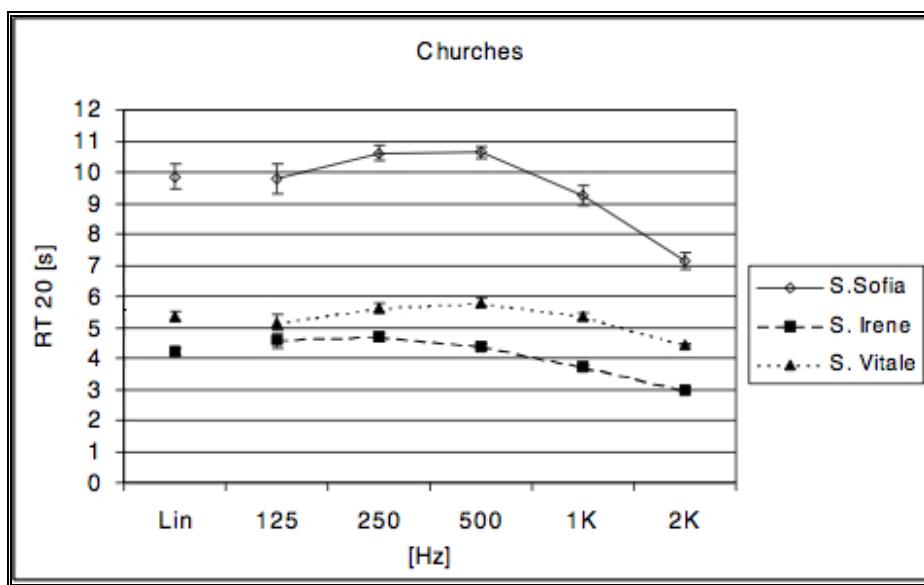
Chart 1.2.1: Comparative Reverberation Times (RT_{20}) of three Byzantine churches (Prodi *et al* 2003:3, Figure 4).

As these acoustical characteristics relate to physical locations within the space, an archaeological investigation of ancient space and place undoubtedly benefits from acoustic science.

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[14] Tronchin & Farina 1997:11.
[15] C_{80} relates to musical perception and the calculated time interval is limited to 80 milliseconds, whereas for the clarity related to speech (C_{50}) the time interval is set to 50 ms (Tronchin & Farina 1997:15).

Transforming hybrid architectural heritage into archaeoacoustical reconstruction

The methods and results of CAHRISMA are of particular interest for the purposes of archaeoacoustics. For acoustical reasons the later use of the sixth-century churches as mosques creates a very different space and place. As noted above, the inclusion of floor carpets in some Late Antique churches affects the overall acoustic character, is one specific example of alterations to the original spatial design. Additionally, for archaeoacoustical purposes it would be necessary to play, or even better perform, a relevant Christian chant that is contextually associated with the churches. For obvious reasons it would be inappropriate to perform Christian chant in a mosque and so another architectural example would need to be found. In other words, the acoustical renovation work conducted by CAHRISMA could feasibly be made reconstructive for archaeological investigation.

The CAHRISMA Project has benefited academia in that it provides a pragmatic foundation and opportunity for interdisciplinary research between Historic Archaeology and Acoustics. The present research takes up this opportunity and develops the work by applying the methodology for archaeoacoustical reconstruction. The acoustic data published by CAHRISMA and the related acoustic survey of San Vitale in 2000, provide an opportunity of comparison between this centrally planned octagonal domed congregational church of Ravenna and Constantinople's similar church of SS Sergius & Bacchus[16]. Chapter Five (Part 5.3) details the methodologies used formerly in surveying San Vitale's acoustic character in 2000 and, for the present research, in 2006.

Fortunately, as part of the CAHRISMA comparative analysis a very useful acoustic survey of San Vitale was conducted by Prodi in 2000[17]. Table 1.2.1 below gives the measured volume, surface areas and comparative ratios of San Vitale and SS Sergius & Bacchus.

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[16] Essentially CAHRISMA was a project about conserving the present acoustic conditions of these structures and so the fundamental difference between my research and their mandate is that I am investigating the acoustic conditions of San Vitale in order to answer questions about its original sixth-century characteristics. Whereas CAHRISMA played a pre-recorded Islamic chant inside SS Sergius & Bacchus, I will be performing a Ravennate chant inside San Vitale and therefore not attempting the conservation of present acoustic conditions but focusing on an archaeological investigation of original social contexts.

[17] Fausti *et al* 2003; Prodi *et al* 2001, Marsilio *et al* 2001.

Church	Volume: V [m³]	Total Surface: S_T [m²]	Floor Surface: S_F [m²]	Ratio of Volume to Total Surface: V/S_T	Ratio of Volume to Floor Surface: V/S_F
San Vitale (SV)	25800	11400	980	2.26:1	26.33:1
SS Sergius & Bacchus (SB)	14900	6700	750	2.22:1	19.87:1
SV/SB Ratio	1.73:1	1.70:1	1.31:1	1.02:1	1.33:1

Table 1.2.1: Geometrical data of San Vitale and SS Sergius & Bacchus (After Marsilio *et al* 2001:1, Prodi *et al* 2001:1, and Fausti *et al* 2003:5).

Since the church of SS Sergius & Bacchus (now the Küçük Ayasophia Cami mosque, 527 - 536) at Constantinople[18] has often been cited as having a direct influence on the design of San Vitale[19], it is now possible to test the veracity of this assumption by making comparisons of their respective architectural design and acoustic properties, as is done in Chapters Three, Four and Five.

San Vitale is the larger of the two churches (with 10900m³ greater volume), while they exhibit a close ratio (1.02:1) of volume to total surface. Also noteworthy are the positions chosen by CAHRISMA (Figure 1.2.1 below) for the placement of the dodecahedron loudspeaker and pre-recorded Imam intonation sound sources, all on the ground floor; S1 in the apse, S2 at the centre of the church, and S3 in the entrance narthex.

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[18] Krautheimer 1965:169; Lassus 1967:75 Hagia Sophia will also enter discussion, taking into account the immensely exaggerated dimensions. San Vitale and SS Sergius & Bacchus are within the same scale and contemporary with each other, therefore comparisons between them are more fruitful.
[19] Krautheimer 1965; Lassus 1967.
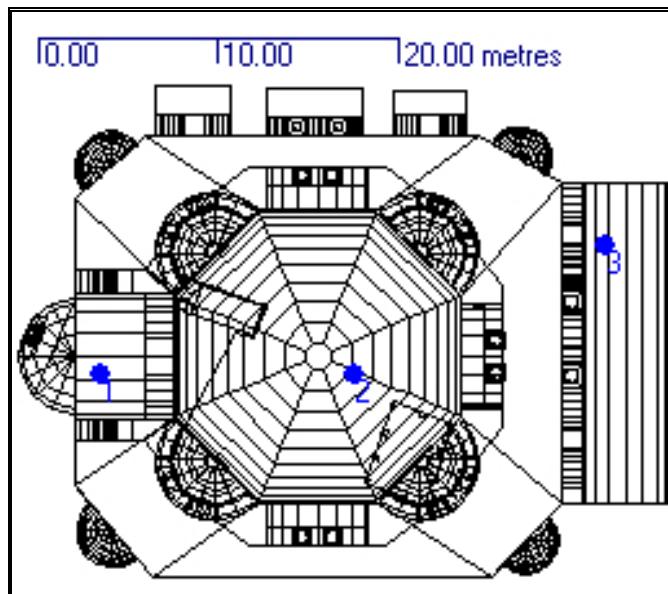
Figure 1.2.1: CAHRISMA sound source positions chosen for SS Sergius & Bacchus (after Lynge 2006[20]).

San Vitale was therefore considered for further acoustical survey and archaeological investigation for the present research according to several criteria as outlined in the following Part 1.3.

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[20] Lynge 2006.

Part 1.3: Case Study - San Vitale, Ravenna

The Archaeological investigation of sixth-century visibility and acoustics can potentially be performed within a contemporary architectural example which has an extant interior enclosed space, and if that space meets with the following criteria:

1:      A Late Antique interior space that has undergone minimal alterations during its biographic existence, namely that the interior space has retained its original dimensions.

2:      An interior space where a contextually associated contemporary sound source might be identified and performed.

3:      An interior space that is accessible in order to perform visibility and acoustic measurements.

4:      An interior space in which it is permissible and logistically possible to perform, record and measure an identified appropriate vocal sound source.

One particular Late Antique structure successfully meets all these criteria, San Vitale (c. 526 - dedicated on April 19 548)[1] in Ravenna. The interior dimensions are preserved including the restoration of the floor-level to its original level throughout. Since the church has continuously been used for its original purpose of congregational Christian Eucharistic celebration, details such as the floor remaining uncarpeted have helped maintain the acoustical character of the original design.

Table 1.3.1 below charts the alterations made to the fabric of San Vitale. Although it has suffered some damage the restorations and repairs afford a good opportunity for visibility and acoustic analysis. Likewise, since the Baroque fittings have been removed a good sense of the original space is apparent. Although certain sixth-century fittings such as chancel screen, tapestry hangings, window glass, and the wooden ceilings of the ground floor and second storey *matroneum* ambulatory can only be speculated upon, this interior is pristine enough for the success of the proposed

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[1] In Chapter Four (Part 4.1) I offer a resolution to whether San Vitale was dedicated in 547 or 548, securing April 19, 548 as the day of dedication.

methodology described in Chapter Five. Additionally, all areas of San Vitale's ground floor and *matroneum* are accessible and permission is attainable from the office of the Archdiocese of Ravenna[2].

San Vitale Alterations	
6th C.	Ambulatory and gallery zones vaulted, wood replaced with plaster[3]. Door to *monasterium* of Nazarius bricked up.
c.595-606	Floor mosaic altered[4]
By 995[5]	Renewal of the façade
Early 11th C.	Construction of a bell-tower (replacement of southern stairwell)
1538-1545	Floor reconstructed after floods (raised 80cm)[6]
17th C.	Earthquake; partly destroyed 11th C. bell-tower[7]
1780 (Baroque)	Baroque Frescoes on dome ceiling and in niches[8]
Baroque	A small organ was erected in front of the apse mosaics[9]
Turn of the 20th C.	C. Ricci restorations[10]
1929	Three-mullioned entrance of the narthex restored[11]

[2] On the evening of April 30, 2006, with express permission from Monsignor Guido Marchetti (Director of Opera di Religione della Diocesi di Ravenna) and Dott.ssa Anna Maria Iannucci (Soprintendenza per i Beni Architettonici e per il Paesaggio per le Provinvie di Ravenna) I initiated the acoustic measurement of San Vitale. The measurements were taken by Prof. Lamberto Tronchin (University of Bologna) and his team (Ryota Shimokura, Lorenzo Orlandi, Bruno Longanesi) over a five-hour period at night (6pm-11pm) when the church was closed to tourists. At the same time Dott.ssa Maddalena Roversi (University of Bologna) and I were recorded singing *Lux de luce*.

[3] *Contra* Krautheimer 1965:170, who states this was done in the 'Middle Ages'. The wooden ambulatory ceilings may have been replaced soon after 548 (Stalley 1999:69-70).

[4] Alterations made by Archbishop Marinianus (c.595-606), and also at San Giovanni Evangelista (Deliyannis 2004:215; Bovini; Gaddoni 1991:55-58).

[5] By 995 San Vitale became the centre of a Benedictine monastery, suppressed in 1797. In 1804 the first museum, the Museo Classense Municipale, was established next to San Vitale and the former atrium/cloisters. In 1885 Enrico Pazzi organised the municipal collection into a "Byzantine" museum, which then passed to the state as the present National Museum (http://www.emiliaromagna.beniculturali.it/index.php?en/179/ravenna-e-provincia).

[6] The Ravenna Maze/Labyrinth may be a copy and replacement of an older original sixth-century version below (Wright 2001:36).

[7] Due to this earthquake and subsequent subsidence external buttressing was added to the north walls but there remains some measurable deviation of plumb recently noted by Binda, Mirabella Roberti and Guzzetti (2000).

[8] By Cafeozzi and Gandolfi of Bologna, and Guarana of the Veneto. Also between 1778 and 1782 by Serafino Barozzi, U. Gandolfi and E. Guarana, specialists in *Quadratura* illusionist ceiling painting (Wittkower, Connors and Montagu 1999:35-36).

[9] 'The area around the altar, where all the mosaics still survive undamaged, was cluttered with the usual heavy Baroque furnishings, and here too a small organ was erected in front of the mosaics' (van der Meer 1967:16).

[10] Ricci renewed the north tower and the marble covering of the apse and presbytery, Modelled on the similar example of the Basilica Eufrasiana at Parenzo (Istria). Also, the choir floor was raised by 50 cm.

1932	Floor mosaic discovered (smaller aisle on south side)[12]
Recent restoration[13]	

Table 1.3.1: The Alterations of San Vitale.

As mentioned above in Part 1.2 San Vitale has a total volume of 25800m^3 and retains much of its original reflective floor[14], while the volume of SS Sergius & Bacchus is 14900m^3 but its floor is now carpeted. Likewise, the Christian liturgical character of San Vitale, with both male and female congregational attendance and vocalisation, is retained, presenting an unaltered belief use of the sacred space. Nevertheless, as mentioned above, the comparison made between San Vitale and SS Sergius & Bacchus by Patrizio Fausti, Roberto Pompoli & Nicola Prodi[15] is used as a starting point to enhance the additional 2006 acoustic survey and analysis of San Vitale undertaken specifically for this present research.

Location of San Vitale

Ravenna (Map 1.3.1 below) is situated in the Emilia-Romagna region of northern Italy, amidst a low-lying tidal marsh[16] at 44˚25' North, 12˚12' East and a short distance west of Italy's Adriatic coast. In the sixth-century two small tributaries of the Po (*Padus*) flowed through the city, approximately sectioning the urban area into a full half east of the *Flumen Padennae* and roughly two quarters to the west, divided by the smaller *Flumisellum Padennae*[17]. These streams were navigable and while the city continues to suffer from subsidence, the streams have been long since reclaimed and covered by roads.

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[11] Bendazzi & Ricci 1987:23-24.

[12] Work began on lowering the floor to its original level with the consequent discovery of two segments of mosaic dating to the sixth-century representations of the Labyrinth and the Months (www.turismo.ravenna.it/eng/storia/storia_mosaici.htm).

[13] By the Soprintendenza Beni Ambientali and Architettonici di Ravenna (UNESCO).

[14] 'To the original group of measured spaces [in the remit of CAHRISMA], also the Byzantine church of S. Vitale was added though not expressly scheduled in the project. This was done because of the architectural similarity between this Byzantine church with the church of St. Sergius and St. Bacchus' Fausti *et al* 2003:1.

[15] P. Fausti, R. Pompoli, N. Prodi 2003 *et al.*

[16] With an elevation of only 4 metres above sea level: http://en.wikipedia.org/wiki/Ravenna

[17] La Rocca 2002:263, Map 6.

1 PORTA TEGURIENSIS	29 Ecclesia S. Demetrii	51 S. Apollinare Nuovo
2 TURRIS UMBRATICA	30 Ecclesia S. Paterniani	52 S. Salvatore ad Calchi
3 POSTERULA AUGUSTI	31 Ecclesia S. Mariae in Gallope	53 S. Agata Maggiore
4 PORTA S. VICTORIS	32 Monasterium S. Stephani	54 Basilica Apostolorum
5 PORTA SERRATA	junioris	55 S. Giorgio de porticibus
6 PORTA ARTEMIDORIS	33 Ecclesia S. Vincentii ad	56 S. Michele in Africisco
7 PORTA PALATII	monetam	57 S. Agnese
8 PORTA WANDALARIA	34 S. Andrea dei Goti Ecclesia	58 Battistero Neoniano
9 PORTA CAESAREA	Gothica	59 Cattedrale Ursiana
10 PORTA URSICINA	35 Ecclesia S. Mariae in horris	60 Episcopium
11 PORTA S. MAMAE	36 Ecclesia SS. Sergi et Bacchi	61 S. Andrea Maggiore
12 PORTA DI GAZZO	37 Ecclesia S. Mariae in Pace	62 S. Maria in foro
13 PORTA AUREA	38 Ecclesia S. Stephani ad	63 SS. Giovanni e Paolo
14 POSTERULA LATRONUM	fundamentum regis	64 S. Eufemia ad arietum
15 POSTERULA S. ZENONIS	39 Ecclesia S. Mariae in	65 S. Vitale
16 PONS S. STEPHANI	Chartilario	66 SS. Nicandro e Marciano
17 PONS AUGUSTI	40 Ecclesia SS. Philippi et Iacobi	67 Battistero
18 PONS MARINUS	41 Monasterium S. Severini	68 Cattedrale e rini degli Ariani
19 PONS S. MICHAELIS	42 Monasterium S. Martini	69 FLUMEN PADENNAE
20 PONS APOLLINARIS	post ecclesiam maiorem	70 FLUMISELLUM PADENNAE
21 PONS CAPITELLUS	43 S. Croce	71 PALATIUM di Odoacre(?)
22 PONS CANDAVARIAE	44 S. Maria Maggiore	72 THEODORICIANUM
23 PONS CALCIATUS	45 S. Apollinare in veclo	73 PALATIUM AD LAURETA (?)
24 PORTA ASIANA (?)	46 S. Vittore	74 CIRCO (?)
25 POSTERULA VINCILEONIS (?)	47 S. Giovanni ad naviculam	75 PORTA PLUVIENSE
26 Basilica S. Stephani Maioris	48 Mausoleo di Teodorico	76 Antico basino del PORTUS
27 Monasterium SS. Iohannis	ad Farum – necropoli gota	CORIANDRI bonificato de
Baptistae et Barbatiani	49 S. Stefano ad balnea Gothorum	Teodorico (?)
28 Monasterium S. Laurentia in	50 S. Giovanni Evangelista	77 PORO
Pannonia	necropoli romano-gota	

Map 1.3.1: Map of Ravenna (La Rocca 2002:263, Map 6).

San Vitale (precisely at 44˚25'14" North, 12˚11'46" East)[18] is situated in the north western "quarter" of Ravenna, north of the *Flumisellum Padennae* and east of the *Flumen Padennae* (refer to Map 1.3.1 above). It stands on the open ground of a cemetery dating to at least the late fifth-century, associated with the now derelict church of St. Croce and protected monument popularly known as the *mausoleum* of Galla Placidia[19]. Between San Vitale and the *mausoleum* excavations in 1912 revealed a fourth-century Roman house with mosaic floor[20]. A monastic cloister with graves of the fraternity has long overlaid San Vitale's original atrium courtyard adjoining the narthex[21]. The remainder of the monastic complex covers the ground to the immediate north and northwest of the church.

There is some indication of a small city gate immediately south of San Vitale's southwest end[22], where Ravenna's west wall kinks to the north. One city block south was a bridge over the *Flumisellum Padennae* known as the *Pons S. Stephani*, the road[23] presently terminates at the Via San Vitale, but may have originally continued north to the sixth-century basilica of S. Stephani Maioris to the north of San Vitale[24]. The Baroque entrance to San Vitale is pierced into its southern octagonal face, led to by a path from a grand ornamented gate of the same late date[25]. Another Baroque door opens from the northeast face of the church providing a view and access to the *mausoleum*.

San Vitale and the other churches associated with the same building project by Bishop Ecclesius are in various states of preservation. Santa Maria Maggiore stands immediately south east of San Vitale[26] and of the original sixth-century construction only a portion of the polygonal apse survives. San Michele in Africisco is now fronted by a piazza covering the original junction of the *Flumisellum Padennae* and *Flumen Padennae*, and stands on what was the latter rivers east bank. Crossing the larger of these

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[18] Google Earth.
[19] Deliyannis 2004:151, note 33.
[20] Bendazzi & Ricci 1993:40.
[21] http://www.emiliaromagna.beniculturali.it/index.php?en/179/ravenna-e-provincia
[22] Observed by the author in 2006, at the western extent of the Via San Vitale where it intersects with the intramural Via Mura di San Vitale, some clearance and exposure of this gate was photographed (see Appendix E.2).
[23] The present Via Gianbattista Barbiani.
[24] See Map 1.3.1 (La Rocca 2002:263, Map 6).
[25] This Baroque gate is at the north termination of the present Via Giuliano Argentario.
[26] The present path extending from Via Pietro Alighieri divides these two churches, and also the mausoleum of Galla Placidia and St. Croce.

two rivers, and immediately south of San Michele, was the bridge *Pons S. Michaelis*[27]. Sant' Apollinare in Classe has faired much better despite the disappearance of many of its nave wall mosaics[28]. Both San Vitale and Sant' Apollinare at Classe are UNESCO World Heritage Sites.

Due to the marshy conditions of Ravenna, the sound marker of frog-song is noticeable[29] and referred to continually through the ages at least since Martial quipped:

…The frogs of Ravenna chatter more melodiously than you…[30]

Descriptions of San Vitale

San Vitale has been perceived as an inseparable element in the "era of Justinian", already noted above in UNESCO's description of the church (Part 1.2). In order to begin unpicking and resetting this impression and to identify the way in which this church is generally placed within the context of Late Antiquity, it is worthwhile citing two further descriptions, illustrating how the perceived conventional popular and scholarly interpretation of this church over the past century has remained essentially unchanged. Countless writers have described San Vitale, at least as early as Agnellus in the ninth-century. An early 20th century description of the church, by Bumpus[31], is one typical example:

> St. Vitalis, the most complicated and at the same time perhaps the most beautiful of the circular churches of its age, was founded in 526 by Bishop Ecclesius, after a journey which he took to Constantinople with Pope John I. Authorities seem divided as to what was the original motif for this structure, but it would appear to be a fusion of western and Oriental ideas as exemplified in the temple of Minerva Medica…and the octagonal church built by Constantine at Antioch. St Vitalis differs from the former in that it is an octagon instead of a decagon, and that it is wholly enclosed by an octagonal wall, besides which its general plan, decorative details and other striking analogies which exist between it and the church of SS.

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[27] Map 1.3.1 (La Rocca 2002:263, Map 6).
[28] The anonymously written Wikipedia article (http://en.wikipedia.org/wiki/Basilica_of_Sant'Apollinare_in_Classe) suggests the mosaics were 'possibly ripped out by the Venetians in 1449', although this remains unverified.
[29] In April of 2006 I was happy witness to Ravenna's ambient frog-song while looking down at the submerged mosaics of St. Croce.
[30] Martial; *Epigrams* XCIII (To Vetustilla), line 8 (Ker 1947).
[31] Bumpus 1907 (1926).

Sergius and Bacchus at Constantinople…leave little doubt that this remarkable edifice at Ravenna was constructed by a Constantinopolitan architect, and that it was the first appearance of the Byzantine style on the western shores of the Adriatic.[32]

Compare this with a recent description published almost a century later:

The churches of S. Vitale in Ravenna and S. Apollinare in Classe may be said to represent the culmination of the architectural trends that began in the age of Constantine. The formal dichotomy…between the longitudinal basilica and the centrally planned church was still very much present in the middle of the sixth-century. But with the collapse of Justinian's empire, these two church types would follow very different lines of development. The aisled basilica, in part because of its association with Rome, became the standard plan for all churches in the West throughout the Middle Ages…In the Byzantine East, on the other hand, the centrally planned, domed church became the norm, following the example of Justinianic churches in Constantinople. Thus, the reign of Justinian marked an architectural as well as a political watershed for western Europe.[33]

What is immediately striking about these two citations is that, although a century apart, they both support the idea of San Vitale as an Eastern, specifically Constantinopolitan imported design. Concessions are made for the identifiable elements that are of local traditional building methods, such as the dome constructed of interlocking amphorae, not found outside Italy[34]. The reign of Justinian (527-November 13/14th 565) is assumed to be the political and cultural *milieu* under which San Vitale must be included, for the apse wall mosaics apparently make it evidently clear that Justinian and his consort Theodora figured large in the *raison d'être* of the design, construction and decoration. To contest this assumption seems heretical: none of the literature within the disciplines of Art, Architecture, History, or Archaeology suggests the churches of Constantinople may have been influenced by ecclesiastic architectural trends originating in Italy. The historical evidence seem only to support the conventional interpretation, that the sixth-century centrally planned octagonal two storey domed congregational church of San Vitale was wholly a "Byzantine" imported design on Italian soil. Ostrogothic Ravenna was invaded and capitulated to Justinian's troops in 540 and

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[32] Bumpus 1907 (1926): 243-244.
[33] McClendon 2005:19-22. On page 19, Figure 20 has the incorrect north arrow direction on the plan of San Vitale; it is pointing east rather than north.
[34] Krautheimer 1965:234.

San Vitale was dedicated eight years following. However, as Bumpus noted, it is also known that the design and construction of the church began in or shortly after the spring of 526, either in the final months of the Arian Ostrogothic King Theoderic's long reign (454-August 30th 526)[35] or at the beginning of his Orthodox daughter Amalasuentha's rule (526-535)[36]. The implications of the latter fact do not match with the assumptions of the former and therefore, to better understand why centrally planned domed congregational churches became popular in the East rather than the West, it is necessary to consider the merits of the concept that Ravennate innovations may have had influence at the Eastern capital.

Such an unorthodox suggestion is admittedly problematic. Typologically there appears to be a design progression from SS Sergius & Bacchus to Hagia Sophia to San Vitale and the respective dedication dates of before 536 (exact dedication date unknown)[37], 537 (December 27th) and 548 (April 19th)[38] also seem to conspire. However, in respect to these dedication dates, when the date at which construction of each church was begun is taken into account, the appearance of this accepted progression immediately dissolves: San Vitale was begun in 526, SS Sergius & Bacchus prior to 536, and Hagia Sophia erected very quickly between 532 and 537[39].

Against the conventional view of San Vitale, Krautheimer was perhaps unwittingly the first to suggest 'the architect…was, I think, a Westerner', but continues by conceding:

> …he was intimately acquainted with the new architecture which was being
> created at that time at the court of Constantinople. He strove to translate into his
> own terms this new architecture of Justinian. Equal to Anthemios and Isidorus, or

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[35] The now famous gold medallion discovered at Sinigaglia is inscribed THEODERICVS PIVS PRINCIS. Also see the inscription set up by Caecina Mavortius Basilius Decius (ILS 827) in which Theoderic is styled 'd.n. gloriosissimus adque inclytus rex Theodericus victor ac triumfator semper Augustus', and ILS 825 which begins 'salvis dominis nostris Anastasio perpetuo Augusto et gloriosissimo ac triumfali viro Theoderico' (Jones, A.H.M. 1962. The Constitutional Position of Odoacer and Theoderic. *The Journal of Roman Studies*. Volume 52, Parts 1 and 2. London: The Society for the Promotion of Roman Studies. Pp. 126-130). Therefore, following A.H.M. Jones, I will use the spelling *Theoderic* rather than *Theodoric*.

[36] Jones 1973:275.

[37] Krautheimer 1965:224.

[38] The support for this dedication date for San Vitale is detailed in Chapter Four Part 4.1.

[39] Krautheimer 1986:232, 227 and 205 respectively.

nearly their equal, he designed the one truly great building of the West in the sixth-century.[40]

Within the same volume, Krautheimer mentions another centrally planned congregational 'tetraconch' church on the Italian mainland, at Canosa (SS Cosmas & Damian), since dated to the sixth-century and, predictably, labelled "Byzantine"[41]. However, as will be explored in Chapter Two (Part 2.1), the historical evidence that Ecclesius and Sabinus, bishops of Ravenna and Canosa respectively, both went with Pope John I to Constantinople in 525/6, a date perhaps prior even to the decision to build SS Sergius & Bacchus there, requires attention.

The consistent assumption of "Eastern", Constantinopolitan influence in general and Justinian's initiatives in particular over the design and construction of San Vitale need to be addressed. For the present research it is enough to suspend judgement and revisit anew the visual and acoustic aspects of Ravenna's octagonal church and let its embedded material, liturgical, symbolic, social and cultural meanings have voice.

The decision to investigate San Vitale also invites the opportunity for some discussion of pre-Gregorian sixth-century chant. To a significant degree, liturgical chant was site-specific, local rites and musical developments theoretically capable of evolving directly from the architectural settings where congregations met. Yet these spatial locations with their regional variations are not satisfactorily addressed in music historical studies, since the majority of early sites either no longer exist or they are much altered. Almost by necessity the musicology of early Christian chant predictably relies upon the remnants of musical notation. Regrettably there are no known sound recording machines from Late Antiquity, unless architecture itself is understood to be a kind of recording technology. Be that as it may, for that way lies fiction.

On the other hand, in architectural and archaeological studies only passing mention is made that churches were the locations of musical performance; the music itself is left to the research of musical historians, and, as just noted, they are reliant upon extant examples of musical notation. The lacuna created by these complementary but

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[40] Krautheimer 1965:236. Anthemios and Isidorus are the known architects of Hagia Sophia.
[41] Krautheimer 1965:229.

separated subjects can be usefully filled with a discussion from archaeologists and acousticians focusing upon the acoustic properties and qualities of extant ancient liturgical spaces. However, very few choices among the examples of ancient churches remain for such an investigation. San Vitale is, therefore, a good choice for present research into contemporary architectural acoustic knowledge and local, Ravennate, musical development within the broader context of Christian liturgical chant and architectural developments. San Vitale is also the only church available to approach an answer to why the centrally planned domed church had greater success as a liturgical and congregational space in the East than the more usual longitudinal basilica hall in the West. The very fact that San Vitale exists in the West has been one of the various reasons for its apparent uniqueness and interpretation as a championed mark of the "Byzantine" world expressed on Italian soil. This long-lived assumption has not been satisfactorily challenged, but will come under considerable scrutiny amidst the following chapters and appendices.

We should be careful not to assume all sixth-century ecclesiastical building activity under "Byzantine" sway was necessarily the work of Justinian and his oft-celebrated architectural foundations. As recently as 2003, for example, San Vitale was said to be 'a very 'Constantinopolitan' church' and 'built by Justinian I in the mid-sixth-century'[42]. San Vitale was begun in c.526 and was likely largely completed by 540 when Belisarius eventually took Ravenna. In no sense, then, can it be claimed that San Vitale was "built by Justinian". The above quote therefore misrepresents the real origin and impact not only of this particular church but also by extension overstates Justinian's

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[42] Harris 2003:109-110, note to figure 30. Utilising some quite outdated concepts of Bréhier (1903, Les Colonies d'Orientaux en Occident au commencement du moyen-âge. *Byzantinische Zeitschrift* 12. Pp. 1-39, 22) she goes on to say: 'it would be incorrect to underrate Byzantine ecclesiastical links with northern Italy in the period before Re-conquest [540] simply because of the historical and cultural importance of Milan. Indeed, the Emperor Zeno's well-documented enthusiasm for the patronage of ecclesiastical architecture may have informally extended to the region. Column capitals at Theodoric's church of San Apollinare Nuovo [St. Saviour], Ravenna, built in about 490, are almost identical to high-quality capitals from the Nea-Anchialos church in Greece. There is textual evidence for Zeno's involvement in the architecture of Apulia – Bishop Laurence of Siponte (modern Manfredonia), requested that Zeno send artists to come and decorate his new Episcopal complex- so an imperial role in northern Italy might also be possible. Rather than Milan being an architectural role-model solely in its own right, it could be the case that its continuing prominence in this way was, at least in part, due to northern Italy's links with the East' (*ibid*).

architectural activities in Italy. Even Procopius, our main primary source for the policies of Justinian, mentions no such Eastern Imperial architectural developments in Italy[43]. The 2003 quote highlights the potential problems of considering architectural developments in the Late Antique.

The term "Byzantine" has become cumbersome. It has been used to group together all disparate activity initiated by a seemingly centralised directive from Constantinope and, thus, usually figured by the reign of Justinian as the head of that centralisation. "Justinian" has become synonymous with a Byzantine Age[44]. This Justinian-centricity found throughout studies in Art History, Archaeology and Architectural History is misleading and requires resetting in the context of other vibrant communities in Constantinople itself, Italy and elsewhere.

The term "Byzantine" has also encouraged scholars to separate the sixth-century communities into discrete ethnic labels such as "Gothic", "Syrian", "Greek" and "Roman". I propose here that the term "Byzantine" has at best an awkward place in studying the sixth-century. Rather, focusing on Ravenna, Milan, Rome and Constantinople's cultural exchanges within the wider enclave of the Mediterranean basin sets the emphasis upon the active role of the city and associated rural and maritime resources. Upon the stage of these urban loci the exchanges between different Bishops of various Christianities influence and directly shape the architecture not of a personality-based Justinianic Age or Early Byzantine or even Gothic world but of a richly interconnected and fluctuating critical and transitory juncture in time, the Late Antique. This holistic approach allows us to consider Ravennate influences in Constantinople and Italian influences upon the East. If labels and terms of easy reference are desirable then I propose "Gothic Byzantine" would make for a refreshing contribution to any study of the sixth-century Mediterranean basin, as it includes the possibility for reflexive relations and exchanges between Ostrogothic, Visigothic, Vandal, Roman and Constintinopolitan communities.

Another problem with "Byzantine Studies" and the "Age of Justinian" is that these headings support an erroneous paradigm whereby Constantinople's influence is

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[43] Cameron 1996 *et al*.
[44] Maas 2005, Cameron 2006.

consistently seen as central and extending outwards to peripheral geographies and peoples in Italy, North Africa, and even the east coast of Spain. This paradigm does not easily allow consideration of influences extending back from those communities to Constantinople itself. The flow of influence is consistently understood to be in one direction only, simply straight from Constantinople and the policies of Justinian. It is almost impossible to discover any scholarly work that addresses the possibility of, for example, Ostrogothic Arian or even Italian Orthodox influences upon Constantinople.

The Ostrogoths of Italy have received growing scholarly attention in recent years. Under Theoderic (493-526) they seem to have desired to create 'a lasting cultural mix in which the Goths would preserve their special status and prestige while adapting to the customs and culture of Roman society' but, at the same time, refused to practice Orthodox Christianity and adhered 'to the Arian creed'[45]. And yet the Orthodox 'Roman' camp did flourish at Ravenna under the Arian Ostrogoths and although this may be explained as a concerted Ostrogothic strategy of political peacekeeping, the rivalries and competition between these Christianities has left its archaeological trace through the extant Late Antique architecture of Ravenna.

Understandably, San Vitale has been the subject of many Art Historical and Architectural Historical interpretations but in far too many cases the church or interior elements (namely the world famous mosaics) are taken in isolation, artificially separated and de-contextualised from the broader context of Ecclesius' other churches, of Ravenna and of comparable structures elsewhere. To bring San Vitale back into an inclusive and holistic archaeological investigation it is therefore necessary to understand the sixth-century context of San Vitale (Chapter Two) before considering its acoustical and visible content.

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[45] '…Referred to as the *lex Gothica* or Gothic law in our sources. It is no coincidence that the only extensive text in Gothic that has survived is the so-called Codex Argenteus, a sumptuous Gothic bible, which is the earliest known long text in any Germanic language. Goths had their own Arian churches (as can still be seen in Ravenna), and surviving documents written by clerics show that Gothic was spoken there' (La Rocca, 2002:19).

Part 1.4: Sixth-Century Knowledge of Sonic Phenomena

Are the acoustic attributes of a sixth-century ecclesiastical congregational space intentional and bound together with decisions made regarding architectural design or are they wholly separate, accidental and epi-phenomenal to those decisions. The question this research aims to answer is, were the architectural acoustics of the sixth-century intentional phenomena? Admitting all constructed space automatically has certain acoustic attributes inviting particular sonic expressions (for example chant, drumming, oratory) in Late Antiquity were the acoustic attributes characteristic of longitudinal basilicas and centrally planned domed churches in some way intentionally experimented with? To provide a way of answering this I will focus on whether there are any identifiable correlations between sixth-century architectural acoustic properties with contemporary developments in chant.

Appendix A is provided as a supplement to this Part, as it follows the ancient theories of acoustic phenomena relevant to the intellectual context of sixth-century Ravenna. Certain analogies of sound propagation are catalogued and commented on and two analogies in particular are found to be relevant at Ravenna in Late Antiquity, the rising cone analogy describing the stereo image of sound and Boethius' analogy of sound waves to water waves. These ideas will be returned to in Chapter Four but, for now, related concepts of geometric symmetry and the significance of number will augment our understanding of the intellect behind San Vitale's design.

Numerositas

It is uncertain whether there was, in the sixth-century, a theology of sound[1] and of music *per se*, but Augustine's expansion of 'the idea that beauty is based upon number into the metaphysics of proportion'[2] indicates late fourth-century interest in the unity of number and the Divine, and that interest certainly extends into the following centuries. Augustine developed the concept that 'participation in the unity of Divine will is possible through beauty, and beauty is possible through number'[3]. For Augustine, number refers

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[1] A Theology of sound has been proposed recently by Foley (1995:107-126).
[2] Augustine; *De musica*, Book VI (Schenk 1992:86).
[3] Augustine; *De musica*, Book VI (Schenk 1992:86).

to the Divine, its' mathematical proportion, rhythmic organisation, and the 'fittingness of parts or *aequalitas*, equilibrium'[4]:

> Beautiful things please by proportion, *numero*, and here as we have shown, equality is not found only in sounds for the ear and in bodily movements, but also in visible forms, in which hitherto, equality has been identified with beauty…Nothing can be proportionate or rhythmic, *numerosus*, without equality…Where there is equality or similitude, there is rhythmicality, *numerositas*, for nothing is so equal or so similar to anything as one is to one.[5]

Cited at the head of Chapter Three[6], Ambrose expressed an implicit connection between number, particularly the number eight, and ecclesiastical architecture, specifically for the rite of baptism, i.e. the baptistery. It is suggestive that Augustine began writing *De musica* while at Milan in 387, in Ambrose's company, whilst preparing for baptism[7]. Ambrose baptised Augustine and his son Adeodatus on Easter Vigil 387. In 388 Augustine returned to North Africa and completed *De musica* not long after. It is therefore not unreasonable to suppose Ambrose may have had some direct influence on the ideas Augustine expressed in the sixth and final book of *De musica*. It is known that the 'first five books were written not long before his baptism…when he was a neo-Platonist, and the final book a few years later…it is more deeply and fervently neo-Platonic, and even neo-Pythagorean with its numerical view of reality'[8]. Since *De musica*, as noted by Knight and Crossley[9], 'is a study not so much of music in our modern sense, but of metrical rhythm', the use of such ideas applied to the other mathematical arts, namely architecture may have been fruitful.

In this sixth book Augustine describes:

> …a series of hierarchically ordered musical 'numbers'. At the lower end are sensible or corporeal numbers, that is, the musical sounds produced by the player and felt by the auditor. At the upper end are 'judicial numbers' whereby the soul evaluates the equality and harmony of the lesser numbers. These judicial numbers in turn reflect a 'numberliness' (*numerositas*) that pervades creation and which ultimately reflects the eternity and immutability of God[10].

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[4] Augustine; *De musica*, Book VI (Schenk 1992:86).
[5] Augustine; *De musica*, Book VI (Schenk 1992:86).
[6] Page 67.
[7] Crossley 1951:127. Ambrose was Bishop of Milan from 374 to his death April 4, 397.
[8] McKinnon 1990:82.
[9] Crossley, reviewing W.F. Jackson Knight's (1949) *St. Augustine's 'De Musica'; A Synopsis* (1951:129).
[10] McKinnon 1990:83.

These historical links are highlighted to illustrate how the 'metaphysics of number' and *numerositas* were influential in Northern Italy, providing the foundation to the intellectual context in which Boethius and Cassiodorus developed their ideas (Appendix A). Further, the ideas of both Cassiodorus and Boethius can be understood to have contributed to the intellectual context of Ravenna in the years when San Vitale was designed and constructed. Cassiodorus, following on from Augustine's *numerositas*, restated the concept that '…simple mathematical ratios accounted for the basic musical intervals'[11].

The important innovation and contribution Boethius made in his *De institutione musica* is his 'famous threefold classification of music into *musica mundana*, *musica humana* and *musica instrumentalis*. The definition of *musica mundana* is 'the harmonious relationship between heavenly bodies – that is to say 'music of the spheres''[12]. Boethius defines *musica instrumentalis* as simply:

> …that music 'residing in certain instruments', thus leaving us to speculate on what he had in mind. The conventional interpretation is that he meant music in our sense, that is, actual sounding music, but this seems improbable in view of his tendency not to concern himself with contemporary music. It seems more likely that he had harmonics in mind, that is, the intervals and systems of pitches that 'resided in instruments' and could be demonstrated on them, particularly on the monochord – the portable laboratory, so to speak, of harmonics[13].

Boethius' threefold classification of music, and especially the *musica humana*, and *musica instrumentalis*, may arguably include architectural settings for musical

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[11] McKinnon 1990:85. '…The more complex doctrines of Boethius could be assimilated and adapted, and by the end of the tenth century a coherent exposition of music space was possible, best exemplified by the gamut of Guido of Arezzo's *Micrologus*' (McKinnon 1990:85). McKinnon concludes his chapter on Christian Antiquity (Chapter 5): 'One can argue…that without the development of medieval music theory, Western music itself would have followed a different course. With the vertical rationalization of harmony and the horizontal rationalization of metrical schemes it seemed driven to pursue architectonic structure at the expense of the melodic and rhythmic subtleties that characterize other world musics. The musical bequest of Christian antiquity, then, was twofold. There was of course the establishment of ecclesiastical psalmody that would develop into Gregorian chant and indeed eventually into Western art music, and, less obvious perhaps, there was the theoretical impulse that would help to form the unique character of that music' (McKinnon 1990:86).
[12] McKinnon 1990:85
[13] McKinnon 1990:84-85

performance, whereby a place such as a church might also have been considered an instrument in which music resided.

Musical theory therefore may have been one impulse that drove the reasoning behind San Vitale, where, to take McKinnon's words out of their intended musical context and supplant them into an architectural idea, '…the vertical rationalisation of harmony and the horizontal rationalisation of metrical schemes'[14] is a physical, material expression of *numerositas* '…that pervades creation and which ultimately reflects the eternity and immutability of God'[15].

The way in which music theory was developed at Ravenna in the same intellectual context and period when the design of San Vitale was being worked out may hold more demonstrable connections than previously explored. An attractive hypothesis can therefore be tested; the "architectonic structure" of music theory may have been expressed in the harmonious vertical rationalisation and rhythmic horizontal repetitions of San Vitale's design and construction.

The suggestion that the design of San Vitale is inseparable from contemporary thought on musical theory, theology and mathematical concepts of harmonic ratios, the metaphysics of proportion and *numerositas* all provide ways forward in opening up the investigation of early architectural acoustics. It also enables archaeological practice to identify and interpret the intentionality of built acoustic spaces, identifying acoustic phenomena and assessing the degree to which they were intentional or unintentional epi-phenomena albeit put to oratorical and musical use.

Having commented on the intellectual context of San Vitale we can now move on to consider its spatial and temporal context and content in Chapter Two.

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[14] McKinnon 1990:86
[15] Augustine; *De musica*, VI; McKinnon 1990:83

CHAPTER TWO

Social / Christian Ritual

San Vitale's Historical Context

Within the context of recent archaeological and historical interest in the sixth-century[1], generally labelled 'Late Antiquity', the present re-evaluation of the architecture of San Vitale at Ravenna (Map 2.1 A, B and C) reveals several important details that have formerly gone un-noticed but are relevant in highlighting aspects of the religious, political, and social issues active at Ravenna in a turbulent period when the city was taken in 540 by Constantinopolitan forces and the Western Empire was undergoing Justinian's re-unification programme. The sudden dramatic changes occurring in the last years of Ostrogothic rule under the Arian King Theoderic (454-526) and especially his Orthodox daughter Amalasuentha (516-535)[2] created a transitional social climate in northern Italy. During a period of such troubled changes the strengthened role of bishops in the urban context and their leadership of lay Christian civilians from all social levels can be identified as a crucial factor in negotiating and implementing strategies of inclusion and unification, albeit often with ramifications of exclusion and fragmentation.

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[1] Amory (1997), Andreescu-Treadgold (1991), Antoniou & Sinakos (2005), Azzara (2002), Baker (1993), Balzaretti (1991), Bardill (1999), Binda *et al* (2000), Bovini (1956, 1961) and Gaddoni (1991), Bowden, Lavan and Machado (2004), Bowersock, Brown and Grabar (2001), Brown (P.; 1971, 1992), Brown (T.S.; 1979, 1985), Browning (1971), Burns (1992, 1998), Cameron (1985, 2006), Cardani (1995), Caseau (2001), Castaldo, Maioli and Restani (1997), Chatford Clark (2007), Christie (1989) and Gibson (1988), Constable (2000), Crook (2000), Deichmann (1969, 1976, 1989), Deliyannis (1996, 2004), Doig (2008), Drinkwater (1992), Duval (1994), Elsner (1995, 1998, 2004), Evans (1996), Ferreiro (1999), Garland (1999), Geanakoplos (1976), Gelichi & Piolanti (1995), Grossmann (1973), Hansen (2001), Harris (2003), Harstone (1991), Hellenkemper (1994), Hodges and Bowden (1998), Hubert (1967), Jensen (1997, 2000), Jones (A.H.M.; 1973), Khatchatrian (1962, 1982), KjØlbye-Biddle (1994), Klingshirn (1985), Knight (J.K.; 1999), Koder (1996), Krautheimer (1965, 1986), Lassus (1967), Lavin (1962), Leone (1998), Liebeschuetz (1992), Little (2006), Llewellyn (1971), Lloyd (1996), Loseby (1992), Lowden (1997), Maas (2005), Magen (1993), Mainstone (1988), Maioli (1997), Mango (1974, 1990), Mas & Cau (2007), Mathisen (1981, 1997), McClendon (2005), McDonnell & Montague (1991), McKinnon (1990), McManners (1990), Meyendorff (1989), Milburn (1988), Miller (2000), Moffatt (1996), Morganstern (1976), Mundell (1977), O'Hea (2006), Painter (1994), Poulter (1994), Reece (1999), Restani (2004), La Rocca (1992, 2002), Rodley (1994), Runciman (1975), Saggioro (2004), Smith (C.A.; 1996-7), Smith (H.; 1990), Smith (J.C.; 1991), Smith (J.M.H.; 2000), Stalley (1999), Tronchin, Knight, Durvilli and Tarabusi (2007), Tronchin & Knight (2008), Verreyke & Monsieur (2005), Ward-Perkins (1981, 1984, 1994, 1999, 2006), Wharton (1995), Whitby (1985), Whittow (1990), Wickham (1981, 2002), Williams & Friell (1999), Wolfram (1997), Zäh (2002), Zarnecki (1975).
[2] Jones 1973:274-275.

Previously, throughout the fifth-century, many cities 'acquired a new Christian identity, founded on the cult of relics of a saint or saints, whose presence provided an ever-effective source of supernatural patronage and protection to those who worshipped at their shrine'[3]. By the sixth-century bishops were engaged in managing both the dead and the living; Christian martyrs whose shrines, often in cemeteries, and the developing infrastructure of the Cult of Saints, and living Christian congregations who required education and shepherding by the evolving ecclesiastic establishment. The bishop's role as shepherd increasingly began to include civic responsibilities for the betterment of congregation and their urban lives, which eventually resulted, in the sixth-century, in the episcopacy wielding immense power of governance over parochial sees and civic jurisdictions[4].

One of the results of the Late Antique bishops lengthening and strengthening the reach of theology into secular administration was the power to plan and execute expansive construction projects of building new churches, a material corollary not only of the social and political status of the episcopacy, but also a sure signal of how far the State had become the fabric of the Church[5]. In this milieu of permeable, blurred, and vanishing boundaries between the secular, lay politic and Orthodox congregations, and particularly in these decades of crisis, several bishops embarked on refiguring the old walled *civitas* centres, physically imbuing them with a Christian sacred topography to be socially negotiated and dwelled in. At the regional scale of northern Italy, this vigour may have been the continuance of that initiated by St Ambrose' fourth-century completion of ambitious large-scale church and baptistery building projects at Milan. The process of reshaping cities to communicate Christological meaning revitalised and strengthened many urban centres, to such a degree '…it was in the guise of the ecclesiastical diocese that the unity of city and territory, which was the essence of the Graeco-Roman city, survived longest'[6].

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[3] Liebeschuetz 1996:18.

[4] The bishops' authority and influence to ransom captives during conflicts - as St. Caesarius of Arles often did and with Theoderic's support - is an indication of a bishop's 'foremost responsibilities' (Klingshirn 1985:185), one example of the relationship of power between bishops and the state (Brown 1979:1). Also Mathisen 1997 *et al* and Azzara 2002 *et al*.

[5] From Constantine's official declaration of Christianity as the new state religion, to the later Theodosian Code (438-439) (Sirks 2007) and Justinian's own set of laws (*Codex* and *Digesta* and the *Corpus Iuris Civilis* published from 529 to 534) (Kunkel 1966) – all additively solidified the ideological, theological and political connections between State and Church.

[6] Liebeschuetz 1996:19.

It is evident the mid-500's were an extremely violent and unstable period, resulting in the "Gothic Wars" and Justinian's forces eventually crushing Ostrogothic rule over Italy. Nevertheless, in the same years, and at Theoderic's capitals of Pavia, Verona and Ravenna there is evidence of local bishops initiating and successfully completing vast building projects. In the context of 'a fundamentally patronal society'[7] these ambitious plans were initiated and fulfilled by a succession of bishops, since:

> It was…by actions meaningful in religious and political terms…as well as by their professions of ideology, that late Roman bishops were able to create within their cities the bonds of loyalty and patterns of continuity which made them formidable protectors of those cities in times of discord and discontinuity, and which remain among the more remarkable features of those troubled times.[8]

In the context of San Vitale, to discover and assess the level of these "bonds of loyalty and patterns of continuity", even if they were also catalysts of fragmentation[9], a better understanding of the church's geometry is proposed. By testing the church's visible and acoustic characteristics it is hoped the congregation's sensorial experience, and, therefore, clues of their loyalty, may be revealed. Sixth-century Ravenna is a prime example of the process of refiguring urban space into sacred topography, and one bishop in particular stands out, Ecclesius. He initiated an ambitious construction programme that significantly recalibrated the symbolic meaning and spiritual experience of this exemplary city.

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[7] Klingshirn 1985:203.
[8] Klingshirn 1985:203 (in footnote 143 he adds: 'Wallace-Hadrill, *op*. *Cit*. (n. 51), 15-16').
[9] As Ferreiro points out in reviewing Amory's (1997) chapter "Complementary and Competing Ideals of Community: Italy and the Roman Empire" (Ferreiro 1999: 1021-1022).

A

B
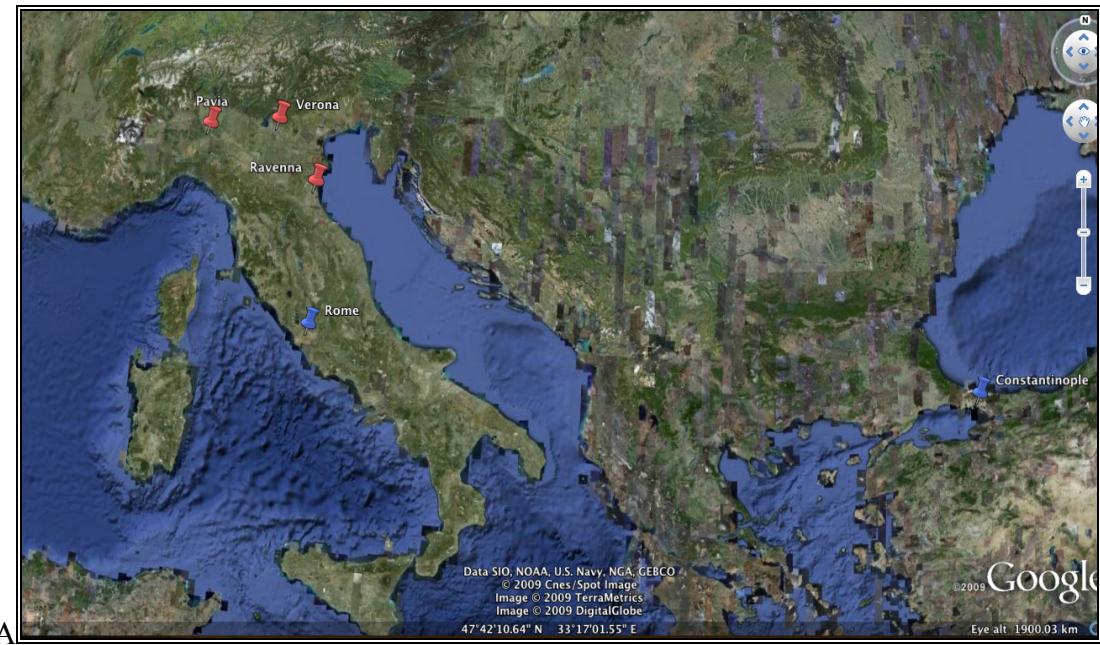
Map 2.1; (A) Location map of Ravenna and Theoderic's other capitals (red pin). (B) San Vitale, San Michele, Santa Maria Maggiore, Sant' Apollinare in Classe (dark blue) and (C) the older structures (light blue) of St. Croce and the *mausoleum* of Galla Placidia
(Images from Google Earth 2005).

San Vitale is a sixth-century double-shell octagonal church[10] situated within the northeast quarter of Ravenna. It is the only centralised congregational church in that city and one of only three[11] such churches in Italy. In the medieval period a monastery developed immediately to the west of the building, altering the character of the original atrium and narthex entrance. Despite some alterations[12] the original function of the church has remained intact. Although not a religious pilgrimage centre *per se* many people visit this UNESCO World Heritage Site to view its extraordinary architecture and mosaics.

The design, survey and construction of San Vitale was initiated by Bishop Ecclesius (522-532) in the final few months of Theoderic's reign until his death (August 30, 526) and over the first six years of Amalasuentha's regency. Under tumultuous circumstances of political change it is a remarkable achievement that Ecclesius' ambitious project continued to fruition through a succession of three bishops, including a twenty-month gap between the

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[10] Its identification as an imperial court church (Watkin 2005:98) requires further verification seeing as no imperial palace is near the church and the exact relationship of Julianus *argentarius* to Constantinople is unknown (Krautheimer 1986:488, note 43).

[11] The others are SS Cosmas & Damian (S Leucio) at Canosa and S Lorenzo at Milan (see Appendix B).

[12] The alterations and renovations are listed above in Chapter One, Part 3, Table 1.3.1, page 33.

episcopacy of Bishop Victor and Maximianus from February 15, 545 to October 14, 546[13]. Crucial to this project's success was the financial support of Iulianus *argentarius*, even during the Episcopal interstice just mentioned, and with his son-in-law Bacauda, the church of San Michele *ad Frigeselo* (in "Africisco") was completed and dedicated on May 7th of 545[14]. This indicates there was a cooperative consensus among the sixth-century Orthodox community of Ravenna, as the concerted efforts of both the ordained and secular worked together at a time when Ravenna had no bishop, and in this respect the project as a whole may have connected, unified and coordinated both religious and social forces in an expression of concord.

Bishop Ecclesius initiated the construction process of three new Orthodox churches in 526 while his successor Ursicinus (533-536) erected a fourth, Sant' Apollinare in Classe. Bishop Maximianus (546-557) saw these projects reach completion in the 540s, the first decade of "Byzantine" rule, and while he had the church of S. Stephani Maiora constructed in the same region as San Vitale (the *regionem apostolorum*), his activities mostly focused on dedicating the new churches and re-dedicating several former Arian establishments for Orthodox use. One example is the rededication of the Arian church of St. Saviour to St. Martin of Tours, which included making significant alterations to the nave mosaics – later the church was further renamed S Apollinare Nuovo[15]. Maximianus' name is literally writ large in San Vitale[16], memorialising and perhaps overstating his achievements. This has tended to overshadow the former biography of Ecclesius' ambitious project, prior to "Byzantine" rule as of 540. Even among modern scholarship San Vitale is often identified simply as a "Byzantine" church in Italy albeit executed with local skills and preferences[17].

The overemphasis of San Vitale's post-540 phase of completion has been an increasing problem, to such an extent that one recent volume entitled *Understanding*

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[13] Bishop Victor died February 15, 545 (Agnellus 68; Deliyannis 2004:184) and Maximian of Pula was consecrated by Pope Vigilius in Patras, Greece on October 14, 546 and immediately sent to Ravenna as its bishop (Agnellus 70; Deliyannis 2004:185, 308). The interstice would have been longer in practice as he travelled from Patras to Ravenna.

[14] Presumably San Michele was dedicated by an officiating senior cleric. Agnellus confusingly states that Maximianus consecrated the church of the blessed Archangel Michael 'which Bacauda built with Julian the banker of blessed memory, in the region which is called *Ad Frigiselo*' (Agnellus 77; Deliyannis 2004:190-191) having already provided the dates of Victor's death and Maximian's succession. An alternative reading may be that Maximian simply formalising what had been done in 545 without a presiding bishop.

[15] Agnellus 69-83 (Deliyannis 2004:184-197); Krautheimer 1986:185.

[16] See Chapter Three, Part 3.2, concerning the mosaics of San Vitale.

[17] Krautheimer 1965.

Architecture actually states that at San Vitale, 'Justinian built a variant on the octagon-dome scheme'[18] as though it were the achievement of Constantinople rather than Ravenna. The equally important first phases of design, survey and beginning of construction, predominantly in the years of Amalasuentha's reign has become obscured. The success and importance of the mosaics in this church have compounded the problem. They include the famous portraits of Justinian & Theodora (Figures 3.2.2 and 3.2.3 in Part 3.2), the highest authorities of the Eastern Empire, and modern art and architectural historians have consistently been blinkered by this obvious "Byzantine" presence by misappropriating the entire initial fourteen-year period of San Vitale's biography away from the context of Ostrogothic Ravenna and instead constructing Justinianic intrigues and infiltrations at Ravenna to justify the existence of this most "Byzantine" of architectural expressions on Italian soil[19].

To remedy this imbalanced tendency it is reasonable, timely, and important to treat Ecclesius' San Vitale, Santa Maria Maggiore, and San Michele "in Africisco" and Bishop Ursicinus' Sant' Apollinare in Classe as a group, even as one archaeological site that was intentionally and meaningfully integrated with earlier known structures such as St. Croce, the *mausoleum* of Galla Placidia and the late fifth-century *sacellum* within San Vitale. By doing so, it will be seen in Chapter Three and Four that intentionally meaningful interrelationships and symbolic connections become apparent for Late Antique Ravennate ecclesiastical

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[18] Roth 1993:252, Figure 13.13. He also, unaccountably dates San Vitale to 532-548, completely ignoring Ecclesius' episcopacy. This is at least better than the more recent inconsistent comments about the church by Shenfield (2008), who also variously inexplicably dates it to 547 (figure 40, pg.420) and also 546-68 (figures 39 and 42c, Pp. 418, 424).

[19] A case in point is the idea still enjoying some currency that Iulianus *argentarius* was Justinian's infiltrator at Ravenna, drumming up support among the Orthodox camp for Byzantine expansion and takeover. Thus, Ecclesius' building programme is seen simply as a Justinianic project in the Western capitol, prefiguring the invasion of 540. Krautheimer noted: 'It remains a point of contention whether or not S. Vitale was intended as a palace church – in view of its plan and decoration, a tempting hypothesis defended by G. de Angelis d'Ossat, Studi Ravennati (Ravenna 1962), 59 ff., and combated by Deichmann, *op. cit.*, II, 2, 21 ff. The question is obviously linked to that of Julianus' position – whether he was just a wealthy banker or also the head of a fifth column in still-Gothic Ravenna – as well as to the significance of the Imperial portraits in the chancel – whether they merely indicate Imperial financial contributions or have a deeper significance' (Krautheimer 1986:488, note 43). It should be remembered that the identification of the persons in San Vitale's Imperial mosaic rests solely upon Agnellus (77; Deliyannis 2004:191) and not even he clarifies which Imperial house is depicted (he simply has *augusti et augustae* '…the emperor and empress…'). Nevertheless, we have come to assume the mosaics are representations of Justinian and Theodora. A controversial hypothesis could be raised; Amalasuentha and Theodehad are represented in intentional mimicry of Justinian and Theodora. Such a suggestion has its problems and would of course require much further exploration, well beyond the scope of the present work.

architecture not otherwise clear if each church is treated alone as a mere discrete entity. The revealed physical, social and symbolic network can be regarded as indicative of underlying sixth-century social and Christian ritual not otherwise understandable.

The individual local rites of the Italian peninsula were mostly lost as of the reforms made under Pope Gregory the Great in the 590s, but survivals have been identified; the most obvious is the Rite of Milan which has retained to the present day its original characteristics. Through studies of ancient chant[20] other rites pre-dating the Gregorian reforms can be glimpsed at, in particular those of Beneventum and Ravenna[21]. Textual sources and archaeological evidence together can be held as a *speculum* to San Vitale to help reconstruct the Ravennate Rite.

Reviewing the primary literary sources relevant to Late Antique Orthodox Christian practice at Ravenna, we are fortunate to have the *Liber Pontificalis Ecclesiae Ravennatis* of Andreas Agnellus (c.805-after 846)[22]. His ninth-century observations remain important since his home was Ravenna and he consistently exhibits a keen interest in, and good accurate observation of, architectural and epigraphic remains no longer extant. His observations can be supplemented with comments and descriptions of liturgical practice made by Procopius (c.500-c.565)[23] and Paulus Silentarius (died c.580)[24]. Although they are contemporary with the first years of San Vitale their comments instead focus upon Constantinople, and specifically Hagia Sophia.

In combination with recent archaeological discoveries and research[25], these sources and the material evidence for the sixth-century ritual celebration of the Eucharist can be provisionally applied to Late Antique Ravenna in an attempt to reconstruct the social organisation within, movement through, and potential sensorial experience of and belief at San Vitale, therefore providing an essential context to considerations of how acoustics and

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[20] Wellesz (1947), Velimirovi (1966, 1971, 1973 *et al*), Strunk (1951, 1952, 1977 *et al*), Levy (1963, 1970, 1971 *et al*) and Quasten (1983).

[21] See Appendix C for a discussion of the surviving Ravennate chants.

[22] We are additionally fortunate that Deliyannis published her translation of Agnellus in 2004. The *Anonymous Valesianus* (*Ordigo Constantini Imperatoris*), which dubs Theoderic 'lover of building and restorer of cities' (*amator fabricarum et restaurator civium*) (70-71) (La Rocca 1996:166) may have been written by Bishop Maximian in the year 548.

[23] Procopius; *De Aedificiis* (*On Buildings*), written in the late 550s, is a panegyric on Justinian's building activities throughout the empire but, intriguingly, there is no mention of any such activity in Italy (Cf. Dewing 1940).

[24] Paulus Silentarius wrote a verse eulogy on Hagia Sophia following the reconstruction of the dome in 562.

[25] I will focus on the recent work by Mathews (1962), Mathisen (1997), and Mainstone (1988).

visibility in combination influenced sixth-century developments in ecclesiastical architecture.

After Emperor Honorius (384-423) moved the capital of the Western Empire from Milan to Ravenna in 402, and certainly by the time Galla Placidia (392-450)[26], his sister, ordered the construction of 'The Holy Cross our Redeemer' (St Croce)[27] in c. 450, the use of the north-western intra-mural quarter of Ravenna had been transformed from a residential area to a place of burial. Certainly by 526, the earliest possible inception of Bishop Ecclesius' building project, the Orthodox Church legally owned the property south and west of St Croce. The Late Antique Ravennate Orthodox church under Bishop Ecclesius and his immediate successors may have been in competition with the Arian Ostrogothic bishops[28], for which the restructuring of Ravenna's sacred topography became an attractive imperative.

The political influence of sixth-century Christian bishops and political influences upon them, especially from Imperial Constantinople, toward a theological and territorial unification, a *renovatio* under Imperial Orthodoxy, is most often seen in opposition to Theoderic's (*ergo* Arian) failed attempts of procuring official Orthodox acceptance of Arian practice. Accordingly, the sixth-century contrasts that were operating between East and West

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[26] Galla Placidia was the Empress consort of Constantius III and mother of Emperor Valentinian III.

[27] Agnellus 41 (Deliyannis 2004:148), '…*ecclesiam sanctae Crucis redentricis nostrae'*. It would not be unreasonable to suggest this church may have been dedicated on September 14th in whatever year it was completed; the Feast of the Holy Cross: *Exaltatio Sanctae Crucis*, and might have housed a piece of the "True Cross" from Helena's Church of the Holy Sepulchre, the earlier church at Jerusalem dedicated on this Feast day. St Croce is a double-aisled longitudinal basilica with adjoining small cruciform *mausoleum* attached to the eastern extension of the church's narthex. Built, according to Agnellus (41), by the niece of Galla Placidia, Singledia (Sunigilda), '…recorded in a fragment of John Antiochenus as being the wife of Odoacer' (Deliyannis 2004:149, note 28) with thirteen of the workers Galla Placidia had employed constructing St Croce, and completed it in thirteen days, '…dedicating it in the name of Zacharias, the father of the Precursor (*praecursoris pater*)' [Father of John the Baptist] (Agnellus 41; Deliyannis 2004:149). A little further in Deliyannis' translation she notes 'The structure known today as the Mausoleum of Galla Placidia is not mentioned by Agnellus…' (Deliyannis 2004:151, note 33). Agnellus tells us this small cruciform structure is '…not far from the church of the Holy Cross' (Agnellus 41; Deliyannis 2004:149) and was built by Singledia. Deliyannis places this structure at the northern end of St Croce's narthex, opposite the *mausoleum* (Deliyannis 2004:xiii), but it could just as easily be the *mausoleum* itself. Indeed, there is no archaeological evidence for any comparable structure to that of the southern cruciform mausoleum at the north extent of the narthex, therefore I follow what Agnellus' story implies, that the building we mistakenly call the *mausoleum* of Galla Placidia was Sunigilda's chapel dedicated to St. Zacharias. Gelichi & Piolanti's recent publication on St. Croce does not indicate any structure at the north end of the narthex (Ibid 1995:347-382).

[28] An alternative reading would be that Ecclesius' construction programme had some level of royal Ostrogothic assent, even perhaps regal secular support of Orthodoxy (perhaps by Arian Theoderic, but more likely his Orthodox daughter Amalasuentha) which could in turn be read as a level of productive political and ecumenical negotiation and a strategy of *Civilitas* between Arianism and Orthodoxy at Ravenna not as strikingly seen elsewhere, especially not at Constantinople. This idea is at present simply a suggestion but lacks support at present.

have been highlighted as being fuelled by Justinian's political ideology of *Renovatio* in opposition to Theoderic's *Civilitas*[29]. Ravenna has been used as a case for the growing tension between Ostrogothic rule and the power of Constantinople, couched as overly simplistic dichotomies: Arianism against Orthodoxy and 'Gothic' against 'Byzantine'.

Prior to 533, and therefore likely ancillary to Constantinopolitan influences, Bishop Ecclesius may have been joined in his efforts of ecclesiastical expansion by other Italian bishops, who together with him, accompanied Pope John 1st on a delegation to Constantinople in 526; Sabinus of Campania (Canosa), Eusebius of *Fanum Fortunae* (Fano), and two others remaining unnamed by the *Anonymous Valesiana*[30]. Evidence from Canosa in Apulia, namely the centrally planned double-shelled church of SS Cosmas & Damian (later San Leucio)[31] (Figure 2.2), supports the need for a new interpretation of ecclesiastical architectural developments centred in Italy and which may have had some influence on the East.

Whereas former study[32] has understood San Vitale to be an 'Eastern' and 'Byzantine' oddity on the Italian peninsula, it is now valuable and instructive to view it as one example among broader influences informed by Gerizim, Milan, northern Italian baptisteries and connections with southern Gaul[33]. Identifying these linkages better assists an archaeological and historical investigation of the reflexive ecclesiastical developments of local Christian rites and related music. Only after acknowledging and understanding these broader issues can a more informed concept of the sixth-century be formed; taking into account the complex exchanges between Ravenna and Constantinople, Syria and Italy, East and West and how much of what we call 'Eastern culture' actually emanated from within the provinces of the West rather than exclusively from the geographic East.

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[29] Burns 1998:1569.
[30] *Anon. Vales*. 15.90. The historical background of their connection is discussed in Appendix B.
[31] Krautheimer 1986:229.
[32] Deichmann (1969, 1976, 1989), Grossmann (1973), Krautheimer (1965), Milburn (1988) and Roth (1993).
[33] Particularly the period of Ostrogothic rule over Provence (510-c.535) and specifically in the case of St Caesarius of Arles and his visit to Ravenna (Cf. Klingshirn 1985).

Architectural Sources for San Vitale

As mentioned in the *Anonymous Valesiana*, it is significant that Bishop Sabinus of Canosa[34] accompanied Bishop Ecclesius of Ravenna as part of Pope John 1st's embassy to Constantinople in 526. An important architectural detail that has as yet not made its way into the debate over the date of SS Sergius & Bacchus is the fact that the dimensions of the inner octagon in both churches is equivalent (see Appendix B), and yet only San Vitale's exterior octagonal walls fully reflect the central geometry. Even disregarding the dates, San Vitale is the more fully realised version of a possible common "blueprint". Be that as it may, we see in Appendix B a direct architectural influence on San Vitale from The Church of the Theotokos on Mount Gerizim in Palestine (Figure 2.3), built in the reign of Zeno (c.425-491) in 484, the same emperor who suggested to Theoderic that the Italian peninsula was for the taking. The theological background of the *Theotokos* becomes suggestive; at the Council of Ephesus (431)[35], in the Church of Mary, Nestorius and his view that Mary could not be both the mother of Christ (*Christotokos*) and at the same time the mother of God (*Theotokos*), was proclaimed anathema and heretical, and the Council agreed that Mary was the *Theotokos*. The Church of the Theotokos at Gerizim[36] follows on from this theological point. The structure is octagonal inside and out, as is San Vitale, and with the added significance of the Marian Cult, the church at Gerizim is an important source for San Vitale, which may also share these same theological meanings[37].

In this connection it is significant that another Ravennate church in Ecclesius' building project, and physically sited closest to San Vitale, is Santa Maria Maggiore, or, in other words, dedicated to the *Theotokos*. As such, the influence of the Marian Cult on sixth-century theological symbolism and church design at Ravenna appears to have been significant. Far to the south, at Canosa, Bishop Sabinus may have shared these ideas. Again

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[34] Sabinus (514-February 9, 556) is the Patron Saint of Bari and was a contemporary and friend of St. Benedict.

[35] Also known as the Third Ecumenical Council, the Church of Mary may have been built specifically for the council, during which the title of Theotokos for the Mother of God was decided. The church is a regular longitudinal aisled basilica: http://www.oeai.at/eng/ausland/marienk.html.

[36] Mentioned by Procopius; *De Aedific*. 5.7. Excavation report by Magen 1993.

[37] Another important influence on San Vitale's design may be the sequence of octagonal congregational churches at Philippi, the first structure dating to the late fourth-century. Krautheimer 1986:128-130, Figure 85. Verhoef's schematic plan (2008:714, Figure 3). See also Gerstel (2006) who places the date of the second phase of the octagonal church at c.500 (Gerstel 2006:68, Table A). An inscription reads: "Porphyrios, bishop, made the embroidery [mosaic floor] of the basilica of Paul in Christ": http://www.sacred-destinations.com/greece/philippi.htm

in 535-536 this bishop was part of the embassy of Pope Agapitus I[38] to Justinian. On this occasion King Theodehad requested Agapitus to travel to Constantinople and convince Justinian not to carry out recent threats of invading Italy. With five bishops, including Sabinus of Canosa, the pope set out in mid-winter, arriving at the Eastern Imperial court in February of 536. The pope was unsuccessful in stalling Justinian's invasion plans, and was also upbraided by the local clergy, if not by the Emperor himself, for opposing the veneration of the *Theotokos* and refusing to allow her icons to be displayed in Roman churches[39]. The pope died while in the Eastern capital on April 22nd of 536 and his body was returned to Rome, accompanied by Sabinus, on September 20th.[40]

Sabinus may not have held the views of Agapitus; if the relationship between the church of SS Cosmas & Damian at Canosa, San Vitale at Ravenna, and that of the *Theotokos* at Gerizim includes not only the physical centrally planned octagon but also the theological meanings associated with the Marian Cult, then it also follows that at least two Italian bishops were planning similar "new" expressions of ecclesiastical architecture, in accord with Constantinopolitan sensibilities to the *Theotokos*. The earliest known Marian dedication in Rome was much later, in 608, when the Pantheon, an exemplary ancient Roman centrally planned sacred space, was consecrated as *Santa Maria ad Martyres*[41]. The exact relationship, if known, between Marian symbolisms and centrally planned octagonal spaces must remain for future investigation.

Returning to Ecclesius' Marian dedication at Ravenna, the original name of the church is given by Agnellus (57) as 'the church of the holy and always inviolate Virgin Mary' (*ecclesia sanctae et semper virginis intemeratae Mariae*). Agnellus further notes that in the vault of the apse of this church, perhaps meaning the "Triumphal arch" over the chancel entrance, the following verse was written[42]:

Virginis aula micat, christum quae cepit ab astris,

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[38] Agapitus I was pope from May 13, 535 to his death on April 22, 536.

[39] Mundell 1977:72.

[40] In 536 Easter Sunday was March 23rd, therefore Agapitus (and Sabinus) spent Easter at Constantinople, dying one month and one day following. Calculations from the Julian calendar (Easter calculator) (Montes 2001).

[41] Nelson & Olin 2003:217. The earliest Marian feasts were introduced into the Roman liturgical calendar by Pope Sergius I (687-701) (Mundell 1977:72).

[42] Of the original church only a few angles of the polygonal apse remain, the remainder of the church being much restored and the verse no longer extant.

Nuncius e caelis angelus ante fuit.
Misterium! Verbi genitrix et virgo perennis
Auctorisque sui facta parens Domini.
Vera magi, claudi, caeci, mors, vita fatentur.
Culmina sacra Deo dedicat Ecclesius.

The hall of the Virgin shines, she who received Christ
From the stars, with an angel from the heavens
Announcing it to her before [his birth].
O mystery! The mother of the Word and perennial virgin, made
Parent of the Lord her Creator. Truth, the Magi,
The lame, the blind, death, life confess her [5],
Ecclesius dedicates these holy rooftops to God.[43]

Here, Mary's description as *verbi genitrix* (mother of the Word) and *auctorisque sui facta parens Domini* (parent of the Lord her Creator) reiterate the Nicene sense of the *Theotokos* as Mother of God, and, therefore, this verse is a clear public statement of Nicene Orthodoxy.

A further significance of the church at Gerizim is that it replaces and re-figures the mount as an *axis mundi*, a centre of the "world". If San Vitale and SS Cosmas & Damian in Italy, and SS Sergius & Bacchus and Hagia Sophia in Constantinople do have meaningful interconnected relationships to each other, then it is worth considering if some or all of these churches also shared the concept of being distinct *axis mundi*. In other words, if the octagonal design of these churches, along with several other layers of symbolic meaning, connotes *axis mundi*, it becomes significant where they were built as they reshape the sacred topography of Christendom. San Vitale, in the capital of the Western Empire, makes sense as an *axis mundi*, as does Hagia Sophia (allowing that the church is not ostensibly an octagon) and SS Sergius & Bacchus in the capital of the Eastern Empire. This line of thought requires further investigation to ascertain the right of Canosa to also be considered as such. However, such a line of inquiry appears initially to be based on textual sources and architectonic similarities, potentially leading down paths outside the remit of this present study.

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[43] Translation by Deliyannis 2004:171.
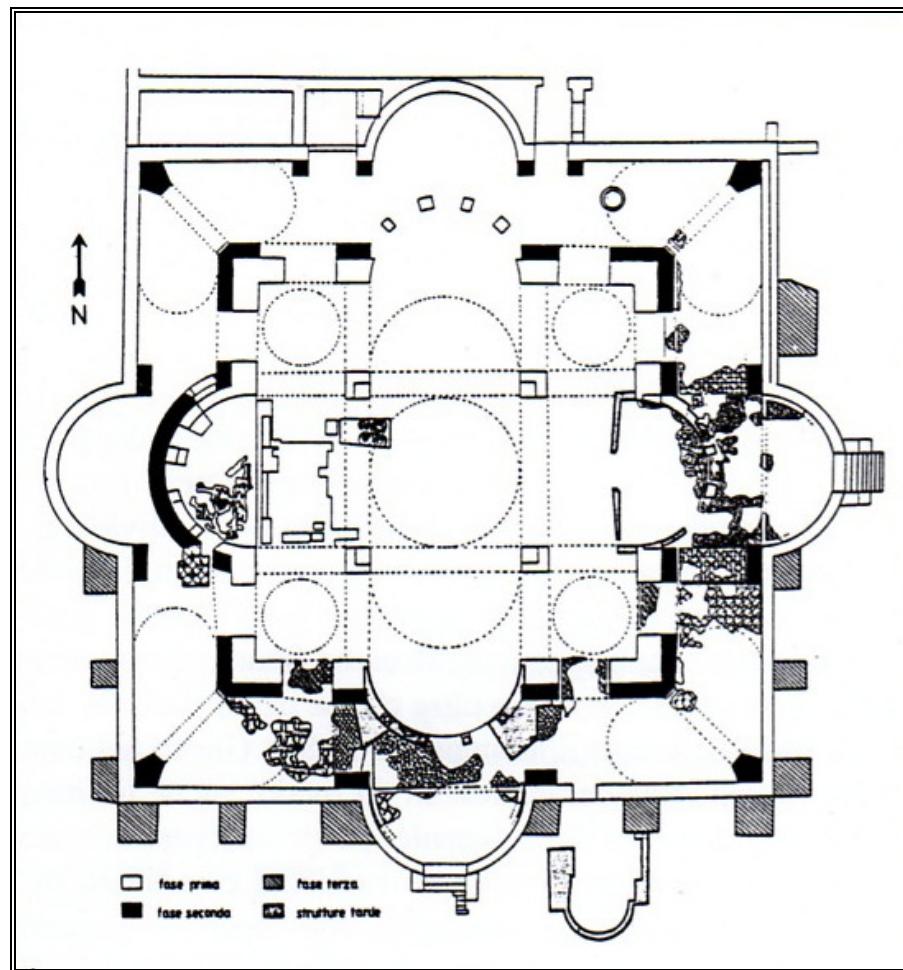
Figure 2.2: Plan of SS Cosmas & Damian/San Leucio at Canosa (after Volpe 1998:320, Figure 345, 1).
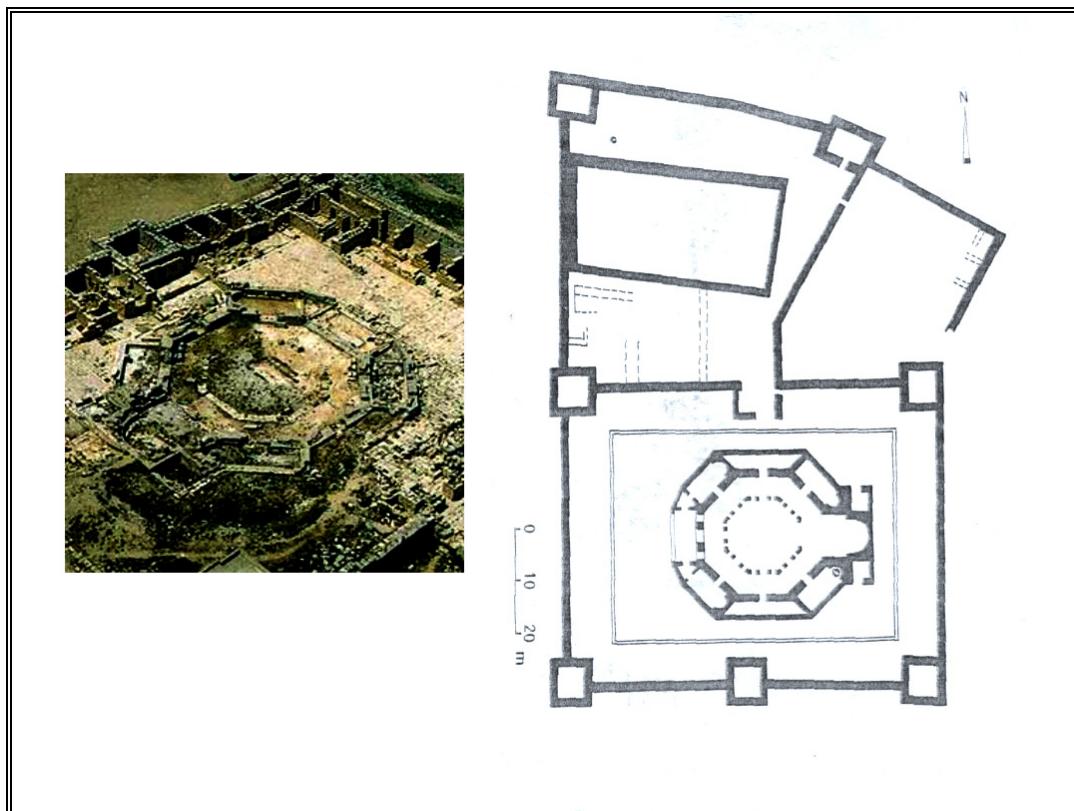
Figure 2.3: The Church of the *Theotokos* at Mount Gerizim (after Magen 1993).

The Arian Ostrogothic and Orthodox Roman communities of Late Antique Ravenna

Before considering the construction of San Vitale in Part 3.1, its mosaics (Part 3.2), its dedication (Part 4.1) and how young and adult males, females, clergy and laity entered and were socially organised on San Vitale's ground floor and *matroneum* during the Mass celebration (Part 4.2), it remains to identify the social make-up of the congregation at large.

Characteristic of sixth-century Ravenna was the co-existence of two distinct versions of Christianity, those following the Creed agreed upon at the Council of Nicea (June 19, 325), proclaimed as "Orthodoxy", and those following a version of Christianity developed by Arius (c.250/6-336), deemed heretical at the same Nicene Council but the native Christianity of the Ostrogoths[44]. Hence, two bishops with two distinctive congregations existed at Ravenna. The civic and ecclesiastical relationships between these Arian Ostrogothic and

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[44] At the core of Arianism was a denial that Jesus could have existed at the same time as the Father and the Creed agreed upon at the Council of Nicea explicitly includes the word *homoousis* (consubstantial / "one in being"), incompatible with the ideas of Arius.

Nicene Orthodox Roman communities can be partially understood by drawing upon extant examples of their respective ecclesiastical architecture.

At Ravenna there are preserved a number of Arian architectural examples, namely the "Arian" baptistery (Figure 2.4), the tomb of Theoderic, and The Church of the Saviour[45]. Appendix B supports the preliminary conclusion that the Arian baptistery of Ravenna has a design detail rare amongst other Late Antique centrally planned octagonal baptisteries, a detail also shared by San Vitale; the termination of the ambulatory at the chancel.
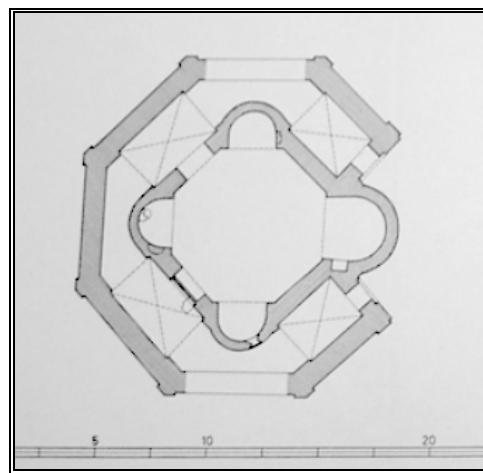
Figure 2.4: Plan of Arian baptistery at Ravenna (Verzone 1968:52, Figure 22; Deichmann 1989).

In other words, in both cases the chancel extends directly from the inner octagon and interrupts the ambulatory, whereas in other extant cases analysed in Appendix B the chancel spurs from the eastern exterior section of the ambulatory. The liturgical meaning for this interruption in the Arian baptistery is not known, but its translation into San Vitale's design is highly significant and not formerly noted.

As seen in Figure 2.5B, the octagons constituting the Arian baptistery at Ravenna are replicated in San Vitale's design. The baptistery's external and internal octagons closely fit the internal and apse exterior octagons of San Vitale. Since this relationship of dimension equivalency is not true for the Orthodox (Neonian) baptistery (Figure 2.5A)[46] at Ravenna,

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[45] Re-consecrated and renamed St. Martin of Tours by Maximianus, an apt choice considering Martin's challenges against Arianism, and further re-dedicated and renamed S Apollinare Nuovo when the remains of Apollinaris were translated here in the ninth-century, from 'old' Sant' Apollinare in Classe. The church is otherwise known as S. Apollinare *dentro le Mura* (Hodgkin 1896a:302).
[46] The dimension of the external octagon used in the Arian baptistery is seen to delimit the extent of the apsidal-cornered rectangle of the Neonian baptistery may indicate some otherwise unnoticed late fifth-century

nor any other centralised baptistery analysed in Appendix B, coincidence can be safely ruled

out.

A
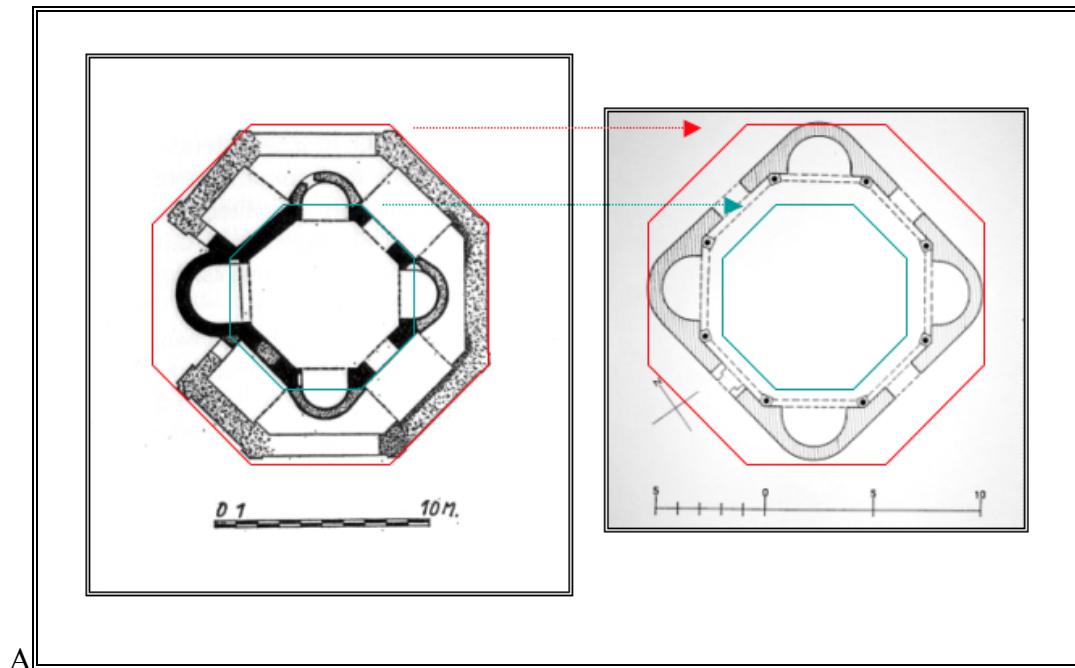
relationship between the two buildings. The internal octagons of the two baptisteries are seen to have no
relationship to each other.
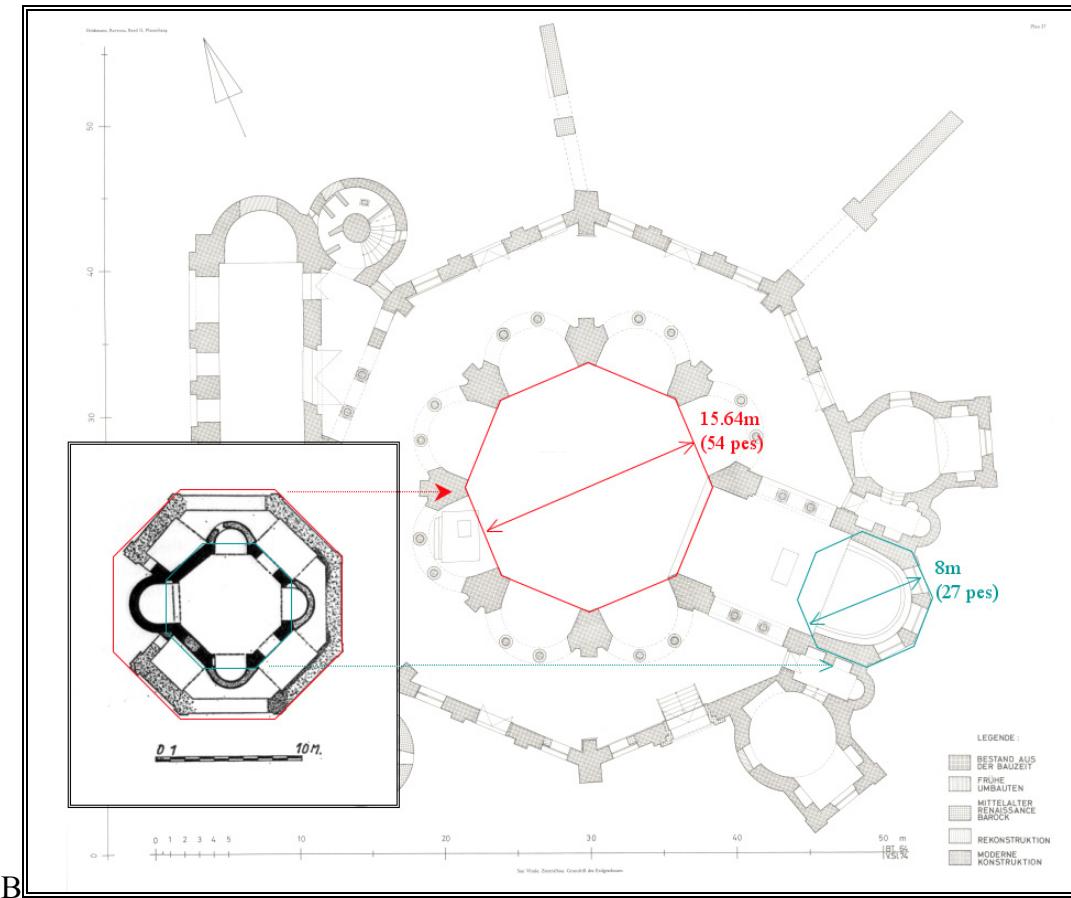
Figure 2.5: (A) Octagon comparison between Arian and Neonian baptistery of Ravenna. (B) The measurements of two octagons of the Arian baptistery used within San Vitale (After Verzone 1968:52 and Deichmann 1989; Knight 2009)[47].

The significance of the dimensions of these two octagons in Figure 2.5B requires further research, but for the moment it can be observed that the relation of the smaller to the larger has the ratio of 2:1 (27 *pes* x 2 = 54 *pes*). The Arian baptistery's smaller octagon is contained within the larger whereas in San Vitale the relationship is augmented, while the inner octagon contained within the larger octagon (119 *pes*) echoes the baptistery's layout there is no obvious proportional relationship. The lateral distribution of the baptistery octagons in San Vitale may also be significant; the exterior of the internal baptistery octagon is translated as the exterior of the external polygonal face of San Vitale's apse. In both cases this octagon encloses the most important liturgical space, the baptismal font and the apse restricted to the seats for the clergy, the benches (*synthronon*) and bishop's throne (*sedis*).

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[47] The metric measurements of San Vitale and their conversion into Roman feet (*pes*) are given in Appendix D.5.

The larger octagon is the external enclosing face of the baptistery and in San Vitale it describes the innermost space below the dome.

These details together have striking implications. Despite, or in spite of, differences in theology, San Vitale, in these two important details, is a continuation from an Arian architectural development local to Ravenna. This may be read as rivalry between Orthodox and Arian clergy and communities of Ravenna[48].

These observations in combination, in the context of Ecclesius' building project reveal how the sixth-century designers incorporated and complemented existing structures and ideas creating a re-structured sacred topography of Ravenna. How did the people of Ravenna engage with such a sacred topography? An answer might be posited by studying the contemporary liturgical Celebration of the Eucharist and understanding how it may have been enacted within San Vitale, hence glimpsing how the congregation was socially organised within the church's complex space and how they may have experienced the liturgical drama through the senses of sight and hearing. Before discussing the Late Antique liturgy in Part 4.2, enabling us in Part 4.3 to evaluate the Ravennate chant *versus Lux de luce* as a potential and appropriate sound source for assessing San Vitale's acoustic properties, it is first necessary to follow the sequence of how San Vitale was surveyed and constructed, and posit reasons why Euclidean geometry was applied to Ecclesius' legal property.

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[48] A concept developed by Ward Perkins (1984) and Wharton (1995).

CHAPTER THREE

Constructing San Vitale

IN VSVS OCTORCHORVM SANCTOS TEMPLVM SVRREXIT
OCTAGOVS FONS EST MVNERE DIGNVS EO
HOC NVMERO DECVIT SACRI BAPTISMATIS AV-
LAM SVGERE QVO POPVLIS VERA SALVS REDIIT[1]

Eight-sided is the lofty shrine to match its sacred use;
Eight-angled is the font to show its benefits profuse;
With such a number grace and life supplanted human guilt
And with such number must the hall of baptism be built.[2]

Having reviewed the historical context of San Vitale in Part 2.1, and in order to assess whether acoustical knowledge was part of the architectural vocabulary of the design, it is necessary to follow the processes by which the chosen site of the church was contextualised with former and contemporary structures, surveyed, constructed, decorated (Part 3.2), dedicated (Part 4.1) and occupied (Part 4.2).

Part 3.1: San Vitale's physical symmetrical geometry

Agnellus tells us that Bishop Ecclesius built the church of the '*sanctae et semper virginis intemeratae Mariae* / holy and always inviolate Virgin Mary' on his own "legal property" (*proprietatis iura*)[3]. As this church, now known as Santa Maria Maggiore, is within a few meters of San Vitale, and since Ecclesius also initiated the construction of that church, it seems reasonable to assume his "legal property" in this particular intramural area known as the *regionem apostolorum* extended over the land on which both churches were erected. This is significant since it means the bishop of Ravenna, by at least 526, owned a parcel of land which was a cemetery (Figure 2.8) immediately south and west of the *mausoleum* of Galla Placidia (St. Zacharias) and which also included the

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[1] Cabrol and Leclercq 1925:394.

[2] Written by Ambrose of Milan '…of the octagonal baptistery that used to stand near the church of St Thecla at Milan' (Milburn 1988:206). 'This *inscriptio ad fontem S. Teclae* is given by Dölger in *Sylloge Laureshamensis* III (Monastery of Lorsch)' (Ibid:214). The significance of octagonal baptisteries and baptismal fonts in particular has been summed up by Wainwright & Westerfield Tucker (2006) 'Usually the symbolism is that of resurrection, or that of the Eighth Day, the day of Christ's Resurrection as the eschatological dawning of the new age, which is entered in the waters of holy baptism' (Wainwright & Westerfield Tucker 2006:798).

[3] Agnellus: 57 (Deliyannis 2004:171).

late fifth-century *sacellum* now inside San Vitale. Therefore, the physical context of San Vitale (and Santa Maria Maggiore) should be seen as funerary. Indeed, Agnellus (61)[4] further notes that there were metrical verses rendered in silver *tesserae* in the atrium courtyard to San Vitale (now lost), reading:

> Ardua consurgunt venerando culmine templa
> Nomine Vitalis sanctificata Deo.
> Gervasiusque tenet simul hanc Prothasius arcem,
> Quos genus atque fides templaque cunsotiant.
> His genitor natis fugiens cuntagia mundi
> Exemplum fidei martiriique fuit.
> Tradidit hanc primus Iuliano Ecclesius arcem,
> Qui sibi commissum mire perfecit opus.
> Hoc quoque perpetua mandavit lege tenendum,
> His nulli liceat condere menbra locis.
> Sed quae pontificum constant monumenta priorum,
> Fas ibi sit tantum ponere, seu similes.

> The lofty temples rise to the venerable rooftops,
> Sanctified by God in the name of Vitalis.
> And Gervase and Protase also hold this stronghold, whom family and
> Faith and church join together. The father fleeing the
> contagions of the world was to these sons [5]
> an example of faith and martyrdom.
> Ecclesius first gave this stronghold to Julian, who
> wonderfully completed the work commissioned to him. He
> also ordered it to be maintained by perpetual law that in
> these places no one's body is permitted to be placed [10].
> But because tombs of earlier bishops are established here,
> It is allowed to place this one, or one like it.[5]

In this verse San Vitale is twice referred to as an *arcem*, translated by Deliyannis as "stronghold". The use of the word *arcem* is of interest; where *ara* (refuge, altar, sanctuary, shelter) could just as easily have been used, the defensive denotation of *arcem* was preferred. Linked to this may be the clause at the end of the passage stating that only bishops, or presumably comparably senior clergy (perhaps priests and archdeacons), may ever be entombed within the church. San Vitale, then, may have been intended as a continuation of the funerary character of Ecclesius' legal property (*proprietatis iura*) in this quarter of the city, the region of the Apostles (*regionem apostolorum*)[6], perhaps

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[4] It is unclear whether the original verse was in Latin or if Agnellus was translating from Greek.

[5] Translation by Deliyannis 2004:177.

[6] From Agnellus we learn of several named districts of Ravenna; that in which San Vitale is situated is most probably of the Apostles (Agnellus 30; Deliyannis 2004:128), near the Ovilian Gate, also where Peter II (Chrysologus) consecrated the church of Sts. John and Barbatian (51) and Maximianus built the church of

theologically understood as a defensive citadel against the corruption of the flesh and contagion of the world. As a matter of interest, the only known earlier figure to have been placed in San Vitale, in the south chapel called by Agnellus the *monasterium* of Nazarius[7], was Galla Placidia. What 'tombs of earlier bishops (*pontificum*) are established here' has not yet been substantiated by archaeology.

It is possible the protective tone of *arcem* and the phrase describing Vitalis as fleeing the contagions of the world and seeking refuge with his sons Gervasius and Protasius, may relate to a sixth-century rather than a fourth-century situation, for example the deadly pandemic plague that broke out in the Mediterranean Basin in 541/2[8].

There are several points of reiteration throughout the buildings on and around Ecclesius' parcel of land; the verses in Santa Maria Maggiore naming Mary the *Verbis genitrix* echo the first lines outside nearby St Croce (*Christe, Patris verbum*), this older church commemorates the Word of God, while that of the Virgin commemorates her as the Mother of the Word. Quite literally, it was intended that these buildings were read together, holy words about the Word, written directly upon the architecture in verse. The educational function of a book (manuscript) and architectural space is combined, creating not only a complex yet readable place, but also an occasion for inner reflection and/or public instruction[9].

Contemporary with St Croce and Galla Placidia's *mausoleum* and a short distance to the southwest, still within the cemetery grounds, a small rectangular *memoria* or

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St Stephen the Proto-Martyr (*St. Stephani Maioris*) (72). The *Posterula Ovilionsi* is marked on Deliyannis's map of Ravenna (2004:xiii), to the east of the *Porta Teguriensis*, but not on La Rocca's (2002:263).

[7] Agnellus uses the term *monasterium* in several ways, but, as Deliyannis notes, 'at San Vitale, the two chambers flanking the apse are called *monasteria*, and one can probably be identified with that of St. Nazarius (cc. 59, 65, 68, 42)' (Deliyannis 2004:331, note 101). The other chamber to the north, may, logically, have been associated with St Celsus as Nazarius and Celsus are usually identified together, as with SS Sergius & Bacchus and SS Cosmas & Damian.

[8] Known as the "Plague of Justinian", it decimated the empire, killing an estimated 100 million people at a time when this verse was composed and executed in mosaic; Smith (1996-7), Little (2006) and Rosen (2007).

[9] Kendall (1998) dealt specifically with Romanesque church portal inscriptions but also traced the history of early Christian verse inscriptions. His premise is that 'the portals reflect the typological allegory of the biblical metaphor for Christ: "I am the door" (John 10.9)' (Verzar 2000:948). Kendall interprets the verses as "voices in space" helping 'to interpret the imagery and guide the medieval spectator from the liminal space in the external realm into the church' (*Ibid*.). Although the fifth to sixth-century Ravennate inscriptions in mosaic were depicted on the face of the churches above the narthex entrance (St. Croce and San Vitale) or inside above the triumphal arch (Santa Maria Maggiore), the relationship to the passage in John may still hold.

sacellum was constructed[10]. To whom this structure was dedicated is not known but their memory was likely important to the people of Ravenna[11] since this structure is not only retained within and respected by the geometry of San Vitale, its location, dimensions and orientation may have provided the reasoning behind surveying and founding the sixth-century church at its location. What is certain is that the Late Antique church not only respects and encloses the *sacellum*, but also its original altar remained an important liturgical focus[12].

Two specific characteristics of St Croce and the *mausoleum* possibly dedicated to St Zacharias provided Ecclesius and Iulianus with a context and techniques with which to refer and create a harmonious continuation from Galla Placidia's earlier building scheme. The first is the famous mosaic decoration of the *mausoleum* covering every interior wall and ceiling surface of this small space. In the barrel vault ceiling mosaics of the *mausoleum*, and reiterated in San Vitale, is the eight-pointed, octo-foil star possibly signifying the star of Bethlehem, seen in Figure 3.1.1 below.

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[10] Deichmann calls this small structure a *memoria* while at present in Ravenna it is called a *sacellum* (see Bendazzi and Ricci 1987:39).

[11] As the *sacellum* has been dated to the late fifth-century, it was erected sometime between Galla Placidia's building scheme in the 440s and certainly by Bishop Ecclesius' building scheme beginning in 526. The Orthodox bishops of this time-span were Peter I (c.431-450), Neon (c.450-473), Exuperantius (c.473-477), John I (477-494), and Peter II (494-520) (dates by Deliyannis 2004:307) and their burial locations are known, therefore the *sacellum* was erected in honour of some other personage.

[12] At present, and probably for many centuries, the *sacellum* is a rectangular depression filled with water, most likely later dubbed the Well of St Vitalis. The original *sacellum* mosaic floor now rests framed against the wall of the south ambulatory. The small altar has long ago disappeared but the column bases are extant, presumably for supporting a small *baldachin* (or *ciborium*), a canopy over an altar or throne.

Figure 3.1.1: Barrel vault ceiling mosaic of stars in the *mausoleum* of Galla Placidia (Photograph by Knight 2006).

The second aspect is no longer extant but equally significant. Formerly part of the exterior and interior of St Croce were metrical verses displayed in *tesserae*. On the exterior façade, at the narthex entrance, the following verse appeared above a rendering (in mosaic or paint) of Christ above the four rivers of Paradise, and could be read from outside by as late as the ninth-century when Agnellus noted the words:

Christe, Patris verbum, cuncti Concordia mundi, Qui
Ut finem nescis, sic quoque principium.
Te circumstant dicentes ter 'sanctus' et 'amen',
Aligeri testes, quos tua dextra reget.
Te coram fluvii currunt per secula fusi Tigris et Eufrates,
Fison, et ipse Geon. Te vincente, tuis pedibus
Calcata per aevum Germanae morti crimina
Saeva tacent.

O Christ, Word of the Father, concord of all the world, you who know
no end, so also no beginning. The winged witnesses, whom your right
hand rules, stand around you saying "*sanctus*" and "*amen*". In your presence the rivers run, poured through
the ages [5], the Tigris and Euphrates,
Fison and Geon. With you conquering, savage crimes are silenced by true
death, trodden for eternity under your feet.[13]

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[13] Agnellus 41 (Deliyannis 2004:150).

The "winged witnesses" (*aligeri testes*) ruled by the right (*dextra*) hand of Christ, are angels (messengers), and as they were not depicted with wings until at least the time of Theodosius I (379-395), and seeing as it was John Chrysostom (c.347-407) who first explained the signification of depicting wings on angels[14], this reference of winged witnesses, dating to the final years of Galla Placidia (392-450), is an early example.

The four rivers of Paradise (Genesis 2:11) are not only depicted and referred to on the exterior of St. Croce (Tigris, Euphrates, Fison[15] and Gihon), but also shown in the mosaic of the chancel vault in San Vitale, the four unnamed rivers streaming down from the central roundel containing the Lamb of God (the *Agnus Dei*) (Figure 3.1.2).
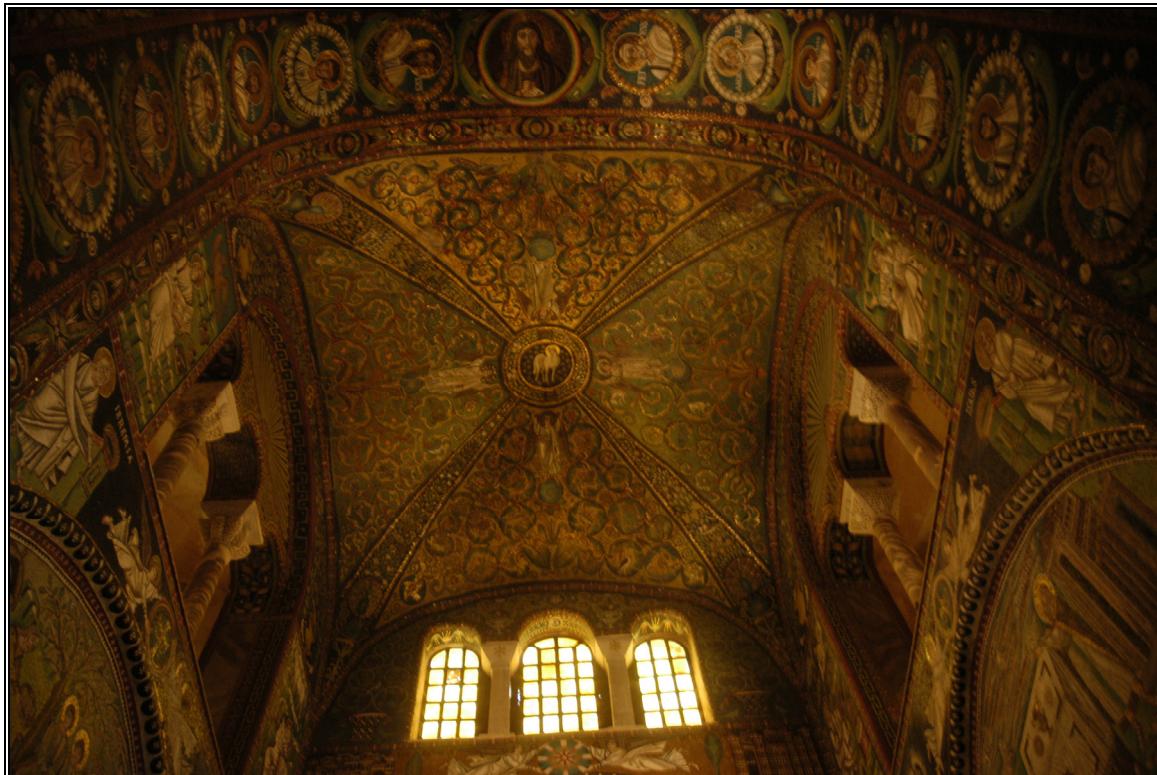
Figure 3.1.2: Chancel vaulting showing the *Agnus Dei*, from which the four rivers of Paradise flow
(Photograph by Knight 2006).

[14] '…wings attributed to these powers have no other meaning than to indicate the sublimity of their nature' (Proverbio 2007:34). From the time of Chrysostom, 'though of course with some exceptions, Christian art represented angels with wings, as in the cycle of mosaics in the Basilica of Saint Mary Major dating to the time of Pope Sixtus III (432-440) (ibid).

[15] The river of Paradise known as Pison is also named Fison (ØICWN), beginning with the Greek letter *phi*, in the Late Antique basilica of Olbia, Turkey (Cohen 2007).

Agnellus also notes a verse inside St Croce, 'in the roundness of the arches (*et in rotunditate arcus…*) there are metrical verses reading thus':

<div align="center">
Christum fonte lavat paradisi in sede Iohannis,
Quo vitam tribuit felicem, martirem mostrat.

John washes Christ at the font in the seat of paradise,
Where he gives a happy life, he points the way to martyrdom.[16]
</div>

This overt connection made between baptism and martyrdom can be seen as a precursor to the combinatory design of San Vitale, as it harkens back to octagonal baptisteries and to centrally planned baths (*thermae*) and *martyriae* of the pagan empire[17].

Therefore, the interior of San Vitale may intentionally symbolise eternal Paradise, the perfection of Creation, protected as a fortification using theologically symbolic geometry and ordered according to the believed vertical hierarchy of angelic beings. It is apparently also a sacrosanct burial-place for Ravenna's bishops while echoing the local architecture of baptism and, following on from precedence in the Holy Land at Gerazim, a new architectural expression for the *Theotokos*. San Vitale is named and dedicated to the Roman martyr Vitalis whose name denotes "life", situated in an intramural cemetery yet also acting as a congregational church where the celebration of the Eucharist is writ large in the wall mosaics. Indeed, San Vitale is sublime complexity and complexly sublime.

Surveying San Vitale

The process of surveying the site for San Vitale on Ecclesius' legal property and demarcating the geometry can be seen in the following Figures (3.1.3-3.1.8). Firstly, as shown in Figure 3.1.3, the measurement of the main octagonal body of San Vitale[18]

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[16] Agnellus 41 (Deliyannis 2004:150). This combined reference to baptism and martyrdom may be significant in light of centralised octagonal architecture being used for both baptisteries (developing on from ancient Roman baths) and *martyria*.

[17] See Appendix B for a comprehensive discussion of octagonal baptisteries. A good study of Roman *thermae* is that by Yegül (1992).

[18] All measurements taken by me at San Vitale were in metric (using a metric laser distance meter), additionally Deichmann's plans and sections are in metric and subsequently Giannakopoulou and also Garagnani's virtual models (both based on Deichmann) are in metric. With the assistance of my father Daniel J. Knight, this situation was rectified by converting important measurements using Roman and Late

equals an *actus quadratus*, that is 120 Roman feet (*pes*) square (one acre) superimposed by another *actus quadratus* which is rotated by 45°. The significance of the formerly unnoticed detail is that the *actus* and the *actus quadratus* are significant Roman land measurements.
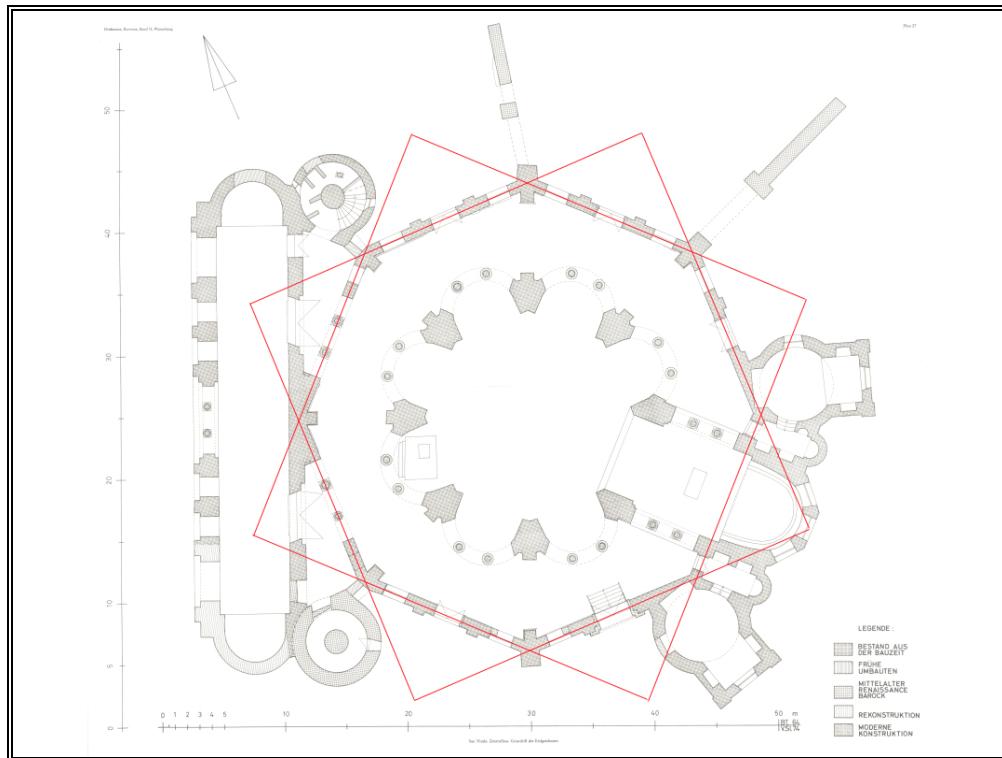
Figure 3.1.3: Two superimposed *actus quadratae*, forming the geometry of the octagon
(San Vitale ground plan by Deichmann (Plan 27) 1989; overlay construction lines by Knight 2009).

As seen in Figure 3.1.4 below, the north/south *actus quadratus* and the second rotated 25° south of true East, do not fit with any of the known alignments of Ravenna. The rotated *actus quadratus* acting as the main axis of the chancel, is offset by 9° to the street-grid south of the *Flumisellum Padennae*, and 17° off that of the grid system north of this tributary. Additionally, by applying a repetition of the *actus quadratus* along the alignment of the northern street-grid immediately south of San Vitale it can be seen that to the west of the *Cardus Maximus* continuation north of the *Pons Augusti*, there are precisely four *actae* (480 Roman feet) between that major road leading to the forum and the property division immediately to the church's southeast. The remaining three full

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Antique units, namely the *uncia*, *pes*, and *actus* provided by Campbell 2000:482, Appendix 8. Significant measurements and proportions have been collated in Appendix D.4. Also see Table 5.1.1 on page 163.

actae to the west of this point likewise have no obvious relationship with either of the church's superimposed *actae*.
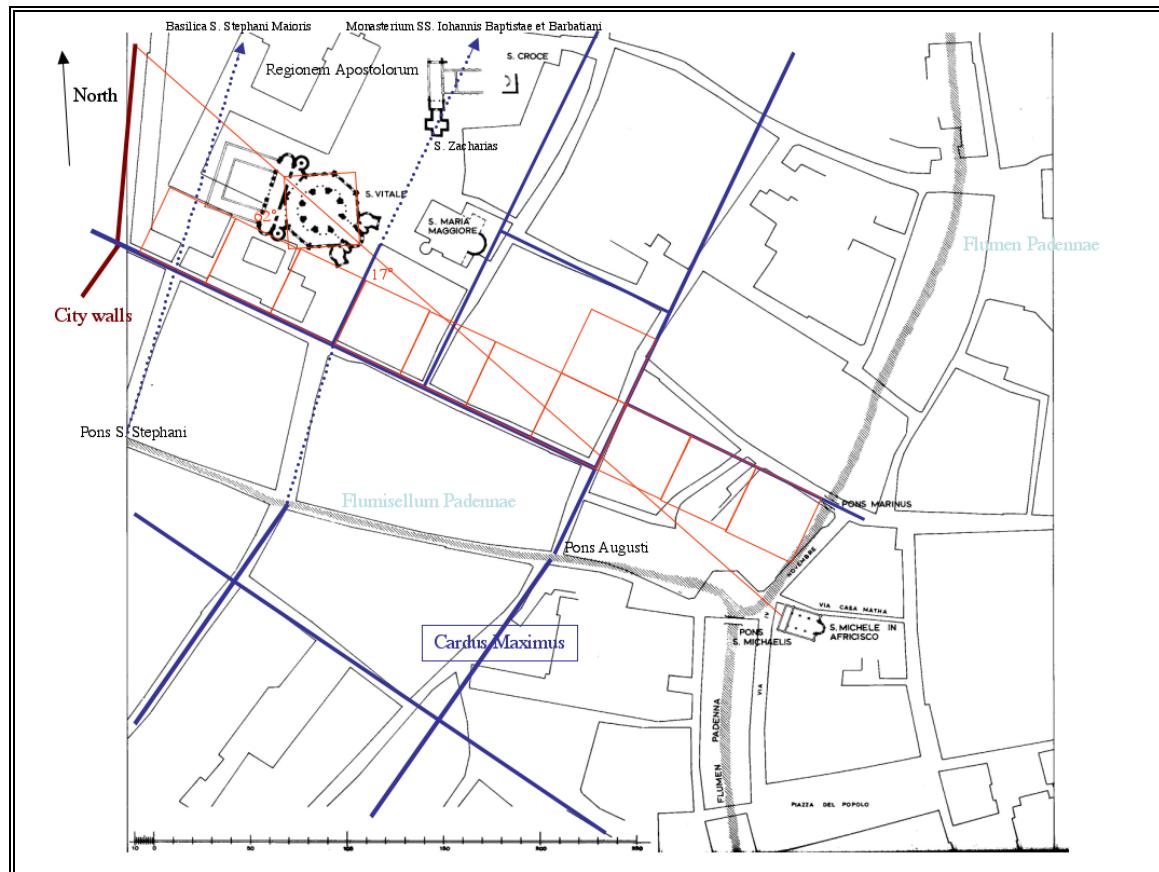
Figure 3.1.4: Detail map of the north-western area of Ravenna (after Grossmann 1973: Tafel 36-37, La Rocca 2002:263, Map 6 and Deliyannis 2004:xiii; Knight 2009).

From these two intersecting *actus quadratae*, the interior layout of the church becomes apparent. In Figure 3.1.7 is shown the mathematical logic of the construction.

A

B
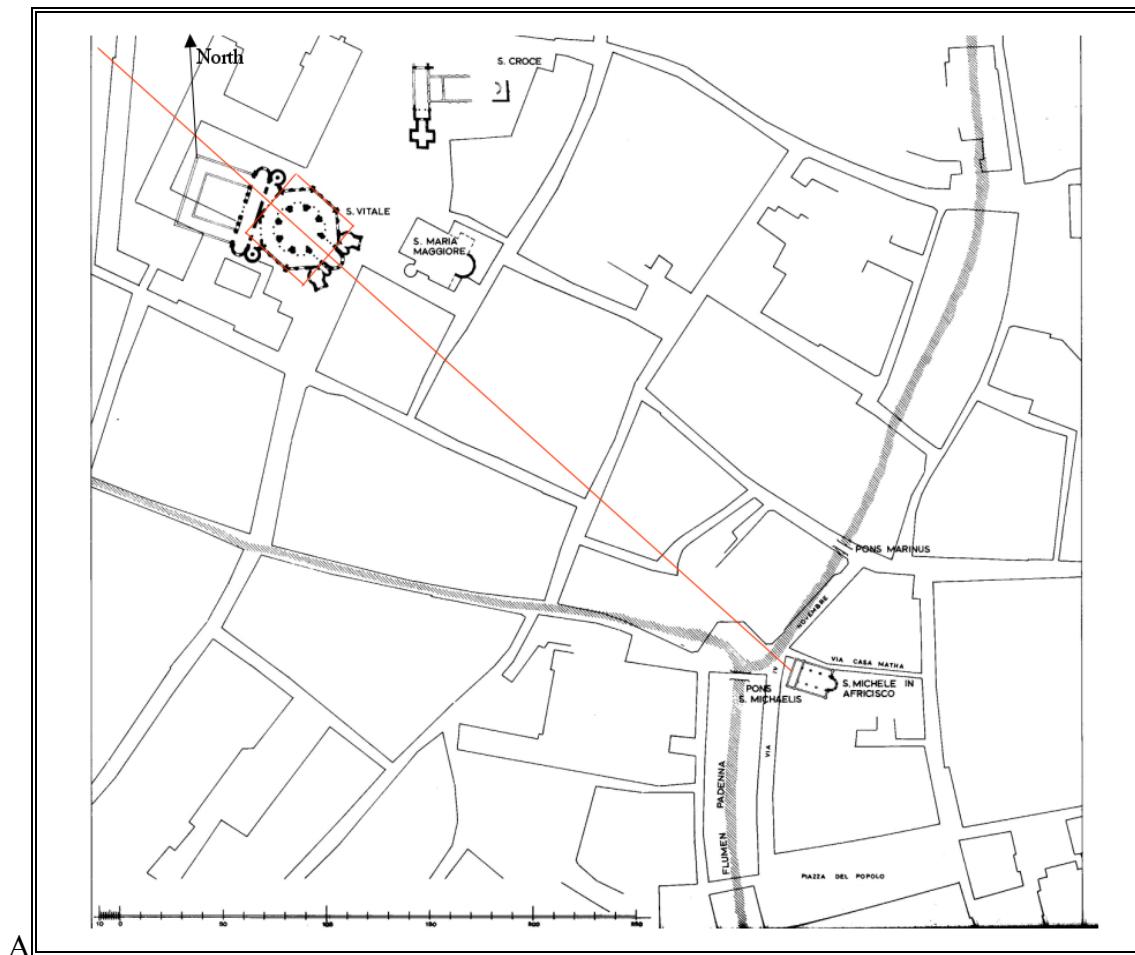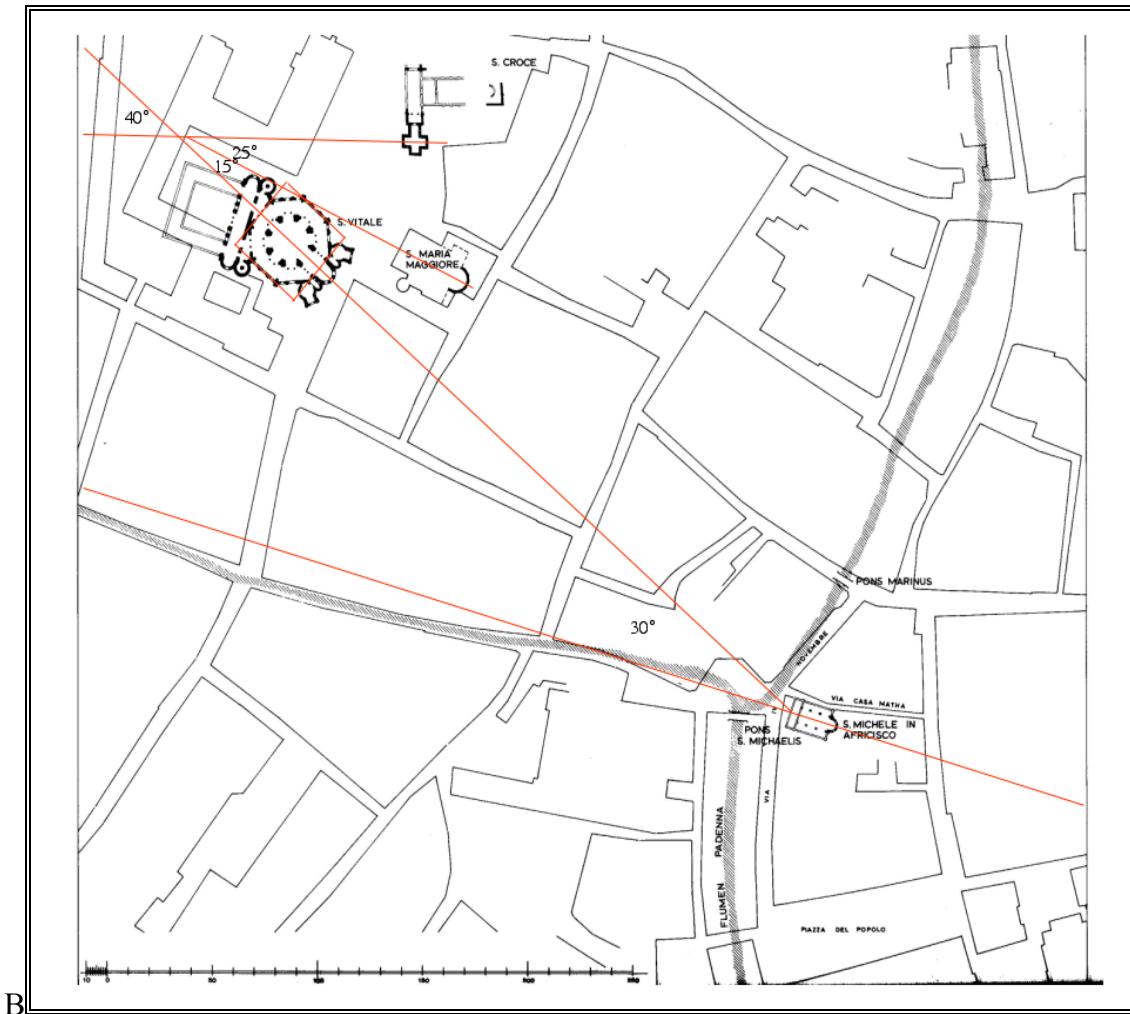
Figure 3.1.5: (A) Projected alignment of San Vitale (B) Relational alignments and angles between the *mausoleum* of Galla Placidia, San Vitale, San Maria Maggiore and San Michele in Africisco (Composite plan by Grossman; Overlay lines and angles by Knight 2009).
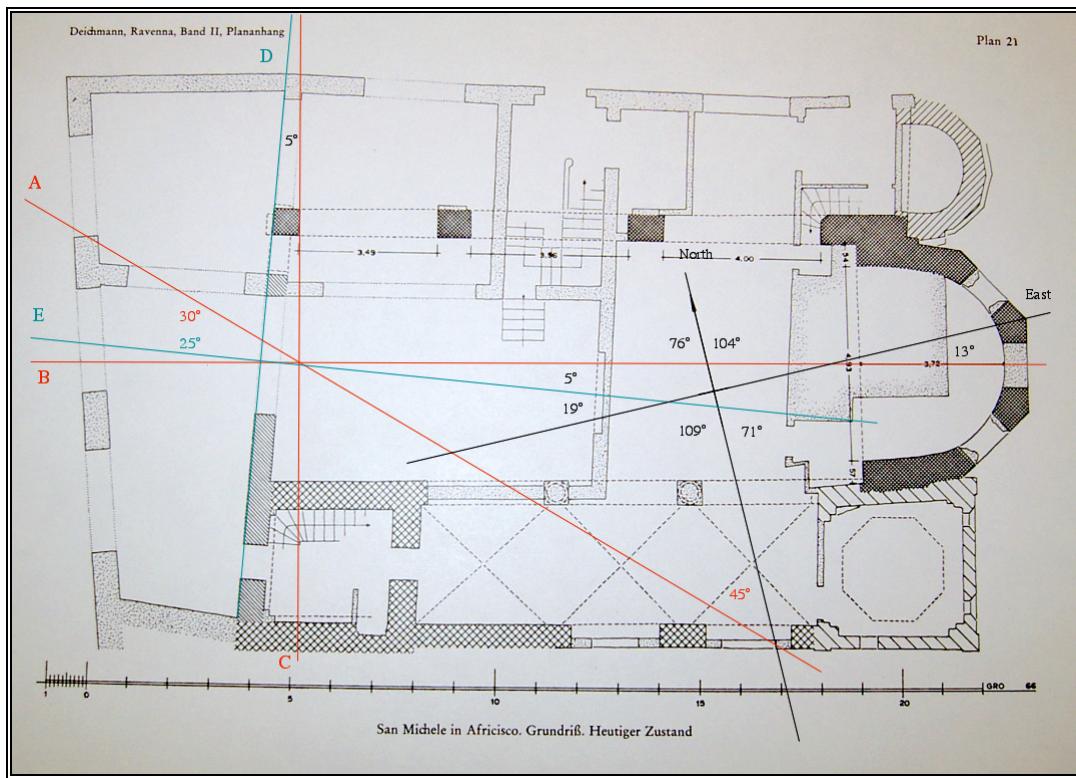
Figure 3.1.6: Phased plan of San Michele in Africisco with original alignment (red) and later entrance alignment (blue) (Plan by Deichmann 1989; overlay lines and angles by Knight 2009).

B

C
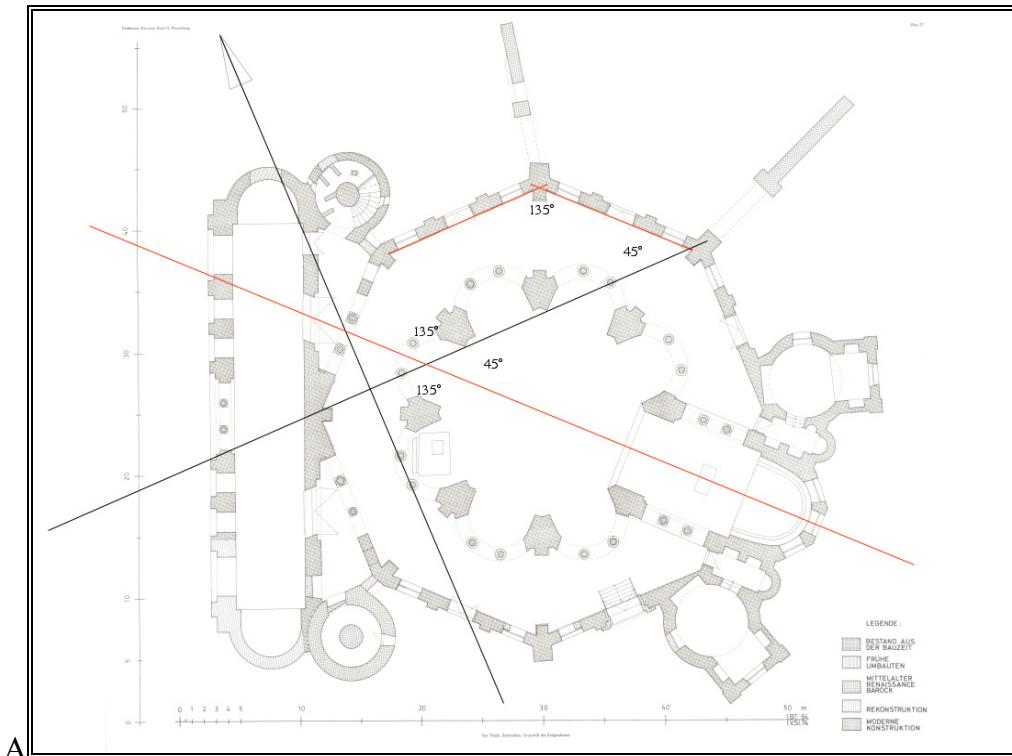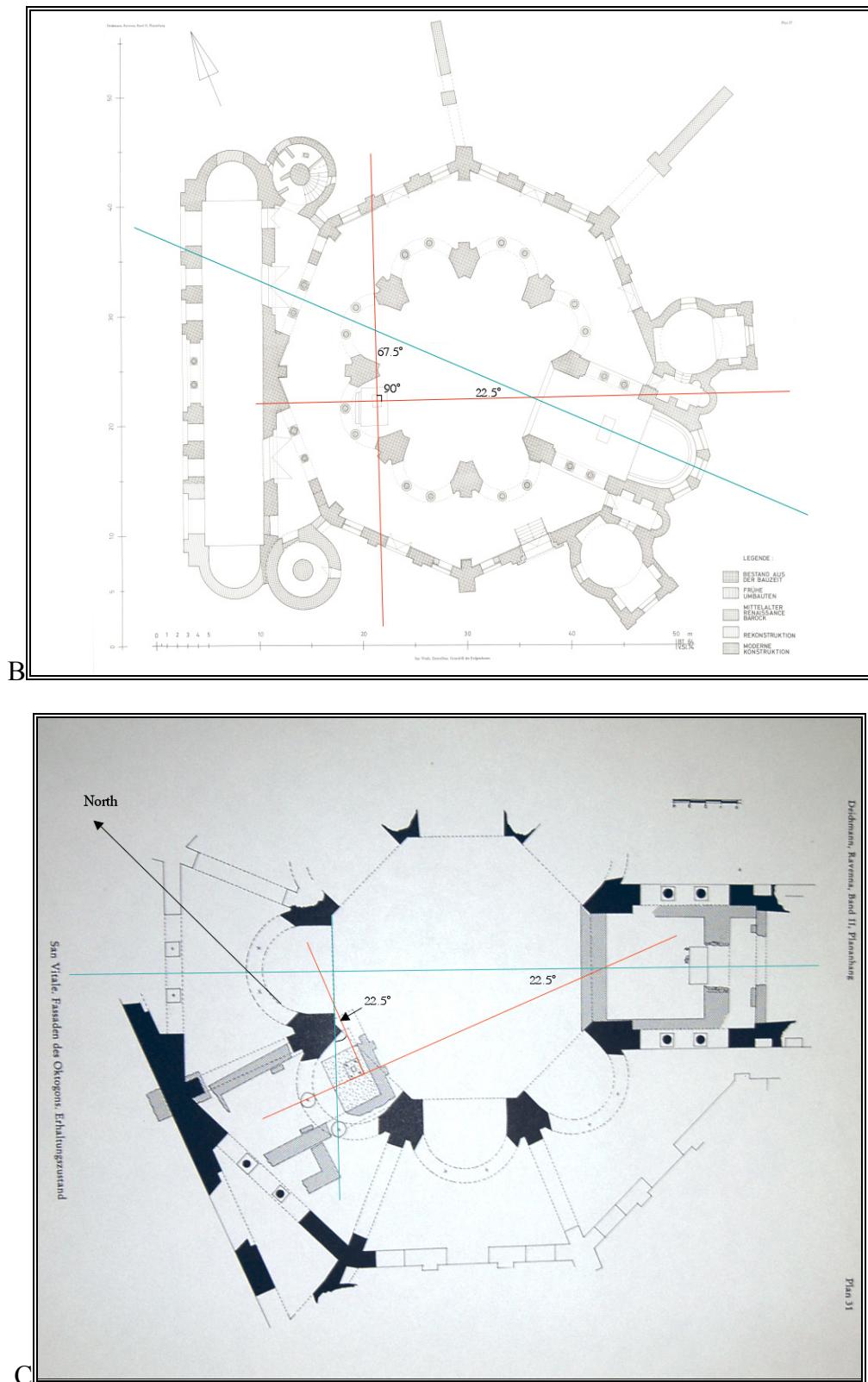
Figure 3.1.7: (A) San Vitale's 45° rotation south of true east (B) *sacellum* altar projected alignment (C) detail of *sacellum* and San Vitale's geometry (After Deichmann 1989; overlay lines by Knight 2009).

Once the chancel axis was rotated 22.5° the two *actus quadratae* provided much of the remaining geometry for the church. As seen in Figure 3.1.8 the main octagon derives from the *actus quadratae*.
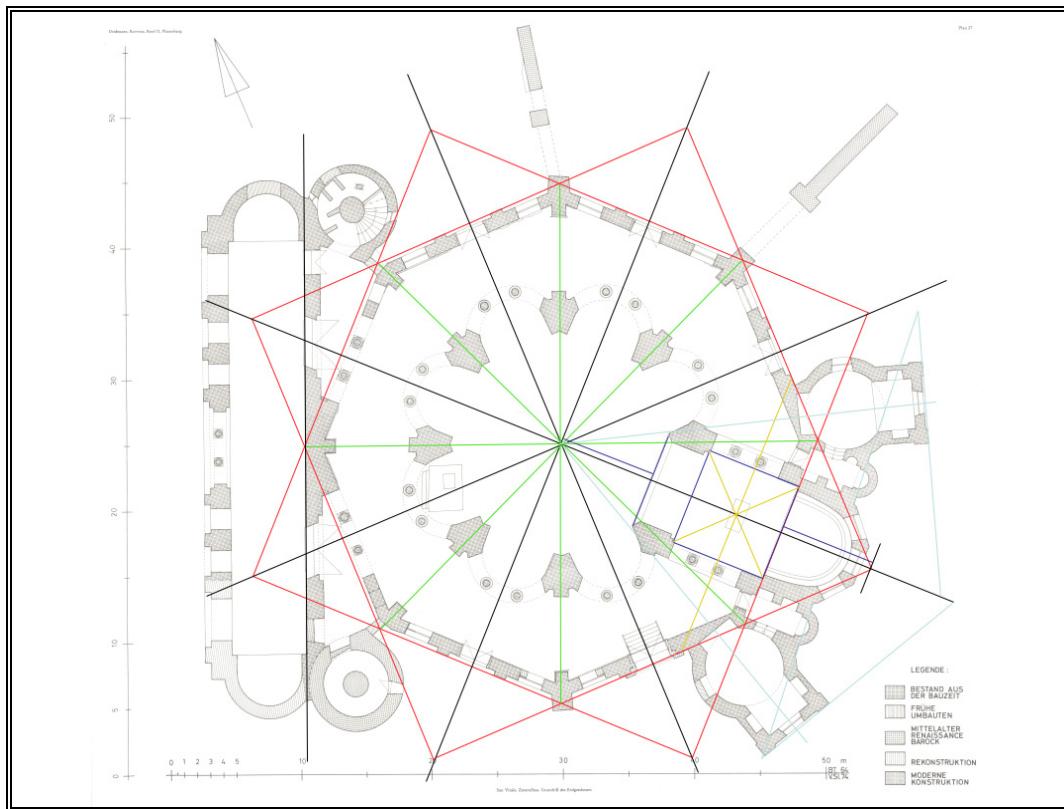
Figure 3.1.8: Red lines=*actus quadratae*, black lines=projections through the eight points of the *actus quadratae*, green lines=projections through intersections of the two *actus quadratae*, yellow lines=centre projection of chancel "house", dark blue lines=measurement from centre of church to chancel step applied to other parts of the chancel and apse, light blue lines=alignment and projections from the two side chapels and apsidal-ended entrance spaces
(After Deichmann 1989:Plan 27; overlay lines by Knight 2009).

Exceptions to the overall symmetry are the southern *diakonikon* and northern *prothesis* sanctuaries, if the external rectilinear faces of the sanctuaries are projected to the main axis of the chancel there is a mismatch, quite noticeable when compared to the overall precision and accuracy of measurement in the main body of the church. Although their respective alignments stem from the centre of the inner octagon their idiosyncratic relation to the accuracy of the rest of the church may mean the *actus quadratae* only served as guides for the initial surveying stage, used for marking out where to dig the

exterior wall foundation trenches but beyond this their use was not extended. Alternatively, their precision with the church was not imperative[19].

The construction of San Vitale

Several equivalent measurements can be identified within the church. Figure 3.1.8 shows in dark blue lines the repeated distance from the centre of the octagon to the first step of the chancel, between the piers upholding the Triumphal Arch. This distance appears again not only as the dimensions of the rectangular centre of the chancel, but also the distance from this rectangle to the south-eastern corner of the *actus quadratus* defining the chancel axis.

Similarly, as seen in Figure 3.1.9 below, the height of the exedrae (55.36 *pes*) very closely fits the length of the chancel (55.31 *pes*). The eighth exedra arch is laid down in plan to become the floor of the chancel and apse.

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[19] In describing San Vitale Stalley noted: 'The addition of a chancel, which compromised the logic of the centralised design, illustrates a widespread reluctance on the part of the Church to place the altar in the centre of the building. Yet this was the spot where the altar and its relics would have acquired most emphasis. Instead the central space came to be used like the nave of a basilica' (Stalley 1999:70).
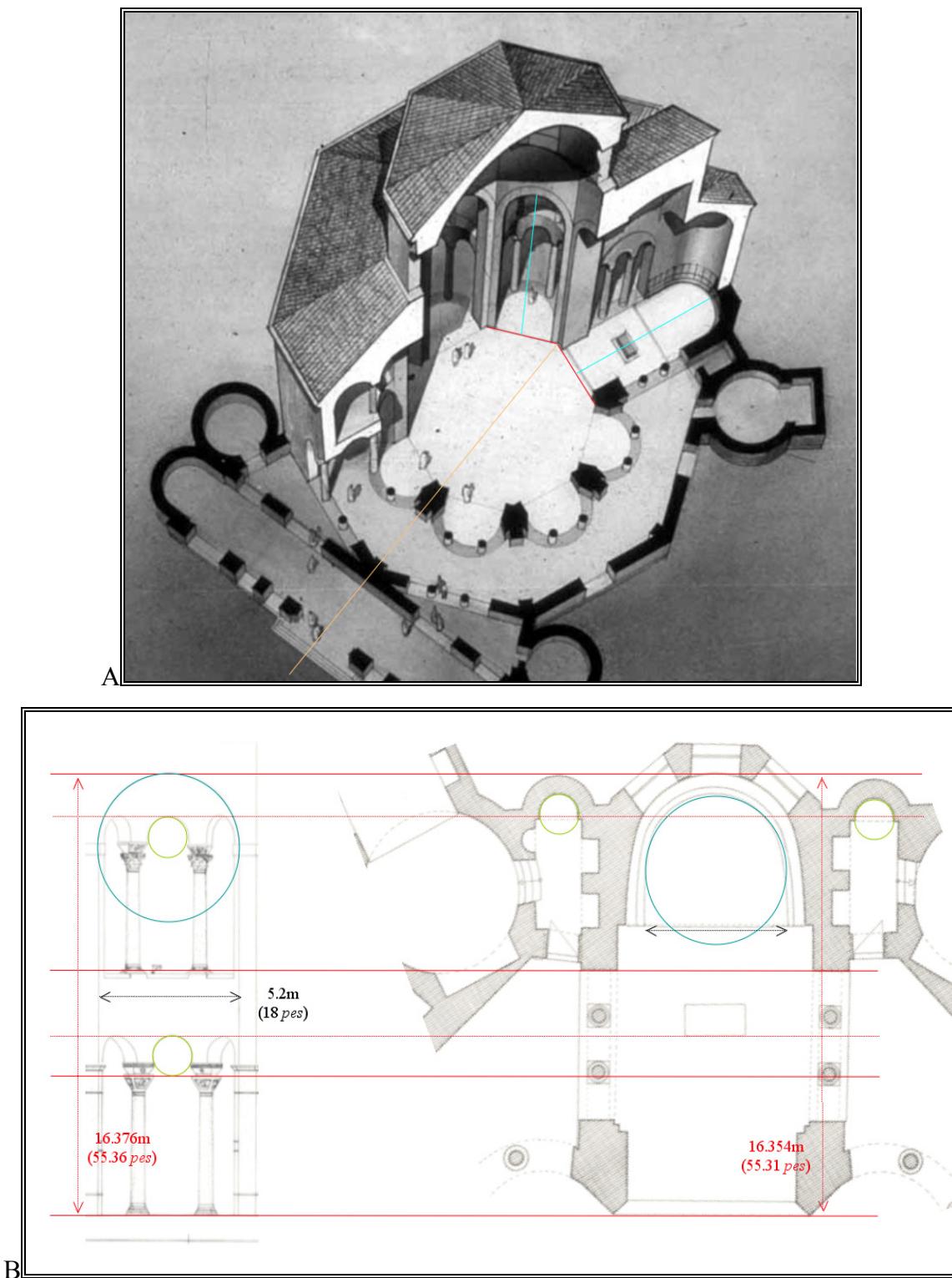
Figure 3.1.9: (A) equivalent height and length (blue lines) (B) Detail of exedra section and chancel plan
(After Deichmann 1989; overlay lines by Knight 2009).

Similarly, the inner width of the exedrae (18 *pes*) and the projected circle describing their arches is translated into the width of the apse floor to the first bench level of the *synthronon* (blue circles on Figure 3.1.9B). In addition, the small arches between the column capitals of the exedrae are equivalent to the apsidal ends of the entrance spaces to the sanctuaries either side of the apse (light green circles in Figure 3.1.9B).

Combining the observation that only the ground floor column capitals bear Bishop Victor's monogram and therefore must have been completed by 545[20], and the equivalency of dimensions noted above together reinforce the idea that the full height of the exedrae had been worked out prior to construction, and, therefore, indicate the existence of accurately drawn plans and elevations.
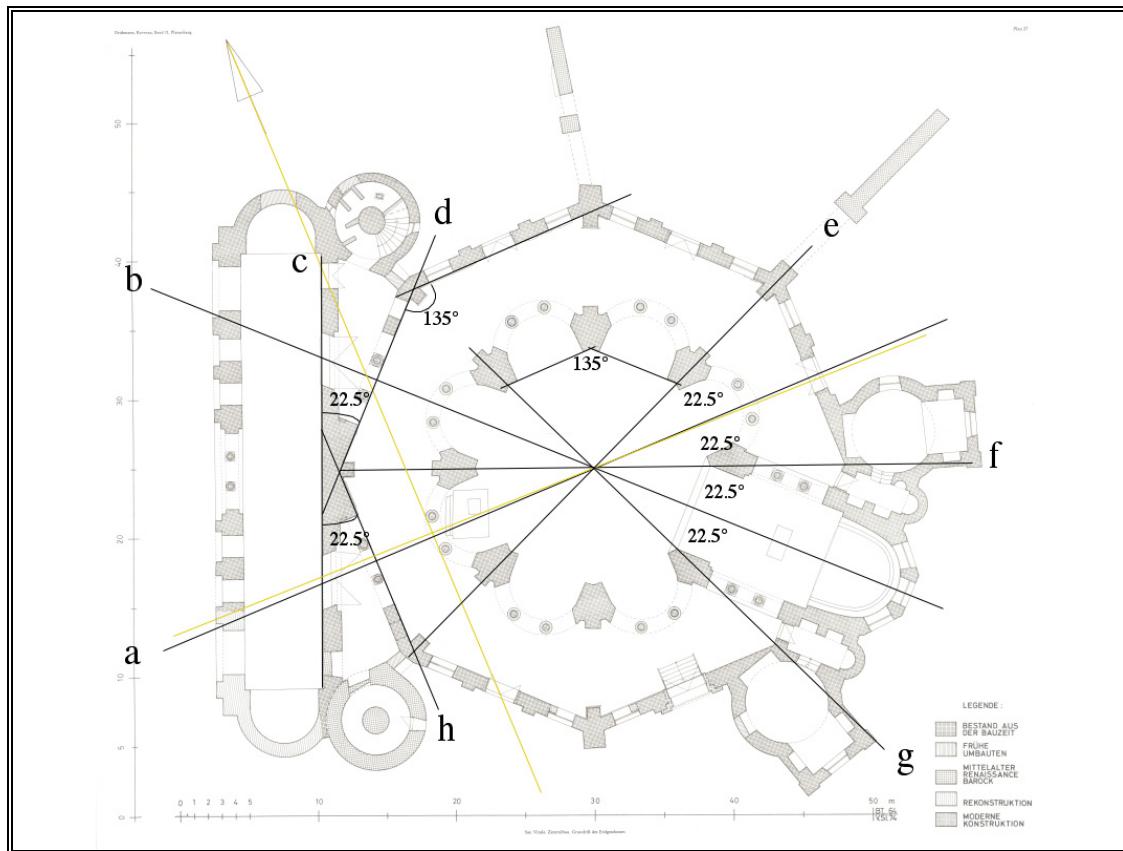
Figure 3.1.10: Angles of projected geometry (black lines), compass projection (yellow lines)
(After Deichmann 1989:Plan 27; overlay lines by Knight 2009).

Taking the north arrow in Deichmann's Plan 27 as correct (in his Plan 37 it is not correct), the east/west projection through San Vitale (line a in Figure 3.1.10) is offset by

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[20] Krautheimer 1986:232.

approximately 1.5° and may simply be explained as a slight inaccuracy, in this instance, of the sixth-century calculation of north, and subsequently that of east. Apart from this, the remainder of the geometry of San Vitale makes logical sense. Particularly noticeable, and relevant to the intentional connections made in Late Antiquity between materiality (physics) and acoustic, musical thought[21], is the repetition of the 22.5° angle. These 1/16th sections are central to the allocation of areas within the church and the logic behind two former "oddities" is apparent.

The axis of San Vitale's chancel and apse is not directly east. Nevertheless, Figure 3.1.10 demonstrates that the entire chancel and apse are perfectly situated, within a 45° (an 8th) section demarking the beginning of the chancel piers of the Triumphal Arch (lines f and g), and the bisection of this zone into two 16th sections of 22.5° is also exactly the alignment of the chancel and apse (line b).

Another peculiarity often noticed is why the main body of the church (ergo the octagon) receives the narthex at a point (at lines c, d, and h) rather than "nicely" at the linear edge directly opposite the chancel and apse. Again, Figure 3.1.10 reveals the angles of 22.5° were intentionally repeated (at both c and d, and c and h), creating two 16th slice spaces between the main entrances from the narthex and access to the circular stairwells. This reiteration of the same angle as found throughout the church interior nicely resolves receiving a longitudinal narthex to an octagon while also facilitating people moving further into the church ground floor or up by way of the stairwells to the *matroneum*.

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[21] See Appendix A for a full treatment of the ancient theories of sound.
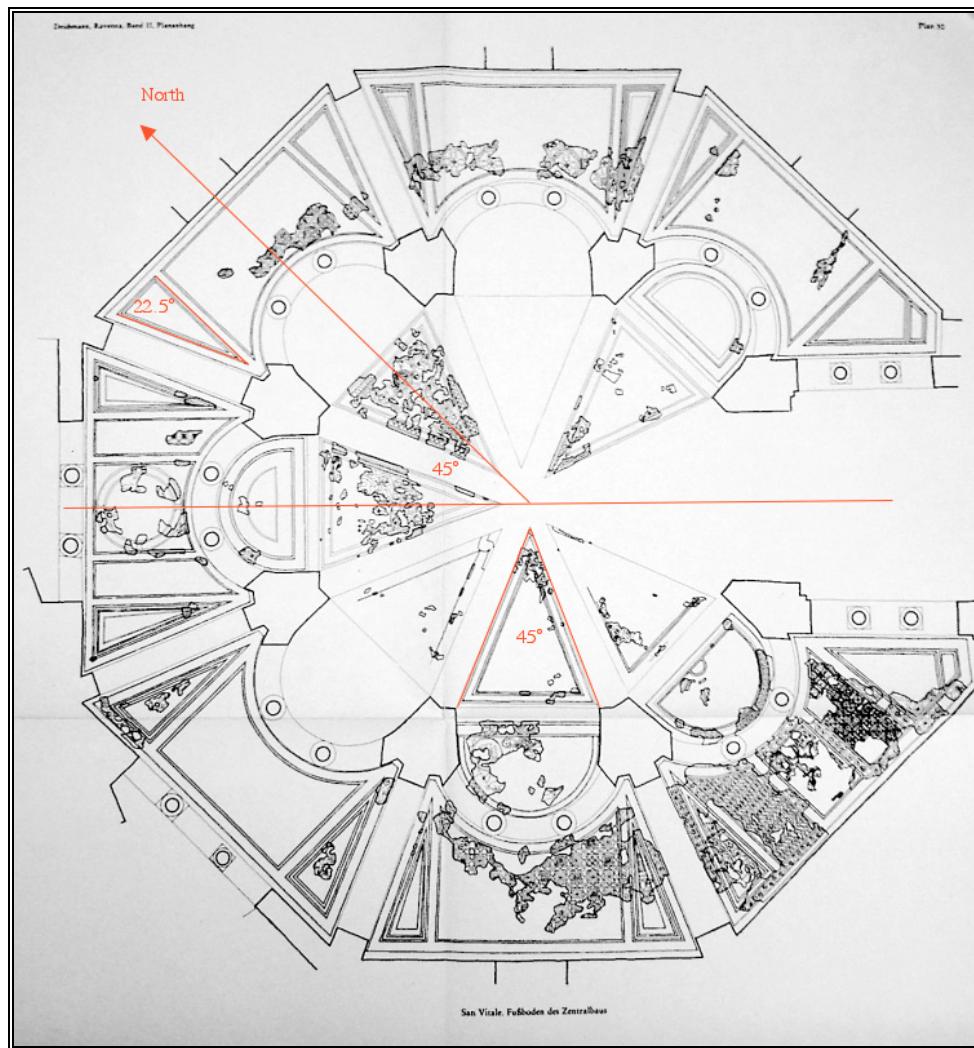
Figure 3.1.11: Plan of original floor mosaics (After Deichmann 1989; overlay lines by Knight 2009).

The original ground floor mosaics[22] are sectioned into geometric 'slices'. As seen in Figure 3.1.11 the inner octagon had at least seven triangular divisions, the angle at the centre being 45°. These triangles are extended into the ambulatory zone and again divided, at the widest extent at the walls two complementary triangles are made with an angle of 22.5° each, numbering twelve around the entire ambulatory. The remaining shape behind each exedra is further divided into three areas. The middle of these, particularly inside the northern entrance has a central roundel, or *rota*[23]. Unfortunately the comparable floor area inside the southern entrance, and immediately before the

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[22] The mosaic scheme in San Vitale is further discussed in Part 3.2.
[23] Agnellus 41; Deliyannis 2004:148-150, 336.

sacellum, is not extant, but this too may have had a roundel and, therefore, a significant demarcation for each area of entrance.

It is worthwhile testing if the logical sectioning of the octagon seen in plan has any relevance in elevation. Using the centre point of the inner octagon on the ground floor as the derivation of projected gradients Figure 3.1.12 reveals some intriguing correspondences. The smaller angles of 22.5˚ identified in the floor mosaic are applied as gradients to the elevation along the main axis of the church. The two sections described by lines *c*, *d* and *e* closely delineate the location of the beginning of the dome drum. The section bounded by lines *e* and *f* exactly demarcates the length of the chancel roof at its peak. The opposite section, between lines *c* and *b* closely mark the extent of the *matroneum* sloping roof. Line *a* points to the apex of the entrance arch at the northwest. The section between lines *f* and *h* roughly marks the southeast extent of chancel and apse roof, but if this section is further halved into two sections each 11.25˚ (between lines *f* and *g* and between lines *g* and *h*) line *g* is seen to mark the exact beginning of the apse ceiling. If the final 22.5˚ section between line *h* and the ground is quartered (at 5.625˚) line *i* is observed to project directly to just above the bishop's throne, at the height of the head of the person seated there.
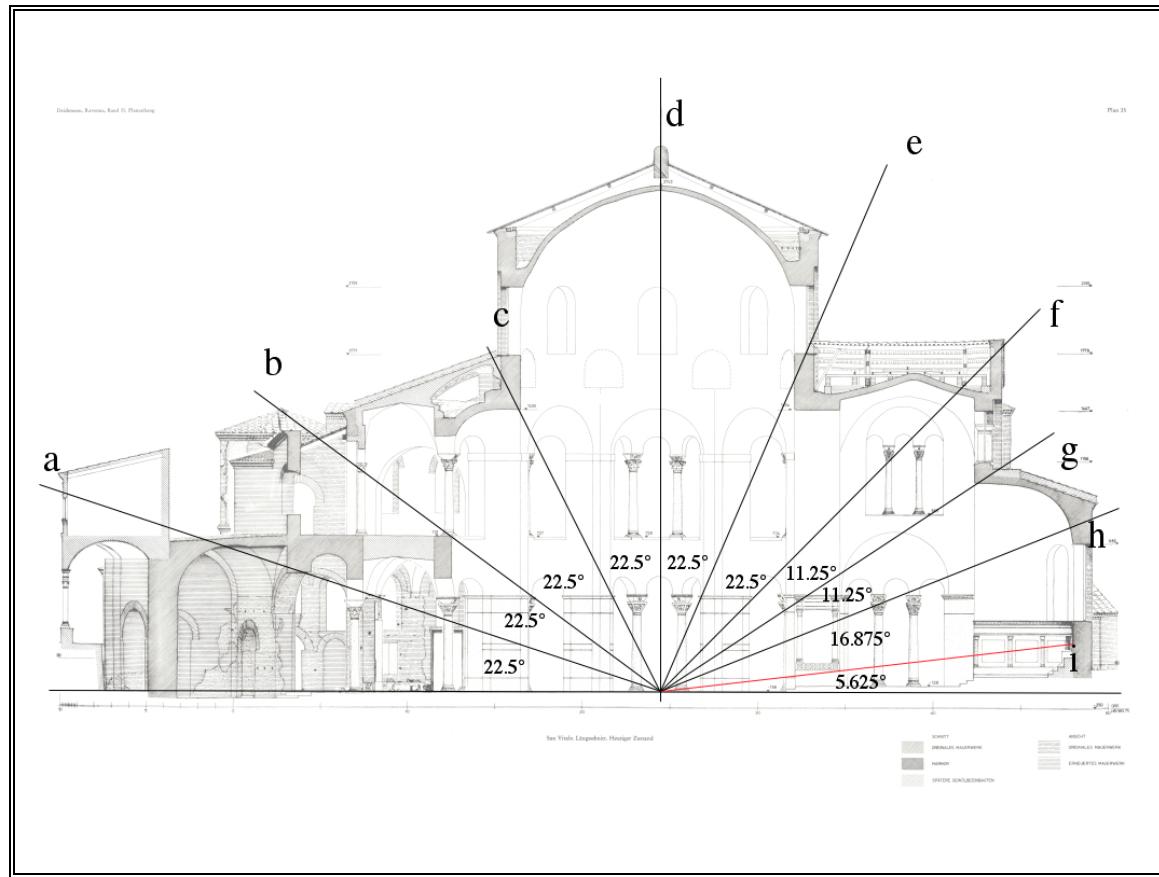
Figure 3.1.12: Gradient projections from centre of church from northwest (a) to southeast (i)
(After Deichmann 1989; overlay lines by Knight 2009).

A similar test of gradients is shown below in Figure 3.1.13, along the northeast/southwest section facing the chancel. The clearest correspondence is seen for the two sections between lines *d*, *e* and *f*. Lines *d* and *f* closely demarcate the lower interior edge of the dome drum window openings. The only other close correspondence[24] appears for lines *b* and *h*, both projecting to the tops of the ground floor ambulatory windows.

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[24] Lines c and g vaguely point towards the internal junctions between *matroneum* ceiling and uppermost extent of the church's external walls.
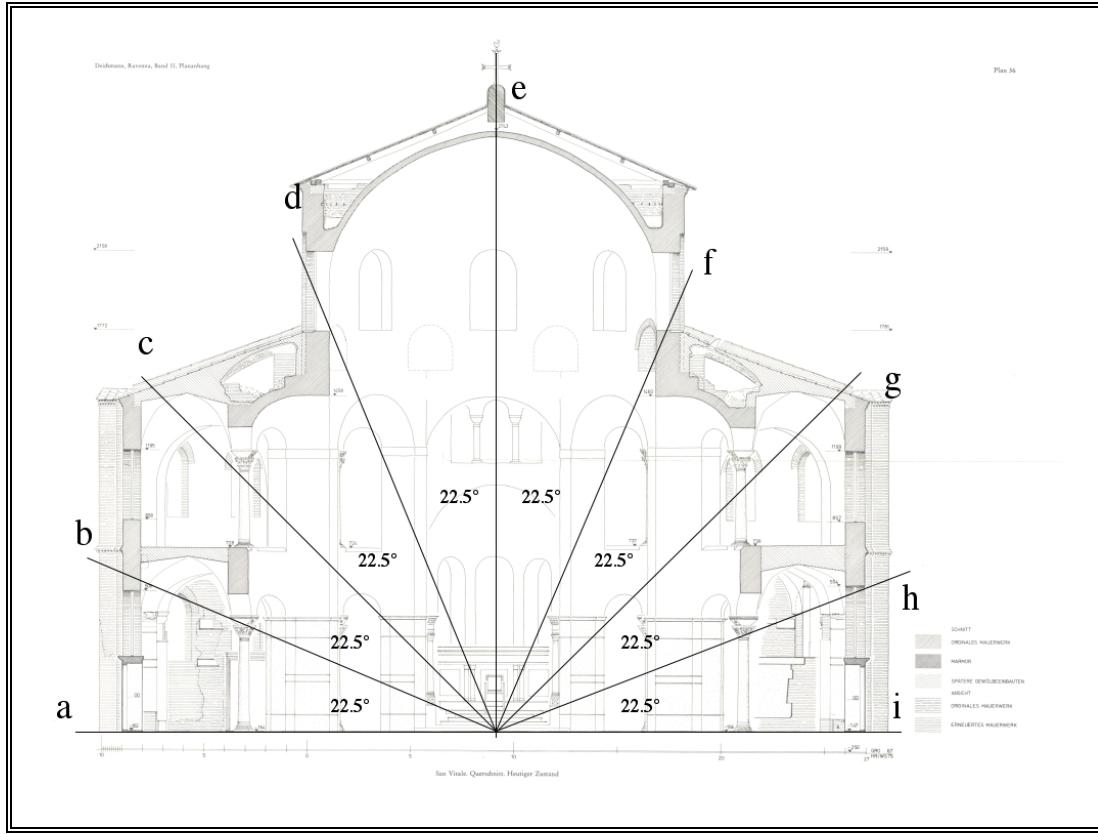
Figure 3.1.13: Gradient projections from centre of church from northeast (a) to southwest (i)
(After Deichmann 1989; overlay lines by Knight 2009).

With some confidence it can be asserted that the division of the octagon both in plan and elevation becomes both a decorative feature as in the floor mosaics and guides for locating the heights of some ceiling, roof and window zones. The implications of these correlations between angles derived from the octagonal symmetry and important aspects of San Vitale's interior space will be discussed in Chapter Seven.

Complementary to these logical proportions demonstrated above, it remains necessary to briefly include one specific detail of San Vitale's construction not elsewhere mentioned. As can be seen in Figure 3.1.14 A and B below, the distribution of column-base shapes reveals an intentional symmetry. The predominant column bases on the ground floor (A) are octagonal on circles (green), a total of 14 all within the main body of the church. The remainder on the ground floor are circular on square (red), with 8 examples in the church and two small versions at the central triple-window of the

narthex[25]. The majority of column-bases on the *matroneum* level (B) are circular on square (red), with 14 at the *exedrae* and 4 at the angular spaces leading to the stairs north and south. Only 4 octagonal on circular (green) column bases are represented at this level, but, significantly, they are above their opposites on the ground floor. As shown, the column base shapes on the ground floor and *matroneum*, at the same positions in plan, are, in elevation, exactly opposite. This reflection of architectural elements in the context of who was situated on these two respective floors further demonstrates an intentional and internal logic not altogether perceptible by the senses alone. Without studiously surveying the building, and with no virtual or real scaled model to study, members of the congregation would hardly have been aware of this column-base symmetrical vertical spatial distribution. Perhaps members of the clergy had privileged knowledge of this harmonic detail, certainly it was known by the designers, *archiergatus*, workmen, Iulianus *argentarius* and the bishops involved in constructing San Vitale.

To test whether these inscrutable details are unique to San Vitale (and therefore "San Vitalisms") relies on future comparisons with other contemporary churches.

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[25] The examples in the narthex are included with caution, for although they are originals of San Vitale from the National Museum, their placement is part of the 1929 restoration of the narthex and therefore it cannot be known with certainty if their present location is completely accurate (Bendazzi & Ricci 1987:23-24).
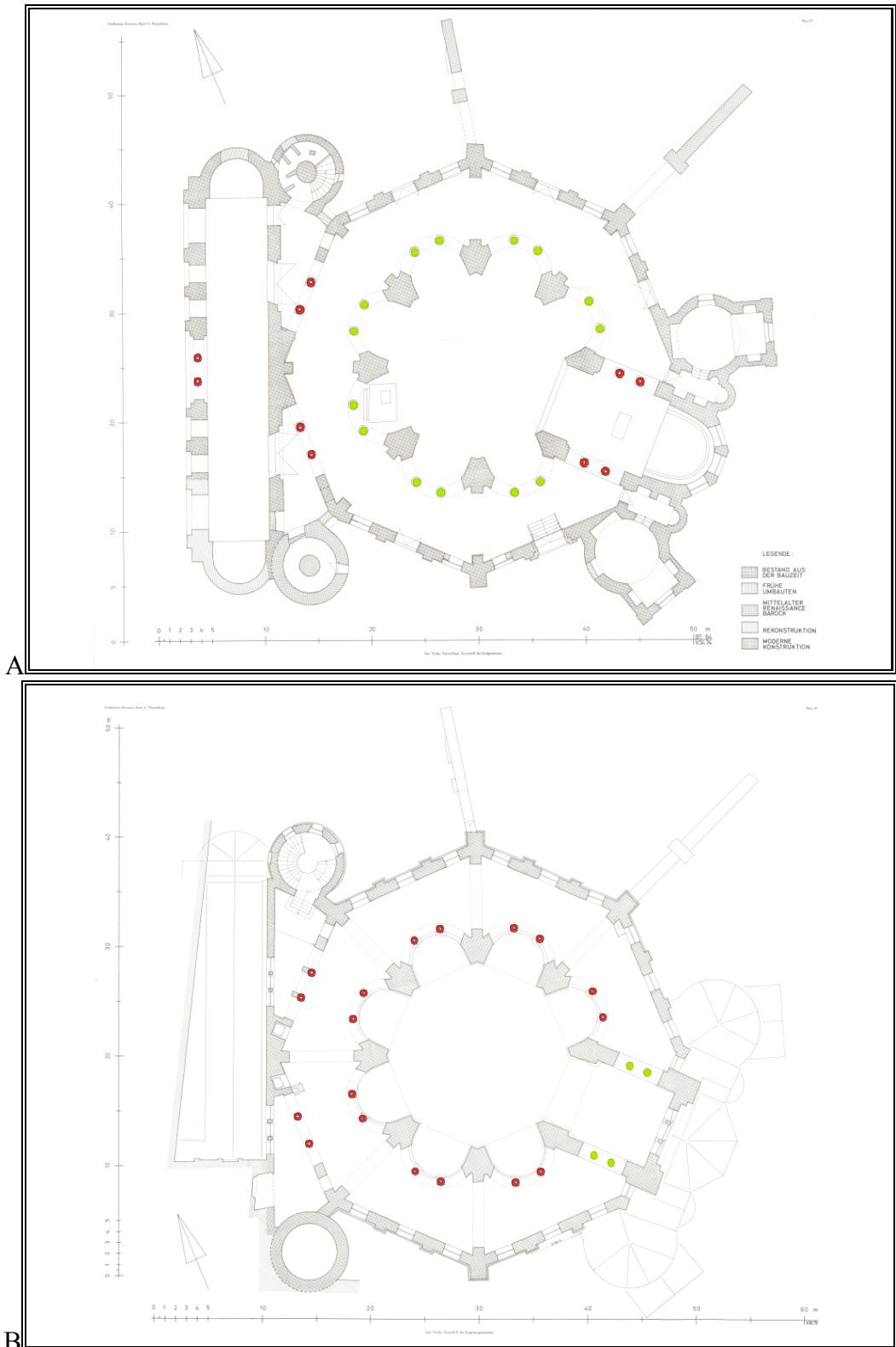
Figure 3.1.14: Positions of columns with circular on square (red) and octagonal on circular (green) bases
on the ground floor (A) and *matroneum* (B)
(After Deichmann 1989; column-base colourisation by Knight 2009).

We understand that Bishop Ecclesius and his successors, and Iulianus *argentarius* together ensured the construction and finance of San Vitale. The name of the "architect(s)" is not known but the *archiergatus / princeps operas*[26] likely had a similar education and comparable skill-sets to the *mechanopoioi*[27] of Hagia Sophia, Isidorus of Miletus and Anthemius of Tralles. While Isidorus was an able mathematician and had taught physics in Alexandria, Anthemius was a Greek professor of geometry at Constantinople and a consummate mathematician[28].

Sixth-century knowledge of surveying and geometry ultimately derived from Euclid's *Elements*, but with an overlay of contemporary ideas such as those of Proclus, Probus and the Pseudo-Dionysius. All these, and the ideas expressed by St Ambrose on the theological significance of numbers, were significant to the concepts behind San Vitale's design and construction. Indeed, it has been noted:

> The *ars musica* of medieval times, stemming from treatises by Aristides Quintillianus, Boethius, Cassiodorus and Isidore of Sevilla through the mediation of the *artes quadriviales*, relied on a philosophy of number as its rational basis. And this philosophy of number in turn relied on metaphysics.[29]

A work that had great influence on scholasticism as expounded by both Boethius and Cassiodorus at Ravenna, namely the *quadrivium*, was *De Coelesti Hierarchia* (*Celestial Hierarchy*) ascribed to Pseudo-Dionysius, or, an anonymous writer and dated to the fifth-century[30]. This work on angelology influenced the development of Orthodox theology, as it divided angels into three hierarchies containing three orders, based on their proximity to God[31]:

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[26] The Greek term and Latin translation are provided by Agnellus (73) in the context of Bishop Maximianus conversing with the "master of the work" of the church of St. Stephen the Proto-martyr at Ravenna in c.550. Deliyannis notes (2004:312, note 17) that *archiergatus* is a 'transliteration of the Greek [*arxiergatos*]; it must not have been in common use [by the time of Agnellus], as Agnellus feels he has to define it as the "master of the works" (*princeps operis*)'.

[27] Krautheimer 1986:206.

[28] Anthemius described the string construction of the ellipse [according to Procopius, *De Aedific*. I. 1] and he wrote a book on conic sections, which presumably prepared him for designing the elaborate vaulting of Hagia Sophia http://www.1911encyclopedia.org/Anthemius and http://www.1911encyclopedia.org/Isidore_Of_Alexandria.

[29] Smith 1979:40.

[30] http://www.tertullian.org/fathers/areopagite_13_heavenly_hierarchy.htm

[31] Cf. Heil & Ritter 1991.

1:      Seraphim, Cherubim, and Thrones
2:      Dominations (Dominions), Virtues, and Powers
3:      Principalities, Archangels, and Angels

Returning to the anagogical quality and vertical symbolism depicted in the chancel mosaics of San Vitale, it is apparent that the eighth order, the Archangels Michael and Gabriel, are situated at eye-level to those in the *matroneum* balcony. If this interpretation is correct, then Christ enthroned is depicted in the ninth order of Angels and directly above mankind, personified in real terms by the bishop in his throne. The number eight is significant in Christology, as St Ambrose alludes to in the verse at the head of this Part, as it signifies resurrection, rebirth and renewal; the eighth day is new perfected time, following the seven days of Creation.

Therefore, ecclesiastical architecture in the sixth-century cannot be understood by solely studying engineering physics and mathematics utilised by the designers and architects. The symbolic theological significations believed to be within the power of numbers and geometric shapes needs to be incorporated, as evidently the *archiergatus* of San Vitale did when designing and constructing that church.

It may be that the acoustic architecture was one part of this symbolic architectural vocabulary, where proportions and spaces had theological and numerological significance. Whether, by extension, this means there was a kind of "theology of acoustics" operating among ecclesiastical architects can only at present remain an area of speculation. However, the archaeoacoustics of a congregational space, and the acoustemology of the spiritual, religious experience, could provide archaeologists with new tools with which to reconstruct more accurate models.

Part 3.2: San Vitale's Mosaics in Context

Having followed the survey and construction sequence of San Vitale it is appropriate to look afresh at the interior decoration, namely the sixth-century mosaic scheme surviving on the walls and ceiling of the chancel and apse[1]. By acknowledging the mosaic depictions are inseparable from the specific context of the geometric architectural interior spatial layout of San Vitale and the broader context with other contemporary mosaic schemes at Ravenna and Classe, a number of new observations are presented.

The Late Antique mosaics of Ravenna are outstanding and impressively beautiful. The excellence of their design, craft and execution is celebrated. However, art historical studies of the mosaics, from Rahn, Richter and Müntz's 19th century critiques[2] onwards, have tended to colour present perceptions regarding their original contextual spatial interrelationships. In one important case the mosaics have been physically de-contextualised, the heavily restored apse mosaic of San Michele in Africisco now resides in Berlin's Bode Museum[3]. As the church has been a bakery and now a Max Mara clothing shop the removal of this mosaic has probably saved it. The winged angels blowing trumpets are particularly interesting as they are emblematic of sound and music, indicating acoustics and *aurality* were qualities uppermost in the attention of the designers of Ecclesius' building project.

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[1] The original floor mosaics in the chancel area do not survive and the wall and ceiling mosaics of the remainder of the church interior are likewise missing. Consideration of the ornate plasterwork will be left for future investigation.

[2] Rahn 1869, Müntz 1885 and Richter 1878.

[3] The heavily restored apse mosaic of San Michele is now in the Byzantine Art Collection of the Bode Museum, Berlin (formerly the Kaiser Friedrich Museum).

Figure 3.2.1: San Michele in Africisco apse mosaic (Online image from the Bode Museum, Berlin[4]).

Our current knowledge of Ravenna's Late Antique mosaics remains substantially based on Bovini's[5] interpretations, subsequently followed by Krautheimer[6]. Bovini identified the imperial mosaics of San Vitale (Figure 3.2.2 and 3.2.3) as a moment in the *oblatio Augusti et Augustae*, the earliest representation of 'the presentation of liturgical vessels as imperial gifts'[7]. The most recent scholarly work includes Wharton's[8] analysis of the mosaics of the Orthodox and Arian Baptisteries. Although the important work of Dunbabin[9] intentionally avoids the mosaics of churches and synagogues, she raises a crucial argument that the architectural settings and their various forms and uses played a significant role in relation to the mosaic design and content. Her suggestions are a vital foundation for the interpretation of San Vitale's mosaics in their spatial and symbolic context, explored further in the following chapters.

In San Vitale the exceptional mosaics surviving in the chancel and apse, and in particular the portraits of Justinian and Theodora, have been unanimously accepted as

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[4] http://www.sacred-destinations.com/germany/berlin-bode-museum-photos/slides/IMG_3561p.php
[5] Bovini 1956 *et al*.
[6] Krautheimer 1965 and additional editions (the fourth edition of 1986 has also been consulted in this research).
[7] Bovini 1956:46.
[8] Wharton 1995 *et al*.
[9] Dunbabin 1999:304-316.

some of the finest Late Antique mosaics in the west. The justification for the inclusion of the church in the UNESCO World Heritage List is revealing:

> The church of S. Vitale is a unique example of Byzantine art; firstly because it blends in a most original way eastern and western styles into its architecture and secondly because its mosaics are complete and express with great clarity the ideology and religiosity of the Justinian era which has been defined by the historians as the First Golden Age of Byzantine Art.[10]

However, the fame of San Vitale's mosaics tends to overshadow significant contextual details that have gone unnoticed by art historical critique. The photographic reproduction of these mosaics for inclusion as manageable colour plates in illustrative books emphasises the framed 2-dimensionality of picture panels seen out of scale, up close and at eye-level. Interpreting the full meaning of any de-contextualised mosaic is fraught with danger. For example, the importance of the slight but noticeable concave curvature of the southeast portions of the imperial mosaics (Figure 3.2.2 and 3.2.3) is completely lost when represented as a face-on 2-dimensional colour plate. Therefore, it is of the utmost importance to look afresh at San Vitale's mosaics within their specific and broader spatial and symbolic contexts.

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[10] UNESCO: Basilica of S. Vitale; Justification for the inclusion to the World Heritage List:
http://www.turismo.ra.it/binary/turismo_ravenna_new/arte_monumenti/svitale.1102598750.pdf.

Figure 3.2.2: Mosaic of Justinian on north chancel wall, San Vitale (Photograph by Knight 2006).

The most important addition to our knowledge of San Vitale's mosaics has come from a recent study by Baker[11], who convincingly demonstrated at least two different phases of the imperial mosaics, correcting Krautheimer's assumption that all the mosaics were executed under Bishop Maximian[12]. Baker showed that the silver-backed glass *tesserae* of the original wall and ceiling mosaics are older than the added name of MAXIMIANVS and the replaced head of that bishop in stone *tesserae*. Baker comments that the overall effect is a rather 'gauche intrusion'[13], considering not even Justinian or Theodora are privileged with names.

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[11] Baker 1993 *et al*.
[12] Krautheimer 1986:232.
[13] Baker 1993:186.

Figure 3.2.3: Mosaic of Theodora on south chancel wall, San Vitale (Photograph by Knight 2006).

If the original mosaic scheme was designed prior to the Constantinopolitan takeover of Ravenna in 540 and executed by the end of the first two years of Bishop Victor's episcopacy (538-45)[14], then the message of the Great Entrance is one of inclusion, inviting conciliatory union with Orthodox Constantinople. This sentiment reminds one of the Orthodox and pro-Roman position of Queen Amalasuentha, her wishes for union with the court of Justinian are historically known[15] and the inclusion of depictions of the Constantinopolitan court in San Vitale may indicate some level of involvement by the Queen prior to 535.

The collection of alms (gifts including the bread and wine) at the beginning of the Communion service precedes their consecration and therefore the mosaics point to the next temporal event in the liturgical sequence, the consecration of the bread and wine, depicted either side of the chancel where Melchizedek (*Melchisedec*) (Genesis 14:18-

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[14] This suggestion is based on Krautheimer 1986:232 and Baker 1993:186.
[15] Amalasuentha died in April of 535 having been imprisoned for entering upon negotiations with Justinian (Jones 1973:274-275). Also Baynes 1925:71-73.

20)[16] and Able (Genesis 4:1-16) both elevate the Eucharist over an altar (on the south wall) and Abraham is halted by the hand of God in sacrificing his son Isaac (Genesis 21:1-5) on the north wall (see Figure 3.2.4 below).

A   **B**

Figure 3.2.4: (A) South chancel wall mosaic of Abel and Melchisedec elevating the gifts for consecration (B) North chancel wall mosaic of Abraham and Sarah (left) and Abraham and Isaac (right) (Photographs by Knight 2006).
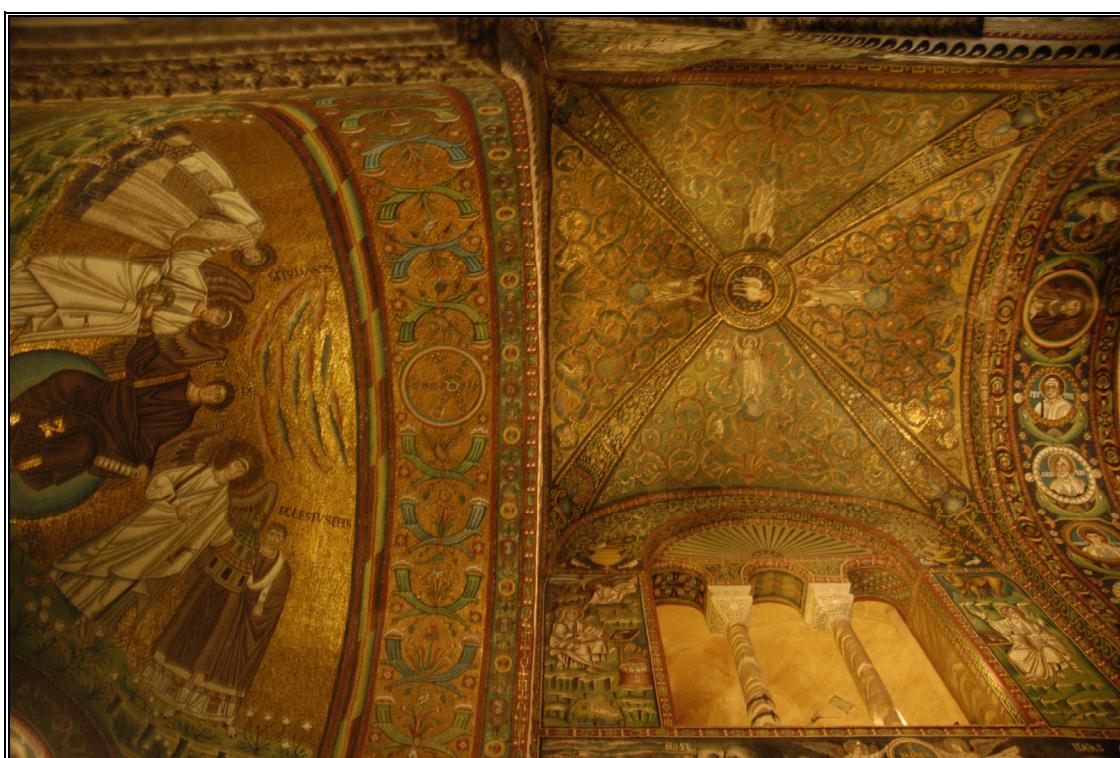
Figure 3.2.5: View from area between main altar and bishop's throne (*sedis*), looking straight up with the north chancel wall behind (top of image) (Photograph by Knight 2006).

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[16] The priest-king Melchizedek (*Genesis* 14: 18-20) is mentioned in the Roman Canon, in the First Eucharistic Prayer of the Roman rite.

The orientation of the mosaic depiction of the *Agnus Dei* in Paradise above the main altar (Figure 3.2.5) suggests the officiating celebrant of the Mass may have faced the apse at crucial times in the liturgy as the *Agnus Dei* is seen right side up if one is located in front of the main altar looking towards the apse triple windows and mosaic of Christ enthroned (Figure 3.2.6). At other times, for the *pars virorum* and *pars mulierum* locations of congregated men and women to be on the right and left side of the celebrant, as indicated by the respective locations of the imperial mosaics, the celebrant faced the congregation. Therefore, the orientations of key elements in the mosaic iconography appear to cue and echo the liturgical actions of the Mass celebrant.

Figure 3.2.6: Chancel apse ceiling mosaic (Photograph by Knight 2006).

Additionally, the representation of the *oblatio Augusti et Augustae* can be physically positioned along a temporal sequence; behind these panels of Justinian and Theodora, in the western portion of the chancel, are shown the first, ancient, Eucharistic offerings of Abel, Melchisedec and Abraham. In this sense, the chancel depicts movement through time from west to east. In the mosaic of Theodora a male figure holds back a tapestry to reveal the "future" in the form of a life-giving fountain of water

gushing from an urn resting on a short column with Corinthian capital. This may be a visual reference to the supposed presence of a fountain in the centre of the atrium courtyard to the west, but if this is meant to indicate the future, a new life, and Paradise, then it also makes sense this is towards the eastern rising sun, the new, eighth day of Resurrection. Beyond this mosaic scheme are three windows and directly beneath the central window is the bishop's throne (*sedis*) at the apex of the chancel apse. In this position the bishop sits looking from the east as the earthly representative of Christ enthroned, depicted immediately above in the apse ceiling mosaic (Figure 3.2.6).

The emperor and empress of the Eastern Empire bring oblations to this bishop resident at San Vitale, at Ravenna, the capital of the Western Empire. The meaning of this is particularly loaded at the dates when the church and its mosaics were designed, constructed, and dedicated. The message of invitation to the East remains open but also under the premise of paying homage to the West. Again, this does not seem entirely in keeping with interpretations that the mosaics are entirely post-540 and "Byzantine".

Observations of San Vitale's mosaic scheme

The first observation[17] is that the style and exuberant bright colours of the wall and ceiling mosaics are predictably very different from the earlier late fifth-century *sacellum* floor mosaic which now rests framed against the ground floor south ambulatory wall. It has been shown that the *sacellum* was a crucial structure for the survey positioning of San Vitale, as the church respects and seems to intentionally encompass and protect the older structure. With the additional demonstration in Chapter Four of isovists from positions at the south entrance of the church (Figure 4.2.2 and 4.2.9) funnelled to converge directly at the *sacellum* altar, it is possible to interpret this as its continuity of liturgical use throughout, at the very least, the first decades of San Vitale's service. The *sacellum* mosaic floor would therefore have been seen when the mosaics for the church interior were being designed and applied and so the differences and similarities between them are important. One particular comparative observation may suffice; the *sacellum* floor mosaic is black and white with a few highlights of light red

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[17] To the authors' best knowledge none of the following observations have been made in any of the former literature on San Vitale's mosaics.

and blue (Figure 3.2.7) whereas the emphasis of the sixth-century mosaics in San Vitale is on multicoloured vibrancy with a relative scarcity of black and white.
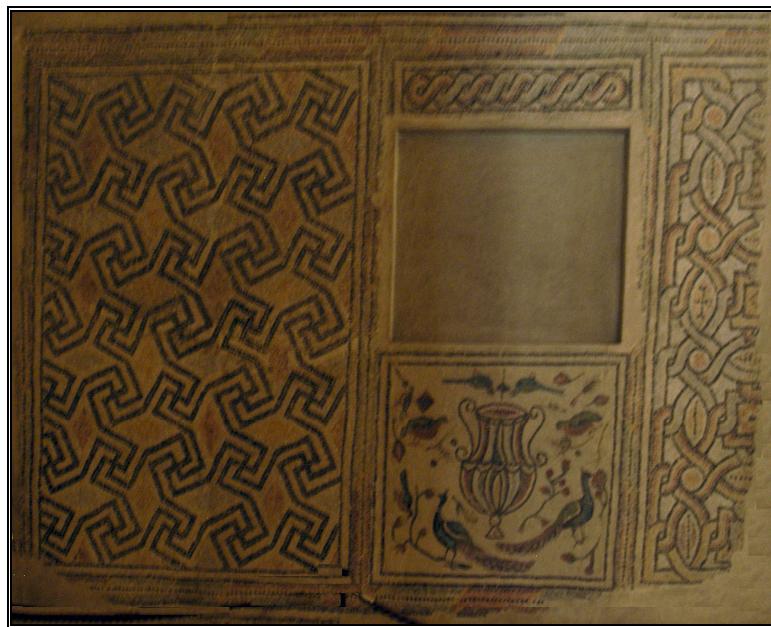
Figure 3.2.7: Late fifth-century *sacellum* mosaic floor (photograph by Knight 2006)

The difference in colour is significant in that it strongly suggests an intentional decision to introduce a broad range of intense colours into the new church interior while at the same time respecting the liturgical meaning and function of the older *sacellum*.

The second observation is only made possible by considering the collection of original window glass as detailed in Appendix B. San Vitale's circular coloured window discs have not received attention in any of the art historical literature on the building and yet the distribution of round coloured lenses of light would surely have been a vital complement to the mosaics. For instance, the visual and symbolic relationship between the jewels depicted in the imperial mosaics and the coloured shining jewel-like window discs would not have gone unnoticed. The entire church interior may have been perceived and understood at a sensory and intellectual level as an immense bejewelled crown, the congregation standing within the compass of imperial Orthodoxy, if not at least a space sanctioned by both the Christian religion and the secular political power of the state. This reading is admittedly highly conjectural but it does illustrate the importance of re-introducing original architectural elements such as the coloured window glass to

potentially reveal meanings that are otherwise unnoticed by merely considering the mosaic design and depictions as discrete panels dislocated from their context.

The third observation is that San Vitale's mosaic representational content is shared in symbols and imagery elsewhere at Ravenna and nearby Classe. The most obvious example, but not previously commented upon, is that of the representations of the three Magi, firstly depicted on the hem of Theodora's dress in San Vitale's chancel wall mosaic, secondly at a larger scale in S Apollinare Nuovo proceeding toward an enthroned Madonna with Child on the north wall mosaic, and thirdly as a frieze on the late fourth / early fifth-century sarcophagus[18] formerly in San Vitale's southern chapel (*monasterium* of St Nazarius) and now in the ground floor south ambulatory. Figure 3.2.8 below shows these three related examples.

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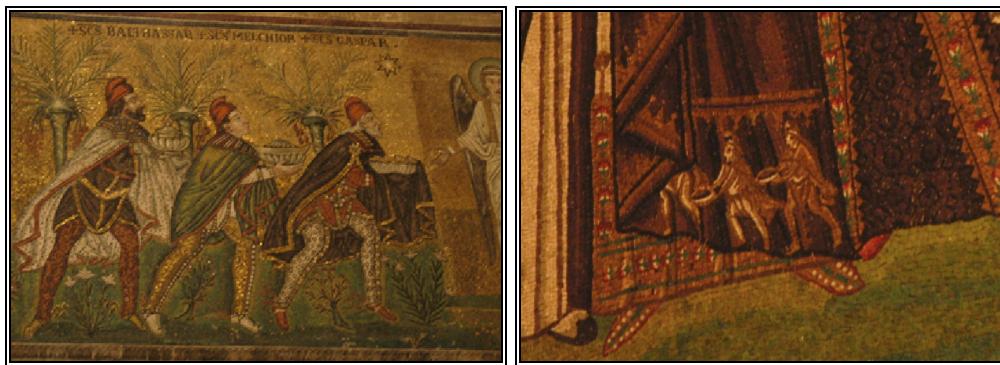
[18] The lid is later and inscribed to the Armenian Governor Isacius who died in 643 (Bendazzi & Ricci 1993:39).

Figure 3.2.8: Magi mosaics in S Apollinare Nuovo (top left) and San Vitale (top right); Magi frieze on sarcophagus in San Vitale (photographs by Knight 2006).

The Magi represented in S Apollinare Nuovo are named *Balthassar*, *Melchior* and *Gaspar*[19] and led to the East by an eight-pointed star of Bethlehem, there is a six-pointed star above Mary's head on the sarcophagus, but no star is shown in the San Vitale imperial mosaic, a dress fold intentionally obscures Gaspar's upper body and the position of the star. Despite their opposite pictorial direction of procession both mosaics depict the Magi walking to the East, in S Apollinare Nuovo they are on the northern nave wall, in San Vitale the south chancel wall, again supporting the identification of San Vitale's *pars mulierum* as the south area of the church.

All three representations are extremely similar, the forward leaning poses and the clothing all resemble an iconographic type. As the sarcophagus depiction is the older of the set it may have been used as a template for the mosaics[20]. The mosaic depictions are

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[19] The *Excerpta Latina Barbari* (51B; 49) has: 'The names of the Magi were Bithisarea, Melichior and Gathaspa' (translation from Schoene's text; Eusebius, Appendix VI: Online at http://www.attalus.org/translate/barbari.html#51B). The text dates to c.500 and is apparently the oldest source for the Magi's names. Therefore, the mosaic names in S Apollinare Nuovo may only date from at least c.500, but they may have been added when the church was rededicated to St Martin of Tours in the 540s by Bishop Maximian and therefore after the mosaic depiction in San Vitale.

[20] Further investigation is required in order to establish the derivation of this particular style of representing the Magi. The examples from Santa Maria Maggiore in Rome (the triumphal arch mosaic) are similarly

mirror images of each other, not dissimilar to what Wharton[21] noted in the ceiling mosaics of the Orthodox and Arian baptisteries of Ravenna.

Like the Magi depicted on the hem of Theodora's dress, the *oblatio* procession moves forward to the east, moving away from the main body of the church and congregation in the west. It is perhaps remarkable that women are presented in the chancel, an area restricted to the male clergy, but as empress, the offering of earthly fruits, the secular homage to the divine, all combine to create a compelling, anagogic message that might be summed up thus; however powerful, all humans baptised into Christianity are invited to the Eucharistic celebration. The presence of the empress and her female attendants in San Vitale's chancel, albeit in a mosaic depiction, may indicate the Ravennate rite included women at the point in the Mass when the gifts were brought to the altar for consecration, the women giving bread and proceeding to the altar from the south. If this is correct, then the ground floor southern ambulatory may also have been demarcated as the *pars mulierum*.

Another sixth-century iconographic repetition present at Ravenna is the metaphor of sheep and shepherds as Christians and clergy[22]. The most important examples include:

- The *mausoleum* of Galla Placidia: Christ the Good Shepherd under a canopy of stars.

- Sant' Apollinare at Classe: sheep in green field grazing either side of *S Apolenaris*

- San Vitale, right wall of the presbytery: Moses grazing the flock, Abel dressed as a shepherd with red cloak offering a lamb to the altar opposite Melchisedec who is offering the Eucharist (Figure 3.2.3 A1 below).

- San Vitale, left wall of the presbytery: Abraham about to sacrifice Isaac (the sacrificial lamb).

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dressed in capes, Gallic caps and bejewelled pantaloons and sandals but these are far more static in pose. The star is eight-pointed.

[21] Wharton 1995 *et al*.

[22] An early representation of Christ as the Good Shepherd is in the ceiling painting of the third-century *arcosolia* (burial chamber) in the Catacomb of Priscilla, Rome (Zarnecki 1975:14-17). The fifth-century example in the apse mosaic of San Lorenzo, Milan is of special relevance to examples at Ravenna (Müntz 1886:296).

- S Apollinare Nuovo mosaic[23]: The separation of the sheep and the goats, likely referencing Augustine (*De civitate Dei*, XX 27):

The difference between the rewards of the just and the penalties of the wicked, which is obscured in the light of this sun that shines on us every day, shall be made manifest in the light of the Sun of Justice…[24].

One other example of mosaic repetition relevant to San Vitale is worth mentioning. At San Vitale and Sant' Apollinare near Classe, both part of Bishop Ecclesius' building programme, are depicted a repeated symbol appearing on altar cloths. Figure 3.2.9 below shows, from San Vitale, the altar at which Abel and Melchisedec celebrate the Eucharistic offering (A1 and A2) and on the altar cloth appears a symbol comprised of two superimposed rectangles with an octagon at the centre[25]. In the context of San Vitale this strongly suggests a reference to the plan of the church.

A1   **A2**

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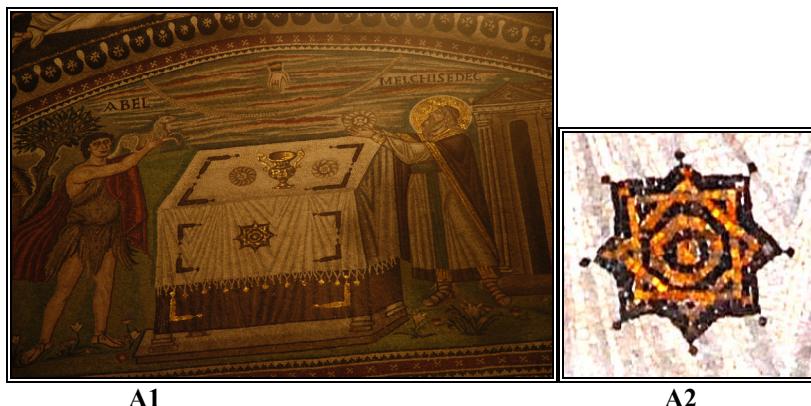
[23] We also find the prominent mosaic representation of the Magi in S Apollinare Nuovo (re-consecrated in 561 as Sanctus Martinus in *Coelo Aureo* / Saint Martin in Golden Heaven).

[24] Markus 1970:117.

[25] Zarnecki (1975:61) points out that Ambrose' words regarding the sacraments are relevant here: 'We pray that by the hand of the angels thou wilt receive this offering upon thy heavenly altar as thou didst receive the gifts of thy servant Abel the Just, and the sacrifice of Abraham our father, and which the high priest Melchizedek offered to thee' (*De sacramentis* IV). Ambrose also calls Melchisedec 'the author of the sacraments' in reference to 'the order of Melchizedek' (*Ps* 109:4; *Heb* 7:17) (Mazza 1989:39-40). Further, von Simson notes 'the Syrian Bishop James of Batnae in Sarug (A.D. 451-521) in his hymn on the mass for the dead compares the members of the congregation who offer their oblation during mass to Melchizedek, Moses, and Abraham' (von Simson 1954:599).

Figure 3.2.9: (A1 and A2) Detail of altar cloth from Melchisedec mosaic on the south chancel wall of San Vitale (B) Melchisedec mosaic in Sant' Apollinare Classe (C) Detail of symbol worn by Justinian's male attendant on the north chancel wall of San Vitale (D) Detail of dress worn by Theodora's female attendant on the south chancel wall (San Vitale mosaic Photographs by Knight 2006; Sant' Apollinare Classe mosaic photograph at: http://images.google.co.uk/imgres?imgurl=http://www.sacred-destinations.com/italy/images/ravenna/san-apollinare-in-classe/).

Figure 3.2.9 B1 and B2, from Sant' Apollinare near Classe, shows Abel, Melchisedec, Abraham and Isaac all offering at the altar which is likewise adorned with a cloth and similar symbol. In this example, the symbol is comprised of two superimposed rectangles enclosing a diamond within a circle. Some modern interpretations associate the symbol only with Melchisedec and make it an arcane insignia of ancient priesthood[26]. The veracity of such a reading is highly dubious, as it seems to be based entirely on these two images alone. Nevertheless, it is clearly significant that the symbol is repeated with minor variations in the mosaics of two churches in Bishop Ecclesius' scheme. The example at San Vitale can also be recognised in two further mosaics there. The insignia worn on the shoulder of Justinian's male attendant (Figure 3.2.9 C) appears to be related,

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[26] Hugh Winder Nibley identified it as the *Seal of Melchizedek* as part of his apologetics for The Church of Jesus Christ of Latter-day Saints. According to him the symbol connotes the ancient lineage of the Melchizedek priesthood (http://www.templestudy.com/2008/09/10/the-seal-of-melchizedek-part-3/).

as does the insignia on the dress of Theodora's female attendant[27] (Figure 3.2.9 D). The symbol is also found in an earlier manuscript illumination of *De material medica* by Dioscurides (folio 6v) made for the princess Juliana Anicia in c.512[28]. The two superimposed rectangles as two interwoven cords stand interlocked within a circle and inside the inner octagonal space the princess is seated between allegorical personifications of Magnanimity and Prudence[29], an altogether different use and meaning to the later device in San Vitale and Sant' Apollinare near Classe.

The meaning of these repeated symbols is beyond the scope of the present work, but since the symbol in San Vitale resembles so closely the plan of the church, this strongly suggests a meaningful interconnection between the high station of secular power, the continuity of Eucharistic celebration throughout human history and the geometry of San Vitale's architectural design.

Transposing theological symbolic meaning onto the vertical physical structuring of mosaic scenes and decorative elements reiterates the vertical hierarchy of San Vitale's architecture. One instance of this vertical visual expression is in the representation of Christ's resurrection depicted in the chancel mosaics; above the bishop's throne at the apex of the chancel apse, and the middle of the *synthronon* seating for the clergy, celestially enthroned Christ is depicted in mosaic and above him the two winged archangels Michael and Gabriel hover, holding a disc containing the Greek letter *alpha* from which eight rays of light emanate. The full significance of this vitally important symbol to the interior spatial logic of San Vitale will be further explored in Chapter Seven.

The related device of winged angels upholding the crucifix enclosed in a wreath of victory is depicted either side of San Vitale's chancel (Figure 3.2.10 A), directly below the triple opening of the *matroneum* ambulatory terminations, where females could look directly down onto the altar and clergy. The same iconography is shown on a Late Antique ivory diptych book cover (Figure 3.2.10 B).

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[27] Variously identified 'as an arguable assumption' as Belisarius and his wife Antonina (Baker 1993:186, note 31).
[28] Rodley 1994:105 Figure 79b.
[29] Zarnecki 1975:65 and Figure 64.

A   **B**

Figure 3.2.10: (A) Archangels on north wall of chancel (B) Archangels on the Late Antique Barberini
ivory book cover (Photograph (A) by Knight 2006; (B) Bendazzi & Ricci 1987:65[30]).

Our current knowledge of San Vitale's mosaics has been supplemented with these new observations. Iconographic repetition has been identified across several of the buildings in Bishop Ecclesius' project and beyond to other contemporaneous Ravennate churches. An emphasis on the vertical structuring of space and differences in the conventional lateral locations of the *pars mulierum* and *pars virorum*, as indicated by the mosaic scheme, reinforce the need to understand San Vitale in entirety. If one element is de-contextualised, the full meaning of the harmonious whole is obscured and the profound impact of this sacred place intended to suspend disbelief is merely understood as overly complicated rather than exquisitely and sumptuously complex.

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[30] Also known as the Murano diptych at Monza Cathedral, the image was first published by Ludwig von Sybel, 1909. *Christliche Antike*. Volume 2. Marburg.

CHAPTER FOUR

The Content of San Vitale

Part 4.1: Dedicating San Vitale - symmetrical temporality

Related to the exploration of the intrinsic logic of San Vitale's design and construction I propose the dating of the church's dedication on April 19th was in the year 548 (contrary to the generally stated year 547), on the Octave of Easter (*Quasimodo* Sunday) explaining why this significant day is the more appropriate. Understanding how this dedication fits within the overall sequence of dedications for the other related churches of Bishop Ecclesius' original building scheme reveals the important relationships between the material logic of San Vitale and that of its temporal symbolic liturgical calendar.

The date of San Vitale's dedication is given by Agnellus, who cites a no longer extant inscription in the narthex:

> Beati martiris Vitilis [*sic*] basilica, mandante Eclesio vero beatissimo episcopo, a fundamentis Iulianus argentarius aedificavit, ornavit atque dedicavit, consecrante vero reverentissimo Maximiano episcopo sub die XIII [Kal. May] sexies p. c. Basilii iuniores [v. c., indictione X].[1]

This has been recently translated by Deliyannis:

> Julian the banker built the basilica of the blessed martyr Vitalis from the foundations, authorized by the *vir beatissimus* Bishop Ecclesius, and decorated and dedicated it, with the *vir reverendissimus* Bishop Maximian consecrating it on April 19, in the tenth indiction, in the sixth year after the consulship of Basilius.[2]

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[1] Agnellus 77.

[2] Deliyannis 2004:192. The 13th Calends of May is generally taken to be April 19. Unfortunately, Deliyannis does not provide definitions and references in her glossary for her italicised *vir beatissimus* and *vir reverendissimus* (*sic*). The former can mean "blessed man" while *vir reverentissimus* can mean "reverent man".

However, as Baker[3] commented, debate surrounds whether the year was 547 or 548. Deliyannis has the year as 547[4] but provides no explanation, whereas Baker outlines a fine argument for 548, that is up until he tries to resolve finding an appropriate occasion at Ravenna for the imperial *oblatio* depicted in the chancel mosaics:

> In 547 Easter fell on 24 March, and 19 April had no liturgical significance in that year: it was not even a Sunday. In 548 Easter fell on 12 April, allowing a Sunday dedication on 9 April [*sic*, he means 19 April], but on Low Sunday, not at Easter.[5]

Despite having commented immediately prior to this passage that '…this is the oldest known representation of the imperial offering – an offering made by the Byzantine emperors at Easter time and other holy days…' Baker forgets that Low Sunday is more accurately known as *Quasimodo* Sunday, and, significantly, the Octave of Easter[6]. This first Sunday after Easter is liturgically highly important as it concludes the Paschal season. It is definitely within "Easter time" and as a Sunday with added significance completely appropriate for a church dedication. It is also worth noticing that the Octave (eight) and the octagonal design of San Vitale share a sacred geometry; the acknowledged symbolism of number and its significance to both symmetrical architectural construction and temporal divisions in the liturgical calendar, operating in both space and time makes intuitive sense in this church where every detail is meaningful.

Therefore, I offer this new dating of San Vitale's dedication, *Quasimodo* Sunday, the Octave of Easter, on April 19 of 548. With this secure dedication date for San Vitale, other significantly related dates in the liturgical calendar are given in Table 4.1.1 below.

Year	Month	Date	Day	Event
545	April	16	Sunday	Easter Sunday
	May	**7**	**Sunday**	**Third Sunday (21 days) after Easter; San Michele in Africisco consecrated**
	May	8	Monday	Feast of the Archangel Michael

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[3] Baker 1995.
[4] Deliyannis 2004:192, note 21: 'The year is 547'.
[5] Baker 1995:186.
[6] From the Introit at Mass: "Quasi modo geniti infants, rationabile, sine dolo lac concupiscite"; *Catholic Encyclopedia*, 1913. Low Sunday:
http://en.wikisource.org/wiki/Catholic_Encyclopedia_(1913)/Low_Sunday

547	March	24	Sunday	Easter Sunday
548	April	12	Sunday	Easter Sunday
	April	18	Saturday	Dedication vigil for consecration of San Vitale
	April	**19**	**Sunday**	**Octave of Easter (*Quasimodo* Sunday); San Vitale consecrated**
	April	28	Tuesday	Feast of St Vitalis and Valeria
	May	7	Thursday	Feast of San Michele in Africisco
	May	8	Friday	Feast of the Archangel Michael
	June	19	Friday	Feast of SS Gervasius and Protasius
	June	28	Sunday	Third Sunday after Trinity; Death of Theodora
	July	20/23	Monday/Thursday	Feast of St Apollinaris of Ravenna
	July	27	Monday	Feast of St Ecclesius
	July	28	Tuesday	Feast of SS Nazarius and Celsus
	November	4	Wednesday	Feast of St Vitalis and Agricola
	November	27	Friday	Possible commemoration of Galla Placidia
549	April	4	Sunday	Easter Sunday
	April	19	Monday	Feast of San Vitale
	April	28	Wednesday	Feast of St Vitalis and Valeria
	May	8	Friday	Feast of the Archangel Michael
	May	**17**	**Sunday**	**Fifth Sunday (35 days) after Easter; San Apollinare at Classe consecrated**
	June	19	Saturday	Feast of SS Gervasius and Protasius
	June	28	Monday	Possible commemoration of Theodora
	July	20/23	Tuesday/Friday	Feast of St Apollinaris of Ravenna
	July	27	Monday	Feast of St Ecclesius
	July	28	Wednesday	Feast of SS Nazarius and Celsus
	November	4	Thursday	Feast of St Vitalis and Agricola
	November	27	Saturday	Possible commemoration of Galla Placidia
550	**December**	**11**	**Sunday**	**Second Sunday before Christmas; St. Stephen the Proto-martyr consecrated**
	December	26/27	Monday/Tuesday	Feast of St Stephen the Proto-martyr

Table 4.1.1: Dates of Easter and significant days in the liturgical calendar of Ravenna relevant to San Vitale (After Agnellus, Catholic Encyclopaedia).

Several observations can be made from these dates; firstly, San Vitale, San Michele in Africisco (*Ad Frigiselo*)[7] and San Apollinare in Classe were all dedicated on Sundays following Easter (the 1st, 3rd and 5th respectively)[8].

Secondly, it is highly suggestive that San Michele was dedicated one day before the Feast of the Archangel Michael on May 8th. Relevant to this, it is worth noting a further possible connection between Canosa and Ravenna, or at least Apulia and Emilia-Romagna; the famous apparition of the Archangel Michael in c.494 or between 530 and 540, at Monte Gargano (*Garganus Mons*), a mountain in Apulia forming the backbone of the peninsula Promontorio del Gargano on the Adriatic Sea. Monte Gargano is the site of the oldest shrine in Western Europe dedicated to Michael and Pope Gelasius (492-496) directed that a basilica be erected enclosing the sacred grotto. Despite the suggestion that the date of this apparition, May 8th, is supposed to be a seventh-century addition to the story[9], it is remarkable that at Ravenna, as seen above in Table 4.1.1, San Michele *ad Frigiselo* (in Africisco) was dedicated the day before May 8th, the third Sunday after Easter, May 7th 545, making it one of the earliest churches dedicated to Michael with his apparition in Apulia in mind. Again, news of the apparition and ideas of dedicating a church to the Archangel at Ravenna soon after indicate the linked ecclesiastical designs of these two different Italian sees, and the efforts of their respective bishops could not have escaped the notice of the clergy, Imperial court and people of Constantinople. This providential influence from West to East reinforces the need to consider San Vitale as a significant Italian development.

It has been shown in Parts 3.1, 3.2, and here (4.1) that San Vitale was designed, surveyed, constructed, decorated and dedicated with precise, logical reasons. The basis of

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[7] Agnellus 77. San Michele in Africisco: 'The two oblong piers along the north edge of the nave…indicate that the sixth-century structure was a broad-arcade pier basilica, and not a column church, as thought before', and '…whether the original church was preceded by a narthex or a portico is unclear' (Morganstern 1976:108).

[8] It is unfortunate that the dedication date for Santa Maria Maggiore is not recorded. Any one of the Marian feast days may have been chosen.

[9] As related in the Roman Breviary, on 8 May, at his renowned sanctuary on Monte Gargano, where his original glory as patron in war was restored to him. To his intercession the Lombards of Sipontum (Manfredonia) attributed their victory over the Greek Neapolitans, 8 May 663. In commemoration to this victory the church of Sipontum instituted a special feast in honour of the archangel, on 8 May, which has spread over the entire Latin Church and is now called (since the time of Pius V) "Apparitio S. Michaelis", although it originally did not commemorate the apparition, but the victory.

the church rests upon a symbolic number, eight, the new day of resurrection and divine perfection. This perfection is expressed further through sacred geometry, symmetry, balance, proportion and harmony. The plan is rotated in a significant manner, sitting asymmetrically to the street grid of Ravenna while adhering to its own interior logic including consistent angles and measurements. It sets up a new alignment across large sections of the city, pointing to the entrance of San Michele. It has a symbolic and physical relationship to the older structures in the immediate proximity and, in tandem with Santa Maria Maggiore, contributes new expression to the established scriptural, iconographic and theological meanings and styles communicated by the older cemetery church of St. Croce and the *mausoleum* (possibly St. Zacharias).

San Vitale's sacred geometry is anagogical, bringing the vertical hierarchy of the people of Ravenna, the Orthodox congregation, the clergy, the martyred saints, and the Heavenly Host with Christ enthroned all into one specific place. This church's spatial and temporal organisation is intentional and meaningful, including details that are not easily noticed (such as the reflective distribution of column base shape). In the next Part, 4.2, an attempt will be made to people the sixth-century liturgy at San Vitale to understand their viewpoints and view-sheds, and then lastly, in Part 4.3, evaluate the Ravennate *versus Lux de luce* as an appropriate sound source for acoustic measurements detailed in Chapter Five.

**Part 4.2: Peopling San Vitale; The Late Antique Ravennate Orthodox congregation
and the Celebration of the Eucharist**

The mental (theological and symbolic) and 'believed place' of San Vitale, as a House of God (*Domus Dei*), was intended as a site where, during the Celebration of the Eucharist, Heaven communicated with the World – a universal 'place', a microcosm of Divine Creation shaping and shaped by belief. We have seen how the intentional geometric symmetries of San Vitale's material construction, spatial organisation, and the temporal significance of its dedication according to the liturgical calendar together coalesced in creating a meaningful place for the acclamation of Orthodox faith and the suspension of disbelief. I will describe the various co-ordinated ways the 'place' of San Vitale was communicated physically and symbolically to the congregation during the liturgy of the Eucharistic celebration while attempting to "follow in the footsteps" from entry into the narthex and on into the two storeys of the main church.

In other words, an attempt will be made to answer where the Late Antique members of the Ravennate Orthodox congregation were allowed or perhaps expected to position themselves inside the church, therefore identifying from what positions they might have experienced the full phenomenological sensorial impact (in particular visually and aurally) of the architecture, iconographic scenes, liturgical actions and vocalisations (singing and speech). It is hoped that by identifying these positions for best receiving the church's multi-sensory, multi-media message, the performance of the non-extant, non-material content (Ravennate chant) implied by the acoustic properties, will reinforce the identification of who it was that spoke, intoned, and sang, who listened, and when was it that these sonic events happened along the temporal periodicity of the liturgical drama.

Through this process of investigation an assessment with preliminary suggestions will then be offered in Chapter Five concerning whether San Vitale's reverberation qualities were part of the intentions of the designer(s) in the church's spatial organisation of the congregation and therefore a viable example of Late Antique acoustic architecture, or if they were merely epi-phenomena, albeit utilised and experimented with in the development of contemporary communal chanting as a contextual precursor to Pope Gregory's reorganisation of the *scola cantorum*.

Accordingly I will demonstrate the interior views[1] from specific positions in relation to entering the church by the atrium and narthex, moving to particular areas of the church at both ground and *matroneum* level, focusing on both the *sacellum* altar and the principal altar in the chancel. In order for this to be effective, the Mass celebration is chosen as the context for comparing the views afforded by the architecture to the clergy and congregation.

Since the Celebration of the Eucharist is the central liturgical act in Christian worship, and particularly because depictions of the early lineage of the Mass figure prominently in the chancel mosaics of San Vitale, it is necessary to follow the steps (literally) of clergy and congregation as far as is possible and demonstrate what aspects of this church's design shaped the sixth-century Sunday Mass liturgy of Ravenna.

Congregational Shepherding

Christ is depicted in the fifth-century *mausoleum* of Galla Placidia as a young shepherd, and the shepherding role of the bishop can be broadly identified by several liturgical actions, but of special interest for the present study is how the congregation of "sheep", the flock of Christians, the social makeup of the "body" of the Church was spatially organised in San Vitale.

The traditional layout of where members of the congregation were intended to position themselves is known and Mathews[2] provides a useful schematic diagram that can be used as a starting point for understanding San Vitale's comparable spatial hierarchy. Figure 4.2.1 below displays how the architecture of San Vitale dramatically shifts from tradition the spatial allocation of male and female members of the congregation.

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[1] Technically the space syntax as expressed by isovists at key meaningful positions in the liturgical drama. Cf. Batty 2001, Turner 2001 and 2003, Clark 2007 and Paliou 2008.
[2] Mathews 1962.
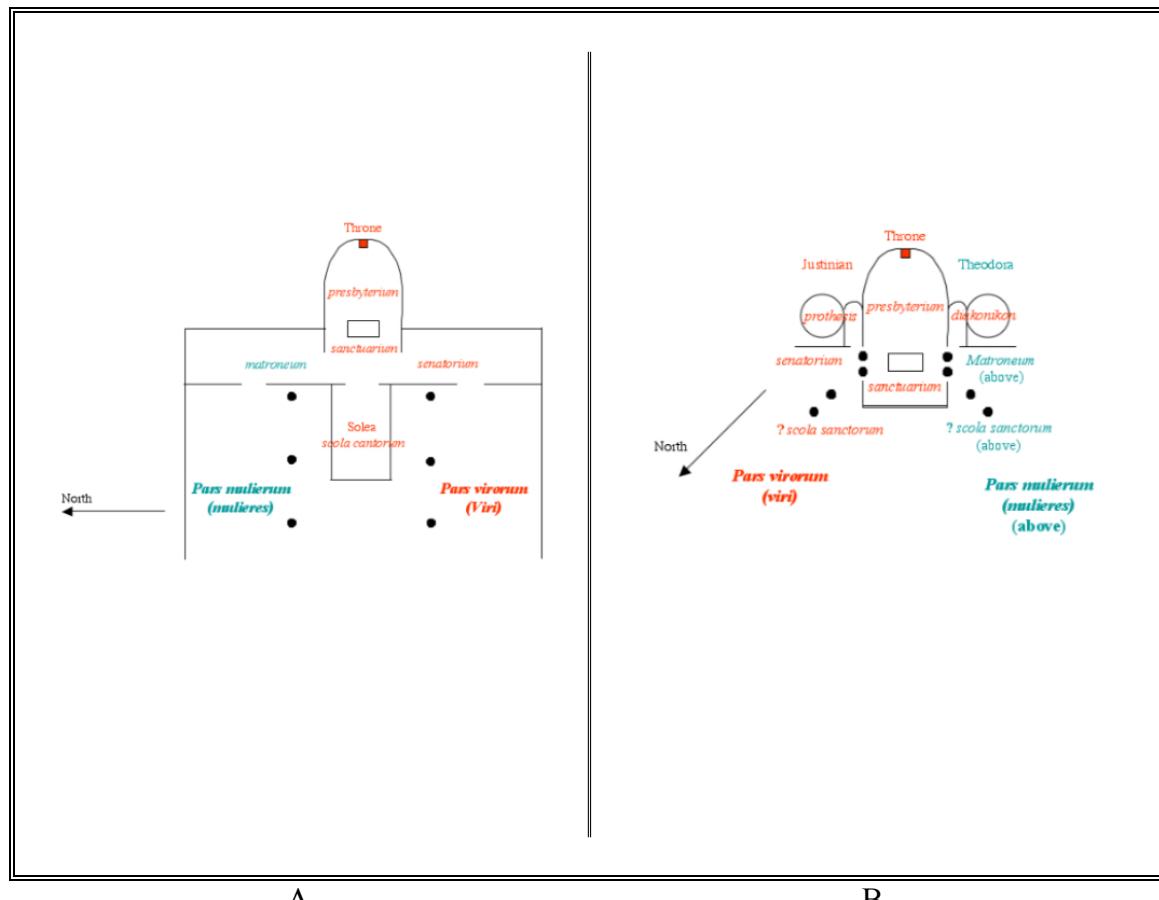
Figure 4.2.1: (A) Schematic diagram of a typical fourth-century longitudinal basilica spatial layout (after Mathews 1962:94; Knight 2009) (B) comparable schematic diagram of San Vitale (Knight 2009).

The social context of San Vitale in the sixth-century can be approached simply by investigating possible answers to four questions: who was part of the clergy and congregation of San Vitale, where were they positioned inside the space and by what paths did they move to those positions?

For the members of the Ravennate Orthodox clergy during the episcopacy of Ecclesius we are fortunate to have a glimpse. Agnellus gives us the names and positions of the clergy attending this bishop to Rome in order to meet with Pope Felix IV (526-30):

> Priests (*presbiter*): Patricius, Stephanus, Constantinus, Servandus, Honorius, Exuperantius
> Deacons (*diaconus*): Clemens, Ursus, Felicissimus, Vigilius, Neon, John, Stephen
> Subdeacon (*subdiaconus*): Geroneius[3], Honorius, Petrus, Vitalis[4]

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[3] Deliyannis has *Gerontius* (2004:176).

[4] It is interesting that, within the first four years of the construction of San Vitale, at least one cleric already bore the name Vitalis possibly indicating the church dedication was not altogether new. It suggests an already established devotion to Vitalis at Ravenna, assuming this person was originally from the city and baptised there.

Acolyte (*acolitus*)[5]: Iulianus, Faustinus, Romanus, Severinus, Andreas
Reader (*lector*): Petrus, Marcus, Asterius, another Petrus, Andreas
Defensor (*defensor*): Marinus
Notary Defensor (*notarius defensor*): Maiorianus[6]
Senior Defensor (*primocerius defensor*): Hermolaus
Cantor (*cantor*): Honorius, Tranquillus, Antonius, Melitus.[7]

…and further:

Priest: Victor, Laurentius, Rusticus, Tomas
Archdeacon (*archidiaconus*): Mastalus
Deacon: Magnus, Paulus, Agnellus
Subdeacon: Maurus
Acolyte: Stephanus, Vincemalus, Vindemius, Colos, Cassianus, Laurentius, [a second] Stephanus.
Reader: Tomas, Laurentius, Florus, Reparatus, Luminosus, Calunnios[8], Ysaac
Superintendent of Stores (*orrearius*): Laurentius
Dean (*decanus*): Petrus, Stephanus[9]

It is not beyond reason that many of these clerics witnessed the construction of San Vitale and lived to be involved in its dedication. Of special interest are the four named cantors, and yet it cannot be determined from this reference alone whether they were organised into a *scola cantorum* predating Gregory's reforms.

Concerning the social makeup of the Late Antique congregation attending San Vitale, they can have included Orthodox Nicene Christians of any and all ethnographic, geographic and linguistic traditions from across the Eastern and Western Empire and beyond. Ostrogothic *gentes*, Arians and *infidiles* (pagans and Jews) may also have been free to attend the Mass up to the Address of the Catechumens[10], exiting together with them prior to the offertory and communion. The sociological makeup of Ravenna's Christian congregation at any particular time in Late Antiquity could have included

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[5] 'Before August 15th, 1972 (with the issuing of Pope Paul VI's *moto proprio*, suppressing the minor orders) the acolyte was the highest of the minor orders, having as duties the lighting of the altar-candles, carrying the candles in procession, assisting the subdeacon and deacon, and the ministering of water and wine to the priest at Mass. Acolytes wore the cassock and surplice. While acolytes did not receive the sacrament of Holy Orders, they were considered part of the clergy, and were considered a step on the way to Holy Orders. In the Latin Rite, they still do exist licitly in some capacity in traditional Catholic groups' (http://en.wikipedia.org/wiki/Acolyte).

[6] Deliyannis has *Majoranus* (2004:177).

[7] The presence of four cantors and the implications of an early *scola cantorum* at Ravenna will be discussed further below.

[8] Deliyannis has *Calumnios* (2004:177).

[9] Agnellus 60 (Deliyannis 2004:176-177).

[10] Mathisen 1997:694.

travellers, visitors, pilgrims and foreign traders. After all, Ravenna was the capital of the West and its Orthodox laity, as well as its Arian community were not simply urban dwellers (*civilis*) but essentially cosmopolitan in the vital context of sixth-century exchanges. Additionally, Theoderic's reign was characterised, in general, by a desire for *Civilitas* and presumably this inclusiveness continued into the years of Amalasuentha's regency. Likewise, up to the Address of the Catechumens, the Orthodox Church too was inclusive. Then, the doors of the church were closed to those 'unworthy of the sacred sight of the mysteries'[11]. The clergy and Orthodox congregation together were known as *servi dei* and *servi Christi*, servants of God/Christ.

To understand the spatial organisation of San Vitale and the areas within that real and symbolic place, where human spiritual experience was intended to occur, where the clergy and congregation positioned themselves, a comparison with tradition is necessary. Mathews[12] illustrated the conventional layout of a typical longitudinal basilica from the fourth-century (see Figure 4.2.1 above) and of particular interest are the areas reserved for the male and female laity. The convention was to position the men south of the central aisle in an area called *pars virorum* while the women were to the north in the *pars mulierum*. To the east of the *pars mulierum* and adjoining the *sanctuarium* was the *matroneum*, likely where women received communion; while to the east of the *pars virorum* the *senatorium* was where men received communion[13]. A similar layout has been noted for S Apollinare Nuovo by Deliyannis[14], where the wall mosaic representations of the proceeding virgins are on the north wall while the procession of male saints is on the south wall. This example demonstrates the placement of the mosaic representations of women was directly above where the female congregation was expected to gather, and likewise the male saints are shown above the men's designated area.

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[11] Maximius Confessor; *Mystagogia* XIV, XV, PG, Volume 91, cols. 692-3 (Mainstone 1997:228).

[12] Mathews 1962:94. Doig comments: 'Working back from the architectural form to the liturgical function, in an early article on the archaeological data, Mathews qualifies what earlier liturgists (including Jungmann, Duchesne and Dix) had to say, by mapping the chancel arrangement (in the absence of earlier manuscript evidence) onto the rubrics of the *Ordo Romanus I*, 'which is generally accepted as a description of the stational mass in the seventh-century in Rome' (Mathews 1962:75)' (Doig 2008:85).

[13] Mathews 1962:83.

[14] Despite confusingly giving the incorrect placement in her footnote number 9 (Deliyannis 2004:183), the correct layout is given in her glossary (ibid 2004:334-335).

Similarly, if we can take the famous mosaic depictions of processions on the walls of San Vitale's chancel as an indication of how the congregation may have been divided, comparison with S Apollinare Nuovo reveals a reversal of the convention at San Vitale, i.e. Theodora and her female attendees proceed east on the south wall while Justinian and his male retinue proceed east on the north wall, diametrically opposite to the convention.

The reversal is intentional as can also be seen by the representations of the Magi on the hem of Theodora's dress; as mentioned above in Part 3.2 they are stylistically the same as the Magi in S Apollinare Nuovo, except that in San Vitale, they are reversed in order to also proceed eastwards. Hence, the Magi in San Vitale face to the left whereas in S Apollinare Nuovo they face to the right, proceeding as they do, to the east on the north wall. The implication is that in San Vitale other factors were present in the division of male and female laity. The most obvious difference is that San Vitale is centrally planned with an upper storey gallery (*hyperoa*), the *matroneum* (*gynaikonitis*)[15]. This raises two questions; did this upper floor act in the same way as the *matroneum* of the typical longitudinal basilica layout? Was it here in the balcony where women received communion and, if so, did some cleric (perhaps a deacon) have to walk from the altar to the stairs near the narthex entrances to ascend to the *matroneum* level to administer the Eucharist? Significantly, if San Vitale's *matroneum* was the place for females then it is also likely that this upper storey was the church's *pars mulierum*.

An explanation can be offered for the reversal of the *pars* implied by the placement of the San Vitale's processional mosaics. For the men to be at the right (*dextra*) hand of the presiding celebrant (the priest conducting the Mass at the altar) and the women at the left (*sinistra*), and if we first acknowledge the conventional layout of male and female members of the congregation, then, in San Vitale the celebrant would have faced the congregation whereas in S Apollinare Nuovo for this same relationship to work the celebrant would have faced away from the congregation. In this latter, conventional system, the celebrant is at the head of the people, the men behind and to the right, the women behind and to the left; he the ordained shepherd leading his flock forward to the east. In San Vitale the celebrant faces his flock, setting up a very different psychological relationship; he takes on the aspect of Christ addressing his apostles and

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[15] Procopius; *De Aedific*. I, I, 55-8 (Mainstone 1997:230).

followers. This ritual shift is most likely theological, allotting the area for the female congregation, the *pars mulierum*, up to the *matroneum*, but the exact symbolic and/or scriptural reference being expressed remains for further study.

For the time being, the identification of San Vitale's *pars virorum* as the ground floor and the *pars mulierum* as the *matroneum* upper floor can remain a working hypothesis. In this proposed scheme, the sensorial perceptions of male and female members of the congregation would be markedly different. If this interpretation is correct then we can begin to reconstruct where male and female members of the congregation were positioned during Mass[16].

The sixth-century changes to the Eucharistic celebration are found in the *Chronicon Paschale*, '…and the picture that emerges can be further checked against the architectural, archaeological and documentary evidence of planning and furnishings'[17]. The liturgy began in the atrium, at San Vitale long covered by a monastic cloister, with the formal entrance of the clergy into the narthex, the usual north/south oriented space for exorcisms, funerals, purification, preparation, and repentance[18].

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[16] Although this interpretation seems reasonable a comprehensive explanation would only come from a full study of contemporary liturgical practice across different provinces, a task well beyond the scope of this present work.

[17] Mainstone 1997:227.

[18] Cf. Hart 2003. Thanks to Mr. Hart for personal communication (email) March 6-7th 2009.
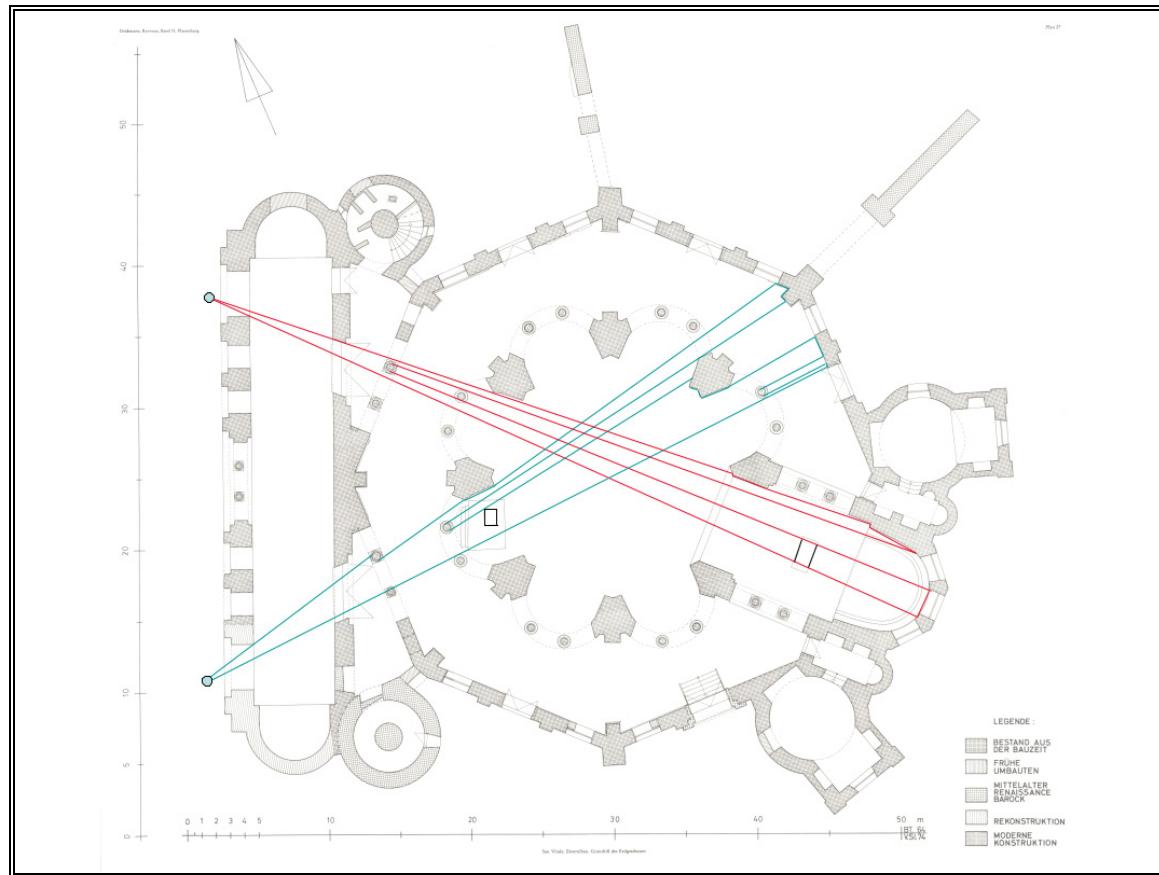
Figure 4.2.2: The only two positions from the atrium from which the interior of San Vitale can be seen (assuming doors are open). Red isovist for male member of congregation / clergy, blue isovist for female member of congregation
(After Deichmann 1989:Plan 27; overlay isovists by Knight 2009).

Figure 4.2.2 demonstrates the women, entering the southern entrance of the narthex, only had a clear view of the *sacellum* altar while the men, at the northern narthex entrance, only had a clear line of sight to the main altar, while the women had no view of the main altar and the men had no view of the *sacellum*. The men's view of the main altar, from this entry position and also at the main northern entrance to the church shown in Figure 4.2.4, may have been somewhat hampered by the original chancel screens between the piers of the Triumphal Arch (Chapter Five, Figure 5.1.5)[19]. Stone versions of these short screens from San Vitale are now kept in the neighbouring museum, but originally, as Agnellus indicates:

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[19] Bumpus 1926:246.

…ante altarium infra cancellos, quos fuerunt aerie, qui nunc lapidei esse videtur.[20]

…the chancel screens, which were bronze, but which now are seen to be stone.[21]

Supposing eyesight was very good and interior illumination was bright enough, even at this distance, a male had an unobstructed view of the northerly Imperial procession mosaic, that of the men, Justinian and his armed court. Even at the position shown in Figure 4.2.4, no female had any view of these mosaics, rather, their focus was drawn solely to the *sacellum*.

If the north and south entrances can be used as corollaries for male and female entrance respectively, in other words entrances to the *pars virorum* and *pars mulierum*, this may also be applicable to the north and south apses of the narthex[22]. Particularly at funerals and when theological direction was given to catechumens the north narthex apse may have been designated for males and the south for females. Following this suggestion, Figure 4.2.3 below shows the isovists of clerics positioned in the north and south narthex apses. One interesting observation is that the cleric in the southern apse, at a very specific location, has a direct sightline to the middle of the *sacellum* altar. Supposing, for instance, a chalice was placed at the centre of the *sacellum* altar, the cleric at an altar in the southern narthex apse might have had occasion to direct his sight to the *sacellum* chalice and perhaps genuflect or vocally acknowledge the memorialised saint of the older structure. This little reconstruction is simply intuited supposition with no known liturgical support, but the possibility of seeing the *sacellum* altar from this narthex apse is highly suggestive.

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[20] Agnellus 42; in relation to the chancel screen in the *monasterium* of St. Nazarius, i.e. the small southern chapel adjoining San Vitale's chancel.
[21] Deliyannis 2004:151.
[22] There is a lack of direct supporting evidence for this suggestion but it seems unreasonable to assume men or women crossed paths by entering the narthex differently to how they entered the main church doors.
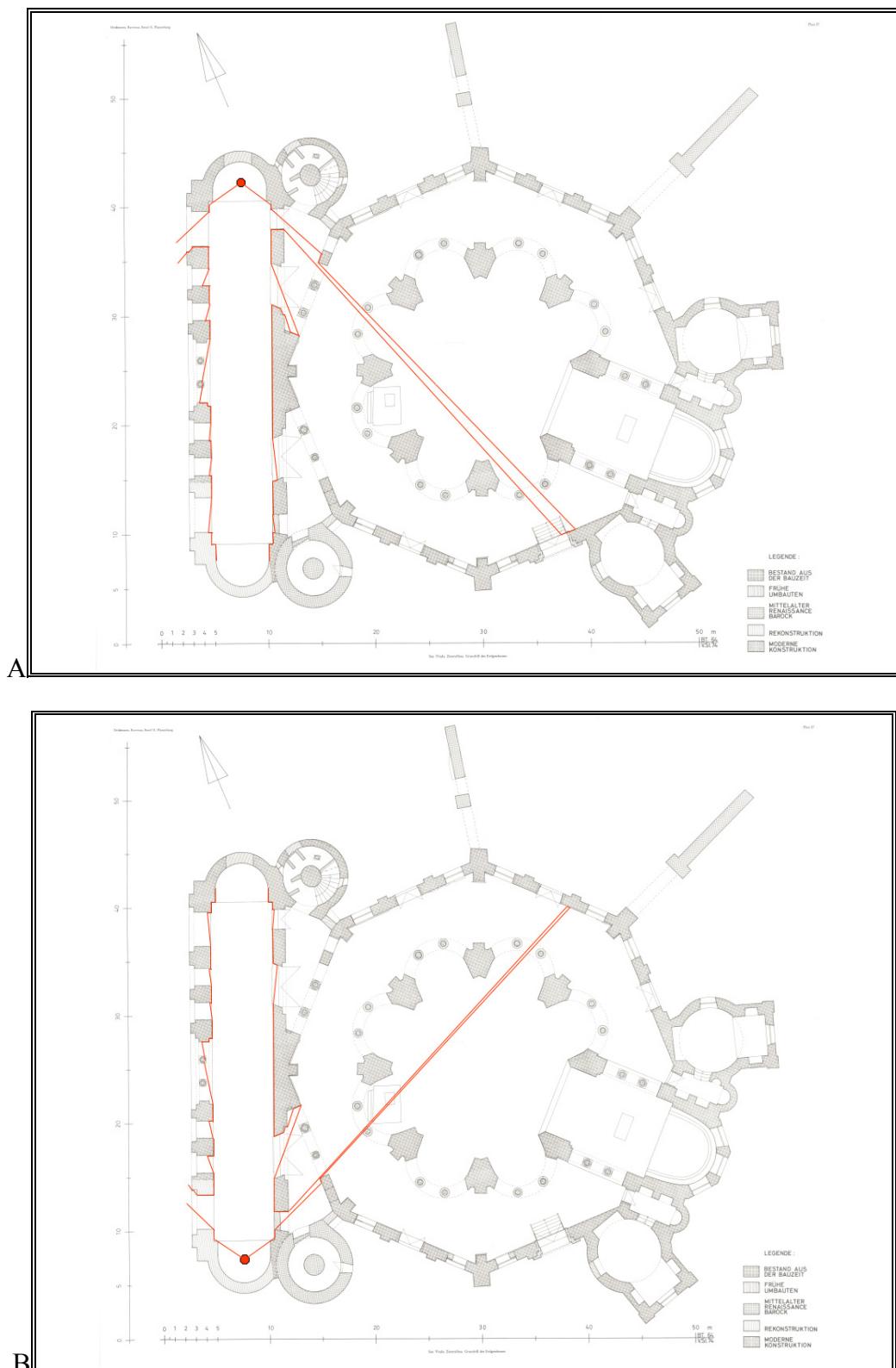
Figure 4.2.3: (A) View of cleric in the north narthex apse (B) View of cleric in the south narthex apse
(After Deichmann 1989:Plan 27; overlay isovists by Knight 2009).

The Lesser Entrance

The ceremonial entrance into the main body of the church is known as the "Little" or "Lesser Entrance"; in the Byzantine rule the most senior cleric led, while in the West he proceeded last, following from behind[23]. The "Lesser Entrance" occurs during the service known as the Liturgy of the Catechumens[24]. The presiding priest would silently pray:

'O Master, Lord our God, Who has appointed in heaven ranks and hosts of Angels and Archangels for the ministry of Thy Glory: cause that with our entrance may enter also the holy Angels with us serving Thee, and with us glorifying Thy goodness…'[25]

The "Little Entrance" symbolises the Incarnation of Christ and his baptism in the Jordan River, an image not only popular in the octagonal baptisteries of Ravenna, but prefigured by the verse reference on the exterior of St. Croce[26].

The isovists, in Figure 4.2.4, from the north and south entrances reveal the division of *foci* in San Vitale and to whom they were intended to be seen; the women (and children) were drawn to the *sacellum* altar, the men to the main altar in the chancel. The proposal that the south entrance was designated for women is somewhat supported by the fact that later, in the Renaissance[27] the small secondary entrance immediately south of the southern entrance was walled up when the church became the sole property of a monastic establishment; male brethren would not be needing the female entrance.

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[23] Mainstone 1997:227.
[24] Hapgood 1922:83.
[25] Hapgood 1922:83.
[26] Agnellus 41; Deliyannis 2004:150. See pages 68, 71 (Chapter Three, Part 3.1) and 253 (Chapter Eight).
[27] See the key on Deichmann's Plan 27.
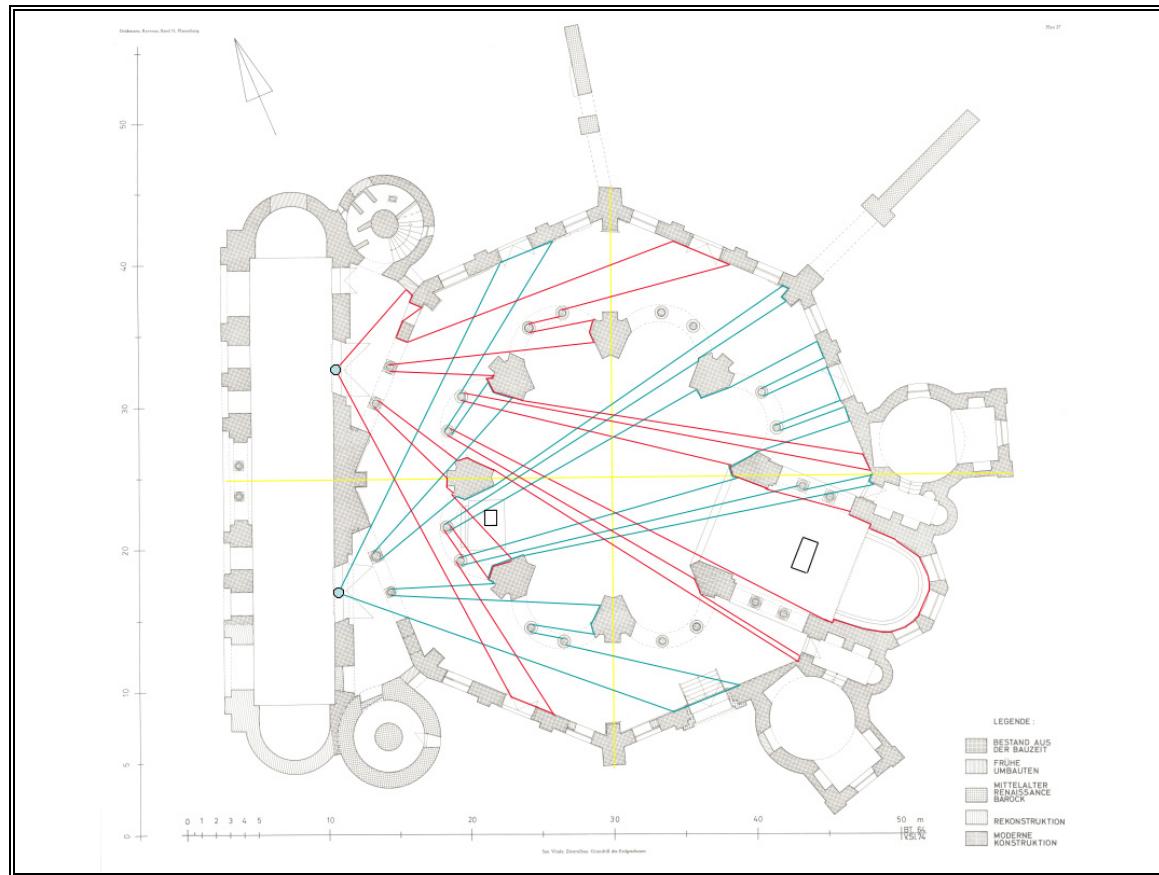
Figure 4.2.4: Views from the north and south main entrances of the church. Yellow cross marks one main axis of the church (After Deichmann 1989:Plan 27; overlay isovists by Knight 2009).

The experiences of men and of women entering this supremely symmetrical church are remarkably different. Already, at the very entrance the architectural design of San Vitale shepherds the congregation in decidedly different ways[28].

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[28] Today, it is only possible to enter San Vitale from the north narthex and north church entrances; additionally the entrance in the south wall west of the *diakonikon* along with the opposite exit in the north wall facing the *mausoleum* are both modern alterations. One antique alteration is however worth bearing in mind; originally the *diakonikon* had an exterior southern entrance, eventually bricked up leaving remaining communication with the main body of the church by way of the small connecting space south of the chancel. Presumably this original entrance can be associated with when the *diakonikon* was also known as the *monasterium* of St. Nazarius (and St. Celsus).

Figure 4.2.5: Present day Mass, viewed from the inner octagon looking southeast towards the chancel apse (Photograph by Knight 2006).

Once the clergy and congregation had entered the church three routes were operative. The clergy probably proceeded straight through to the chancel by way of the central octagon (nave) while the male congregation either followed or walked north along the ambulatory, coming to stand in the semicircular *exedrae* spaces, gathered "in the round" and facing the chancel. The female congregation may have paid a brief visit to the *sacellum*, but then returning to the south entrance space, ascended the south stairwell to the *matroneum*[29].

After arriving at the chancel and main altar[30] the clergy eventually sat on the *synthronon* benches, with the bishop (or senior officiating cleric) seated in the central

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[29] The northern stairwell may have been used by females with young boys, but any attempt to adhere too strictly to the spatial gender divisions implied by the north and south entrances can quickly dissolve under a complexity of social situations and exceptions. For instance, were old women allowed to remain in the ground floor ambulatories? Were some catechumens allowed into the church, and if so were the males meant to follow the females up to the *matroneum* level? Were little girls allowed to peep over the *matroneum* ramparts down to the main altar? And where were babies allowed to wail? Some questions must remain unanswered.

[30] Mainstone (1997:227) relates that, in Hagia Sophia, '…the clergy procession would have passed down the centre of the nave and then, on reaching the ambo, would have entered the solea'. San Vitale does not have an ambo or solea (or a bema) but the full length of the chancel and the area in front of the altar may have been utilised as such. In many late Antique churches of the East (including Hagia Sophia) a solea

sedis from where he greeted the congregation[31]. This was followed by the Kiss of Peace known as the *pax*[32]. Presumably, in San Vitale, the *pax* was not shared between men and women as they were by this point already on two different floors.

The Readings and Sermon

It is unclear, especially regarding the fragmentary evidence for Ravenna, whether the readings from the Old Testament and Epistle were preceded by antiphonal chants[33], but cantors may have intoned or sung the readings by themselves. No special ceremony accompanied these first two readings, but for the third the Gospel would have been ceremonially carried forth. In Hagia Sophia it was carried down the *solea* from the altar by the deacon, and afterwards returned to it in the same way[34], but the lack of a *solea* in San Vitale suggests an alternative arrangement; perhaps the readings took place at the centre of the church, at the *rota* in the middle of the inner octagon.

The climax of the first part of the service was the ceremonial entry and reading of the Gospel with subsequent sermon, traditionally given by the bishop (or principle celebrant) seated in his throne (*sedis*), as shown in Figure 4.2.6.

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extended from the chancel out into the central area, leading to a raised ambo or bema, forerunners of the pulpit. From here the Old Testament readings and Gospel was read, the solea walkway and ambo physically dividing the congregation. These are not present at San Vitale. The side access to the chancel from north and south by means of an open colonnade of two columns may have acted as a partial *templon* (Kazhdan 1991:2023-4) with the modification that no colonnade closed off the front of the chancel. Chancel screens are known from San Vitale (long ago removed and in the neighbouring National Museum), they are short divisions and most likely originally placed between the chancel piers of the Triumphal Arch, providing a barrier between the inner octagon and the chancel floor. With this layout, the entire inner octagon was left free and presumably for the use of standing male members of the congregation.

[31] The Latin name for the bishop's throne is *cathedra* (Krautheimer 1986:517).

[32] The *pax*: "Let us offer each other the sign of peace / *Offerte vobis pacem*" (Muldowney 1959:197). The kiss of Peace would then have been exchanged by all in the church (Mainstone 1997:228).

[33] Mainstone 1997:227.

[34] Mainstone 1997:227-228.

Figure 4.2.6: View of bishop from his throne (*sedis*) in the chancel apse, looking northwest (After Deichmann 1989; overlay isovist by Knight 2009).

Following the readings and sermon the celebrant and clergy descended from the *synthronon* benches and proceeded to the main altar for the Eucharist proper, the central rite of the Mass. Deacons meanwhile dismissed the catechumens after a prayer on their behalf, the Liturgy of the Catechumens[35].

Maximius Confessor described this juncture in his *Mystagogia*:

> After the reading of the Holy Gospel, the bishop comes down from his throne and the priests dismiss the catechumens and the rest who are unworthy of the sacred sight of the mysteries that are about to be shown….And there takes place the closing of the doors of the church.[36]

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[35] Mainstone 1997:227.

[36] Maximius Confessor; *Mystagogia* XIV, XV, *PG*, vol. 91, cols. 692-3 (Mainstone 1997:228).

Having closed the first part of the liturgy the deacons would have gone to the north chapel, variously named the sacristy, the *prothesis* chapel, or the *skeuophylakion* to gather a selection of gifts previously prepared[37].

A

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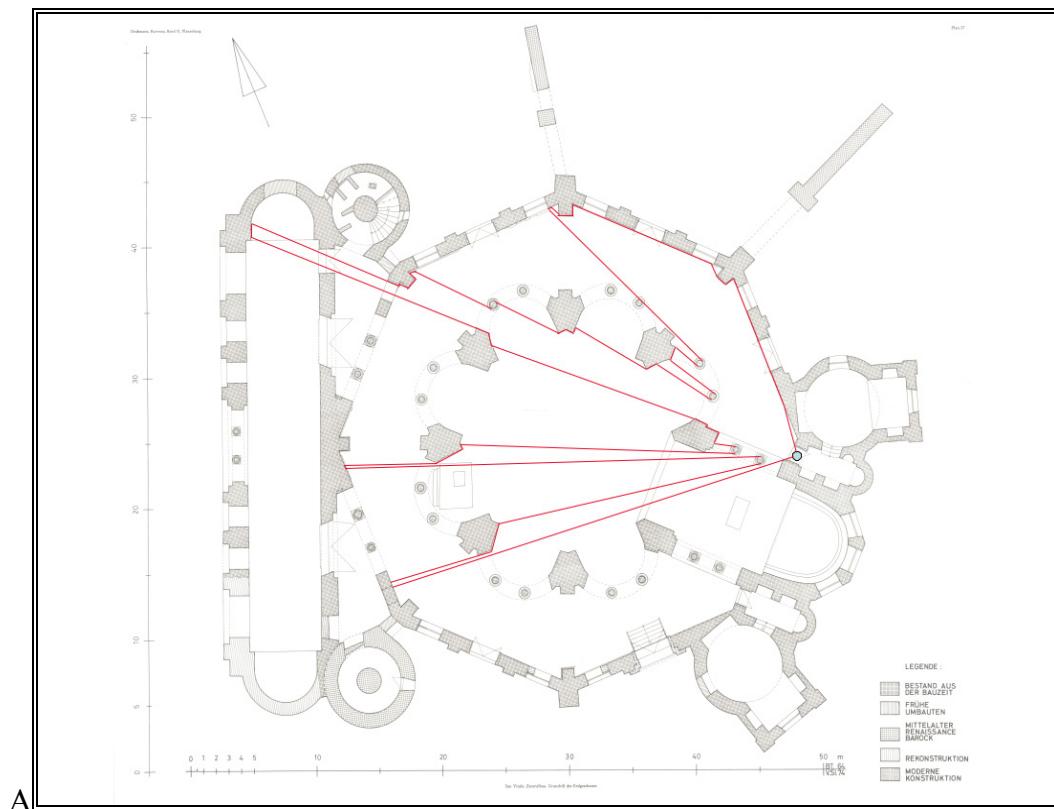
[37] Mainstone 1997:228.

B
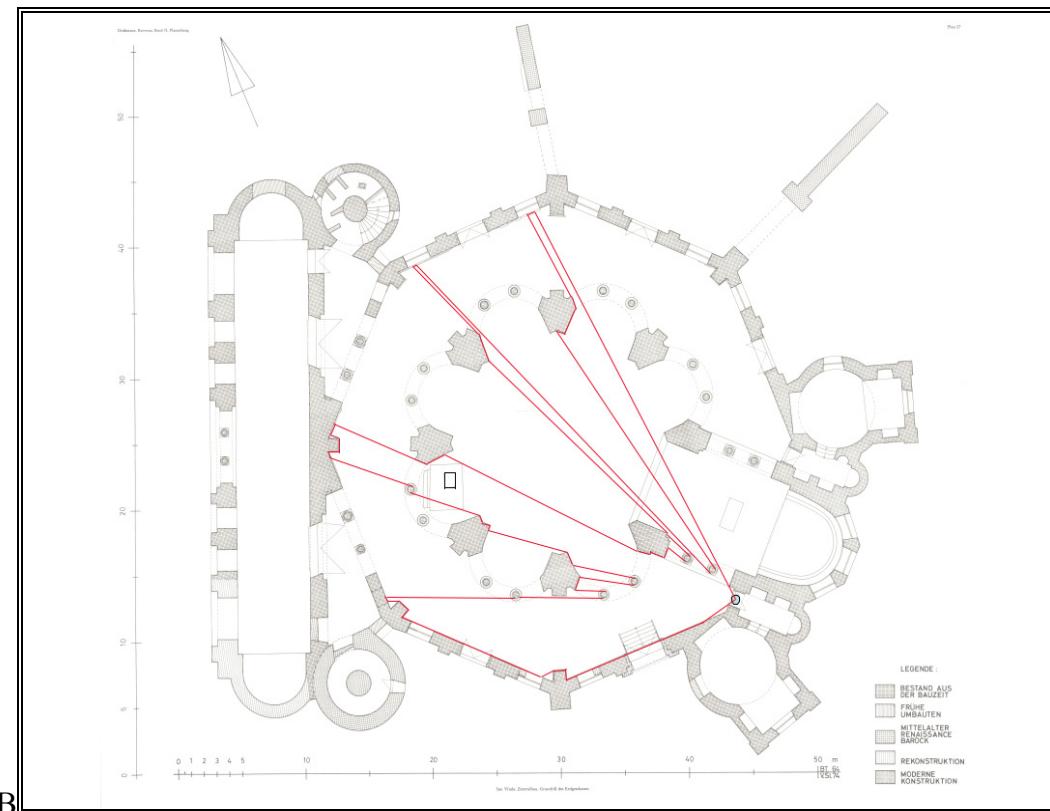
Figure 4.2.7: (A) View of male cleric from the opening to the north chapel (*prothesis / skeuophylakion*) looking northwest (B) View of male cleric from the opening to the south chapel (*diakonikon / monasterium* of St. Nazarius)
(After Deichmann 1989:Plan 27; overlay isovist by Knight 2009).

Figure 4.2.7A above reveals what a cleric standing at the entrance of the north chapel would see. Looking straight ahead he had an unobstructed view over a great distance, right to the west wall of the north narthex apse. If we compare this cleric's view with that of an associate's (Figure 4.2.7B) exactly opposite at the entrance of the south chapel, the view is remarkably different. The southern cleric has an unobstructed view of the *sacellum* altar. If this focus was liturgically important from this position it may indicate that from the south chapel officiating clergy at the *sacellum* altar utilised the short south ambulatory route.

The *diakonikon* to the south may have included the small longitudinal apsidal space and the adjoining circular 'chapel' which by the ninth-century was the *monasterium* of St Nazarius (and St Celsus) and may also have been what Agnellus

called the *secretarium*[38]. The clergy assembled before Mass in a small chamber; Deichmann followed Agnellus' implied distinction between the *salutatorium* and *sacrarium* while Deliyannis proposes they are different names for the same space[39]. The location of the *secretarium / salutatorium / sacrarium* in San Vitale may be identified under the general term *diakonikon*, where the vestments and Gospel were stored. The congregation greeted their return to the main altar with the gifts by singing the 24th Psalm and Cherubic Hymn. Although the hymn dates to a little after San Vitale's dedication, its vocal expression would have made eminent sense in this church, as Cedrenus quotes the words sung by the congregation:

> We who mystically represent the Cherubim and sing the thrice holy hymn to the life-giving Trinity, let us lay aside all worldly care to receive the King of All, escorted unseen by the angelic hosts. Alleluia.[40]

The explicit association made between the congregation and the Cherubim, the Heavenly Host of Angels, reminds us of the *Theophany* represented in the apse mosaics. The vertical hierarchy of San Vitale is reiterated in this hymn and the balances struck in the church between geometry, order, proportion, symmetry, complexity, and detail reinforces its anagogical quality. Indeed, the anagogic function of geometry [41] is:

> …its ability to "draw one up" to a contemplation of higher realities. In this understanding, the material world has its order and beauty from God, who arranges all things with due harmony, a harmony which can be partially expressed in mathematics and geometry…analogical buildings consequently lead those who use them upwards, closer to the divine[42].

If the women in the *matroneum* also sang the Cherubic Hymn, or any other Ravennate chant, as either an antiphon or response, the "affect" would have been striking. Further discussion of women singing in the *matroneum* of San Vitale will be addressed in the next Chapter (5).

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[38] Agnellus 112; Deliyannis 2004:230, 338.
[39] Agnellus 161, 149; Deichmann 1974, 2.1:207-208, Deliyannis 2004:273, 337, note 120.
[40] Cedrenus, *PG*, vol. 121, col. 748 (Mainstone 1997:228).
[41] *Ergo* Euclid's *Elements*, especially perhaps the fifth *Common Notion*: 'the whole is greater than the part. Taken from Heath (1956, Vol. I, pp. 154, 155) (Gray 2003:28).
[42] Hart 2003.

The bishop officiated the Eucharistic celebration from his throne (*sedis*) at the apex of the apse (Figure 4.2.6), in the middle of the *synthronon* (*sedilia*) stone benches for the lesser clergy lining the apse[43] and directly below the mosaic depiction of Christ enthroned. It is likely he sang portions of the liturgy from before the altar (*ante altare*)[44] and also from the *sedis*, behind the altar (*post altare*), as several examples in earlier churches at Ravenna depict a bishop above the throne looking straight out over the congregation, as at St. John the Evangelist[45].

The *offertorium* / Great Entrance

The mosaic depiction in San Vitale's chancel of Justinian and Theodora (see Part 3.2, Figures 3.2.2 and 3.2.3) has been identified as the imperial procession, the *Oblatio Augusti et Augustae*[46]. This Imperial Eucharistic oblation (offering) most likely represents the Great Entrance oblation (*offertorium*/Offertory)[47], when the un-consecrated bread and wine are presented[48]. The mosaic, then, crystallises one particular moment in the liturgical service, the exact details of the Ravenna Rite being lost to history.

Musically, the Offertory is the vocal setting of the offertory sentences (Gregorian, which, of course, is at a slightly later date). In the Roman Rite Mass the Offertory chant

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[43] Agnellus 71; Deliyannis 2004:186-187, 338.

[44] Agnellus 23; Deliyannis 2004:120, note 7.

[45] Where Galla Placidia had the mosaic image of Bishop Neon; '…This image was made thus: having a long beard, with hands extended, as if he is singing the mass' (Agnellus 27; Deliyannis 2004:124).

[46] Bovini 1956:46. Later cited by Baker 1995:186.

[47] Mainstone has it that these mosaics represent the Lesser Entrance, '…the procession about to enter the church' (1997:232). On the contrary, this *oblatio Augusti et Augustae* is the Great Entrance, the offertory, and, therefore, it is the interior of the church, not the exterior, being represented. He continues: '…On the opposite wall the Empress Theodora stands in the atrium surrounded by ladies of her court, and hands another gift to one of the clergy before they enter the church – whose portal is seen, with its curtain drawn aside, at the left' (ibid.) His identification of this being the atrium of the church is presumably based on the presence of a fountain of water on a column with Corinthian capital preceding a draped entrance, Theodora seems to be standing in either a narthex apse or an interior exedra as she holds a golden chalice encrusted with jewels, presumably containing the un-consecrated wine, and, therefore, as part of the *offertorium*. The Corinthian capital of the column is another reiteration of the similar column capitals of the *matroneum* and may signify the Apostles. The additional argument against this portraying an exterior scene is the physical position of the mosaic in the chancel apse, where the figures move toward the bishop's throne and Christ enthroned above. One would expect a depiction of the Lesser Entrance to have been displayed rather closer to the church entrances. Therefore, the column and fountain and birds beyond the drapes, in a dark space, may mean the life to come, resurrection, and in Theodora's case, perhaps knowledge of impending death.

[48] The Greater Oblation, the *oblation proper*, forms the latter part of the prayer of consecration, when the Body and Blood are ceremonially presented. Mainstone (1997:232) mistakenly assigns the chalice to Justinian and the woven paten (*diskos*) to Theodora when the reverse is true.

verses were followed by a Litany or response chant sung by the choir and the people. We cannot know with certainty what the musical procedure was at Ravenna during the depicted imperial procession.

Importantly, this memorialised liturgical offertory is an invitation, in perpetuity, for the Eastern emperor and his consort to bring the sacred gifts to San Vitale, Ravenna, Italy, the Western Empire. In this way, the mosaics may be read as a message of conciliation from Ravenna to Constantinople. That Justinian and Theodora did not visit Ravenna supports this thesis over readings of Ravenna displaying a post-540 "Byzantine" ascendancy over the Western capital.

Having moved into the angular "wedge" inside the southern entrance and ambulatory space beyond, the women would have stood immediately before the *sacellum* altar, perhaps the focus of regular or special reverence. If, for instance, Mass was offered at this altar on specific days such as the Feast Day of Saint Vitalis (April 28th and November 4th) the presiding priest's view would be that shown in Figure 4.2.8.
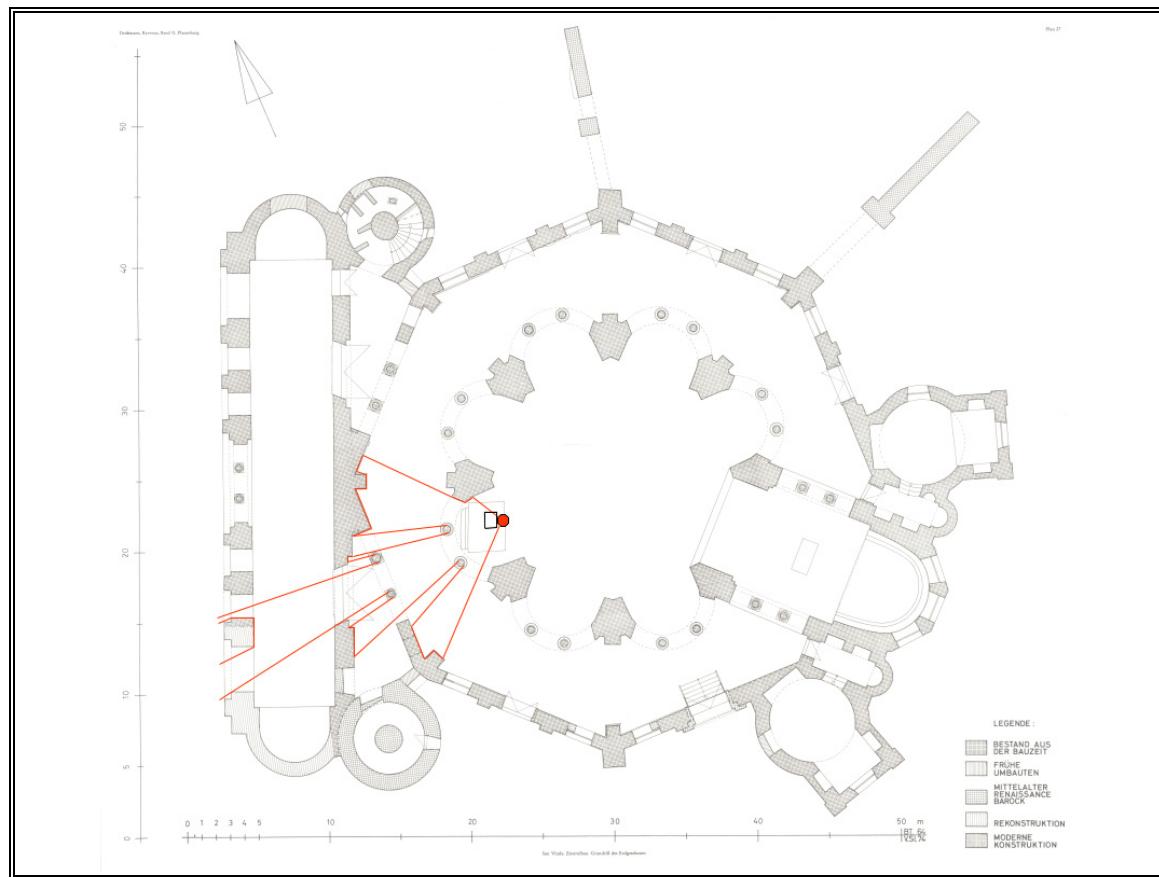
Figure 4.2.8: View of celebrant at the *sacellum* altar, looking west (After Deichmann 1989; overlay isovist by Knight 2009).
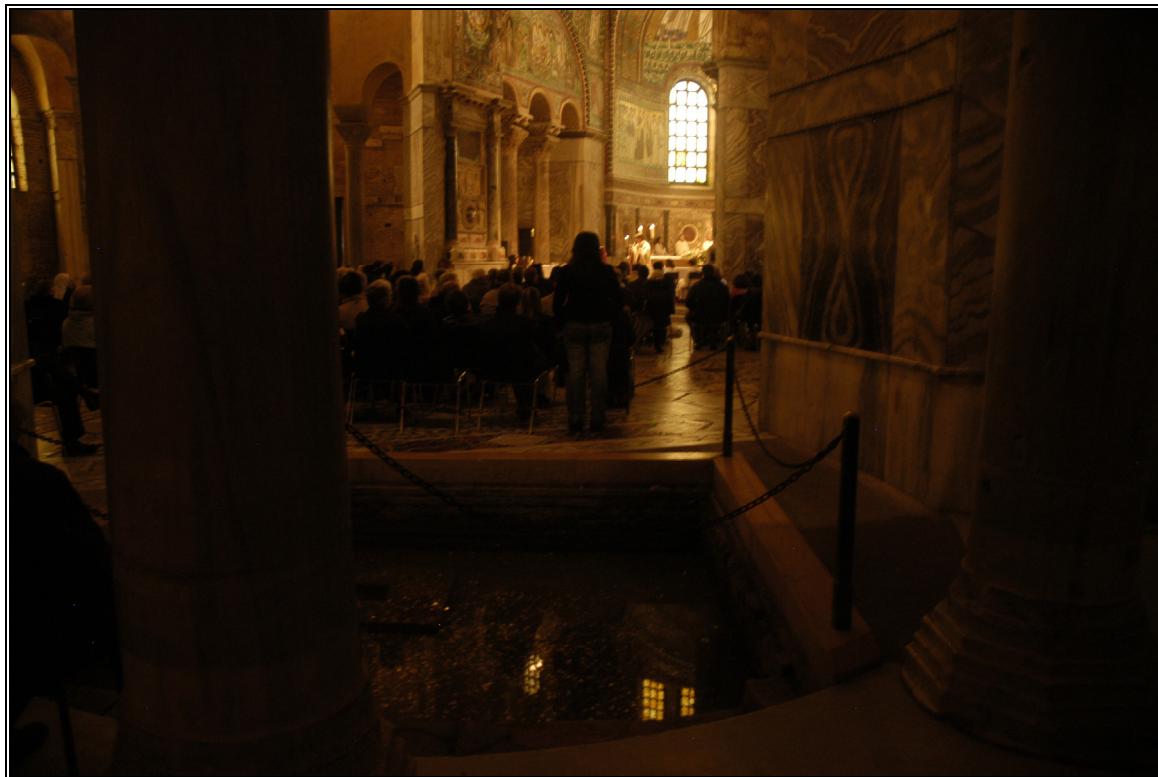
Figure 4.2.9: Present view from before the *sacellum* (filled with water), looking towards chancel (Photograph by Knight 2006).

Figure 4.2.9 illustrates one possible view of the women standing before the *sacellum* altar, from where the mosaic of Justinian is clearly seen in the distant chancel apse.

The Consecration

The consecration of the gifts[49] was conducted in silence, only punctuated by the principle celebrant praying the Secret (*oratio secreta*) almost inaudibly. With con-celebrating clergy the principle celebrant then received the Eucharist and wine and offered it to congregational members prepared and willing to receive. In San Vitale the ground floor access to the main altar, by the north and south terminations of the ambulatory, acted as the *senatorium*, where the male congregation queued to receive the Eucharist. Alternatively, the men could have approached the chancel screens delineating the division between the inner octagon and chancel, and received there. The arrangement for the women receiving the Eucharist involved a deacon walking back to the stairwells (likely the northernmost) and ascending to the *matroneum*. Once on the upper floor the deacon probably remained at the northwest end, in the middle of the ambulatory and perhaps also facing northwest with his back to the chancel apse, providing the receiving women with a view of the main altar on the ground floor, as shown in Figure 4.2.13.

The view of the principal celebrant at the main altar in the chancel, as shown in Figure 4.2.10 below, is predictably expansive. Not only did he obviously have a clear view of the main altar, but he could also see the *sacellum* altar.

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[49] The Eucharist was placed on a circular silver paten called a *diskos*. Over this, for protection, was a metal cage-like covering called an *asteriskos*, representing the Star of Bethlehem. One might intuit some kind of inspiration of San Vitale's design on this Eucharistic arrangement: the *diskos* is the ground floor octagon, where the "Body" of the "Church" stood, the male congregation. Over this scaled up paten is a protective *baldacchino*, the *asteriskos*, equivalent to the walls and *matroneum* and dome. Following this line of thought, the city of Ravenna therefore becomes a sacred altar-top and the entire church of San Vitale is an oversized *pyx*, an ornamental container for the Eucharist. The meanings are loaded and perhaps not too far from reality in the context of sixth-century Ravenna. The following is a description from http://www.orthodoxchristian.info/pages/Liturgy.htm: 'Before the start of the Divine Liturgy, as the Priest places the Star over the Lamb, he recites the words, "And the star came and stood over the place where the child was." (Matthew 2:19). Then he censes the Gifts. The smoke from the incense symbolises prayer. As the smoke rises to Heaven, so the Prayers of the Priest and the faithful rise to Heaven. Next the Priest takes two small covers (Veils) shaped like crosses, and places one over the Diskos and the other over the Potirion. Then he takes a large rectangular cover called the Aer and places this over the two together. Meanwhile he recites Psalm 92 praising the wonders of the universe. The covers represent the layers of the firmament. Aer means "air", which in terms of our modern concept of the universe would be "space". The Proskomide ends with the prayer of benediction. The Gifts have been prepared and remain at the side altar until the proper time for their removal during the Liturgy of the Faithful'.
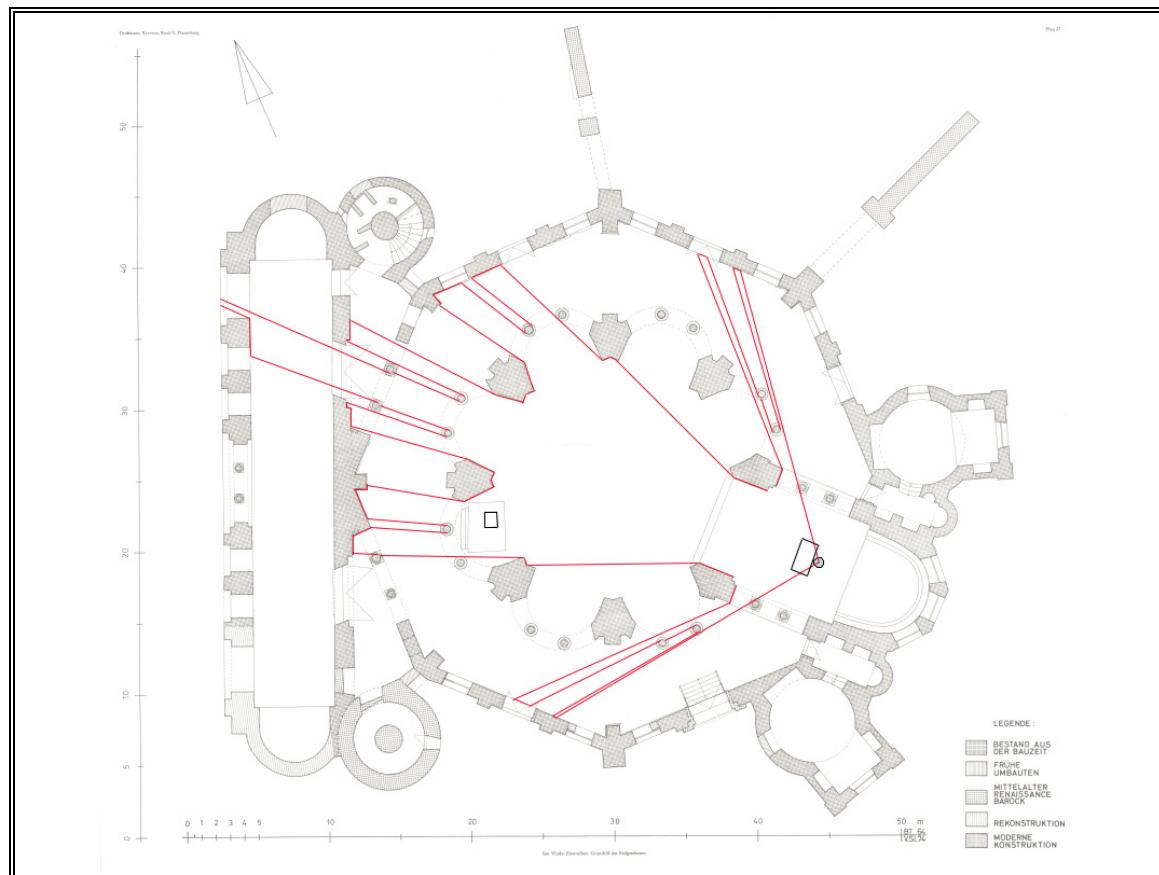
Figure 4.2.10: View of principal celebrant of the Mass from "behind" the main altar in the east, looking northwest
(After Deichmann 1989:Plan 27; overlay isovist by Knight 2009).

Figure 4.2.11 shows the corresponding view as shown in Figure 4.2.10 while Figure 4.2.12 shows the view of the priest when between the main altar and the congregation, looking southeast towards the bishop's throne in the chancel apse.
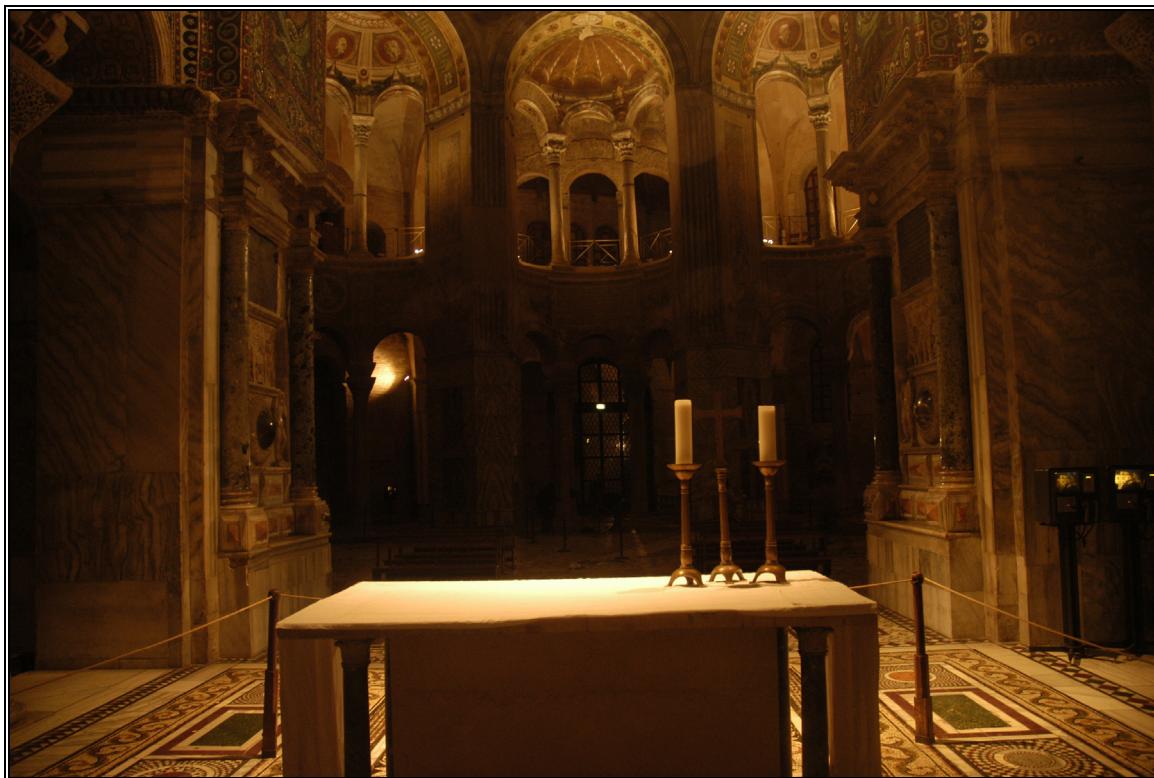
Figure 4.2.11: View from area between the main altar and bishop's throne (*sedis*), looking northwest
(Photograph by Knight 2006).
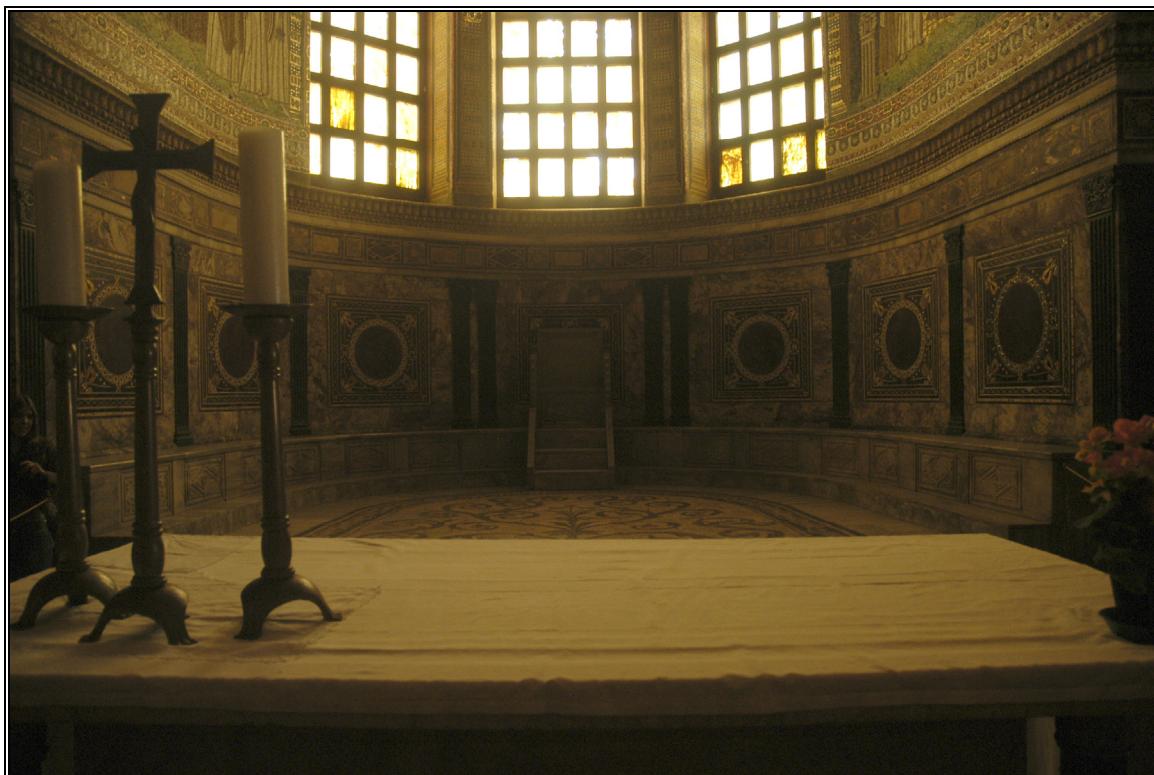
Figure 4.2.12: View from in front of the main altar, looking southeast towards the bishop's throne
(Photograph by Knight 2006).

Returning to the women (and children)[50], after ascending the stairwells to the *matroneum* floor[51], only two choices were possible regarding where to proceed, either around the south ambulatory or that of the north. The open space at the centre of the church demarks how far one can stand and see.

Despite Mainstone's[52] focus on the liturgy at Hagia Sophia, his observations regarding women in the *matroneum* and the ease and difficulty of visual and aural perception of the rite are of interest:

> Some would have been much better placed than others. Those close to the sanctuary and ambo would have seen and heard most. Those further away, even in the nave, would have seen less, and may have heard little of the spoken prayers and of any sermon. Of those in the aisles and galleries, only those fairly well forward and clear of the dead areas created by the massive piers would have seen anything. Real participation from the galleries would be possible only for those right at the front. Indeed, Silentarius wrote of the women there resting their elbows on the parapets, no doubt partly to see more.[53]

The view shown in Figures 4.2.13, 4.2.14 (A and B) and 4.2.15 below is remarkable for two reasons. Firstly, this is the best position in the *matroneum* from which to see most of the church interior including the main altar.

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[50] Mainstone notes (1997:230) '…the place of women and catechumens has more recently been well summarised and analysed by Taft (1977) in a review of Strube, *Eingangsseite*, OCP, vol. 42, 1976, pp. 296-303.

[51] After tackling the ambiguities of Procopius and Evagrius Mainstone (1997:230) notes 'Only Silentarius is completely consistent. He refers no less than four times to the galleries as the women's place, implying that only men were at ground level' (Silentarius, *ecclesia*, lines 389, 537-41, 562, 586-9).

[52] Mainstone 1997.

[53] Mainstone 1997:230-231.
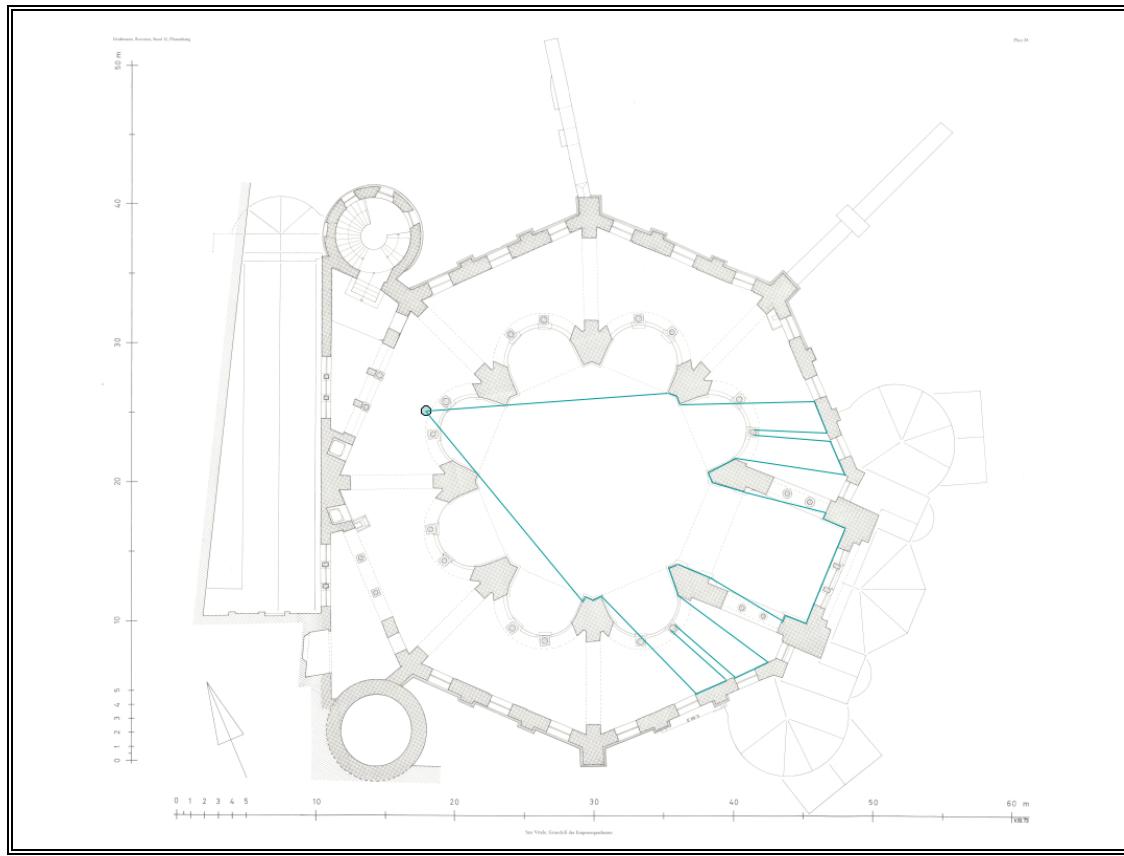
Figure 4.2.13: View (female) from where most of the church interior at eye-level in the *matroneum* can be seen, looking southeast
(After Deichmann 1989; overlay isovist by Knight 2009).
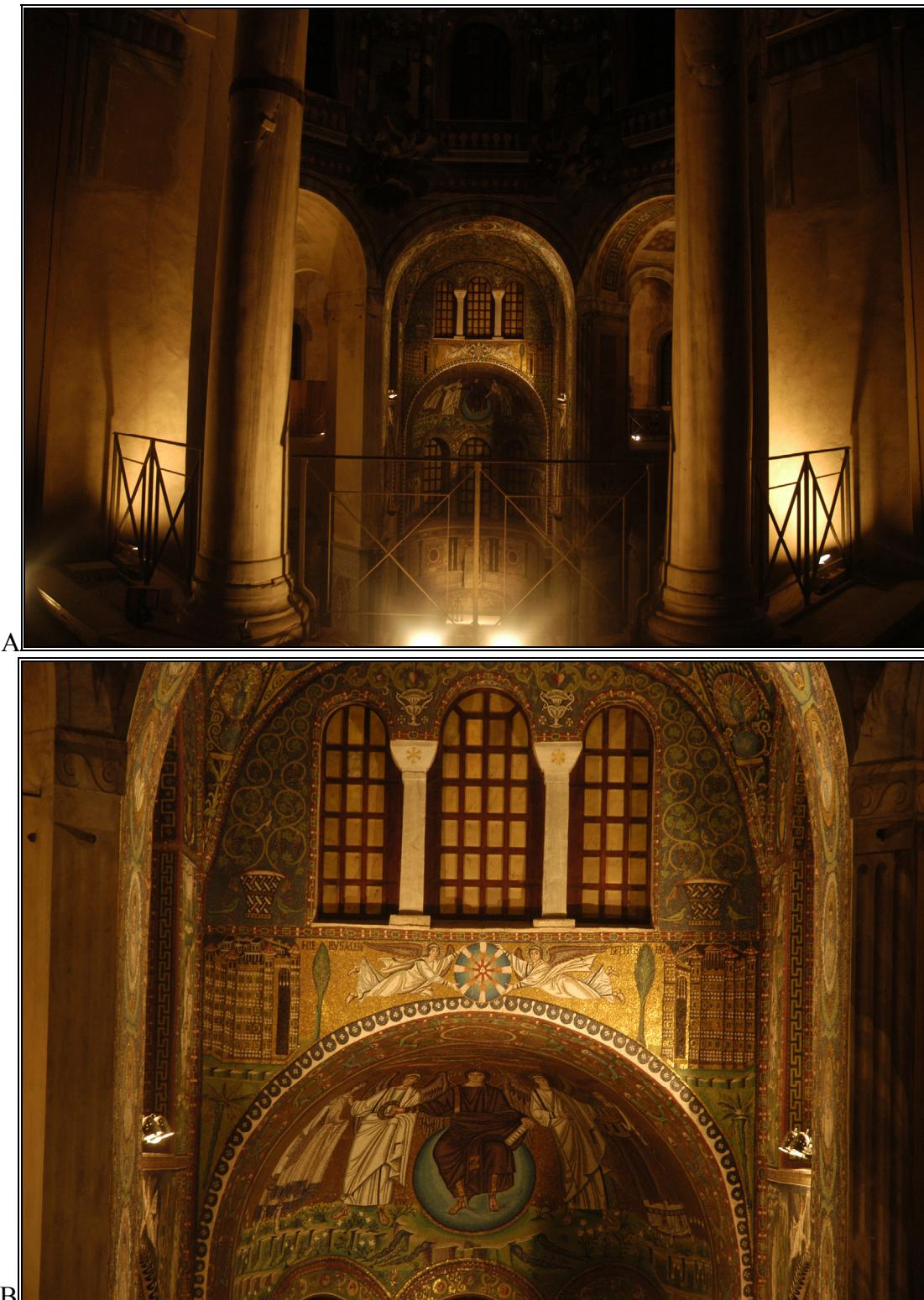
Figure 4.2.14: (A) Comparable real view to Figure 4.2.13 (B) Photographic close-up of Archangels and disc at eye-level (Photographs by Knight 2006).

Secondly, looking straight ahead, the woman at this position would be immediately in front of and at the eye-level of one of the most important mosaic features of the chancel, the depiction of the winged Archangels Michael and Gabriel holding aloft a disc at the middle of which is the Greek letter *Alpha* rendered in white *tesserae* and from which emanate eight rays of light. From the ground floor, even at close range and staring up it is difficult to discern the Greek letter.
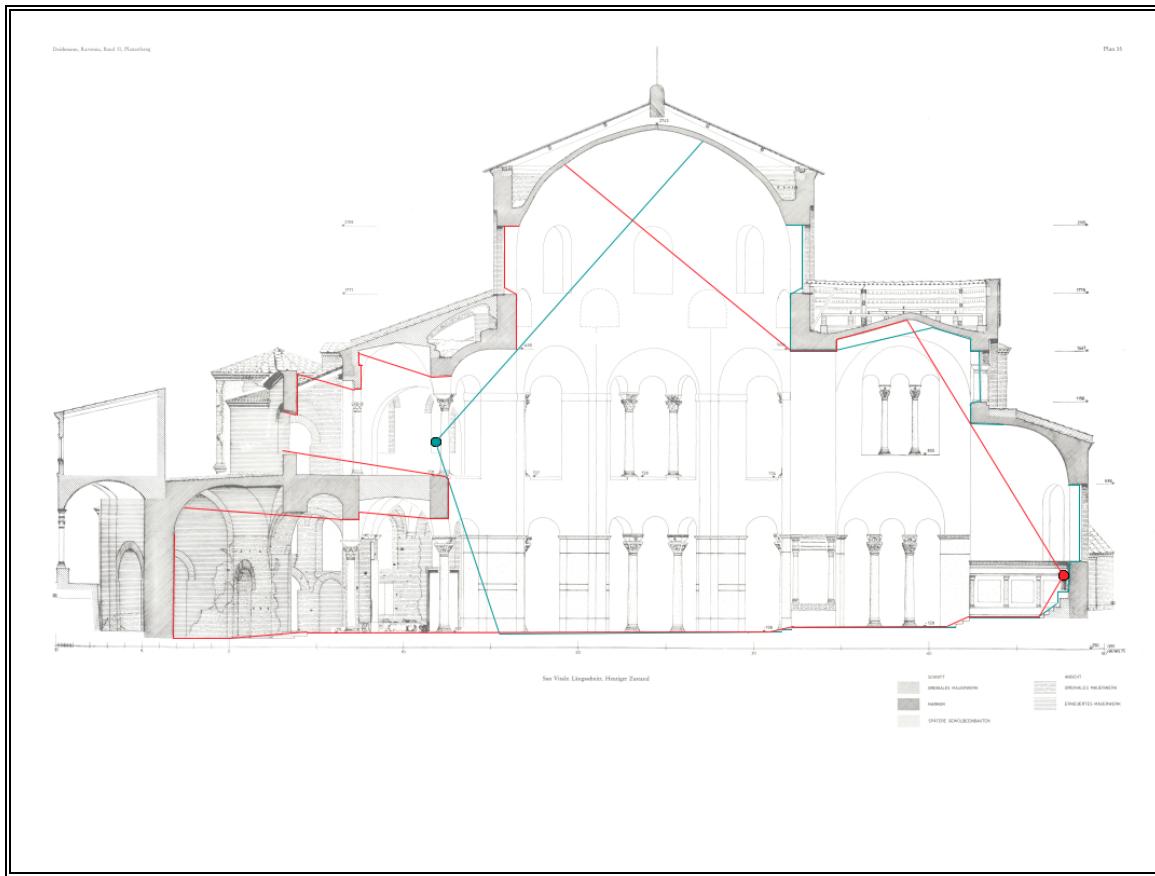
Figure 4.2.15: Northwest/southeast elevation showing female view (as in Figure 4.2.13) and that of the principal celebrant's seated in the bishop's throne
(After Deichmann 1989; overlay isovists by Knight 2009).
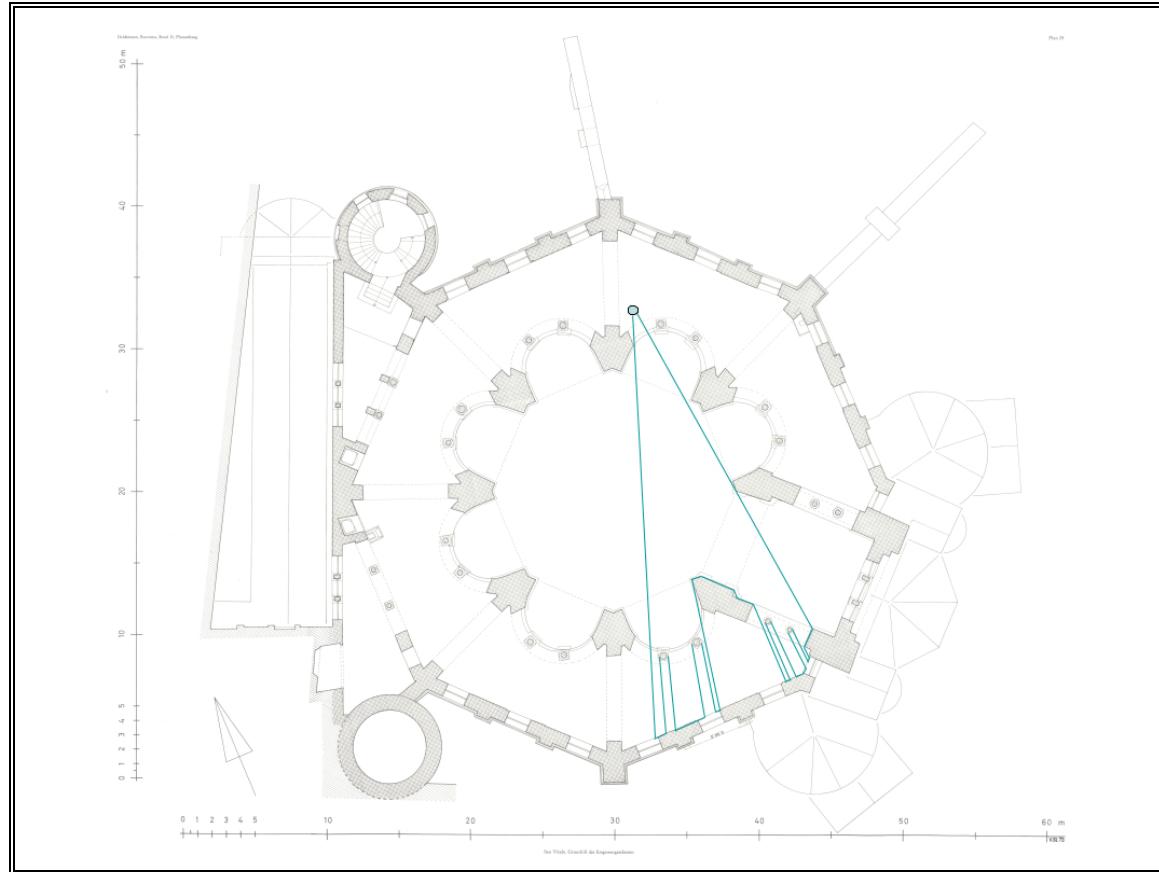
Figure 4.2.16: View (female) position in *matroneum* north ambulatory looking south; position of female vocalist in 2006
(After Deichmann 1989; overlay isovist by Knight 2009).

As a person moves around the *matroneum* north ambulatory, the view of the upper range of the chancel becomes increasingly curtailed. Such an obstructed view is shown above in Figure 4.2.16, the position at which the female vocalist[54] stood and sang *Lux de luce* during the acoustic measurement of the church in 2006[55].

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[54] Madalenna Roversi (University of Bologna, Musicology Department).
[55] Discussed in Chapter Five, Part 5.2.
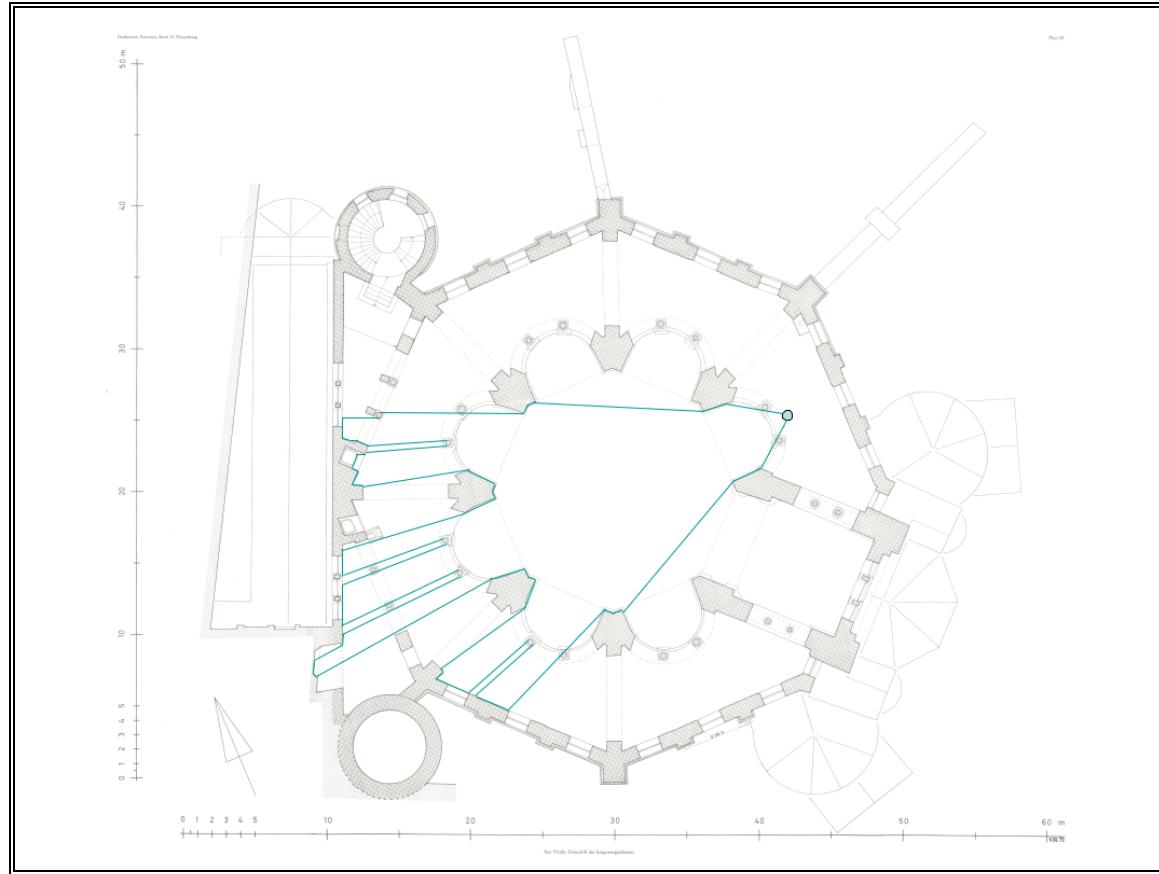
Figure 4.2.17: View (female) position at the centre of east exedra looking west
(After Deichmann 1989; overlay isovist by Knight 2009).

Moving further along the northern *matroneum* ambulatory, the female position shown in Figure 4.2.17 reveals a much clearer view than in Figure 4.2.16, opening out across the inner space to the opposite western area of the *matroneum*, and, by looking down, the *sacellum* is also clearly seen.
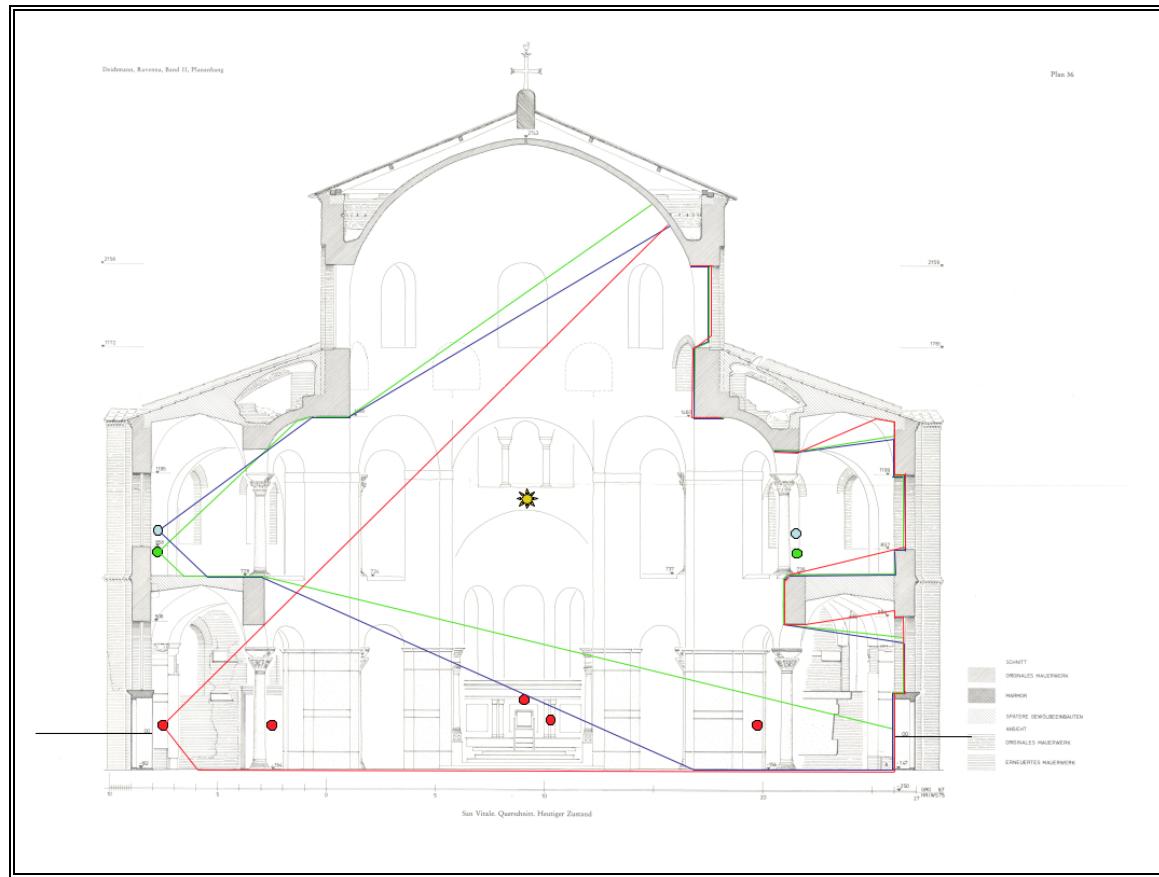
Figure 4.2.18: Elevation looking southeast showing views of female (blue) and child (green) in the north *matroneum* ambulatory, and a male (red) on the ground floor north ambulatory, each looking south (After Deichmann 1989; overlay isovists by Knight 2009).

If people stood near the exterior wall, in the *matroneum* ambulatory (Figure 4.2.18), their views of the ground floor inner octagon and the clergy at the main altar would be obstructed. From a comparable position below on the ground floor, the upper range of the view to the dome is intriguingly the same as the adult female in the *matroneum*, but the male can also see the entire inner octagon and width of the church.
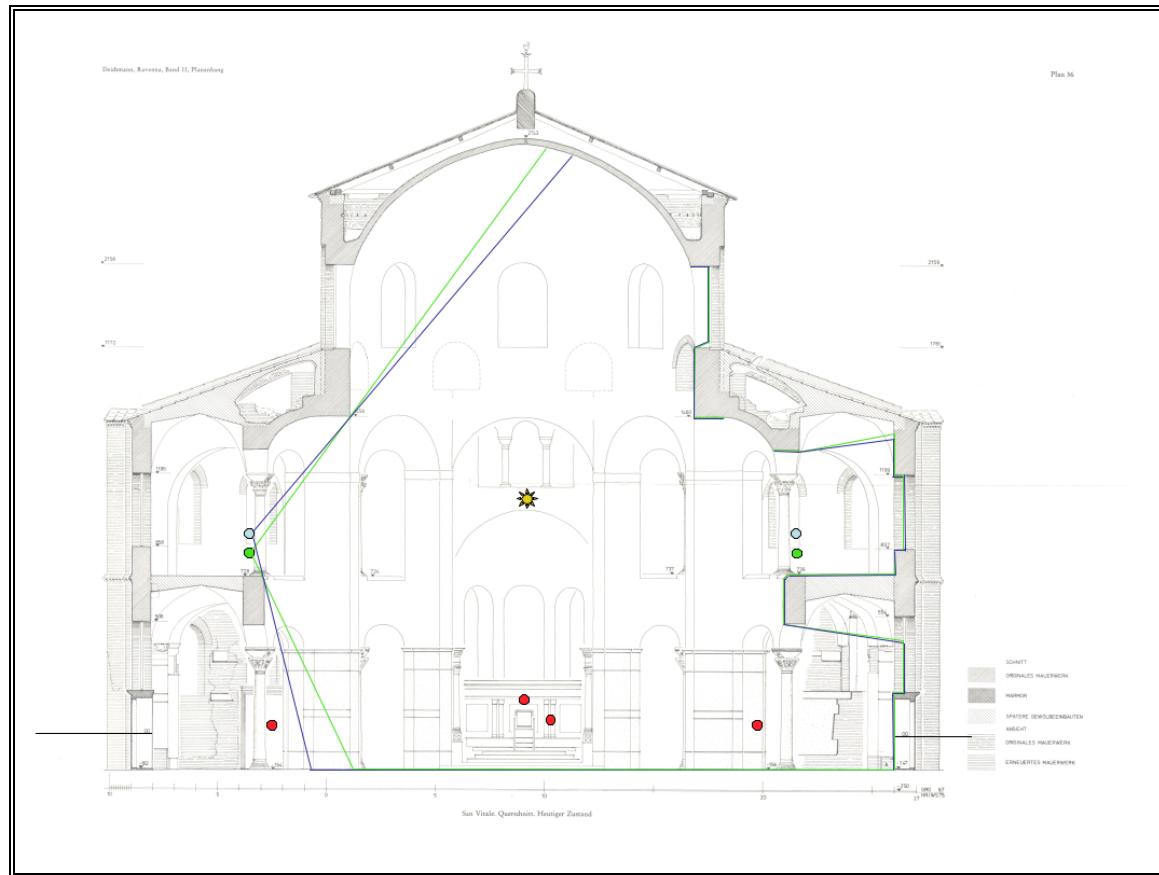
Figure 4.2.19: North/south elevation looking east showing views from female (blue) and child (green) in the north *matroneum* ambulatory close to the inner octagonal space, looking south
(After Deichmann 1989; overlay isovists by Knight 2009).

Figure 4.2.19 above reveals the views of the same characters in Figure 4.2.18, but a few paces forward. Predictably, the views open onto a greater area, now including all of the ground floor inner octagon and therefore the male congregation and clergy. Figure 4.2.20 below is the view from the main altar up to the *matroneum* immediately to the south. The priest could see and direct his attention to those women who gazed down from this termination of the upper level ambulatory.

Figure 4.2.20: View from area between main altar and bishop's throne, looking south and up to the *matroneum* south ambulatory termination at the triple-mullioned window (Photograph by Knight 2006).

It has been shown how the interior logic of San Vitale's material architecture is symmetrical in both plan and elevation. We have also reconstructed above a possible sequence of movement during the celebration of the Eucharist in the sixth-century and how different areas within the church afforded specific fields of vision. This has revealed a marked contrast to who had visual access to specific foci, for instance the two altars in the church at the *sacellum* and chancel, the imperial mosaics and the representation of Archangels Michael and Gabriel high above the main altar.

Before comparing these identified areas and views with the acoustic properties and maps of reverberation in Chapter Five, it is necessary to first understand social congregational movement in the particular context of Ravenna's liturgical calendar. Specifically, an attempt will be made to identify the appropriate occasion(s) on which *Lux de luce* would most likely have been sung and listened to, and where the congregation may have stood in order to see and hear this performance (Part 4.3).

Part 4.3: The Liturgical Context of *Lux de luce*

The extant examples of Ravennate liturgical music are sparse[1] and although there is a sequence for St. Vitalis, *Annua presentis recolamus gaudia festi*, which would obviously be appropriate for performance in San Vitale on the saint's Feast Days (April 28th and November 4th), and likely also the commemoration of the church's dedication on April 19th, the musical notation is unfortunately lost[2].

Of the remainder, one in particular has received musicological attention. Levy[3] identified the Ravennate chant *Lux de luce* as a *versus* with a regional relationship with other chants from Beneventum which share the same words, although the example from Ravenna[4] has an additional two ending stanzas. This musical connection with Beneventum is best seen in the Greco-Latin Good Friday antiphon *O quando in cruce*, drawing from roots at Jerusalem spanning the sixth to the ninth-century[5]. There are eastern connections of some Ravennate chants (namely the chants for the Easter-Vigil neophytes' Mass)[6].

Levy usefully provides the notation and corresponding words for the Ravennate *Lux de luce*:

(1) *Lux de luce Deus tenebris illuxit Averni*
(2) *Vespere quae prima refulgens luce diei*
(3) *Victor ab inferni remeavit nexibus atris*
(4) *Sustulit inde suos devicto principe mortis*
(5) *Tartara* [*saeva*] *chaos destruxit media dira*
(6) *Clausit et obscuris valvans aulamque maligni*
(7) *Regna benigne piis reseravit claustra polorum*
(8) *Ut pateant digni sumentes premia digna*
(9) *Cum quibus angelicum spreta tellure squaloris*
(10) *Participes Christi possimus scandere nomen*[7]

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[1] See Appendix C for a list of the known examples.

[2] Levy (1971:57) further comments '…this curious piece has its line beginnings paired in sequence fashion, but its line endings obey an independent order of musical rhymes' (ibid, note 47).

[3] Levy 1971.

[4] Alternately, it may come from the immediate vicinity, in the region of Forlimpopoli (Levy 1971:48, note 18).

[5] Levy 1971:50.

[6] Levy 1971:50.

[7] God, light from light, has illumined the shadows of Avernus.
At eventide shining with first light of day

God, Light from Light, shone forth into the darkness of Hell [*Avernus*]
in the evening, and shining at first light,
He came back triumphant from the underworld,
And thenceforth set free his people from their terrible debt, having conquered the prince of death.
He destroyed the forbidding underworld [*Tartarus*] and Chaos, with its terrible fortifications, and shut its dark doors and the hall of the spiteful one.
With kindness He unlocked the closed kingdom of Heaven
In order that the worthy might be free to accept worthy rewards,
With whom, separated from this land of squalor, we might be able to ascend like the angels as partakers in the name of Christ.[8]

The naming of three distinct types of "Hell" is useful for understanding this rather gloomy piece. *Averni* (verse 1) is a group of noted lakes and grottos with noxious vapours[9], from the example of *Avernus*, near Cumae, Campania, which is a crater exuding foul air and believed to be one of the entrances to the underworld. The other two damned places that are named (verse 5) are from Greek mythology; *Tartarus* is a dark place below *Hades*[10] and *Chaos*, the antithesis of *Cosmos*, is a primal expansive empty space[11]. Hell, as a fiery tortuous place is not mentioned, rather, the torments of noxious fumes (supposed carriers of disease), darkness (blindness), and emptiness (loneliness) are identified as the "places" that Christ has redeemed us from. The combination of pagan Roman and Greek myth in this Ravennate chant is intriguing.

The liturgical context for *Lux de luce* has been suggested by Levy as originally 'intended as a communion chant'[12], but more specifically:

The victor has returned from the infernal regions
And removed his own from their dark bounds, having vanquished the prince of death
And has destroyed frightful Tartarus, the dread walls of chaos
And has closed the dark gates and the hall of the evil one
And has benignly opened the kingdom for the pious
So that the worthy may take and seize their just reward.
These words, translated in Levy 1971:43, are from *Lux de luce*, the longer of two Beneventan sequence versions, the text of the Ravennate *versus Lux de luce* 'is the twin of the longer Beneventan version – the same hexameters are there but with two additional closing lines', however, the Ravennate version is musically very different Levy 1971:47-48.

[8] Thanks to Dr. Charlotte Tupman for this full translation, personal communication February 24 2009.

[9] Also known as *mephitis* or *mefitis*, a pagan Roman plague goddess (Cf. Adkins & Adkins 1995:5, 150).

[10] Hesiod: *Theogony*; Homer: *Odyssey*, XI, 576 ff; Virgil: *Aeneid*, VI, 539-627.

[11] Due to later misunderstanding the meaning changed to "disorder" (Ovid: *Metamorphoses*, Book 1, Online: http://classics.mit.edu/Ovid/metam.1.first.html

[12] Levy 1971:50-51.

The likeliest original position for *Lux*, however, is earlier in the Easter Vigil than the concluding Mass. It comes before the baptismal rites and the prophetic lessons that precede them – among the opening ceremonies of the Vigil, where the new fire is brought forth and the paschal candle is lighted and blessed. In broad terms this is a *lucernarium*…Specifically, it is a *lucernarium* for the primal Vespers of the liturgical year on Holy Saturday, when the new fire presages the imminent victory over death…If *Lux de luce* has an original place among these ceremonies at the opening of the Vigil, it is likely to be with the new fire, for this is what the text is about.[13]

Therefore, although this Easter Vigil chant was probably not sung in San Vitale in 548, as the dedication was one week later, it was most likely performed there as of 549. It is known to be at least ninth-century in date but the elaborate Ravennate Easter rite is known as of 601, and *Lux de luce* may be older still[14], and, therefore the best choice as a sound source for understanding San Vitale's acoustics. Since *Lux de luce* is thought to have been 'in use before the mid eighth-century'[15] and perhaps as early as the sixth-century, it is therefore the best choice among the six extant identified Ravennate chants[16].

The intellectual setting of the construction and dedication of San Vitale shows interest at Ravenna of acoustics[17]. The writings of two eminent men of high office require special attention as they were present and influential at Ravenna, in the years when San Vitale was being planned and constructed, require special attention.

Anicius Manlius Severinus Boethius (480-524/25):

As already noted, Boethius reiterated the analogy of sound propagation to waves in a standing pool of water[18]. The popularity of Boethius' writings in the medieval period, namely his unfinished *De institutione musica libri quinque*[19], ensured the

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[13] Levy 1971:52-54.

[14] Levy 1971:54.

[15] Levy 1980:879.

[16] Refer to my Appendix C.1, a compendium of Ravennate Chant.

[17] See Appendix A.

[18] He was stripped of his official rank and after being imprisoned by Theoderic at Ravenna on the suspicion of colluding with the Eastern Empire, was infamously imprisoned where he died in c.525, approximately one year before Theoderic's own death and the rather disappointing end of an otherwise long tolerant and peaceful rule. Cf. Jones 1973:532, 542, 561 and 987; Bark 1944; Patch 1947.

[19] Boethius' *De institutione musica* introduced the three classifications of music: *Musica mundana* (music of the spheres), *Musica humana* (harmony of human body and spirit), and *Musica instrumentalis* (the praxis

continuance of the analogy of water waves to sound waves until the 20th century. When Boethius' work is read in conjunction with his contemporary, Cassiodorus, some acoustic and musical observations of Late Antique Ravenna come clearer into focus, as revealed below.

Flavius Magnus Aurelius Cassiodorus Senator (c.485-c.585):

Cassiodorus[20] was *magister officiorum* to King Theoderic at Ravenna until 526 and it is known that he remained in the city until shortly after 540, with the Byzantine takeover[21]. His writings on music can be dated to between 550 and 562 and although this places his composition of the *Expositio in psalterium* slightly after the completion of San Vitale in 548, it is not impossible some of his comments were informed by personal experience at Ravenna, perhaps even within San Vitale itself when construction was substantially completed and finishing touches such as the wall mosaics were being applied, perhaps even attending the dedication of the church on *Quasimodo* Sunday, April 19th, 548.

In the *Expositio in psalterium*, Cassiodorus describes the vocal performance of the Mass Alleluia[22]:

> *Hinc ornatur lingua*
> *Cantorum: istud aula*
> *Domini laeta respondet,*
> *Et tanquam insatiabile*
> *Bonum tropis semper*
> *Variantibus innovatur*[23].

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of playing a musical instrument). He possibly wrote an *Ars Geometriae* of which there are extracts (L 413-416) in the *Corpus Agrimensorum Romanorum (*Campbell 2000:451).

[20] Cassiodorus wrote a geometrical work, part of the scientific *quadrivium* (arithmetic, geometry, music, and astronomy) in his *De Artibus ac Disciplinis* (Rouse Ball 1960:133), also included in the *Corpus Agrimensorum Romanorum* (L 393-412) (Campbell 2000:451).

[21] He went south to family property at Vivarium (Squillace) in Calabria where he founded a monastic order and library (Knight 2008:19).

[22] The useful study of Ambrosian Alleluias by Bailey (Bailey 1983) focused on the liturgical alleluia of the Mass. The second, simpler form of the liturgical alleluia '…is related to the psalmodic practice: alleluia is attached as a brief coda, usually of independent musical origin, to certain chants of the Mass and Office, especially in Eastertide…it is clear from St. Benedict's Rule that the alleluia was a regular addition to antiphons and responds of the Daily Office, in Eastertide and beyond, by the early sixth-century. The use…of alleluia as an antiphon text has, obviously, the same origin' (Bailey 1983:4).

[23] Cassiodorus; *Expositio in psalterium*, PL LXX, 742 (Bailey 1983:14).

Comment [DK1]:

Hence, by the tongue of the
Singer, [the alleluia] is
Embellished: this the glad
House of the Lord echoes, and
then like an un-wearying
delicacy, with ever-changing
turns, it is renewed.

A little further on, he says:

In melodia hoc compositum
Nomen diversos tonos
Recipit, ita ut
Multiplices causas ad
Vim suae praedicationis
Assumit[24].

In singing, this compound
Noun [alleluia] receives
Varied [winding] tunes,
Multiplicity of means the
Force of its message.

He describes an Alleluia that is ornate (*ornatur lingua cantorum, diversos tonos recipit*), long (*tanquam insatiabile bonum, multiplices causas*) and, in all probability, improvised (*tropis semper variantibus innovatur*)[25]. The Mass Alleluia that Cassiodorus is referring to is a responsorial chant ending with a melismatic[26] vocalisation on the final syllable, a contraction of *Yahweh*, the name of God.

The contemporary friend of Ambrose, Augustine (AD 354-430), likewise described the vocalisation of the *jubilus*[27]:

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[24] Cassiodorus; *Expositio in psalterium*, PL LXX, 811.
[25] Bailey 1983:14.
[26] A melisma is the vocal technique of changing the pitch of a single syllable of text while it is being sung.
[27] Augustine; *Enarratio in Psalmum* XCIX, PL XXXVII, 1272. 'Another melodic form with its roots in Jewish tradition is the *jubilus*. This consists of the joyful explosion of a vocal melisma, sometimes very long, without accompanying text. The fullest and most enthusiastic account of this musical form – a kind of contemplation- is given by St. Augustine (354-430), who rarely misses an opportunity to discuss it, especially in his *Enarrationes in Psalmos*. He describes it as a chant much used in connection with the responsorial psalm, and thereby refutes the opinion of those who see in the *jubilus* no more than the direct ancestor of the alleluia in the mass. (It is noteworthy that the alleluia is compared by Augustine and others to the *kéleuma*, originally an oarsmen's song and therefore strongly rhythmical.) Furthermore, from certain

Qui jubilant non verba
Dicit, sed sonus quidam
Est laetitia sine verbis:
Vox est enim animi
Diffusi laetitia, quantum
Potest, exprimentis
Affectum, non sensum
Comprehendentis

One who jubilates does not
Utter words; the sound is
Rather a kind of wordless
Joy; indeed, the utterance
Is that of a soul filled with
Joy making every effort
To express its feelings,
Not to convey meaning[28].

There is musical evidence that the Mass Alleluia of Rome, Milan and the Gregorian regions were originally improvised, for, of all the liturgical chants, it provides the occasion *par excellence* for vocal display. Prior to 590 (i.e. Gregory the Greats' liturgical reforms), the Alleluia was improvised as an exclusively Paschal chant, but between 590 and 598 its use beyond Eastertide was extended[29]. The significance for San Vitale is that, since its dedication can be dated to the first Sunday after Easter (the Octave of Easter, *Quasimodo* Sunday[30]), it is likely this Mass Alleluia was sung and improvised

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other passages of Augustine it might be inferred that the performance of the *jubilus* was not the exclusive preserve of the soloist, but that the congregation joined in; and one must therefore imagine simple or even standardized forms of *jubilus*' (Cattin 1984:10-11).

[28] Augustine; *Enarratio in Psalmum* XCIX, PL XXXVII, 1272 (Bailey 1983:14).

[29] Bailey 1983:15.

[30] See Part 4.1. Also known as Low Sunday, White Sunday, Alb Sunday, St. Thomas Sunday, and, most recently (as of Pope John Paul II) Divine Mercy Sunday. In the East it is known as Thomas Sunday. The name Low Sunday probably derives from *Laudes*, the first word of the Sequence of the day: *Laudes Salvatori voce modulemur supplici* (Let us sing praises to the Saviour with humble voice). Traditionally, the newly-baptised would receive baptismal gowns that would be worn until this day, and the official Latin name is *Dominica in Albis* [*Depositis*], "Sunday in [Setting Aside the] White Garments", hence "White" and "Alb" Sunday. The name Quasimodo came from the Latin text of the traditional Introit for this day, which begins "*Quasi modo geniti infantes…*" ("As newborn babes, thirst for the pure milk of the word so that by it you may grow in your salvation"), from the First Epistle of Peter (I Peter 2:2). Literally, *quasi modo* means "as recently [sc. born babes]" (Catholic Encyclopaedia: http://en.wikisource.org/wiki/Catholic_Encyclopedia_(1913)/Low_Sunday).

on at least that day. We can, therefore, identify at least one musical acoustic element on Sunday April 19th, 548 within the new space of San Vitale.

This is a significant identification for the musicological and archaeological understanding of San Vitale, Ravenna and Late Antique Italy since it is almost impossible to accurately locate where other extant Ravennate chants were sung, particularly in which specific city church. However, we do also know that two other Ravenna churches, both also financed by Iulianus *argentarius*, were dedicated on the Sundays following Easter (within Eastertide); San Michele in Africisco[31], was dedicated by Bishop Maximian on May 7th, the third Sunday following Easter of 545 and Sant' Apollinare in Classe was dedicated on May 9th 549, the fifth Sunday after Easter of that year[32]. Therefore, the Mass Alleluia would also have been sung at the consecration of these three churches, further illustrating their shared connection. It is possible to go a little further with this discovery by considering in detail the two passages by Cassiodorus.

Bailey gives us Cassiodorus' comments in reverse order[33] and builds an argument for the improvisation of the Alleluia, but the sequence Cassiodorus intended invites an alternative reading. It seems probable that LXX, 742 describes the reverberation (*respondet*) within a church (*istud aula Domini laeta*) and the performed vocalisation dependent on the complexity of the resultant echoes (*et tanquam insatiabile bonum tropis semper variantibus innovatur*). If Bailey is correct in his interpretation here of improvisation, it seems to be in direct relation to the reverberation time of an interior acoustic space, *variantibus innovatur* being 'innovating variances' or 'unpredictable variety'. However, Bailey has translated *lingua cantorum* as 'by the tongue of the singer' rather than the more correct plural 'singers'[34], indicating Cassiodorus was instead

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[31] Agnellus; Maximian, 77 (Deliyannis 2004:191). In the Paschal cycle of the Eastern Orthodox Church the reading for the 3rd Sunday after Easter is on Christ healing the paralytic (Mark 2).

[32] Julianus Argentarius also financed the construction of Sant' Apollinare at Classe, dedicated by Bishop Maximian on May 9th of 549 (Agnellus; Maximian, 77; Deliyannis 2004:192), this being the 5th Sunday following Easter of that year (April 4th), known also as Rogation Sunday. Further investigation of historic sources is required in order to establish whether this was a usual mid sixth-century practice at large or just at Ravenna, or if this was peculiar to the episcopacy of Bishop Maximian, or, indeed, unique to these three churches.

[33] PL LXX, 742 should obviously precede PL LXX, 811.

[34] Bailey 1983:14. As *lingua* is the nominative singular of *lingua*, *-ae*, f, and means tongue/language/speech/voice, and *cantorum* is the genitive plural of *cantor*, *-oris*, m, 'singer' or 'poet', so it means 'of singers' and therefore a better translation would be 'the voice of singers'. Thanks to Dr. Charlotte Tupman for this clarification; personal communication July 27th 2009.

describing more than one singer chanting in unison and not an improvising soloist. In this respect, he may be alluding to an early *scola cantorum* active at Ravenna.

As already mentioned, Cassiodorus is known to have left Ravenna shortly after 540, when the city fell to Byzantine rule, retiring to Vivarium (Squillace) in Calabria. His writing on music (*Expositio psalmorum*/Exposition of the Psalms), of which the lines above are taken, can be dated to between 550 and 562. If this reading is correct then a thesis may be posited parallel to Bailey's: the sixth-century development of elongated melismatic Alleluia chants could in part be a result of developments in ecclesiastical architecture and, more specifically, the acoustics afforded by particular enclosed spaces. In other words, the kind of vocal display in relation to long reverberation times indicated by Cassiodorus may represent musical developments in direct relation to the architecture of contemporary performance spaces.

Although Cassiodorus was apparently absent from Ravenna at the time of writing, his comments are within the very first few years following the completion and dedications of San Michele in Africisco in 545, San Vitale in 548, and Sant' Apollinare at Classe in 549, and as we have just seen, on San Vitale's dedication day of *Quasimodo* Sunday the Mass Alleluia that Cassiodorus is describing was performed in the new church, highly suggestive that he visited the new church before writing, and, additionally, describing the interior reverberation and musical performance inside San Vitale[35]. On the other hand he may simply have been making general observations and comments based on experience (still, these may represent general comments based on his thirty-year experience as minister within the court of Theoderic at Ravenna) and/or comments on another specific interior space at Vivarium or elsewhere. Nonetheless, it is tantalising that Cassiodorus, with so much experience at Ravenna, describes the acoustic effects of the Mass Alleluia, a chant performed in San Vitale on its dedication day. It is plausible that this man was invited back to Ravenna for this important occasion hence his comments may be directly based on his own experience inside San Vitale. Such a thesis cannot be proven, but its consideration is instructive.

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[35] Cassiodorus could also be describing the acoustics of San Michele in Africisco or Sant' Apollinare at Classe, or describing combined personal experiences he had in other churches besides. It is not impossible that he visited Ravenna in 545, 548 and 549 for the Sunday dedications of these three churches.

Thus far the intentionality of San Vitale has been tested by revealing aspects of the geometry and symmetry of both the material design and construction of the church and also examples such as the case of the column-bases and the dedication date in 548 have been highlighted to demonstrate how and when that symmetry makes theological and symbolic sense in the sixth-century. It remains now to investigate whether these intentions may also include aspects that are phenomenologically but not necessarily materially perceptible. For instance, some of the material aspects of San Vitale are intentional but hardly perceptible as phenomena. The inconspicuous measurement equivalency between exedrae height and chancel length as well as the reflective layout of column-base shapes[36] bear this out. On the other hand, are there identifiable phenomenological aspects of the church that do not readily reveal their material intentionality? Can the archaeological investigation of the material past also include those aspects that may be highly significant but are now materially missing? More specifically, can there be an archaeoacoustic approach to San Vitale in order to identify and reveal otherwise unknown and "lost" intentions, in particular, those aimed at creating a desirable acoustic space for the vocal necessities of various liturgical actions? The next chapters (5, 6 and 7) reveal and describe the results of the 2006 acoustic survey of the church in order to test whether the acoustic properties were intentional or if they were epi-phenomenal but nevertheless experienced and utilised in the sixth-century Ravennate liturgy.

Having revealed some of the intentional sacred geometry and symmetry of San Vitale's design, construction, dedication date, and the harmony and concord these together created for the purpose of suspending disbelief and instructing the Orthodox congregation, a relevant sound source (*Lux de luce*) has been identified and chosen for the acoustic measurements detailed in the next Chapter (5).

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[36] See Part 3.1.

CHAPTER FIVE

The Acoustic Measurement of San Vitale

Having discussed the background of Archaeoacoustics in Chapter One, where the emphasis of its practical application has hitherto been popular in studies of prehistory, and following on from the discussion in Chapter Two of the archaeological and historical context of San Vitale, this chapter elucidates the methodologies used to measure the acoustic properties of the church. Further calculations of the acoustic quality of the church and the overall results will also be discussed. The chapter is divided into four parts, detailing the four stages taken to understand the acoustics of the church and how they might better inform us of the dynamic social context of sixth-century Ravenna.

In order to achieve a virtual acoustic model of San Vitale four main stages were worked through.

Firstly (Stage One; Part 5.1), a three-dimensional virtual photorealistic acoustic model was constructed. Having completed the acoustic survey of San Vitale, upon my return to the UK and the University of Southampton, it was discussed and agreed[1] to give the option of constructing a 3-dimensional virtual model as part of the MSc Dissertation for Archaeological Computing; Virtual Pasts. Ioanna Giannakopoulou chose this option and, with my assistance, successfully completed the 3-dimensional model in autumn of 2007. In tandem with this, the acoustic team under Professor Lamberto Tronchin at Bologna also constructed a 3-dimensional virtual acoustic model of San Vitale (Dr. Mattia Nori, Dr. Ilaria Durvilli and Dr. Simone Garagnani), a working version completed by spring of 2008. While Giannakopoulou's model was ostensibly a study in the affects of natural lighting inside the church, the Italian model was both photorealistic and all the virtual materials were calibrated with acoustic attributes (reflectivity and absorbency). It was the Italian model into which the final convoluted vocalisation of *Lux de luce* was applied, and subsequent walkthroughs filmed. I provided advice and assistance for the construction of Giannakopoulou's model while also making suggestions to the Italian team on their model, especially ongoing discussions for the original windows and artificial lighting (hanging lamps).

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[1] By Dr. David Wheatley and Dr. Graeme Earle.

Secondly (Stage Two; Part 5.2), the notation of *Lux de luce* was prepared for vocal performance in San Vitale. I was solely involved in designing and implementing the 13 methodological steps of this stage, utilising my background in music technology.

Thirdly (Stage Three; Part 5.3), San Vitale underwent an acoustic survey, including recording the singing of this *versus*. The data collected was collated and several acoustic phenomena were identified and mapped. With my own finances I initiated the acoustic survey, necessarily involving an acoustic team headed by Professor Lamberto Tronchin (University of Bologna), recommended to me by Professor Angelo Farina (University of Parma). With the valuable assistance of my supervisor Professor Simon Keay the appropriate permissions were granted for the survey: from Monsignor Guido Marchetti (Opera di Religione of the Diocese of Ravenna), Professor Maria Grazia Maioli (Soprintendenza per I Beni Archeologici dell'Emilia-Romagna), and Dr. Anna Maria Iannucci (Soprintendenza per I Beni Ambientali e Architettonici di Ravenna). Within a short three-week period immediately prior to the date set for the survey (April 30th 2006), I was aided by the immense generosity and "on the ground communications" of Professor Donatella Restani (University of Bologna Department of Musicology). On Professor Restani's recommendation I invited the female vocalist Dr. Maddalena Roversi to sing the Ravennate *versus* with me, which she keenly did.

Fourthly (Stage Four; Part 5.4), *Lux de luce* was sung again in an anechoic chamber with no reverberation information, in order to have a "dry" vocal rendering onto which San Vitale's reverberation could be convoluted. Dr. Matthew Wright at the ISVR (Institute of Sound and Vibration Research; University of Southampton) was instrumental in the success of this stage[2].

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[2] Also thanks to Dominic Barker for photo-documenting the ISVR recording session.

Part 5.1: Stage One –Virtual San Vitale

I will now briefly discuss my involvement in the creation of the photorealistic virtual acoustic model of San Vitale created at the University of Bologna (Nori, Durvilli and Garagnani 2008-present) in addition to the model by Giannakopoulou[3]. There were a number of tasks involved in creating a 3-dimensional virtual model of San Vitale, both the model constructed at the University of Bologna and that at the University of Southampton shared the following steps[4]:

1   Plans and sections published by Deichmann[5] were scanned and mosaiced in AutoCAD.

2   These plans and sections were then digitised

3   The digitised plans and sections were assembled into a single AutoCAD drawing (.dwg)

4   Metrical laser measurements I had taken inside San Vitale in 2006 were superimposed onto the Deichmann drawings.

5   Groups (layers) of architectural elements were created; for instance all the columns were created on a dedicated column layer.

6   After completion of constructing each architectural detail, from narthex to the main body of the church, the layers in AutoCAD were imported into 3DsMax.

At this point the steps to complete the lighting model by Giannakopoulou and the photorealistic acoustic model by Nori *et al* diverged. In the case of Giannakopoulou's model, in 3D Studio Max materials with calculated light reflection, refraction and absorption qualities were applied to the different architectural elements in order to render the effects of natural lighting within the church during the daytime. In the model of Nori *et al* further regimes of work followed:

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[3] This MSc dissertation project (Giannakopoulou 2007) was completed in early October of 2007 and focused on the effects of natural lighting within the church. Giannakopoulou and Nori had no communication, nor influence upon each other's work at this time. After completion of her MSc, Giannakopoulou, in early 2008 and from Athens Greece, gave some advice to Nori regarding candle lighting.
[4] I had much involvement in Giannakopoulou's model construction at Southampton, namely providing regular advice on how elements of the real church could be modelled. The details of the entire process can be referred to in Giannakopoulou 2007.
[5] Deichmann 1989.

A   A return visit to San Vitale was made in 2007 in order to take a numerous series of well-lit digital photographs of the interior surfaces.

B   These digital photographs were mosaiced and applied to the architectural elements of the virtual model.

C   The architectural elements, with mosaiced photographs, were applied with materials having calculated light and acoustic properties including reflectivity and absorption.

D   The anechoic recording of *Lux de luce* was convolved with San Vitale's measured Impulse Responses and applied to the model.

E   A further research trip was made to Ravenna[6], where each of the original window glass discs ('*tessere*' / *fensterverglasung*[7]) of San Vitale at Ravenna's National Museum were digitally photographed and the luminescence measured.

Figure 5.1.1: Virtual model of San Vitale (Giannakopoulou 2007[8]).

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[6] By Simone Garagnani on my advice to Professor Lamberto Tronchin.

[7] As a technical term for the glass window discs is not known, Garagnani and I decided on the term *tessere*. Deichmann (1976:Abb.81) calls them *fensterverglasung*. Cf. O'Hea 2006.

8 Thank you to Ioanna Giannakopoulou for permission to use images from her University of Southampton MSc Dissertation research (Giannakopoulou 2007).
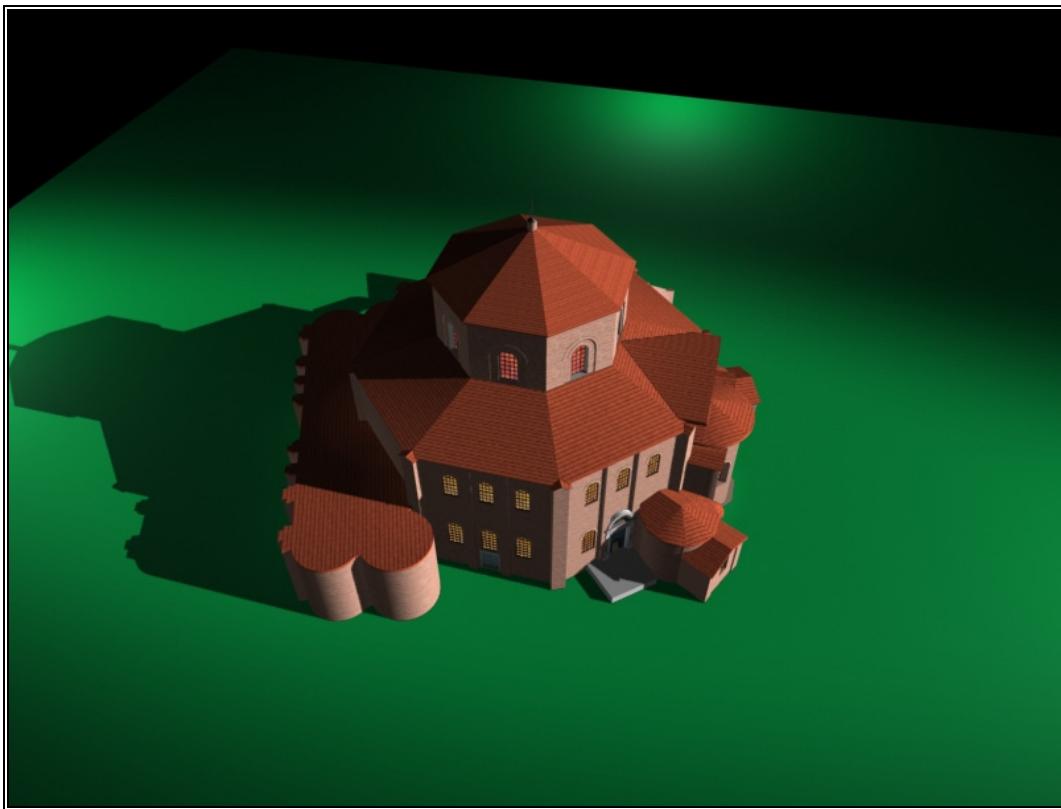
Figure 5.1.2: Virtual model of present-day San Vitale (Nori, Durvilli & Garagnani 2008[9]).

The major differences between the two virtual models are that Giannakopoulou's (Figure 5.1.1) is an attempt to show San Vitale as it originally was in the sixth-century whereas Durvilli & Garagnani's model is how the church is at the present, including, as seen in Figure 5.1.2, the modern entrance in the south wall. As the narthex was not of interest to the acoustic model, the northern and southern towers are not to their true height, whereas in Giannakopoulou's model the narthex is reconstructed with as much attention to detail as given to the main body of the church. Both models were created using AutoCAD and 3DsMax and both derive from the plans and elevations of Deichmann[10]. Therefore, both models are only as accurate as Deichmann's drawings, and this will remain problematic until a full standing building survey is performed. For example, the changes in height of the ground floor ambulatory ceiling is only given in section, the gradual and uneven sloping from south to north is only captured in two

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9 Thank you to Dr. Mattia Nori, Dr. Ilaria Durvilli and Dr. Simone Garagnani for permission to use images of their model.
[10] Deichmann 1989.

measurements in Deichmann's section drawing. Giannakopoulou's model benefits from the additional measurements I took with laser meter in 2006.

The most important difference between the two models is the reason behind building each of them; Giannakopoulou's was constructed to demonstrate and understand the natural lighting effects within San Vitale (Figure 5.1.3) paying particular attention to the original architectural design and building materials with corresponding characteristics of reflection and diffraction. This was ostensibly a visual study of how natural light and shadow played throughout the church interior during the course of the daylight hours.

Figure 5.1.3: Natural light rendered view of main altar seen from the *matroneum* (Giannakopoulou 2007)[11].

On the other hand, the photorealistic acoustic model of Nori, Durvilli & Garagnani (Figure 5.1.4) was ostensibly constructed to create a virtual acoustic space into which the calculated, convoluted reverberation of San Vitale could be applied and

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[11] The light render virtual time was set at 12 o'clock noon on April 19th, 548, the day of San Vitale's dedication. The view is the same as the female position shown in Figure 4.2.13 and 4.2.15 in Chapter Four.

demonstrated. This acoustic premise was complemented with equal attention to the surfaces and acoustic materials overlaid with high-resolution digital photographs, therefore giving both a visual and an acoustic virtual reality to the model. However, this model was a replication of the present day state of the church, including later alterations.
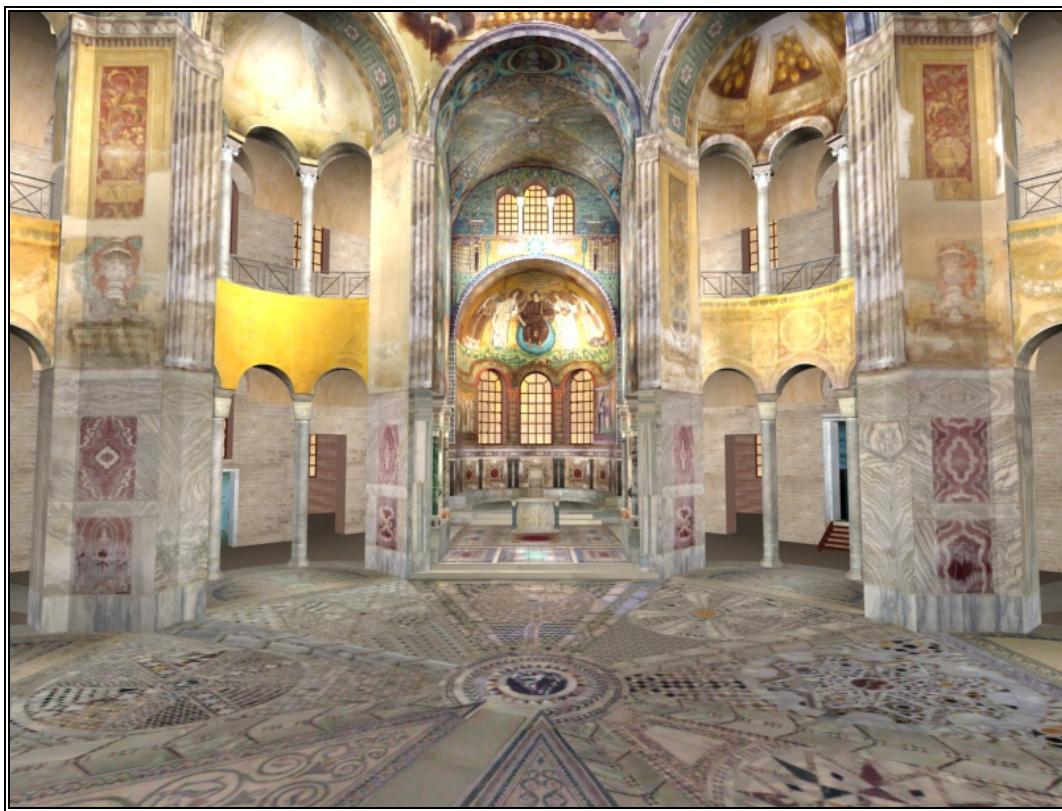
Figure 5.1.4: Virtual photorealistic acoustic model interior (Nori, Durvilli & Garagnani 2008).

Once the acoustic model was complete, a short fly-through video was edited (the video is in Appendix E7), including the convolved recording of me singing *Lux de luce*. The video was ostensibly the achievement of the acoustic team at Bologna[12] and therefore the church is visually treated as a performance venue for concerts of choral music. The presence of singers standing before the altar, in suits, bears no relationship to the aims of this present research. The narthex is ignored and modern doorways are instead used for the entrances for the video. Additionally, the camera does not explore the *matroneum*, left un-peopled. The video is therefore a simulation of present conditions but shown used as a concert hall rather than a liturgical space. Nevertheless, what the video

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[12] The video credits: Tronchin, Durvilli, Tarabusi, and Knight 2008.

does offer is a glimpse of how the church is spatially experienced and the correct reverberation on the sung *Lux de luce* provides a good starting point for further interest in Ravennate chant, centrally planned congregational spaces, sixth-century 'atmosphere' and makes the church academically accessible.

Further to the construction of these two virtual models it was important to convert their metric scales into the original measurements so that the underlying sixth-century logic and symmetry of the church could be understood. On April 30th of 2006, during the acoustic survey, I measured key distances within San Vitale using a laser distance meter with a range of 100 metres. This set of measurements has not only provided verifications and amendments to those of the plans and section drawings by Deichmann but also provided a further data set of the original Late Antique measurements[13]. Table 5.1.1 shows the equivalencies of the Roman units of measurement[14].

Actus	35.500m / 120ft
Pertica	2.960m / 10ft
Passus	1.480m / 5ft
Gradus	.740m / 2.5ft
Cubitus	444mm / 1.5ft
Pes	296mm (29.57cm) / 1ft
Palmus	74mm / 1/4ft
Digitus	18.5mm / 1/16th ft
Uncia	24.66m / 1/12th ft

Table 5.1.1: Roman measurements converted to Metric and Imperial.

As previously discussed in Chapter Three, some of the geometric relationships, equivalencies and similarities of measurements in the architectural design of San Vitale have been identified. Two important discoveries have been made due to these measurement conversions; firstly, the height of the *exedrae* (ground floor to concave ceiling) is equal to the length of the chancel and apse together. This illustrates the logic behind the design: eight upright elongated 'arches' set about an octagonal plan, and the eighth laid down, effectively translating the elevation onto the floor plan. Secondly, the

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[13] For at least this particular reason I thank my father Daniel J. Knight, a retired Chief Draughtsman and Electrical Engineer formerly employed for 35 years at SIHI Pumps (Siemen & Hinsch), Guelph, Ontario, Canada. He keenly helped me calculate these series of conversions.
[14] A very useful table of measurements is provided by Campbell (2000:482, Appendix 8).

identification and significance of the two superimposed *actus quadratae* on which the entire design and scale of the church is based has only been revealed by performing these conversions. These reconstructions of the Late Antique design and survey stages of constructing San Vitale are best aided by seeing the original measurements. Completing the application of these conversions to every architectural element of the entire church would be of great benefit but well beyond the scope of the present research.

In order to properly simulate the sound conditions during the sixth-century, the physical properties, for acoustics and lighting, of the ancient window-glass have to be considered. For this reason a measuring campaign began in 2008 on the original fragments of glass, conserved in the National Museum in Ravenna (see Appendix D.1). The measured luminescence data was afterwards used during the calibration and modelling of the church. Some examples of stained glass windows were reconstructed and utilised throughout the virtual photorealistic acoustic model of the church.

An historical investigation has also occurred to reconstruct some architectural aspects of the church during the sixth-century, with regard especially to its original lighting. Candles and hanging glass and metal lamps are a likely solution for lighting San Vitale but the exact placement is not known. For the expedience of completing the photorealistic acoustic model candelabra and wax candles were placed at the altar. One solution for positioning the hanging lamps could be investigating Greek Orthodox churches where they are hung as chandeliers from the centre of the dome[15].

Other original elements of the church do not appear in either of the virtual models and await further investigation. For example, the chancel screens (Figure 5.1.5 below) have been removed in the last century and require consideration when discussing the visibility of the liturgical actions at the altar during Mass, who can see the Bishop seated in his throne, and, conversely, who he is able to see. A preliminary suggestion is that the chancel screens[16], although pierced with interlaced design, may have been a visual obstruction to the male congregation on the ground floor whereas the female congregation in the *matroneum* had no difficulty seeing every detail of the liturgy.

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[15] Hanging lamps are positioned near the iconostasis wall, but that feature is a later development.

[16] Agnellus (42) states that the stone screens in the *monasterium* to the south of the chancel were replacements of the original screens of bronze (Deliyannis 2004:151). If this is true, and whether this also applies to the chancel screens, is at present unknown.
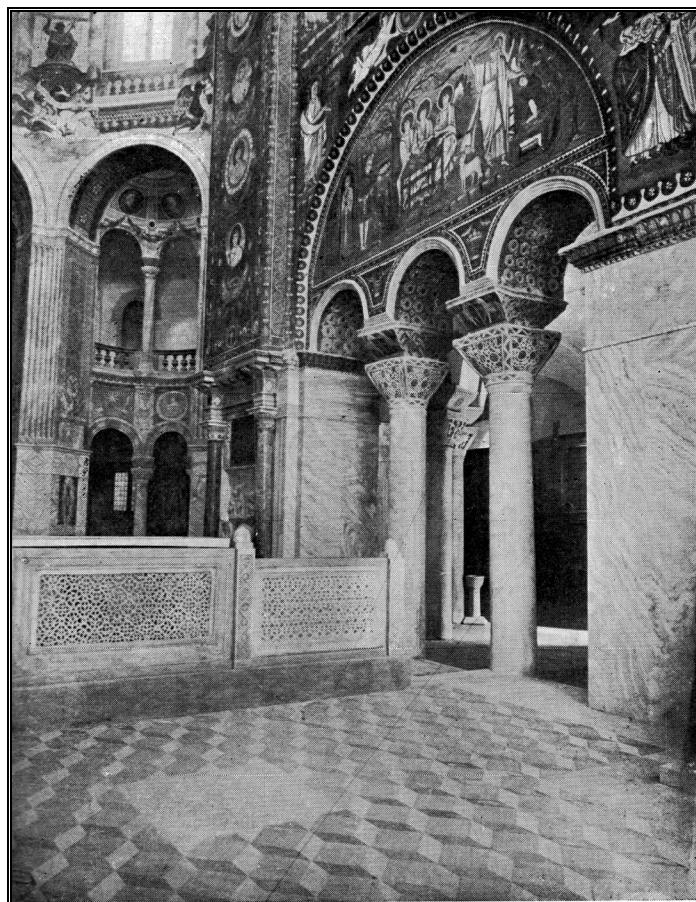
Figure 5.1.5: Photograph from c.1906 of San Vitale interior with chancel screens (Bumpus 1926:246)[17].

These ongoing experiments with the reconstruction of San Vitale's original windows, lamp lighting, and fittings (such as the above-mentioned chancel screens and hanging tapestries) are all investigations that will extend beyond this present work, and therefore will be mentioned below in Chapter Seven.

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[17] Thomas Francis Bumpus' Cathedral Series first edition of The Cathedrals and Churches of Northern Italy has this image. I have consulted his 1926 edition (with a map on the lining paper) in Hartley Library, Southampton and this scan comes from that volume. Bumpus, T.F. 1907 (1926 edition). The Cathedrals and Churches of Northern Italy. London: Werner Laurie.

Part 5.2: Stage Two - Preparing *Lux de luce* for recording

The *versus Lux de luce* has been identified in Chapter Four (Part 4.3) as an appropriate chant to sing in San Vitale in order to complement the acoustic survey of the church and provide the final acoustic photorealistic virtual model with a vocalised sound source. The preparation of this *versus* was subsequently solely for these purposes, while an accurate musicological rendering of the piece is beyond the expertise and intent of this work. In other words, the recorded performances of *Lux de luce* in this work do not in any way purport to be absolutely accurate to an original sixth-century performance nor meant to be held up to rigorous musicological scrutiny. Nevertheless the process did reveal aspects of interest for studies of early medieval, pre-Gregorian chant. Since it appears as though no modern attempt has been made to perform and record any of the ancient Ravennate chants, perhaps not even since as the ninth or tenth-century, the endeavour to sing this *versus* is important and therefore some observations will be offered regarding its musical shape.

It is worth stating at the outset that the aim of the following process was to provide a reference for performing *Lux de luce* in San Vitale, specifically as a sound source of human (male and female) vocalisation as part of the acoustic survey (Part 5.3) and subsequent placement into the acoustic model (Part 5.1). In no way was this version of the piece intended to be a purely musicological endeavour. Accordingly, certain liberties were taken in order to perform it more comfortably. Most importantly, I transposed the notation such that it fell easily within my own singing range, in the key of C Major. This decision informs all the observations made in Part 5.3 regarding what frequency ranges *Lux de luce* is comprised, however, through experiment and practice, it was found that this key was suitable, and therefore the observations have integrity. Even though the emphasis of performing this Ravennate chant was placed on the archaeological and acoustical investigation, nevertheless certain of the revelations about the piece, in relation to its context in San Vitale, may be of great interest to the study of pre-Gregorian chant.

A series of thirteen steps were taken, from the notation published by Levy in 1971 to an initial vocal stereo recording using a PC and VST Plug-ins. Although this entire process was PC-based, the resultant vocal recording was sufficient for rehearsal purposes

by Knight & Roversi in order to learn the *versus* and then sing it together on location in San Vitale April 30th of 2006, as part of the acoustic survey.

Step 1:
      The notation of the Ravennate version of *Lux de luce* was taken from Levy[1] (Figure 5.2.1 below).

Figure 5.2.1: Notation of the Ravennate *versus Lux de luce* (Levy 1971:48).

Step 2:
      The notation was entered into the Score facility of Emagic Logic (1998 PC Windows version)[2] and eventually into Logic Express version 8 (Figure 3.2 below).

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[1] Levy 1971:48.

[2] In 2005 Tom & Tehmina Goskar generously gave me a Mac to replace the PC they had previously given me and I purchased Logic Express 7. In 2006 I purchased a MacBook and in 2008 I upgraded to Logic Express 8; the present images are screen-shots from the MacBook using the latter version.

Figure 5.2.2: Converted notation of *Lux de luce* (Knight 2005-6).

Step 3:

Saved as a Logic song project the Beats Per Minute (BPM) was adjusted to 35, slow enough to give comfortable time for unhurried breathing and singing.

Step 4:

Ten bars at 4/4 time were created as ten separate MIDI sequences in Logic's Matrix page.

Step 5:

The length of each MIDI event was adjusted for breathing and singing.

Step 6:

The bars were coloured according to similarities. A piano MIDI instrument was chosen to rehearse to.

Step 7:

Each verse was learned and rehearsed individually. Each verse was then sung (Knight, November 25, 2004) and recorded individually as Wave files (.wav) using a Sure C606 microphone and Genius Sound Maker Value 5.1 Soundcard.

Step 8:

The Wave files were Normalised in Logic; applying a constant amount of gain to the audio waveform to increase the amplitude. This process also made it easier to visually identify the waveform and find the exact beginning and end[3].

Step 9:

The individual Wave files were opened in SoundForge[4]. Fade In was applied at the beginning and Fade Out at the end to "top and tale" the file to the vocalisation waveform. Parametric EQ[5] was used to De-Hiss the recording, cutting frequencies above 6Hz by 40dB.

Step 10:

The individual Wave files were opened in Cool Edit Pro[6], where several processes were applied. Through the Graphic Equaliser[7] a High Cut Filter was applied. Using a Parametric Equaliser the frequency of 250Hz was cut with a Low End Shelf. Also using the Parametric EQ, Hum & Hiss Removal was applied; at 336.12Hz, a width of 2Hz, levelled at –48dB.

Step 11:

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[3] Normalisation: http://en.wikipedia.org/wiki/Audio_normalization

[4] Soundforge is a Sony audio editing software package. The version being used in 2004 did not have non-destructive editing capabilities. Currently (2009), version 9 is available: http://www.sonycreativesoftware.com/soundforge

[5] Parametric Equaliser (EQ): http://en.wikipedia.org/wiki/Parametric_equalizer

[6] Cool Edit Pro was a powerful 'digital audio editor' by Adobe Systems. In 2003 the package was renamed Adobe Audition: http://en.wikipedia.org/wiki/Adobe_Audition

[7] Graphic Equaliser: http://en.wikipedia.org/wiki/Equalization#Graphic_equalizer

The Wave files were opened again in SoundForge where Fade In and Fade Out, from and to silence, was applied between phrases[8]. Graphic equalisation was used to cut low frequencies below 125dB by –60dB. A Multi-band dynamic De-Sibilance and Plosives removal application was used and Dynamic Compression[9] was set to 6dB. With the compression increasing the apparent volume, the master volume was then adjusted to compensate and decreased. Further, a parametric equaliser 200Hz High-pass Filter was applied to the compressed waves. Using a paragraphic equaliser[10] hum, rumble, and inaudible but present artefacts were removed. The audio wave files were then dynamically expanded[11] and the master volume was adjusted to within 6dB.

Step 12:

In SoundForge a TC Native Reverb VST (Figure 3.3 below)[12] was used to give an approximation of the shape of San Vitale as well as a predicted reverberation time; a 5.1 second reverberation time in a circular interior was applied to each of the Wave files. Following the acoustic survey of San Vitale, its' exact reverberation time value could then be entered either here in NT Native Reverb or Cool Edit Pro's Convolution Reverb[13] facility.

Figure 5.2.3: The TC Native Reverb VST Plug-in used in Step 12.

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[8] Editing the wave in SoundForge was unfortunately destructive. It wasn't until I got Logic Express on the MacBook that I could perform non-destructive editing.

[9] Compression: http://en.wikipedia.org/wiki/Dynamic_range_compression#Music_production

[10] Paragraphic Equaliser: http://www.sweetwater.com/expert-center/glossary/t--ParagraphicEqualizer

[11] Opposite to compression, 'an expander increases the dynamic range of the audio signal': http://en.wikipedia.org/wiki/Audio_level_compression

[12] TC Native Reverb VST: http://www.espace-cubase.org/anglais/page.php?page=avistcreverb

[13] Convolution reverberation: http://en.wikipedia.org/wiki/Convolution_reverb

Step 13:

      The stereo wave files, with applied TC Native Reverb, were re-imported into Emagic Logic onto two stereo tracks, verses alternating between tracks 1+2 and 3+4. The second (right) stereo wave was shifted 81 clicks to the right. In order to give a stereo-spread psycho-acoustic image for monitoring purposes, track 1 was panned to the left by 30° and track 2 to the right also by 30°, track 3 was panned to the left 15°, and track 4 right 15°.

      With the acquisition of a Mac and further purchase of a MacBook the *Lux de luce* file was imported into Logic Express, initially version 7 in 2007 and then, in 2008, version 8. The steps outlined above were rendered redundant on the Mac since VST Plug-ins are not compatible nor required as non-destructive editing with a wider selection of virtual studio processes could now be utilised. Nonetheless the original recording using the PC and VST Plug-ins remained useful for the purposes of rehearsal. The following Figures (3.4–3.16) are screen-shots from the song-file after being imported into the MacBook and the new Logic Express version 8.
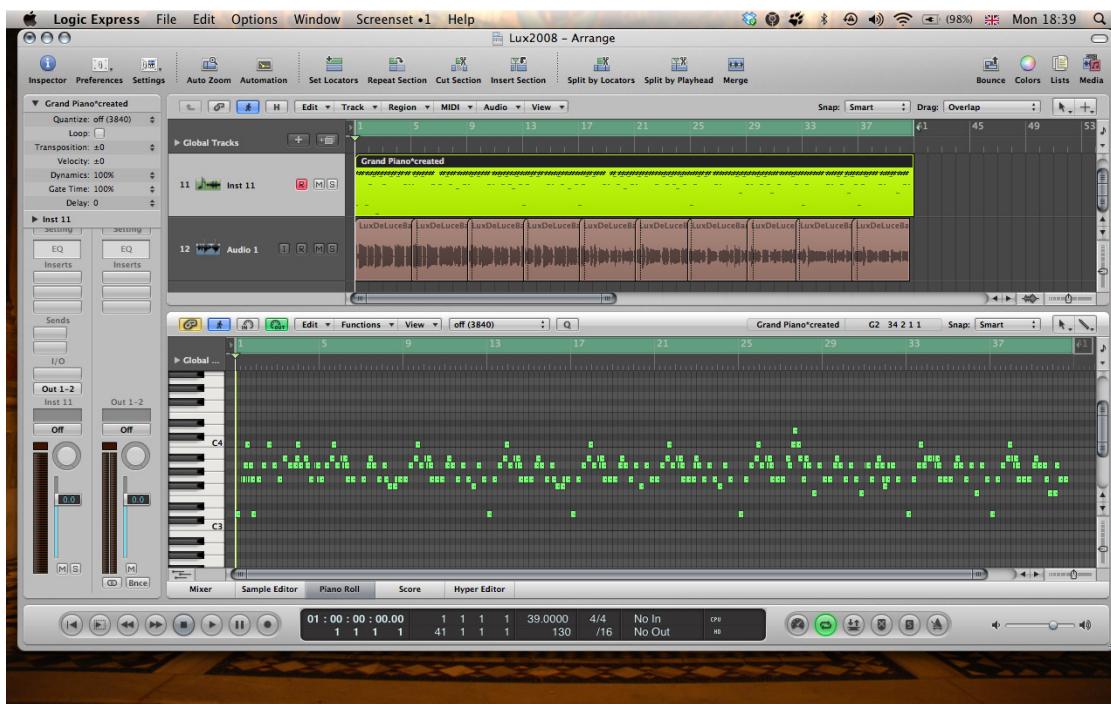
Figure 5.2.4: *Lux de luce* in MIDI events.
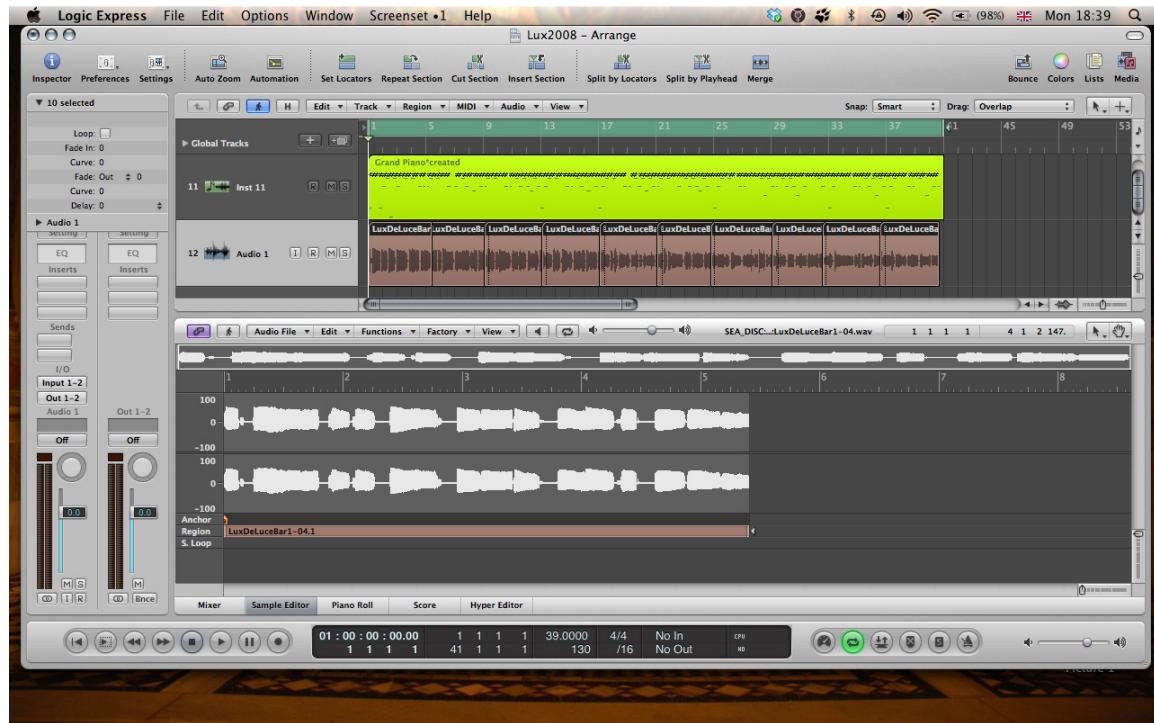
Figure 5.2.5: Waveform of the first verse of *Lux de luce*.

Figure 5.2.6: The ten separate MIDI verses of *Lux de luce*.
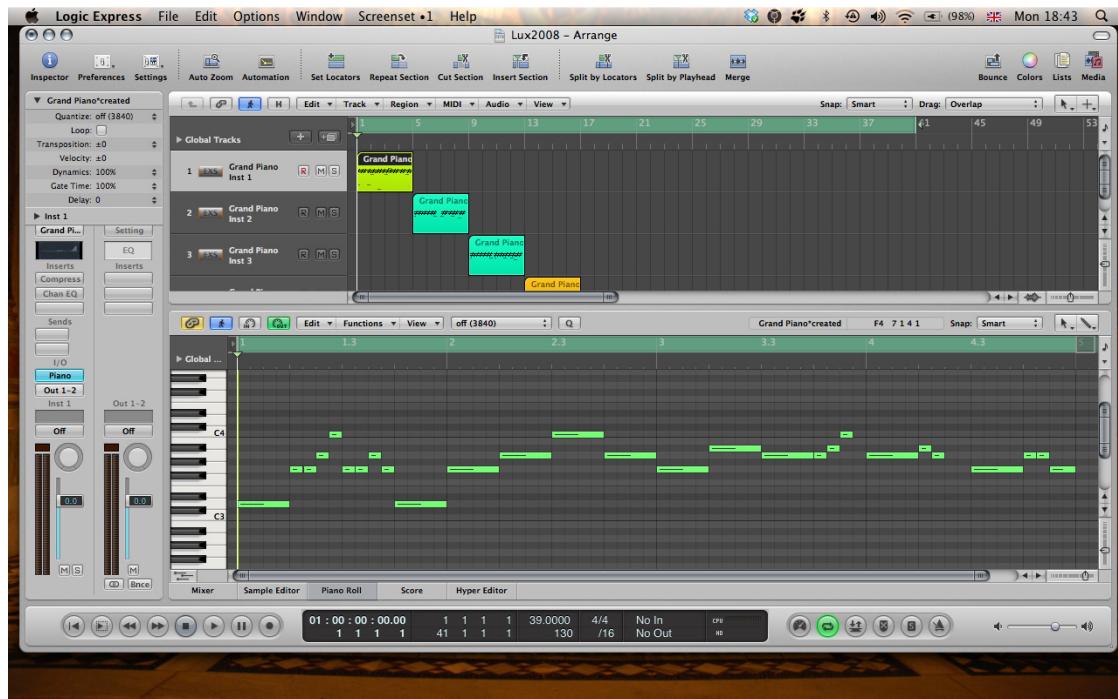
Figure 5.2.7: Detail of MIDI verse one.
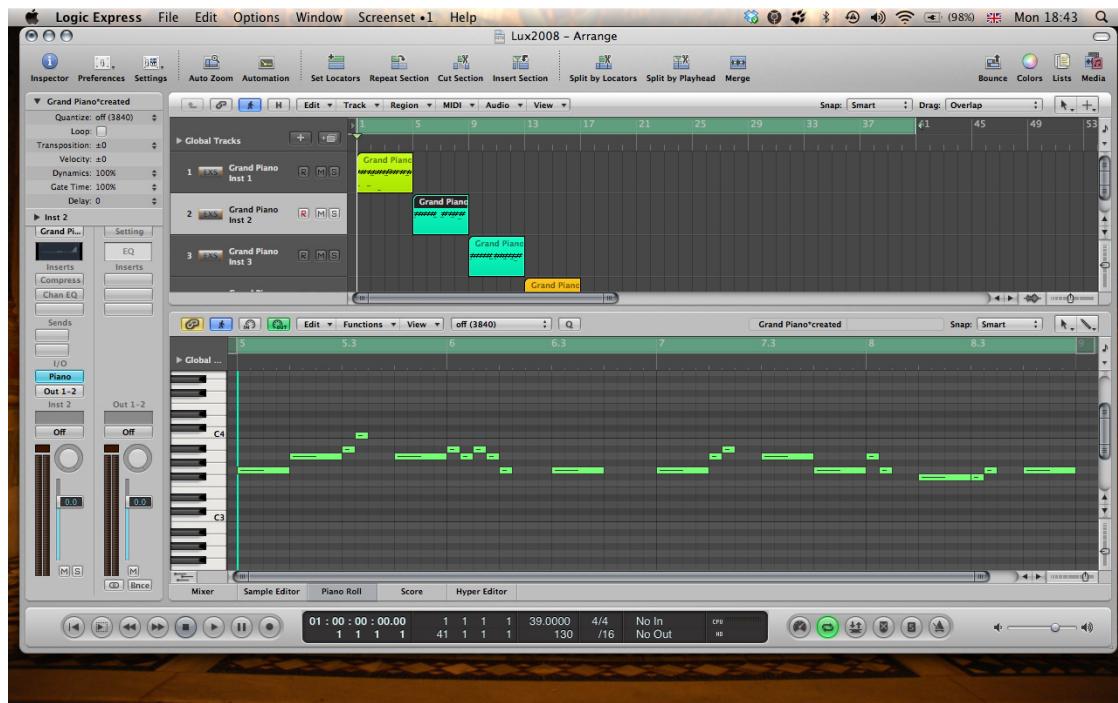
Figure 5.2.8: Detail of MIDI verse two.
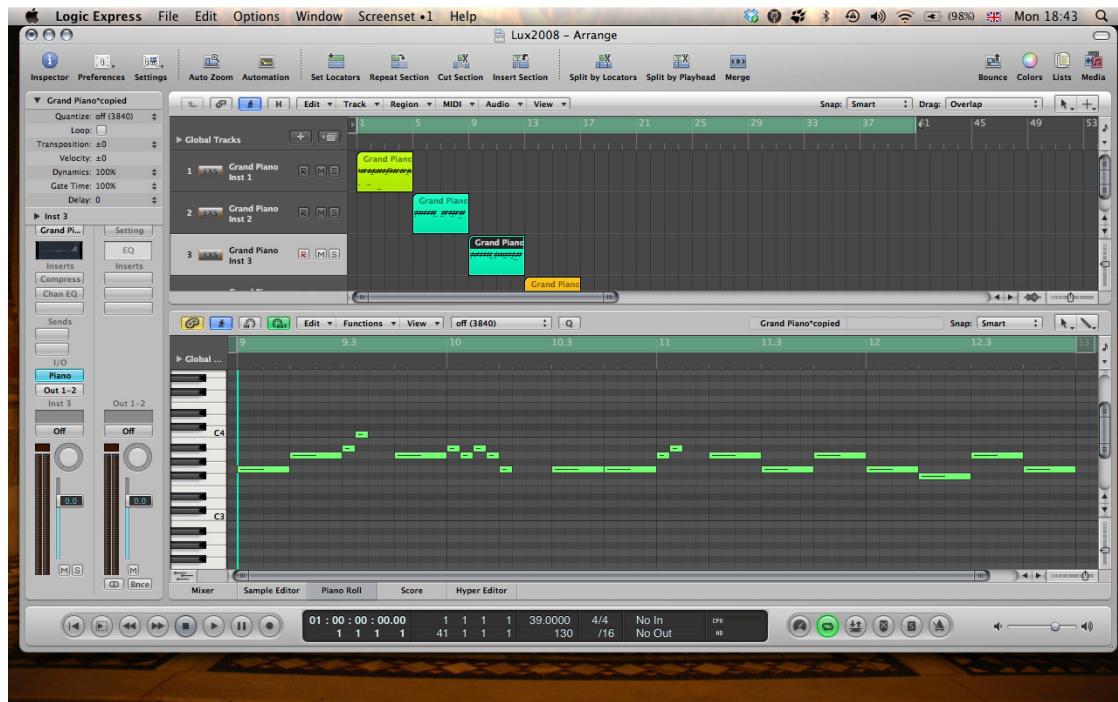
Figure 5.2.9: Detail of MIDI verse three.
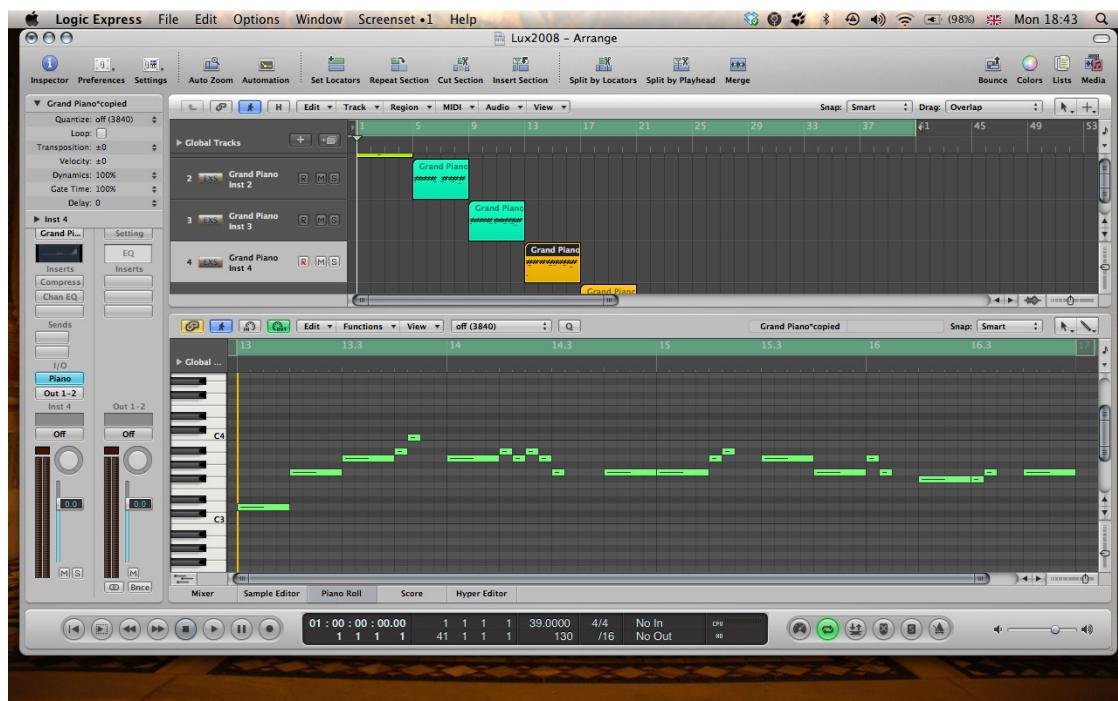
Figure 5.2.10: Detail of MIDI verse four.
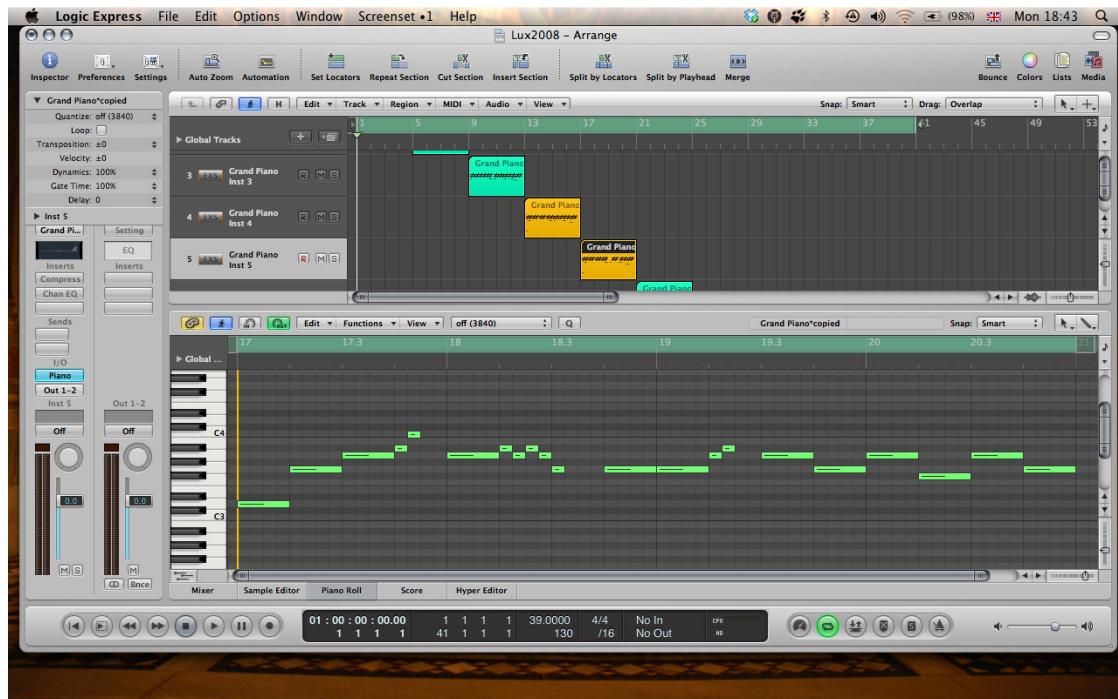
Figure 5.2.11: Detail of MIDI verse five.
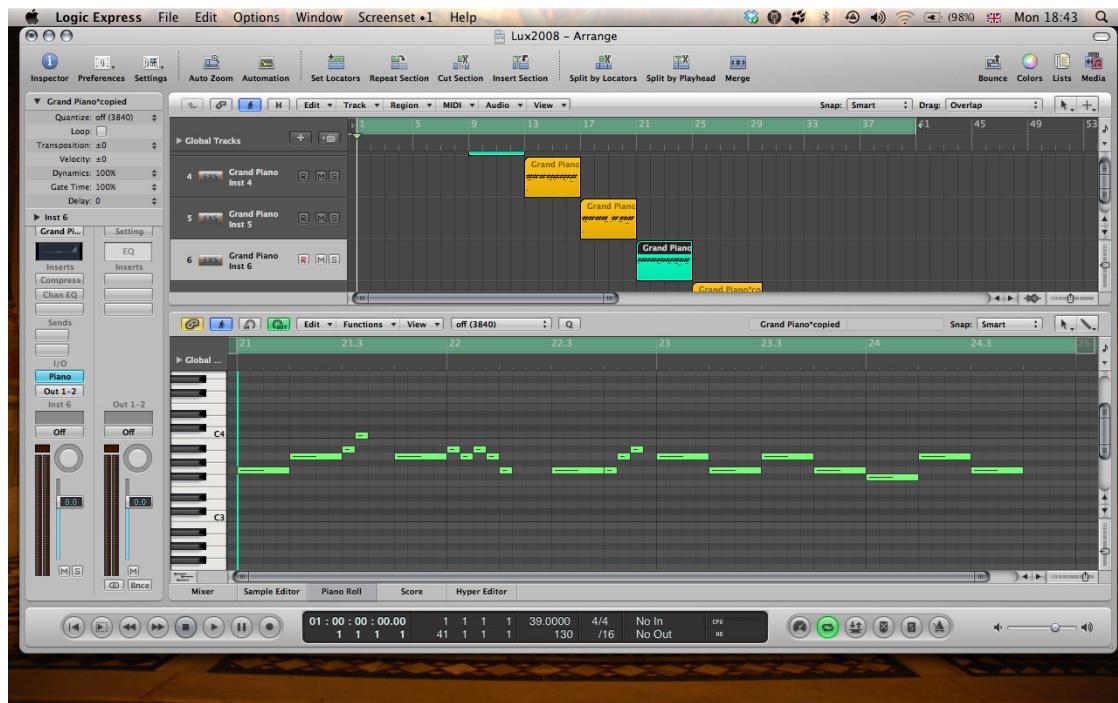
Figure 5.2.12: Detail of MIDI verse six.
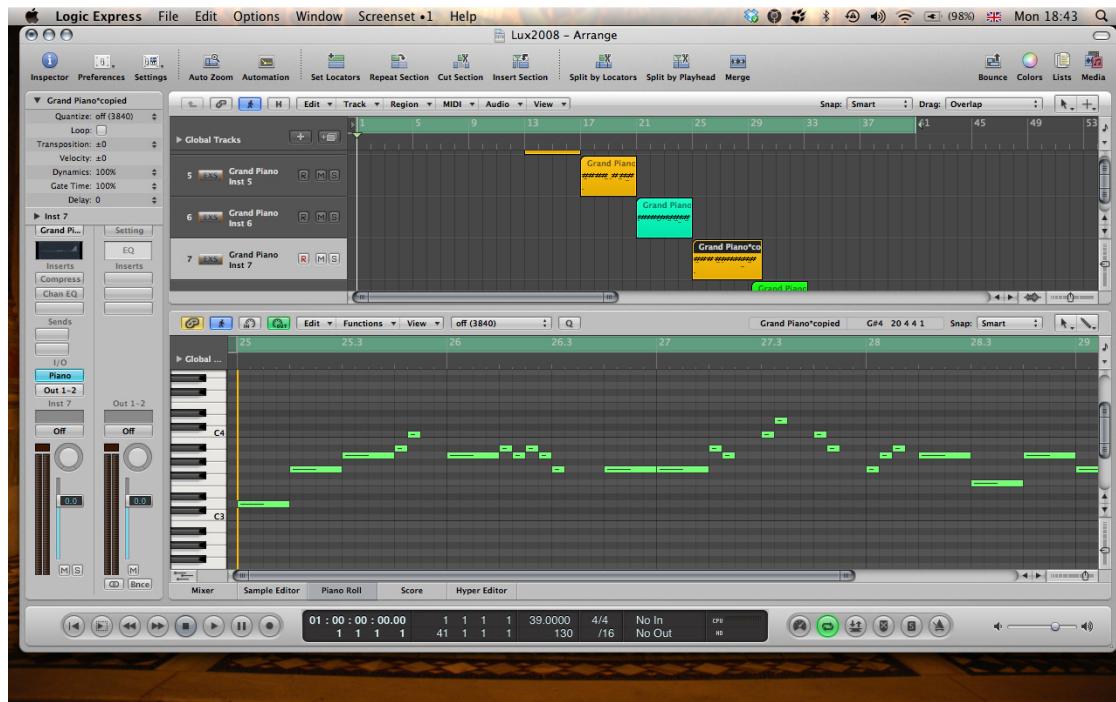
Figure 5.2.13: Detail of MIDI verse seven.
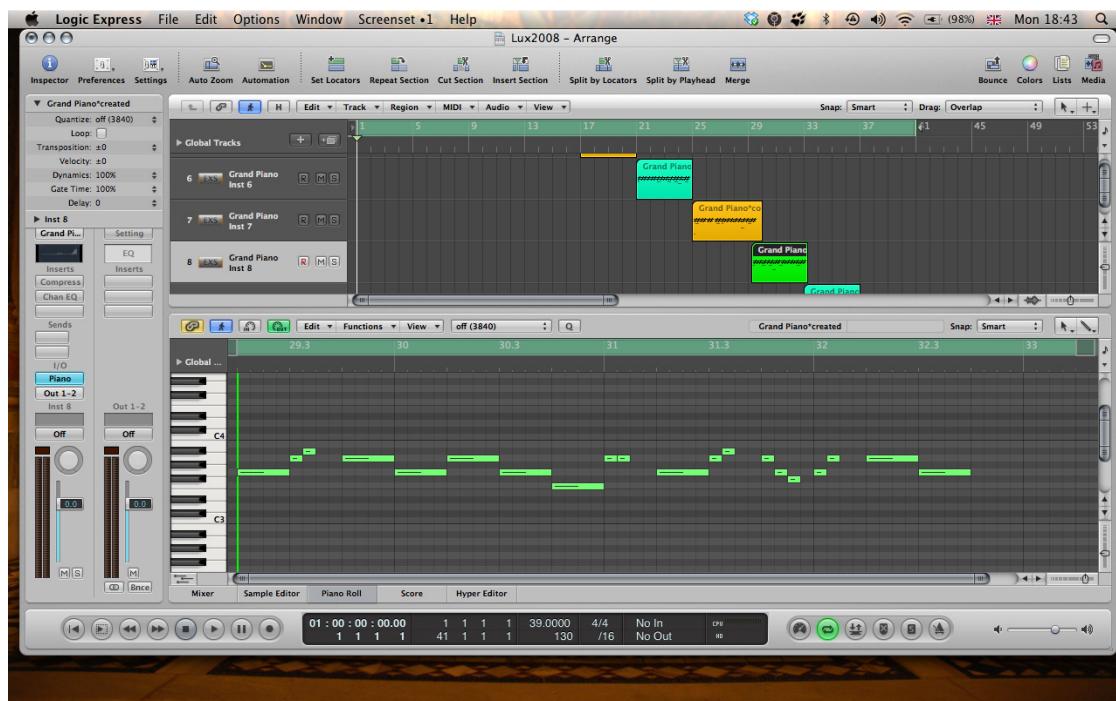
Figure 5.2.14: Detail of MIDI verse eight.
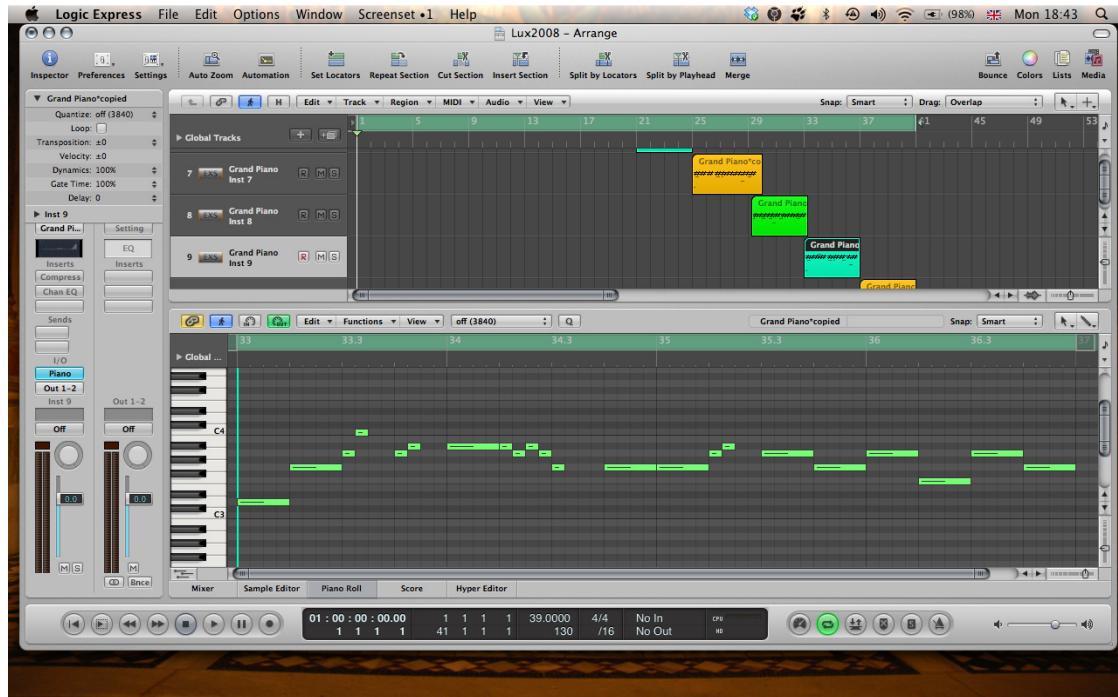
Figure 5.2.15: Detail of MIDI verse nine.
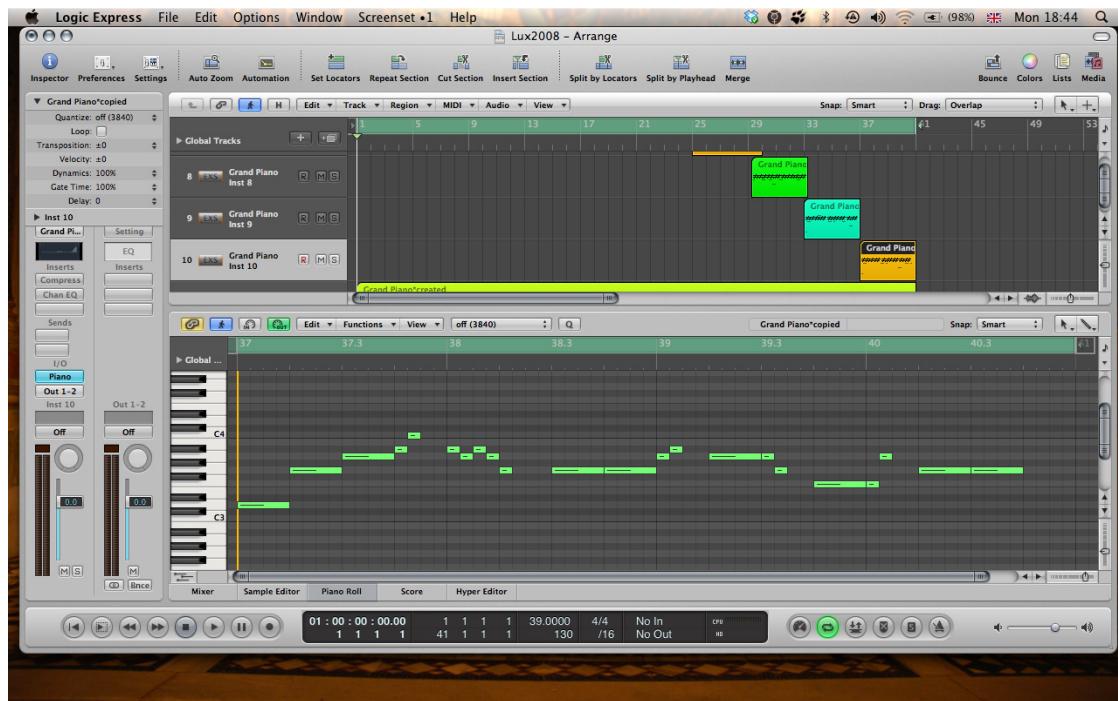
Figure 5.2.16: Detail of MIDI final verse ten.

As can be observed, verse three and six are musically exactly the same, and there is also some similarity to the sentiment of the words:

(3) *Victor ab inferni remeavit nexibus atris*

He came back triumphant from the underworld /
The victor has returned from the infernal regions[14]

(6) *Clausit et obscuris valvans aulamque maligni*

shut its dark doors and the hall of the spiteful one /
has closed the dark gates and the hall of the evil one[15]

This may be an artefact of the older layer of hymn the words were transplanted onto, and extended from eight to ten verses as suggested by Levy[16].

The amount of waveform processing described in the thirteen steps above were necessary at the time due to the low quality of the microphone available. Also, since all monitoring had to be done with headphones (in halls of residence) I had my hearing tested in Southampton, fortunately calibrated as above normal and able to identify acoustic phenomena within a broad aural range.

Distribution of the occurrence of notes sung through the ten verses of *Lux de luce*

	1	2	3	4	5	6	7	8	9	10
D4	0	0	0	0	0	0	1	0	0	0
C4	3	1	1	1	1	1	3	0	1	1
Asharp3	0	4	4	4	4	4	6	2	5	4
A3	10	7	8	7	8	8	8	9	8	7
G3	9	8	7	8	6	7	6	7	6	7
Fsharp3	0	2	1	2	1	1	0	1	0	0
F3	0	0	0	0	0	0	1	1	1	2
D3	2	0	0	1	1	1	0	1	1	1
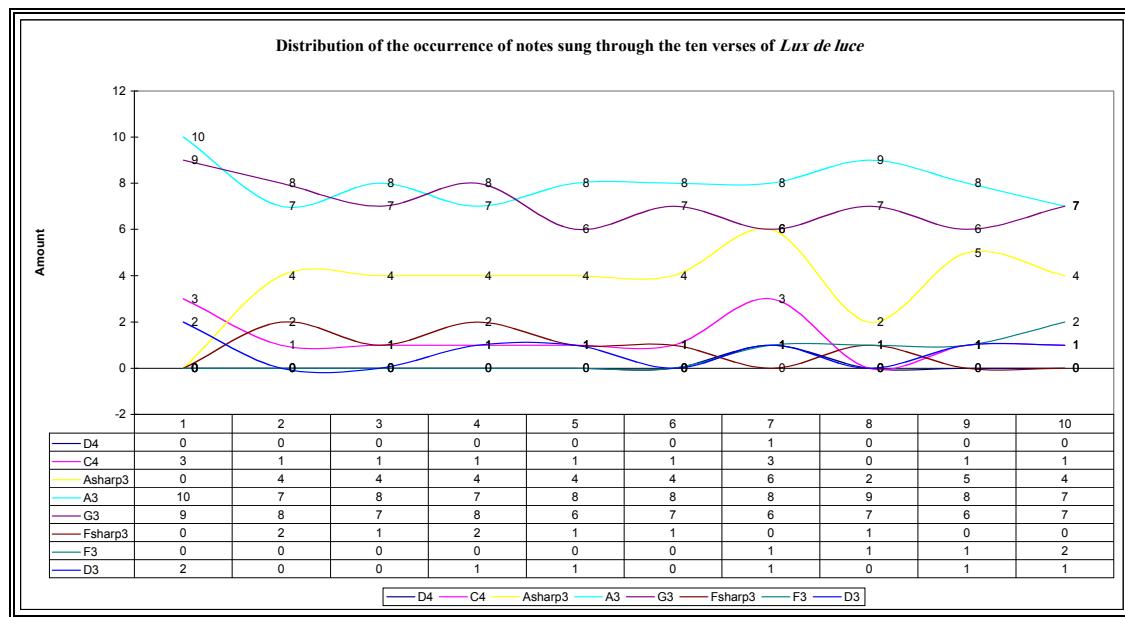
Chart 5.2.1: Analysis of note occurrence distribution in *Lux de luce* (Knight 2009).

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[14] The first translation is by Dr. Charlotte Tupman (unpublished, by personal request, 2009), and the second in Levy 1971:43.
[15] Ibid.
[16] See Part 4.3.
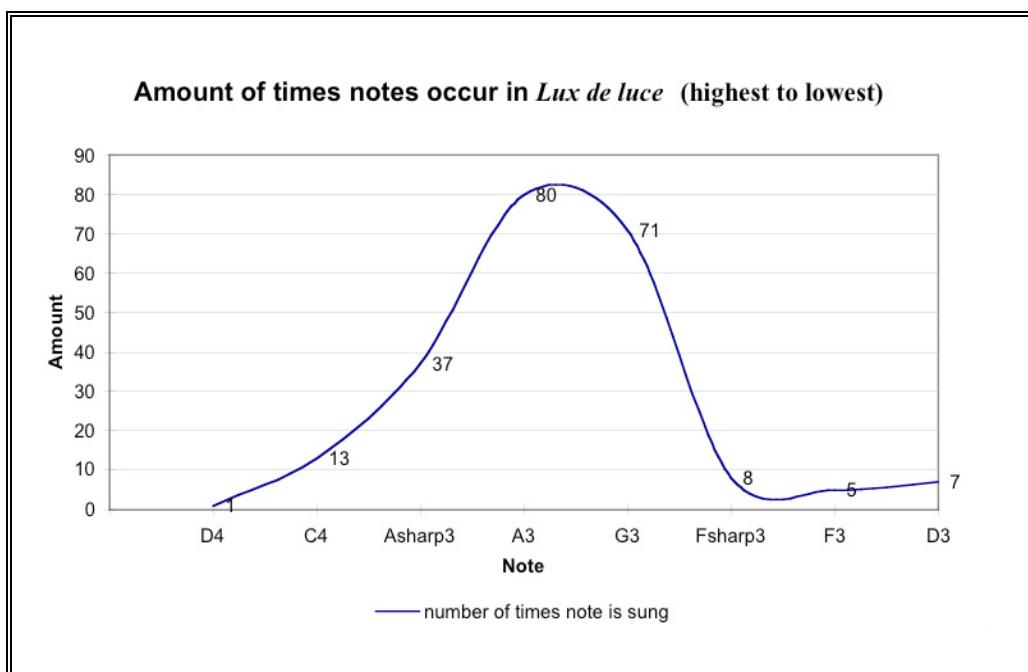
Chart 5.2.2: Frequency occurrence amounts in *Lux de luce* (Knight 2009).

Charts 5.2.1 and 5.2.2 above show the amount each note of *Lux de luce* is sounded throughout the piece. This is useful in demonstrating the predominance of certain notes, but, as discussed in Part 4.3, in the case of D4 which is only sounded once (and therefore statistically insignificant), a low percentage or number does not necessarily indicate less importance. The opposite has been shown to be true in Part 4.3 where D4 is sung at a significant and meaningful point in the Easter Vigil.

I made the decision to sing *Lux de luce* myself because although I do not have the credentials of formal voice training, I grew up with continuous informal classical training and, having a baritone voice, performed live on several occasions and professionally recorded[17]. With this background I am able to combine practical music engineering and production skills with performance. There is no evidence that sixth-century clergy or congregation had formal vocal training[18]. Evidently they sang through praxis, perhaps at least weekly attending Sunday Mass. Therefore, with an ostensibly untrained but

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[17] My mother Audrey E. Knight taught piano and voice for many years and has been vocal coach to my father, Daniel J. Knight (a baritone with a range of G below middle C to A flat two octaves higher). Their additive influence and encouragement on me is inestimable.

[18] The documented *schola cantorum* of Pope Gregory the Great is slightly after the dates considered here. *Schola cantorum*: http://en.wikipedia.org/wiki/Schola_cantorum_(papal_choir) (anonymous).

informed voice I was satisfied that I was adequately qualified to approach *Lux de luce* as a middle-aged male vocalist.

When the initial vocal recordings were completed in Emagic Logic, a stereo MP3 'bounce' (a recording of combined active tracks) was created and emailed as an attachment to the post-graduate music student Maddalena Roversi (University of Bologna) to rehearse to for the recording date in San Vitale (Part 5.3).

Part 5.3: Stage Three - The Acoustic Survey of San Vitale

Former work has examined the resonant frequency of ancient churches. A relevant example is shown in Figure 5.3.1 below, where the resonant frequency of a closed organ pipe is shown as twice the length of the pipe. From this it has been observed that 'long, narrow basilicas functioned much like organ pipes' although their complex interior space, including side aisles, may render the analogy inaccurate[1]. Nevertheless, it has been posited that since Sant' Apollinare in Classe, as an example:

> …with a length of 185 feet (112.8 meters)[2], has a resonant frequency of about 3.0405 cps. All musical tones consist not only of the basic note but also of a series of ascending harmonics, and the upper harmonic of this extremely low frequency is near F below middle C[3]. The triad up from F is A, meaning that if the priest chanted the liturgy using the harmonic intervals around A, the air…would soon vibrate on its inherent upper resonant frequencies, and the building itself would carry the message to the worshippers.[4]
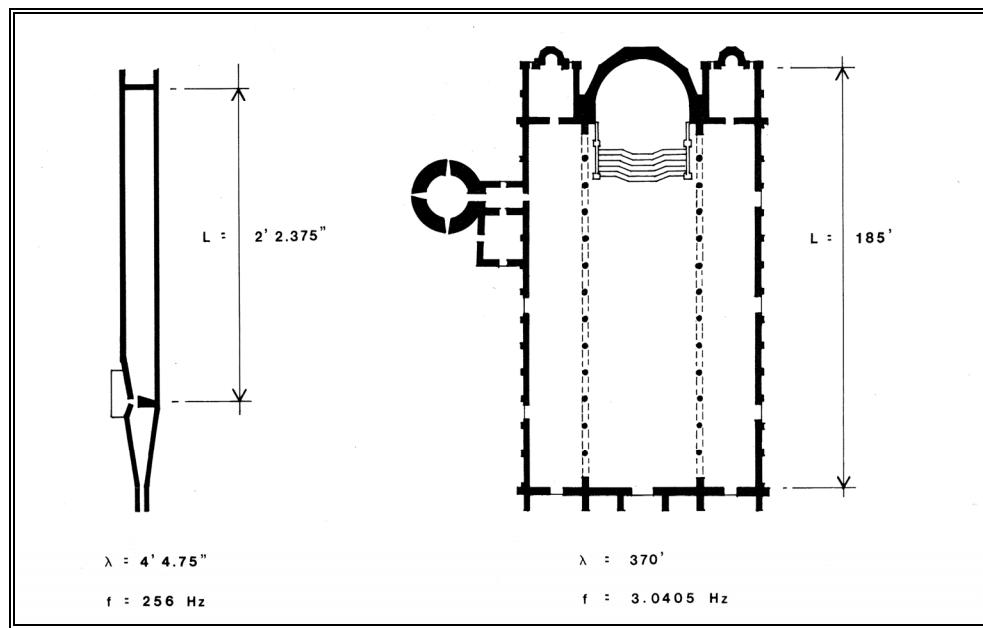
Figure 5.3.1: Comparison between a closed organ pipe and Sant' Apollinare near Classe (After Roth 1993: 97; Figure 5.8).

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[1] Roth 1993:97 and 103, footnote 3.
[2] This is incorrect; 185ft = 56.388m and 370ft = 112.776m.
[3] More accurately, the frequency is at F-3 and so its upper harmonic is also on F.
[4] Roth 1993:97.

The resonant frequency, or 'character', of an enclosed space can be calculated using the following equation:

$$\lambda = C/F$$

Where:

λ = wavelength (metres)
C = speed of sound in air (metres per second)
F = frequency (Hertz)[5]

The interior length (main chancel apse axis) of San Vitale is 43.790 meters (143.7 feet)[6], therefore λ = 87.580m (287.4ft), rounding this off to 88 metres, as shown in Table 3.2.1 below, San Vitale has a resonant frequency of 4 Hertz (87.580m=340.29m/s[7] / 4).

Wavelength (Feet)	576'	432'	288'	216'	144'	108'	72'	36'	18'	9'
Wavelength (Metres)	176m	132m	88m	66m	44m	33m	22m	11m	5.5m	2.8m
Frequency (Hertz)	2 Hz	3 Hz	4 Hz	6 Hz	8 Hz	12 Hz	16 Hz	31.5 Hz	63 Hz	125 Hz

Table 5.3.1: Wavelength to Frequency equivalencies (after Egan 1972 and 1988).

The resonant frequency of San Vitale may however not be of any great importance, since it is, by its very design, not the shape of an organ pipe as are longitudinal basilicas[8]. However, a comparison with the resonant frequencies of the other churches included in Ecclesius' building programme remains worthwhile.

This resonant frequency is higher than that of S Apollinare Nuovo and, while the priest in that church may have intoned on the harmonic intervals around A, in San Vitale the priest may have intoned around E, as C-2=4.09Hz and the triad (perfect third) above this is E. Importantly, this demonstrates that for optimum vocal resonance San Vitale resounds at a different tone from other contemporary Ravenna churches, and therefore

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[5] Egan 1988:95.
[6] See Appendix E for San Vitale measurements.
[7] Where the speed of sound at sea level is 340.29 metres per second, an appropriate value for Ravenna.
[8] It has been suggested by Professor Tronchin (personal communication May 11th and 15th, 2009) that San Vitale's resonant frequency, taking into account its perpendicular shape, could be best calculated using an Eigenvalue formula from modal analysis, or by using a Finite Element Method (FEM) software. 4 Hertz remains accurate as San Vitale's fundamental, the upper frequencies on C.

the character of the acoustics affords a noticeably different set of tones on which to most effectively vocalise. Using Deichmann's 1989 plan of San Michele in Africisco[9], the resonant frequency for this church can also be calculated. Having a length of approximately 17.75m (57.4ft), λ = 35.5m (116.5ft), and, therefore a resonant frequency of about 13Hz. This is around G-1 and the triad above this is B, the best tone on which to speak in this church. The same calculation for Santa Maria Maggiore is not possible as only the original apse survives successive rebuilds. For Sant' Apollinare at Classe, the fourth church in Bishop Ecclesius' construction scheme, the inner length is 55.5m (182ft), λ = 111m (364.2ft), and, therefore a resonant frequency of about 3.5Hz. This is around F#-3 and the triad above this is A#.

Church	Length	λ	Hertz	Tone	Triad
San Vitale	43.790m (143.7ft)	87.580m (287.4ft)	4	C-2	**E**
San Vitale (narthex)	39m (128ft)	78m (256ft)	5	D-2	**F**
San Michele in Africisco	~17.75m (57.4ft)	35.5m (116.5ft)	~13	~G-1	**B**
Sant' Apollinare at Classe	55.5m (182ft)	111m (364.2ft)	~3.5	~F#-3	**~A#**
Santa Maria Maggiore	~37m (121.4ft)	74m (243ft)	~5	D-2	**F**
S Apollinare Nuovo	56.4m (185ft)	112.8m (370ft)	3.0405 (3)	F-3	A
St. Croce	37m (121.4ft)	74m (243ft)	~5	D-2	F

Table 5.3.2: Resonant frequency comparisons of the four churches of Bishop Ecclesius' scheme, the originally Arian S Apollinare Nuovo and the fifth-century St. Croce (Knight 2009).

As seen in Table 5.3.2, the churches within Bishop Ecclesius' construction scheme (in bold) that share the same resonant frequency are the narthex of San Vitale and the longitudinal basilica of Santa Maria Maggiore. This suggests that if the Deacons

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[9] See Chapter 3, Part 1, Figure 3.1.6, page 78.

reading the Epistles and the Bishop or Priest speaking the Gospel and prayers of benediction found the upper harmonic and triad on which to intone, each church, aside from the two structures just mentioned, afforded very different tones on which to speak with amplitude. One noticeable relationship is between San Vitale and the formerly Arian S Apollinare Nuovo, E being a perfect 5th above A. The supposed original length of Santa Maria Maggiore, if similar to the extant length, is the same as the older St. Croce and therefore the tone on which to intone in each is F, but the shared length alone may not have been purely for an acoustic result. Nevertheless, they do share the same resonant frequency with the narthex of San Vitale, where funerals took place[10].

A tentative conclusion can be posed, the oratorical styles in each of these churches may have used the respective resonant frequencies and, if this is correct, then the intonation from church to church would differ, suggesting a Deacon and/or Priest of San Vitale would have to alter his intonation when requested to celebrate the Mass at any of these other churches. Whether the resonant frequency also afforded the development of a chant style specific to each or any of these churches is an important musicological question but well outside the aims of this present research.

Ray-diagram analysis of San Vitale

Following the assumption that women were singing in the *matroneum* and men were singing on the ground floor, an additional methodological tool for understanding the acoustic spatial characteristics of San Vitale is a ray-diagram analysis in order to see the direction and focus of sound reflections in relation to direct sound paths. Barrel vaulted and domed ceilings are notoriously "bad" for the requirements of modern concert venues[11].

On the ground floor the 'billowing' semi-circular plan of each exedra and their curved ceilings provide some surface undulation surrounding the inner octagon to diffuse and minimise the focusing of reflected sound[12].

While a full detailed evaluation of sound diffusion and scattering is only possible with a modified model, a worthwhile study for the future, for now a few ray-diagrams

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[10] Hart 2003.
[11] Egan 1972:161.
[12] Egan 1972:157.

can reveal how and where the curved surface of the dome focuses sound down onto the ground floor[13]. A ray-diagram is:

> …an acoustical analogy to the *specular* reflection of light where the angle of incidence ∠i of an impinging sound wave equals the angle of reflection ∠r, with angels measured from the perpendicular to the surface[14].

Taking the position of a female vocalist in the *matroneum*, a preliminary ray-diagram can be plotted showing the sound source to listener sound paths of both direct and reflected paths. Figure 5.3.2 demonstrates the focus of the reflected sound paths from a female vocalist, as she sings facing directly forward.
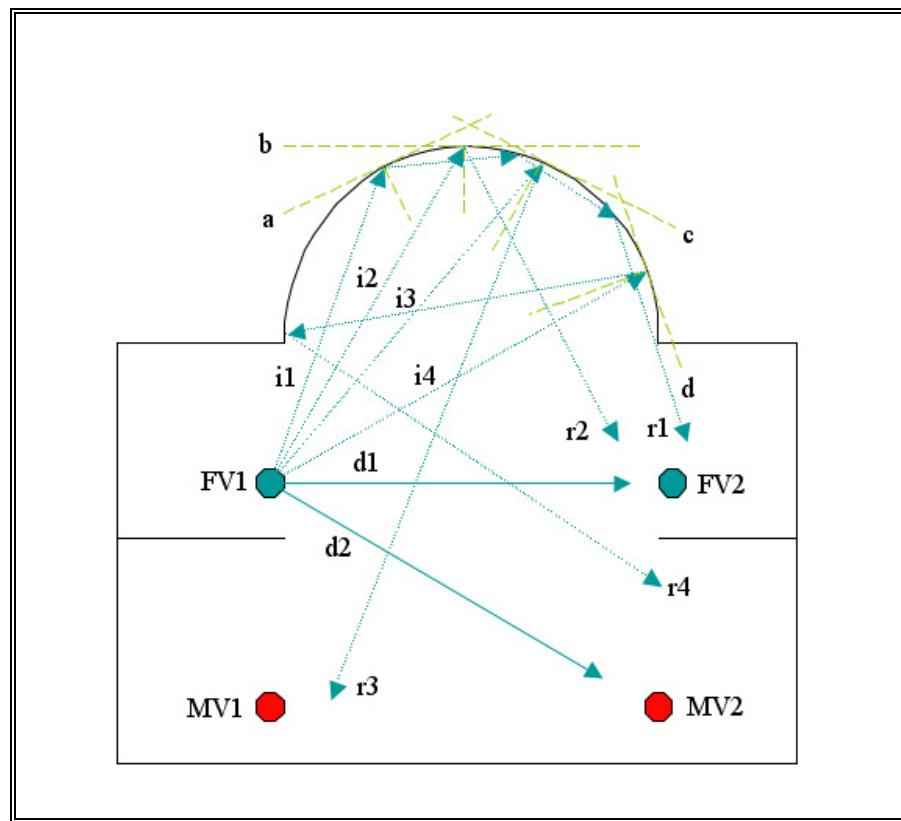
Figure 5.3.2: Predicted ray-diagram of selected direct and reflected sound paths from a female vocalist in the *matroneum* (Knight 2009).

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[13] 'Concave sound-reflecting surfaces such as barrel vaulted ceilings and curved auditorium rear walls [*or apse*] can focus sound, causing echoes. Because concave surfaces focus sound, they are also poor distributors of sound energy and therefore should be avoided where sound reflections are important' (Egan 1972:145) My Italics.
[14] Egan 1988:95.

Predictably, the direct sound path from one female vocalist (FV1) flows across to the opposite side of the *matroneum*, where another female vocalist (FV2) is singing. Another direct path is to the opposite male vocalist on the ground floor (MV2). If there were at least one vocalist per inter-columnar space of the *matroneum exedrae*, then a minimum of 21 vocalists could have been singing at any one time. With this minimum number of female vocalists singing in unison it can be safely assumed that there was enough sound for each vocalist to monitor the others and individually make adjustments to sing in unison, as in a choir. The focus of the reflected sound paths from near the apex of the dome, predictably descend towards the ground floor (*r3*), as 'sound reflecting from a concave surface is focused'[15]. The reflected sound path from the angle of incidence *i1* 'creeps'[16] around the inner surface of the dome until it eventually travels down to the opposite *matroneum* level, heard by a second female vocalist (FV2). By the time it arrives it is much weakened and dissipated but still present and therefore still an essential part of the acoustic characteristics of the church.
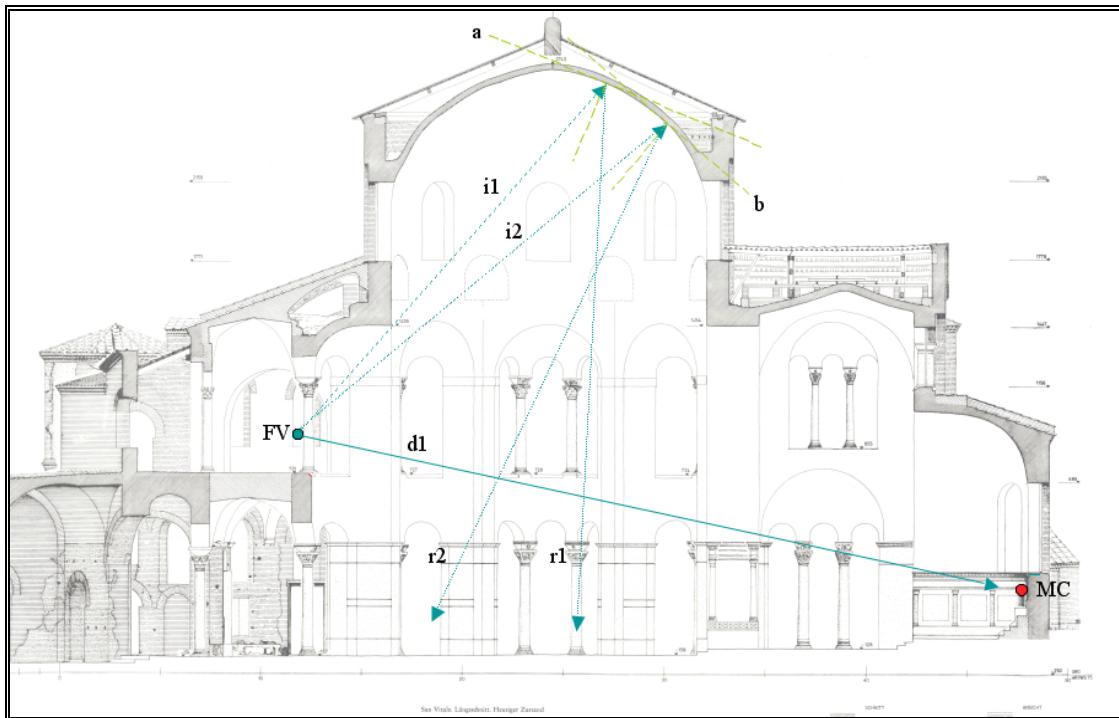
Figure 5.3.3: Ray-diagram of direct and reflected sound paths from female vocalist (After Deichmann 1989, Knight 2009).

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[15] SRL 1976:26.
[16] Egan 1972:157.

Figure 5.3.3 shows the direct (*d1*) and reflected sound paths (angle of incidence paths: *i1* and *i2*, reflected paths: *r1* and *r2*) from a female vocalist (FV) standing in the southwest ambulatory of the *matroneum*, directly opposite the Bishop (MC) seated in his throne. The reflected sound paths from the dome converge and focus on the inner octagon below. The angle of incidence and reflection are equal, related to the perpendicular surface lines *a* and *b*. The distances covered by the reflected sound paths are much greater even than when echo begins to take affect, as shown in Diagram 5.3.1 and Table 5.3.3 below.
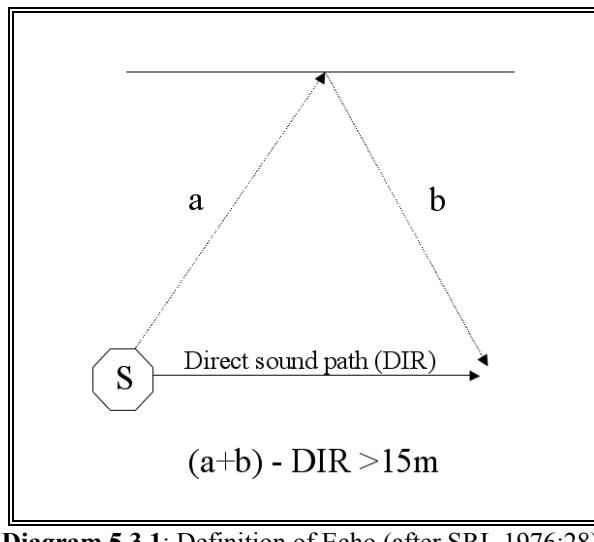
Diagram 5.3.1: Definition of Echo (after SRL 1976:28).

Sound Path Difference	Listening Conditions
<8.5m (28ft)	Excellent for speech and music
8.5m-12m (28-40ft)	Good for speech, fair for music
12m-15.24m (40-50ft)	Marginal
15.24m-20.7m (50-68ft)	Negative
>20.7m (68ft) or 15m (49.21ft)	Echo if strong enough

Table 5.3.3: Distances at which sound is heard (after Egan 1972:146 and SRL 1976:28).

A similar ray-diagram of the northeast-southwest section of San Vitale, in Figure 5.3.4, shows two direct sound paths from a female vocalist in the *matroneum* (FV1) and male vocalist below on the ground floor (MV1).
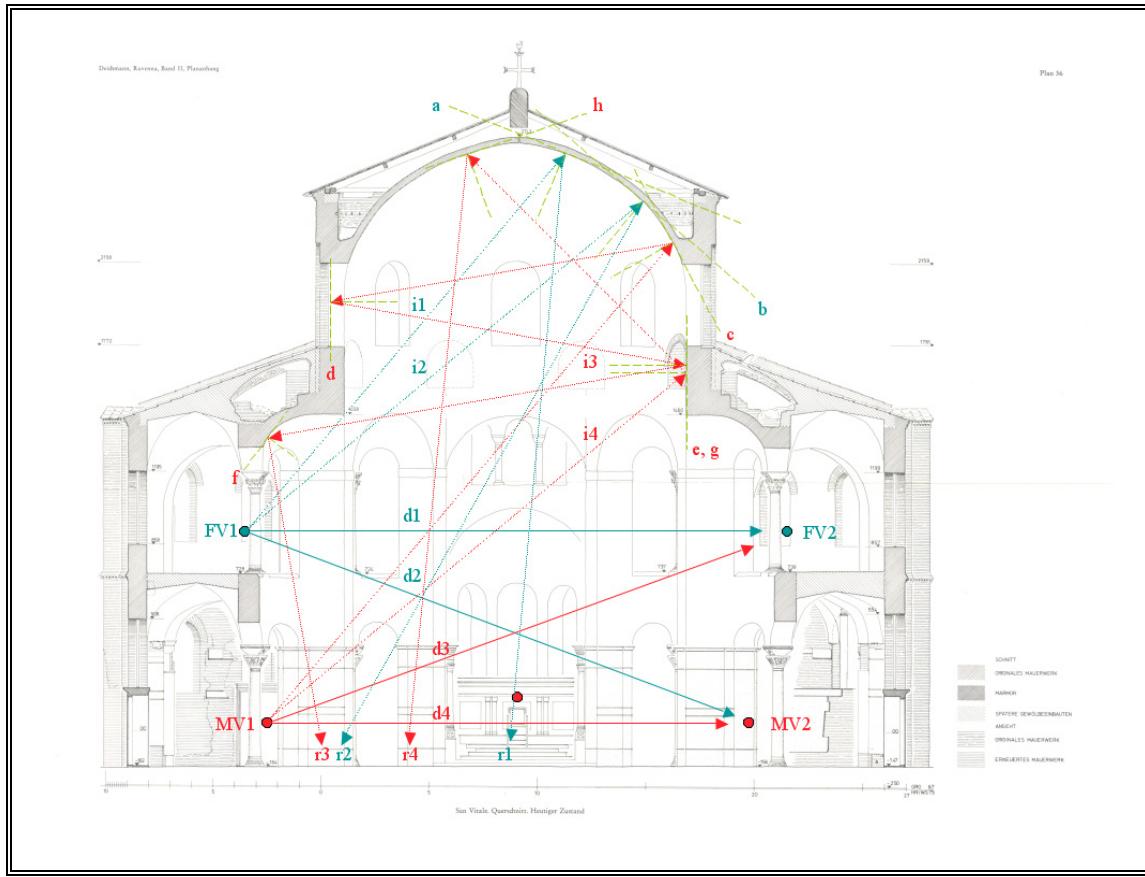
Figure 5.3.4: Ray-diagram of sound paths from a male (MV1) and female vocalist (FV1) (After Deichmann 1989; Knight 2009).

The reflected sound paths from the female vocalist *r1* and *r2* descend to the inner octagon, as similarly in Figure 5.3.3. The first example of the male vocalist's reflected sound path (*i3*) makes its circuitous way to an area near the edge of the inner octagon, as does the female *r2*. The same initial angle of incidence sound paths are the same for each and yet the female reflected paths *r1* and *r2* span a larger area. The Figure shows only the paths for the male and female vocalists (MV1 and FV1) in the northeast exedra of the ground floor and *matroneum*, if the reflected sound paths of the male and female vocalists standing in the southwest (MV2 and FV2) were included the full range of where these particular reflected paths would show the female to spread over the entire inner

octagon floor whereas the male is focused in a ring at the outer edge of this space. Many more ray-diagrams would have to be performed and at greater accuracy to reveal the full extent of all possible reflections, but for the present purposes suffice it to conclude that the female reflections are more direct, covering less distance than the male counterparts. Nevertheless, all the distances covered are far greater than 20.7m (68 feet) and, if a piece like *Lux de luce* were sung with full voice by several female and male vocalists there would be an immense amount of resultant echo.

Compensations for these echoes at high volume may have been made by adjusting singing to within a volume range such that echo was avoided, although this seems unlikely. Echo may have been a desirable phenomenon, a possibility discussed in Chapter Seven. Alternatively, if echo was undesirable then certain dampening and 'noise-control' methods may have been employed to lower their occurrence while at the same time still allowing for high volume singing. These contingencies are complex and require further study, but an outline of one in particular will be given.

Where the marble columns and wall panelling throughout the church are highly reflective surfaces for sound, the presence of hanging tapestries would noticeably change the church's acoustics, as they would absorb sound. If the mosaic representations of tapestry curtains hanging between columns[17] indicates the sixth-century presence of actual curtains, then these need to be factored into the acoustic analysis. As a conjecture, if curtains were hung between each of the exedra columns on the ground floor, then the ambulatory behind would very much be a quiet zone or alternatively a space where whatever sounds did occur here (for example, walking) were blocked from being perceived in the inner body of the church, both a visual and aural shield.

This much can be understood of San Vitale's acoustics from simple measurement and ray-diagram analysis, but for more detailed and informative information desired, a full acoustic survey was conducted.

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[17] Curtains hung between columns in churches are shown in the mosaic representations of Theodora and her entourage in San Vitale's chancel apse and also in the famous *Palatium* mosaic in S Apollinare Nuovo, Ravenna.

The 2006 Acoustic Survey of San Vitale

The details of San Vitale's acoustics were fully understood after the survey, which took place from 18:00 to 23:00 on April 30th of 2006. The methodology used for recording the raw acoustic data of San Vitale has been developed by Farina and Tronchin[18] and has been previously used to successfully measure the acoustics of ancient spaces including the Greek Theatre at Syracuse, Sicily, and the Greco-Roman Theatre at Taormina, Italy[19]. My involvement, aside from initiating, organising and coordinating the survey, singing *Lux de luce*, taking laser metric measurements of the interior and photographing the church and survey process, was primarily deciding the positioning of the dodecahedron omni-directional loudspeaker and microphones throughout the church. One major restriction influenced some of these decisions, namely San Vitale has only one accessible electrical power source, in the entrance space of the northern chapel (*diakonikon*). Therefore, in the southern area of the *matroneum*, the length of lead down to the main workstation dictated the restricted positions possible for microphone placement. This workstation was placed in the first exedra north of the chancel, a pivotal position between the power-supply and desired sound source and microphone positions. Figure 5.3.2 shows the positions at which the microphones, sound generator, and dummy head were placed in addition to where the vocalists stood. In the case of the female vocalist in the *matroneum*, she stood in the position later occupied by the decagonal sound source. Both vocalists had a clear, unobstructed line of sight of each other.

It is interesting that, despite this clear line of visibility between the vocalists, they had difficulty in hearing each other while singing. I found the local reflections from the exedra in which I stood masked my perceiving the reverberation throughout the church and also the voice of the female soloist. Compensated for this problem I waved my right arm at the tempo (35BPM). This lack of aural monitoring suggests there would have been greater success in hearing each other if there were more vocalists, males and females singing in unison throughout the ground floor and *matroneum*. It also demonstrated that those not singing but simply listening could perceive our two voices clearly, the difference in experience revealing a possible original scheme whereby a selection of

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[18] Tronchin & Farina 1997, Farina & Tronchin 2005. Professor Angelo Farina also kindly loaned us a dummy head: http://pcfarina.eng.unipr.it/
[19] Farina & Tronchin 2005:6, Table 2.

males and females performed, at specific times during the Mass, to the rest of the congregation who could fully appreciate the music and acoustic quality of the interior.

Alternatively, singing full chants or responsorial sequences (in unison or separately) may have been divided among select female and male vocalists if not across the entire body of the female and male congregation. It is speculation to suppose whether the full congregation sang in unison or not, nevertheless a third party present who we know did not sing would certainly have appreciated the full listening experience. This group, as already discussed in Chapter Four, Part 4.2, were the un-baptised catechumens, the non-Orthodox (probably Arian), and pagans, all of whom had access to the beginning of the Mass up until the sanctification of the gifts. The impact of the collective singing on those listening would no doubt have been striking but we have no exact way of understanding archaeologically the subjective level and import of the experience. All that can be said at present is that the performed musical elements of the Mass (and other occasions such as the Easter Vigil of which *Lux de luce* is a part) in San Vitale, the only centrally planned congregational church in Ravenna, would likely have produced a noticeably different effect upon listeners to that produced inside any other church of the city, whether Orthodox or Arian. In this sense, the combined symbolic and sensory meaning of San Vitale was special, a unique place where disbelief could be suspended.

The particulars of that uniqueness were no doubt characterised by the new way of physically dividing and positioning the male and female members of the congregation. We have also seen that the architecture of San Vitale is rooted in concepts of inclusion, unity and harmony[20] in ways that work together conspicuously and also inconspicuously. It would therefore not be unreasonable to suppose the acoustic character of the church to have contributed and reinforced, through spoken and musical vocalisation, these attributes.

However, not until a full female and male choir sing in unison on the two floors of San Vitale can any conclusive statement, albeit predominantly subjective, be posed regarding the full experience of being immersed in the church's psycho-acoustic space in the sixth-century. Nonetheless, the experiment successfully captured the acoustic

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[20] See Chapters Three and Four.

characteristics of San Vitale and singing *Lux de luce* "on site" allowed for further realism for the virtual acoustic model walk-through video.

The equipment used in the acoustic survey of San Vitale included an equalised, omni-directional dodecahedron loudspeaker, a Neumann dummy head and attached Soundfield microphone (MK V). The measurements were conducted by means of a logarithmic sine sweep with a range between 40Hz to 20kHz. The signals that were acquired by the microphones were stored in a 20bit 96kHz sample-rate Layla soundboard (Figure 5.3.8) and then post-processed in the acoustic laboratory at the University of Bologna[21]. The placement of the loudspeaker, microphones and vocalists are shown in Figure 5.3.5.
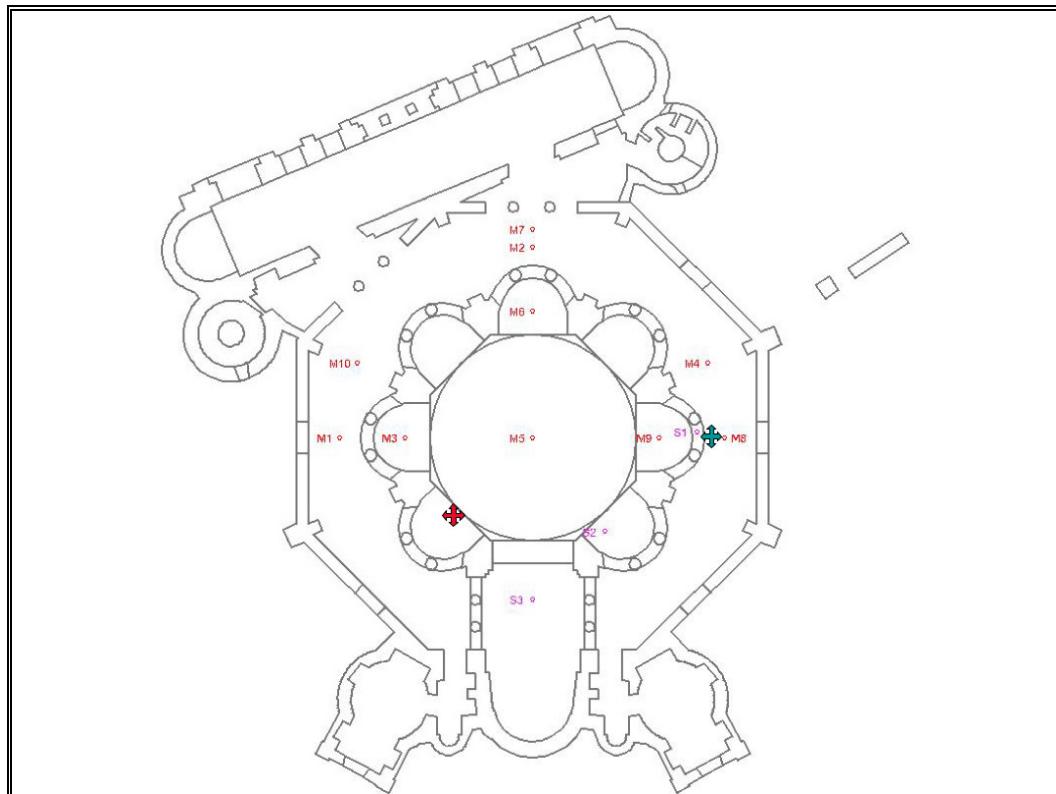
Figure 5.3.5: Positions of the microphones (M), loudspeaker (S), and vocalists April 30th 2006 (Tronchin, Knight, Durvilli, and Tarabusi 2007).

The binaural microphones were placed in seven positions on the ground floor and three in the *matroneum*. The omni-directional loudspeaker (Figures 5.3.6, 5.3.7, and

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[21] Tronchin & Knight 2008.

Table 5.3.4) was placed at two positions on the ground floor, one (S3) immediately before the main altar in the chancel, the second (S2) in the exedra immediately north of the chancel, and one position in the *matroneum* (S1), in the north east exedra. These three locations would represent the positions of celebrant at the altar, and male and female congregational members on the ground floor and in the *matroneum* respectively.

Positions of Loudspeaker	X	Y
S1 (in *matroneum*)	14.1	6.8
S2 (on ground floor)	7.5	0.7
S3 (on ground floor)	0	-5.7
Positions of Vocalists	**X**	**Y**
V1 (in *matroneum*)	14.1	6.8
V2 (on ground floor)	-5.7	1.0

Table 5.3.4: Positions of the loudspeaker and vocalists for the acoustic survey (Knight 2006).

The male vocalist[22] (red cross) stood in the exedra immediately south of the chancel and the female vocalist[23] (blue cross) at the same position occupied later by the loudspeaker S1.

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[22] The author.
[23] Dr. Maddalena Roversi (Department of Music, University of Bologna).
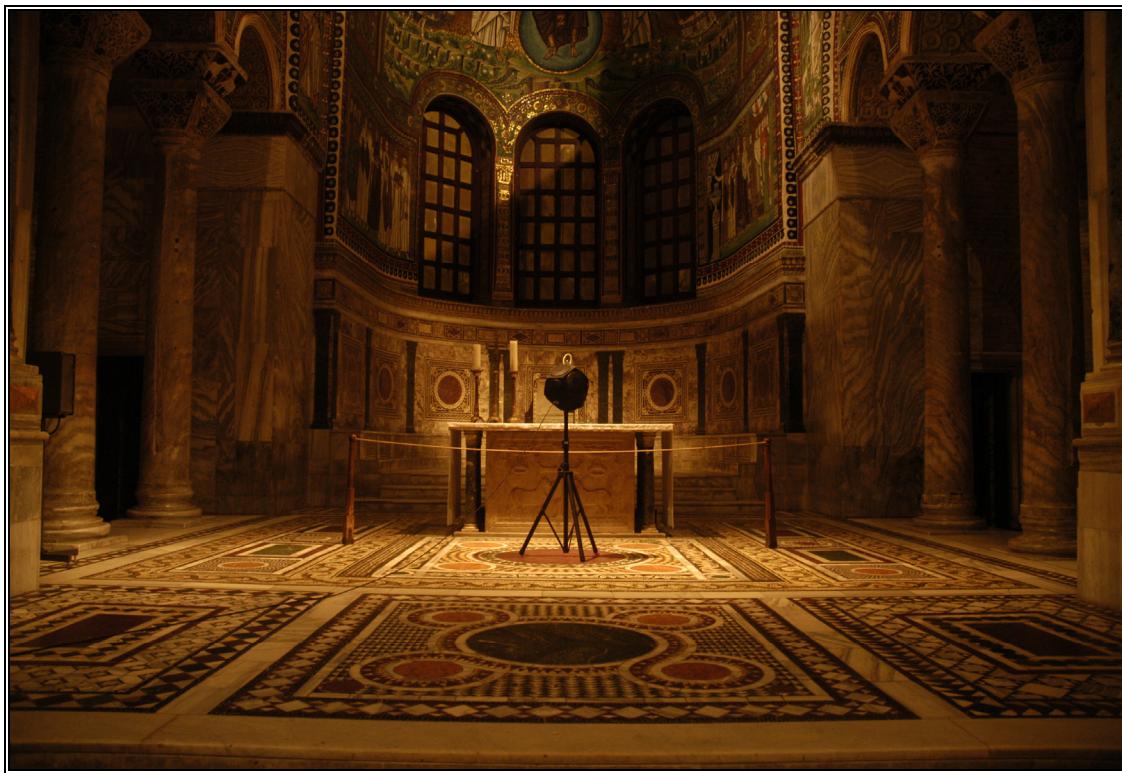
Figure 5.3.6: The dodecahedron equalised omni-directional loudspeaker at the main altar (Photograph by Knight 2006).
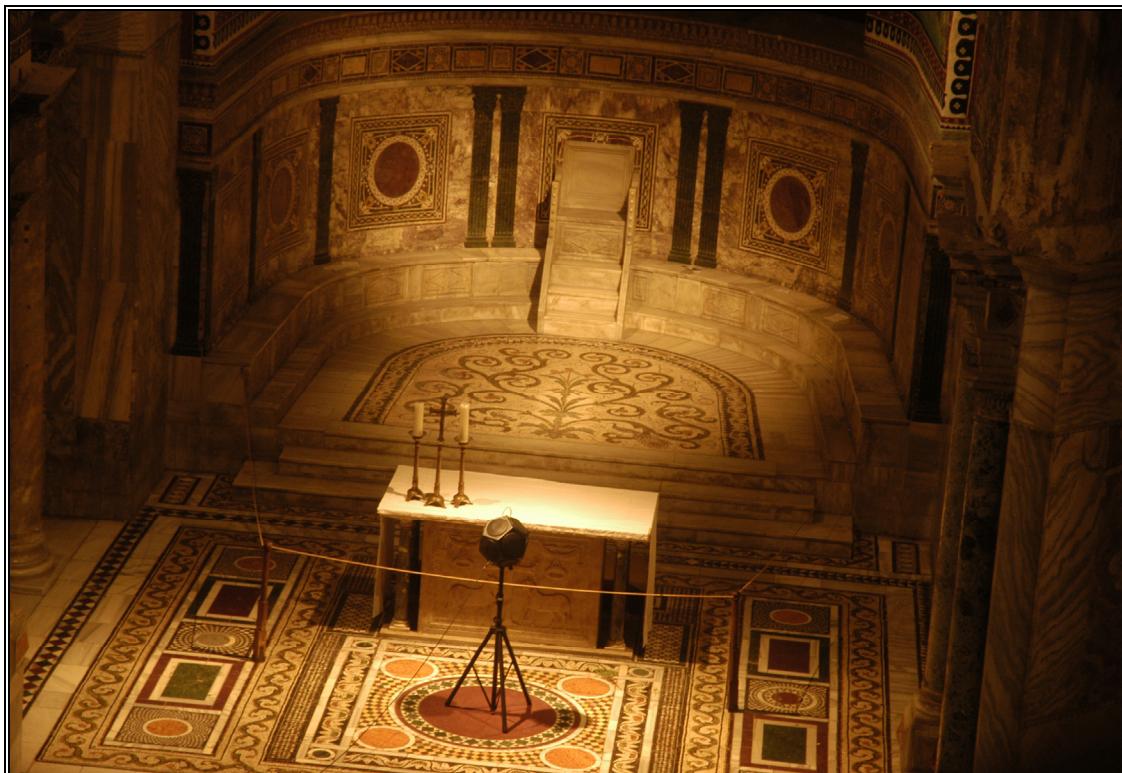
Figure 5.3.7: Dodecahedron omni-directional loudspeaker before the main altar, as seen from the *matroneum* (Photograph by Knight 2006).
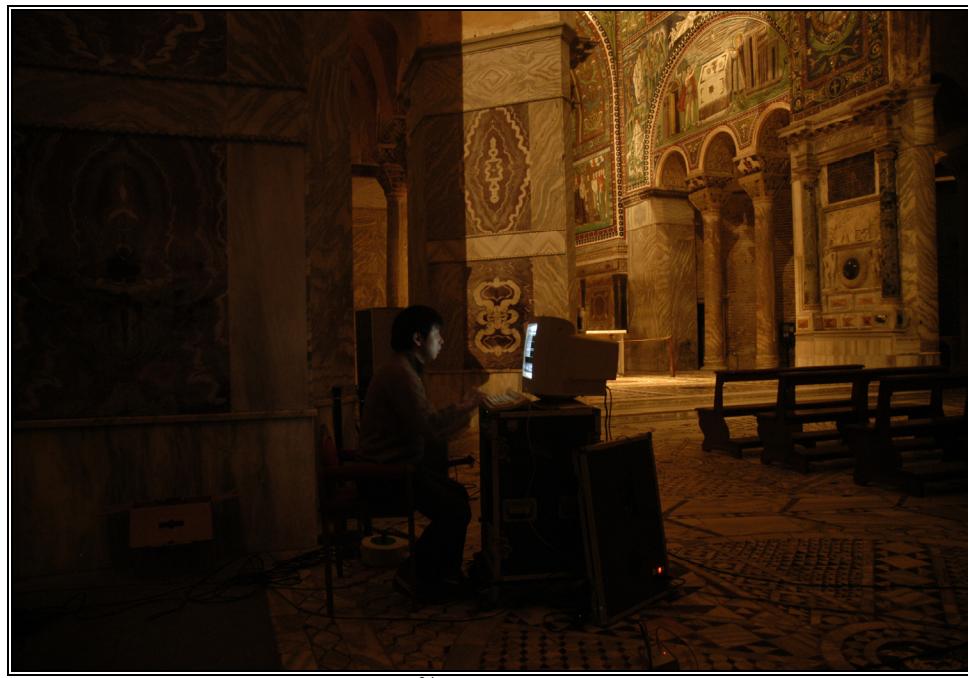
Figure 5.3.8: Acoustician Ryota Shimokura[24] at the portable workstation located at the opening of the eastern exedra, recording the Impulse Responses (Photograph by Knight 2006).

From the recorded Impulse Responses (IRs) the most important acoustical parameters were calculated[25]. These included Clarity (*Klarheitsmass*) C_{50} and C_{80}[26], Ts (Centre Time or *Schwerpunktzeit*)[27], EDT (Early Decay Time)[28], T_{20}, T_{30} (reverberation time calculated from the decay range between -5 and -35 dB)[29], T user (Reverberation Time between -10 and -25 dB) and IACC (Inter-Aural Cross Correlation)[30].

For the purposes of this research those of particular interest[31] are the perception of speech and music, Clarity (C_{50} and C_{80}) respectively, and the Reverberation Times T_{30} and T_{20}. T_{30}, calculated from the decay range between -5 and -35dB, averaging 4.70

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[24] The acoustic team that Professor Tronchin brought from the University of Bologna to conduct the acoustic survey included Ryota Shimokura (AIST, Japan), Dr. Mattia Nori, Dr. Ilaria Durvilli, Lorenzo Orlandi, and Bruno Longanesi (Bologna).
[25] Tronchin & Knight 2008.
[26] Tronchin & Farina 1997:15.
[27] Tronchin & Farina 1997:13.
[28] Tronchin & Farina 1997:13.
[29] Tronchin & Farina 1997:11.
[30] Only for the Dummy Head (Tronchin & Farina 1997:14).
[31] Siebin & Kinzey (1999:242, Table 6.1) provide a list of the 'Acoustical Qualities That Contribute to Overall Impression'; The Primary Qualities are Clarity, Loudness, Reverberation, Spaciousness and/or envelopment, Localization, Timbre (tonal balance), and Ensemble. The 'Secondary Qualities' are Intimacy, Diffusion and Background noise or audible echoes.

seconds, and T_{20} from the decay range between -5 and -25dB, averaging 4.46 seconds (Table 5.3.5).

Frequency [Hertz]	31.5	63	125	250	500	1000	2000	4000	8000	16000	Av.
T_{20} (seconds)	5.53	5.59	5.17	5.58	5.74	5.27	4.39	2.91	1.69	0.74	4.46
T_{30} (seconds)	7.02	5.80	5.02	5.60	5.77	5.35	4.44	2.95	1.78	0.11	4.70
C_{50} (dB)	-6.31	-8.96	-10.84	-11.12	-9.64	-10.28	-8.86	-6.05	-2.92	2.99	-7.10
C_{80} (dB)	-4.45	-6.05	-8.68	-8.53	-7.50	-7.56	-6.33	-3.65	0.07	6.92	-4.71

Table 5.3.5: T_{20}, T_{30}, and Clarity (C_{50} and C_{80}) calculations (values in seconds) obtained from the recorded Impulse Responses in San Vitale.

Chart 5.3.1 below illustrates the relationships between the Reverberation Times and Clarity in San Vitale and Chart 5.3.2 illustrates the church's acoustic Clarity for both speech (C_{50}) and singing (C_{80}).

Reverberation Times T20 and T30 of San Vitale

	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz
T20	5.53	4.62	5.17	5.58	5.74	5.27	4.39	2.91	1.69	0.74
T30	7.02	5.8	5.02	5.6	5.77	5.35	4.44	2.95	1.78	0.11

Frequency
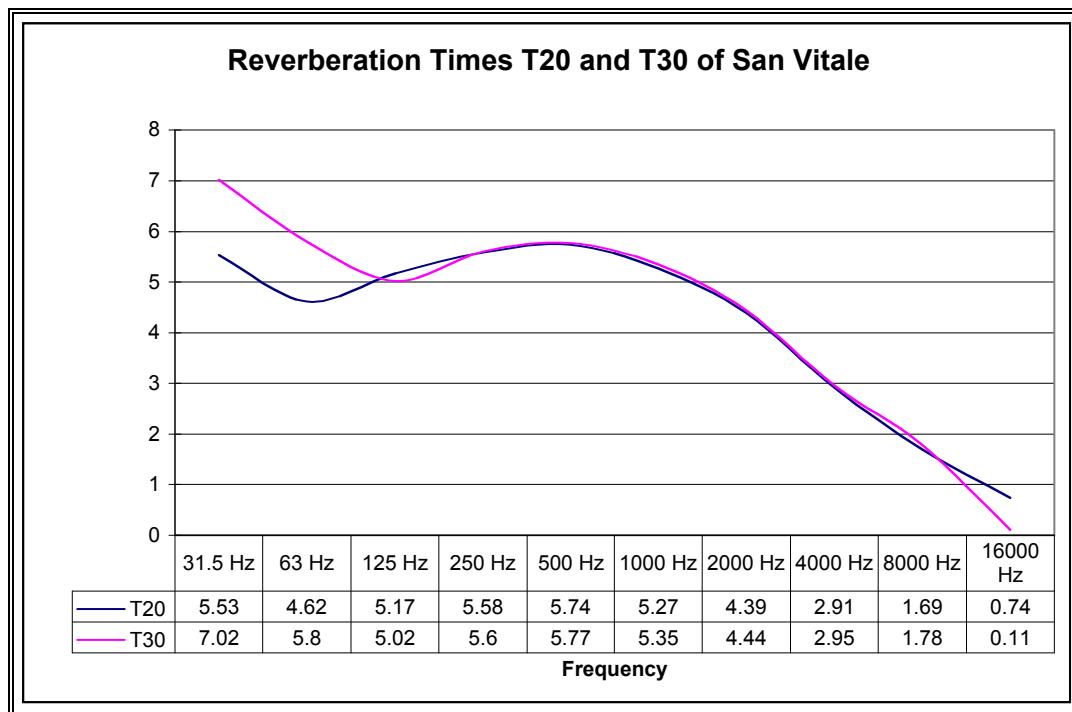
Chart 5.3.1: Reverberation Times of San Vitale.

The reverberation times for the original interior material layout of San Vitale cannot be accurately calculated, but it is crucial to keep in mind the ground floor and *matroneum* ambulatories had wooden ceilings, probably pine from the nearby *Pineta de*

San Vitale (see Appendix D.1). These wooden ambulatory ceilings would have noticeably reduced the reverberation of the church. However, they were altered soon after construction and replaced with the extant plaster ceilings, thus the acoustic character of the church may have been intentionally changed, such that what has been acoustically measured in 2006 is the amount of reverberation desired in the sixth-century[32].

Clarity C50 and C80 of San Vitale

	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz
C50	-6.31	-8.96	-10.84	-11.12	-9.64	-10.28	-8.86	-6.05	-2.92	2.99
C80	-4.45	-6.05	-8.68	-8.53	-7.5	-7.56	-6.33	-3.65	0.07	6.92

Frequency
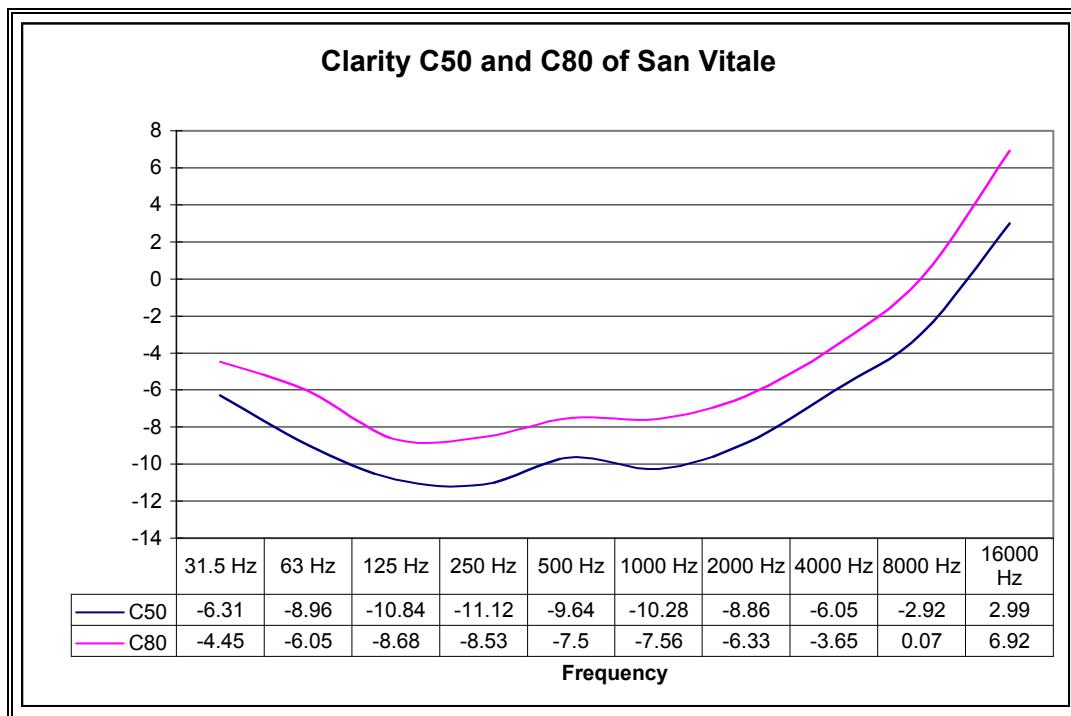
Chart 5.3.2: Acoustic Clarity dB values of San Vitale.

These reverberation times are very long but not unexpected in a place of worship. The comparison of the two different types of Clarity (*Klarheitsmass*), are of interest, as C_{80} is related to musical perception, the time interval being limited to 80 milliseconds, and C_{50} is related to the perception of speech, with the time interval limited to 50 milliseconds. From Chart 5.3.2 it can be seen that musical perception is consistently clearer on average by about 3 decibels. The reverberation tail caused low values of

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[32] Alternatively, the wooden ceilings were replaced with plaster to reduce the risk of fire and the resultant noticeable change in reverberation was epi-phenomenal (unintended, but perhaps a fortuitous by-product) of the decision.

Clarity, also in agreement with other measured places of worship[33], greatly helping to spread vocalised music (singing) across the entire church interior.

Speech

Considering the normal human speaking range from 125Hz to 8000Hz[34], the following observations can be made. Chart 5.3.3 illustrates the frequency range of normal adult speech within the Reverberation Times (T_{20} and T_{30}) of San Vitale. Chart 5.3.4 illustrates this same speech frequency range within the perceptible Clarity of speech (C_{50}) dB values of the church.

	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz
T20	5.53	4.62	5.17	5.58	5.74	5.27	4.39	2.91	1.69	0.74
T30	7.02	5.8	5.02	5.6	5.77	5.35	4.44	2.95	1.78	0.11
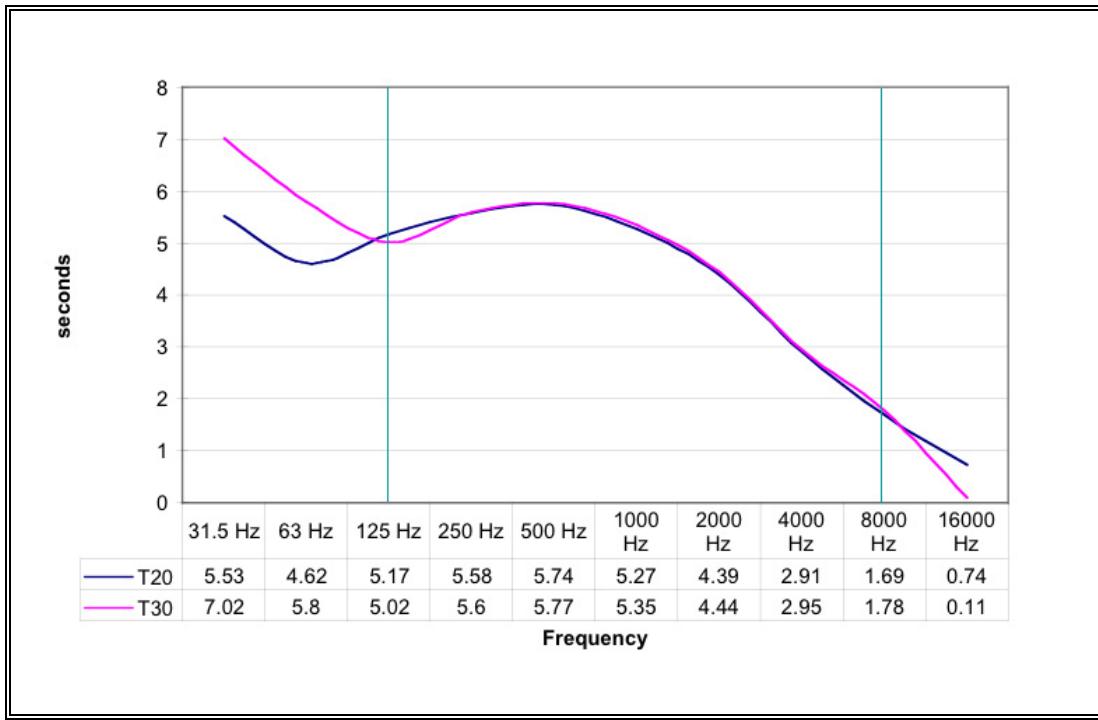
Chart 5.3.3: Human speech frequencies within the Reverberation Times of San Vitale.

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[33] Definition of Clarity in Tronchin & Farina 1997:15.
[34] Egan 1988:8.
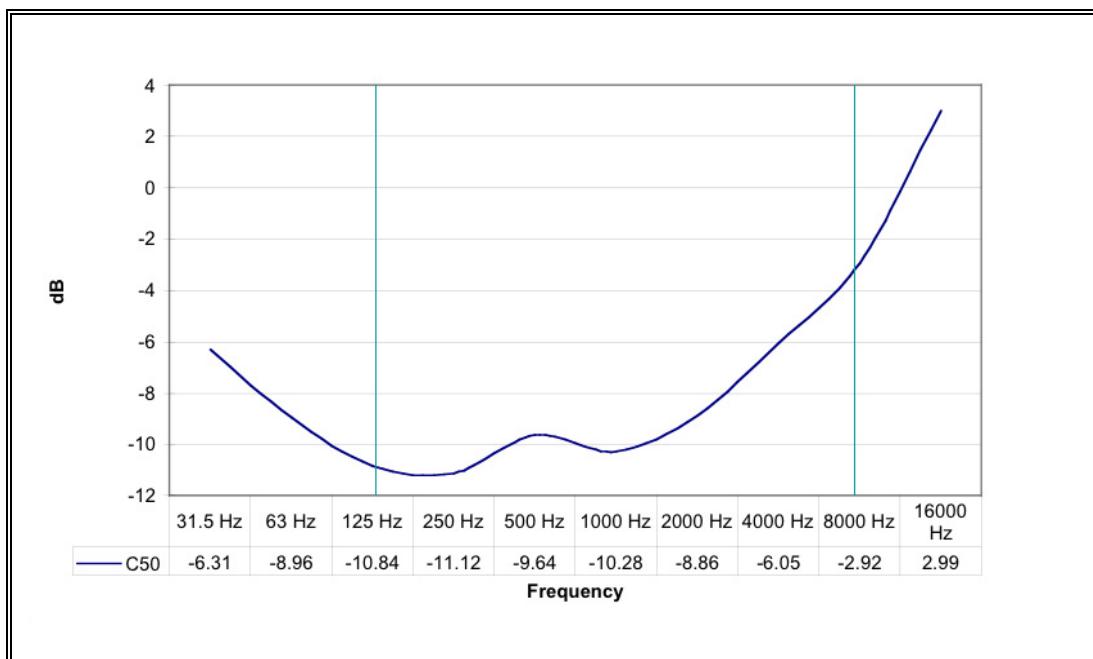
Chart 5.3.4: Human speech frequencies within the Clarity (C_{50}) of San Vitale.

As can be seen (Chart 5.3.3), the Reverberation Time (RT) at 125Hz is 5.17 seconds (T_{20}) and 5.02 seconds (T_{30}), and (Chart 5.3.4) better Clarity (C_{50}) at the top extreme of the speech range, –2.92dB at 8000Hz. Therefore, for speech in San Vitale, the most effective and intelligible is at the top of the frequency range between approximately 4000Hz and 8000Hz, a higher pitch of male and female spoken voice intoning, as demonstrated above, on E. The relationship exists where the deeper the voice is, the less is the perceptible Clarity and with increased reverberation, the worst area being around 250Hz. Therefore, for normal speech in the mid-range the acoustics of San Vitale are not effective, but they are rather well suited for oratorical acclamation. In other words, compensation for the poor intelligibility of speech in San Vitale may have operated on the speakers' choice of speech rate, articulation, and oratorical voice projection, intoning on E. In Chapter Four (Part 4.2) the speakers during the liturgical sequence of the Mass have been identified as the Deacon and the principal celebrant (Bishop or Priest). As mentioned above, the Deacon(s) reading the Epistles may have utilised these methods of compensating for the low intelligibility in the church, as also may have the celebrant (priest or bishop) reading the Gospel and saying the prayers of benediction.

Singing

Within the human singing frequency range, Chart 5.3.5 illustrates the Clarity of musical perception, C_{80}, in San Vitale, where the lowest value is –8.68dB at 125Hz and the highest is –6.05dB at 63Hz, supposing a male bass voice could sing that low. Therefore, averaging at –7.37dB, the Clarity of musical perception in San Vitale is low. From this it can be posited that the intelligibility of sung words, as in *Lux de luce*, is low unless compensations were taken in the tempo of articulation. In other words, in San Vitale, for the individual words of a chant to remain intelligible, the rate of singing would have to be relatively slow in order to be understood. This suggestion reinforces the initial decision to perform *Lux de luce* at a beats-per-minute (BPM) of 35, as described above in Part 5.2.

	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz
C80	-4.45	-6.05	-8.68	-8.53	-7.5	-7.56	-6.33	-3.65	0.07	6.92
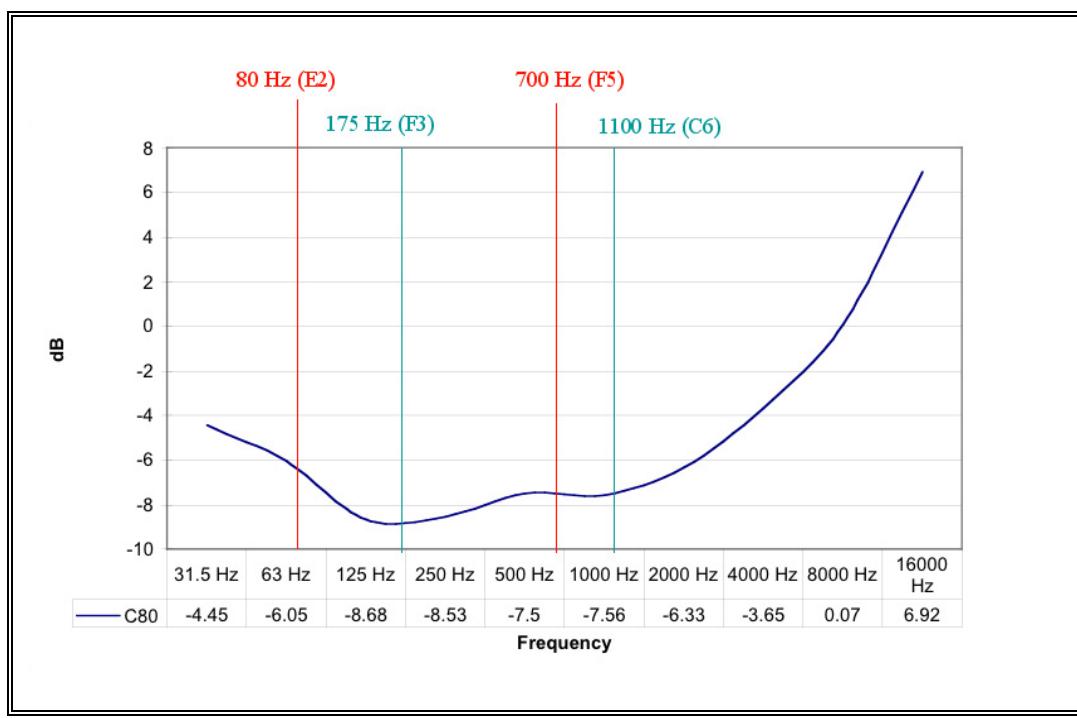
Chart 5.3.5: Musical perception Clarity C_{80} of male (red) and female (blue) singing range frequencies in San Vitale.

The frequency range of the normal male singing voice, from bass to alto (or countertenor[35]), is from 80Hz to 700Hz, while the normal female singing voice, from

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[35] Alto: http://en.wikipedia.org/wiki/Alto_(voice)

contralto to upper soprano is from 200Hz to 1100Hz[36]. Chart 5.3.6 illustrates the position of the male and female singing range in relation to San Vitale's Reverberation Times at the comparable frequencies.
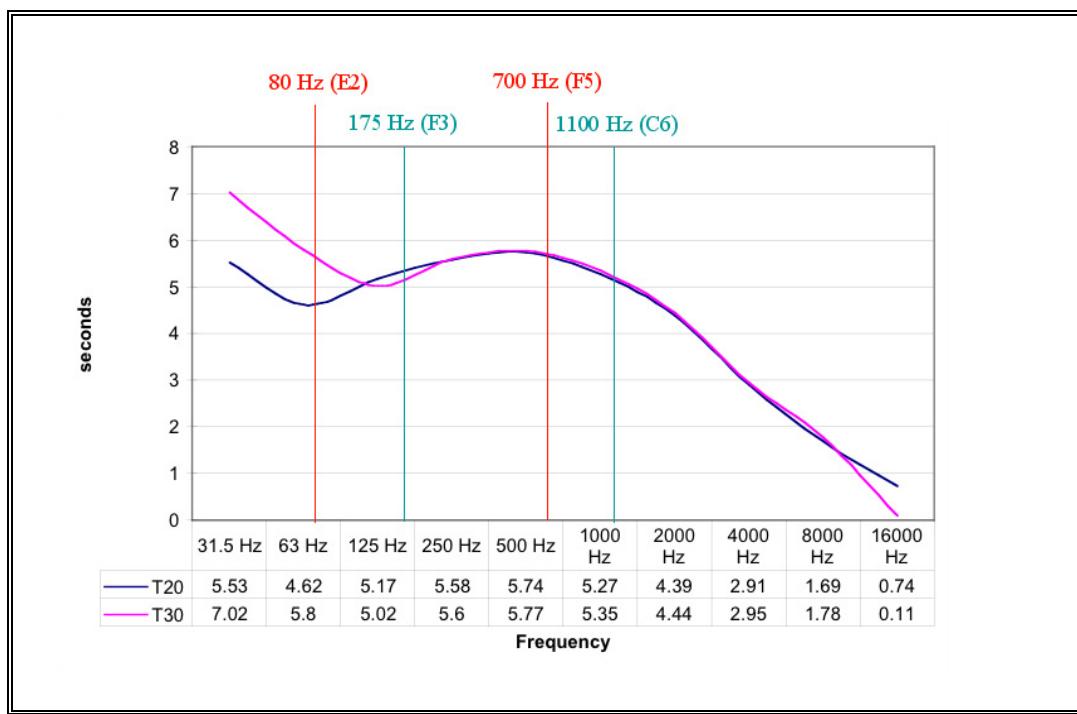
Chart 5.3.6: Male (red) and female (blue) singing ranges in relation to the Reverberation Times of San Vitale (Knight 2009).

The frequency range of the prepared *Lux de luce*, and therefore the range of my singing, can be identified and seen in relation to Reverberation Time and Clarity C_{80}. Keeping in mind the following observations are of the piece as I have transposed and interpreted it for comfortable singing and not necessarily as an accurate musicological exercise, there are nevertheless some instructive points of interest. The first note of *Lux de luce* is also the lowest, D3 = 146.83Hz[37], and the highest note through the majority of the piece is Middle C (C4 = 261.63Hz). Only one note exceeds this, D4 (293.66Hz), in the *melisma*[38] on the word *reservavit* (specifically on the "*ra*") in the seventh verse:

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[36] Frequency of human singing range:
http://en.wikipedia.org/wiki/Vocal_range#Vocal_range_in_terms_of_frequency. Alternatively, Cavanaugh & Wilkes (1999:6) has: female voice from ~300Hz to ~4,100Hz, and male voice from ~150Hz to ~2,100Hz.
[37] Frequency of musical notes: http://www.phy.mtu.edu/~suits/notefreqs.html
[38] Singing several tones over one syllable: http://en.wikipedia.org/wiki/Melisma

Regna benigne piis <u>reseravit</u> claustra polorum

And has benignly <u>opened</u> the kingdom for the pious[39]

Or, an alternative translation:

With kindness He <u>unlocked</u> the closed kingdom of Heaven[40].

It is more than likely intentional that this word *reseravit* meaning 'open up, unseal, unbar (gate or door), unfasten; make accessible; uncover, expose'[41] is on the highest note of the piece. The *melisma* swiftly climbing to this brief note (D4) musically expresses Christ's Ascension to open the doors of Heaven. Further, the liturgical context and position of this *versus* is relevant, convincingly argued by Levy as part of the Easter Vigil:

> …before the baptismal rites and the prophetic lessons that precede them – among the opening ceremonies of the Vigil, where the new fire is brought forth and the paschal candle is lighted and blessed. In broad terms this is a *lucernarium*, the solemn lighting of candles at Vespers, widely cultivated in early Christian traditions. Specifically, it is a *lucernarium* for the primal Vespers of the liturgical year on Holy Saturday, when the new fire presages the imminent victory over death'[42].

Following on from this, it seems reasonable to suggest that this highest singular note (D3) may have occurred at the very instance when the paschal candle was lit. If so, then it is exemplary of how light and sound are used in combination to transmit theological meaning to the congregation.

Aside from this singular highest brief note, the most common frequencies of the music are very nearly evenly distributed between 220 Hz (A3 at 36 %) and 196 Hz (G3 at 32 %)[43]. Chart 5.3.7 illustrates the frequency position of a male (red) and female (blue)

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[39] Levy 1971:43.
[40] Dr. Charlotte Tupman 2009.
[41] http://ablemedia.com/ctcweb/showcase/wordsonline.html
[42] Levy 1971:52.
[43] See Part 5.2 above, particularly Chart 5.2.1, page 178 and Chart 5.2.2, page 179.

singing this prepared *Lux de luce* (the female vocalist singing one octave higher) in relation to the Reverberation Times T_{20} and T_{30} of San Vitale.
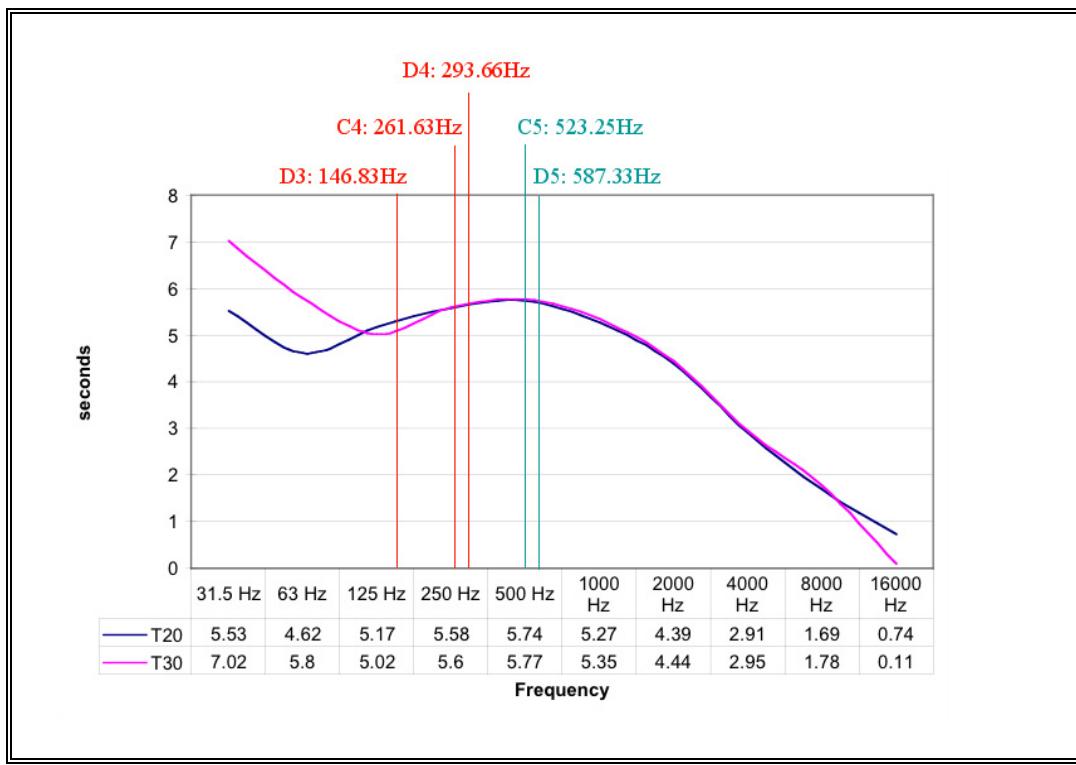
Chart 5.3.7: Frequency ranges of *Lux de luce* in relation to San Vitale's Reverberation Times T_{20} and T_{30}; male voice (red) and female voice (blue) (Knight 2009).

The amount of reverberation San Vitale provides a male and female singing *Lux de luce* is therefore very high, between 5 and 6 seconds, slightly less for the lowest notes (D3) sung by a male vocalist.

The sung words of *Lux de luce*, in my (male) baritone voice, have to contend with a low musical perception of Clarity decibel value in San Vitale (Chart 5.3.8), between –8 and –9dB (e.g., at 250Hz = -8.53dB). The female voice fairs slightly better, between –7 and –8dB (e.g., at 500Hz = -7.50dB). The combined high Reverberation Times and low Clarity values were intuitively compensated for by singing at a slow BPM as mentioned above, and with some voice projection (but without vibrato) to "fill" the space.
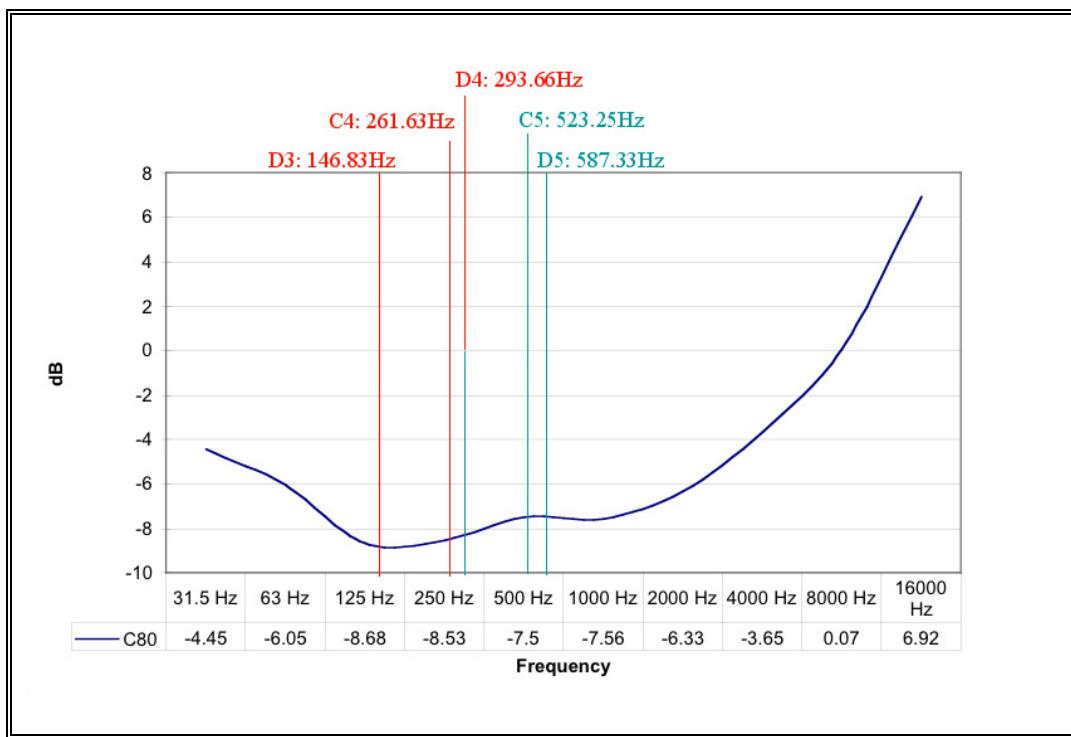
Chart 5.3.8: Frequency ranges of *Lux de luce* in relation to San Vitale's music Clarity C_{80}; male voice (red) and female voice (blue) (Knight 2009).

Auralisation

It was not until the process of Auralisation was completed, following the acoustic survey, that a proper comprehension of the acoustic effects of San Vitale caused by the architecture and the performed *Lux de luce* could be properly understood. The process of Auralisation went beyond my involvement, but acousticians under Professor Tronchin continued to make calculations from the recorded Impulse Responses at the University of Bologna. Nonetheless, it is instructive to briefly outline the Auralisation process and the creation of a virtual model into which my voice was digitally convolved.

Auralisation can be achieved by convolution, where 'the impulse responses are employed as very long FIR (Finite Impulse Response)[44] filters, applied to dry (anechoic) recordings'[45], convolution being a very efficient filtering technique[46] to sample real spaces and simulate the acoustics of a real space[47]. Once the anechoic recording of *Lux de luce* (as described next in Part 5.4) had been convolved with San Vitale's acoustics the

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[44] Cf. Rabiner & Gold 1975.
[45] Farina & Tronchin 2005:6.
[46] Farina & Tronchin 2005:6.
[47] Convolution Reverb: http://en.wikipedia.org/wiki/Convolution_reverb

church's space could be experience in the newly built "Arlecchino" listening room at the laboratory of DIENCA – CIARM, University of Bologna[48] and a fly-through video of the virtual photorealistic acoustic model was subsequently produced.

Mapping the Distribution of Reverberation and Clarity

Several contour maps were produced at Bologna showing the spatial distribution of measured and calculated acoustic parameters in relation to different positions of sound source and receiver. This is useful in showing where the "best" and "worst" locations are within the church in relation to reverberation (Figure 5.3.9) and Clarity C_{50} for the perception of speech (Figure 5.3.10).

A   B

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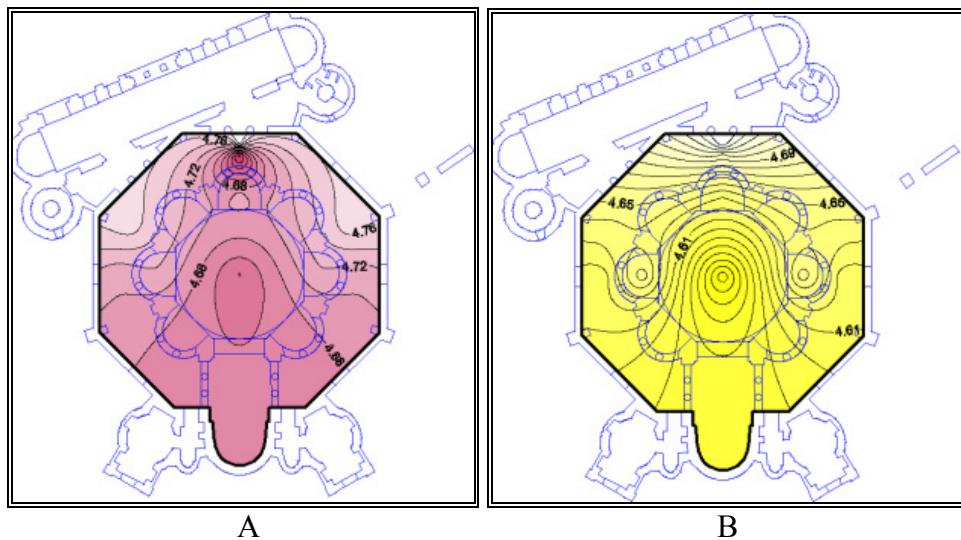
[48] Il Dipartimento di Ingegneria Energetica, Nucleare e del Controllo Ambientale (DIENCA) and Centro Interuniversitario di Acustica e Ricerca Musicale (CIARM): (Farina & Tronchin 2005:10). Also Tronchin *et al* 2005.

C
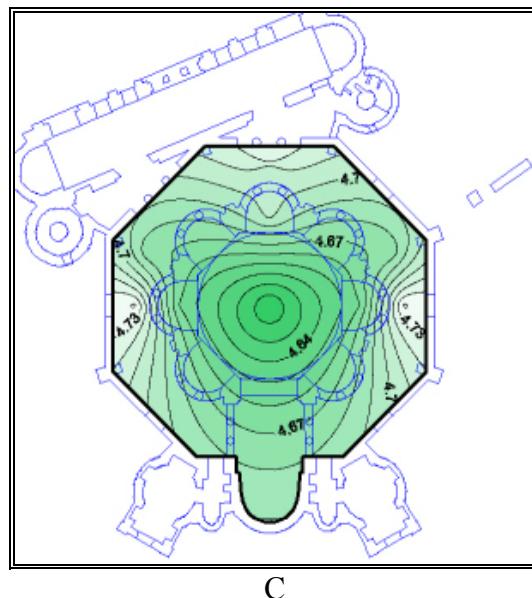
Figure 5.3.9: Reverberation Time T_{30} spatial distribution. Map A shows the distribution for loudspeaker S1, Map B for S2, and Map C for S3 (Tronchin, Durvilli and Tarabusi 2007)[49].

Map A of Figure 5.3.9 (purple) shows the spatial distribution of the Reverberation Time T_{30} when the sound source (loudspeaker) is at S1 (in the north exedra of the *matroneum*). The least amount of reverberation is seen to be at the forward centre of the inner octagon, with a further spread of reverberation at 4.68 seconds enveloping the entire chancel and apse area. There is a secondary area of low reverberation at the back of the church, immediately inside the main north entrance along the chancel axis of the church. The greatest amount of reverberation, at 4.76 seconds duration, are in two pockets in the ambulatory, at the north and west walls.

Map B (yellow) shows the spatial distribution of the Reverberation Time T_{30} when the sound source (loudspeaker) is at S2 (in the exedra on the ground floor immediately north of the chancel). The least amount of reverberation is at the centre and chancel end of the church, at and below 4.61 seconds, marginally better than the results for S1. Reverberation uniformly increases at the back of the church, inside the north entrance, inverse to what is observed for S1.

Map C (green) shows the spatial distribution of the Reverberation Time T_{30} when the sound source (loudspeaker) is at S3 (before the altar in the chancel). The least amount

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[49] As part of the presentation by Knight in Barcelona, 2007 (Tronchin, Knight, Durvilli, and Tarabusi 2007).

of reverberation, at and below 4.64 seconds, is at the centre of the church. This time increases towards 4.7 into the apse and ambulatory. The most reverberation is seen to be in three pockets, at the main north entrance, and at the walls of the northeast and southwest ambulatories.

From these three maps if can be seen that the sound source in the *matroneum* (argued here to be a female vocalist) is most reverberant at the centre and front of the church, while a sound source on the ground floor (a male vocalist) in the exedra produces the least. However, the negligible difference between these reverberation times may not be of any significance to the overall acoustical experience of the space.

A   B

C
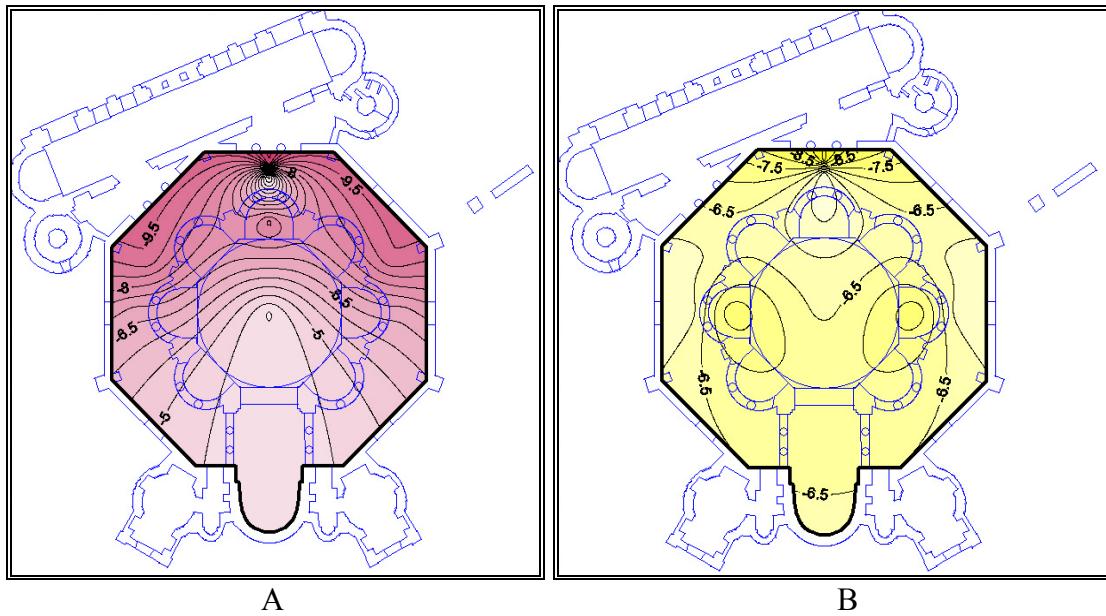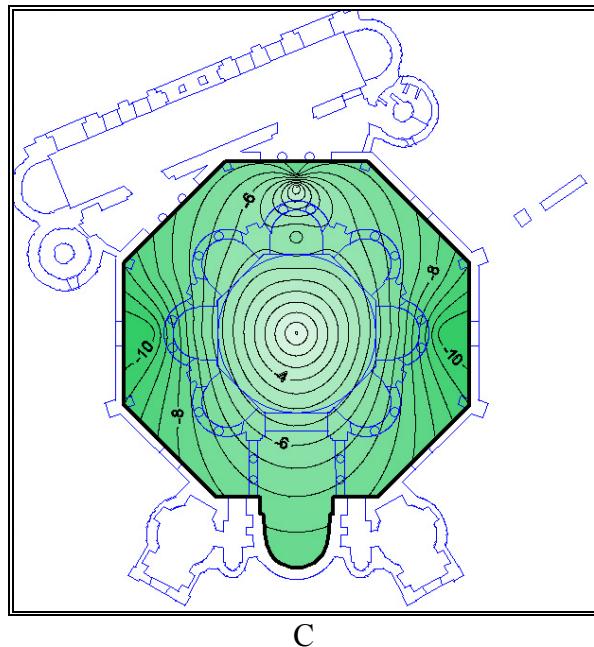
Figure 5.3.10: Perceptible speech Clarity C_{50} decibel value mapping of San Vitale. Map A shows the distribution for loudspeaker S1, Map B for S2, and Map C for S3 (Tronchin, Durvilli and Tarabusi 2007).

In Figure 5.3.10 Map A (purple) shows the distribution of Clarity C_{50} perception of speech when the speaker is situated at S1 (at the north exedra of the *matroneum*). If a female spoke from the *matroneum*, as for instance in response to prayers on "Amen" or during the exchange of the sign of Peace, the perception of the spoken voice is seen to be best at the centre and forward of the church. At the north entrance, in the ambulatory near to the western exedra, clarity of female speech is also best perceived. Near the north entrance along the western walls of the ambulatory the clarity of female speech is least perceived.

Map B (yellow) shows the distribution of Clarity C_{50} perception of speech when the speaker is situated at S2 (in the exedra on the ground floor immediately north of the chancel). The best Clarity is throughout the church but particularly at the western north-most entrance, extending into the western exedra. The poorest position for clearly perceiving speech is immediately to the west of this area, at the western north-most entrance itself and along the adjoining ambulatory walls.

Map C (green) shows the spatial distribution of Clarity C_{50} when the speaker is at S3 (before the altar in the chancel). As this is the position of the clergy and celebrant of the Mass, this distribution is of particular interest. Intriguingly, the best position from

which to perceive the priest's spoken voice is at the very centre of the inner octagon and also in the ambulatory between the western north-most entrance and western exedra. The positions from where this perception is least effective, is along the ambulatory walls in the northeast and southwest.

The different building and surface finishing materials have been taken into account, some having a greater effect on the acoustical quality of San Vitale. In Chart 5.3.9 below the main materials are listed with their absorption coefficients across the frequency range 125Hz to 4000Hz, also the range in which speech and singing would be affected.

Absorption Coefficients of materials

	4000 Hz	2000 Hz	1000 Hz	500 Hz	250 Hz	125 Hz
Plastered Walls	0.05	0.05	0.04	0.03	0.02	0.02
Marble	0.02	0.02	0.01	0.01	0.01	0.01
Glass	0.02	0.02	0.03	0.04	0.05	0.18
Curtains hung in folds	0.65	0.65	0.55	0.35	0.15	0.05
Audience per person standing	0.45	0.45	0.43	0.42	0.38	0.15
water surface	0.025	0.02	0.015	0.013	0.008	0.008

Octave Band Centre Frequency (Hertz)
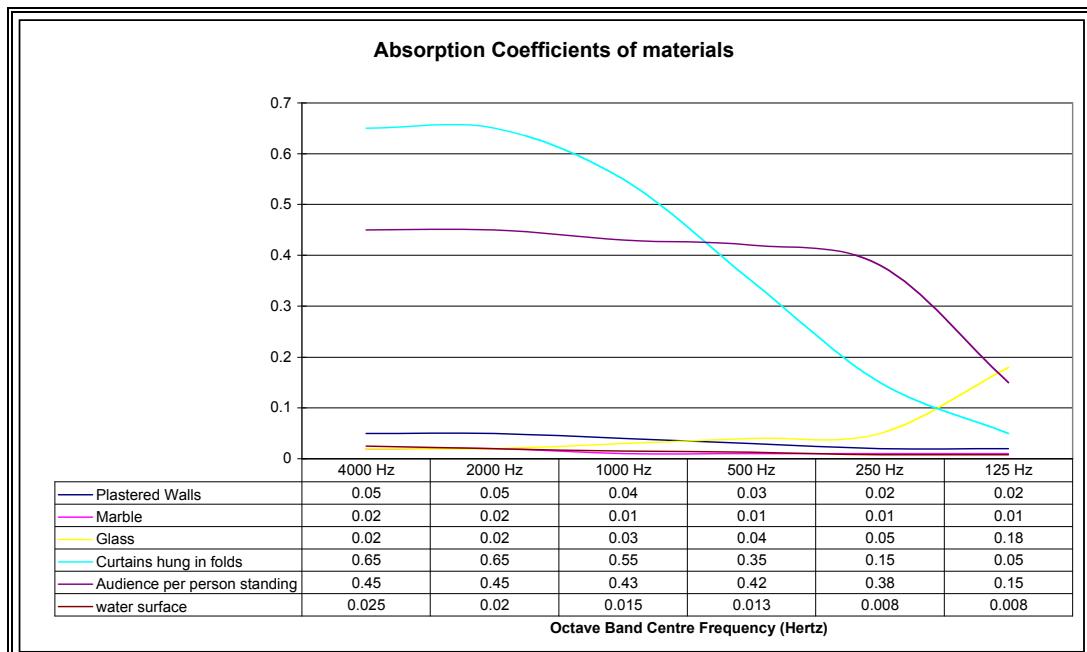
Chart 5.3.9: Absorption Coefficients (after SRL 1976, Templeton 1993, and Pirn 1999; Knight 2009).

As can be seen, only three materials have any noticeable affect upon sound transmission in San Vitale. Hanging curtains or tapestries are not now present in the church, thus having no affect on the acoustic survey of 2006. Likewise, an audience was not present during the acoustic survey, but for purposes of future investigation, the sound absorption of each human body (with approximations of sixth-century clothing) would have to be factored into perception, especially Clarity C_{50} (of speech) and C_{80} (of music). The third noticeable acoustically absorbent material, at the lower frequency of 125Hz, is glass (the

values given here are by Pirn[50] for large panes of heavy plate). At present some of San Vitale's windows have clear glass and some have alabaster sheets, the absorbency of alabaster is not at present known. The original glass discs of the windows are discussed in Appendix D.1 as investigation and virtual restoration continues.

The remaining materials in Chart 5.3.9 have negligible acoustic absorbency, the highest being the plaster (increasing only to 0.05Hz at 4000Hz) applied to some walls and the ambulatory ceilings of the ground floor and *matroneum*. In other words, the high acoustic reflectivity of marble, stone, glass (in the mid and high frequencies), and water (the small pool filling the former *sacellum*) are all within a similar range and cumulatively provide the church with its elongated Reverberation Times.

The measurements of acoustical quality were necessary not only to understand the effective acoustic characteristics of the church at present, but also to create a numerical model of the church, calibrated on the experimental values of the Reverberation Time, which could be used afterwards to render the acoustics and the architecture of the original sixth-century church.

Having surveyed the acoustics of San Vitale, recording the Impulse Responses and extrapolating the calculated acoustic characteristics such as Reverberation Time and Clarity, putting these results into a three-dimensional virtual model of the church would further allow for better understanding the visual and aural experience of moving through the space. By having a virtual model constructed that both replicated the extant acoustics, incorporating the vocal performance of *Lux de luce,* and seen with reconstructed lighting by candles, lamps and windows, it was hoped the combination of the material and non-material survival of the sixth-century church would provide a new set of tools with which to interpret San Vitale. The following Part (5.4), describes the process of recording *Lux de luce* in an anechoic chamber so that it could then have San Vitale's acoustic characteristics applied directly to it, for the purposes of entering it into the virtual acoustic model already described in Part 5.1.

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[50] Pirn 1999.

Part 5.4: Stage Four - Vocal recording of *Lux de luce* in an Anechoic chamber

Having obtained the calculated Reverberation Times from the recorded Impulse Responses in San Vitale, this provided Professor Tronchin's acoustic team in Bologna the capability to begin constructing a virtual acoustic photorealistic model of San Vitale[1]. In order to virtually reproduce the extant acoustic characteristics of San Vitale in the Arlecchino listening room at the University of Bologna[2] and to apply the male vocal performance of *Lux de luce* into the acoustic model with the calculated acoustic characteristics of the church convoluted onto the voice, it was necessary for me to again sing and record *Lux de luce,* this time in the 90 Hertz anechoic chamber at the Institute of Sound and Vibration Research (ISVR) at the University of Southampton. This was to obtain a dry recording with as little Impulse Response as possible, and therefore devoid of any reverberation information.

On 30th of April 2007[3], with the assistance of Dr. Matthew Wright, I recorded myself singing the *versus*. Figures 5.4.1 and 5.4.2 show the interior of the ISVR anechoic chamber, setting up the Logic Express song project on my MacBook and rehearsing the piece into the mono-aural microphone (USB Samson CO3U). The 90Hz chamber is 9.15m wide, 9.15m long, and 7.32m high, and from the tip of the installed foam wedges rendering the walls anechoic, the chamber is 7.3m by 7.3m and with a height of 5.1m[4]. I was positioned on a narrow walkway and platform at the centre of the chamber.

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[1] See Part 5.1.

[2] See Part 5.3.

[3] It was by pure coincidence that singing occurred in San Vitale and then at the ISVR exactly one year apart. Dr. Matthew Wright kindly booked the anechoic chamber and assisted with recording at the ISVR.

[4] Measurements given by Dr. Matthew Wright: personal communication May 11th 2009.

Figure 5.4.1: Preparing to record in the anechoic chamber (Photograph by Dominic Barker 2007).

The images were taken prior to actual performance and recording, as no photography was possible once the chamber was hermetically sealed from the exterior. I was left alone inside to sing and record until I gave the signal on a walky-talky to release the seal[5].
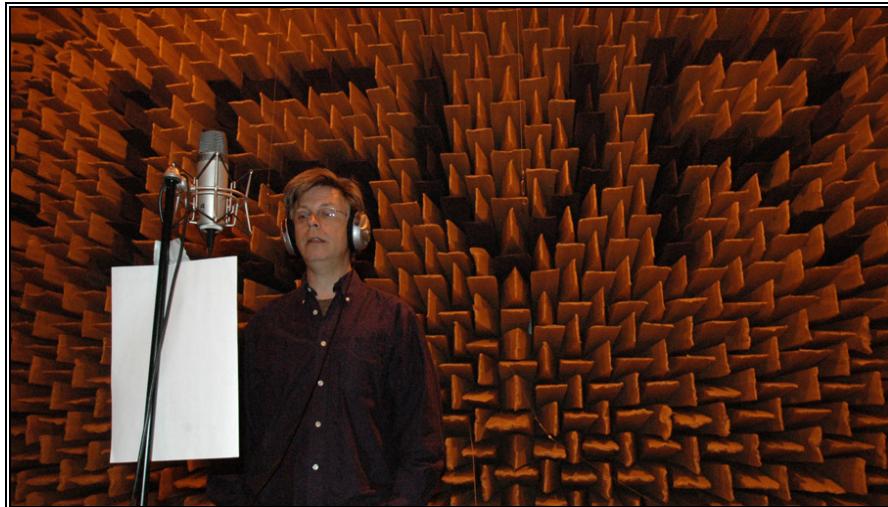
Figure 5.4.2: The author singing *Lux de luce* at the ISVR (Photograph by Dominic Barker 2007).

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[5] Definitely one of the strangest recording sessions I've ever been involved in.

The procedure employed for singing was similar to the 2006 performance in San Vitale; it depended on learning the *versus* and performing at natural time, previously decided to be 35 beats-per-minute (BPM). The original practice recording outlined in Part 5.2 and the additional recordings made in San Vitale (Part 5.3) were used simply as references and for rehearsing counting the timing at 35 BPM. No attempt was made to exactly replicate my performance in San Vitale as the ISVR recording would become the "master" onto which the church acoustics would then be convolved.

My involvement with the practical aspects of acoustic science did not extend beyond this second dry recording for the acousticians in Bologna. The additional processes involved in preparing the vocal recording and constructing the acoustic virtual model fell well outside of my archaeological expertise and research aims. Nonetheless, I remained in communication and advised on aspects of the model, described above in Part 5.1. Ongoing experiments continue regarding the original wooden ambulatory ceilings and windows, described in Appendix D.1.

Part 5.5: San Vitale's Acoustical Characteristics

The additional set of data for San Vitale's acoustical characteristics can now be compared with those recorded and calculated for SS Sergius & Bacchus. Chart 5.5.1 below shows the Reverberation Time (T_{30}) for SS Sergius & Bacchus recorded by the CAHRISMA Project (pink line) and for San Vitale, recorded by Prodi in 2003 (orange line) and Tronchin in 2006 for this present research (dark blue line).

Reverberation Time T30 Comparisons: San Vitale and SS Sergius & Bacchus

	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz
SV T30	7.02	5.8	5.02	5.6	5.77	5.35	4.44	2.95	1.78	0.11
S&B T30			3.2	3.55	3.4	2.95	2.4	1.95		
Prodi SV			5.1	5.6	5.77	5.35	4.44	3.45		

Frequency

SV T30 — S&B T30 — Prodi SV
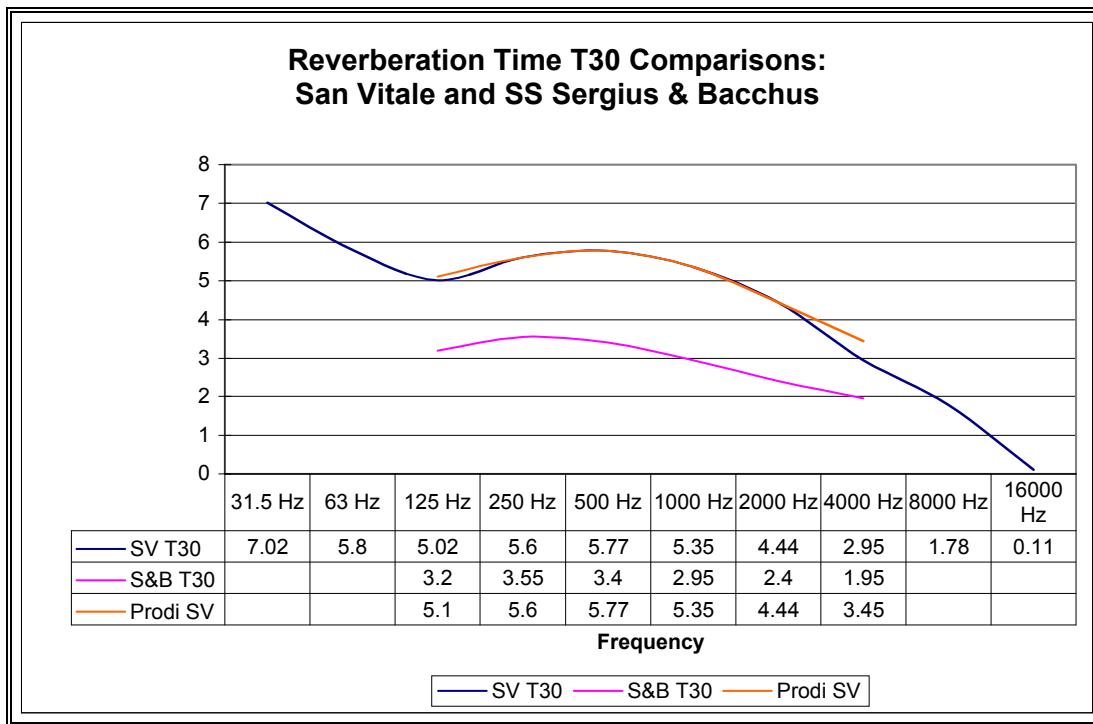
Chart 5.5.1: San Vitale and SS Sergius & Bacchus Reverberation Times (T_{30}) (After Fausti *et al* 2003, Figure 9, Tronchin 2006).

Due to the smaller proportions of SS Sergius & Bacchus, its Reverberation Time is less pronounced than San Vitale's, from only 1.95 and 3.55 seconds between the frequency range 125Hz to 4000Hz. Taking Tronchin's values for San Vitale and CAHRISMA's for SS Sergius & Bacchus, the difference of Reverberation Time between the two churches is reported below in Chart 5.5.2.
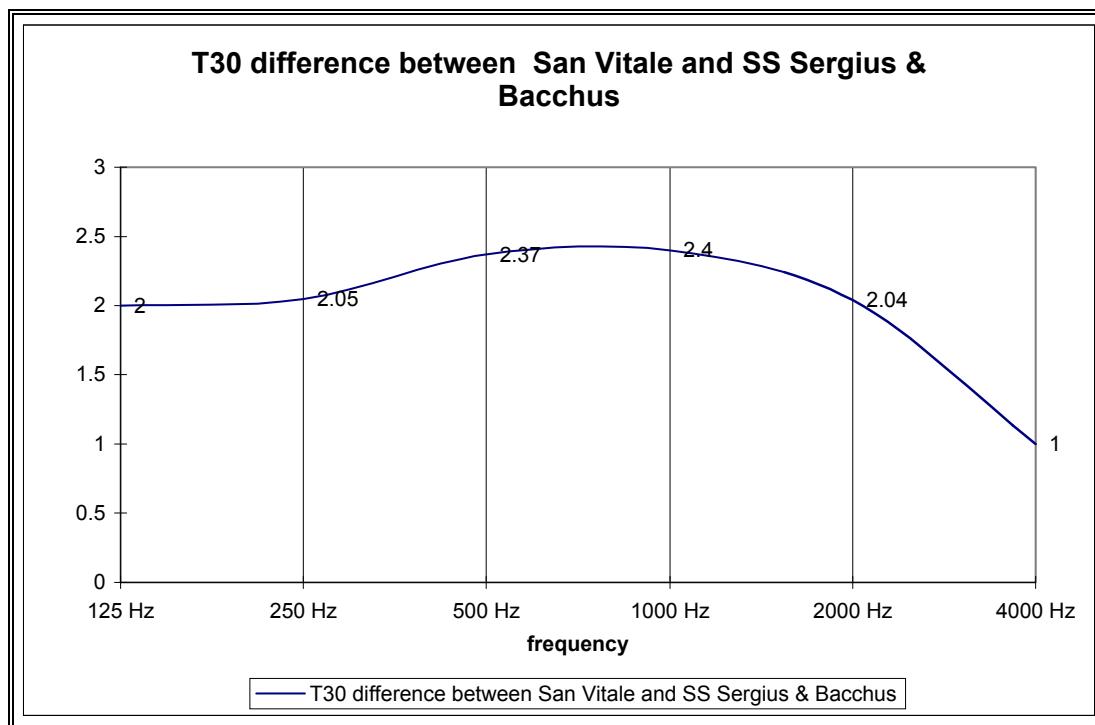
Chart 5.5.2: T_{30} difference between San Vitale and SS Sergius & Bacchus (Knight 2009).

In the lower frequencies the two churches have a reverberation difference of 2 seconds, which increases slightly at 1000Hz, returning again to about 2 seconds at 2000Hz. In the higher frequency range of 4000Hz the difference is only 1 second, meaning the reverberation within the two churches becomes more similar the higher the pitch. Due to the constraints of what CAHRISMA and Prodi have published, only the Reverberation Time (T_{20}) can be used for a comparison between San Vitale (dark blue line) and Hagia Sophia (pink line). In Hagia Sophia, singing around the 500Hz frequency produces the immense 10.78 second reverberation (Chart 5.5.3) and due to the vast volume of the space, echo proliferates. Echo may have been important in San Vitale but perhaps less so in SS Sergius & Bacchus.

**Reverberation Time T20 Comparison:
San Vitale and Hagia Sophia**

	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz
SV T20	5.53	4.62	5.17	5.58	5.74	5.27	4.39	2.91	1.69	0.74
HS T20			9.95	10.75	10.78	9.3	7.3			

Frequency
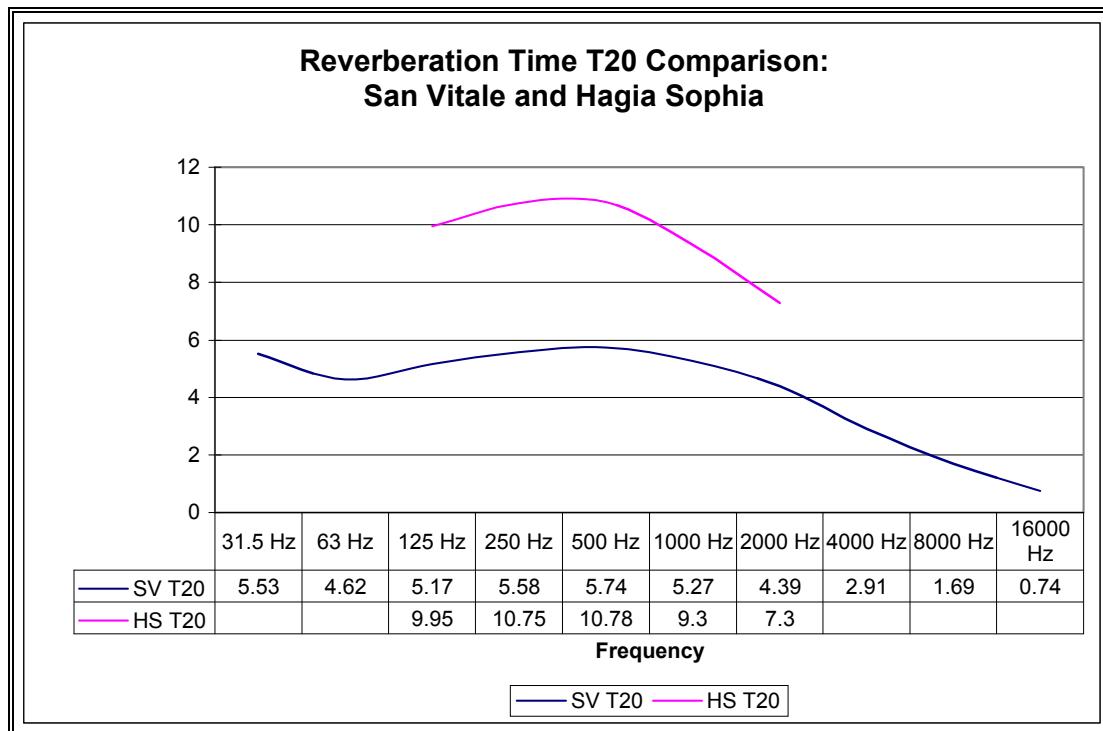
Chart 5.5.3: San Vitale and Hagia Sophia Reverberation Times (T_{20}) (After Fausti *et al* 2003, Figure 4, Tronchin 2006).

The differences of T_{20} in San Vitale and Hagia Sophia are reported in Chart 5.5.4 below.

T20 difference between San Vitale and Hagia Sophia

4.78   5.17   5.04   4.03   2.91

frequency

T20 difference between San Vitale and Hagia Sophia
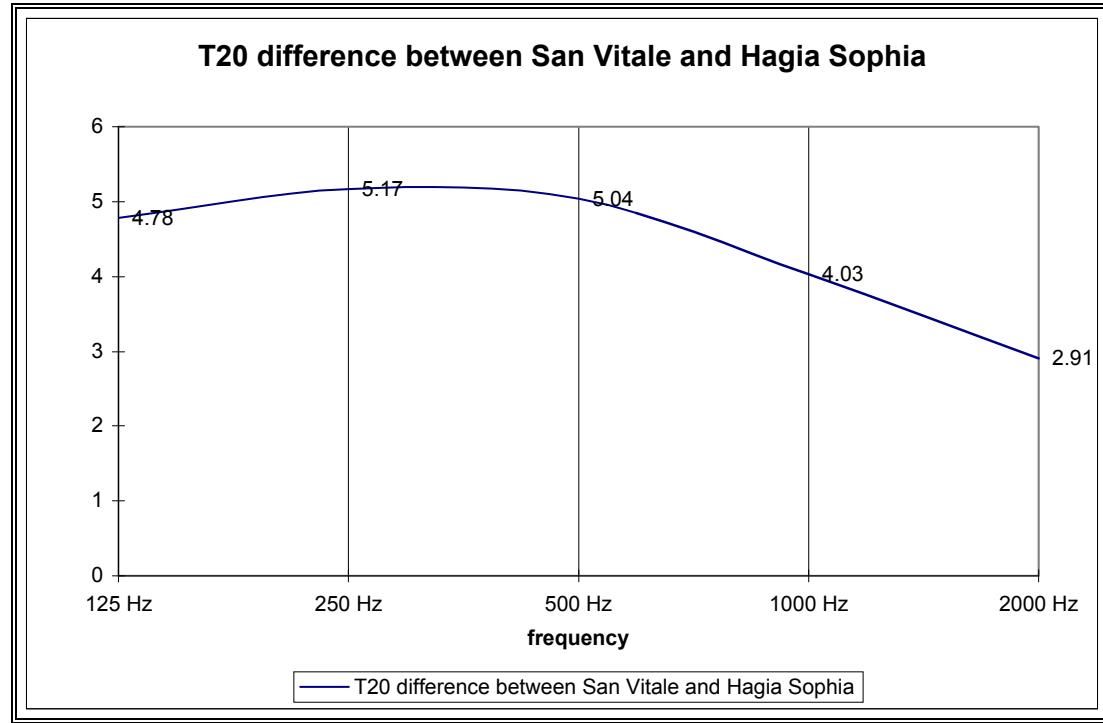
Chart 5.5.4: T_{20} difference between San Vitale and Hagia Sophia (Knight 2009).

The difference is predictably greater than that shown between San Vitale and SS Sergius & Bacchus, but steadily decreases above 500Hz. Only at the very highest pitches would these differences contract sufficiently for noticeable similarities of reverberation. At the lower frequencies the differences increase. Sound dampening strategies were certainly utilised in Hagia Sophia[1], and in San Vitale it seems likely there were originally a number of furnishings such as hanging tapestries to decrease the reverberation in key areas. But in SS Sergius & Bacchus it does not seem likely that any such strategies were necessary, unless tapestries were hung for liturgical and other reasons.

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[1] Mainstone 1988 *et al*.

CHAPTER SIX

Summary

This chapter summarises the revelations and results of the presented research on San Vitale's spatial and temporal design, its historical and liturgical context, its architecture, lines-of sight, acoustical character, and how these all synthesise to communicate a cohesive set of messages to a sixth-century congregation.

Chapter One (Part 1.1) introduced the research question and a review of the former acoustical work done by archaeologists. Concepts of past acoustic phenomena were discussed in relation to phenomenology, place, ephemeral content, impermanence, immersion and the affects of belief upon the sensory registers of perception within the modality of exteroception. The importance of Scarre's *Archaeoacoustics* 2006 monograph has been outlined and a predominant emphasis on Prehistory was identified. In Part 1.2 the results of the CAHRISMA Project 2000-2003 were reviewed and, in Part 1.3, advances to that project's remit of conservation and renovation were suggested, by initiating a programme of archaeological inquiry for restoring and reconstructing acoustical spaces of the historic past, namely the sixth-century centrally planned domed congregational church of San Vitale in Ravenna. Part 1.4 (and Appendix A) addressed and identified the particular contemporary sixth-century theories of sound propagation relevant to the intellectual context of San Vitale's design, namely analogies of sound acting like waves of water in a pool and rising as in a conical stereo image. It is reasonable to suggest that these analogies and concepts operated in Late Antique ecclesiastic architectural design.

Chapter Two (Social/Christian Ritual) examined the social and cultural linkages operating in Late Antique Ravenna, mediated by the pivotal Episcopal position held by the city's bishop[1]. The discussion of the historical context of San Vitale identified former Roman architectural examples of *thermae* (baths) and palatial audience chambers as potential influences[2], specifically the octagonal centrally planned bathing complex at the

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[1] For the role of the bishops in late Roman Italy, see Azzara 2002:85-101.
[2] See Appendix B, Part 1, page 322 (Krautheimer 1965:152).

Piazza Armerina in Sicily (Figure 6.1), and the octagonal rooms of the second-century villa at Desenzano near Verona (Figure 6.2), later one of King Theoderic's three capital cities.
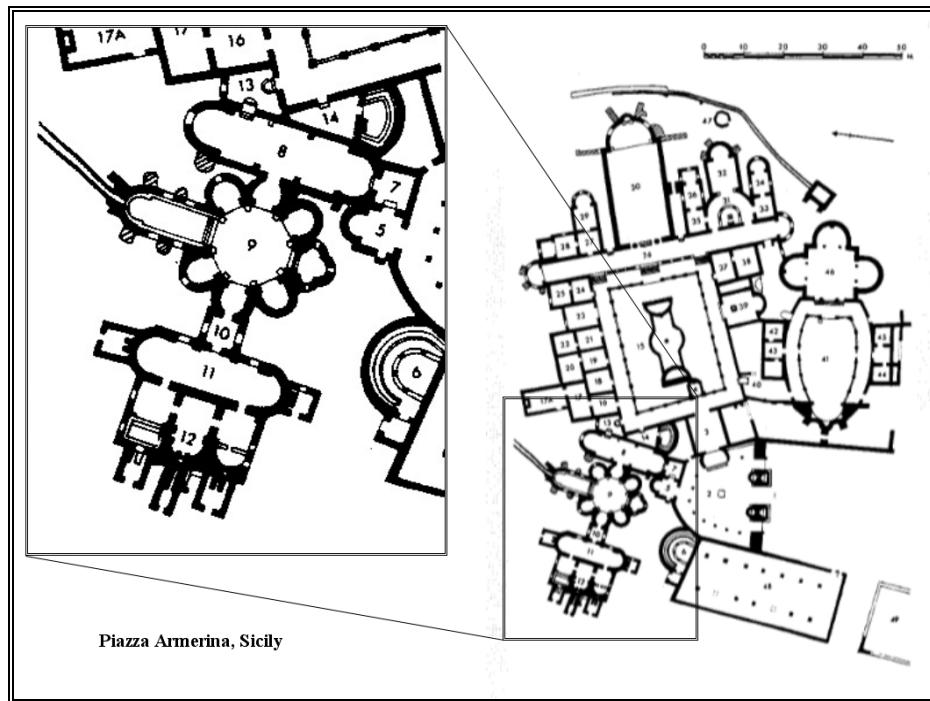
Figure 6.1: Piazza Armerina, Sicily[3]; the bathing complex of rooms 8-12 are particularly striking as a potential architectonic influence on San Vitale (after Volpe 1998:308, Figure 345:1).

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[3] Known as the Villa Romana del Casale and dating to the first quarter of the fourth-century: http://en.wikipedia.org/wiki/Villa_Romana_del_Casale
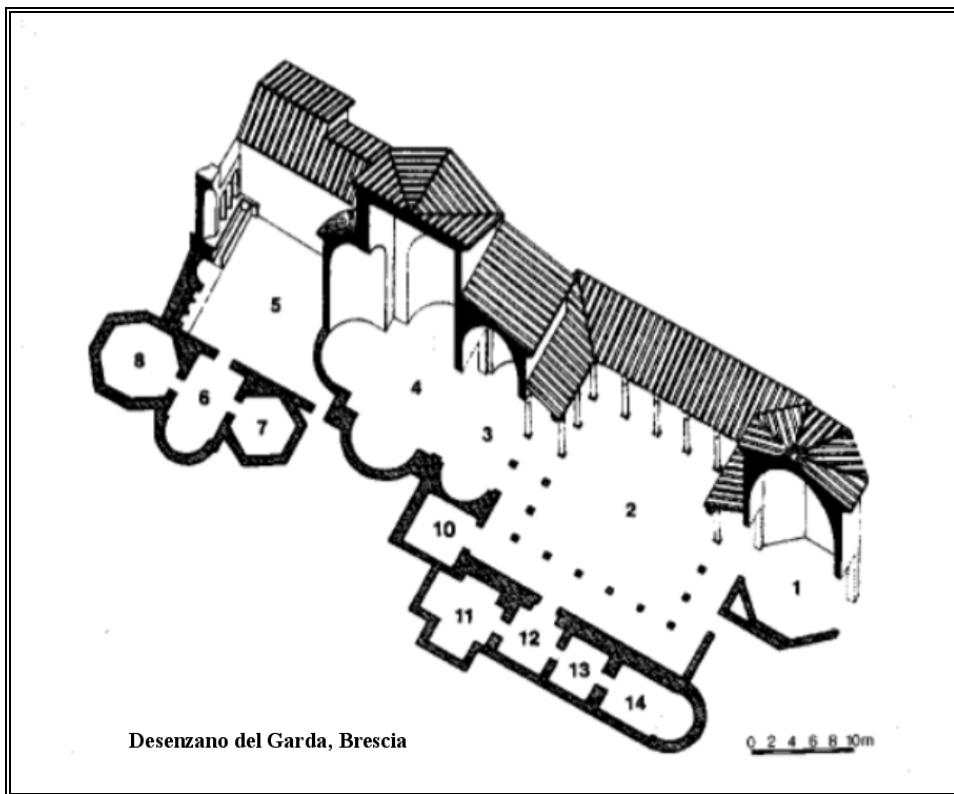
Figure 6.2: Second-century villa at Desenzano del Garda[4] (after Volpe 1998:308, Figure 345:5).

Of particular importance are three Christian architectural examples identified as having primary importance to San Vitale's design. While the late fourth-century octagonal congregational church at Philippi[5] may have had some influence, a more direct example is the octagonal congregational Church of the Theotokos on Mount Gerizim, built in the reign of Zeno, in 484, and further restored by Justinian (Figure 6.3). Although this church is laid out as an octagon within an octagon it lacks a narthex. The seven *exedrae* are parallel to the faces of the inner octagon, presumably supporting a second storey *matroneum* floor above, and are described by piers and two columns each, the eighth section occupied by the chancel; these features are further developed in San Vitale.

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[4] Second-century villa discovered in 1921 on the *Via Emilia* between Brescia and Verona: http://www.onde.net/desenzano/citta/traduzione/Cenni_uk.html
[5] Krautheimer 1986:128-130, Figure 85. See Chapter Two, page 58, note 37.
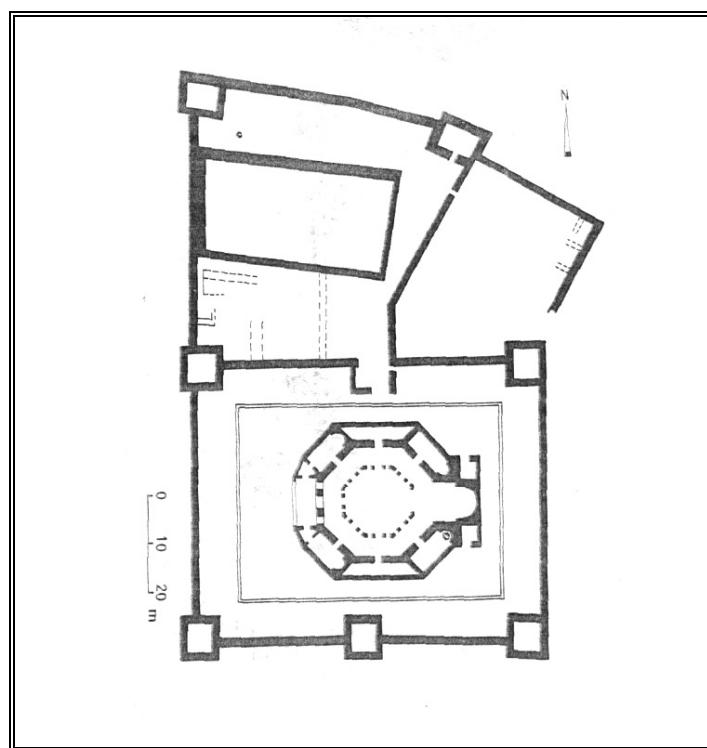
Figure 6.3: The Church of the Theotokos on Mount Gerizim; AD 484 (After Magen 1993).

The dedication of this church to the Theotokos may have been taken up at Ravenna at least in the dedication to Santa Maria Maggiore, the church physically nearest to and contemporary with San Vitale.

The third, and most important influence upon the design of San Vitale is, perhaps controversially, the late fifth-century octagonal Arian baptistery at Ravenna. By 565 the baptistery was converted to Orthodoxy and used as an oratory, dedicated to Santa Maria[6]. The architectural design of the Arian baptistery has an extremely rare innovation, possibly also in the octagonal church at Philippi[7]; the apse interrupts the ambulatory. It is significant that this unconventional design feature is reiterated in San Vitale. There are two further aspects of direct influence; the exterior dimensions of the Arian baptisteries octagon and the inner octagon of San Vitale are the same as the exterior dimensions of the internal octagon of the baptistery and the external octagonal face of San Vitale's apse (Chapter Three, Figure 3.1.1). These Arian measurements repeated in San Vitale at the

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[6] Following this, during the Exarchate of Ravenna it was again rededicated, as Santa Maria in Cosmedin: Bendazzi & Ricci 1987:156.

[7] Krautheimer 1986:129.

same scale are highly significant when reconsidering the relationship between Ravenna's centrally planned church and Constantinople's SS Sergius & Bacchus.

This outer octagon of the Arian baptistery and inner octagon of San Vitale is also used as the inner octagon of SS Sergius & Bacchus, suggesting a controversial sequence: the Arian baptistery octagons were the direct source of San Vitale's octagons and then transplanted to Constantinople as the inner octagon of SS Sergius & Bacchus. Considering the three octagons seen in San Vitale's plan, their width is 27, 54, and 120 *pes*, whereas at SS Sergius & Bacchus they are 37 and 54, the largest so poorly delineated it is impossible to assign one width measurement to it. A more detailed discussion of the two churches will be returned to a little later.

By considering the original process of surveying and constructing San Vitale (in Part 3.1) new insights were revealed into the relationship and context of this structure to the other churches of Ecclesius' building scheme, demonstrating the calculation and positioning of the octagonal geometry and its symbolic and sacred significance to the intentional transformation of the sacred urban topography of Ravenna, and also their relevance to the process of acoustical and visibility mapping. The analysis of San Vitale's design, construction, and dedication has revealed several new points of interest.

The formation of the exterior octagon by two superimposed *actus quadratae*

Converting the metric measurements of San Vitale was essential for identifying and understanding the original significance to dimensions and proportions. From a number of significant measurements noticed was the discovery, not elsewhere mentioned, that the exterior walls of the church adhered to a Roman land measurement of primary importance, the *actus quadratus* (120 Roman square feet/*pes*). By superimposing a second rotated *actus quadratus*, by exactly 45° rotation to the south, San Vitale's main exterior octagon was formed. The centre line of this second rotated *actus quadratus* (therefore, at 60 *pes*) provides the church with its main axis, described next.

The chancel and apse axis rotated 45°

The often-noted rotation of San Vitale's main axis, away from true east towards the south, has fostered the notion that this is an anomaly that deviates for some

inexplicable reason from the expected and generally followed east-west alignment of congregational churches. The rotation away from East is by exactly 45˚, an 8th portion of a circle within an octagon (again, the number 8 is utilised)[8]. Also the late fifth-century *sacellum* appears to provide the necessary angle for calculating and positioning the main exterior and inner octagons, as the east projection of the south face of its small altar intersects the rotated church axis at an angle of 22.5˚, one 16th of the whole. Any structure on the decided site would have provided such an angle of intersection, but since the *sacellum* is enclosed, protected, preserved and liturgically engaged with in San Vitale, its significance to the church cannot be overemphasised, despite this research being the first to call attention to the fact.
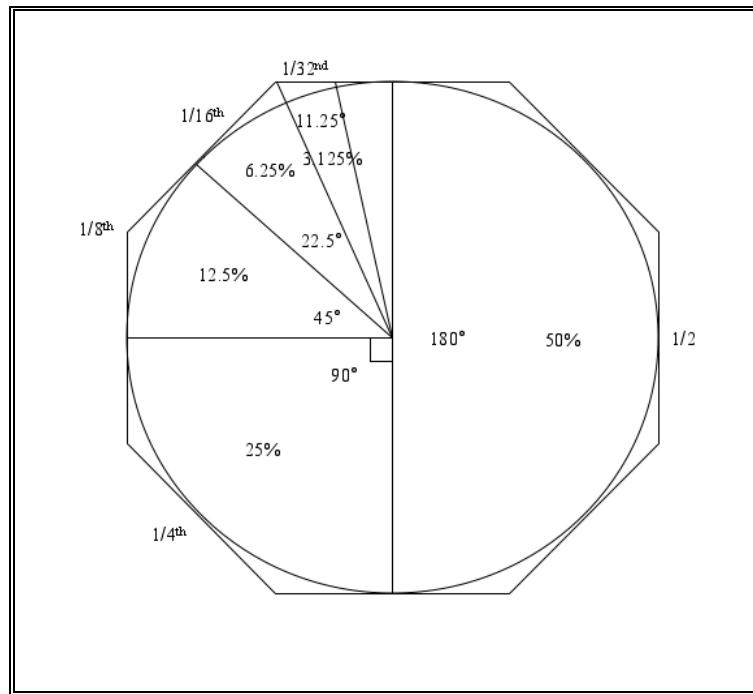
Figure 6.4: Fraction and degree divisions of a circle within an octagon (Knight 2009).

As can be see in Figure 6.4 above, 22.5˚ describes one section within an octagon, from one corner to the centre of an adjoining face. It was found that this angle along with 45˚ and 11.25˚ was reiterated throughout San Vitale as angles and gradients in plan, elevation and within the spatial organisation of the original ground floor mosaic bordered

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[8] See Figure 3.1.7A in Part 3.1 of Chapter Three, page 78.

segments[9]. Although this is a predictable outcome for the geometry of the octagon, it was a new and significant discovery to identify the rationale of this geometry extended also to the superimposed *actus quadratus*, which is precisely rotated south at an angle of 45˚ south of east, and the decision to also have the main axis of the church further rotated south by 22.5˚.

Further to this it was noticed that the main axis, along the rotated line of the chancel, projected across several urban streets and quarters to the exact position of the entrance to San Michele in Africisco. This projection has not been mentioned before and has been identified and interpreted here as intentional and intrinsic to the overall design and survey of at least these two churches of Ecclesius' building programme. Such evidence of superimposing sacred alignments across the urban topography of sixth-century Ravenna is one exciting contribution of the present research.

San Vitale is therefore resplendent with a Late Antique interest in the geometrical relationship of the circle and globe to the octagon, further displaying the expertise and accuracy of the designer(s), surveyors, architect(s) (or *archiergatus*(*ae*)), engineer(s) and builders at Ravenna.

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[9] See Figure 3.1.11 of Part 3.1 of Chapter Three, page 85.
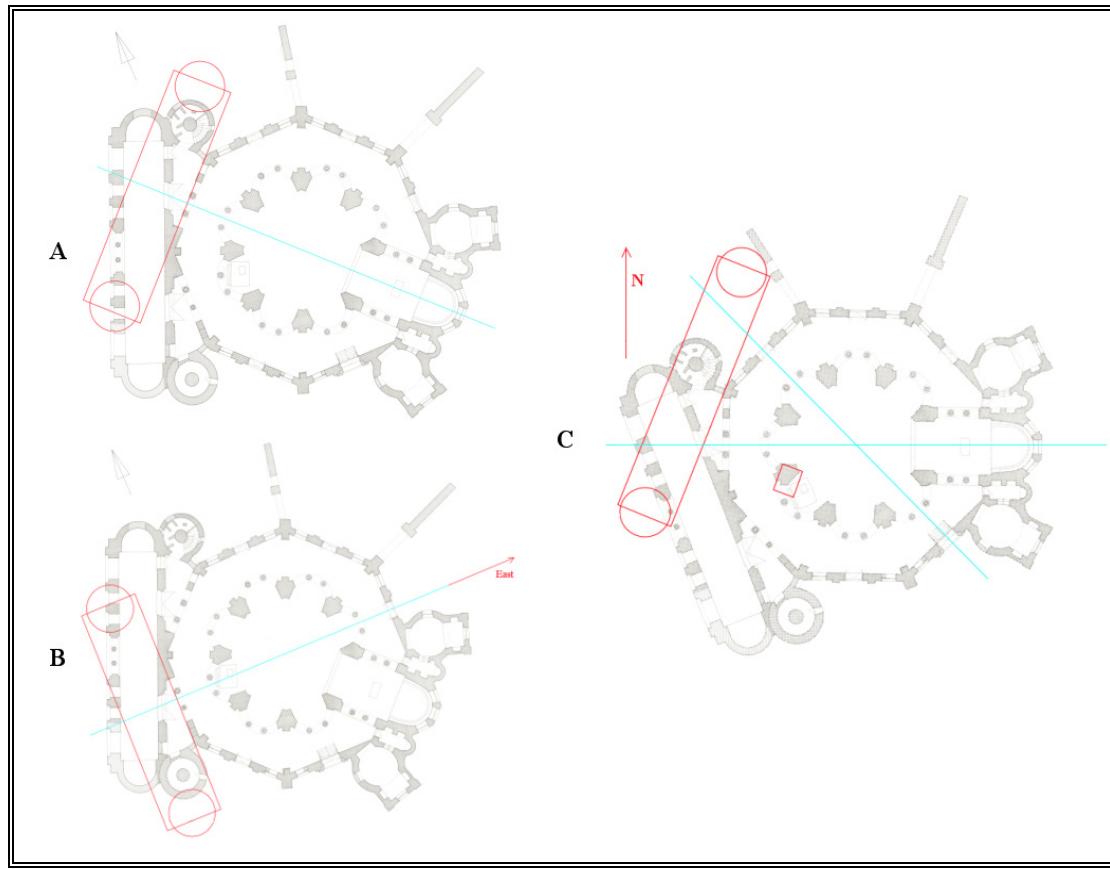
Figure 6.5: Alternative solutions (Plans A, B and C) to San Vitale's entrances (Knight 2009).
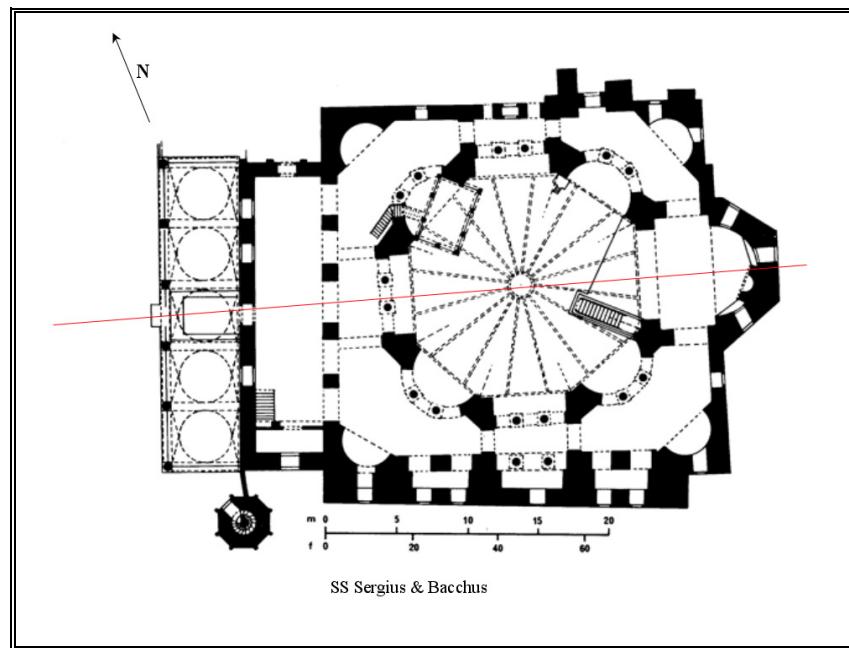
Figure 6.6: SS Sergius & Bacchus narthex layout (After Lassus 1967:75, Figure 47, Knight 2009)[10].

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[10] Lassus used this plan from the original by Toesca 1927:116, Figure III.

The southern rotation of San Vitale's main axis, formerly generally believed to be an anomaly, has been demonstrated here to be intentional, fulfilling at least two purposes. Firstly, the rotation allows for two distinct entries from the narthex into the main body of the church. If we consider the facility of two separate entrances was not important, two alternatives are possible, the schemes shown in Figure 6.5 A and B where one main entrance from the narthex into the church is acceptable. In example A the narthex could have been rotated clockwise westward, adjoining the northwest face of the church, giving all who entered clear and direct visual access to the main altar. In example B, the narthex could have been rotated anti-clockwise to the southwest, adjoining the western face of the church, and directly perpendicular to true east, but this does not allow for any clear access to the main altar.

If we consider the facility of two separate entrances as an imperative of the design, only two alternatives are possible, the scheme shown in Figure 6.5 (Plan C), and the way it has in fact been built. A fourth option is evident at SS Sergius & Bacchus (Figure 6.6), where the narthex is perpendicular to the Easterly oriented main axis, and while providing for several entrance points, only the central door gives access to the altar (shown as a red line).

The inconspicuous 3-dimensional distribution pattern of column base shapes[11]

- Only the females standing in the second storey *matroneum* would be able to see the column base shape on their floor and also those on the ground floor, contrary to the males on the ground floor who would not be able to observe the column bases on the *matroneum*. However, in order for a female to fully appreciate the logical 3-dimensional pattern of the distribution of all the bases, she would have to walk around the entire *matroneum* ambulatory with note-pad and pen (parchment and *stylus*).

- This logical 3-dimensional pattern was most likely worked out prior to construction during the design phase. Alternatively, the reflection and alternation of the column base shapes installed on the *matroneum* floor may have been decided upon after those on the ground floor had been constructed. In either case,

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[11] See Figure 3.1.14 A and B, Part 3.1, Chapter Three, page 90.

the logic of the 3-dimensional distribution of the pattern may have been best calculated by the use of original drawings and/or a scaled model[12].

- This pattern is inconspicuous yet important. It falls outside current visibility analysis even though it is an intrinsic visual material attribute of the church architecture. Aside from those directly involved in the design and construction it is doubtful if anyone else realised or saw or even understood the patterning. It is conceivable that it remained unknown until this present research[13]. And yet, this pattern is meaningful in that it suggests the architectural details working together to make logical, theological and symbolic sense was believed to be essential but not necessarily identifiable. In other words, the inner logic and geometry was understood to impart meaning but it wasn't necessary for all or any of the congregation to know the specifics of the details in order to understand how this was achieved, it was simply taken as a matter of faith that the church was meaningful.

In this way the column base 3-dimensional distribution pattern in San Vitale implies a separation between those who had knowledge of the design details and those who believed such details existed in the architecture without necessarily seeing them or knowing why the overall effect works in union. This potentially further indicates a level of trust on the part of the congregation and a responsibility of custodianship held by the clerical offices. Whether the privileged knowledge of details such as the column base distribution was actively considered to be a secret only to be understood by an elect few, as a sort of Gnostic mystery, must remain for future consideration.

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[12] Stalley (1999:252) noted that 'apart from studies of the St. Gall Plan, there has been little discussion of the use of drawings in the late Antique and Early Christian period; there is a useful survey by W.E. Kleinbauer, 'Pre-Carolingian Concepts of Architectural Planning' in *The Medieval Mediterranean: Cross-Cultural Contrasts,* eds M.J. Chiat and K.L. Reyerson (Minnesota, 1988), 67-79'. A scaled model may be what Bishop Ecclesius is depicted holding in the apse ceiling mosaic of San Vitale. This may be a representation of an actual model used for the purposes of design, construction sequencing and demonstration. This iconography is not unique, perhaps it was common practice for such scaled models to be built prior to construction, or this may be reading too much into the iconography.

[13] As far as I am aware none of the literature on San Vitale, except for one densely packed figure by Deichmann (1989) of the capitals and bases, makes note of this column base patterned distribution.

Equivalencies between plan and elevation

A particularly interesting equivalent relationship was found between the *exedrae* heights and the length of the chancel and apse (Part 3.1). This equivalency extends not only to the same arc (completed blue circle) for the exedra arch and the apsidal end of the chancel, but also the arcs (light green) for the triple exedra inter-columnar arches and the apsidal ends of the small entrance spaces to the north and south chapels adjoining the apse. Further important equivalencies will be discussed in fuller depth below when comparing San Vitale with SS Sergius & Bacchus.

Symbols and Reflections:

Octagons

San Vitale is resplendent with both obvious and inconspicuous symbolism. The most apparent symbolic element is the use of the octagon as a structuring geometry on which the church is based. In Chapter Two and Appendix B attention was given to the development and distribution of the ecclesiastical use of the octagon in baptisteries, *mausolea*, and congregational churches. It was found that octagonal baptisteries were being built with proliferation in northern Italy, likely stemming from Ambrose' ideology of the octagon and his late fourth-century building activities at Milan. His specific reference to the suitability of the octagon for baptistery design has been cited in Chapter Three (Part 3.1). The presence at Ravenna of the two baptisteries that have octagonal exteriors and interiors is important and it has been argued here that the Arian example was a direct source of influence on San Vitale. The liturgical function of the baptistery is not theologically opposed to that of the mausoleum, of which San Vitale is a very specialised example where only Orthodox Bishops of Ravenna (and the body of Galla Placidia if Agnellus was correct) are to be interred. Baptism is the death of the old self and rebirth of the new practicing Christian. The rite takes place at the Easter celebration of Christ's triumphant resurrection from death. Thus:

> …baptism and death, the two poles of Christian existence, were…firmly linked in iconographical terms, being represented by buildings that were centralized in plan and covered with a dome or vault[14].

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[14] Stalley 1999:71.

It has also been suggested that the octagon has resonant meaning in relation to the Cult of Mary, the Theotokos, as expressed in the congregational church at Gerizim. The concept of the centralised church in general being both womb and tomb can be more clearly defined as specifically octagonal churches referring ultimately to Constantine's initial Christian architecture in the Holy Land, namely the octagonal east end of the Church of the Nativity at Bethlehem[15] and the octagonal Anastasis rotunda in the Church of the Holy Sepulchre at Jerusalem[16].

Eight-pointed figures

Several examples of eight-pointed stars are represented in the ceiling mosaics of the *mausoleum* of Galla Placidia and there is obvious similarity between these and similar stars within San Vitale's mosaics. It may be that the eight-pointed star represents the star over Bethlehem heralding the nativity of Christ. In San Vitale another eight-pointed figure is of primary importance, the eight rays of light extending out from the letter *Alpha* (the beginning), within a disc held aloft by the Archangels Michael and Gabriel. It was demonstrated this symbol is at eye-level to those standing in the *matroneum*, but difficult to make out from the ground floor.

From the various observations discussed above it can now be better understood that there are a series of intentional elements to San Vitale that are not necessarily intended to be seen. They may have been designed to evoke awe and mystery, perhaps believed to be the mimicry of the Divine intellect as expressed through the laws of geometry, mathematics, *numerositas*, symmetry, rhythm and pattern.

Discussion followed in Part 4.1, of how the logic and geometry of San Vitale's material architecture is also temporally echoed in the choice of dedication date in accordance with the liturgical calendar. The Octave of Easter, the first Sunday after

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[15] Krautheimer 1986:59, Figure 26.
[16] Krautheimer 1986:62, Figure 27B. Also Biddle 1994 *et al*.

Easter, was shown to be the most likely date of dedication, in the year 548, the eighth year following Ravenna's administrative takeover by Constantinople in 540[17].

Part 4.2 demonstrated a series of lines-of-sight, following the recreated clerical and congregational procession into and throughout San Vitale during the celebration of the Eucharist. This reconstruction revealed the spatial organisation of the congregation on two floors. The north area of the narthex and church were found to be somewhat privileged with better views of the main altar. Taking the chancel apse wall mosaics as a cue, where the male court is depicted on the north wall and the females on the south, it was also found the conventional congregation division according to gender appears to have been reversed in San Vitale, whereby the male *pars virorum* was, upon the "Little Entrance" from narthex into the main body of the church, probably took place by means of the north entrance while the female *pars mulierum* entered by the south entrance, with only the small *sacellum* altar visible. Proceeding through this unconventional partitioning the females moved up to their own floor, the *matroneum* while the males followed the clergy and stood on the ground floor facing the main altar. Such a reconstruction of movement during the Mass has not been previously attempted for San Vitale and the suggestions made in Part 4.2 are hoped to provide grounds for further study.

For the purposes of understanding San Vitale's acoustical character Part 4.3 identified one of only six extant Ravennate chants, *Lux de luce Deus tenebris illuxit Averni* [18], as a close contemporary of San Vitale certainly 'in use before the mid eighth-century'[19] and perhaps as early as the sixth-century[20] and therefore an appropriate vocal sound-source.

Chapter Five detailed the methodological stages and steps taken to measure the acoustical characteristics of San Vitale. Part 5.1 discussed the processes of creating a virtual 3-dimensional model of San Vitale, and how the male vocalisation of *Lux de luce* was convolved into the model. To supplement this Chapter, Appendix D provides two sets of data, the metric measurements of San Vitale and their conversion into

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[17] See Table 4.1.1 in Part 4.1 of Chapter Four, pp. 110-111.
[18] Levy 1971:48.
[19] Levy 1980:622.
[20] Refer to my Appendix C; Compendium of Ravennate Chant.

contemporary measurements[21], and renderings from Giannakopoulou's 3D model of San Vitale. Appendix E provides an extensive image bank of further renderings, photographs, plans, sections and Powerpoint shows from the virtual models, and walk-through videos.

Part 5.2 describes the process of preparing *Lux de luce* for rehearsal and live performance. A number of points of musicological interest were discussed regarding this *versus*, including its liturgical context as a *lucernarium* chant sung during Easter Vigil at the point when the Paschal candle was lit. It was found that the highest note of the *versus* occurred only once, on the word *reseravit* in verse seven meaning "open" (describing when Christ unlocks the gates of Heaven) and it was suggested that when this word was sung the candle was lit, perhaps signifying a unique liturgical corollary between light and high-pitched notes (and the inverse: darkness and low-pitched notes).

Part 5.3 described the 2006 acoustical survey of San Vitale initiated by this research and highlighted the particular calculations for Clarity and Reverberation Time from the measured Impulse Responses. Appendix C provides information on the surviving examples of chant from the Ravenna Rite (C.1) and also the raw acoustic data from the 2006 acoustic survey (C.2).

Part 5.4 summarised the further vocal recording of *Lux de luce* in an anechoic chamber at the Institute of Sound and Vibration at the University of Southampton in 2007. This was successfully performed to provide a dry vocal signal for convolving with San Vitale's measured reverberation for use in a virtual simulation.

The data collection of the acoustic survey, further calculations from the recorded Impulse Responses, and application of the anechoic recording of *Lux de luce* into the virtual 3-D photorealistic acoustic model has shown the church to possess a long reverberation time and, at the frequencies where the reverberation time increases, the Clarity of perception regarding speech and vocal music decreases. Within the normal adult human male and female vocal frequency ranges of speech and singing, the reverberation and Clarity do not make San Vitale an especially successful venue. However, that is the conclusion drawn from the present acoustic study of the church but

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[21] Using both the uncial and digitus scales (Campbell 2000:482, Appendix 8). Significant measurements and proportions have been collated in Appendix D.4. Also see Table 5.1.1 on page 163.

not perhaps that of the Late Antique designers, builders, clergy nor congregation. Accordingly, there are several suggestions that can be made:

1:   The sixth-century designer(s) of San Vitale intended to create a specific sacred congregational interior where both vision and audition were directed to the liturgical focus of the main altar, at which the celebrant and attendant clergy may have been both seen and heard with ease. The visual and aural experience of the processional entry into and exit from the narthex and the main body of the church was likewise intended, where certain material and sonic phenomena were both conspicuous and inconspicuous in order to create a sense of the depth of harmonious rhythm and unity of the church, the sequence of the Mass, Theological symbolic meaning, and the collectively believed tenets of Orthodoxy.

2a: The sixth-century designer(s) of San Vitale intended only to create a specific sacred congregational interior, considering only the visible and material *numerositas*, "numberful" rhythmic symmetries that are conspicuous and inconspicuous, spatial and temporal. The acoustic characteristics were unintended epi-phenomena.

2b: The acoustic characteristics of San Vitale were unintended epi-phenomena but were nonetheless successfully utilised and a Ravennate, perhaps even a San Vitale specific, oratorical style and vocal music developed in direct relation to these characteristics, namely the Reverberation Time and Clarity of both speech and musical perception. If this is correct then a series of compensations may have been developed (or already existing techniques applied), including oratorical voice projection while also speaking and singing at a slow rate in order for the words of prayers, benediction, and chant verse to be intelligible.

3a: The acoustic characteristics of San Vitale are the result of sixth-century theoretical and practical experimentation with architectural acoustics, according to contemporary theories of sound propagation[22].

3b: As an experiment in architectural acoustics San Vitale was deemed by the clergy to be unsuccessful. The length of reverberation times and reduced Clarity were not desired but "they lived with it", making certain compensations for better vocalisation.

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[22] See Appendix A for an overview of relevant theories of acoustic phenomena.

The results of further experimentation favoured the longitudinal basilica design (in the West).

3c: The experiment of architectural acoustics at San Vitale was deemed successful. The Ravennate rite favoured the long reverberation times and low Clarity values identified in the survey.

Of these possible interpretations, it seems the most likely is 3b, while each of the remaining possibilities may individually or collectively also have some validity. Considering some of the historical points mentioned in Chapter Two, it might be possible to narrow which of the remaining suggestions are most likely.

Firstly, it is known that at an early date shortly following the church's dedication in 548 the wooden ceilings of both ground floor and *matroneum* ambulatories were replaced with decorated plaster. One reason may have been to reduce the risk of fire to the building, supposing the risk was already high with the presence of a number of candles, hanging oil lamps and flammable partitioning tapestries. The entire roof frame of the church is also wooden and it seems reasonable to suppose any risk of conflagration from the interior was dealt with. However, it is noteworthy that the original design and construction did not anticipate the threat of fire. Since these ambulatory wooden ceilings would have had a noticeable acoustic effect on the interior, their removal should be considered also as an intentional change to the acoustic character of San Vitale. Replacing the ambulatory ceilings with plaster may have been executed for acoustic reasons as well as the desire to reduce the risk of fire, and if so, then the extant Reverberation Times and Clarity values can be considered to be intentional, thus supporting the following additional suggestions:

3d: The original acoustic characteristics of San Vitale were not desirable and swiftly altered by removing the wooden ambulatory ceilings. With this alteration the acoustics were deemed better suited to the spoken and sung sections of the liturgy.

3e: The original acoustic characteristics of the church were desirable but, with the threat of fire, the wooden ceilings were replaced with plaster. The resultant noticeably changed acoustics were not desirable but "lived with".

3f: The resultant noticeably changed acoustics were desirable.

Secondly, it has been noted (in Chapter Four, Part 4.3) that the sixth-century observations and potential influence at Ravenna of both Boethius and Cassiodorus may bear upon the design of, if not the experience in, San Vitale. Boethius' use of the analogy of water waves to sound propagation[23], from a centre radiating outwards in concentric rings, may have provided, along with the analogy of sound rising upwards as a conical stereo image[24], the intellectual and experimental context for architectural acoustics. Cassiodorus' description of the *jubilus* sung as a wordless improvised play with the surrounding acoustics points to an intentional combination of singing method with architecture. It is quite possible his observations are rooted in his own experience at Ravenna, perhaps even inside San Vitale. If he was describing the reverberation inside this church, it was most likely before the removal of the wooden ambulatory ceilings, and so, although the description is intriguing and of interest to the history of architectural acoustics, it cannot be used alone to throw any substantial light upon the specific altered acoustic space of San Vitale, if indeed it was even that church he was describing or simply making a general observation.

Thirdly, and most importantly, it has been shown[25] that the *pars mulierum* was elevated to the *matroneum* floor and that at the dates considered there remains the possibility that women were allowed, even encouraged, to sing. The acoustic characteristics of the church, even if not noticeably different to those of the traditional longitudinal basilica, would be experienced in a very different way. Modern acoustical science shows us that a centrally planned two storey building does *not* have especially *better* acoustics for vocal performance, but the use of the aesthetic term "better" is problematic, as it is rooted in subjective judgements at whatever times it is used. Suffice it to say that if the assessment of San Vitale's acoustic qualities were rooted in current aesthetic values, the assessment would alter year by year according to fashion. To briefly illustrate the fluidity of aesthetic judgement, one need only consider that, for the overwhelming majority of modern visitors to San Vitale, the church remains a primary

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[23] See Appendix A, the water analogy.
[24] See Appendix A, the rising cone analogy.
[25] See Chapter Four, Part 4.2.

example of beauty exhibiting a high level of craftsmanship, all the more extraordinary to the tourist because this work was conceived and achieved in what is popularly known as the "Dark Ages". Despite this present acclamation of San Vitale's excellence, in 1891 one journalist writing for The New York Times published this:

San Vitale, a singularly hideous church outside…[26]

There is no doubt that the innovative changes placed on where male and female members of the congregation were to walk while entering San Vitale, and where to stand once inside, were meaningful and understood. As shown in Chapter Four (Part 4.2), the physical location of the male and female congregation is one of the primary differences between this church and other Ravennate churches such as S Apollinare Nuovo. The vertical spatial distribution of male and female singing can be understood as a vital part of this important difference. The resulting experience of the singing would also be noticeably different. For example, during those chants and responses that required and/or allowed for female singing, the male congregation and clergy on the ground floor would hear the higher voices literally from above. Visiting non-Christians, non-Orthodox Christians, and Arians would have had perhaps the best appreciation of the liturgical vocalisations as they stood listening until their required exit before the gifts were sanctified. The experience of hearing the higher voices from above can be understood as yet another way Late Antique theological ideas were conveyed as realism, or *trompe l'oreille*[27], in that those voices heard from above were substantially understood to be the voices of the angels, voices from Heaven descending for a time to the earthly plane. The long reverberations and un-Clarity would have only reinforced this perception.

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[26] Charles de Kay; *The New York Times*, September 27th, 1891.
[27] Tricking or fooling the ear, as *trompe l'oeil* refers to tricking the eye. A much later example of visual illusionism in San Vitale is the dome ceiling painting by Serafino Barozzi (1735-1810), Ubaldo Gandolfi (1728-1781), and Jacopo Guarana (1720-1808). Guarana had worked with the *trompe l'oeil* specialist Geralomo Mengozzi Colonna. The Late Baroque dome painting of San Vitale is an excellent example of *Quadratura*. Barozzi was known as a *quadraturista*, an artist specialising in illusionist ceiling paintings. The term is applied to Italian painting: 'unlike other *trompe-l'oeil* techniques or precedent *di sotto in sù* ceiling decorations, which often rely on intuitive artistic approaches to deception, *quadratura* is directly tied to seventeenth-century theories of perspective and the representation of architectural space' (Wittkower *et al* 1999: 35-36).

Verticality is emphasised in the church in several respects. Physically, as just noted, the congregation is partitioned vertically. Design aspects such as the distribution of column base shape noted in Chapter Two works inconspicuously yet harmoniously upon the vertical axis. Theologically, the mosaics in the chancel apse of the *theophany* (manifestation) of the risen, victorious and enthroned Christ, crowned by the Archangels Michael and Gabriel suspending the radiating *Alpha*, are primary representatives of the vertical hierarchy of angels. Through these media the symbolism and meaning of this verticality central to the tenets of Christianity are distributed harmoniously throughout the entire church, in its material architecture, symmetry, meaningful geometric angles, and its temporal dedication within the liturgical calendar. This integration results in a subjective sense that the space is sacred and profound but while the details and larger relationships are completely explicit, there is a measure of intentional obscurity and secrecy in San Vitale. The church was built to be sacred and that may have also meant making everything from its geometry to its mosaics resonate with meaning. Some of its visible meanings are still known, some additional and complementary meanings have been uncovered in this research, others assuredly await discovery.

It remains difficult to prove, but it appears possible that the non-material acoustic characteristics of San Vitale were also utilised with verticality in mind. The main altar in the chancel was the liturgical focus for the male congregation (*pars virorum*). Facing towards this altar and involved in the celebration of the Mass, there is only one known time in the liturgical drama when the men may have turned around to look up at the *matroneum* level, during the exchange of the sign of Peace. Aside from this brief exchange the male congregation would have no reason to see the female congregation. However, they could certainly have heard the female voices from above during any of the sung portions of the Ravennate Mass rite, including the Easter Vigil chant chosen here (*Lux de luce*). The female congregation (*pars mulierum*), on the other hand, had fairly good visibility of the ground floor once they were near to the edge of the *matroneum* floor and the space of the inner octagon, but the main altar and liturgical actions remained the intended focal point. Nevertheless, they would have seen and heard the men below.

San Vitale, like all other Christian churches, is not only a place where belief is expressed but also where disbelief is to be suspended. In this regard, San Vitale, with its emphasis on the vertical, invites such suspension in a literal, easily recognisable way.

In light of this research the following Chapter (7) reconsiders the relationship between San Vitale and SS Sergius & Bacchus.

CHAPTER SEVEN

Discussion

Memories are hunting horns
Whose sound dies among the wind[1]

Reconsidering the phases of San Vitale and its relationship to SS Sergius & Bacchus

Having summed up the findings and results of this research, the sequence of phases involved in San Vitale's creation can now be provisionally reconstructed. Necessarily, the relationship with the similar church of SS Sergius & Bacchus at Constantinople will be detailed. In Chapter Two (and Appendix B) some discussion was provided for the historical background of the centrally planned octagonal domed congregational church of SS Sergius & Bacchus. In essence, as it was completed before Hagia Sophia, in c.536, it is cited[2] as being older and a direct influence on the design of San Vitale. This assumption has long required contesting, and the following arguments and demonstrations are an answer to that need.

As SS Sergius & Bacchus and Hagia Sophia are championed as Justinian's own "new" architecture and therefore taken to be the point at which discussion of centrally planned domed ecclesiastical architecture subsequently refers, the following considerations and comparisons between their design and acoustical characters will be most fruitful.

The main difference between SS Sergius & Bacchus and San Vitale is often overlooked; as it exists SS Sergius & Bacchus stands alone on fairly open ground, as does San Vitale, but SS Sergius & Bacchus was originally one of two churches (Figure 7.1), abutting each other and sharing the same narthex entrance.

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[1] From *Hunting Horns* by Guillaume Apollinaire (1880-1918).
[2] Krautheimer 1986:232.
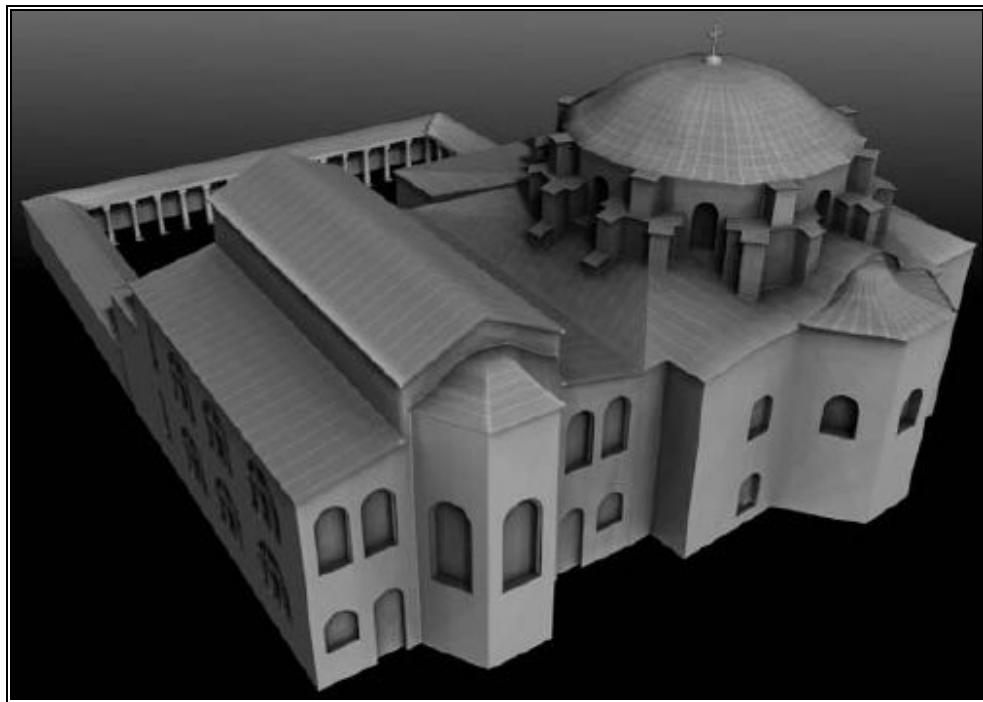
Figure 7.1: Virtual reconstruction of SS Sergius & Bacchus and SS Peter & Paul double church[3].

Fortunately, we have a description in Procopius' *Buildings*[4] where he states that the adjoining 'unnamed shrine' 'stood at an angle to this one [the church of SS Sergius & Bacchus]' and that:

> …these two churches do not face each other, but stand at an angle to one another, being at the same time joined to each other and rivalling each other; and they share the same entrances…in just one respect, however, they do differ. For the long axis of one of them is built straight, while the other church the columns stand for the most part in a semi-circle. But whereas they possess a single colonnaded *stoa*, called a narthex because of its great length, for each one of their porches, they have their *propylaea*[5] entirely in common, and they share a single court, and the same doors leading in from the court, and they are alike in that they belong to the Palace.

Elsewhere, it is known the second church, Procopius' 'unnamed shrine', was dedicated to SS Peter & Paul[6]. This was apparently a traditional longitudinal basilica

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[3] SS Peter & Paul no longer exists. Image online at:
http://campus.belmont.edu/honors/HagiaSophia/ConstSergBacchusModelONER.jpg
[4] Procopius; *Buildings* 1.4:3-7.
[5] A monumental gateway.
[6] Krautheimer 1986:224 and 487, note 22.

while SS Sergius & Bacchus was centrally planned, SS Peter & Paul having been constructed slightly earlier[7]. To study SS Sergius & Bacchus in isolation of its original context as a double church is therefore hazardous. Nevertheless, with regard to San Vitale, the attempt is revealing.

As mentioned above (Part 3.1), the dimensions of two octagons of the Arian baptistery at Ravenna were used wholesale for San Vitale's apse exterior shape and also the church's inner octagon. What is striking is that the inner octagon of SS Sergius & Bacchus is exactly the same dimension as that of San Vitale. As the Arian baptistery dates to c.500 at the latest, the equivalency in San Vitale and SS Sergius & Bacchus is extremely important. San Vitale was certainly dedicated after SS Sergius & Bacchus but the date at which they were designed needs clarifying.
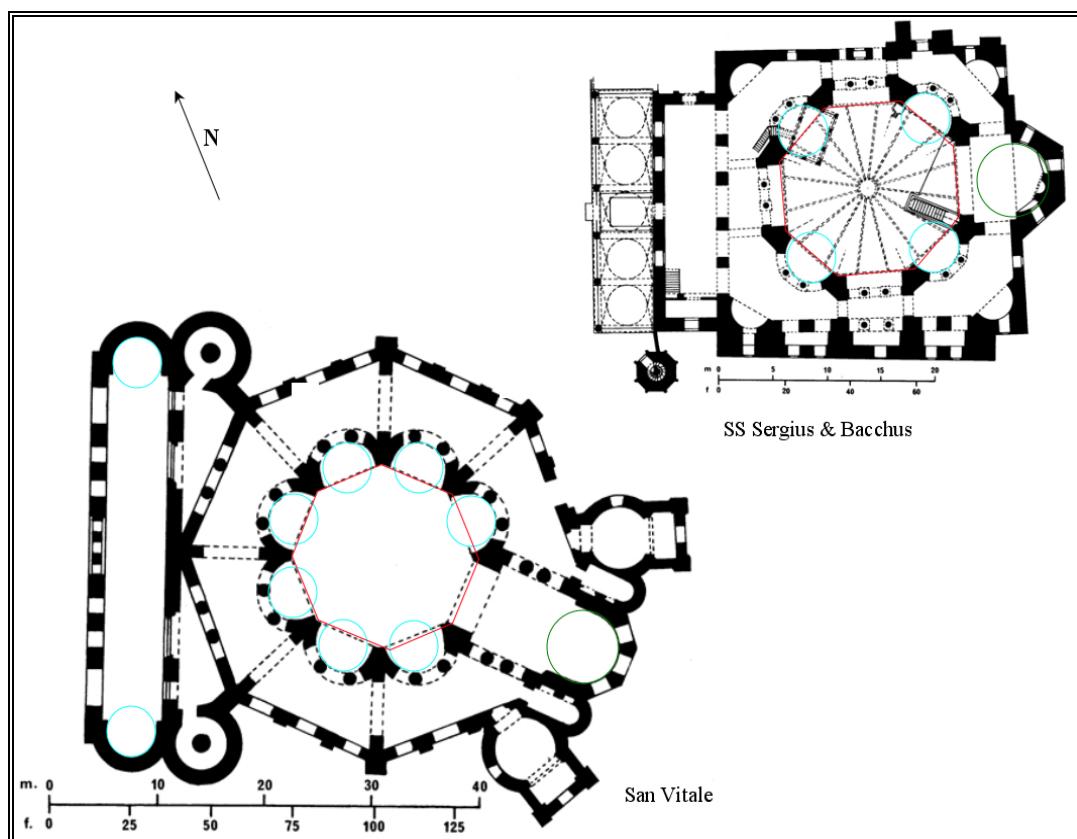
Figure 7.2: Comparable measurements of San Vitale and SS Sergius & Bacchus (After Lassus 1967:75, Figure 47, Knight 2009).

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[7] SS Peter & Paul may have been built before SS Sergius & Bacchus, in 518-19 (Krautheimer 1986:487, note 22).

Figure 7.2 demonstrates the important measurement equivalencies of San Vitale and SS Sergius & Bacchus. Ground plans sized to the same scale, the inner octagon of SS Sergius & Bacchus has been traced from Lassus' plan (red octagon), rotated and superimposed on the inner octagon of his San Vitale plan. The difference is negligible and can be explained by SS Sergius & Bacchus's slightly skewed geometry. The four semicircular *exedrae* arcs of SS Sergius & Bacchus have been drawn as closed circles (light blue) and likewise applied to the plan of San Vitale, showing the closeness of fit to be good in the seven equivalent semicircular *exedrae* of the inner octagon. The arc of San Vitale's apse curved interior has been drawn (green circle) and applied to SS Sergius & Bacchus's apse. The fit is very close on the north side, later alterations accounting for the apparent inaccurate fit on the south side. Therefore, the dimensions and scale of these three geometric elements are equivalent in San Vitale and SS Sergius & Bacchus.

None of the former literature contributing to the debate over the date and influence of SS Sergius & Bacchus, nor the consistently reiterated association between SS Sergius & Bacchus and San Vitale, mentions or illustrates these equivalencies. Lassus' popularly copied Figure 47 shows the plans and elevations of SS Sergius & Bacchus and San Vitale together, out of scale to each other, giving a false impression (Figure 7.3 below).
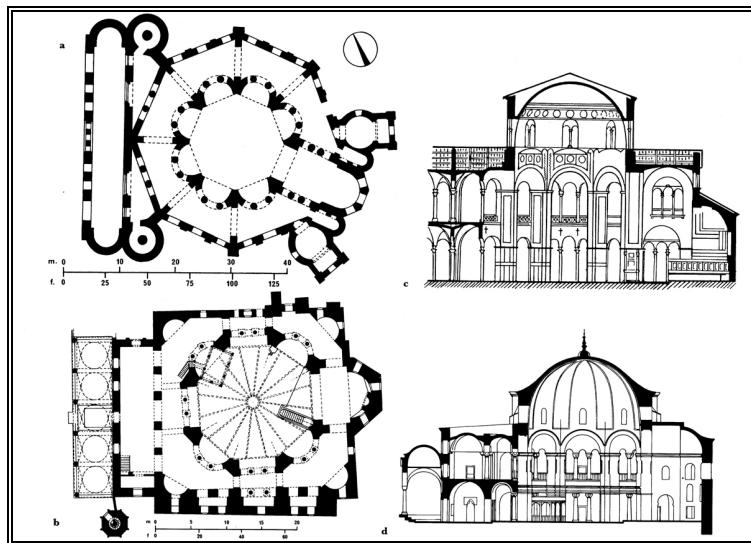
Figure 7.3: Plans and elevations of San Vitale and SS Sergius & Bacchus as published by Lassus[8]

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[8] Lassus 1967:75, figure 47. San Vitale is above (a and c) and SS Sergius & Bacchus is below (b and d). He says in the caption to this figure that '(a) S. Vitale, Ravenna, is practically identical to the contemporary

Scaled correctly to the same measure San Vitale is almost double the size, but as has just been shown, the inner octagon and the *exedrae* and apse arcs of San Vitale and SS Sergius & Bacchus are so close, their relationship cannot be supported as being merely coincidental. The precise difference in scale between the two churches is revealed in Table 7.1 below:

	San Vitale	**SS Sergius & Bacchus**
Interior length	148 *pes*	103.5 *pes*
Difference	Larger by 44.5 *pes*	
Internal height	97 *pes*	70.1 *pes*
Difference	Larger by 27 *pes*	

Table 7.1: Differences in scale of San Vitale and SS Sergius & Bacchus (Knight 2009).

The differences specifically at the chancel apse are particularly noteworthy. The distance from San Vitale's inner octagon to the interior surface of the apse is exactly double (55.3 *pes*) the distance in SS Sergius & Bacchus from that church's inner octagon to the division between its eastern ambulatory and apse (27.73 *pes*), providing San Vitale with a sizeable chancel not present in SS Sergius & Bacchus.

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building of H. Sergius and Bacchus (b) (fifth-century). The sections show how the architect of S. Vitale (c) has given this monument an elegance and lightness in the height of the openings of the octagon not found in the church of H. Sergius and Bacchus (d)' (*Ibid*). He is mistaken in ascribing either of these buildings to the fifth-century as they are of the sixth-century.
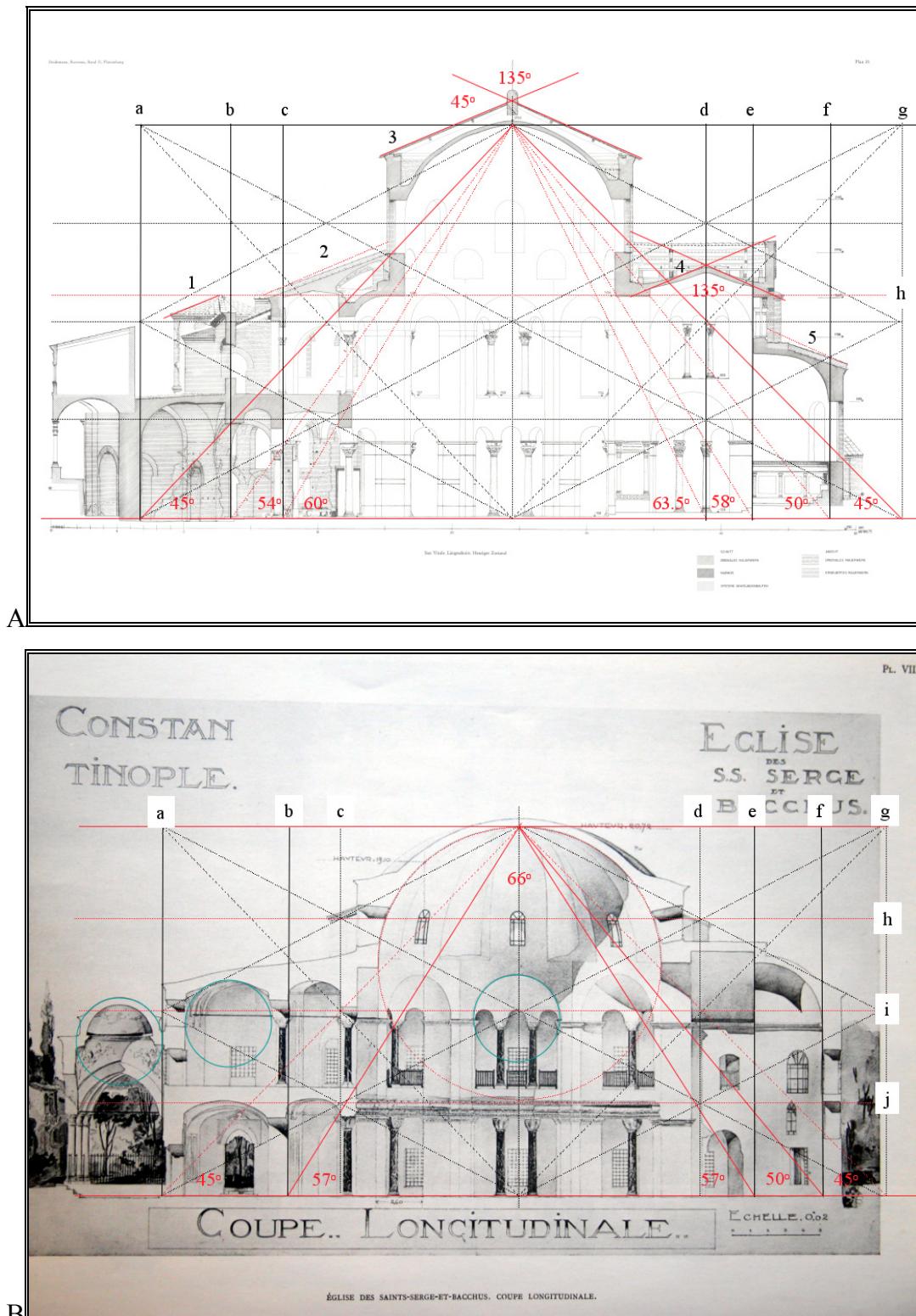
Figure 7.4: Elevation plans of San Vitale (A) and SS Sergius & Bacchus (B) showing angles (After Deichmann 1989 and UIUC; Knight 2009)[9].

The comparison of angles utilised in San Vitale (Figure 7.4 A) and SS Sergius & Bacchus (Figure 7.4 B) is revealing. In SS Sergius & Bacchus a triangle with angles 57˚, 57˚, and 66˚ fills the interior space, marking the beginning of the *synthronon* in the east (at line *e*) and the west ambulatory wall (at line *b*). A triangle superimposed onto San Vitale's similar elevation, at the same points (at the inner centre of the dome, and at line *c* and *e*) the angles are asymmetrical, 60˚, 58˚, and 62˚.

In SS Sergius & Bacchus, if a triangle with angles 45˚, 45˚, and 90˚ is applied to the section, creating a rectangle described by lines *a* and *g* (with the church floor as the base-line), and if this rectangle is then equally divided, the lines *h*, *i*, and *j* (dashed red) reveal significant zone changes within the architecture. Line *h* projects as the top opening of the dome windows, line *i* is the top of the *matroneum exedrae* inter-columnar triple arches, and line *j* describes the top of the central apse window opening and, roughly, the division between the ground floor columns and *matroneum* floor.

In San Vitale the roof pitch over the dome has an interior angle of exactly 135˚, the angle of each interior vertex of an octagon. It was further noticed that the roof over the chancel groin vault has the same pitch. Taking the differences in measurement between the two roofs into account, the internal face of the largest of San Vitale's octagons (the outer face of the ground floor ambulatory) with the inner octagon have been superimposed onto the plan and sections in Figure 7.5 below.
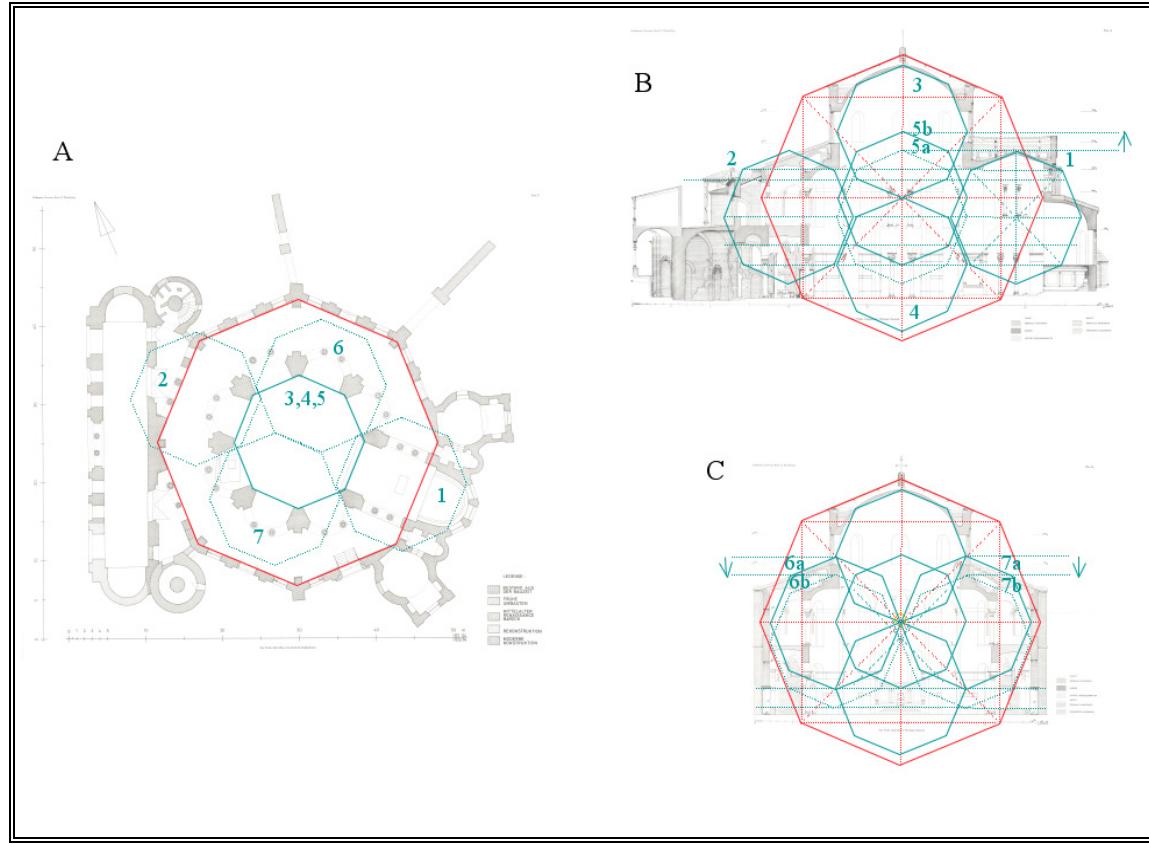
Figure 7.5: The inner octagon replicated seven times within San Vitale (Knight 2009).

The results were not predicted, adding to the excitement of the discovery. In section 7.5B the largest of San Vitale's octagons (red) was applied to the dome roof. Its extent to the left (north west) is at line *c* in Figure 7.5A, where lines (red) from the centre of the dome interior and floor meet at the northeast at an angle of 60˚. The extent to the right (south east) is at line *e* in Figure 7.5, where comparable lines (red) meet at an angle of 58˚. The smaller octagon *1* (blue) was copied from the inner octagon and initially applied to the chancel vault. The horizontal line through the middle of this octagon was found to describe accurately the base of the triple arched opening at the *matroneum* ambulatory termination at the chancel. The vertical line through the middle of this octagon was found to pass very accurately through the centre of the west-most column of the ambulatory termination at the chancel on the ground floor.

The octagon *2* (same measurement and scale to *1*) was then applied to an equivalent position to the northwest and octagon *3* to the inner surface of the dome. This predictably fit remarkably well into the entire dome area. A fourth small octagon (*4*) of

the same size was applied below the latter, whereby the lowest point of *3* was the highest point of *4*. The horizontal middle line of *4* is extended both ways through the lowest vertices of octagons *1* and *2*, exactly describing the height of the *synthronon* in the apse. A fifth equivalent octagon *5a* was applied so that it shared alignment with the lowest and highest vertices of octagons *1* and *2*. This octagon (*5a*) was then moved up (octagon *5b*) such that its centre was where the vertices of the two previous octagons meet, and therefore also in the same relationship at the centre of the largest octagon as is found in plan. The horizontal line projected through the two lower vertices of this central octagon *5b*, were observed to pass through the apex level of the *exedrae* arches and chancel triple arched ambulatory termination. The process was extended to the north east/south west section facing the chancel and main altar (Figure 7.5C).

Accordingly, octagons *6a* and *7a* were positioned so that they met at the centre point of the large octagon. This completed a beautiful geometric symmetry, the large octagon enclosing the smaller self-same octagons *3*, *4*, *5b*, *6a* and *7a*. It is important to note that the centre of this geometric figure is exactly at the base of the mosaic depiction of the *Alpha* with eight radiating rays of light. The presence at this position of such a symbol, so closely related to the eight segments described by the interlocking octagons is, at the very least, intuitively resonant.

The perfect symmetry of the octagons is meaningfully broken in that *6b* and *7b* are shifted down to the same level as octagons *1* and *2* and *5a*. It is noteworthy that if lines are projected horizontally through the lowest vertices of both *6a*[10] and *6b* and also *7a* and *7b*, they bound exactly the upper surface of the *synthronon* and the height of the throne (*sedis*). In total, including the large octagon, this exercise has revealed eight octagons utilised significantly in the geometric and symmetrical plan and elevation logic of San Vitale's design.

It cannot be proven with absolute certainty the designer(s) of San Vitale executed the repetition of octagons just described, but the findings are highly suggestive that the angles, projections and volumes may have been rationally calculated in three dimensions, reinforcing the idea that a scaled model may have been built during the design phase. In

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[10] The same line that also passes through the middle of octagon *4*.

regards to SS Sergius & Bacchus, no similar symmetry based on the volumetric repetition of octagons is present.

It is apparent that great attention and care was taken in constructing San Vitale's interior space. That the internal space has perfect geometric shape may also indicate the internal volume of air was considered as an important architectural element, intentionally bounded by calculated geometric forms (triangles, circles, globes, octagons) in order to create an acoustic space. The result of shaping and sculpting the interior volume of air is a place in which acoustical properties and effects were welcome and useful.

From the various observations and demonstrations of this research a new sequence of phases for the design and construction of San Vitale can be proposed:

Phase 1 (from c.500 to 525/6):
At Ravenna, the design and measurements of the Arian baptistery are used in the design for a new centrally planned octagonal domed congregational church. Drawings and perhaps a scaled model are produced. Cassiodorus is the *magister officiorum* under King Theoderic.

Phase 2 (525/6):
In 525 Boethius dies in prison at Ravenna. In the autumn of 525 Bishop Ecclesius of Ravenna joins the delegation of Pope John I to Constantinople, taking the plans (and model) of the proposed church. The court and clergy of the eastern capital are so impressed with the design copies are made of the drawings (and model) for a comparable church to be erected there. In the spring of 526 Bishop Ecclesius returns to Ravenna and begins an ambitious building programme for four new churches. On August 30th King Theoderic dies. Theoderic's grandson Athalric ascends to the throne, but since he is only 10 years old, the regency is assumed by his mother (Theoderic's daughter) Amalasuentha. Her Orthodoxy and aspirations to emulate the prolific church building of Galla Placidia are renowned. Survey of the site of San Vitale and San Michele in Africisco begins, the former on Ecclesius' legal property near to Placidia's church of St Croce (and the "mausoleum" / chapel of St Zacharias). It is decided to position the centrally planned church such that it encloses and protects the late fifth-century *sacellum* for continued use. The direction of true East is known and the second of two superimposed *actus quadratae* is rotated 45˚ to the south, also locating the position for the entrance of San Michele.

Phase 3:
Construction of San Vitale's ground floor begins. At Constantinople, on February 23rd of 532, Justinian has construction of Hagia Sophia begun. October 2nd of 534 Athalric dies and Amalasuentha becomes Queen, making her cousin Theodahad her regal partner. Cassiodorus continues his public office as Amalasuentha's chief minister and literary

adviser. Amalasuentha negotiates with Justinian. Theodahad imprisons Amalasuentha and on April 30th of 535 she is murdered.

Phase 4 (c.536):
At Constantinople SS Sergius & Bacchus is completed together with its adjoining longitudinal basilica dedicated to SS Peter & Paul[11]. At Ravenna, King Theodahad dies. On December 27th of 537 the newly completed Hagia Sophia is dedicated.

Phase 5:
At Ravenna, construction of San Vitale's second storey *matroneum* begins. The column base shape distribution pattern is completed. Decoration begun.

Phase 6:
Construction of San Vitale substantially completed. Decoration continues.

Phase 7:
Completion of decorative elements including floor and wall mosaics, window glass, plasterwork, painting and wooden carving. Installation of furnishings being completed, including vestments and tapestries, hanging lamps, candles and liturgical plate.

Phase 8 (540):
Ravenna falls to Justinian's troops. Some of San Vitale's mosaics are altered, notably stone *tesserae* are added to the chancel wall mosaics spelling the name MAXIMIANVS.

Phase 9 (May 7th 545):
San Michele in Africisco dedicated on the third Sunday following Easter.

Phase 10 (April 19th 548):
San Vitale is dedicated on the Octave of Easter, the first Sunday following Easter of that year (April 12th). On June 28th Theodora dies.

Phase 11 (May 9th 549):
Sant' Apollinare at Classe dedicated on the fifth Sunday following Easter.

Phase 12:
Exterior door to the *monasterium* of St Nazarius (San Vitale's south chapel) is bricked up. The wooden ceilings of the ground floor and *matroneum* are replaced with brick vaulting and plasterwork. The bronze altar screens in the *monasterium* of Nazarius and before San Vitale's main altar are replaced with intricately pierced stone altar screens.

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[11] Or, as already mentioned, SS Peter & Paul may have been built before SS Sergius & Bacchus, in 518-19 (http://www.arch.uiuc.edu/).

Phase 13:
Inside San Vitale, due to subsidence and/or rising water table, water submerges the ancient *sacellum* floor and its former liturgical function is abandoned. The small *sacellum* altar and columns are removed. Subsequently the pool is known as the "Well of St Vitalis".

The present research has combined archaeological and acoustical methods to answer why centrally planned domed churches became so popular in the East while in the West the longitudinal basilica remained the standard form. It was found the centralised plan for baptisteries and churches was, from Ambrose' episcopacy, an important feature of Italian ecclesiastical architecture. It was also found that San Vitale was more than a mere "Byzantine" import, but that elements of its design and measurements were taken from the Arian baptistery also at Ravenna. The controversial implications of this discovery (that San Vitale may have originally been conceived as an Arian church) will be left to future research. Acoustical reasons may have contributed to the experimentation with octagonal churches using the symbolism of eight and the octave. The acoustical effect of echo may have been desirable, as also long reverberation times. Conversely, and simultaneously, these attributes may have been compensated for and used. Sound dampening techniques may have been experimented with to provide more clarity especially to the perception of speech at the reading of the Epistles and Gospel. When responsorial chants or *versus* were sung, and especially when singing the *jubilus* on the Alleluia, the long reverberation and also echo may have been desirable, aiding in the development of site specific Ravennate styles of performance.

The fact that very few centrally planned congregational churches are known from the West may be explained not only by supposed differences in liturgical practice between East and West, but that the style became associated with Justinian, Emperor of the East. With his death in 565 and subsequent turmoil on the Italian peninsula, the trace of centrally planned churches dramatically disappears. The former importance of the Milanese/Ravennate style was supplanted by a return to the standard longitudinal basilica, almost like safe harbor during the Lombardic storm.

A definitive answer to the research question will only come with future research, several points of which will be discussed in the next and final Chapter Eight.

Nevertheless, combining the methods of Archaeology and acoustical science has revealed several new significant and important findings. After spending eight years scrutinising San Vitale with my eyes, ears and mind, the lasting sense is that much more awaits revelation.

CHAPTER EIGHT

Suggestions for the Archaeoacoustic Future

This final chapter makes a series of suggestions for further research in the specific case of San Vitale and also the general field of Archaeoacoustics and its future application to the historic past.

Figure 8.1: Entrance of clergy at the beginning of Mass, Sunday April 30 2006 (photograph by Knight 2006).

For all of San Vitale's intricacy there is one over-riding quality, this church is complex, noticeably different to longitudinal basilica designs in Ravenna and elsewhere. The rich abundance and complexity within San Vitale is at such a pitch the senses seem intentionally overloaded and even confused[1]. The mosaic and plaster depictions bespeak a sanctuary protecting all the wealth and produce of the world, the Church, fruit, food from land and sea, all of God's Creation. The presence of numerous *cornucopiae* echoed throughout the wall mosaics reinforces this impression as it is a symbol of plenty

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[1] San Vitale bewilders and confuses, in the original sense of the word: con-fuse, to bring together here, in this mesmerising place Latin *confusus*/*confundere* (mingle together).

consisting of a goat's horn overflowing with flowers, fruit and corn[2]. A longitudinal basilica such as Sant' Apollinare Nuovo does not have this same abundance; rather it feels more like an enclosed street, a direct processional pathway to the altar.

To validate the observations and suggestions borne from the present research a number of in depth comparisons need to be made with other centrally planned congregational churches to fully appreciate San Vitale's contribution to the ecclesiastical architecture of Late Antiquity. Accordingly, a number of suggestions are offered here for future research into the sensorial vocabulary of sixth-century architecture.

It remains for future research to discover whether the examples of inconspicuous logic and patterning discussed in Part 3.1 extends to other elements and features of the church, for example, window dimensions and relative proportions and ratios can be compared as well as the 3-dimensional distribution of the different column capitals. They would become significant if they displayed a co-dependency; one distributed pattern intersecting with and complementing another, translated across several features in the overall architectural vocabulary and expression.

Additionally, do intentional inconspicuous features contribute to the non-material content of San Vitale, the liturgical actions and performance of choral music? If so, the structuring and details of performance (e.g. movement, gesture, intended fluctuations of vocal volume and expression, variations in the rate and tempo of singing, additional instrumental accents and/or accompaniment[3]) may have combined to create a synaesthetic "architexture" of sound, vision, scent and touch. It does not seem unreasonable to suggest that repetition and vertical (hierarchical) call-and-response patterning between ground floor and *matroneum* also shaped how a Ravennate piece of music such as *Lux de luce* was performed in this centrally planned church.

Following are a series of suggestions for potential future investigation, beginning with the specific case of San Vitale in comparison to other Late Antique churches and baptisteries. Then, a broader critique and discussion is offered identifying problems

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[2] Latin: *cornu copiae*: horn-abundance; the horn of plenty, symbol of female fertility.
[3] Liturgical instrumentation (the organs and sistrum) and "soundmarks" (bells, chimes) have remained outside the consideration of the present research, but certainly the related field of Music Archaeology (Cf. d'Errico & Lawson 2006:51-53) would complement the Archaeoacoustic study of San Vitale.

within the current debate on an Archaeology of the Senses, and outlining areas and ways in which the study of acoustics in the context of Archaeology (Archaeoacoustics) can be integrated with studies of visibility, beneficial to the understanding of both the prehistoric and historic past.

San Vitale's *Agnus Dei* and *Alpha* as geometries of perfected time and space

It has been argued here that the inner consistency of San Vitale is intentional and purposeful. The question remains whether it can be demonstrated that one of the purposes was to provide an acoustic space in order to reverberate vocal performance through speech and singing. An answer can be articulated from the suggestive symbolism of geometry portrayed at key points within the church.

It seems very likely that the *Agnus Dei* in Paradise as depicted on San Vitale's groin vaulted chancel ceiling intentionally refers to the similar fifth-century iconography formerly depicted on the exterior of St Croce, as noted by Agnellus[4]. If, as Deliyannis suggests, Nauerth[5] is correct that this image portrayed Christ enthroned above the four rivers of Paradise, 'treading on the two monsters'[6], this would mean the iconography was an apocalyptic vision and therefore eschatological, the end of time. However, instead of this emphasis on the end of days, in San Vitale the *Agnus Dei*, with the *Alpha* symbol (Figure 8.1 below), together bespeak a new, eighth day, the fulfilment of the promised return to Paradise, and therefore looking ahead to a happy future[7], a resonant positive message pertinent to maintaining hope in the midst of the extraordinary political turmoil in mid-sixth-century Ravenna.

As seen below in Figure 8.2 the symbolic disc held aloft by the Archangels Michael & Gabriel, contains eight radiating lights from the *Alpha*, signifying the

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[4] Agnellus 41; Deliyannis 2004:150.
[5] Nauerth 1974: 93-4; Deliyannis 2004:150, note 30.
[6] Agnellus cites the inscription above the image on St Croce, ending with *Te vincente, tuis pedibus calcata per aevum Germanae morti crimina saeva tacent* (With you conquering, savage crimes are silenced by true death, trodden for eternity under your feet); translation by Deliyannis 2004:150. There is no overt mention of "two monsters".
[7] Therefore a more positive eschatological message than the end of days implied by Nauerth's reconstruction of St Croce's imagery, emphasising the beginning of eternity rather than the apocalyptic end of days.

beginning of time to the fulfilment of time, from the first day[8] to the eighth day, the Octave[9], the new and perfect day of Resurrection, the crowning victory of Christ enthroned[10]. The symbol is an analogy of temporality, of all time that has been and is yet to come, from Creation (*Alpha*), through the succession of "present" times, to perfected eternal time consequent of Resurrection. Therefore the symbol encapsulates concepts of Christological Divine time, the fulfilled promise for mortal time to end and the return to Paradise and perfected time.

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[8] Gematria (sharing the same root as the Greek word *geometry*), also known as *arithmology* (Penner 1971:44, cf. Robbins 1921): Plato claims in his *Dialogue Cratylus* the 'essential force' of a thing's name is to be found in its numerical value, and words and phrases of the same numerical value may be substituted in context without loss of meaning (Sedley 2003:6, 13-14; MacKenzie 1986:133). Related to Isopsephy, the Greek practice of adding up the number values of the letters in a word to form a single number. The *isopsephic* calculation for *Alpha* is also number one, *Eta* is 8 and *Omega* is 800. At the core of Plato's *Cratylus* is the 'dispute between those who accepted and those who denied "natural" language, the real correspondence of word and thing signified…are names conventional or natural, are they just an expression of the human voice, or is there a correctness, a truth in them?' Jowett, B. (transl.). 1953 (4th edition). *The Dialogues of Plato*. Oxford (Borchardt 1968:416). Further research is needed to test whether gematria equivalencies between letters, monograms, words and/or names (e.g. *Vitalis*) were in any way part of the architectural dimensions, proportions and/or ratios of San Vitale.

[9] The first documented Christian octave is the dedication of the Churches of Tyre and Jerusalem, under Constantine, and that these solemnities, in imitation of the dedication of the Jewish Temple, lasted eight days (Eusebius, *De vita Constant*. III, xxx sq.; Sozomen, *Church History* II.26 http://www.newadvent.org/cathen/11204a.htm. It is highly likely San Vitale's dedication day on the Octave of Easter is reflected in the *Alpha* symbol, and *vice versa*. Sunday is also considered to be the eighth day, when a "new creation" was made to replace the original seven day creation as described in Genesis 21:4; also the *Epistle* of Barnabas 15:8-9 (*ibid*).

[10] The symbol is depicted immediately above Christ's head as shown in the apse ceiling mosaic, the Archangels are depicted in reference to earlier Roman images of winged Victories holding the wreathed crown, as in the Murano Diptych (Bendazzi & Ricci 19887:65). The iconography of Christ enthroned is not unique, Müntz mentions the former apse mosaic of Sta Agatha Maggiore (c.425) at Ravenna (Müntz 1885:117) where 'the Saviour is seated on a throne…in his left hand he holds a volume; his right is slightly raised…' and surrounding his head is a cruciform nimbus. At San Vitale Christ is presumably enthroned (the throne itself is not seen) in a circular blue disc. In his left hand is a volume but in his right he clutches a wreath of victory. Also at Ravenna, Müntz mentions similar iconography in S. Giovanni Evangelista (Ibid:118-121).
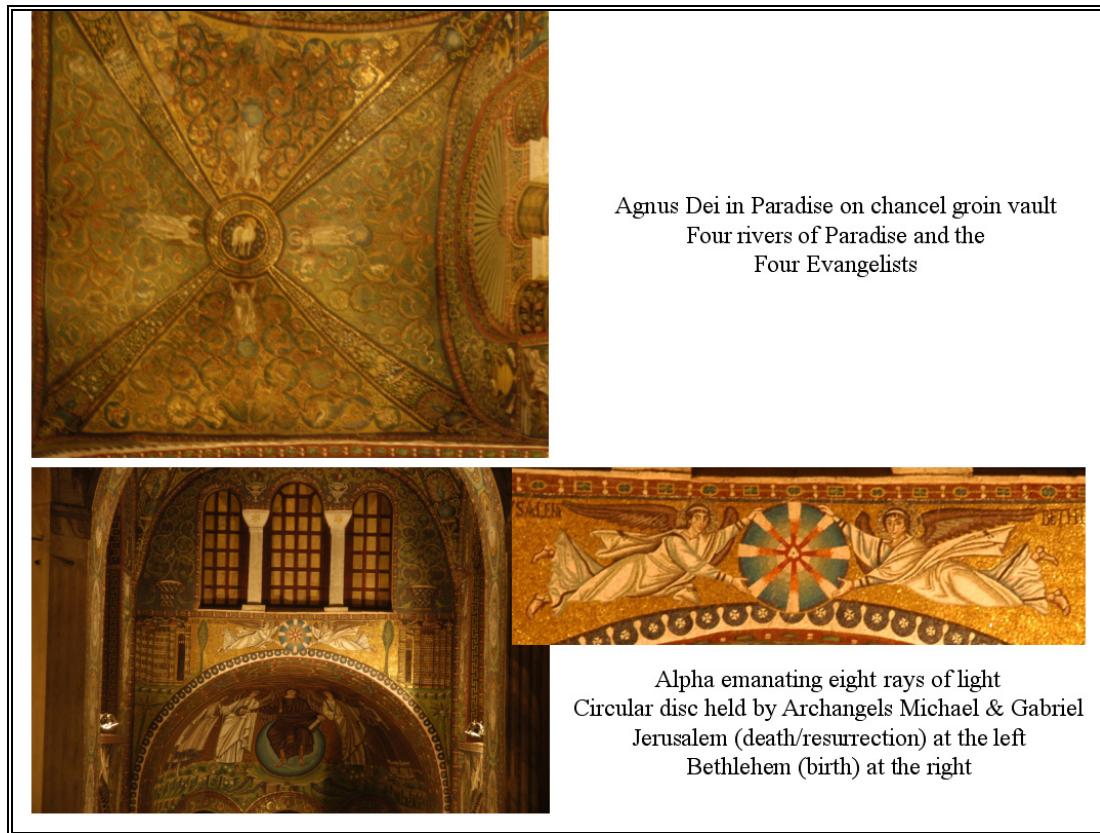
Figure 8.2: Details of *Agnus Dei* and symbol of *Alpha* (Photographs by Knight 2006).

This symbol can be read as a spatial reference to physical creation from Paradise at the beginning of time, radiating light through the present mortal world, to the future world perfected and redeemed of mortality. In this sense, it is a reminder of a perfect place (Paradise) and a promise of a return to a perfected place (Heaven) following the last day of Resurrection and Judgement. The rays of light radiating from the *Alpha* signify the days of the week emanating from the centre of the disc carried aloft by the Archangels, referring, most likely, to the 'disc' of the dome, which may in turn signify the heavenly canopy (the star-filled sky). As the circumference of the dome is the eight-segmented figure of the octagon, so the eight radiating lights (days) are inside the *Alpha* disc.

This symbol may be translated onto the architectural design of San Vitale. It is suggested here that the physical location and orientation in space of this symbol may be significant. The symbol crowns the vertical hierarchy of the Ascension depicted in chancel and apse. Seen in elevation, its radiating lights can be projected beyond the pictorial frame of the disc, out into the spatial volume and acoustical structure of the

church. The alternation of the four zones and fields of water and land in the mosaic of the *Agnus Dei* also add up to eight, and the eight rays of light radiating from the *Alpha* may relate to the architecture in a direct way.

If we agree that the *Alpha* symbol represents Time, and the *Agnus Dei* represents space and spatial relationships (topographical), an expression can be posited: from the source (God the Father as *Alpha*) of all Time comes the perfected Time of the eighth day, and from one source (the Son of God as the Lamb of God, the *Agnus Dei*) come eight areas comprised of two elements (water and land) repeated four times. At the centre of this symbolic geography is the *axis mundi* of the *Agnus Dei*, from Christ's sacrifice comes the fulfilment of the promise of a new Time, eternity. This symbolic centre of the world is directly above the main altar of San Vitale, and may be interpreted as this church's claim at being the *axis mundi* of the Western Empire, comparable to the *axis mundi* of the Eastern Empire, the octagonal Church of the Theotokos on Mount Gerizim (484).

Therefore, in San Vitale, time, as signified by the *Alpha* symbol, is in elevation (physically and figuratively) while topographical and territorial space (length and width) is in plan. How this is situated within the context of contemporary mathematical and geometrical theories accessible to the designer(s) and architect(s) of San Vitale would be a fruitful future investigation[11]. Namely, does this corollary of Time to elevation and Space to surface area (plan) explain how the builders of San Vitale calculated and structured the architecture? The number eight and octagons apply to both symbols and also to the "octaves" of the interior "temporal elevations", and as such may relate to musical time or timing and acoustic space – the space of time thought to order the acoustic qualities. The concept of space implied by the *Agnus Dei* scheme may signify the territorial measurement and land surface of the earth. The complementary implication of the *Alpha* symbol is that there is a corollary between spatial octagons and temporal octaves, perhaps the building blocks of sixth-century choral musical developments at San Vitale.

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[11] For instance, what relationship this implied scheme has to Pappus of Alexandria's Hexagon Theorem in his *Collectio* on projective geometry of c.320 AD (Cf. Downey 1948 and Coxeter 1969).

It is worth considering whether the *Alpha* symbol with eight radiating lights is also a visual corollary of acoustic symbolism, emphasising time and non-visual temporal geometries used as elevated shapes and volumes to structure the vertical and lateral zones of San Vitale. Figure 8.3A below takes the *Alpha* as the centre of a projected geometry from which eight gradients originate. The intersection of the ground floor (base) by the two lower projected angles describes a regular triangle bisected down the middle towards the centre of the church (and at the altar) with inner angles of 45˚.

The *Alpha* symbol is also taken as the centre of the re-applied inner octagon (red) of the church. A second smaller octagon (light green), at the same angle of rotation as the church axis (45˚) is also applied. Together, the longitudinal and vertical projections through the internal vertices of these octagons do not reveal any obvious significant architectural zone transitions. The projected circle of the dome elevation is applied four times such that they meet at the *Alpha*. Such an exercise could be extended into the 3-dimensional model to identify other relationships.

A
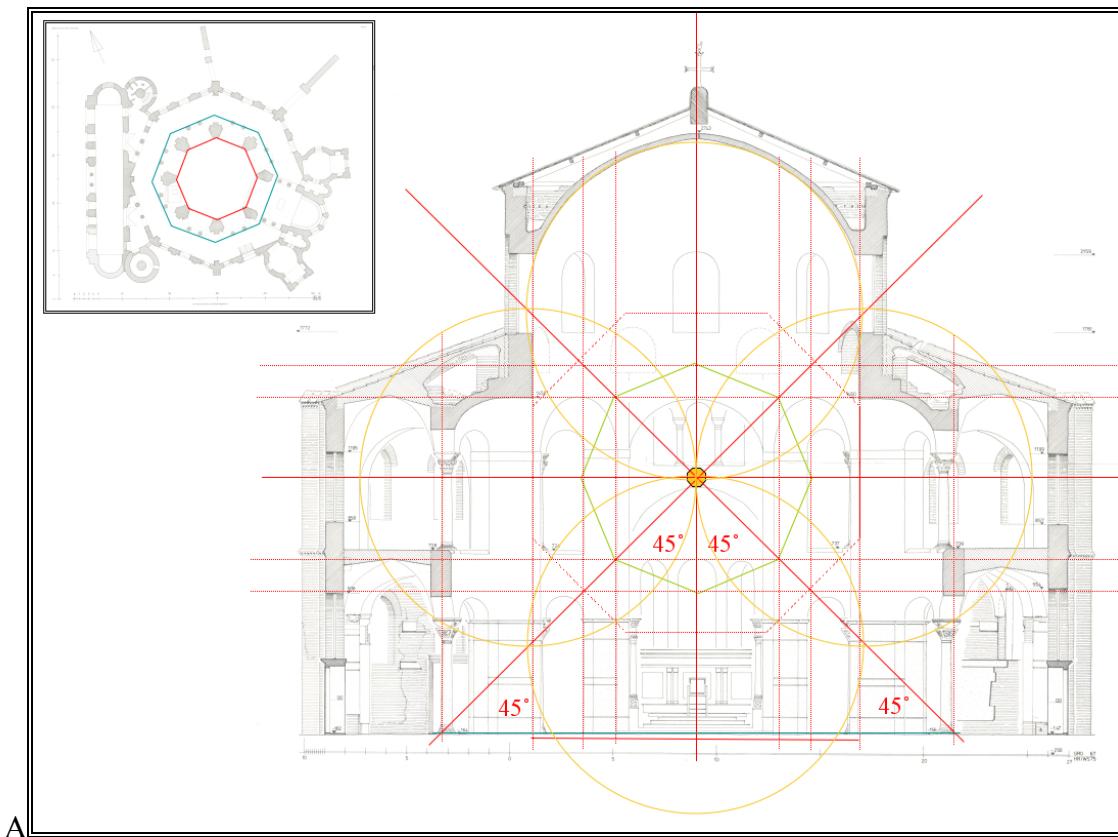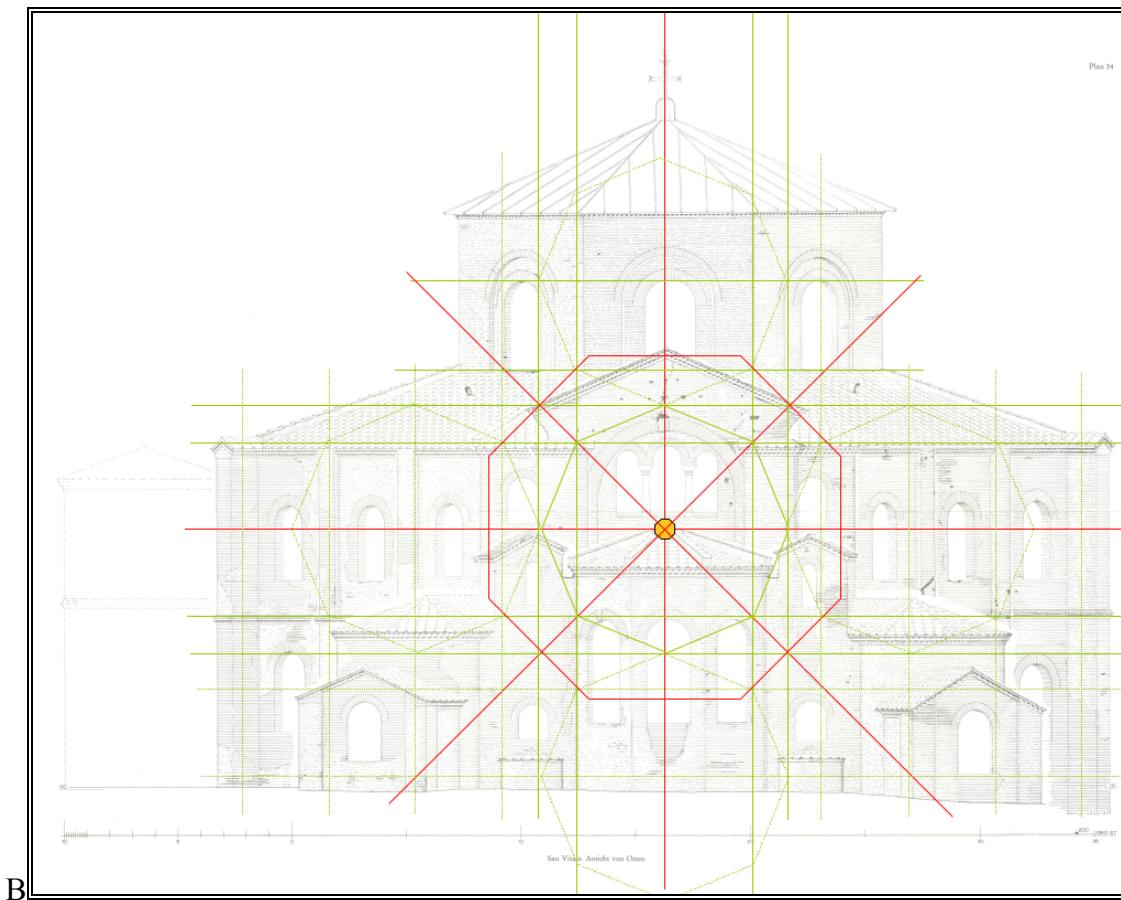
Figure 8.3: (A) Possible interior theoretical geometry projecting from the *Alpha* symbol (B) Exterior equivalent (After Deichmann 1989; overlay lines by Knight 2009).

In Figure 8.3B line projections from the *Alpha* and the inner octagon of the church are re-applied as in A, but to the exterior elevation of the church's apsidal end. The longitudinal and lateral projections through the interior vertices and joining of the smaller octagons (light green) do reveal several significant zone transitions: the top and bottom of the eight arched windows in the dome drum, the intersection of projections from the *Alpha* and smaller octagon joins at the exact limit of the chancel *templum* roof edge, and the vertical zoning distances of each window segment of the ground floor and *matroneum*.

Sixth-century concepts of perfected space and time are expressed in San Vitale's design by means of both conspicuous and inconspicuous patterning, symmetry and geometry. The conspicuous visible geometry is based on octagons and their associated angles of 135˚, 45˚ and 22.5˚ (octagons enclosing circles and segmented by regular angles). The space represents the perfectly geometric space of the beginning of Creation

(Paradise) by the hand of God (*Alpha*) and, through the historic lineage of the sacrificial Eucharistic celebration from Abel through Abraham and Melchisedech, all prefigured by the image of Christ as the Lamb of God (*Agnus Dei*). An inconspicuous non-visible perfection of time is expressed through theoretical octagons ordered upon a vertical hierarchy related to that suggested by the flying Archangels Michael & Gabriel at the level of the *matroneum*. They uphold the symbol of perfected time; from the beginning (*Alpha*) comes the eighth day, the Octave which is the end (*Omega*)[12] of mortal time, the *eschaton*[13] of the seven days of the week according to Genesis, and the return to perfection through Resurrection. This baptismal new beginning through the Eucharistic sacrifice reinstates the abundant fruits of Creation, figured as *cornucopiae* in profusion as mentioned above.

San Vitale, therefore, expresses profound messages of perfected time and space. The logic and rationality of patterned, repeated and distributed geometry structures the interior "global" architectural elements and details. The contained volume of air is also theoretically ordered by the geometry of repeated octagons and their associated angles and gradients. It is proposed here that this vertical ordering of space is intentional and best interpreted as the ordering of time into octaves related to the liturgical calendar and also even to musical octaves. As such, this temporal geometry is also likely related to sixth-century theories of music and sound propagation, namely reverberation and echo. In San Vitale these acoustic qualities are therefore imbued with theological meaning; the rhythm of repeated Eucharistic celebration connected by a long lineage from the beginning of time. *Alpha*, in this context, combines the word (the Word) and Time, vocalisation and musical timing and intervals in the form of chant. San Vitale may therefore have been figured as the home of the Word in perfected time and space.

Therefore, an acoustic space may have been intentionally created in San Vitale by ordering theoretical octaves figured as octagons. This provisional conclusion requires exploration by comparing the similarities and differences of many other sixth-century churches and baptisteries.

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[12] *Revelation* 1:8 and 22:13.
[13] From the New Testament, the day at the end of time, the end of the present world, eschatology being the branch of theology or biblical exegesis concerned with the end of the world: http://encyclopedia2.thefreedictionary.com/Eschaton+(theology).

Intuitively, these results are highly significant but remain speculative and requiring greater future attention to assess whether and to what extent this unseen "geometry of time" explains or assisted in the creation of this, or any other sixth-century acoustic space. However, for the moment, the present research has made at least one major contribution towards such an investigation, by establishing that in San Vitale the celebrant of the Eucharist (bishop or priest) faced the congregation at key moments when he was required to sing or speak.

This interpretation of the celebrants' orientation has been interpreted by considering the mosaic locations of the male and female entourage of emperor and empress, taken as visual cues for how the congregation was spatially organised, breaking with tradition by instead situating the *pars virorum* to the north (to the celebrant's right) and *pars mulierum* to the south (on his left side) even though the *matroneum* above seems to have been occupied by females. Exactly how this vertical shift affects who is on the celebrants right and left side has yet to be substantiated. Nevertheless, the centralised church plan allows for the celebrant to face the congregation, confident he will be heard and understood with the aid of the engulfing volume of space, whereas in the longitudinal basilica the apse alone is used for reflecting his voice back (behind him) to the congregation. In this way then, San Vitale seems to be more expressly designed with acoustic resonance in mind, to aid a liturgical innovation. A centralised geometrically regular space does not necessarily provide any noticeable advantage of acoustical character to that of a longitudinal basilica, instead the dome affords longer reverberation times and introduces the presence of noticeable echo. However, it may be that centrally planned churches with domes became prevalent precisely because of these characteristics, which may have encouraged new developments in how chants were to be composed and sung.

Counter to this Reznikoff[14] noticed that:

> Sometimes an adverse acoustic consequence of a dome is that it can concentrate sound under its own volume; a well-proportioned apse, on the other hand, may correct or at least offset this flaw, when the celebration of the Divine Offices is performed at the altar and the celebrant is facing the apse…The apse has the

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[14] Reznikoff 2006.

> shape of a half-dome (or semi-cupola)…There is absolutely no architectural reason for such a complicated construction, when a simple flat wall would be perfectly adequate…The reason for the complex curved shape of the apse is obviously acoustic: it focuses the sound of the singing voice facing the apse where the altar is located (from the earliest times, the celebration was sung by the priest). From there the voice can be heard very distinctly up to 100m away. Because of the apse's shape and of the vaults above, the whole church may resound quite extraordinarily, even with a single voice singing; the resonance and the richness of the harmonics often give the impression of a singing choir, the choir of angels…[15]

These are good points, except that in San Vitale, it has been shown that the celebrant did not just face the apse, but also turned to face the congregation standing on two floors. The echo may have been an annoyance and compensated for by orating on a loud projected voice or speaking slowly. Experimentation would be useful to at least establish a subjective sense of what contingencies may have been used. Or, echo was not an annoyance at all, and, with reverberation, was desirable for its immersive transformative qualities.

These details also feed into a large range of possible musicological investigations regarding Ravennate chant, discussed briefly below.

Musicological possibilities

It is important to have a female vocalist sing *Lux de luce* in an anechoic chamber and to also convolve that recorded voice into the acoustic model of San Vitale. An ideal set-up would be to have a full complement of vocalists, male and female, perform the *versus* in San Vitale, but this would requiring extensive permissions from the Diocese of Ravenna and UNESCO and potentially expensive. This would provide a good quality recording of how the piece sounds but the process of then recording the choir in an anechoic chamber is impossible as the chamber would have to be large enough to accommodate the vocalists standing in the same spatial relationship; *ergo*, there is no anechoic chamber yet built that could facilitate a large choir standing on two levels.

The identified description of reverberation and also echo by Cassiodorus in relation to the *jubilus* sung on the Alleluia has been highlighted as an early description of

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[15] Reznikoff 2006:82.

architectural acoustics and the relationship to musical innovation. This can be combined with other ancient descriptions to further the essay offered here in Appendix A. One other description of particular interest has received some recent attention in the context of Archaeoacoustics, where Reznikoff noted:

> It is very remarkable that the incipit of the Easter Alleluia (on the word *alleluia*, before the *melisma*) sounds very like trumpets of Victory and can be easily shouted out; it sheds light also on how this Alleluia has to be performed: as the song of our Lord's Victory over Death.[16]

Other descriptions of reverberation may elucidate the intentions embodied by San Vitale and therefore further augment Appendix A. For instance, in the fourth-century Prudentius described Saint Vincent as being 'accompanied by a choir of angels' because his voice resounded so effectively. As Reznikoff notes, this explanation "by angels" 'is often referred to in early medieval texts when describing the sound of a voice singing in a church and what appears to be the choir of harmonics heard in the resonance'[17]. The vertical hierarchy of angels and Archangels has been discussed here and may relate directly to how sixth-century church builders conceived acoustic space.

Associated with the idea of arranging for a full male and female choir to be recorded singing in San Vitale, is another that would present an equal amount of obstacles to overcome; to suspend tapestries between each of the exedra columns and re-survey the acoustics of the church. This might be achievable in the acoustic model, as well as replacing the existing plaster ambulatory vaulting with wood. The type of wood can be identified as pine and applied as an acoustic material to the model.

A further acoustic survey of the narthex would also be desirable, understanding in greater detail how this elongated space facilitated certain rituals such as the Lesser Entrance and funerals. Unfortunately the narthex was beyond the available area allowed

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[16] This is in reference to the *Vita S. Germani* (III, 17-18) written c.480 by Constantius of Lyon and later recounted in 731 by Bede (*Hist. Eccles.* I 20), describing 'the Easter Alleluia and its echo' (Reznikoff 2006:78), more correctly its reverberation.
[17] Reznikoff 2006:79.

by the permissions acquired for the 2006 survey[18]. With the additional acoustic data for the narthex, and further consideration of architectural elements and original furnishings would allow for a finer-grained identification of the aural texture of local anomalies[19] shaping macro-acoustic features[20] of San Vitale's space. Some of these elements have already been under consideration in the course of this research and are briefly presented in Appendix D.

Specific to San Vitale it would be beneficial to initiate a full standing building survey and to include the nearby structural remains of St Croce, the *mausoleum* of Galla Placidia, Santa Maria Maggiore, San Michele in Africisco, San Apollinare in Classe (and the nearby fourth-century basilica near the *Ca' Bianca*)[21] and to then phase the details such as the late fifth-century *sacellum*, chancel mosaics (glass *tessarae* prior to the stone *tesserae* used on the figure of Bishop Maximianus), and include the 1912 excavation details of a fourth-century Roman house with mosaic floors unearthed directly north of San Vitale and subsequently reburied[22].

Several PhD and Post-Doctoral research topics can be generated from this present work. In particular, the different social experiences related to how congregations were physically organised either horizontally or vertically into the *pars virorum* and *pars mulierum* requires clarification for the early centuries of the Christian era.

An example of continued academic Archaeological investigation of San Vitale is the work of Dr. Eleftheria Paliou[23], who is conducting Post-Doctoral research at the Free University of Berlin specifically on the visibility within San Vitale and how the 2D

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[18] Likewise the two small circular chapels were not included into the acoustic survey, as the southern (formerly the *monasterium* of St Nazarius) was not made available, as it is the present sacristy and the northern chapel is now a boutique cluttered with postcard racks. The interior of the northern stairwell tower was also not included in the survey.

[19] Blesser & Salter 2006:58.

[20] D'Errico & Lawson 2006:42.

[21] Discovered in 1965, this important longitudinal three-naved basilica with bema and adjoining octagonal baptistery, may have been the inspiration for Sant' Apollinare near Classe (Cf. Bendazzi & Ricci 1987:206 and 235, Figure A).

[22] Bendazzi & Ricci 1987:40.

[23] Cf. Paliou 2008.

isovist views[24], visibility mapping in fully 3D spaces, and the acoustic measurement mapping can be integrated and combined into a 3-dimensional representation to assist in further understanding social organisation within this sixth-century context.

Further investigation of the combined acoustics and visibility within contemporary longitudinal basilica churches such as Sant' Apollinare Nuovo (Ravenna), as well as other centrally planned domed churches, is necessary to identify and clarify differences and similarities between a broad number of examples in order to test and develop the suggestions made in this present work.

Applying a rigorous methodology of integrated acoustic and visibility analysis will encourage the growth of Archaeoacoustics and its application to a wider variety of sites across the prehistoric and historic periods, and across different cultures and societies from all periods. With the further development of combining acoustics and visibility into archaeological research it is hoped new techniques will be created to restore and reconstruct past acoustic interiors that are either in an incomplete state of preservation or no longer extant. For such work to be of real benefit, the current debate over an Archaeology of the Senses needs to be critiqued, accordingly the following section supplies this and makes constructive suggestions for the future of Archaeoacoustics in particular and the Archaeology of Perception in general.

Keeping Archaeoacoustics on track

In order to answer archaeological questions of the historical past current concepts of *aurality* and archaeoacoustics have been brought to the fore in this research. The call for an "Archaeology of the Senses" is rooted in phenomenology while the exteroceptive sensory registers of hearing, smell and taste, due to their transitory, impermanent and ephemeral non-material traces, have been regrettably yet understandably side-lined by the tradition of Archaeology, predominantly concerned with the material past, implicitly favouring the sense of sight and touch in isolation. The ephemera of the other senses are usually relegated to mere discursive citation alone. The consequent situation, labelled

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[24] Cf. Clark 2007.

here as the "gnarled impasse", has fostered new incentives to create a more inclusive archaeology.

The particular sensory register of hearing has gained a measure of recent interest and collaborative research between archaeologists and acousticians has produced enough viable results to warrant the important initiation in 2006 of a monograph by Scarre & Lawson entitled Archaeoacoustics, a useful enough label situated within broader theoretical discussions on sensory experience. The visual bias (optic-centricity) of archaeology needn't necessarily be 'folded back into the mix of the sensorium'[25], for that implies regression is a direction along which to advance. Perhaps it would be better, and simpler, for archaeology to bring the other senses "up to speed" rather than regress and subvert the developments and tools made by an apparently over-emphasised visuality.

The advanced tools and techniques developed and used in archaeology to digitise, construct in three-dimensional virtuality, utilising GIS for visibility view-shed and movement analysis are all welcome. It appears reasonable to predict any further inclusion of the other senses into Archaeological practice will be facilitated by these visual corollaries. Rather than blend and blur the visual emphasis back into the sensory fold, a more sustainable option would be to accept and use the visual emphasis to generate and assist studies of the invisible / non-visible such as sound and scent. The human state of embodiment and the physiological capability for perception covers the perception modes of proprioception, interoception, and exteroception, the latter includes the specific registers of sight, touch, hearing, smell, taste, and balance (equilibrioception). All these in union provide us with direct and nuanced experiential information of dwelling in the world. The resulting socially constructed concepts, analogies, metaphors, and rationalisations in turn are affected by (or equally, affect) our memories, feelings (emotions and imaginations), ideologies, and beliefs. Belief in particular affects how and what and when we perceive, along a fluidly shifting spatial and temporal streaming of immersive experience, a characteristic of the act of living.

In other words, more appropriate and fruitful than "Archaeology of the Senses" would be a completely holistic archaeology of perception and reception, inclusive of all major modes and all six registers of exteroception. Within such an immense gamut the

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[25] Frieman & Gillings 2007:4.

complex interlinking connections between the material and non-material past, between, for instance, sight and hearing and movement and belief, could be accepted as worthy of archaeological investigation and not only as a discursive theoretical component (compartment) but as a series of practical archaeological methodologies. The particular example of involving the methodologies and expertise of acousticians within an archaeological remit of reconstructing past life (and not simply the past material object) has already received some attention and produced some successful results. Archaeoacoustics, albeit firmly referring to one specific exteroceptive sensory register, is a vital step towards a synthesised synaesthetic archaeology.

Parallel and related to the archaeological drive for greater sensory inclusion, recent work by acousticians has been concerned with creating a "hybrid" study of architectural heritage, working by renovation and conservation. As the reasons behind the sixth-century popularity of centrally planned domed congregational churches has been under scrutiny here, the particular acoustic renovation project of CAHRISMA 2000-2003 has been highlighted.

Recent criticism has been laid at the door of digital and multimedia approaches to viewing and seeing. It has been argued that although these approaches are:

> …invariably based upon the delineation of a carefully mapped, binary 'shed' (i.e. a map identifying zones that are in – and out of – view from a specific viewpoint) these developments continue apace, offering the curious a dizzying array of options, variants and refinements (cumulative, reflective, projective, directional, total, Higuchi, fuzzy, probable, to name but a few) that all seek to better capture the nuances of visual perception (e.g. Wheatley and Gillings 2000).[26]

But these are not mere "curiosities" for the curious; they additively reveal (not necessarily "capture") the immense complexity of sight and through these 'options, variants, and refinements' it is hoped that what light reveals, sound and scent and taste and touch may also contribute. It is true that far too many virtual recreated past spaces remain distilled and dead in a silent vacuum, perfect for miniature statistical robots to inhabit and bounce around or look at walls, encapsulated in a scent-free, tasteless, glassy virtual model menagerie – it gives the unwanted impression all we did in the past was

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[26] Frieman & Gillings 2007:5.

robotically look, walk, and build. The quantification of subjective and ephemeral qualities is the Achilles heal of all statistical modelling.

A sudden waft of *Rosmarinus officinalis* (Rosemary) is blown across a green field populated in one soggy depression near a stream by chanting frogs, *brekekekex koax koax*[27]…while I finish a bowl of *Risotto ai Funghi Porcini* and forget for a moment that I missed an important appointment in town half an hour ago…a mosquito suddenly bites me, the angelus bells sound across the land from the ancient battered campanile two miles away and a sheep bleats to my left. I lean back and cover my face with my straw sun-hat. With closed eyes I watch the speckled sun filter through and onto my eyelids…I'm bathed in red and warm as I'm immersed in the cool sounds of nearby water. The Rosemary is gently replaced by the scent of riverine, riparian moss and mud. I remember a tune my father used to sing, I hear it in my head…

This preceding fictive paragraph of 'evocative writing'[28] is meant to demonstrate the complexity of living, all studies that aim to document and understand it, now and/or in the past, look through a tinted speculum of bias, a point-of-view. Certainly visibility is not the only 'synonym for sensory engagement'[29], nor on occasions the primary, for the recipe of sensory proportions shifts continuously and continually, by intent or not.

Outdoor acoustics are extremely difficult to calculate and model, for fluctuations in air pressure, temperature, 'weather', unpredictable flights of noisy insects and birds, leaves blowing in the wind, changes in precipitation levels (and density of fog and rolling mist), and only fuzzy logic can be employed. Attractive research ideas such as

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[27] This forerunner of "croak croak" is from Aristophanes' *The Frogs*.

[28] There is always a danger in using fictive 'evocative writing' (Hamilakis 2002:103) as a means of effecting a truly sensory Archaeology, as it is completely open to misuse by revisionist agendas, culturally specific biased narratives used for political means and propelling it at light-speed far away from the archaeological sensory envelope. If Archaeology becomes mere storytelling it will have been comprehensively thieved of its investigative interest in what actually happened. Archaeological fictions could certainly flesh out the dry mute vacuum-sealed reconstructed simulations and robotics of virtuality, but, like Historical Fiction, the past would be (un)wittingly revised along non-investigative and conjectural pathways.

[29] Frieman & Gillings 2007:5.

Mlekuz's[30] bell-shed mapping over a 5 square kilometre mountainous terrain containing nine medieval churches in central Slovenia, in the area of *Polhograjsko hribovje*, is an early instance of applying fuzzy binary acoustic horizons[31] by using a ray-tracing algorithm to identify sound shadows. But, as Mlekuz admits, the 'radius of the acoustic horizon is extremely sensitive to the environmental factors'[32]. Due to the importance of these complex factors he is saliently doubtful whether 'a comprehensive paleoenvironmental record describing exact past states of the atmosphere on a very fine-grained time-scale'[33] is possible. To side-step this quandary he has chosen to study how past soundscapes changed 'through the construction and reinterpretation of soundscape features, especially by soundmarks', focusing only on 'stable or long-term properties of a landscape (i.e. topography)' as, he believes, 'unstable and transitory properties (e.g. states of the atmosphere) can safely be ignored as they do not contribute to the long-term structure of sound profiles.' Mlekuz concludes from this that the 'study of past soundscapes becomes study of past soundmarks and their role in social life'[34].

Unfortunately the concept of the soundmark is taken uncritically from the pioneering Canadian acoustic ecologist Murray Schafer[35] and Mlekuz (and others) has unreservedly assimilated his classifications of keynotes, foreground sounds and soundmarks[36]. Schafer, and more recently Truax[37], was concerned with preserving Canadian natural soundscapes from the encroachments of unwanted industrial noise (e.g. traffic, planes, machinery) and his classifications resemble visual cues within a pictorial plane. His contention that 'not all sounds in an acoustic space are equally important to the

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[30] Mlekuz 2004.

[31] 'An obvious and straightforward approach is to create a binary acoustic horizon, where raster cells are set to one (1) where church bells can be heard and to zero (0) otherwise' (Mlekuz 2004:4.3.1 and Figure 3).

[32] Mlekuz 2004:4.3.1.

[33] Mlekuz 2004:4.2.

[34] Mlekuz 2004:4.2. Commenting on Mlekuz's work, Frieman & Gillings note that 'to approach the question of shared identity through the concept of the synaethscape (sic; elsewhere they have *synaesthscape*) is to acknowledge that a map of overlapping sound-sheds is a single component rather than an end in itself' (Frieman & Gillings 2007:11).

[35] Cf. Schafer 1977 and 1985.

[36] Keynotes are undifferentiated background sounds, for example the sea to a maritime society, or traffic noise to the inhabitants of a city. Foreground sounds are those intended to attract attention (known as sound signals), for example car horns. Sounds that are particularly regarded by a community and its visitors are called Soundmarks, in analogy to landmarks (e.g. church bell ringing) (Mlekuz 2004:4.2).

[37] Cf. Truax 1995 and 1999.

listener'[38] is, for the Archaeoacoustician, problematic at best since understanding past societies requires being unbiased particularly regarding what may have been subjectively deemed 'noise' and what was acceptable.

By way of illustration, the particular *sound ghost* of steam trains chugging and whistling through the British countryside may have been considered noise in the 1800s, then a little later symbolic of Empire, industry and success, and now a missed bygone attractive sound that added to the rural setting, not detracted from it. Changing attitudes to the Age of Steams' soundmarks is a catalogue that should remind us of how 'noise' is negotiable and also just how transitory soundmarks are. Stability then can only mean longevity of presence, exclusive of the complex unstable nuances of how the presence is received.

For Archaeology it is vitally important to avoid imposing onto the past our present definitions of what is a soundmark. If we instead tap into broader ideas of *aurality* (Cage, Eno, Toop, Zahn) and allow for the possibility that the frame of listening is socially and culturally negotiated according to context, then any acoustic event or effect may be considered a soundmark. However, the term soundmark is not adequate, as it is an analogy of landmarks (e.g. stable, topographic, long-term properties) and, aside from Mlekuz's bells, applied to socially constructed space. Ravenna's frog-song, by the limits of this definition, is not a soundmark because it is transient, momentary and seasonal. But there seems no reason why this amphibian chant should not be included as one of Ravenna's most important and characteristic aural events. Instead of "soundmark", an alternative term for consideration might be "soundpan", any sound characteristic of a place or time within the binaural panning sweep (acoustic reception frame) of human hearing. In other words, if any sound is heard across places and times, then it has the potential of being "earmarked" as important.

Although it is debatable whether vision is simply a 'product of classification'[39], certainly:

> What is needed is an archaeology that is sensitive to the rich and complex way in
> which individual sensory threads are woven together, their interdependencies and

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[38] Schafer 1977:9-10.
[39] Frieman & Gillings 2007:5.

the tensions that can arise between them. Put simply, having successfully extracted vision from the sensorium we need to rise to the challenge of putting it back, and in so doing explore more fully the role played by the senses in shaping and structuring understandings.[40]

To augment this advice we need to take care not to presume to put vision *backwards* into the sensorium, but rather, by using the tools we've acquired while developing the methodological musculature of visibility studies, to turn our scrutiny on the other senses in order to bring them *forwards* to a comparable level of development. For instance, visibility studies can inform how to advance studies of past *aurality*.

The tendency to elevate vision above all the other sensory registers within the modality of exteroception[41] is perhaps at least as old as the Enlightenment, 'vision being strongly associated with objective science and Cartesian rationality (e.g. Hamilakis 2002)'[42]. In the West, the reification of sight is ancient, stemming from philosophical classifications (Aristotle, Plato) and medical knowledge (Galen, Celsus).

It is misleading to claim archaeologists (and others) have ordered the agreed "modalities" into a hierarchy[43]. No, the classification and hierarchies of sight, touch, hearing, smell and taste are ancient and archaeologists would surely be interested in how these hierarchies were expressed through material culture. It would be like looking a gift-horse in the mouth to lament the elevation of sight; the legacy is that it gives us the necessary tools with which to visualise sound – acoustical science, as one example, is dependent on visual demonstrations. No need to make a man blind in order to have him concentrate on hearing.

It is appropriate that Archaeology accepts 'the dynamic way in which the senses interweave and blend'[44], and 'a shift away from solely viewing space to thinking more carefully about perceiving it'[45] would be welcome. Further to this, and more to the point, we need to augment the theoretical discussion with practical ways of collecting

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[40] Frieman & Gillings 2007:6.
[41] Frieman & Gillings confuse what a modality is (on pages 5, 6, 7, 8, 9, 11, 12, and 13), repeatedly stating that vision is a sensory modality when it is not. "Sensory modality" is an oxymoron, more accurately it is one of six registers within the modalities of reception, namely exteroception.
[42] Frieman & Gillings 2007:7.
[43] Frieman & Gillings 2007:6.
[44] Frieman & Gillings 2007:7.
[45] Frieman & Gillings 2007:8.

measurable data for understanding how space and place are received and perceived, as they act together in shaping our sensory experience, our sense of living.

The statement that 'our knowledge of the past is limited by what is visible, in the archaeological record'[46] can be reworded; our knowledge of the past has been limited by what is defined as *material*, and by making the non-material visible, we can bring the neglected ephemeral aspects of the sensorium into archaeological practice. The only way to discuss the blending, blurring, interweaving sensorium is to visualise it, to shift and reframe archaeology's gaze to also include the non-material; to make material the non-material is how scientific investigation works. For example, concepts, theorems, calculi, algorithms, and geometry are all notated, symbolised, ciphered, written and modelled in real or virtual space. If Sabine hadn't written his calculations for measuring sound, we would not have a measurable acoustic science or archaeoacoustical investigation. If it is true that all the sensory registers act interdependently, then when we visually model, calculate, sculpt, and design, then all the senses are engaged.

Frieman & Gillings suggest a welcome 'shift away from solely viewing space to thinking more carefully about perceiving it'[47]. They take perception to be 'a culturally contingent and profoundly reflexive relationship between sensation and cognition'[48]. To augment this, perhaps it would be beneficial to move away from a purely "sensational archaeology" to one that includes all reception and, specific to archaeoacoustic studies, audition. The salient point has been made that:

> Each of the senses necessarily informs the others, and dividing them arbitrarily according to our culturally mediated manner of perceiving will only limit our understanding. Reconstructing perception means reconstructing people, not just the height of their eyes or the acuity of their ears.[49]

But, more to the point, reconstructing perception means reconstructing *life*, and although it may be desirable that this goal may eventually be reached, the reasons for revivifying the past need first to be debated in wider circles of philosophical, social, political, ideological and theological discourse, well outside and beyond the pretensions

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[46] Frieman & Gillings 2007:8.
[47] Frieman & Gillings 2007:8.
[48] Frieman & Gillings 2007:8.
[49] Frieman & Gillings 2007:8.

of archaeology. Reconstituting a Roman with artificial intelligence within an insane "Westworld" kind of Julio-Claudian theme park is perhaps not the most ideal way of understanding a real dead Roman who formerly lived.

Intuiting a Metaphenomenology

The sensory immersion in the content and context of a designed interior space could more usefully be termed exteroceptive architexture, taking us beyond phenomenology to a metaphenomenology, the immersive plenum of sensory awareness of lived experience. Architexture could refer to the inclusive integrated inter-relationships of designed co-existent spaces (e.g. street corners) and all perceptible stimuli within temporal and spatial geometries.

The soundmark, or *soundpan* of Ravenna, frog-song, is part of its characteristic everyday soundscape, famously referred to as early as the late first-century by Martial[50]. Entry into a voluminous and shaded reverberant interior space such as San Vitale's, dampens and blurs the usual outdoor sounds, refiguring them as distant, diminished yet expanded, unclear and perhaps mysterious vestiges of everyday urban life. Once inside San Vitale, and after a moment of ocular adjustment to the reduced light levels, Ravenna is placed outside, put on hold, temporarily sent away at an experiential distance. The ecclesiastical architecture postpones other commitments and shapes the listening experience, directing the eyes and attention of the congregation to the foundations (tenets) and necessities of their public and private religion, faith and beliefs. The presence of special acoustical effects like echo help to create an extra-ordinary place different from the outside world. Quiet reflection, contemplation, prayer, communal worship, private spiritual experience, sanctuary and commemoration are the activities and states of mind (and soul) intended to be engaged in within this special place. If elements of the everyday soundscape gain entry (people chatting at normal volume, laughing, as tourists regularly do at present) the interior feels momentarily polluted.

It is fairly safe to conclude the predominant sound within San Vitale, in Late Antiquity, was the human voice. Singing in unison as a single voice (*una voce*) was a

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[50] Marcus Valerius Martialis (38/41 AD – c.103 AD); *Epigrams* XCIII (To Vetustilla): '…though the frogs at Ravenna chatter more melodiously than you…'
http://www.tertullian.org/fathers/martial_epigrams_book03.htm

method of both amplifying the individual voice and also uniting the community (of Orthodox Christians) and perhaps, amidst the political turmoil of sixth-century Ravenna, a regular act of unity and inclusion (rather than privilege and exclusivity) in an enveloping space likely provided both solace and encouragement to continue living into the uncertain future.

To complete this paper I offer an intuitive suggestion about San Vitale; I have read the *Alpha* symbol with the eight rays as a corollary between light and time, the reflection of this immediately suggests itself, that sound is space. The particular space referred to is a circle within an octagon, two geometric figures perhaps also analogous for the sixth-century Ravennate Orthodox congregation of time and space, light and sound. In this way the architectural design embodies decisions of creating a place in which the visible and aural are intentional aspects of the architectural vocabulary.

Springing from this idea is another association; circles and globes depicted in the Alpha symbol, the *Agnus Dei*, the "universe" in which Christ sits enthroned in the apse ceiling mosaic[51], the voluminous globe of the dome interior, and the glass window discs together call to mind the circular Eucharist offered not only by Abel and Melchizedek but also the Eucharist elevated and offered at every Mass within the church since 548. From this connection comes the observation that San Vitale resembles a giant polygonal pyx[52] (Figure 8.4) containing the Body of Christ, the Church (the body of believers).

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[51] This image also reflects the mimesis of the Christian empire on earth to 'God's rule over the divine order in heaven' (Geanakoplos 1976:118).

[52] The repository for the Blessed Sacrament. Also called a lunette; 'composed of a ring of metal (usually lined with gold) holding two glass or crystal disks, to create a round, flat, glass-enclosed space for the Eucharistic Host': Catholic History (March 1997), Dove: Symbol of the Holy Ghost. *The Seraph*. Volume 17, number 7. Online at: http://friarsminor.org/xvii7-2.html

Figure 8.4: Sixth-century polygonal ivory Pyx (Musée de Sens[53]).

The pyx is a sacred vessel often with a metal *asteriskos* symbolising the star of Bethlehem and this rests as a protective canopy over the container. The architecture of San Vitale is very like examples of Late Antique polygonal pyxides. This church is like a giant pyx containing the Eucharist, like an encircling body, a womb forested and encrusted by displays of natural (the veined Proconnesian marble columns) and designed complexity. If this identification is correct, it can be read as a figuratively enlarged sacred vessel, to an architectural scale, placed on the altar, which is the entire urban topography of Ravenna. The implications are worthy of extensive future investigation. At the very least, San Vitale cannot be understood in isolation of the other churches in Ecclesius' building programme, nor as a purely material container for sight alone. To echo the first suggestion, San Vitale is a sacred place about the corollaries of light and time and sound and space, the choir of angels and a single voice.

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[53] Image online: http://commons.wikimedia.org/wiki/File:Sens_Châsse.jpg. Musée de Sens online: http://commons.wikimedia.org/wiki/Category:Musée_de_Sens
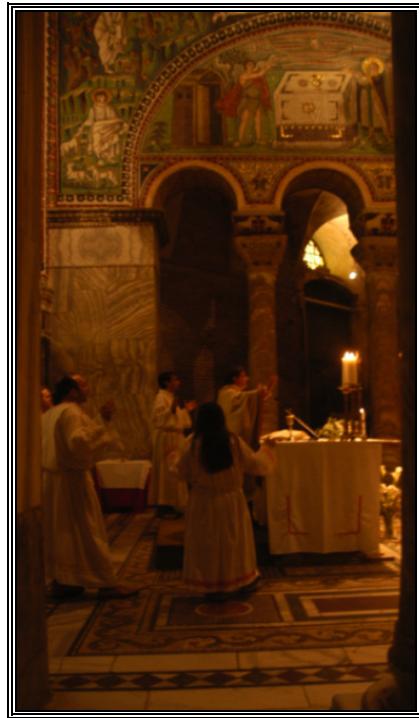
Figure 8.5: Offering the Sign of Peace at Mass in San Vitale, April 30, 2006 (photograph by Knight 2006).

Pax

Appendix A

Acoustic Theories and Musical Practice Relevant to Late Antiquity

The beginning of a good and honest life is to be a good and honest hearer.[1]

For the purposes of understanding what analogies of acoustic phenomena may be embodied by the architecture of San Vitale this appendix has two aims. Firstly, I will outline ancient Mediterranean analogies used to describe and understand sound and hearing, providing the background to Late Antique concepts of acoustic phenomena. Secondly, I will discuss specific analogies and musical practices as expressed by Boethius and Cassiodorus at Ravenna in the sixth-century and assess their influences on the design and construction of San Vitale.

With these aims in mind, it is necessary to catalogue and elucidate theories of sound expressed by classical thinkers, in particular outlining their ideas on the sense-object, or πραγμα (*pragma*)[2] of sound and the sense-mechanism (αισθήσεις, or *aisthèsis*) of hearing. The various unique 'aural analogies' used by classical writers to describe sonic phenomena will assist in locating the various disputations over sound within a broader matrix of concepts on the physics of 'nature' from different philosophic schools. These ideas can be understood as the intellectual backdrop to extant examples of sixth-century acoustic design and music making. In other words, in order to understand the conceptual environment and setting for Late Antique architecture and attendant social responses, the study of contemporary theories of sound provides this research with suggestions of particular concepts of sound production and reception that may have influenced the construction of San Vitale.

Rather than immerse too deeply into the panoply and minutiae of Stoic, Epicurean, and Sceptic philosophic rhetoric, already comprehensively dealt with in the past[3] and with far more philosophic emphasis than is suitable here, I will simply outline the different and descriptive analogies utilised within the physics of sound and hearing by ancient western writers. This task necessarily includes several Greek (Plato, Aristotle, Aristoxenus) conceptions of the nature of sound and how those

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[1] Plutarch; *The Right Way to Hear*, 177.
[2] Einarson & De Lacy 1967:167.
[3] French 1994.

concepts influenced complementary or opposed interpretations within the gamut of Roman thinking.

Therapeutic Harmony

Stoicism and Epicureanism are two Roman schools of thought well represented by extant texts and they arguably enjoyed more popularity in promoting philosophy as a "therapeutic art" than traditional sophistic Greek philosophy[4]. Nevertheless, for the purposes of discussing ancient theories of acoustics it is necessary to situate Roman "therapeutic art" in the context of Greek tradition, and to achieve this I shall focus upon Plato's *Timaeus*, written in c.360 BC.

Three passages from the *Timaeus* are concerned directly with music, hearing and sound, the first of which highlights the traditional consideration that music is divinely bestowed and embodied within all of nature:

> Music…in so far as it uses audible sound, was bestowed for the sake of harmony. And harmony, which has motions akin to the revolutions of the Soul within us, was given by the Muses to him who makes intelligent use of the Muses, not as an aid to irrational pleasure, as is now supposed, but as an auxiliary to the inner revolution of the Soul, when it has lost its harmony, to assist in restoring it to order and concord with itself. And because of the un-modulated condition, deficient in grace, which exists in most of us, Rhythm also was bestowed upon us to be our helper by the same deities and for the same ends (47.D-E).

Plato's reasoning behind why we can 'attain by discipline and philosophy to catching the "music of the heavens" is just that the circles in our souls can execute revolutions answering to those in the heavens'[5]. He identifies 'harmony' or 'concord' as a supra-musical philosophic and spiritual quality[6]. His account of hearing is based on Alcmaeon of Croton (born c.535 BC)[7], who seems to have set down the general lines of the theory, along with Empedocles (fl. 450 BC) and accounts in Theophrastus and doxologies based on him[8].

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[4] Gottlieb 2001:284.
[5] Taylor 1928:296.
[6] Concordia's counterpart in Greek was Harmonia, Discordia's was Eris.
[7] Taylor 1928:477-478.
[8] Taylor 1928:477-478.

Alcmaeon was the Anatomist discoverer of the Eustachian tube, while Empedocles 'compared the funnel-like outer ear with a bell and claimed that it is capable, not only of receiving, but also of generating sound'[9], an idea which only received experimental verification as recently as the 1970s[10], when evidence demonstrated 'otoacoustic emissions, i.e. sound that is produced in the cochlea'[11].

The relevant passage on hearing in Plato's *Timaeus*:

> …sound is a stroke transmitted through the ears, by the action of the air upon the brain and the blood, and reaching to the soul; and that the motion caused thereby, which begins in the head, and ends about the seat of the liver, is "hearing" [ἀκοήν]; and that every rapid motion produces a "shrill" [ὀξεῖαν] sound, and every slower motion a more "deep" [βαρυτέραν] sound; and that uniform motion produces an "even" [ὁμαλήν] and smooth sound and the opposite kind of motion a "harsh" [τραχεῖαν] sound; and that large motion produces "loud" [μεγάλην] sound, and motion of the opposite kind "soft" [σμικράν] sound (67.B).

Although, according to the modern understanding of acoustics, it is true that 'rapid vibrations in the air give rise to sounds of high pitch, less rapid to sounds of low pitch'[12], Plato has been described as confused regarding the velocity involved in differently sized vibrations[13]. This 'confusion' is most explicitly seen in the following passage:

> …causes…of all the sounds which because of their quickness or slowness seem shrill or deep, and the movement of which is at one time discordant because of the irregularity of the motion they cause within us, and at another time concordant because of its regularity. For the slower sounds overtake the motions of the earlier and quicker sounds when the latter begin to stop and have already fallen to a speed similar to that with which the slower sounds collide with them afterwards and move them…(80.A-B).

Taylor argued that Plato 'confuses rate of vibration with rate of transmission of vibration, supposing that the more rapid vibrations are propagated through the air with a greater velocity', and that 'this is a delusion'[14], a rather harsh indictment upon

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[9] Gitter 2002.
[10] Kemp 1978 and Kemp *et al* 1990.
[11] Kemp 1978.
[12] Taylor 1928:477.
[13] Taylor 1928:477.
[14] Taylor 1928:477.

'pre-modern' natural philosophy aimed no doubt at illustrating how modern physics is far more quantitatively and qualitatively advanced, i.e. 'better'.

Plato further asserted 'melody is composed of three things, the words, the harmony, and the rhythm…(and that) the harmony and the rhythm must follow the words'[15]. This concept was re-iterated throughout Western music history; for example, by the 16th century, Gioseffe Zarlino (1517-1590) stated that 'melody is a combination of speech, harmony, and rhythm'[16], Giovanni de'Bardi (1534-1614) agreed, defining music as 'a combination of words and harmony and rhythm'[17], while a little later Claudio Monteverdi (1567-1643) concluded that 'the manners of performance must take account of three things: text, harmony, and rhythm'[18]. The extensive influences of Platonic and Aristotelian ideas have remained dominant and deeply nested within later ways of conceptualising music.

A former pupil of Pythagoras, Aristoxenus (born c.350 BC), chose as his subject matter 'all melody, whether vocal or instrumental'[19], and his method rested:

> …on an appeal to the two faculties of hearing and intellect. By the former we judge the magnitudes of the intervals, by the latter we contemplate the functions of the notes[20].

He believed that for:

> …the student of musical science accuracy of sense-perception is a fundamental requirement. For if his sense-perception is deficient, it is impossible for him to deal successfully with those questions that lie outside the sphere of sense-perception altogether[21].

The hegemony of this tradition potentially obscures opposing concurrent contemporary ideas of sound, hearing, and music, namely the Stoic concepts found in the writing of Vitruvius, the Epicurean work of Philodemus and Lucretius, and the

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[15] Plato; *De Rep*. Book 3.
[16] Strunk 1952:256.
[17] Strunk 1952:292.
[18] Strunk 1952:414.
[19] Strunk 1952:27.
[20] Strunk 1952:27.
[21] Strunk 1952:27.

Sceptic arguments of Sextus Empiricus, all revealing and contributing to a complex fabric of thought on acoustics in the Roman era.

I have focused on Plato's *Timaeus* as a background to later thinking on the subjects of sound, hearing, and music in order to contextualise just how different, yet related, were later Stoic, Epicurean, and Sceptic concepts of these topics. I shall now give an overview of these three schools of thought before discussing how their respective constructions of analogies formed new concepts of sound.

Stoicism

The Romans seem to have sympathised with Stoicism, since it 'struck a chord with the old Roman virtues of *gravitas* and *pietas*'[22]. For both Stoics and Atomists the world was ordered by the constancy of Nature, and they emphasised its materiality. A short discussion of Stoic thought is necessary in order to understand how this influential school conceptualised acoustic phenomena.

The Stoics are understood to have adhered to a trichotomy of philosophical discourse, the tri-partite physics, ethics, and logic. It was Zeno of Citium (333-261 BC), the recognised founder of the Stoics, who was the first to make this division. Diogenes Laertius (7.39-41) tells us that the Stoic 'Apollodorus calls these parts 'topics', Chrysippus and Eudromus 'species', and others 'genera''[23]. He continues, saying the Stoics:

> …compare philosophy to a living being, likening logic to bones and sinews, ethics to the fleshier parts, and physics to the soul. They make a further comparison to…a fertile field: the surrounding wall corresponds to logic, its fruit to ethics, and its land or trees to physics; or to a city which is well fortified and governed according to reason. [Some]…assign the first place to logic, the second to physics and the third to ethics[24].

The Stoic ideal of *apatheia* (a good life) was one that conformed to Nature, and although there are similarities with the Epicurean ideal of *ataraxia* (life without disturbance), the difference between the two philosophy's conceptions of Nature leads to different conclusions as to what living in conformity with Nature amounts to[25].

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[22] French 1994:149.
[23] Long & Sedley 1987:158.
[24] Long & Sedley 1987:158.
[25] Hamlyn 1988:81.

Something (*ti*)

incorporeal   body   (Neither?)

Sayable   void   place   time   Functional entities   limits
(*lekton*)

Substrate   Qualified   Disposed   Relatively disposed
(*hupokeimenon*)   (*poion*)   (*pôs echon*)   (*pros ti pôs echon*)

Commonly qualified   Peculiarly qualified
(*koinôs poion*)   (*idiôs poion*)
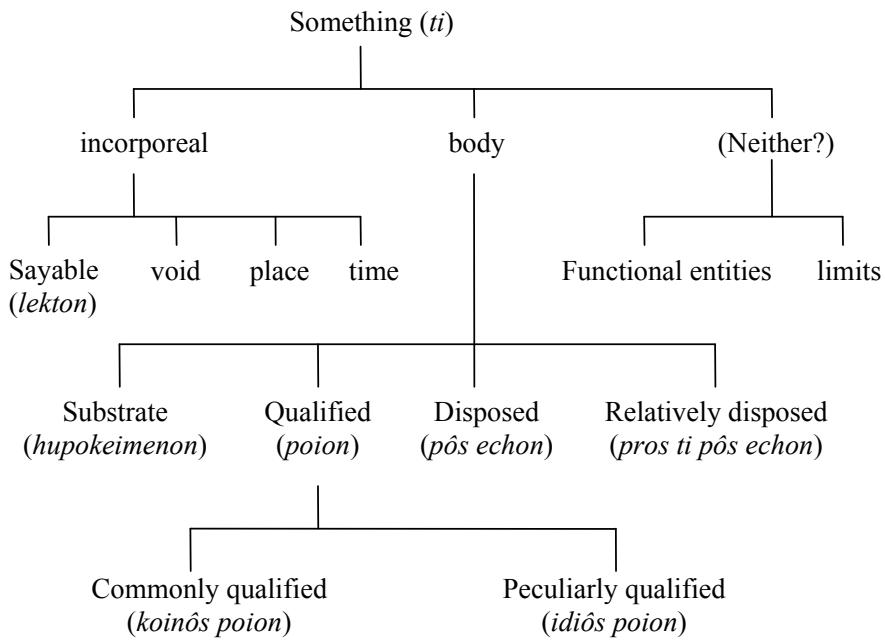
Diagram A.1: Stoic ontological distinctions (After Long & Sedley 1987:163).

Epicureanism

Epicurus (342-271 BC) continued on from Democritus' (c.460-c.370 BC) Atomism[26], treating sensation 'as a physical fact, a result of the impact of one set of atoms and void on another'[27]. For example, a "sweet" flavour is a name for:

> …a certain configuration of atoms and void and the movement it imparts to another configuration of atoms and void in ourselves; it does not name an intimate and un-analysable feeling[28].

The first principle of Epicurean physics is that nothing is created out of nothing and matter cannot be destroyed. Since there was nothing but causeless atoms and void the Epicurean world-view was radically different from the imposed and

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[26] Einarson & De Lacy 1967:162.
[27] Einarson & De Lacy 1967:162.
[28] Einarson & De Lacy 1967:162.

innate teleologies of Plato and Aristotle[29]. The two Epicureans highlighted here are Lucretius (c.99-c.54 BC) and Philodemus of Gadara (c.110-35 BC), the friend and contemporary of Cicero, and therefore firmly situated within the 'intelligentsia' of the Roman Late Republican and early Augustan age.

Lucretius asserted that it is Nature, not the gods, that is in control of the physical world, and therefore to understand how Nature works and why things happen is to remove man's fear of being pursued by the gods[30]. 'Matter, being atomic, is for Lucretius an important factor in the fixity and regularity of Nature'[31].

Considering the acoustic effect of echo, he thought:

> …the part of the voice that doesn't find the ears floats past in the wind and perishes in vain; part dashes against a hard place and hurls back its sound, the empty mockery of a word.[32]

Further he commented that he had personally:

> …seen a place give six or seven echoes for every cry you send, as the hills themselves dash the words back and forth and back again.[33]

He went on to describe the directional characteristics of sound and how they are more flexible than light:

> …the voice can twist itself intact through the winding tunnels in things, while semblances refuse. They'll be sliced to ribbons unless the tunnels are straight, like windows, through which all sight can fly.[34]

He admitted, however, there are qualitative depreciations when:

> …sounds that pass through the doors in a house
> Are blunted and make their garbled way to the ears
> So we hear the noise rather than hear the words.[35]

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[29] French 1994:151.
[30] Lucretius; *De Rerum Natura* (On the Nature of Things); French 1994:152.
[31] French 1994:157.
[32] Lucretius; *De Re. Nat.*: 4.566-569 (Esolen 1995).
[33] Lucretius; *De Re. Nat.*: 4.575-577.
[34] Lucretius; *De Re. Nat.*: 4.597-600.
[35] Lucretius; *De Re. Nat.*: 4.610-612.

Philodemus of Gadara (c.110-35 BC) is finally being recognised as an important Greek intellectual requiring attention in order to understand Roman poetry in the first-century BC[36]. He taught Virgil, influenced Horace, and was praised by Cicero[37]. Philodemus' writings have been discovered in the library of Piso's "Villa of the Papyri" at Herculaneum and Daniel Delattre's[38] useful work at the Institut de Papyrologie de la Sorbonne, focuses upon his *On Music*[39], the main points of which are well worth reviewing.

Central to Philodemus' argument in his *On Music* is the separation of poetry from music, because 'the material of poetry is essentially words'[40] combined to carry meaning, 'whereas music is deprived of meaning (*asemantos*)'[41]. This division reiterates that between the category of *logos* (reason, language, and the rational) and *alogon* (what is irrational). The explicit aim of Philodemus is to 'establish that music is deprived of all *logos*'[42] and Delattre proposes to answer why Philodemus wished to situate music in the domain of the *alogon* by working through 'the perspective of Epicurean physics'[43].

Philodemus' Stoic adversary Diogenes of Babylon (also known as Diogenes of Seleucia 200-152 BC) worked from the thesis that there exist two types of sensation. Firstly, there is *autophuès aesthèsis*, or "natural and spontaneous sensation" which the amateur musician must rely upon. Secondly, there is *epistèmonikè aesthèsis*, or knowing and learned sensation which only the professional musician has access to. Philodemus' notably 'anti-Stoic polemic'[44] proposes a crucial point in opposition to this thesis; that "learned sensation" is not self-evident like "natural and spontaneous sensation" which merely informs us of the 'purely physical character of the perceived

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[36] Pearcy 1997.

[37] Philodemus was an innovative thinker in aesthetics, was a friend of Lucius Calpurnius Piso Caesoninus, and influenced Horace's *Ars Poetica* (Obbink *et al* 1995).

[38] I would like to thank Daniel Delattre for his advice and assistance in acquiring the English rendition of his work, which represents the most current analysis of Philodemus' *De Musica* (cf. Kemke J., *Philodemi De musica*, Leipzig 1884, van Krevelen A. D., *Philodemus. Die Muziek. Met Vertaling an Commentar*, Hilversum 1939, Rispoli G. M., *Il primo libro del Peri mousikês di Filodemo*, Ricerche sui papiri Ercolanesi, I, Naples 1969, Neubecker A., *Philodemus, Über die Musik IV. Buch*, La scuola di Epicuro, 4, Naples 1986, Delattre D., "Philodème De la musique : livre IV, colonnes 40 à 109", dans *CErc.* 19, 1989, p. 49-143; all cited in http://www.scd.univ-lille3.fr/bsa/Philodemus.htm).

[39] Of the many parchment scrolls being unravelled from this Herculaneum library, several works by Philodemus are represented; *On Music* is catalogued as PHerc. 1497.

[40] Delattre 1998:287.

[41] Delattre 1998:287.

[42] Delattre 1998:287.

[43] Delattre 1998:287.

[44] Delattre 1998:287.

object'[45], but 'absolutely linked to *logos*, in that it tells us whether a melody or musical rhythm is harmonious or not'[46]. Indeed, Philodemus states:

> …all men have, through the sense of hearing, the same apprehension (*antilèpsis*) of the same melodies, and that the pleasures which they gain from them are very similar.[47]

Unlike the usual Epicurean concept of all sensations being *alogos* (irrational), 'or rather "rough" and "lacking memory"'[48], Philodemus argues that professional musicians (theorists, performers), and what he calls *pepaideumenoi*, or 'cultivated non-specialists'[49], be put on equal footing 'as far as the perception of music is concerned'[50]. Delattre finds the consequence of this concept of equivalency between professional musicians and "cultivated non-specialists" in conformity with Epicurean teachings. Their hedonistic 'calculus of pleasure and pain'[51] is substantiated by Philodemus' question of why a person should study and be trained in the musical arts as they are 'very painful' and keeps 'whoever devotes himself to them away from occupations essential to attaining happiness'[52]. As the etymology of 'the word *aesthetic* relates directly to *sensation* (*aisthèsis*) and to its workings'[53], Delattre finds it necessary to provide a new translation of Epicurus' description of the mechanism of hearing from his *Letter to Herodotus*[54]:

> [52] Again, hearing arises when a *breath* is carried off from something which emits an articulate sound, resonates, produces an unarticulated sound or causes in some way an effect proper to hearing. This flow spreads out in volumes consisting of parts similar among themselves and which have, along with a kind of mutual sympathy, a unity whose character is proper to hearing; these things (i.e. mutual sympathy and unity) extend to the emitting object and most of the time produce the *specific sensation* related to its presence or, at the very least, simply provide the evidence from the exterior of the object. [53] For, if a kind of sympathy coming from the object did not relate to it, there would be no sensation specific to the object.

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[45] Delattre 1998:287.
[46] Delattre 1998:287-288.
[47] Philodemus; *On Music*: Column 116.9-15 (Delattre 1998:288).
[48] Philodemus; *On Music*: Column 116.9-15 (Delattre 1998:288).
[49] Philodemus; *On Music*: Column 116.9-15 (Delattre 1998:288).
[50] Philodemus; *On Music*: Column 143.33-39 (Delattre 1998:288).
[51] Philodemus; *On Music*: Column 143.33-39 (Delattre 1998:288).
[52] Philodemus; *On Music*: Column 143.33-39 (Delattre 1998:288).
[53] Philodemus; *On Music*: Column 143.33-39 (Delattre 1998:288).
[54] Epicurus; *Letter to Herodotus* (52-53) in Chapter 52 of Book Ten of the *Lives* of Diogenes Laertius (Hicks 1931).

One must not think, therefore, that it is the air itself which is shaped by the projection of the articulated sound or by sounds of the same type; for the air will have a considerable *inadequacy* if it is affected in this way by the articulated sound. But it is directly the impact upon us, when we emit an articulated sound which I have been *called upon*, by virtue of the fact of the existence of masses whose nature is such as to produce a flow of breath, to take as that which causes for us the affect proper to hearing[55].

From this *Letter*, it is useful to highlight some of the most important similarities and differences to other contemporary schools of thought in describing sound and hearing. The "flow" of "unarticulated sound" spreading out in "volumes" (52) could be considered as an "emanation" if this term 'were not reserved for the sense of smell'[56]. Delattre goes on to explain that this idea of volumes spreading out 'is not of a surface but of a hollow mass in three dimensions, of a sonorous relief (technically called, today, 'stereo'), just as seeing or touch cause relief'[57]. Also, the concept of the ear not only receiving 'a flow of "simulacra" of sound in relief'[58], but also producing "mutual sympathy and unity" that 'extend to the emitting object' (52)[59] reflects Empedocles' earlier idea (cited above) of the ear 'generating sound'[60]. Further, Delattre notes that Epicurus 'rejects very clearly the mediation of the imprint upon the air which is at the centre of other conceptions of hearing, in particular of the Stoa which defined *phônè* as 'beaten air'[61].

Therefore, Delattre finds that Philodemus effectively attacks the doctrine made traditional since Plato[62] and defended by the Stoic Diogenes of Babylon[63], that music enjoys an 'eminent status…by virtue of its allegedly exceptional mimetic character'[64] and capable of arousing in the soul of the auditor "moral qualities" such as 'nobility and lowliness, courage or the lack of it, hesitancy or boldness'[65]. Contrary to this traditional view, the Epicureans argued that imitations (*homoiomata* or *mimemata*) cannot be 'substituted for the real objects (*ta kyria*) of which they are the imitation'[66] since they lack the characteristic third dimension of depth which gives 'the "atomic

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[55] Delattre 1998:288-289.

[56] Delattre 1998:288.

[57] Delattre 1998:288.

[58] Delattre 1998:289.

[59] Delattre 1998:288.

[60] Gitter 2002.

[61] Cf. Diogenes of Babylon in von Arnim 1905: 212, no.17-19 (Delattre 1998:289).

[62] Namely Plato's *Laws* 1.668a and 2.699b-e.

[63] Philodemus; *Letter to Herodotus*: Column 89.32 to 90.14 and 88.39 to 95.12.

[64] Delattre 1998:289.

[65] Philodemus; *Letter to Herodotus*: Column 117.28-34 (Delattre 1998:289).

[66] Philodemus; *Letter to Herodotus*: Column 117.28-34 (Delattre 1998:289).

pulsation" internal to the real object or living body from which the sound comes'[67].
Therefore, music, for Philodemus, is a *trompe-l'oreille* just as painting is a *trompe-l'oeil*[68]. The ear, capable of being fooled, can only judge qualities of sound alone, not
moral qualities[69]. He finds that it is 'the intellect taking the form of fallible opinion
which arbitrarily attributes moral qualities to melodies and rhythms'[70] and equally
fallible distinctions between what is in tune (*to hermosmenon*) and out of tune (*to
anharmoston*)[71].

In Epicurean physics, of the five senses, hearing alone has two aspects. Similar
to the other senses 'the act of hearing grasps certain perceptible qualities of its object-
in fact, its specifically auditory properties'[72]. But, importantly, unlike the other
senses:

> …the ear also has another function, essential to the nature of man as a creature
> which thinks: it is in fact by this organ, and by this alone, that what is *logikon*
> can reach him[73].

Language by way of speech and reason (*logos*) 'has no other means of access to a
human being than via the ear'[74]. It is strange that the act of reading, visually
comprehending the meaning of written language, is not included. Nevertheless, it was
argued the ear receives both the rational and the irrational concurrently and the
process of the separation of these two kinds of "information" is such that the ear's:

> …concave shape brings it about that atoms of sound, lacking in *logos*, enter it
> to leave it at once, after having caused us pleasure or pain by their passage; on
> the other hand, the ear has extremely fine internal pores, which let pass only
> those very unusual atoms which contribute to produce *logos*. These atoms then
> enter the interior of our body (unlike those other atoms which produce *aloga*
> sounds) to affect by a wholly natural process the animus which consists of the
> same kind of atoms-ones that are sparse, very round and smooth, and very
> mobile[75].

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[67] Philodemus; *Letter to Herodotus*: Column 117.28-34 (Delattre 1998:289).
[68] Philodemus; *Letter to Herodotus*: Column 117.28-34 (Delattre 1998:289).
[69] Delattre 1998:290.
[70] Delattre 1998:290.
[71] Delattre 1998:290.
[72] Delattre 1998:290.
[73] Delattre 1998:290.
[74] Delattre 1998:290.
[75] Delattre 1998:291.

This supports Philodemus' claim that music is incapable of setting the soul in motion since melodies and rhythms belong to the category of the pure *alogon*, or irrational[76]. In defence of this 'undoubtedly…revolutionary position' Philodemus compares music with cookery (*opsartutikè* or *mageirikè*)[77] since:

> …their complexity and the subtle refinements typical of them both add nothing to the pleasure of the ears and the stomach, the natural needs of which are rapidly and well satisfied by a simple tune played on a rustic pipe or by a little bread and cheese with a few olives[78].

While Philodemus argues that learning a musical instrument is a painful experience contrary to the more important goal of happiness, he mentions:

> …the selfish and arrogant behaviour of music-lovers, who could spend their lives attending public concerts, as well as the disgust inevitably linked with the excessive prolongation of any activity, including listening to concerts that go on endlessly[79].

Philodemus, then, has cut 'definitively any link between learning an instrument and being initiated into a virtuous way of life'[80], and therefore is in complete opposition to the most traditional form of education in Greece as supported by Cicero[81]. It is beyond the emphasis and scope of this research to follow the influence of these ideas upon Roman musical thought and practice but it is doubtlessly significant coming from the quill of a philosopher with so many personal connections with influential contemporary Roman poets and thinkers.

These differences, then, between the Stoic and Epicurean concepts of sound and hearing help to delineate potential differences in the practicum of music. Nevertheless, common to both schools was the concept that everything was material, thus placing them diametrically opposed to Plato and Aristotle[82].

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[76] Delattre 1998:291.
[77] Philodemus; *Letter to Herodotus*: 88.1-6, 117.26-35, 134.29-35 (Delattre 1998:292).
[78] Philodemus; *Letter to Herodotus*: 88.1-6, 117.26-35, 134.29-35 (Delattre 1998:292).
[79] Philodemus; *Letter to Herodotus*: 88.1-6, 117.26-35, 134.29-35 (Delattre 1998:292).
[80] Philodemus; *Letter to Herodotus*: 88.1-6, 117.26-35, 134.29-35 (Delattre 1998:292).
[81] Philodemus; *Letter to Herodotus*: 88.1-6, 117.26-35, 134.29-35 (Delattre 1998:292).
[82] Gottlieb 2001:310.

Scepticism

In his *Against the Musicians* Sextus Empiricus, the second-century AD Sceptic, systematically argued that 'sound does not exist'[83], and that 'music does not exist'[84], and finally that 'time does not exist'[85]. Within this argument, and for the purpose of disputation Sextus highlights elements of both Stoic and Epicurean theory. In the section below on Tactile Analogy, passages of Sextus will provide acoustic illustrations from these other schools of thought.

Before outlining the various specific analogies employed to describe and explain acoustic phenomena, it is worth discussing broadly the different types of analogy and how analogous comparisons contribute to concepts of sound.

'Intuition Pumps' and Analogies of Materiality

Methods of creating and maintaining analogies in relation to their function of describing and "constructing" cultural ways of perceiving can be brought into the context of sound, hearing, and music in the Roman and Late Antique periods. Put very simply:

> Analogy can be considered to work in four different ways: as formal or piecemeal analogy; as cross-cultural generalisation; as relational analogy between structuring principles in different societies; and as analogies of materiality, appreciating the physical tangibilities of the world as experienced[86].

Of these *schemae* Roman and Greek philosophers constructed analogies of materiality in order to describe sound as a material object and therefore making it comparable to other materials such as water, light, scent, and colour. These 'constructions of analogy' will be collated and commented upon, allowing us to

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[83] Sextus Empiricus; *Against the Musicians*: 6.54 (Bury 1949:397).
[84] Sextus Empiricus; *Against the Musicians*: 6.58 (Bury 1949:399).
[85] Sextus Empiricus; *Against the Musicians*: 6.63 (Bury 1949:401).
[86] Parker Pearson & Ramilisonina 1998:309.

understand them as the foundation for the study of Roman performed music[87] and how they could have influenced architectural acoustic design.

The literature on architectural acoustics and music history is lacking such a collection of ancient analogies of sound[88]. For the purposes of this research it is important to collate these analogies in order to provide a reference to the possible conceptual sources for Late Antique consensual musical culture and in particular the acoustic concepts available to the architects of San Vitale. In support of the links between concepts of acoustics and sixth-century architecture it is also necessary to highlight the relevant contemporary comments made by Boethius and Cassiodorus, two ministers of Theoderic at Ravenna who affected the course of Western musical culture and education in an inestimable way, iterating ideas about music and acoustics popular at Ravenna when San Vitale was being constructed and newly opened.

As mentioned above, the following ancient analogies of sound have not previously been collected into one accessible catalogue, perhaps because each has been successively disproved by later scientific investigation. However, it is not important for the purposes of this research whether or not these ancient concepts of sound propagation and reception are scientifically correct. Instead, what is important is that these concepts had currency and most likely inspired ways of constructing acoustic spaces for the performance of speech and music. This sets up a potential problem when dealing with ancient, classical and Late Antique acoustic and musical practices. In a church such as San Vitale it is important to realise that it was in part intended as a performance space. However, applying modern techniques to measure sixth-century acoustic attributes cannot in itself be the sole way of passing any kind of assessment or judgement on whether Late Antique architecture was acoustically successful. The acoustic success of San Vitale (or indeed any building prior to

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[87] Although speaking about a relational analogy that 'links different manifestations through a common structuring principle', Parker Pearson and Ramilisonina point out that 'we need to construct a hermeneutic bridge between the analogy and the data' (Parker Pearson & Ramilisonina 1998:310).

[88] I have been seeking a comprehensive list of ancient theories of sound since 1992 and, having only discovered citations and footnotes scattered amidst many volumes on philosophy, music theory, and medical history, it seemed appropriate to finally bring the information together into a readable form, not least as a potential resource for future research. I have not yet come across any literature on architectural acoustics that seriously includes the theories of acoustics applicable to and contemporary with ancient buildings. Therefore, this catalogue of analogies of sound at the very least provides a research tool from which identifications can be made and better supported, understanding the links between ancient concepts of acoustics and contemporary experiments and developments in architectural design and construction.

Sabine's work in the 1920's) should instead be contextualised to the sixth-century and discussed in relation to contemporary concepts of sound and hearing even if those concepts are subjective analogies based purely on observation and logical argument.

Unfortunately, apart from the outdoor Greek and Roman theatres, interior performance spaces before the 20th century have been deemed acoustically poor, viewed as inferior precursors to later advances in concert hall design, set along a linear trajectory of progress in acoustic architecture, all according to modern sensibilities and musical developments like the size and character of orchestras and the placement and enhancement of electronic amplification. It is however too simplistic to argue that most ancient churches are too reverberant due to too many reflective surfaces such as polished marble. There is a danger in evaluating ancient (and, indeed perhaps especially prehistoric) acoustics against the modern yardstick of what constitutes qualitatively 'good' acoustics as scientifically supported by experimental quantitative proofs. The original concepts and interpretive experiences of acoustic phenomena are our only real access to understanding ancient material decisions that can be archaeologically identified. This raises an important issue for any study of ancient acoustic knowledge and music making; we should avoid attempting to slot this research into anachronistically modern concepts of what constitutes a clear musical performance and whether a space is acoustically successful[89]. Definitions of clarity and 'success' are ultimately bound up with subjective attitudes on aesthetics that shift over time and across various cultural contexts. In the sixth-century, for example, it may have been that the words of a chant were expected and/or allowed to blend and become 'muddled' in a richly reverberant space, perhaps even leading to chant developments that anticipated the long reverberations afforded by ecclesiastical architecture in specific locations. A case in point is the jubilus of the Alleluia, detailed in Appendix C.1. A space that a modern audience might find too reverberant and unclear for the purposes of musical performance, an audience in the sixth-century may have expected and preferred. It is not altogether impossible they would find the acoustic clarity of our modern concert halls disconcerting, far too proscribed, sterile and bereft of unpredictable busy

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[89] It ought to be kept foremost in mind that all and any interior space has clearly identifiable acoustic properties, but this does not necessarily mean those acoustic properties were intentionally designed or even utilised. As Professor Matthew Wright (ISVR, Southampton) has recently commented regarding the study of acoustics in prehistoric chamber tombs (Devereux, Watson, *et al.*), his garden shed has good acoustics but it doesn't mean it was intended as a performance or reception space…let alone whether any sound produced inside or out has any paranormal meaning.

intricate aural reflections. In the acoustic parlance established by Sabine, the sixth-century congregation of Ravenna may have preferred extremely "wet" acoustic spaces[90].

Therefore, allowing it is without doubt useful to employ modern acoustic techniques in this research it is also equally important to discuss and comment upon Late Antique acoustics from the perspective of contemporary theories of sound. If acoustic choices can be identified in sixth-century architecture, they will be sixth-century choices with their own subjective and objective reasoning.

It has been asserted[91] that the first recorded use of analogical thinking, or indeed 'conceptual blending / integration'[92], was Vitruvius' recognition that sound is propagated as waves. Modern cognitive science identifies the water waves in this example as providing the '*source* analog,…which Vitruvius used to understand the unfamiliar *target* analog, the nature of sound'[93]. Cognitive constraints are accepted to be active during the construction of analogies, and in the case of Vitruvius' analogy of sound to water, Holyoak and Thagard[94] delineate three basic types of cognitive constraints. Firstly, the practice of mapping directly similar elements 'as in the case of the natural tendency to model airplane wings on bird wings[95]. Secondly, there is the identification of '…correspondences that will achieve their *purpose* in using the analogy'[96], where focus upon a structural detail is transferred over to a problem-solving construction. Thirdly, and the most pertinent cognitive constraint in relation to constructing analogies of sound, is finding correspondences based on shared structure. This is apparent by how sound waves and water waves 'share such structural properties as rebounding after striking a barrier, and diminishing in intensity with distance from their origin'[97]. The ability to 'see to the core of the matter (known as

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[90] There appear to be no ancient analogies that express a corollary between "dry" and "wet" in discussions on acoustics, however appropriate Sabine's 20th century analogy is to the context of Ravenna's water issues.
[91] Holyoak & Thagard 1995b.
[92] Cf. Blending and Conceptual Integration Website.
[93] Holyoak & Thagard 1995b.
[94] Holyoak and Thagard 1995a, and 1995b.
[95] Holyoak & Thagard 1995b.
[96] Holyoak & Thagard 1995b.
[97] Holyoak & Thagard 1995b.

'gist extraction'), is the key to analogy making - indeed, to all intelligence'[98], and has been described in the context of cognitive science as the 'sense for essence'[99].

Analogy is held to provide 'plausible conjectures, not infallible deductions'[100], however, the analogies of sound that enjoyed currency in Rome may be argued to have been considered 'infallible deductions' and integral to broader schools of philosophic thought. The particular context of argumentation amongst the Stoic and Epicurean schools is one in which 'analogies called *intuition pumps* are proposed by philosophers to get people to see abstract issues in a particular, biased way'[101]. Sound and acoustic phenomena has been one such 'abstract issue', approached by various 'intuition pumps' ever since physics was transformed by the early seventeenth-century rediscovery of Epicurus' version of Atomism; an infinite and mechanical universe of interacting particles - and also of his empirical approach to knowledge, with an emphasis on the importance of observation and experience[102]. However, contemporaneous with and contrary to the Epicureans, sound was argued to be not simply an 'abstract issue', but rather a synesthetic 'observable' material object analogous to other material objects; sound was conceptualised as seen, smelt, tasted, touched and weighed.

Ancient Analogies of Sound

Having identified the relevant philosophic schools of the ancient Mediterranean and the various ways of creating analogies, it remains to catalogue those pertinent to the topic of acoustic phenomena.

1: Tactile Analogy

The second-century AD physician and philosopher Sextus Empiricus wrote *Adversus musicos* (*Against the Musicians*) and in his sixth book on *Adversus*

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[98] Hofstadter 1995:75.
[99] Hofstadter 1995:75.
[100] Holyoak & Thagard 1995b.
[101] Hofstadter 1995:79.
[102] Gottlieb 2001:290.

mathematicos, more usually known as *Against the Professors*[103], in which he identified the Stoic idea:

> …sound is a body, because everything that performs an action is a body; sound makes an imprint on the hearing as a finger does in wax. Everything that moves and annoys is a body; εύμονσια (musicality) moves and άμονσια (want of musicality) annoys. Sound is moved and is reflected when it makes an echo[104].

A 'tactile analogy' is applied to the subject of sound by Empiricus thus:

> …of sound one kind is "sharp", another "grave", each of these deriving its name by transference from the sense-objects of touch; for just as custom has given the name of "sharp" to what pricks or cuts the sense of touch, and "grave" to that which causes crushing and compresses, in the same way it calls the sound which cuts, as it were, the hearing "sharp", and that which crushes it, as it were, "grave".[105]

The Latin *gravis* / *grave* means "heavy", "weighty", and "burdensome"[106], and is used as a description of a low deep sound (*opp. acutus*)[107]. The physical 'weighting' (*gravity*) of sound is also found in the Epicurean assertion that 'shape and weight are…inseparable from the atom'[108]. Lucretius states categorically that voice is corporeal and likewise 'sound[s], since they can strike and stir the senses'[109].

2: Colour Analogy

Sextus Empiricus also mentions in passing that sounds are described 'as grey or black or white'[110]. Apparently, a similar colour analogy is expressed by Aristides Quintilianus (c. 200 AD) in his *On Music*[111].

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[103] This work seems to have been written as a conscious display of 'effective argument' (6.68) (Bury 1949:405) against the prevailing schools of Epicureans and Stoics in his midst, representing the 'most complete treatment of ancient Pyrrhonian Skepticism' (Strunk 1998:94-109).
[104] Strunk 1951:106; Note 78.
[105] Sextus Empiricus; *Adv. Mus.*: 6.40.
[106] Marchant & Charles 1935:244.
[107] Marchant & Charles 1935:244.
[108] Plutarch; *Adv. Col.* 1110.
[109] Lucretius; *De Re. Nat.*; 524-525.
[110] Sextus Empiricus; 6.41; Bury 1949:391: '…just as we describe sounds as grey or black or white,…" (6.41; Bury 1949:391) …Φαιάν τινα καί μέλαιναν καί λευκήν… (Bury 1949:390). …'ΦΑΙΟ´Σ (Thaian), ά, όν, *dusky, dun, gray* (sic.), Latin *fuscus*, Plat.' (Liddell & Scott 1994:854). μείλανι (melainan) = black, and λευκήν (leukon) = white; '*fuscus*: -*a* –*um* (orig. *Furseus*, from root FUR, whence *Furvus*), 1 dark-coloured, dark, black; *cornix*, Cic. *Purpura paene fusca*, Cic.; 2 applied to the voice, hoarse, rough; *genus vocis*, Cic. (Marchant & Charles 1935:236). Grey is also '*canus* –*a* –*um* 1 Lit., whitish-grey; *fluctus*, Lucr.; *lupus*, Verg.; esp. of hair, *capilli*, Hor. Subst., *cani* –*orum* (sc. *capilli*),

3: Fire Analogy

Lucretius the Epicurean appears to have introduced a fire analogy, an early noteworthy description of the self-propagation and 'generative' characteristics of sound:

> A sound, moreover, divides in every direction,
> For each produces another as soon as the first
> Sound rises and bursts into many, as often a spark
> Will spray and scatter and set fires from itself.[112]

4: The Cone Analogy (Rising Sound)

A fourth type of analogy is what may be called the "cone analogy", describing sound as rising vertically and propagating in "waves". Lucretius implies the rising of sound[113] while the Stoics expressly 'noted that the undulations of sound moved "spherically" through the air, and not merely horizontally'[114]. We have seen above that Epicurus characterised sound as 'volumes spreading out'[115] which has been translated as a hollow mass in three dimensions, a sonorous relief known today as "stereo"[116]. The simple diagram below (Figure A.2) illustrates this rising cone-like sonorous relief in three dimensions, where x = time, y = space, and z = "depth", or 'atomic pulsation'[117].

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grey hair, Cic. 2 *Meton* – old, aged; *senectus*, Cat.' (Ibid.:82). The Greek *melainan* is transferred into Latin most notably as '*melancholicus –a –um* (μελαγχολικός), having black bile, melancholy, Cic.' (Marchant & Charles 1935:339).

[111] Aristides Quintilianus (On Music in Three Books. *Music Theory Translation Series*. New Haven: Yale University Press.); 1.9.57 (Strunk 1998:104, Note 31. See Mathiesen, T.J. (transl.) 1983).

[112] Lucretius; *De Re Nat.*: 4.601-604.

[113] *De Re. Nat.*; 4.493 (Esolen 1995:136).

[114] Plut. *loc. cit* (Granger 1955:267).

[115] Epicurus; *Letter to Herodotus*; 52.

[116] Delattre 1998:288.

[117] Delattre 1998:289.

x Time

"Atomic pulsation"
(stereo)

z "depth"

✕ Sound object ("source")

y Space
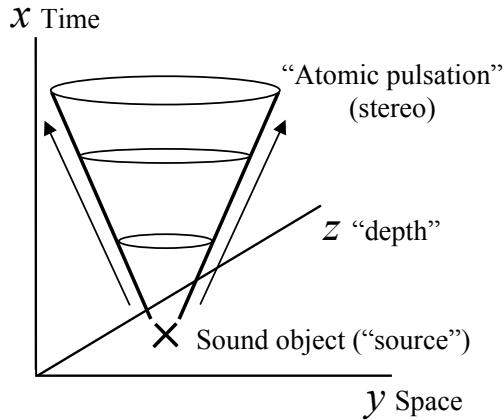
Diagram A.2: The concept of rising sound; the "Cone Analogy".

Virgil (70 BC – 19 BC), in his third Eclogue (*Are These Meliboeus' Sheep?*), writes the shepherd Damoetas singing:

> *O quotiens et quae nobis Galatea locuta est!*
> *Partem aliquam, venti, divum referatis ad auris.*[118]

Rieu[119] has translated this as:

> To think how often Galatea talks with me!
> And ah, the things she says! Winds carry some of them at least to the gods' ears[120].

Again, in his sixth Eclogue (*The Song of Silenus*), Virgil writes:

> *Omnia quae Phoebo quondam meditante beatus*
> *Audit Eurotas iussitque ediscere laurus,*
> *Ille canit (pulsae referunt ad sidera valles),*
> *Cogere donec oves stabulis numerumque referre*
> *Iussit et invito processit Vesper Olympo* (82-86).

> Indeed, he gave them all songs that once upon
> a time Eurotas, happy river, heard from Phoebus'
> lips and bade his laurels get by heart. All these
> Silenus sang. The music struck the valleys and the
> Valleys tossed it to the stars – till the lads were

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[118] Virgil; Eclogue III: 72-73 (Rieu 1949, 1954 reprint).
[119] Rieu 1954.
[120] Rieu 1954:47.

Warned to drive home and to count their sheep, by
Vesper, as he trod un-welcomed into the listening sky[121].

Both passages indicate the analogy of vertically rising sound, and more specifically the medium of wind (air pressure) as the facilitator of sound rising upwards "to the gods' ears". Sounds, in the form of "music" strike a valley basin and are thrown up to the stars. The winds are therefore understood to be carriers of messages, reverberation aided by moving air towards great heights.

Concurrent with the rediscovery of Epicurean physics, it should also be remembered that 'until the seventeenth-century work of Torricelli (1643), Boyle (1660) and Von Guericke (1672), there was no adequate conception of the physical nature of air pressure'[122].

5: Water Analogy

Dominant among the analogies of sound is that which likens the characteristics of sound propagation to waves in water. Within a study of Chaucer's *Hous of Fame* Delany[123] footnotes that '…the image of the stone thrown into water is fairly well known in medieval scientific and encyclopaedic literature…in their expositions of the nature of sound'[124]. Indeed, this analogy can be traced back to Zeno of Citium (333-261 BC), the founder of the Stoics[125]. The later Stoics Chrysippus (c. 280-207 BC) and Vitruvius (c.90-20 BC); the Platonist Plutarch (c. AD 45-125); the late Roman Christian Boethius (c. AD 480-c. 525); and the mediaeval Vincent of Beauvais' (died AD 1264)[126] all follow this analogy, it is used and maintained by disparate ideologies and philosophic schools through different historic periods, therefore its importance and popularity cannot be overstated.

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[121] Rieu 1954:77.
[122] Sumner 1958:24. Evangelista Torricelli's *De motu gravium* (in his *Opera geometrica* of 1644) 'proved that the flow of liquid through an opening is proportional to the square root of the height of the liquid, a result now known as Torricelli's theorem. Some have suggested this result 'makes him the founder of hydrodynamics' (Evangelista Torricelli Website). Robert Boyle (1627-1691), although best known for Boyle's law (sometimes called Mariotte's Law) which describes an ideal gas, also proved in an appendix written in 1662 to his work *New Experiments Physio-Mechanicall, Touching the Spring of the Air and its Effects* (1660), 'among other things, that sound did not travel in a vacuum' (Robert Boyle Website). Otto Von Guericke (1602-1686) is noted for inventing the air pump in 1650, but also 'when he learned of the Torricellian experiment, he repeated it, made barometric forecasts of the weather based on systematic observations over a period of years, and proposed a network of stations to make systematic reports of the barometer and weather' (Otto Von Guericke Website).
[123] Delany 1972.
[124] Delany 1972:72.
[125] As cited by Diogenes Laertius.
[126] Book 16 of his *Speculum Naturale.*

Zeno of Citium is quoted as describing hearing thus:

ώς κυματουται τό έν τη δεξαμενη υδωρ κατά κύκλους υπό του έμβληθέντος λίθυ [127].

We hear when the air between the sonant body and the organ of hearing suffers concussion, a vibration which spreads spherically and then forms waves and strikes upon the ears, just as the water in a reservoir forms wavy circles when a stone is thrown into it (7.158).

While Κυματουται means "waves", and Κύκλους means "circles", Δεξαμενη is 'a reservoir, tank, cistern' [128]. A slightly different translation of the same passage is given by Arnold [129]:

…in the case of hearing, the pulsation…spreads from the ear to the speaker, and…from the speaker to the hearer; this reverse pulsation being circular in shape, like the waves excited on the surface of a lake by throwing a stone into the water [130].

From a Stoic vantage, Chrysippus, in the third-century BC, wrote:

Hearing occurs when the air between that which sounds and that which hears is struck, thus undulating spherically and falling upon the ears, as the water in a reservoir undulates in circles from a stone thrown into it [131].

The analogy was popular and re-used, as Cicero (106 BC – 43 BC), Plutarch (AD c.46 - 120) [132], Seneca (c.4 BC – AD 65), and Aulus Gellius (AD c.125 – after 180) [133] all cited Chrysippus.

Following Stoic thinking, Vitruvius expressed the water analogy thus:

[6] Now the voice is like a flowing breath of air, and is actual when perceived by the sense of hearing. It is moved along innumerable undulations of circles; as when we throw a stone into standing water. Innumerable circular undulations arise spreading from the centre as wide as possible. And they

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[127] In Diogenes Laertius's (AD c.230) *Lives of Eminent Philosophers*, Book 7 (Hicks 1931:260).
[128] Liddell & Scott 1994:179.
[129] Arnold 1911.
[130] Arnold 1911:250.
[131] Kahn 1999: 206; note page 409.
[132] Plutarch *De Plac. Phil*. 4.19.4 (Granger 1955:266).
[133] Aulus Gellius; *Noctes Atticae* (*Attic Nights*).

extend unless the limited space hinders, or some obstruction which does not allow the directions of the waves to reach the outlets. And so when they are interrupted by obstacles, the first waves flowing back disturb the directions of those which follow. [7] In the same way the voice in like manner moves in a circular fashion. But while in water the circles move horizontally only, the voice both moves horizontally and rises vertically by stages[134].

In this way the water and the 'rising cone' analogies are brought together for a fuller description of acoustic phenomena.

6: Light Analogy

The Stoic philosopher Seneca (4 BC-AD 65), in his *Natural Questions*, used the analogy of the stone in water and applied it to a description of light as a series of circular waves[135], thus making a parallel observation between the behaviour of sound and light by the unifying analogy of water waves.

These six analogies of sound have been identified and gathered here in order to provide a foundation for understanding developments and experiments in architectural design and construction in antiquity. Alongside these various analogies there exist descriptions of acoustic phenomena. One example is the description of echo by Decimus Magnus Ausonius (AD c.310-394) in his *Mosella* (a poem about the River Moselle):

> *Blanda salutiferas permiscent liltora uoces,*
> *Et uoces et paene manus: resonantia utrimque*
> *Uerba refert mediis concurrens fluctibus echo.*[136]

> On these shores one need never raise his voice,
> The opposite bank echoes every word
> So that talking is almost touching hands.[137]

> *nobilibus Celbis celebratus piscibus, ille*
> *Praecipiti torquens cerealia saxa rotatu*
> *Stridentesque trahens per leuia Marmora serras*
> *Audit perpetuos ripa ex utraque tumultus.*[138]

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[134] Vitruvius *De Architectura*, Book 5, Chapter 3.
[135] Veltman 1986.
[136] Ausonius; *Mosella*: 295-296 (Isbell 1971).
[137] Isbell 1971:59.
[138] Ausonius; *Mosella*: 361-364.

…the Ruwar hears the screams of his mills
as they furiously saw the marble
and make the distant shore-line, hills and trees,
ring with the din of a marble quarry.[139]

The intention of this first section of Appendix A has been to comment on and catalogue ancient theories of acoustic phenomena and their relationship to music practice. In the second section a more focused consideration of San Vitale at Ravenna will be contextualised with contemporary ideas and observations of acoustics and specific musical displays having a direct relationship to interior ecclesiastical spaces.

Late Antique Acoustic Theory Embodied in San Vitale

Related to the Cone, Water and Light analogies outlined above, and with special relevance to the intellectual context of the sixth-century, the writings of two eminent men of high station at Ravenna, in the years when San Vitale was being planned and constructed, require special attention.

Anicius Manlius Severinus Boethius (480-524/25):

As already noted, Boethius reiterated the analogy of sound propagation to waves in a standing pool of water. He was stripped of his official rank and after being imprisoned by Theoderic at Ravenna on the suspicion of coercing with the Byzantine Empire, was infamously put to death in c.525, approximately one year before Theoderic's own death and the end of an otherwise long tolerant rule. The popularity of Boethius's writings in the medieval period, namely his unfinished *De institutione musica libri quinque*[140], ensured the continuance of the analogy of water waves to sound waves until the 20th century. If we were only to consider Boethius' work it would only be pure speculative conjecture to extrapolate any material meaning this analogy had on sixth-century Ravennate architecture. However, when read in

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[139] Isbell 1971:61.
[140] Boethius' *De institutione musica* introduced the three classifications of music: *Musica mundana* (music of the spheres), *Musica humana* (harmony of human body and spirit), and *Musica instrumentalis* (the praxis of playing a musical instrument).

conjunction with his contemporary, Cassiodorus, some acoustic musical observations of Late Antique Ravenna come clearer into focus.

Flavius Magnus Aurelius Cassiodorus Senator (c.485-c.585):

Cassiodorus was *magister officiorum* to King Theoderic at Ravenna until 526 and it is known that he remained in the city until shortly after 540, with the Byzantine takeover. He proceeded south to family property at Vivarium (Squillace) in Calabria where he founded a monastic order and library[141]. His writings on music can be dated to between 550 and 562 and although this places his composition of the *Expositio in psalterium* slightly after the completion of San Vitale in 548, it is not impossible some of his comments were informed by personal experience at Ravenna, perhaps even within San Vitale itself when construction was substantially completed and finishing touches such as the wall mosaics were being applied, perhaps even attending the dedication of the church on *Quasimodo* Sunday, April 19th, 548.

In his *Expositio in psalterium*, Cassiodorus describes the vocal performance of the Mass Alleluia[142]:

> *Hinc ornatur lingua*
> *Cantorum: istud aula*
> *Domini laeta respondet,*
> *Et tanquam insatiabile*
> *Bonum tropis semper*
> *Variantibus innovatur*[143].

> Hence, by the tongue of the
> Singer, [the alleluia] is
> Embellished: this the glad
> House of the Lord echoes, and
> then like an un-wearying
> delicacy, with ever-changing
> turns, it is renewed.

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[141] Knight 2008:19.

[142] The useful study of Ambrosian Alleluias by Bailey (Bailey 1983) focused on the liturgical alleluia of the Mass. The second, simpler form of the liturgical alleluia '…is related to the psalmodic practice: alleluia is attached as a brief coda, usually of independent musical origin, to certain chants of the Mass and Office, especially in Eastertide…it is clear from St. Benedict's Rule that the alleluia was a regular addition to antiphons and responds of the Daily Office, in Eastertide and beyond, by the early sixth-century. The use…of alleluia as an antiphon text has, obviously, the same origin' (Bailey 1983:4).

[143] Cassiodorus; *Expositio in psalterium*, PL LXX, 742.

Comment [DK1]:

A little further on, he says:

> *In melodia hoc compositum*
> *Nomen diversos tonos*
> *Recipit, ita ut*
> *Multiplices causas ad*
> *Vim suae praedicationis*
> *Assumit*[144].

> In singing, this compound
> Noun [alleluia] receives
> Varied [winding] tunes,
> Multiplicity of means the
> Force of its message.

He describes an Alleluia that is ornate (*ornatur lingua cantorum, diversos tonos recipit*), long (*tanquam insatiabile bonum, multiplices causas*) and, in all probability, improvised (*tropis semper variantibus innovatur*)[145]. One interpretation of the derivation of the word 'alleluia' is that it is "Hallelu-Ya", Hebrew for "Praise God", and indeed the psalter (book of psalms) concludes with:

> Let everything that breathes praise Yahweh! Alleluia!

From the conjunction of "praise Yahweh" and "Alleluia" in this verse it is obvious 'the final word has a significance beyond its simple meaning'[146]. The Mass Alleluia that Cassiodorus is referring to is a responsorial chant ending with a melismatic[147] vocalisation on the final syllable, a contraction of "Yahweh", the name of God.

This interpretation of the word Alleluia taking its roots solely from Judaism has been challenged by Cattin[148], who has pointed out that the jubilus on the final syllable is referred to by several classical sources including the pre-Christian writings of Marcus Terentius Varro (116 BC – 27 BC), the first-century epic poet Silius Italicus (AD c.26 - 101), within the Stoic writings of Marcus Aurelius (Emperor from

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[144] Cassiodorus; *Expositio in psalterium*, PL LXX, 811.
[145] Bailey 1983:14.
[146] Bailey 1983:1.
[147] A melisma is the vocal technique of changing the pitch of a single syllable of text while it is being sung.
[148] Cattin 1984:10-11.

AD 161 - 180) and later by St. Ambrose (339-397). Cattin argues that the classical sources of the jubilus are significant in illustrating:

> …the custom of performing the prolonged vocal passage was widespread even among the Romans, especially as the particular slogan of a given social or military group. This seems to be the meaning also of the Jewish t'rû'āh, a shout which in the oldest translations of the Bible is always rendered in words of similar etymology (*jubilatio, jubilare*). Given the evidence for its existence in the Latin world, it cannot be maintained that the jubilus is derived exclusively from the Jews; it is in fact a related phenomenon which the Christians, because of Biblical precedent, felt able to develop and thereby make more common.[149]

In Judaism "Yahweh" is the Unutterable Name, Distinctive Name or Ineffable Name (*Shem HaMeforash*) of God, not to be vocalised. It is even possible YHWH, without vowels, signifies the breath of the Holy Spirit and therefore whispered. The correct pronunciation of YHWH is intentionally unknown. In some editions of the *sidur*, the Jewish prayer book, there are no vowels under God's name, to signify we do not know God's name and that there is absolutely no pronunciation[150]. However, the "Yah-" ending of Alleluia receives elongated jubilant vocalisation in Christian chant. Complex melismas:

> …seem always to have been customary in the synagogue to adorn important words or syllables in certain chants. And the practice was not confined to the Jews: the priests of ancient Egypt astonished the Greeks with similar vocalisations in their invocations of the gods. The Alleluia provides the *locus classicus* for such melismas, since the syllable to be adorned is IA, the name of God himself. The jubilus (also called *jubilatio, melodia, melos, neuma, tractus*, etc., words that convey the sense of extended, pure melody) was certainly not restricted to the Mass, but after the ecstatic enthusiasms of the early Christian worship had subsided into a formal liturgy, the Mass jubilus was virtually the only regular survivor[151].

The contemporary friend of Ambrose, Augustine (AD 354-430) likewise described the vocalisation of the jubilus[152]:

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[149] Cattin 1984:11.

[150] *Encyclopaedia Britannica*: 1994.

[151] Bailey 1983:13.

[152] Augustine; *Enarratio in Psalmum* XCIX, PL XXXVII, 1272. 'Another melodic form with its roots in Jewish tradition is the jubilus. This consists of the joyful explosion of a vocal melisma, sometimes very long, without accompanying text. The fullest and most enthusiastic account of this musical form – a kind of contemplation- is given by St. Augustine (354-430), who rarely misses an opportunity to

Qui jubilant non verba
Dicit, sed sonus quidam
Est laetitia sine verbis:
Vox est enim animi
Diffusi laetitia, quantum
Potest, exprimentis
Affectum, non sensum
Comprehendentis

One who jubilates does not
Utter words; the sound is
Rather a kind of wordless
Joy; indeed, the utterance
Is that of a soul filled with
Joy making every effort
To express its feelings,
Not to convey meaning[153].

In c.450 the Byzantine historian Salaminius Hermias Sozomenus (c.400-c.450)
wrote the following description of an independent chant, most likely the Mass
Alleluia:

Moreover, in Rome they sing the
Alleluia only once in each year,
On the first day of the Paschal
Festival, so that for many of
The Romans, to hear or sing
The chant is considered a
Suitable pledge for an oath[154].

Bailey further commented:

The sense of solemnity of the occasion is given by his [Sozomen's] mysterious
reference to the oath. Such a chant could not fail to be impressive, both long
and ornate. The rarity of its occurrence, whether once a year or, as

discuss it, especially in his *Enarrationes in Psalmos*. He describes it as a chant much used in connection with the responsorial psalm, and thereby refutes the opinion of those who see in the jubilus no more than the direct ancestor of the alleluia in the mass. (It is noteworthy that the alleluia is compared by Augustine and others to the *kéleuma*, originally an oarsmen's song and therefore strongly rhythmical.) Furthermore, from certain other passages of Augustine it might be inferred that the performance of the jubilus was not the exclusive preserve of the soloist, but that the congregation joined in; and one must therefore imagine simple or even standardized forms of jubilus' (Cattin 1984:10-11).
[153] Bailey 1983:14.
[154] Church History (*Historia Ecclesiastica*); Migne 1857-1866: LXVII, 1475 (Bailey 1983:8).

subsequently, eight times (on Easter and the following seven Sundays), obviously precludes a large repertory, and suggests, in fact, what the ecstatic, essentially wordless character of the chant almost demands, an improvised performance[155].

There is musical evidence that the Mass Alleluia of Rome, Milan and the Gregorian regions were originally improvised, for, of all the liturgical chants, it provides the occasion *par excellence* for vocal display. Prior to 590 (i.e. Gregory the Greats' liturgical reforms), the Alleluia was improvised as an exclusively Paschal chant, but between 590 and 598 its use beyond Eastertide was extended[156]. The significance for San Vitale is that, since its dedication can be dated to the first Sunday after Easter (the Octave Day of Easter and known as Quasimodo Sunday[157]), it is likely this Mass Alleluia was sung and improvised on at least that day. We can, therefore, identify at least one musical acoustic element on Sunday April 19th, 548 within the new space of San Vitale. This is a significant identification for the musicological and archaeological understanding of San Vitale, Ravenna and Late Antique Italy since it is almost impossible to accurately locate where other extant Ravennate chants were sung, particularly in what specific city church. However, we do also know that two other Ravenna churches, both also financed by Julianus Argentarius, were dedicated on the Sundays following Easter (within Eastertide); San Michele in Africisco (*Ad Frigiselo*)[158], was dedicated by Bishop Maximian on May 7th, the third Sunday following Easter of 545 and Sant' Apollinare in Classe was dedicated on May 9th 549, the fifth Sunday after Easter of that year[159]. Therefore, the Mass Alleluia would also have been sung at the consecration of these three churches,

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[155] Bailey 1983:15.

[156] Bailey 1983:15.

[157] Also known as Low Sunday, White Sunday, Alb Sunday, St. Thomas Sunday, and, most recently (as of Pope John Paul II) Divine Mercy Sunday. In the East it is known as Thomas Sunday. The name Low Sunday probably derives from Laudes, the first word of the Sequence of the day: *Laudes Salvatori voce modulemur supplici* (Let us sing praises to the Saviour with humble voice). Traditionally, the newly-baptised would receive baptismal gowns that would be worn until this day, and the official Latin name is *Dominica in Albis* [*Depositis*], "Sunday in [Setting Aside the] White Garments", hence "White" and "Alb" Sunday. The name Quasimodo came from the Latin text of the traditional Introit for this day, which begins "*Quasi modo geniti infantes…*" ("As newborn babes, thirst for the pure milk of the word so that by it you may grow in your salvation"), from the First Epistle of Peter (I Peter 2:2).

[158] Agnellus; Maximian, 77 (Deliyannis 2004:191). In the Paschal cycle of the Eastern Orthodox Church the reading for the 3rd Sunday after Easter is on Christ healing the paralytic (Mark 2).

[159] Julianus Argentarius also financed the construction of Sant' Apollinare at Classe, dedicated by Bishop Maximian on May 9th of 549 (Agnellus; Maximian, 77; Deliyannis 2004:192), this being the 5th Sunday following Easter of that year (April 4th), known also as Rogation Sunday. Further investigation of historic sources is required in order to establish whether this was a usual mid-6th century practice at large or just at Ravenna, or if this was peculiar to the episcopacy of Bishop Maximian, or, indeed, unique to these three churches.

further illustrating their shared connection. It is possible to go a little further with this discovery by considering in detail the two passages by Cassiodorus.

Bailey gives us Cassiodorus' comments in reverse order[160] and builds an argument for the improvisation of the Alleluia, but the sequence Cassiodorus intended invites an alternative reading. It seems probable that LXX, 742 describes the reverberation (*respondet*) within a church (*istud aula Domini laeta*) and the performed vocalisation dependent on the complexity of the resultant echoes (*et tanquam insatiabile bonum tropis semper variantibus innovatur*). If Bailey is correct in his interpretation here of improvisation, it seems to be in direct relation to the reverberation time of an interior acoustic space, *variantibus innovatur* being 'innovating variances' or 'unpredictable variety'. However, Bailey has translated *lingua cantorum* as 'singer' when it is actually plural, 'singers', indicating Cassiodorus was instead describing more than one singer and not an improvising soloist.

As already mentioned, Cassiodorus is known to have left Ravenna shortly after 540, when the city fell to Byzantine rule, retiring to Squillace in Calabria. His writing on music (*Expositio psalmorum* / Exposition of the Psalms), of which the lines above are taken, can be dated to between 550 and 562. If this reading is correct then a thesis may be developed parallel to Bailey's: the sixth-century development of elongated melismatic Alleluia chants could in part be a result of developments in ecclesiastical architecture and, more specifically, the acoustics afforded by particular enclosed spaces. The kind of vocal display in relation to long reverberation times indicated by Cassiodorus may represent musical developments in direct relation to contemporary performance spaces. Although Cassiodorus was apparently absent from Ravenna at the time of writing, his comments are within the very first few years following the completion and dedications of San Michele in Africisco in 545, San Vitale in 548, and Sant' Apollinare at Classe in 549, and as we have just seen, on San Vitale's dedication day of Quasimodo Sunday the Mass Alleluia that Cassiodorus is describing was performed in the new church, highly suggestive that he visited the new church before writing, and, additionally, describing the interior reverberation and musical performance inside San Vitale[161]. On the other hand he may simply have

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[160] PL LXX, 742 should obviously precede PL LXX, 811.
[161] Cassiodorus could also be describing the acoustics of San Michele in Africisco or Sant' Apollinare near Classe, or describing combined personal experiences he had in other churches besides. It is not

been making general observations and comments based on experience (still, these may represent general comments based on his thirty-year experience as minister within the court of Theoderic at Ravenna) and/or comments on another specific interior space at Vivarium (Squillace), Calabria, or elsewhere. Nonetheless, it is tantalising that Cassiodorus, with so much experience at Ravenna, describes the acoustic effects of the Mass Alleluia, a chant performed in San Vitale on its dedication day. It is plausible that this great man was invited back to Ravenna for this important occasion hence his comments may be directly based on his own experience inside San Vitale. Such a thesis cannot be proven beyond doubt, but its consideration is instructive.

Summary

By focusing upon Plato's *Timaeus* and the ideas of Pythagoras through Aristoxenus, I have shown how the Greek traditional philosophic concepts of sound, hearing, and music strongly influenced later discourse; however, the hegemony of the Pythagorean, Platonic and Aristotelian tradition obscures opposed yet concurrent contemporary ideas. Namely the Stoic ideas nested in Vitruvius, the Epicurean work of Philodemus and Lucretius implicated within the poetry of Virgil and Horace, and the sceptic arguments of Sextus Empiricus have been shown to contribute to a complex fabric of acoustic thought in the Roman era. Philodemus in particular has been described as categorically rejecting 'the whole of Greek tradition, from Pythagoras down to the Stoics, by Damon, Plato and Aristotle'[162]. It is high time Epicurean ideas were brought into discussions on Roman music. It is unfortunate that Ingold[163] has based such lucid and compelling sensorial archaeological thinking about hearing on the Platonic idea that sound 'reaches directly into the soul'[164].

The exercise of picking apart some of the Roman analogies of sound to other material objects has been a "gist extraction" in order to clearly outline and catalogue references to certain analogies. Several different philosophic schools, regardless of their other conceptual differences, maintain certain analogies, such as the "water

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impossible that he visited Ravenna in 545, 548 and 549 for the Sunday dedications of these three churches.
[162] Delattre 1998:292.
[163] Ingold 2000.
[164] Ingold 2000:244.

analogy". What can be said by way of a general conclusion is that sound was perceived and constructed through discursive analogies of materiality. Sound, then, was thought to be a substance that could be seen, smelt, tasted, touched and weighed.

Of the several ancient analogies of sound, two in particular have been identified as important to San Vitale, those of the water waves and the rising cone. Additionally, the Mass Alleluia and its final elongated jubilant melisma were not only sung at the dedication of San Vitale, but are described with reference to acoustic phenomena by the pre-eminent contemporary Cassiodorus, just possibly the earliest ear-witness to the new acoustics of that church and its Ravennate rite.

Appendix B, Part 1:

Influences on the Architectural Design of San Vitale

In Ravenna's churches, adorned with the finest mosaics ever made, such an interruption as the Dark Ages seems to disappear, and you experience the development of Italian history and art from ancient to medieval times as a continuous and logical process[1].

Appendix B1 reviews the modern debate over the derivations of longitudinal basilicas and centrally planned domed churches. The second part (B2) explores the correlation between the design of San Vitale and other ecclesiastical structures that are octagonal internally and externally. On the accompanying CD is the Excel file B3 with three worksheets; Centralised baptisteries with octagonal elements, Octagonal churches/chapels and Churches with polygonal apses.

Part B1: The Longitudinal Basilica versus the Centrally Planned Domed Church

The debate over the architectural origin of the Christian basilica has engaged the attention of scholars from Alberti, in 1465[2], up to and including recent work such as Welch[3]. The lines of investigation are divided, each favouring one of two sources for the basilica; the Western influence centred at Rome and the Eastern source within Judaism. Alberti championed the Western line of argument, attempting to show that the Christian basilica developed from the great Imperial law court basilicas typically found in the Forum. They are characterised as rectangular oblong structures with interiors divided into nave and flanking aisles separated by ranges of columns or piers, and an apsidal end where 'the judge was enthroned behind a bar or chancel rail'[4]. However, several problems with this theory have been criticised. For instance, whereas the Roman basilica was a monumental public building projecting from and dependent on the Forum, the Christian basilica was a slight construction. The following statement by Swift[5] requires careful reconsideration:

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[1] Facaros & Pauls 2000:228.
[2] Alberti; *De re edificatoria* 1465.
[3] Cf. Welch 2003. Also see Cross & Livingstone 1997 and Ferguson 1990.
[4] Swift 1970:13.
[5] Swift 1970.

The very purpose and function of the pagan basilica would have prevented it from having served as a model for the Christian house of worship.[6]

Kraus[7] amended this theory, arguing that the Christian basilica originated from the smaller Roman private basilica. However, due to the rareness of these structures and their placement within wealthy complexes only seen by the privileged it seems unlikely they could have shaped such a widespread and uniform architectural type. Theories have also been advanced that the Catacombs near Rome, funeral *cellae* and freestanding *exedrae* sanctuary apses influenced the Christian basilica. More plausibly, Dehio[8], in 1885, demonstrated how the church was derived from the Roman private house. His choice of the Republican Roman house 'differed considerably from the characteristic house of the Imperial period, chiefly in that it lacked the feature known as the *peristyle*, an open colonnaded court to the rear of the *tablinum*'[9] and Schultze[10] subsequently modified the theory. Working from the Eastern basilica's lack of atrium, he argued that the Hellenistic *peristyle* house became its source, whereas in the West the large Greco-Roman patrician house (for example the House of Pansa at Pompeii) with *peristyle* was the model for the Western basilica. However, it has been noted that 'his entire approach to the problem is theoretical, based for the most part on mere architectonic resemblances, which are admitted to be notoriously misleading in any search for origins'[11]. Another exponent of the house theory was Lemaire[12], who, extending Schultze's work, included mention of the raised exedra (called the *oecus*), a rectangular alcove at the back of the *peristyle* of the Greco-Roman house. The *oecus* lined up with the main axis of the house and 'served as a sort of out-door summer dining room, with a pleasant view of the open garden and fountain enclosed by the colonnaded *peristyle*'[13]. Lemaire argued that the *oecus* 'became the prototype of the raised sanctuary and bema of the later Christian

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[6] Swift 1970:13.
[7] Kraus: *Geschichte der christlichen Kunst*, I 1896-1908.
[8] Dehio: *Die Genesis der christlichen Basilika*, 1885.
[9] Swift 1970:18.
[10] Schultze: *Archäologie der altchristlichen Kunst*, 1895.
[11] Swift 1970:19.
[12] Lemaire: *L'Origine de la basilique Latine*, 1911.
[13] Swift 1970:19. For the Roman domestic architecture of northern Italy see George 1997.

church[14]'. With the growth of congregations in the third-century, the "church house" (or the "house of God", the *domus dei*) gave way to the basilica structure.

Zestermann[15] proposed that architects created a new style of architecture in the Christian basilica based on 'selected elements from the pagan basilica'[16], Roman house and Jewish synagogue. Swift's criticism of the theory is problematic:

> It is scarcely necessary to mention that the very method of eclectic architectural design is of comparatively recent origin, having appeared no earlier than the last half of the nineteenth century.[17]

The Eastern approach to the debate has focused on the logical assumption that early Christians sourced Jewish architecture for the basilica[18]. The synagogue, and especially the Great Temple at Jerusalem (although razed by the Emperor Titus in AD 69) may have influenced the basilica design, but the Temple's grand 'forecourts lined with colonnades, the great portals leading to the sanctuary, the altar of burnt-offerings to Jehovah, and the veiled holy of holies'[19] is at best remotely reflected in the more modest Christian basilica. It is impossible to rigorously assess the influence that the Temple at Jerusalem may have had on Christian architecture because there is not any reliable description of it. Although the synagogues that have been archaeologically investigated adhere to no standard form, few suggest the basilica design[20]; there is a group of ancient Galilean synagogues that may have contributed to the Eastern early church type.[21] The

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[14] Lemaire (pp.77-82) bases the proof of his theory on the 'liturgy and ritual of the early church as well as on purely archaeological grounds and succeeds in demonstrating conclusively that when the large Roman house with peristyle was used as a meeting place for the early congregations, the Eucharist was regularly celebrated at the back of the peristyle directly in front of the raised platform of the oecus; upon this platform and within the rectangular alcove the altar must have been located, with the officiating clergy ranged about the altar. The baptised members of the congregation took their stand in the lateral aisles of the peristyle, arranged according to sex and social position – men in the right aisle, women in the left, with those of higher rank in front nearest the altar, the poorer and more plebian members relegated toward the rear. Finally, the catechumens and penitents, who might not partake of the sacred mysteries, were allowed to approach no closer than the tablinum or atrium' (Swift 1970:19).

[15] Zestermann: *Die antiken und die christlichen Basiliken*, 1847.

[16] Swift 1970:20.

[17] Swift 1970:20. That is, immediately *after* Zestermann published his theory in 1847! One wonders why Swift was not acquainted with the Arch of Constantine, itself a triumph of eclecticism.

[18] Kreuser: *Der christliche Kirchenbau*, 1851; Mothes: *Die Basilikenform bei den Christen der ersten Jahrhunderte, ihre Vorbilder und ihre Entwicklung*, 1869; Kempeneers: *Le Type des églises construites par et depuis l'empereur Constantin*, 1881.

[19] Swift 1970:15.

[20] Swift 1970:15.

[21] Swift 1970:20.

synagogue at Tell Hum (copied closely by those at Kefr Bir'im and Irbid), near ancient Capernaum, is oblong and rectangular, but instead of having an atrium a walled court flanked the eastern side.[22] This arrangement 'is paralleled in many of the early Christian churches of Syria'[23]. Eusebius tells us, moreover, that the Church of the Nativity at Bethlehem and the Eleona Church on the Mount of Olives at Jerusalem, as originally built by Constantine, had the synagogue positioning of aisles and galleries carried about three sides of the nave[24]. Swift notes also that the iconostasis of the Eastern or "Byzantine" church 'is considered by most authorities to have derived from the Torah shrine of the synagogues'[25]. But, whereas the old basilica theory (Alberti) had been abandoned and the house theory revealed many flaws, the synagogue theory applied only to certain features. On the other hand, Gabrial Leroux in 1913[26] took a completely different approach to the problem. Questioning whether the Roman basilica and Christian church traced their origins back to ancient Egyptian architecture, he made a comprehensive study of 'every known ancient building which had used columns to organise the interior and support the roof'[27]. Such an investigation is breathtaking, but it assumes that architecture produces "types" that grow into "families" and therefore have a common ancestral, genealogical root. It is not surprising therefore that Leroux shows a lineage from the "primitive" hut of the Neolithic, Bronze and Iron Ages to Egyptian temple halls and Homeric Greece. Nevertheless, Swift claims it is generally agreed (as of 1951) that Leroux has proved 'that the basilican church of the early Christians is nothing more nor less than the Western type of Roman civil basilica'[28]. Swift's next sentence is instructive:

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[22] Swift 1970:21. The orientation is such that the main façade faces south (Swift 1970:21).

[23] Swift 1970:21. In the reign of Theoderic 'strife arose between the Christians and the Jews of the city of Ravenna; accordingly the Jews, being unwilling to be baptised, often in sport threw the holy water that was offered to them into the water of the river. Because of this the people were fired with anger, and without respect for the king, for Eutharicus [Theoderic's son-in-law], or for Peter [Peter II 494-520], who was bishop at the time, they rose against the synagogues and presently set them on fire…Accordingly Theoderic…gave orders that the whole Roman population should furnish money for the rebuilding of the synagogues of Ravenna which had been burned' (*Anon. Vales*. 81-82; Rolfe 1939:558-561).

[24] Likewise, akin to the synagogues, they had no clerestory but received light from two ranges of windows in the outer walls (Swift 1970:21).

[25] Swift 1970:21.

[26] Leroux: *Les Origines de l'édifice hypostyle en Grèce, en Orient et chez les Romains*, 1913

[27] Swift 1970:22.

[28] Swift 1970:29.

It is the type which, having originated in the primitive oval hut of prehistoric Western peoples, descended through palaces, temples, and Roman courts of justice to become the true progenitor of that glorious line of splendid churches and great cathedrals which, through almost two thousand years have arisen in every land to bear witness to the Christian faith.[29]

As this last quote demonstrates, investigations into the origins of the early Christian basilica have often been laden with charged feelings[30]. It is likely that the study of the basilica has reached such a pitch due to its central role in Western architecture. The centralised domed church on the other hand is regarded as a subordinate Eastern development and therefore an atypical adjunct to the cultures of the West. The present research critically addresses this overly simplistic dichotomy by revealing the complex and symbolic combinations of architectural forms as holistic experiential places of engagement between the living and the dead. Differences in the expression of that relationship will be shown to be far more interesting than a mere East/West polarity suggests.

The early Christian basilica has long been seen as an independent architectural type 'adapted to the liturgical requirements of Christian worship'[31], albeit 'incorporating elements from both Roman and earlier sources'[32]. For the moment it may be useful to cite the main features of "a generic basilica" in order to then comment on differences and developments.

The early Christian basilica is an oblong rectangular structure usually aligned with its apsidal chancel towards the East, the direction of the rising sun, emblematic of triumphant resurrection from death/mortality to new life and eternal Paradise. A square cloistered court (atrium) adjoined the church at its western entrance creating a vestibule (narthex). At the centre of the atrium was often a fountain used for ceremonial ablutions. The basilica interior was divided into a central nave flanked by side aisles beyond ranges

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[29] Swift 1970:29. For Roman palaces see Barton 1996, for Roman gardens Purcell 1996.

[30] For example, 'Of all the varied kinds of churches which arose in the Middle Ages the basilica is by far the most important, not only because it served as the earliest and most wide-spread of Christian houses of worship but also because of the fact that from it are descended most of the churches in use today. Due, then, to the key position which it occupies in the history of church architecture, the problem of its origin assumes a peculiar significance. If we can discover the true source of the basilica, we shall thereby reveal the fountainhead of the great stream of Christian architecture itself, a stream still flowing strongly and creatively down to the present moment' (Swift 1970:12).

[31] Swift 1970:9.

[32] Swift 1970:9.

of columns running parallel to the nave axis. Above the columns flanking the nave a wall continued above (the clerestory) into which windows were set, looking out over the sloping roofs that covered the aisles.[33] A coffered ceiling concealed the timbers of the nave's wooden double-pitched roof. The nave and aisle floors were paved with marble slabs in formal patterns, and 'the marble columns of the nave arcade were often spoils from ruined pagan temples'[34]. The raised floor within and in front of the semicircular apse formed the *bema*, 'a broad platform divided from the transept by the chancel rail'[35]. At the centre of the *bema* and, therefore, at the centre of the architectural and liturgical focus of the church, stood the altar within a *ciborium* (or *baldacchino*) canopy on four columns. The attention was further directed upon the altar by an arch, the triumphal arch (Christ's triumph over death), across the eastern end of the nave.[36] Rails enclosed the *schola cantorum*, where the choir sang, at the eastern portion of the nave fronting the chancel and the chancel itself. On either side was a raised pulpit (*ambo*); from one the Gospel was read, from the other the Epistle. Where the congregation was substantially larger than the capacity of a church's space, the aisles were constructed on two stories creating a *triforium* gallery above and necessitating a higher clerestory and windows. This, then, is a swift description of the "typical basilica".

There are many divergences from the rule and a few important differences that seem to support a clear distinction between Eastern and Western styles. For instance the atrium was a common feature in Italy but rarely found in Syria and the East and where it is found there it adjoins the south flank of the basilica rather than the west end. The narthex is also either omitted entirely or, 'particularly in Syria – handled quite differently from the Western fashion'[37]. For instance, in the Syrian church of Kalb Lauzeh two towers flank the façade with a recessed narthex between and an open terrace, or tribune, above the narthex.[38] The transept was early on common in Rome and the West but very rare in Syria and Asia Minor, and not present in North Africa. A further variable, 'almost universal in the East, but uncommon during the early days of Christianity in Italy, was

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[33] Swift 1970:9.
[34] Swift 1970:10.
[35] Swift 1970:10.
[36] Swift 1970:10.
[37] Swift 1970:11.
[38] Swift 1970:11.

the side-chambers'[39]. These two small rooms, sometimes rectangular but more often with apsidal ends, were set either side of the sanctuary apse and served specific liturgical functions. The northerly chamber (the *prothesis*) was where 'the holy bread and wine were prepared and "set forth" for later service at the altar'[40]. The southern chamber (the *diakonikon*, or vestry) was where the clergy could retire before and after the liturgical service as well as being a secure repository for sacred utensils and vestments. In San Vitale, this southern chamber was known by Agnellus' time as the *monasterium* of St Nazarius[41].

The adoption of the centralised plan for ecclesiastical architecture has been cast as a development of utility where the basilica was designed for congregational worship, but unsuitable for 'more specialised needs of the new religion'[42]. As is generally agreed[43], the Christian baptistery derives from the Roman baths and in particular the *frigidarium* (the cold pool or plunge bath). In the context of Ravenna the centrally planned octagonal baptistery deserves attention in order to establish its relationship with the similarly designed but functionally different church of San Vitale.

Jones[44] has studied the dimensions and relative scale of extant 'large, free-standing, simple, well-preserved, centralised structures built in or near Rome between 100 BC and AD 500'[45] and groups them according to orientation. The externally orientated buildings are typically early imperial tombs (such as that of Caecilia Metella) and have 'uninterrupted facades with entrances that thrust inwards'[46]. These are 'typically funerary monuments, the exteriors of which act as landmarks to celebrate the memory of the dead while the interiors were usually intended for private use alone'[47]. Internally orientated structures (like the Pantheon) generally have 'uninterrupted interiors

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[39] Swift 1970:11. San Vitale has apsidal chambers flanking the sanctuary. Whether these represent the *prothesis* and *diakonikon* shall be addressed later.
[40] Swift 1970:11.
[41] Cf. Deliyannis 2004.
[42] Swift 1970:12.
[43] According to Swift (1970:40).
[44] Jones 1989.
[45] Jones 1989:107. Jones includes the Mausoleum of Theoderic at Ravenna, which he dates from c. AD 520.
[46] Jones 1989:108.
[47] Jones 1989:108.

with entrances that thrust outwards, often in the form of a portico'[48]. The third group is bi-valent usually having doors 'in the wall thickness which do not project either way'[49].

According to this typological division the Mausoleum of Theoderic at Ravenna is an externally orientated building and a late derivative of the largest examples, the monumental *mausolea* at Rome of Augustus (begun 28 BC) and of Hadrian (c. AD 130). The Mausoleum of Theoderic is built on a smaller scale[50] and is almost exactly one-tenth the dimension of the former examples, perhaps both paying homage and laying claim to former Imperial glory and kudos.

San Vitale is slightly too late for inclusion in Jones' study, but can nevertheless be identified as an internally orientated structure[51]. Typologically grouped with the Pantheon, the 'external diameters of these buildings do not conform to a coherent pattern (implying that) the overall size was in these cases often the sum of the interior diameter and the wall thicknesses, where the latter was presumably determined by contextual and structural considerations'[52]. While such typological divisions of structural design are problematic, Jones does offer a useful argument for differences between externally and internally oriented centrally planned buildings.

The answer to the question of what was new about early Christian architecture may be the experience of that architecture. The beliefs that shaped how the architecture was designed and engaged with were new. Zestermann[53] appears to have had the right idea, that the theories of where the early Christian basilica originated are all partly correct.

We can safely suppose that the basilica was officially "designed" and first constructed immediately following the Edict of Milan in AD 313[54]. No other theory fully

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[48] Jones 1989:108.
[49] Jones 1989:111.
[50] The drum base of the mausoleum of Augustus measures 301.72 feet (c.89.310 meters) (Jones 1989:140), the mausoleum of Hadrian has a podium base originally measuring 297-301 feet (88-89 meters) wide (1989:143), whereas the internal diameter of the upper chamber in the mausoleum of Theoderic is c.30.9 feet (9.1-9.2 meters) (1989:147).
[51] Jones (1989) lists seven internally orientated structures: the Temple of Romulus on the Via Sacra (AD 290-300), Mausoleum of Maxentius (c. AD 310), S. Costanza (mid fourth-century AD), S. Stefano Rotondo (late fifth C.), Temple of the Sibyl at Tivoli (mid first-century BC), Temple of Diana at Baia (Severan era?), and the exedra of the precinct of the Baths of Diocletian (AD 300) (1989:114).
[52] Jones 1989:114.
[53] Zestermann: *Die antiken und die christlichen Basiliken*, 1847.
[54] Known as The Peace of the Church.

explains how as of that date the Christian basilica appears suddenly fully developed throughout the empire and in places where, as Swift[55] has noted, no other source of influence (such as public or private basilica) were located. This sudden, fairly uniform distribution of a new architecture strongly indicates the design was agreed upon by a select few (at the head of the program may have been Constantine), including architects, mathematicians and clergy from both East and West.

The concept of a new architectural expression arising from the co-operation of a select few is not diametrically opposed to or mutually exclusive from the new architecture having references and a "lineage" with former styles. The pagan temple[56], the monumental secular public and private basilica, audience halls, the peristyle house with *oecus*, funerary *exedrae* and the Jewish synagogue all appear to have influences on the new design.

Perhaps nothing *is* new under the sun[57], but at the heart of Christianity is the concept of resurrection from death, a new life, a new *day*. If Christianity, as a belief set, begins with the resurrection of Christ, as an organised state religion it begins with the Edict of Milan in 313. That unique moment is commemorated in a new architecture. Acknowledgement of the early Christian belief in a new life is therefore central to the investigation of ecclesiastical architecture. What is new is of course not wholly divorced from what has preceded it. Although a new architectural expression does not suddenly spring forth from nothing, but relates intrinsically and even explicitly to what has been built before. For instance, in sixth-century Ravenna the use of *spolia* as an aesthetic choice[58] is a synthesis and restructuring of the past. Nonetheless, inventions are regularly achieved.

An appropriate example of architectural inventiveness is the Tower of the Winds (*Horologeion*) at Athens built by Andronicus of Cyrrhus in the late second or mid-first century BC[59], an octagonal monument housing a water-clock (*clepsydra*). Each exterior

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[55] Swift 1970.

[56] For Roman pagan cults see Turcan 1992, 1998 and Adkins & Adkins 1995.

[57] Ecclesiastes 1:9: 'What has been is what will be, and what has been done is what will be done; there is nothing new under the sun'. Ecclesiastes is wisdom literature, not prophecy that there will never be anything new under the sun (www.apocalipsis.org/difficulties/nothingnew.htm) but the concluding phrase has often been pulled out of context and used as a general prediction.

[58] Cf. Elsner 2000 and Wohl 2001.

[59] Glowacki [Online] http://www.stoa.org/athens/sites/romagora.html

facet of the octagon, in the form of a running frieze, is applied with representations of the eight winds[60]. The lotus-and-acanthus capitals of this building were so influential they were 'copied and re-copied right through Christian times'[61]. The Tower of the Winds has been identified as one among a number of buildings, a 'genre' of "inventive eclecticism"[62] and illustrating 'at its best the characteristically Attic mixture of antiquarianism and inventiveness'[63].

Also relevant is a first-century AD example from Rome. The architects Severus and Celer are known to have built the unprecedented Octagonal Suite in the Esquiline Wing of the Neronian *Domus Aurea* at Rome. They were able to refine earlier problems of design encountered in their *Nymphaeum* Suite[64]. They have been heralded as "exquisitely clever", but Ball[65] has countered this opinion by demonstrating how Severus and Celer 'made incremental steps based on previous ideas and, even more impressively, made exciting new motifs out of the actual, standing previous architecture'[66]. Nonetheless, Ball concludes:

> The Esquiline Wing appears to have been one major Neronian step, a magnificent leap beyond the much more tentative use of concrete that had come before. It is so revolutionary that it appears to be the stuff of genius. That may well be true, but my studies indicate that this genius was tempered by careful, sequential reasoning. The ultimate result, the Octagonal Suite, is therefore a massive quantum leap beyond pre-Neronian architecture because it is several steps later, steps taken systematically during the Neronian period, within the Esquiline Wing itself. That is the Neronian architectural revolution evolved in a process that we can reconstruct right on this site. Not only were Severus and Celer masters at seeing what wholly new things could be made out of existing forms, but also they could do that with their own designs.[67]

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[60] The eight winds represented: North (*Boreas*/*Aquilo*), North East (*Kaikias*), East (*Apeliotes*), South East (*Euros*/*Eurus*), South (*Notos*/*Auster*), South West (*Lips*), West (*Zephyros*/*Favonius*), North West (*Skiron*) (Glowacki).
[61] Ward-Perkins 1990:264.
[62] Included are the Inner Propylaea at the sanctuary of Eleusis financed by Appius Claudius Pulcher, a 'little masterpiece of inventive eclecticism' (Ward-Perkins 1990:263-264) and the small circular Temple of Rome and Augustus on the acropolis (Ibid).
[63] Ward-Perkins 1990:265.
[64] West of the Pentagonal Court.
[65] Ball 2003.
[66] Ball 2003:224.
[67] Ball 2003:227.

The Western concept of "genius" and invention are terms loaded with cultural baggage accrued since the Renaissance (apparently the "re-birth" of intelligent inquiry), but the concept of spontaneous originality should not be as sweepingly disregarded as in Ball's earlier statement:

> The prevailing wisdom has been that Severus and Celer were exquisitely clever, coming up with completely new ideas, wholly unlike anything that had come before. Had that been true, Severus and Celer would be unique in the history of Roman architecture. I beg to differ. *All Roman architects and all roman buildings demonstrably make incremental, evolutionary progress over their forebears. Completely unprecedented miracles do not spring fully armed from their foreheads; that is not the Roman* modus operandi.[68]

Invention may be understood as the result of diligent experimentation with combining and simplifying pre-existing components, often leaping well beyond contemporary definitions of what a "component" is, but Ball's rally against "completely unprecedented miracles" seems at odds with his successful demonstration of the genius of Severus and Celer and the consequent Neronian "architectural revolution".

Hagia Sophia is the supreme Late Antique example of architectural genius. The architects Anthemios of Tralles and Isidorus of Miletus[69] who designed and constructed it, from 532 to 537[70], can be understood as occupying a comparable contemporary context to the design and construction of San Vitale at Ravenna from c.526 to 548. However, Justinian recruited Anthemios and Isidorus for a project he personally patronised, whereas San Vitale is the result, and part of an Episcopal building project involving other churches across the city and nearby land with private financial support.

A provisional answer to the question of what was new about early Christian architecture, especially in the form of the congregational basilica, can be posed; what is

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[68] Ball 2003:223. My Italics.

[69] They were *mechanopoioi*, 'scholars grounded in the theory of statics and kinetics and well versed in mathematics…Anthemios was the author of a work on conical sections, an expert in projective geometry, and an inventor who knew the principle of steam power and of the burning-mirror. Isidorus taught stereometry and physics at the universities, first of Alexandria, then of Constantinople, and wrote a commentary on an older treatise on vaulting…They were not architects to start with, but they turned into architects when called upon to devise the plans and statics of a building [Hagia Sophia] never before considered viable on a large scale' (Krautheimer 1965:153). Cf. Henderson 2001.

[70] Hagia Sophia was consecrated December 27, 537 (Krautheimer 1965:153).

new may be the sensory and meaningful experience of that architecture. In other words, what was being facilitated and shaped was a wholly new-shared experience, the beginning of Christianity as an organised state religion as of AD 313.

In the third-century Christianity began to 'sacralise' space, catechumens and converts previously met in private dwellings rather than specific "sacred buildings"[71]. These places of congregation became sacred because the Mass was offered and so many of the persons officiating in these private dwellings were quickly remembered as defenders of the Faith, many of them martyred. Within the first three centuries of the Christian era there developed a variety of sacred spaces outside and within the cities and arguably from the fourth-century a Christian 'sacred urban topography' developed[72].

These developments are crucial for better understanding the changes in architectural expression and the purpose-built constructions of sacred space, the holy places of religious praxis. The growing network of sacred geography[73] in the fourth-century gave Christianity a complex series of privileged locations, creating an infrastructure of pilgrimage exchange and ecclesiastical contact. Churches changed from congregational gathering places into holy places where the relics of saints and martyrs were kept. Churches became microcosms of the heavenly kingdom. To enter a church was to enter into the body of the Church, the collective body of believers in Christ. As such, ecclesiastical architecture represented 'gateways to heaven'[74], portals into one specific place, Heaven manifested on Earth in perfected space and time. The multitude of portals may differ in style but the interior space was deemed to be uniformly holy. But there were several contesting versions of Heaven, Christ and of God, as espoused by the Orthodox, Arians and Monophysites. Therefore, it is only through combining the study of liturgical practice, interior layout, décor and acoustics that answers may be posited to questions regarding the stylistic and cultural preferences for particular architectural forms over others.

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[71] Caseau 2001:40.
[72] McManners 2001:80.
[73] McManners 2001:80.
[74] McManners 2001:80. For a catalogue of saints see Farmer 1992.

While focusing on specific influences upon the design of San Vitale it is important to understand the broader context within which the church of Ravenna operated.

It is problematic to identify which specific estates and territories San Vitale possessed[75]. Certainly by the mid to late tenth-century, in the episcopates of Peter IV (927-971) and Honestus (971-983)[76] San Vitale held property in the territory of Senigallia (*portus Sinogalensis*)[77] and at *Granianum*, *Veclanum* (or *Veglanum*), *Cornutula* (or *Cortula*)[78]. If we include places where churches were dedicated to St. Vitalis and SS. Gervasius and Protasius[79], the area of possible influence becomes considerable.

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[75]The estates owned by the Ravennate church were situated at *Bononia* (Bologna: where Ambrose discovered the bodies of SS Vitalis and Agricola.), *Urbinum*/*Urvinum Metaurense* (Urbino), *Luca* (in Tuscany), *Forum Cornelii* (Imola) (See Prudentius (*Peristephanon Liber* 9; ed. Lavarenne, pp. 109-16) for story of Saint Cassian of Forum Cornelii/Imola, the martyred school teacher. Also Roberts 1993 (Pizarro 1995:181), *Ariminum* (Rimini), *Agubium* (Gubbio), *Patavium* (Padua) (*P. Ital.* (Tjäder, J.O. 1955. *Die nichtliterarischen lateinischen Papyri Italiens aus der Zeit 445-700.* Lund) 12 (Forum Cornelii), 13 (Urbinum, Luca), 18-9 (Agubium), 20 (Ariminum), Pope Simplicius, *Epistulae* 14 (Bononia), Pope Gregory the Great. *Epistulae* xi. 8 (Sicily). *P. Ital.* 3: The two estates at Patavium probably belonged to the Ravenna archives (Jones 1964:250).). Along with the church of Milan (At Milan Ambrose discovered the bodies of SS Gervasius and Protasius (Ambrose: *Epistulae* 22, Paulinus of Milan: *Vita S. Ambrosii* 14, Augustine: *de Civitate Dei*, xxii. Viii. 2, *Confessiones* ix. 16). Also Ambrose found there the bodies of SS Nazarius and Celsus (Paulinus: *V. Amb.* 29, 32-3. Damasus: *Lib. Pont.* xxxix, multa corpora sanctorum requisivit et invenit, cf. Pope Damasus I, *Epigrammata*, 27, 49, 80) (Jones 1964:325).), lands in Sicily (Jones 1964:782. Libybaeum, Sicily is a likely possibility (Baynes 1925:72).). Suffragans of the church of Ravenna were at Bertinoro, Cesena, *Forum Livi* (Forli), Rimini, Sarsina (in the province of Forli-Cesena, Emilia-Romagna) and the ecclesiastical province of Modena including *Regium Lepidi* (Reggio).
'The popes in Rome already had large lands, and, with the collapse of the Senate, took over effective rule of the city in the late sixth-century, supporting the remaining populace with grain handouts. The archbishops of Ravenna had begun to accumulate land as well, particularly from several very large imperial concessions (in return, in some cases, for loans), from 550 [pg.78] onwards. In the seventh-century, the archbishop was second only to the exarch as a power in Ravenna; the two usually co-operated closely, with mutual profit (unlike Carolingian counts and bishops, and unlike the stormy relationship between the exarch and the pope)' (Wickham 1996:77-78).
[76] Vasina 1985:xxvi.
[77] *Brev. Ecc. Rav.* 84 (Curradi, Rabotti and Vasina 1985:46): Pet(icio) qua(m) petiv(it) Gallio et Gisa iug(a)l(is) seu Giselberto et Rocia | iug(a)l(is) a Honesto archiep(iscop)o de t(er)ra S(an)c(t)I Vitalis ubi est fundata | ipsa eccl(esi)a S(an)c(t)I Vitalis: ab uno lat(ere) Graniano, alio lat(ere) Veclano, | t(er)cio lat(ere) Cornutula, quarto lat(ere) via publ(ica). Simul et locum | q(ui) voc(atur) Iovis, ter(ritorio) Sinogall(iense); sub pen(sione) sol(idos) duos. And 85 (Curradi, Rabotti and Vasina 1985:47): Peticio que(m) petivit Hermenulfus et Adelberga iugal(is) | a Petro archiep(iscop)o de capella | S(an)c(t)I Vitalis et sortes et portiones que p(er)tinent de iure | s(an)c(t)e Rav(ennati) eccl(esi)ae, constituto t(er)ritorio Sinogal(ie)ns(e), ple|be S(an)c(t)I Laurentii; sub pen(sione) duodeci(m) denarioru(m).
Senogallia, Senagallica, Senagallia, Sena Gallica was known as Piceno in the time of Tacitus and Pliny.
[78] Curradi, Rabotti and Vasina 1985:46.
[79] S. Vitalis: Rome, Faenza, Rimini, Como, Ferrara, Venice and Verona in Italy; Jadera in Dalmatia. SS. Gervasius and Protasius: Pavia, Nola, Rome (dedicated by Innocent I 402-417) and in the octagonal

In addition to connections of Ravenna land ownership a further suggestive detail is that, in contrast to the numerous wool mills operated by the state through the *comes sacrarum largitionum*, only two linen weaving mills, or *linyphia* were supported and they were located at Vienne in Gaul and at Ravenna[80]. The textile industry at Ravenna may have included possible connections with the eastern silk trade, as in Sicily it is known from a papyrus that 'George, son of Julian, a silk merchant who left his estate to the church of Ravenna in 552, was a citizen of Antioch'[81].

Liturgical developments and differences may have contributed significantly to the popularity of the centrally planned domed church in the East, but as will be shown, other, Western, liturgical and chant traditions (Old Roman, Ravennate, Aquileian, Milanese/Ambrosian, Beneventan, Mozarabic/Iberian, Gaulic/Aquitainian) also grew up with regional differences of expression in both liturgical performance and associated architecture. Since such sacred and sacralising performances include all human perceptive and receptive senses, the ecclesiastic architecture of Late Antiquity (and, no doubt, the secular) can only be best understood by at least attending to how the combined impact of their acoustic design *and* visibility were intended to be engaged with.

The reign of Justinian (527-565) has long been identified as a crucial juncture in architectural history. His celebrated building program has been regarded as an important scheme intended to consolidate and unify the Eastern and Western Empire in an extensive physical display, an enterprise involved in the:

> …restitution of religious orthodoxy, the revival of jurisprudence, the re-conquest of the West, the re-establishment of prosperity, and the security of the frontiers.[82]

The innovations of Justinian's architects are most noticeable in church planning and they are credited with inventing a new bold architecture to meet these agendas of reform.[83] The timber-roofed basilica having dominated in both the West and the East,

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baptistery of Albenga (Liguria) in Italy; Le Mans, Rouen, Soissons and Paris in Gaul c.400. Cf. Menzies 1924.
[80] Jones 1964:836. In the East a linen mill is known to have operated at Scythopolis (Palestine) (Ibid).
[81] Tjäder 1955 (Jones 1964:290, 865).
[82] Krautheimer 1965:151.
[83] Krautheimer 1965:151.

during Justinian's reign, gave way in the East to a completely different form of church plan, the vaulted centrally planned building with an identifiable lineage from palace halls, funerary structures, baths and garden buildings. Krautheimer[84] claims that until the second third of the sixth-century centrally planned churches 'were rare and designed only for specific and extraordinary functions: as palace churches or as martyria'.[85] While he admits that this 'type' of building becomes more frequent after 500, he states that 'only Justinian's architects make the domed central plan the rule in church building in all the major centres of his Empire, and without regard to special function'[86], a radically different program to that chosen in the West, where the basilica remained predominant throughout the Middle Ages. Liturgical practice in the Aegean coastlands developed such that the elaborate celebration of the Mass formalised the processional entrances of the attendant clergy and directed them into the central nave area, the congregation being relegated to 'ancillary spaces enveloping the nave, whether aisles, galleries, or esonarthex'.[87] Apparently the architectural solution to these changes in liturgical practice is the centrally-planned building, where 'the performance of the Mass occupied the central area both liturgically and architecturally'[88], hence the conclusion:

> The architectural concepts of Classical Rome, as they had survived in the Early Christian basilica, finally come to an end in the Eastern Empire. Their place is taken by a new architecture, rooted in Late, not in Classical, Antiquity and developed far beyond. Byzantine architecture starts with Justinian.[89]

Proceeding from this argument and conclusion the singular centrally planned domed church of San Vitale in Ravenna is described as being a translation by a Western architect of the new architecture of Justinian and 'the one truly great building of the West in the sixth-century'.[90]

It is important to understand the development of the Christian church not simply in terms of architectural developments. The interior spaces of Eastern and Western

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[84] Krautheimer 1965.
[85] Krautheimer 1965.
[86] Krautheimer 1965.
[87] Krautheimer 1965:152.
[88] Krautheimer 1965:152.
[89] Krautheimer 1965:152.
[90] Krautheimer 1965:170.

churches are intended to contain one specific *place*. This place is the house of God, the *Domus Dei*, where it is believed the material World ascends to Heaven and Heaven embraces the World by means of the rituals of the Mass. Likewise the baptistery can be argued to be one specific place, the river Jordan in which Christ received baptism from John. Therefore the content and function of all churches and baptisteries connect to specific geographic areas of the Holy Land and temporal events within the life of Christ. Although many different types of Roman buildings had specific functional uses, they do not necessarily intend to contain a symbolic place as the Christian churches and baptisteries so explicitly do. The architectural differences between churches throughout the geography of the Empire can therefore be read as differences and similarities between cultural and social expressions of how to house and decorate the context of a specific sacred place.

Appendix B, Part 2:
Octagonal Baptisteries of Late Antiquity

The octagonal architectural of San Vitale is within the context of the two octagonal baptisteries of Ravenna. The Late Antique architectural development and relationship of similar baptisteries to each other and to congregational churches is therefore a useful study in identifying more precisely the exact influences of octagonal baptistery design upon San Vitale.

The centrally planned, and in particular the octagonal baptistery[1] appears to be a special type of ecclesiastical architectural design that is relatively rare in the East[2] (see Appendix B Excel database worksheet *Centralised Baptisteries with octagonal elements*). The fifth-century Orthodox and Arian baptisteries at Ravenna are both octagonal and, as demonstrated in Chapter Three the Arian example is the source for two of San Vitale's octagons. Also important to this context of early octagonal baptisteries at Ravenna is the converted Imperial mausoleum at Milan[3], the chapel of S. Aquilino in the church of San Lorenzo. Dating from c.370 the chapel is two-storey and octagonal inside and out, with windows in its clerestory providing lighting to an internal gallery below the domed roof. This building 'may have served as a model for the slightly later cathedral baptistery at Milan, known from excavation, and attributed to St Ambrose'[4] (374-397). This transformation of the rotunda designs of major Roman *mausolea* into Christian baptismal structures is not unique but may have begun with this building in Milan. From Ambrose's octagonal baptistery at Milan, it has been noted that 'similar centrally planned

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[1] Concerning fonts and baptisteries, Milburn noted in 1988: 'There is apparently no general study of this subject, apart from articles in the reference books. A. Khatchatrian, *Les Baptistères paléochrétiens* (Paris, 1967) gives nearly four hundred plans, with an alphabetical list and bibliographical details. Full reference to notes in periodicals respecting individual baptisteries, classified geographically, is given in *RLAC* (*Reallexikon für Antike und Christentum*, ed. T. Klauser (Stuttgart, 1950-).)' (Milburn 1988:311).

[2] Krautheimer 1965:133.

[3] 'On the other hand, the octagonal baptistery with corner niches is frequent in the sphere of influence of Milan. A more elaborate type develops in the fifth-century. The Lateran Baptistery, as re-modeled by Sixtus III, fused the octagon plan with that of a Roman mausoleum of the type of S. Costanza, with domed center room, barrel-vaulted colonnaded ambulatory, and narthex with two sideway apses. This fusion need not have taken place first or exclusively in Rome. As early as c.400, octagonal baptisteries with inner colonnade and ambulatory are found in Gallia Narbonensis, for instance at Marseille [pg.134] and Aix-en-Provence. But in the Lateran Baptistery it finds its most powerful expression: a monumental blend of Late Roman architectural concepts, of an Ambrosian Christian symbolism, and of the practical requirements of the baptismal ritual' (Krautheimer 1965:133-134).

[4] Knight 2000:86.

baptisteries spread to southern Gaul and elsewhere'[5]. The baptisteries in northern Gaul (Trier) and North Africa were square or rectangular, the 'octagon or octagon-in-square form was a regional type'[6]. Those at Ravenna must be included in this group of Milanese inspired octagonal baptisteries. The overall links between Milan, Ravenna, Gaul and Istria before and during Ostrogothic rule are important for the purpose of comparing San Vitale with the famous octagonal structures of sixth-century Constantinople and Syria.

Krautheimer[7] suggested 'a standard type of baptistery may have spread from Milan to northern Italy and Provence'[8]. Knight[9] has clarified this by pointing out that 'unlike the Milan structures, octagonal inside and out, Gallic baptisteries are usually an octagon inscribed in a square' but agrees that 'the octagon or octagon-in-square form was a regional type'.[10] Knight investigates provisions made for baptism elsewhere in Gaul, but before doing so makes the following salient observation:

> The baptisteries, like the urban basilicas, show that the cities of southern Gaul were in touch with the architectural traditions of Italy and the Mediterranean throughout the fifth and sixth centuries, with access to stonemasons, architects, mosaic workers and mural painters.[11]

However, the underlying concept of a cohesive regional style requires investigation. In order to reappraise this idea examples have been collated of centralised polygonal baptisteries, chapels and churches provided by Krautheimer[12], Verzone[13], Cabrol and Leclercq[14] while supplemented with recent archaeological discoveries at Dion, Mediana[15], Mallorca, San Giusto and Canosa. The three worksheets of AppendixB.xls are:

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[5] Knight 1999:86.
[6] Knight 1999:93.
[7] Krautheimer 1965.
[8] Krautheimer 1965:132.
[9] Knight 1999.
[10] Knight 1999:93.
[11] Knight 1999:95.
[12] Krautheimer 1965.
[13] Verzone 1968.
[14] Cabrol and Leclercq 1925.
[15] Mediana Baptistery Online: http://www.nis.co.yu/manastiri_i_crkve_grada_nisa

1:   **Centralised baptisteries with octagonal elements**. The fifty chronologically listed examples have octagonal features[16] dating between the fourth and sixth-century and over the geographic areas (following Krautheimer) of Italy (16/50), Gaul (10/50), Aegean Coastlands (8/50), Balkans (6/50), Britain (4/50), Constantinople (1/50), Syria (1/50), Palestine/Jordan (1/50), Mesopotamia (1/50), North Africa (1/50), and the Iberian Peninsula including the Balearic Islands (1/50). Chart B2.1 below shows the percentile distribution.

Late Antique baptisteries with octagonal elements

☐ Italy	■ Gaul	☐ Aegean Coastlands ☐ Balkans
■ Britain	■ Syria	■ Palestine ☐ Mesopotamia
■ Constantinople	■ North Africa	☐ Iberian Peninsula
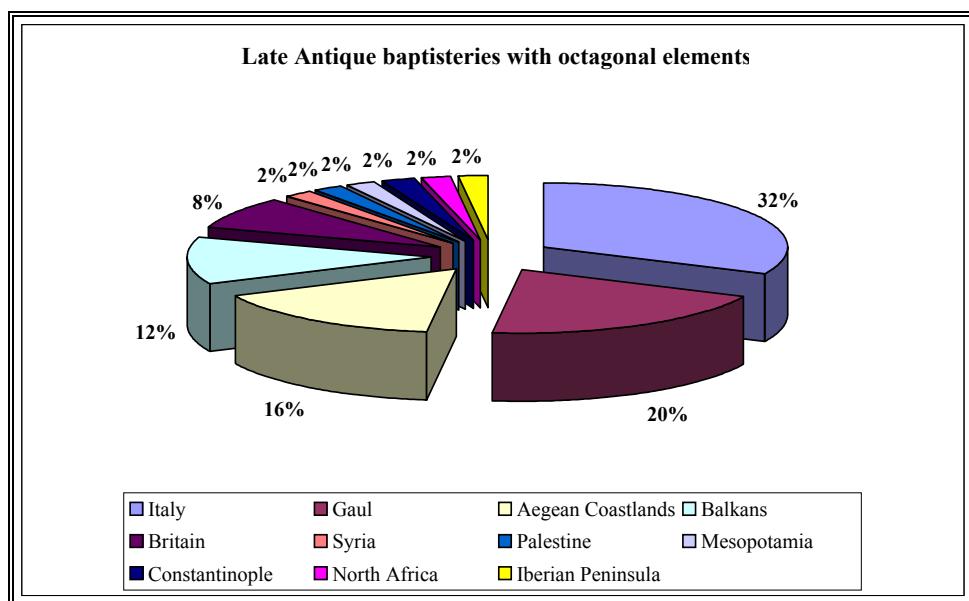
Chart B2.1

2:   **Octagonal churches/chapels**. Twenty-four examples dating between the fourth and sixth-century are listed chronologically from Italy (7/24), Palestine/Jordan (3/24), Constantinople (4/24), Greece (2/24), Syria (2/24), Turkey (2/24), Jerusalem (1/24), Antioch (1/24), Egypt (1/24), and Mesopotamia (1/24). Chart B2.2 below shows the percentile distribution.

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[16] Interspersed throughout the list are an additional thirteen examples, which, while they are without octagonal features, are closely related with centralised design (usually circular).

Distribution of churches with octagonal elements

Italy 18% · Constantinople 18% · Palestine 14% · Turkey 10% · Greece 10% · Jerusalem 5% · Syria 5% · Jordan 5% · Antioch 5% · Egypt 5% · Mesopotamia 5%
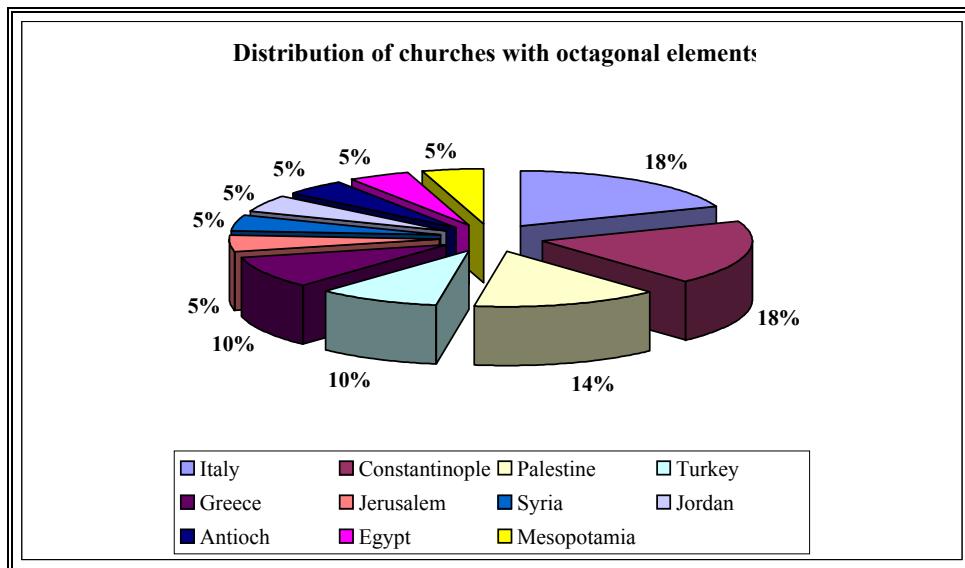
Chart B2.2

3: **Churches/chapels with polygonal apses**. Thirty-four examples dating from between the fourth to the sixth-century are listed chronologically from Ravenna (including Classe area) (12/34), Asia Minor (11/34), Constantinople (5/34), the Balkans (3/34), Syria (2/34), and Bulgaria (1/34). Chart B2.3 below shows the percentile distribution.

Distribution of apse polygons

Ravenna 35% · Asia Minor 32% · Constantinople 15% · Balkans 9% · Syria 6% · Bulgaria 3%
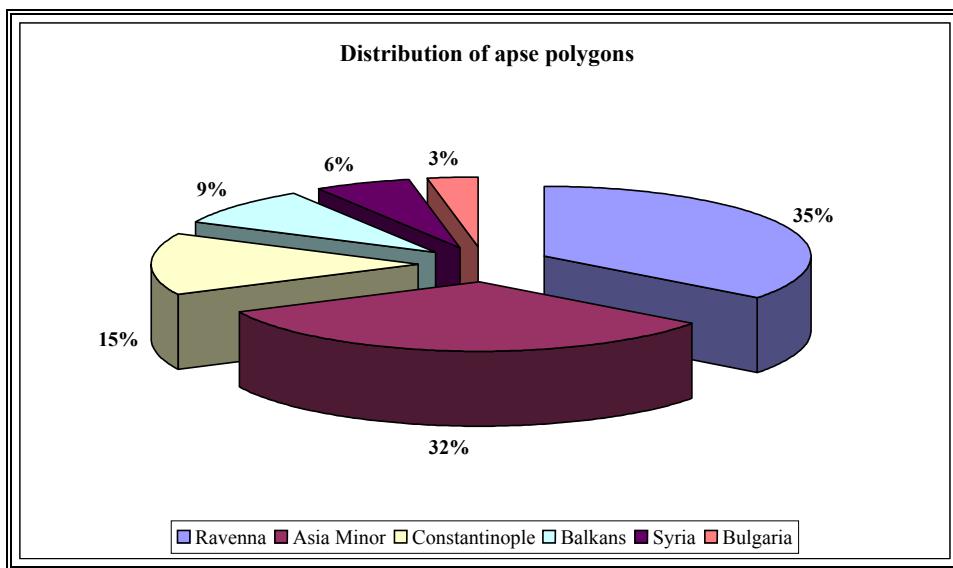
Chart B2.3

Allowing for the range of certainty from the vague term "Byzantine" to specific dates, this can only be a broad sequential outline. Nevertheless, and admitting such a list can only ever be representative as it is contingent on what still remains to be discovered and/or published in an internationally accessible way, the list at least highlights several relationships which can usefully update former studies.

Preliminary results: centralised baptisteries

Firstly, it is apparent that the baptisteries with octagonal interiors and rectilinear exteriors are not exclusively Gallic and cannot be labelled as a regional style. This form is distributed widely throughout the Mediterranean with an example as far as Mâr Gabriel, Qartamin in Mesopotamia.

The majority of baptisteries with octagonal design features (interior and/or exterior walls and/or font and/or *ciborium*) are from the Italian peninsula (including Corsica), at 32% (16/50), whereas 20% (10/50) are from Gaul. Within this broad group of baptisteries, further defining parameters can be analysed (Chart B2.4 below). Only 22% (11/50) were internally and externally octagonal, and of these the examples from Italy dominate at 64% (7/11). Only four other examples were found, two from both the Aegean coastlands (18% 2/11) and the Balkans. The geographic spread of this baptistery style is therefore quite focused, with the earliest examples (fourth-century) at Rome (St John Lateran) and Milan (San Lorenzo).

**Late Antique baptisteries
internally and externally octagonal**

18%

18%

64%

Italy Balkans Aegean Coastlands
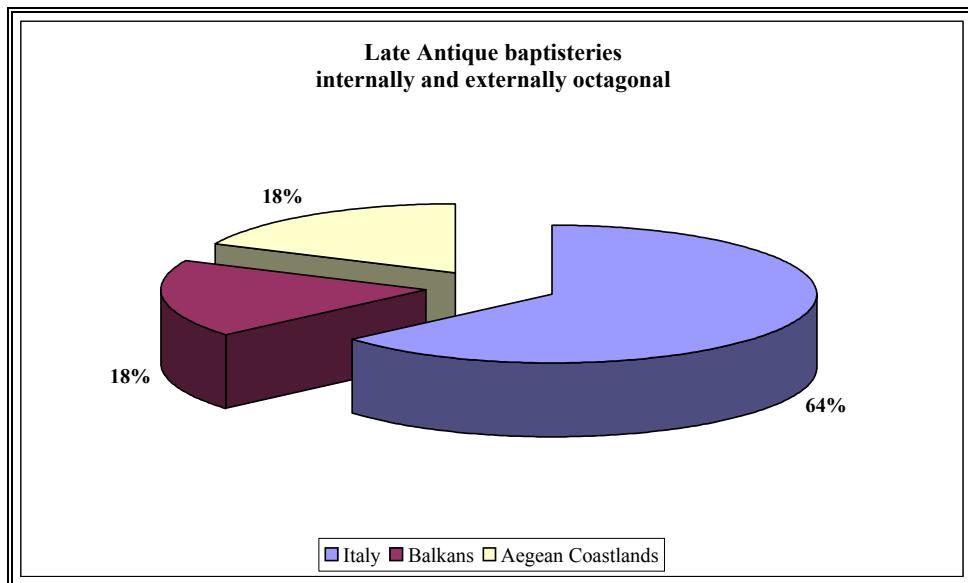
Chart B2.4

The results are very different for baptisteries that are internally octagonal and externally rectangular (Chart B2.5 below), which only make up 24% of the relevant baptisteries (12/50). Examples from Gaul dominate at 34% (4/12) while examples from Italy and the Aegean coastlands are equal 17% (2/12). This type of baptistery design has a greater geographic spread, with the earliest example from Marseilles.

**Late Antique baptisteries
internally octagonal, externally rectangular**

8%

17%

17%

8%

8%

8%

34%

Italy Gaul Balkans Syria Mesopotamia Aegean Coastlands North Africa
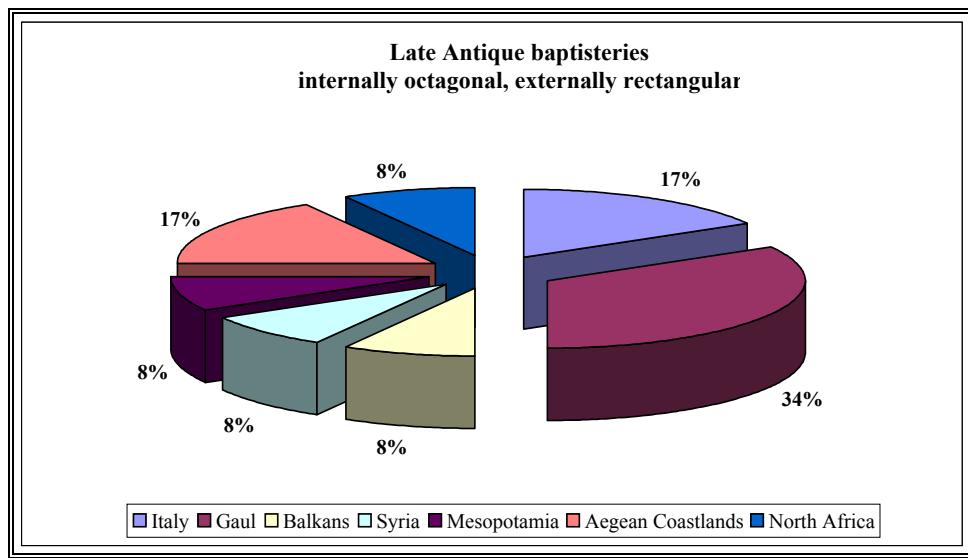
Chart B2.5

These results can be supplemented with the analysis of the shape of the baptismal font. Of the 63 examples only 37 have enough information regarding the font for analysis (Chart B2.6 below).

Distribution of baptistery font shape

19%

14%

19%

48%

cruciform ◼ circular ◻ hexagonal ◻ octagonal
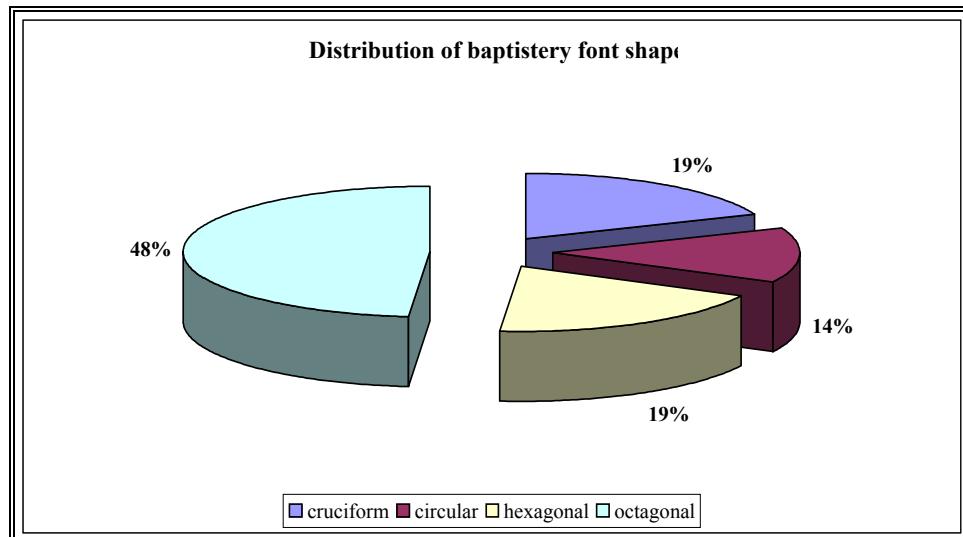
Chart B2.6

Of these only 18 have octagonal fonts, Italy and Gaul each having seven examples (Chart B2.7 below). However, substantially more data is required to make such a statistical analysis meaningful.


Distribution of octagonal baptismal fonts

6%

17%

38%

39%

◻ Italy ◼ Gaul ◻ Britain ◻ Aegean Coastlands
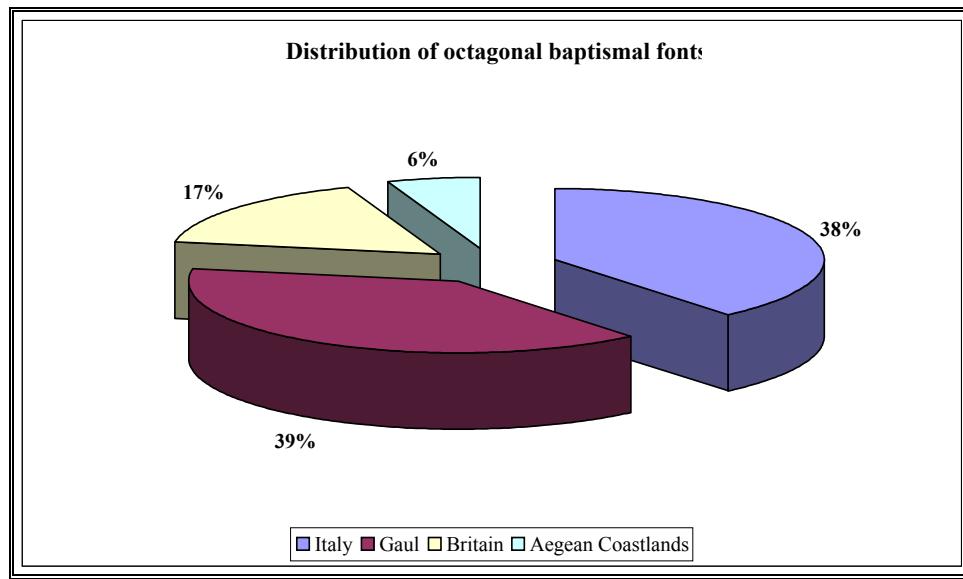
Chart B2.7

Of the baptisteries with octagonal interiors and rectangular exteriors only two examples are located within the geography of northern Italy (Riva San Vitale, albeit at present immediately within the political boundary of Switzerland, and Aquileia) and only four within Gaul[17]. Located on the southern tip of Lago di Lugano, Lake Como in the Swiss canton of Ticino and immediately northwest of the present Italian Alpine border, the Battistero of Riva San Vitale (c.500) is of particular interest, not least for its dedication to Saint Vitalis (Figure B2.1 below). This small baptistery is octagonal within a square with a central circular font c.1.5 meters wide within an octagonal base c.2.5 meters wide. The inner width of the octagon is c.6.5 meters and the walls are approximately half a meter thick. The internal height of the dome from the floor is c.12 meters, and the apse projects northeast by c.2.5 meters and semi-domed to a height of c.5 meters[18].
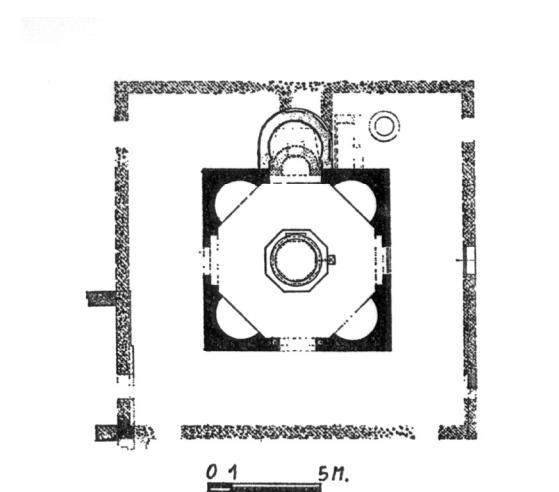
Figure B2.1: Riva San Vitale (Verzone 1968:35).

As a working hypothesis, the baptistery of St. Mary at Ephesus, having been built specifically for the Council of Ephesus in 415, inspired attending representative ecclesiastics to follow in union with this design in their own respective homelands. However, antecedent to this form are the small northern and larger southern cathedral baptisteries of San Lorenzo at Milan (Figure B2.2), most likely built under the

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[17] The baptisteries of Frejus, Marseille, Aix-en-Provence, and Riez are so well known they have tended to be given precedence over other examples with this form.
[18] From Krautheimer 1965:133. Figure 55.

episcopacy of Ambrose (374-97). These are octagonal internally and externally with four alternating square and semi-circular niches.
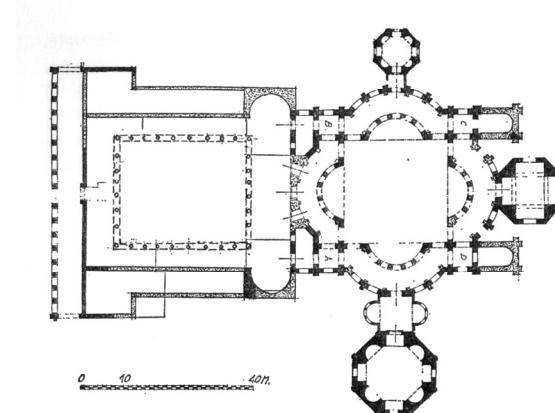
Figure B2.2: San Lorenzo, Milan (Verzone 1968:24).

Indeed, if the renovations of Pope Sixtus III (432-440) at the Lateran baptistery in Rome did not extensively reshape the original structure, then the octagonal interior and exterior form may well be Constantinian. But, we can locate the form with an acceptable level of certainty at Milan between 374 and 395. While the group is not exclusively northern Italian, of the fifteen examples cited ten are on Italian soil and one other (Parenzo) was directly influenced by Ravenna. It is worth noting that this form is not represented in Gaul.

At Parenzo, in Istria[19] (now Poreč, Yugoslavia), on the opposite shore of the Adriatic to Ravenna the Basilica Eufrasiana and its octagonal baptistery (c.540-c.543)[20] are aligned along the same access (east) as the atrium[21]. The plan is by Jackson[22], and

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[19] 'During the second half of the fifth, during the sixth, and perhaps still in the seventh-century, Ravenna and Istria were two of the gates through which eastern elements penetrated into the early medieval architecture of Western Europe' (Krautheimer 1965:198).

[20] Otherwise dated to c.550 (Krautheimer 1965:196).

[21] Grabar 1966:25. 'At Poreč (Parenzo), the aisles terminated in absidioles as at Qalat-Siman, about 470, and at Gerasa in 526/7 and 540. The triconch martyrium, adjoining the cathedral of Poreč, recalls that of Basilica B at R'safah (490-520)' (Krautheimer 1965:198).

[22] Jackson 1913:1.182, figure 38.

later by Verzone[23], and Molajoli[24] as reprinted by Grabar[25]. The octagonal baptistery has an inner width of c.9 meters[26].

The centralised baptistery at Albenga (*Albingaunum*) (Figure B2.3) appears to have been commissioned by Galla Placidia in the mid fifth-century and, therefore, has relevance to her mausoleum immediately north of San Vitale at Ravenna. This baptistery (admitting its irregular decagonal exterior) is geographically close to the southern Gallic baptisteries, only a very few kilometres east of *Cemenellum* and Frejus (Figure B2.4) on the *Via Aurelia*, and yet the form does not extend any farther west of the boundary of the province of *Alpes Maritimae*.

Sulpicius Severus noted that Saint Martin of Tours, having left Milan due to conflicts with Auxentius[27], 'withdrew to an island called Gallinara'[28]. This tiny island is located opposite Albenga[29]. The dome of the baptistery at Albenga is also constructed of interlocking amphorae as at San Vitale.
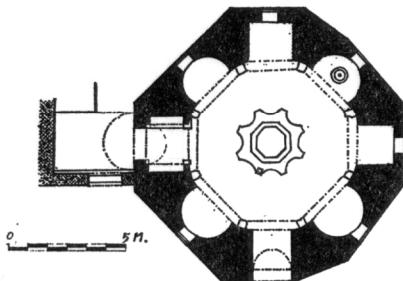
Figure B2.3: Albenga baptistery (Verzone 1968:34).

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[23] Verzone (Verzone, P. 1942. *L'architettura religiosa dell'alto medio evo nell'Italia settentrionale*. Milan) 1942:45, 47.
[24] Molajoli 1943:10. Figure 3.
[25] Grabar 1966:346. Figure 399.
[26] Exterior width is c.10.5 meters, the walls c.1 meter thick (from Krautheimer 1965:197. Figure 78).
[27] Auxentius was the Arian Bishop of Milan from 355 to 374, when Ambrose succeeded him (White 1998:217).
[28] Sulpicius Severus; *Life of Martin of Tours* VI.5 (White 1998).
[29] White 1998:217.
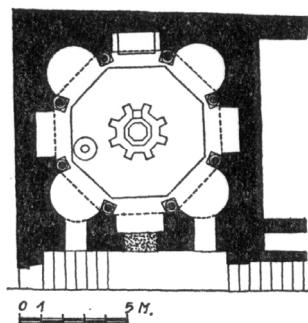
Figure B2.4: Frejus baptistery (Verzone 1968:34).

These four are all baptisteries, the earliest being that at Marseille[30].
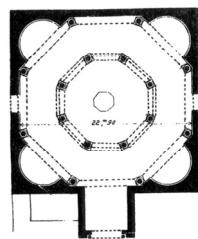
Figure B2.5: Marseille baptistery (after Verzone 1968:83).

This form is distributed evenly and extensively but only Riva San Vitale and Aquileia are located on the Italian peninsula. There are only two examples of baptisteries that are octagonal internally with alternating rectangular and semicircular niches that project externally, one in Milan (Novara; Figure B2.5) and one in Gaul (Nevers; Figure B2.6).

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[30] Krautheimer 1965:133. Probably built by Proculus, Bishop of Marseilles from c.382-428 (Knight 1999:93).
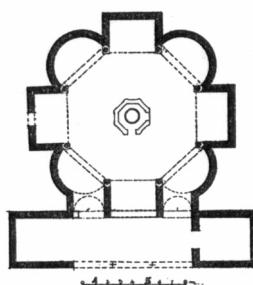
Figure B2.6: Novara baptistery (Verzone 1968:34).
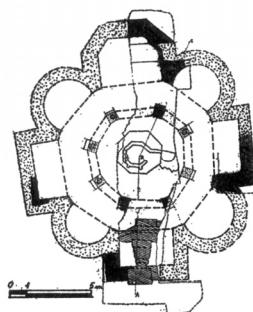
Figure B2.7: Nevers baptistery (Verzone 1968:83).

There is a sub-group of baptisteries with an octagonal *ciborium* surrounding the font. The example of Novara at Milan belongs also to this group, along with Mariana in Corsica, and Valence and Venasque, in Gaul. The example of *Cemenellum* (Gaul), an octagonal baptistery within a re-used irregular rectilinear space of a former bath complex, demonstrates the relationship not only between baptisteries and baths but also cultural trade between southern Gaul and Ravenna.

In an alliance with the Burgundians in a bid to keep the Franks at bay Theoderic settled and garrisoned Southern Gaul and the Alpine passes. The Ostrogoths settled in Provence (especially at Arles) from 509 until 534[31] and this twenty-three year period is of particular interest as it presented a direct link between Ravenna and southern Gaul and provided opportunities of mutual influence and cultural exchange. Regarding the octagonal baptistery as a distinctive architectural 'type', the idea seems to have flowed from Milan in the fourth and fifth-century to Ravenna and Istria and westward to

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[31] Burns 1991:198.

southern Gaul. Therefore, by 509 the two baptisteries at Ravenna were already almost a century old.

The development of the octagonal baptistery in Gaul of the fifth-century can be followed by the main examples at *Cemenelum* (Cimiez)[32], *Forum Julii* (Fréjus)[33], Marseilles and Arles. This group of buildings may be seen to architecturally complement the two octagonal baptisteries at Ravenna but additionally indicate important cultural and ecclesiastical links between the Tyrrenean and Adriatic seas. The connections between Cemenelum and Ravenna are worth investigating in some detail.

Close to Nice (Nicaea/Nikaia), in the province of *Alpes Maritimae*, *Cemenelum*, or *Cemenelensium* (Cimiez, Alpes-Maritimes), was a city of modest size[34]. Under the Emperors Severus and Caracalla (AD 193-217) Cemenelum (Figure B2.8) "peaked" when three baths were built and alterations were made to the amphitheatre[35]. Of particular interest is the third (western) bath complex in *Insula III*, which was converted into a church in the fifth-century.

Aside from the usual ascription of local saints[36], it is known that Cemenelum had a Bishop attendant at the Council of Riez in 439, but the earlier manoeuvrings of Marseilles against Arles at the Councils of Arles (314) and that of Aquileia (381) indicate Cemenelum was already an important See as early as the fourth-century[37]. Later, Marseille's 'rival and neighbour, the former Imperial capitol of Arles, claimed the religious Primacy of Gaul, backed up by the Imperial government at Ravenna'[38].

Presumably at the time when Valerianus was Bishop of Cemenelum, a rescript was issued by Leo the Great (440-61), and confirmed by Hilarus in 465, to unite the sees

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[32] Cf. Fevrier 1973 and Rivet's review of 1979.

[33] Fréjus (Var) was originally Forum Julii. The octagonal baptistery is fifth-century, heavily restored by J. Formigé in the 1920s (Bromwich 1993:262).

[34] The only public buildings so far discovered are the amphitheatre and three public baths (Bromwich 1993:279). As Fevrier (1973) admits, it is bad luck that excavations have only revealed an area in 'the extreme north-west of the town, where public buildings were concentrated' (Fevrier 1973:27).

[35] Bromwich 1993:279.

[36] The Saints of Cemenelum include S. Vincentius and S. Orontius, both natives of the town who helped evangelise Aquitaine and Spain respectively and were martyred under Diocletian (284-305). S. Pontius was a youth who was martyred at Cemenelum c.260.

[37] The 'quarrel of Marseilles with Arles over the metropolitan rights of the latter lasted for much of the fifth-century and underlies the attempt by Arles to replace Nice, the suffragan of Marseilles, with Cimiez, friendly to Arles' (Harries 1978:34).

[38] Knight 1999:93.

of Cemenelum and Nice[39]. However, it is not clear whether Leo meant to combine the two sees or place them both under the authority of one metropolitan, for in 549 a priest at Orleans 'subscribes on behalf of bishop Magnus of Cimiez and Nice, which certainly suggests the sees were amalgamated[40]. Magnus and his successors sign thereafter as bishops of Cimiez or Nice, but not both'[41].
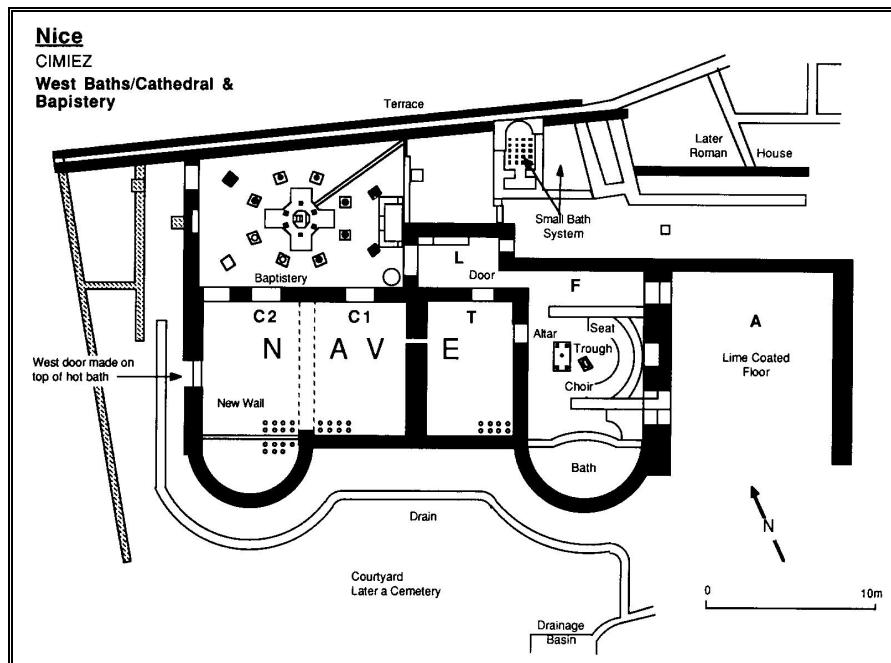
Figure B2.8: Cemenelum (Cimiez) octagonal baptistery and church (before 439)
(After Bromwich 1993:284, Figure 95).

The third-century western bath complex[42] was converted into a church with accompanying baptistery by the early fifth-century after a period of abandonment[43]. The

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[39] The newly formed See remained a suffragan of Embrun until the French Revolution.

[40] *Concilia Galliae* II (A.511-A.695), 160 (de Clercq, C., (ed.). 1963. *Corpus Christianorum*, Series Latina 148A. Turnhout).

[41] Cimiez in 554, *Conc. Gall*. II, 172; Nice in 585 and 614, ibid., 249, 282, cf. Gregory of Tours, *Historiae Francorum* 6.6. Loseby continues: 'However, they chose to describe themselves, bishops never appear simultaneously at both centers, which makes it likely that the two sees had been combined at some point. The emergence of a bishopric at Nice was therefore a response, which proved inappropriate in the long term, to an anomalous secular administrative arrangement' (Loseby 1996:146).

[42] Perhaps a bath complex for the sole use of women, since the drains are filled with hairpins and ear-rings (Bromwich 1993:284). The following structural description comes from Bromwich (ibid:284-285).

[43] Knight 1999:68.

octagonal baptistery was built within the confines of the awkward space[44] where two furnaces had fed the *caldarium* of the former bath complex, and the walls separating this latter room from the *tepidarium* were removed to create the church's nave while the choir and apse, with accompanying *synthronon* bench, were built within the former *frigidarium*. The Christian altar is set immediately in front of a trough that may have contained the relics of a saint. The former oval bath to the south of the new choir was filled in to create a sacristy. On the north side and adjoining the old *frigidarium*, the *laconicum* was possibly converted into a changing room. The baptistery is fitted with deliberate symmetry into the otherwise awkward space formerly occupied by two furnaces, while the:

> …baptismal pool is six-sided and made of pink concrete. A canopy was suspended over the pool on six small columns; three bases survive. The central cupola in the roof was supported by eight marble columns, two of which have been re-erected. The roof was supported by four thick square pilasters, the eastern pair frame a small raised area or podium[45].

Accessible from the baptistery is a long area enclosing a set of smaller baths and bounded in the north by the walls of a late Roman house. These features have been interpreted as the Bishop's palace and private baths[46].

There is an important direct link between Ravenna and Cemenelum not commented upon in the literature. An epitaph discovered at Athens in 1951 by Doyle[47] describes a person in the Ravennate fleet who is a Gaul from Cemenelum.

Having considered some of the main octagonal baptisteries it becomes apparent that Milan, Arles and Ravenna were collectively sharing in new expressions of baptismal architecture not as popular in the East. The historical background to the relationship

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[44] The 'extremely compact unit' of episcopal buildings at Cimiez is in striking contrast to large sprawling complexes like at Geneva 'where, by the sixth-century, the episcopal complex had evolved to encompass a quarter of the intra-mural area' (Loseby 1996:150).
[45] Bromwich 1993:284, Figure 95.
[46] Cf. Benoit, F. *Gallia* viii, 1950, pg. 130; xiv, 1956, pg. 234; xvi, 1958, pp. 440-6; xviii, 1960, pp. 322-4; xx, 1962, pp. 709-713; xxii, 1964, pp. 590-607; xxv, 1967, pp. 429-433; xxvii, 1969, pp. 456-7; *Comptes rensus de l'ac. Des Inscr. Et Belles-Lettres* 1962, pp. 207-219; *Mélanges A. Piganiol* (Paris, 1966), pp. 369-382; *Bull. De la soc. Nat. des ant. De France* 1966, pp. 191-7; *Nice et Cimiez antiques* (Paris, 1968), pp. 32-49; Goudineau, *Gallia*, xxix, 1971, pp. 462-4.
[47] Doyle 1968.

between Southern Gaul and Northern Italy reveals spheres of influence and cultural trade including architecture and liturgical music[48].

      A comparison (Table B2.1) of chronological events from the fourth to the mid-sixth-century reveals several "windows of opportunity" in which political and ecclesiastical relations between Provence and Northern Italy were in direct contact.

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[48] For a more general discussion of the liturgical seasons see Muldowney 1959.

Date	Italy	Gaul
314		Council of Arles
353		Council of Arles
374-397	Ambrose Bishop of Milan	
c.390/400	Orthodox baptistery of Ravenna[49]	
397	Ambrose dies	
c.409-412		Heros Bishop of Arles
412	Constantius deposes Heros Bishop of Arles[50]	
412-426		Patroclus Bishop of Arles, Heros still alive
After 415[51]	Octagonal baptistery of Albenga	
417	Constantius marries Galla Placidia (January 1st)[52]	
417	Zosimus becomes Pope March 18	
421	Constantius Emperor of West Feb. 8 to Sept. 2[53]	
421		Patroclus given privileges by Pope Zosimus on Holy Thursday, March 22[54]
425-450	Galla Placidia Empress of West	
426		Patroclus murdered
426-428		Honoratus Bishop of Arles
428-449		Hilary Bishop of Arles
439		Council of Riez
c.449-455		Ravennius Bishop of Arles
450	Galla Placidia dies	
452		Council of Arles (called the 'second')
455		Council of Arles (called the 'third')
c.455-482		Leontius Bishop of Arles

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[49] Further construction under Bishop Neon in c.450

[50] Duchesne 1960:160.

[51] After 415, c. Galla Placidia

[52] Duchesne 1960:160.

[53] Duchesne 1960. 'The Vice-Emperor Constantius and his favorite Patroclus had sought under Pope Zosimus to make the Bishop of Arles a kind of lieutenant-general of the Roman Pontiff for the Transalpine regions. Their efforts did not come to anything. After the death of Zosimus and especially after that of Constantius (September 2, 421), Patroclus saw his hasty constructions collapse. However...the Pontifical Vicariate did not prosper, but Arles became an ecclesiastical metropolis of great importance' (Duchesne 1960:407).

[54] 'In the first place he was provided with a metropolitan jurisdiction which, without regard to established rights, comprised all the provinces of the ancient Narbonensis and the Maritime Alps, from Toulouse to Embrun, from Lake Leman to the Mediterranean. Further he was constituted Vicar of the Pope throughout the whole extent of the Gauls' (Duchesne 1960:161).

463		Council of Arles
468	Sidonius Apollinaris travels to Ravenna[55]	
475		Council of Arles
482		Leontius dies
494-518/520	Peter II Bishop of Ravenna	
503-543		Caesarius Bishop of Arles
509-534	Theoderic settles Ostrogoths at Arles	
509	Theoderic has Caesarius Bishop of Arles arrested	
513	Caesarius appears before Theoderic at Ravenna[56]	
c.520	Aurelianus Bishop of Ravenna	
521-532	Ecclesius Bishop of Ravenna	
524		Council of Arles (called the 'fourth')[57]
526	Theoderic dies August 30	
526-534	Amalasuntha Regent	
	San Vitale begun c.526	
529		Council of Orange
532-536	Ursicinus Bishop of Ravenna	
534	Amalasuntha murdered. Ostrogoths leave Gaul.	
537-544/546	Victor Bishop of Ravenna	
543		Caesarius dies
545	San Michele in Africisco, Ravenna, consecrated	
546-556	Maximianus Bishop of Ravenna	
548	San Vitale, Ravenna, consecrated	
549	S. Apollinare in Classe consecrated	
554		Council of Arles (called the 'fifth')[58]

Table B2.1: Chronological comparison between Gaul and Northern Italy.

As can be seen from Table B2.1, the period from 513 to 534 is particularly important for direct links between Arles and Ravenna. It is in this nineteen-year span that the design and construction of San Vitale was begun. Not only were the Ostrogoths present at Arles from 509 to 534, but also Caesarius of Arles' royal acceptance at

[55] Anderson 1936.
[56] Theoderic was so impressed with Caesarius he dropped the charges and gave him every assistance.
[57] Provincial council, among other canons on discipline, 'appointed 25 as the age for deacon's orders, and 30 for priests (Mansi, viii. 625)'.
[58] The next Council of Arles was not until 813.

Ravenna in 513 indicates an amicable relationship and opportunities for the exchange of ideas, some of which may have been architectural designs.

It has been noted that the mosaic image of Bishop Ecclesius (521-532) in San Vitale shows him wearing the priest's stole pendant 'under the chasuble at the same time with the *pallium* on top of it'[59]. The Pope in Rome was content simply to wear the *pallium*. Although wearing both insignia seems to be unique (subsequent Bishops of Ravenna only wore the *pallium*) the two are also found together at Autun 'and on the *paliotto* of St. Ambrose of Milan'[60]. As early as 421 Patroclus (supported by Constantius) had been granted special privileges by Pope Zosimus for the metropolitan see of Arles, himself becoming the Pope's Vicar[61].

The Papal *vicarius* situated at Arles is of particular importance to the context of sixth-century Ravenna. If this position of 'Pontifical Vicariate did not prosper'[62], there was a level of continuity[63] and it set a precedent, for on November 6th, 513 (two days following the Feast of St. Vitalis at Ravenna[64]) Caesarius was privileged at Rome with the *pallium* and on June 11th, 514 (Ascension Sunday[65]) was named Papal Vicar by Pope Symmachus (498-514)[66]. It appears that, for perhaps only a brief period, Ecclesius of Ravenna enjoyed the same privilege by at least 521. Whether Caesarius, like his contemporary Ecclesius, was seen wearing both the *pallium* and stole together, it remains that they seem to have shared with the Bishop of Milan comparable Pontifical, Roman distinctions.

This particular historic connection between southern Gaul and Ravenna, although brief, highlights direct exchange between two regions which display a concerted new

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[59] Percival 1961:143.
[60] Percival 1961:143.
[61] Duchesne 1960:407.
[62] Duchesne 1960:407.
[63] Cf. Klingshirn 1985.
[64] Easter Sunday was April 6th in 513 and November 6th was a Wednesday, two days following the Feast Day of S. Vitalis (Nov. 4, a Monday in 513). This makes Nov. 6th seven weeks (49 days) before Christmas (also a Wednesday this year). Therefore, November 6th in 513 falls between the days immediately after the Feast of San Vitale at Ravenna and the first Sunday in Advent (the Sunday closest to November 30, St. Andrew's Day which would have been November 24th in 513). In other words in 513 Caesarius most likely stayed at Ravenna for the Feast of San Vitale on the Monday and then traveled to Rome to receive the pallium on the Wednesday, two weeks before the liturgically busy beginning of Advent.
[65] Easter Sunday was March 30th in 514 and June 11 was the 6th Sunday after Easter, known as Ascension Sunday (Using Montes 2001, Hiley 1993:13).
[66] Whalen & O'Boyle 1967:1047.

style of baptistery construction, and at a time when further church building at Ravenna appears to be influenced by these octagonal baptisteries.

Preliminary results: centralised churches

To supplement this data it is necessary to expand the analysis to include centrally planned churches and chapels from the fourth to the sixth-century. Churches designed as an octagon within a rectangle are represented by four examples[67], three of which (one being circular within a square) are in Syria.

Importantly, there are at present only two identified examples of churches that strictly adhere to the octagon-within-an-octagon form[68], and both are double-shelled. The first example is the Church of the Theotokos on Mount Garizim/Gerizim (Jabal al-Tur)[69], constructed under the Emperor Zeno in 484[70] as part of an attempt to convert the Samaritans to Christianity. The second example is San Vitale at Ravenna and therefore the historical relationship between the two structures is worth exploring.

The Third Ecumenical Council met in 431 at Ephesus and formally affirmed the use of the term *Theotokos* / Θεοτόκος (Mother of God / Child-bearer of God) for Mary[71]. This was in opposition to Nestorius who preferred the term *Christotokos* (Mother of Christ). The Council anathematised Nestorius for heresy (hence the beginning of Nestorianism) and new ecclesiastical structures began to be dedicated to the Theotokos.

The Church of the Theotokos on Mount Gerizim is southwest of the ancient city

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[67] 1: The supposed martyrium of the Apostle Philip at Heirapolis (Pamukkale) in present-day Turkey dating from the early fifth-century (Krautheimer 1965:Figure 51, 122). 2: Bosra Cathedral in Syria, circular within a square, double-shelled and dated to 513 (Swift 1951:Figure 43, 45). 3: The double-shelled church of S. George at Ezraa in the Haurun district of southern Syria dated to 515. 4: The double-shelled church of SS. Sergius and Bacchus at Constantinople dating to c.527-536 (Swift 1951:46) or c.525 (Krautheimer 1965:161).

[68] Only three other Christian structures are closely related. 1: St. George at Thessalonika, Greece (295-306) was originally the mausoleum of Galerius, and octagonal inside but with a circular exterior. 2: Sta. Costanza (c.350 according to Krautheimer 1965:41) in Rome was likewise originally a mausoleum, circular inside and out, with the later addition of an internal octagon of columns for a ciborium. 3: S. Stefano Rotondo (468) in Rome, circular inside and out. None of these three are, however, double-shelled.

[69] Mount Gerizim, 881m, looks across the Nablus Valley to Mount Ebal (Jebel Islamiyeh), 941m (Rogerson 1985:150).

[70] Dedicated to the Mother of God (Krautheimer 1965:Figure 47, 116). The construction of this church is described by Procopius (*Buildings*, V.7; Dewing 1940).

[71] Percival, H.R. 1961:208-210.

of Sechem in Palestine. This church was constructed under the Emperor Zeno in 484[72] in an attempt to convert the Samaritans to Christianity and is an early use of the title *Theotokos*, hence, the design is new and a physical attempt to iterate this new doctrinal concept. The church incorporates four apse-ended chapels in the four diagonals of the outer octagon (30 x 37.4m[73]). It was built within an outer square precinct with pavement and defensive wall incorporating seven towers and a gate.[74] The Mount is referred to in *Judges* 9:37 as the Hebrew *tabbur haiarets*[75], translated as "centre of the land", and in the Septuagint as *omphalos tes ges*, "navel of the earth"[76]. It has been noted:

> …it reveals the "axis mundi" of the territory that surrounds it. The mountain is understood to be a connection between heaven and earth, therefore consecrating the area for those who live and worship near it.[77]

There is obvious symbolism in Christianising this location with the dedication to the Theotokos, the *axis mundi* re-figured as the virgin womb. The Samaritans attacked the church in the reign of Anastasius (491-518) and following a Samaritan revolt in response to Justinian's branding them as heretics in 529 the church was immediately restored and the fortifications extended. Therefore this church introduces a doctrinal shift and accompanying design based upon the symbolism of that shift.

The personal connections between Theoderic and Zeno suggest an attempt on the former to emulate some of the eastern Emperor's directives. Certainly it was upon Zeno's instigation that Theoderic invaded Italy. The similarities of design between The Church of the Theotokos on Mount Gerizim and San Vitale begs the question to what extent, beyond that of the structural relationship, are the two churches related? One possibility immediately presents itself; San Vitale may have been conceived as another *axis mundi*. I submit that the design of San Vitale was in direct response to the contention at Mount Gerizim in the period 491-529 and, more specifically, to the events of 529. This interpretation is new and raises several questions. Most importantly, was San Vitale

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[72] Dedicated to the Mother of God (Krautheimer 1965:Figure 47, 116). The construction of this church is described by Procopius (*Buildings*, V.7).
[73] Magen 1993:492.
[74] Magen 1993:492.
[75] Tabbur-erez מיזרג (Metzger and Murphy 1991:315), or Tabbur-Haares (Grindel 1989:258).
[76] Grindel 1989:258.
[77] Lott http://christusrex.org/www1/ofm/mad/discussion/043discuss.html

designed to express and symbolise the Marian cult as espoused by the Empress Pulcheria (413-53)[78]?

It is useful to note one further ecclesiastical form of architecture, the double-shelled tetraconch. Six of the twelve examples are located in Syria. Although the cathedral at Bosra is early (511-512) and it has been noted that 'resolving a round room within a square building by the use of corner exedra flanked by niches had been used in Roman architecture, particularly in the construction of baths (as at Bosra itself) but its translation into Christian buildings is a southern Syrian initiative'[79]. However, of the two examples from Italy, the Cathedral of San Lorenzo (see Figure B2.2 above) at Milan is earlier than that of Bosra, dating to the late fifth-century[80]. In 1936 a second double-shelled tetraconch church was discovered near Canosa (*Canusium*), in Apulia originally dedicated to SS Cosmas & Damian (later S Leucio)[81].

These architectural examples from the fourth to the sixth-century have been drawn together in order to understand the relationships between baptisteries and churches of similar architectural form. Of particular interest is whether similar interiors built for the different liturgical functions of baptism and the celebration of the Mass somehow share a common acoustic experience that is intentionally operative for associated vocalisation and chant sequences.

The results presented above are provisional and the collation of further examples may alter the conclusions posited here. However, these examples do at least include all those given by Krautheimer and Verzone, and therefore, from the available data set it is apparent that the centrally planned ecclesiastical structure of the fourth to the sixth-century predominates in the Western Empire. This appears contrary to the consistent notice of Justinian's influence in popularising this 'Eastern' architectural form.

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[78] Holum 1982:79-111
[79] Burns 1999:21.
[80] Krautheimer 1965:166-167. It is also possible that the double-shelled tetraconch church at Adrianople similarly dates to the late fifth-century.
[81] 'Near Canosa in southern Italy, the remnants of a tetraconch structure of uncertain date await further exploration' (Krautheimer 1965:166).

Therefore, the design of San Vitale at Ravenna may have been influenced not only by octagonal architectural symbolism emanating from Milan since the fourth-century, a favourable response to the fifth-century building program of Galla Placidia and a complex outcome of rivalry with Arianism at Ravenna, but also a response and acclamation of the singular Church of the Theotokos at Gerizim by the Emperor Zeno in 484.

The relationship between Theoderic and Zeno may have had an influence on the design of San Vitale, notwithstanding Gallic and Syrian influences. The installation of the mosaic program including the depictions of Justinian and Theodora in the chancel may bespeak an altered political climate at Ravenna from when San Vitale was designed and when construction began in the episcopacy of Ecclesius. This is corroborated by contemporary historical events, not least the change from Ostrogothic to Byzantine rule at Ravenna in 540. However, the liturgical sonic and visual expressions of the Ravennate rite continued within the sacred space of San Vitale and as such represent a continuous history that was only dramatically altered as of the episcopacy of Gregory the First in 590.

Summary

It has been identified here that San Vitale is a development of one particular building, the Arian Baptistery of Ravenna[82]. This baptistery (Figure B2.9) has a design feature that is unique among the baptisteries studied; one of the four apses extends through and interrupts the path of the surrounding ambulatory aisle. This uniqueness may be directly related to the fact that this baptistery is the only extant Arian architectural example so far identified and may reflect the liturgical needs of the Ostrogothic community. However, this feature is used within the design of San Vitale and no other identified centrally planned contemporary church. It is worth iterating that this singularity may point to some Arian influence upon the original intentions for constructing San Vitale.

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[82] This conclusion is provisional, based as it is upon a data-set gathered mainly from Krautheimer 1965 and Verzone 1968.

The interior and exterior octagonal forms of the Arian baptistery are used as sources for San Vitale's apse exterior polygon and inner octagon. The unique interruption of the ambulatory by the apse is also featured in San Vitale. San Vitale appears to embody both the inherent symbolism of the baptistery and the concept found at Mount Gerizim as an *axis mundi*.
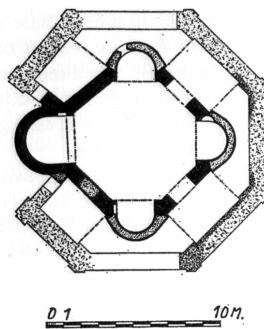

Figure B2.9: The Arian Baptistery, Ravenna (Verzone 1968:52).

San Vitale has long been earmarked as the crowning architectural glory of Byzantine influence in the West[83]. This interpretation tends to bypass the potential contribution of Theoderic's court, a cadre intent on creating a cohesive expression of 'Gothic diversity and independence within overall Roman unity'[84] and its influence on the design and execution of San Vitale[85]. Ostrogothic control of not only northern Italy but also southern Gaul from 509 to 534 has remained outside the discussion of architectural developments of the centrally planned domed church. Neither is the conclusion tenable that identification of 'Syrian' influences at Ravenna necessarily means a simplistic direct and exclusive cultural trade with the "geographic East". What may be

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[83] Krautheimer 1965:170.

[84] Burns 1991:70.

[85] 'The main reason for regarding *de Aedificiis* [by Procopius] as incomplete is the absence of any reference to buildings in Italy, but there is in fact very little evidence for Justinianic constructions in Italy: the Ravenna churches which Downey cited as proof of incompleteness were not financed by Justinian [Downey (n.60) 176; CIL xi I.288 and 294 record that S. Vitale and S. Apollinare in Classe were both built, decorated, and dedicated (in AD 547 and 549 respectively) by Julius Argentarius. See the discussion by F.W. Deichmann, *Ravenna, Kommentar* ii (Wiesbaden 1976) 3-33, particularly 15-21]' (Whitby 1985:145).

called the "cultural East" is amply attested for in the territories of the West, namely Gaul (e.g. Vienne, Arles, Marseille), Spain (Seville, Cadiz), Sicily (Syracuse) and Italy itself (e.g. Rome's Trastevere district, Ravenna, Aquileia, Pozzuoli). For instance, the collection of octagonal baptisteries in Southern Gaul is of particular importance to this study.

This is not to ignore the obvious relationships between San Vitale and the Constantinopolitan churches of SS Sergius and Bacchus and Hagia Sophia, nor the early sixth-century centrally planned ecclesiastical buildings of Syria itself, but discussions of architectural developments need to be broadened beyond physical and territorial concepts of East and West. Perhaps paradoxically, giving attention to sixth-century Ostrogothic dominion of the territory from the Durance and Drôme to the Po[86] is a strategy for re-evaluating Eastern influences coming to Ravenna not simply from the geographic East but also from the West.

Therefore, it is worth challenging the idea that the centrally planned domed ecclesiastical structure, so explicitly championed by Justinian's architects, as the generally acknowledged characteristic *par excellence* of "Byzantine" culture and an exclusive development of the Aegean coastlands. As an architectural design, it has been shown to have had accumulated influences from the West, specifically centrally planned bath and palace rooms from Nero onwards.

The recent attention to the sixth-century by historians and archaeologists[87] is the result of a growing interest in the complex transformations of the Western and Eastern empires, the Gothic oppositions to, and negotiations with, the 'Romans', and the flowering of the "Byzantine" Empire under Justinian. The statement has been made that 'the sixth-century can fairly be regarded as the last of the Roman centuries'[88] and even though Wickham goes on to question 'how Roman it really was'[89] this line of enquiry seems to be founded on the assumption that 'Roman' delineates a constant, stable and identifiable quality (*romanitas*) rather than a flexible fabric of negotiation. The alterations

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[86] The campaign of 523 gave Theoderic dominion over most of Provence and Dauphiné. Bishops from Cavaillon, Apt. Orange, St. Paul des Trois Chateaux (Augusta Tricastinorum), Charpentras, Gap, Embrun and Vaison 'assisted at the Gothic councils held at Arles between 524 and 529' (Hodgkin 1896a:373).

[87] Hodges, R., and Bowden, W. 1998, Maas, M. 2005, Fleischer, J., Lund, J., and Nielsen, M. 2001, Bowersock, G.W., Brown, P., and Grabar, O. 2001; Amory, P. 1997.

[88] Wickham 1998:279.

[89] Wickham 1998:279.

to and/or disappearance of *romanitas* has been read as the decline and collapse of the Roman classical world, and consequentially, in the subtext of such readings there is implicated blame on those who caused this loss, the Goths.

This leaves an immense lacuna in which the Ostrogoths in Northern Italy are central. It is interesting to note that the literature devoted to the Ostrogoths is conspicuously tiny within the corpus of research on the Late Antique[90]. The longitudinal basilica form of congregational church and the centrally planned domed church have been understood as expressing cultural divisions between West and East, between Rome, Milan, Ravenna and Constantinople. In order to re-assess distinctions the North Italian Ostrogothic influence, especially at Ravenna, needs to be included in any discussion of Late Antique architectural expression[91]. Studies of the sixth-century instead tend to be dominated by the reign of Justinian (527-565)[92], even before his reign officially begins his influence is understood to have clouded the achievements of his father Justin I (518-527).

The lineage of particular kinds of centrally planned churches may be seen in a selection of extant audience halls and throne rooms within Imperial palace complexes[93]. The development of centrally planned Christian spaces from these former palatial examples is one possible index of continuity through to the sixth-century.

Continuity during such a period of transformation is itself a material construction, inviting or maintaining stability in a time of flux and crisis. Burns[94] put it succinctly:

> Italy was to be a divided society in which Roman and Goth were to remain separate but complementary[95].

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[90] The standard text remains Burns, T. 1991. *A History of the Ostrogoths*. Bloomington and Indianapolis: Indiana University Press.

[91] Cf. Klingshirn 1985; Burns 1991, 1998; Amory 1997, Ferreiro, 1999.

[92] The sixth-century is so often figured as the 'Age' of Justinian, the very title of a recent work by Maas (Maas, M. 2005).

[93] Namely, the fine example from Diocletian's palace at Split.

[94] Burns 1991.

[95] Burns 1991:71.

One such locus of continuity has been identified with the Ravennate building program of Bishop Ecclesius and the financial backing of Julianus the *argentarius* (banker) and his nephew Bacauda. These two latter secular figures have been used to argue for "Byzantine" influence in Northern Italy. They financed the construction of San Michele in Africisco (545), San Vitale (c.526-548) under the Ostrogothic Queen Amalasuentha (526-534), and both Santa Maria Maggiore (after 526-before 569) and S. Apollinare in Classe (c.535-549) following Justinian's takeover of Ravenna in 540.

Following Theoderic's death, Queen Amalasuentha (526-534) may have styled herself after Valentinian III's Orthodox mother Galla Placidia (423-436). Amalasuentha appears to have attempted to succour favour with Justinian and Theodora, and involved herself in the Ravennate building program of Julianus (in addition to the construction of the churches of S. Victor and S. Euphemia *ad Arietem*). She was perhaps able to be more sympathetic to Orthodox Christianity than her Arian father, Theoderic, although he was also able to express tolerance, for of at least eleven ecclesiastical buildings built in his reign at Ravenna, and nearby at Comacchio and Classe[96], three were Orthodox. Indeed, 'most of the Ravenna churches consecrated in Justinian's reign were begun under the Ostrogoths, and the costs were borne by local benefactors or bishops'[97]. Famously, in the *Anonymous Valesianus* (70-1) Theoderic is dubbed 'lover of building and restorer of cities' (*amator fabricarum et restaurator civium*)[98].

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[96] Ravenna: S. Theodore, the Arian Cathedral *Ecclesia Gothorum* (with adjoining 'Arian baptistery'); S. Eusebius (in 518; Arian), S. Andrea (Arian), S. George the Martyr (Arian), S. Zeno (Arian), The Church of the Savior (Arian), the Chapel of S. Andrew in the Bishop's Palace, Church of the Blessed Mary in Comacchio. Theoderic's Mausoleum should perhaps also be included as an Arian monument.
Classe: S. Sergius *juxta viridarium* (Arian). Of these eleven ecclesiastical/memorial structures, eight were Arian and three Orthodox.
Of those Arian churches that were "reconciled" to Orthodoxy, Agnellus mentions four in the suburbs of Classis and Caesarea (S. Eusebius, S. George, S. Sergius in Classis, S. Zeno in Caesarea), and two within the walls; the Arian baptistery now known as S. Maria Cosmedin, and S. Martin, now S. Apollinare Nuovo (Jackson 1913:172).
[97] Evans 2000:238
[98] '…and reports that at his capitals Ravenna, Pavia and Verona he built or repaired not only the city walls but also ancient public structures like porticoes, aqueducts, baths and amphitheatres. By such munificence Theodoric hoped to confer legitimacy on his rule. His desire to associate himself with the glorious Roman past even extended to construction methods. Thus he ordained that old materials should be carried out to such a standard that 'only the newness of the fabric distinguishes them from the work of the ancients' (Cassiodorus, *Variae* 7.5.5). The re-use of ancient stones, which Theodoric encouraged, should therefore be attributed not to economic difficulties or incapacity to work newly hewn stone, but rather to the continuing appeal of ancient tradition…Theodoric's building policy may have run counter to the trends of the times in its attempt to revive obsolete concepts and ideals, but it is, none the less, significant that his desire to

With the removal of Amalasuentha[99] from state and her subsequent murder, the unstable period between 534 and 540 required (or at least gave reason for) intervention from Constantinople. By the time Ravenna itself was under Constantinopolitan rule several churches were consecrated (San Michele in Africisco in 545, San Vitale in 548, San Apollinare in Classe in 549, S. Euphemia *ad Arietem*) but the only building activities initiated and completed under "Byzantine" rule seem to be S. Stephen the Protomartyr in 550, restorations of the baths adjoining the Bishop's Palace, the erection of a *ciborium* (or *baldacchino*) over the altar of the Ursiana (Orthodox Cathedral), and the replacement of walnut with marble columns in S. Andrew the Great. These (re-)dedications and minor renovations in the Western capital are revealing, and perhaps it is telling that Procopius, in his *Buildings*, does not include Italy, possibly indicating it was not Justinian who scheduled any building program there[100].

Therefore, the Justinianic building program that characterises discussions of sixth-century architecture[101] must be carefully reset in the case of Northern Italy, giving more deserved attention to Ostrogothic building activities[102]. Moffatt[103] made the salient point that, at Ravenna:

> We are left with a rather distorted picture emphasizing the churches completed in the period of orthodoxy after 540, at the expense of the building activity and patronage under Arian rule[104].

What did take place at Ravenna under the active prelature of Bishop Maximianus (546 - 556) was the rededication from Arianism to Orthodoxy of at least six churches and one in Classe[105]. Justinian granted the Orthodox church of Ravenna the lands that had

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legitimise his authority expressed itself in relationship to the city. It was the cities that Theodoric picked on as decisive in setting the seal on his legitimacy. In this context, it is the Lombard invasion of 568 which constitutes the real break with the past' (La Rocca 1996:166).

[99] The regency of Amalasuentha is far more complex, interesting and successful than the passing comment that she coped 'as best she could' (Wallace-Hadrill 1985:37) and that subsequent 'disintegration was bound to follow' (*Ibid*.) gives her credit.

[100] Dewing & Downey 1940. For Procopius' dramatically alternative character sketches of Justinian and Theodora see his *Anecdota* (Dewing 1954).

[101] Krautheimer 1965.

[102] Or, at least, building activities under Ostrogothic rule whether they be Orthodox or Arian endeavors.

[103] Moffatt 1996.

[104] Moffatt 1996:242.

[105] Ravenna: Arian baptistery re-consecrated and rededicated as S. Mary in Cosmedin, S. Theodore as Santo Spirito, S. Eusebius deconsecrated, S. George the Martyr deconsecrated, S. Zeno deconsecrated, The Church of the Savior re-consecrated and rededicated as S. Martin of Tours (later S. Apollinare Nuovo).

formerly been held by the Arian church and then confiscated to the *res privata*[106]. Thus at Ravenna the Justinianic "building program" was characterised by the emphatic purge of Arianism. The biased equation that all Ostrogoths were Arian while the 'Romans' of Italy were Orthodox is far too simplistic and potentially incorrect. As just mentioned, of the eleven ecclesiastical structures completed under Theoderic, three were Orthodox, suggestive that he was able, in his long reign, to achieve social cohesion by prudently offering a level of tolerance for the Orthodox camp who were evidently free to initiate and realise the planning and construction of new churches.

King Theoderic, of the royal Ostrogothic Amal dynasty, was born near Carnuntum, Pannonia in 454. His father Theodemir (? - 474) sent him to Constantinople as part of a treaty with the Emperor Leo I (457 - 474). He was raised and educated there and accrued the honors of *magister militum* in 483 and consul in 484, apparently treated well by Leo I, and his successor Zeno (474 - 491). In 488 Theoderic assumed the crown over the Ostrogoths, and since they required a new home at a time when Odoacer's kingdom in Italy was causing problems for Zeno, the two negotiated an agreement whereby Zeno encouraged Theoderic to invade Italy. Theoderic arrived in Italy with his army and people within the year and by 493 he took Ravenna and killed Odoacer. Theoderic was the viceroy of Zeno but enjoyed autonomy in Italy and was able to deal with the Eastern Emperor as an equal. This friendly relationship between Theoderic and Zeno has important consequences for understanding the character of Ostrogothic rule of Italy from Ravenna.

Also in the year 484, when Zeno raised Theoderic to consular rank, this Eastern Emperor built the Church of Mary the Theotokos on Mount Gerizim in Palestine[107]. It promoted the decisions made at the Third Ecumenical Council held at Ephesus fifty-three years prior, in 431, which proclaimed anathema to Nestorius' claim that Mary was Christotokos, the mother of the human part of Christ, the Council deeming Mary as the Child-bearer of God. Zeno's church to the Theotokos on Mount Gerizim represents a dramatic development not only in the theological import of Mary but also in

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Classe: S. Sergius *juxta viridarium* re-consecrated.

[106] Unfortunately, the first part of this grant, enumerating the various estates with their rentals and taxes, 'is too fragmentary to be intelligible' (Jones 1964:821).
[107] Cf. Magen 1993.

ecclesiastical architecture. It is a centrally planned octagonal church but unlike other octagonal churches before, it is an octagon inside and out. Its octagonal exterior and interior is not a design feature matched by any other church until the planning and construction of San Vitale in Ravenna around forty-two years later, in c.526[108]. At Gerizim, the Samaritan population, whose pagan practices had been removed from the Mount, revolted and destroyed the church. By 529 Justinian had ensured the church was restored[109], including a large defensive wall with turrets.

The Ostrogoths followed Arianism, a non-Trinitarian theological system of Christianity the first Council of Nicaea proclaimed heresy in 325. There are very few extant architectural examples of Arian Christianity, but one example is at Ravenna, the famous octagonal Arian baptistery. This baptistery is not simply unlike the octagonal Orthodox baptistery also at Ravenna, but also unlike the other 50 baptisteries with octagonal elements studied. The elongated apse extends and interrupts the surrounding ambulatory. This unique feature is integral to the design of San Vitale and offers the opportunity to begin an exploration of possible tolerant negotiations between Ostrogothic Arian Christianity and Roman Orthodoxy at a local but important level. However, recent studies of the many baptisteries at Salona in Dalmatia[110], has demonstrated that what was formerly identified as Arian architecture may not be accurate. The case of the Arian baptistery at Ravenna should likewise be re-evaluated.

The significance of the octagon in Ambrosian exegesis on baptism and the music vocalised by the Ambrosian (Milanese) and Ravennate rites indicate a broadly northern Italian symbolic "style" influenced as much by the East as by the West. The inclusion of female singing in the upper storey balcony (*matroneum*) created a new experience and spatial expression of belief and unity.

In concert, these interpretations suggest San Vitale may have been part of an organised sacred urban design at Ravenna under the sanction of the Ostrogoths, an interpretation

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[108] San Vitale's dedication was therefore sixty-four years after that of the Church of the Theotokos at Gerizim.
[109] Magen 1993:492.
[110] Hemans 1997:811.

rendered improbable by the usual simplistic gloss that this church was the pinnacle of Justinianic architectural achievement in the West.[111]

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[111] San Vitale has been described as 'the one truly great building of the West in the sixth-century' Krautheimer 1965:170.

Appendix C

Sound Source and Acoustic Data of San Vitale

Appendix C has four sections, the first (C1 below) identifies the extant Ravennate chants and the second (C2 on CD) is an Excel file of the raw acoustic measurement data as recorded by Professor Lamberto Tronchin and his team from the University of Bologna on April 30th 2006. Also on accompanying CD is C3, the prepared version of *Lux de luce* as a Logic Express 8.0 ISO song-file and sound files C4, 5 and 6 respectively of the vocal recording of *Lux de luce* in San Vitale, in the ISVR anechoic chamber and convolved with San Vitale's Reverberation.

Section C1: Ravennate Chants and Sources

Several important musicological works[1] have been consulted in preparing the following tables of Ravennate chants.

Chants	Title	Source
From the Easter Vigil Mass for neophytes[2]	*Confitemini Domino quoniam*[3]	
	Qui in Christo baptizati estis[4]	
Of Eastern Orthodox origin[5]	*O quando in cruce*[6]	
	Lux de luce Deus tenebris illuxit averni[7]	Padova (Padua) A.47, folio 129; Modena O.I.7, folio 102
Proper Chants[8]	*Annua presentis recolamus gaudia festi*[9]	Padova (Padua) A.47, Modena O.I.7
	Alleluia with the verse *Accipe spiritum sanctum*[10]	

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[1] Bailey 1983, Baumann 1990, Brunner 1981, Burkholder, Grout & Palisca 2005, Cattin 1984, Crocker 1977, Crocker & Hiley 1990, Hiley 1988, 1993, Hoppin 1978, Hughes 1982, Jeffery 1992, Lang 1941, Levy 1963, 1970, 1971, 1980, Quasten 1983, Roederer 1974, Sadie 2001, Strunk 1951, 1952, 1977, Velimirović 1966, 1971, 1973, Wellesz 1947 (1967 edition).

[2] 'They reveal an elegance of centonate structure not matched elsewhere in the West' (Levy 1980:879).

[3] An alleluia with verses from Psalm 135 (Levy 1980:879). Centonisation comes from the Latin *cento*, meaning "patchwork" (Burkholder et al 2005:30).

[4] (?Offertory) Related musically to *Confitemini* (Levy 1980:879). Derived textually and musically from a Byzantine baptismal *troparion, Hosoi eis Christon*.

[5] 'It is thought that both of these chants were in use before the mid-8th century…a northern origin is probable at least for Lux de luce' (Levy 1980:879).

[6] 'The Greco-Latin antiphon *Hote tō staurō / O quando in cruce*, is both musically and textually a borrowing of an Eastern hymn for the Good Friday Hours, attributed to Sophronius, Patriarch of Jerusalem (634-638)' (Levy 1980:879, also Hiley 1993:527).

[7] The hymn or *versus* in hexameters 'found only in the Ravenna sources' (Levy 1980:879).

[8] Alleluias, Offertories and Sequences for Saints venerated locally, particularly Apollinaris, Vitalis, Agricola and Fusca.

[9] Sequence AH, xxxvii, 277 For the Feast of S. Vitale. 'Consists of ten elegaic distichs (see G. Vecchi, "Lirica liturgica ravennate", *Studi romagnoli*, III 1952); this curious piece has its line beginnings paired in sequence fashion, but its line endings obey an independent order of musical rhymes' (Levy 1971:57).

antiphonale missarum[11]	US-Baw W.11[12]	
	I-Pc A.47	Padova (Padua)
	MOe O.I.7[13]	Modena
Ravenna Office-Books	I-Rvat lat. 4750 (fragments)	
	(perhaps) Rvat-lat. 85 (fragments)	

Sources	
The Codex Modena Modena, Biblioteca Capitolare[14]	Modena O.I.7, saec. xi, Gradual, 68 seq., 115 seq., 123 seq.[15]
	Modena O.I.7, folio 102 (Lux de luce)[16]
	Modena O.I.7[17]
	Modena O.I.7[18]
Padova (Padua)[19]	Padova A.47, folio 129 (Lux de luce)[20]
	I-Pc A.47[21]
	Padova A.47[22]
US-Baw	US-Baw W.11[23]
I-Rvat	I-Rvat, lat. 4750[24]
	Rvat, lat. 85[25]

Lux de luce is identified in Chapter 4, Part 3 with the *lucernarium* chant of Vespers[26], supported by the textual reference in verse two to *vespere* (evening):

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[10] For the Feast of Saint Apollinaris, composed later (but before the 11th century) at Ravenna (Levy 1980:879).

[11] From this region, 11th and 12th centuries.

[12] A *missale plenum*.

[13] 11th century.

[14] 'An eleventh century manuscript of the library of Modena, most certainly written at Ravenna' (Wellesz 1967:4, 68), and more specifically at nearby Forlimpopoli (Hiley 1993:317). A Gradual with tropes, sequences, etc. integrated into each Mass in liturgical order with a supplement of festal pieces (ordinary-of-mass chants with tropes, sequences, proper tropes, etc.) (Hiley 1993:317).

[15] Wellesz 1967:4, 205.

[16] 'Probably from the region of Forlimpopoli, near Ravenna' (Levy 1971:48).

[17] One of three versions (11th C.) of Ravennate antiphonal *missarum*.

[18] Proper Chant Sequence for S. Vitale: *Annua presentis recolamus gaudia festi* (possibly also containing chants for SS. Apollinaris, Agricola, Fusca). Modena O.I.7, folio 129[r] is the sequence *Sancte crucis celebremus* (Hiley 1993:184, Example II.22.8).

[19] The Biblioteca Comunale of Padua, perhaps dating to the 12th century.

[20] 'Probably from Ravenna' (Levy 1971:48).

[21] One of the three versions of Ravennate antiphonal *missarum* (c.12th century).

[22] Proper Chant, Sequence for S. Vitale *Annua presentis recolamus gaudia festi*.

[23] A *missale plenum*; one of three versions of Ravennate antiphonal *missarum*.

[24] Contains fragments of Ravenna Office-Books (Levy 1980:879).

[25] Possibly contains fragments of Ravenna Office-Books (Levy 1980:879).

[26] The *lucernarium* (Latin, from *lucerna*: 'lamp') is 'a chant song at the beginning of 'cathedral' Vespers in the early church; also the opening chant of Vespers in the Ambrosian rite, and resembling in function the Mozarabic *respertinus* (Sadie 2001:271, Volume 15). Vespers (from Latin vesper: 'evening') is a service of the Divine Office, traditionally performed at twilight, at the time when the lamps are lit indoors. Among the services celebrated by the early secular churches was an elaborate form of 'cathedral' Vespers. Cathedral Vespers in the 4th century began with the *lucernarium*, the lighting of the lamps and the blessing of the new light, after which was sung the ancient hymn *Phōs hilarion*; a number of psalms followed, including Psalm 141 (Vulgate 140; this Psalm seems to have early associations with the office) accompanied by incensation, after which various other musical items such as hymns, canticles and responsorial psalms might also be included. A single vestige of the older tradition, though not in fact of Roman origin, is the blessing of the paschal Candle at Easter (Sadie 2001:508, Volume 26).

Vespere quae prima refulgens luce diei

At eventide shining with first light of day.[27]

Or, alternatively translated as:

In the evening, and shining at first light.[28]

As such, the *versus* provides an interesting musical corollary between sound and light set within the liturgical timing of the Paschal Season, indicating the possible presence of a 'theology of sound' embodied by the combined temporal timing and rhythmic repetitions of the architectural design of San Vitale.

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[27] Levy 1971:43.

[28] Thanks to Dr. Charlotte Tupman for this full translation, personal communication February 24 2009. See Chapter Four, Part Three, page 148.

Appendix D

Considerations of Virtual San Vitale

Appendix D has four sections; the first (D1 below) provides supplementary discussion regarding selected building materials and architectural elements considered in creating the virtual models of San Vitale. The second section (D2 file on accompanying CD) provides the metric measurements of San Vitale as recorded by the author and subsequent conversions into the original measurements.

D1: Selected Building Materials and Architectural Elements

Windows

As mentioned above in Chapter Five[1], part of the 2007-8 strategy to create the photo-realistic virtual model of San Vitale carried out by Matteo Nori, Ilaria Durvilli and Simone Garagnani[2] included a visit to the National Museum, immediately south of San Vitale, to photograph[3] and measure the luminosity of the collection of original sixth-century window glass from the church[4]. Krautheimer had previously noted glass window discs for San Vitale and described them as ranging in colour from 'dark blue, dark brown with red, whitish, yellow and light red colours'[5]. Deichmann listed and commented on these round *fensterscheiben*, suspending judgment regarding their date in his commentary conclusion:

> Vielleicht sind die Scheiben von S. Vitale also mittel-alterlich. Sollten sie dem 6. Jh. angehören, wären sie die einzig erhaltenen westliche Beispiele, was nicht ausgeschlossen werden kann, aber nicht wahrscheinlich ist: unter diesen Umständen wären die Scheiben von S. Vitale aber kaum ohne einen

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[1] Part 5.1.

[2] Matteo Nori, doctoral thesis for Professor Lamberto Tronchin (UniBo). Ilaria Durvilli and Simone Garagnani have kindly provided me with the glass disc photographs, measurements and further information.

[3] See Appendix E.5, file: SVitaleWindows

[4] Information on the exact deposition of these discs needs to be substantiated. Nevertheless, the following exercise is instructive.

[5] He also gives their diameters as ranging between nine and ten inches (Krautheimer 1986:264).

> Zusammenhang mit den palästinensischen und ägyptischen Beispielen zu erklären.[6]

A loose translation follows:

> Perhaps the panes of San Vitale are also medieval. If they belong to the 6th century, they are the only western examples, which can't be ruled out, but is unlikely: under such circumstances, the panes of San Vitale can hardly be explained without a relationship to Palestinian and Egyptian examples.[7]

The phenomenon of circular panes being produced by the early fifth-century in the eastern provinces, for instance at the glass workshop at Samaria-Sebaste[8], and used with rectangular examples as fixed panes in numerous Levantine churches[9] seems to support Deichmann's suggestion, although it is not impossible the technique arrived in Italy by the sixth-century.

Of the circular panes of San Vitale, Deichmann only published two photographs[10] and unfortunately in black & white (Figure D.1.1 and D.1.3).

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[6] Deichmann 1976 *Ravenna, Hauptstadt des Spätantiken Abendlandes* II, 2. Wiesbaden: Franz Steiner Verlag GMBH Pp. 139-141.

[7] German translation by Nick Ford and also Leif Isaksen by personal communications October 6-7 2008. For the influence of Eastern art influencing Ravenna see the seminal work of Frothingham 1894.

[8] O'Hea 2007:236 (O'Hea, M. 2006 (published 2007). Glass in Late Antiquity in the Near East. In, Lavan, L., and Zanini, A., and Sarantis, A. (eds.) Technology in Transition A.D. 300-650. *Late Antique Archaeology* 4 (2006). Leiden. Pp. 233-248).

[9] O'Hea 2007:236.

[10] Deichmann 1976: Abb. 81 and 82, 83 is a drawing of the disc with Christ and the Alpha Omega.

Abb. 81. Scheibe der Fensterverglasung
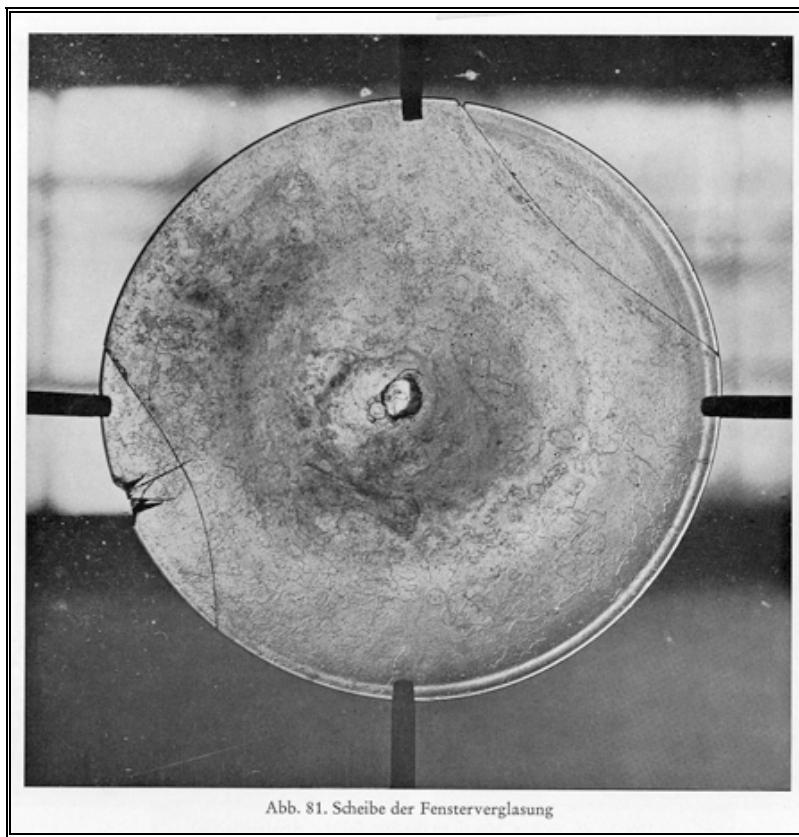
Figure D.1.1: Glass window disc from San Vitale as published by Deichmann in 1976.

Table D.1.1 below usefully supplements the list of glass discs provided by Deichmann, using his descriptors and measurements, with colour swatches, while Figures D.1.2, D.1.4 − D.1.6 are a selection of photographs taken of the glass at the Ravenna National Museum.

|	**Disc Diameter**	**Colour description**	
1	D: 0,205m	Lemon yellow/white	
2	D: 0,205m	Watery pale blue	
3	D: 0,195m	White	
4	Fragment D: 0,22m	White, depicting Christ, A and Ω	
5	D: 0,20m	White	
6	Fragment D: c.0,24m	Light blue	
7	D: 0,205m	White	
8	D: 0,22m	Deep blue	

9	D: 0,195m	White	
10	D: 0,225m	Reddish-brown	
11	D: 0,25m	Light green	
12	D: 0,26m	Light green	
13	D: 0,175m	White	
14	D: 0,19m	White/light yellow	
15	D: 0,245m	Reddish-brown	
16	D: 0,205m	White	
17	D: 0,25m	Brown	
18	D: 0,22m	Yellow	
19	D: 0,235m	Reddish-brown	
20	D: 0,245m	Brown/Light violet	
21	D: 0,26m	Green	

Table D.1.1: The '*tessere*' glass discs from San Vitale's windows (in the order given by Deichmann 1976).

Dominant among the National Museum's collection of San Vitale's original windows are a series of glass discs ranging between 20-25 cm in diameter[11] and between 5-10mm thick. These circular *rotae* or '*tessere*'[12], 'were simply blown as a very shallow plate'[13] with a swirling bulge at the centre[14], and apparently held in place by a lead strip approximately 5mm thick[15].

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[11] Between 7.8 and 9.8 inches. O'Hea notes that the 'circular panes in the Levant tend to be diam. *ca*. 30 cm.' (O'Hea 2007:234).

[12] Through personal communication with Simone Garagnani, we decided on the term 'tessere' to describe these glass discs since, as yet, I have not discovered a more accurate nor technical term for these objects. Deichmann's *runde scheiben* is not altogether useful. Agnellus' use of the word *rota* (41; Deliyannis 2004:150, and 336), circular discs of stone for floors and walls may be a better alternative.

[13] O'Hea continues '…sometimes with a folded edge to them for greater strength where they would be plastered into a wall' (O'Hea 2007:234).

[14] Most likely caused by the production process of spinning the glass.

[15] Although at present, as seen in the photographs, the discs are either mounted in wooden frames or left un-mounted on museum acid-free tissue.
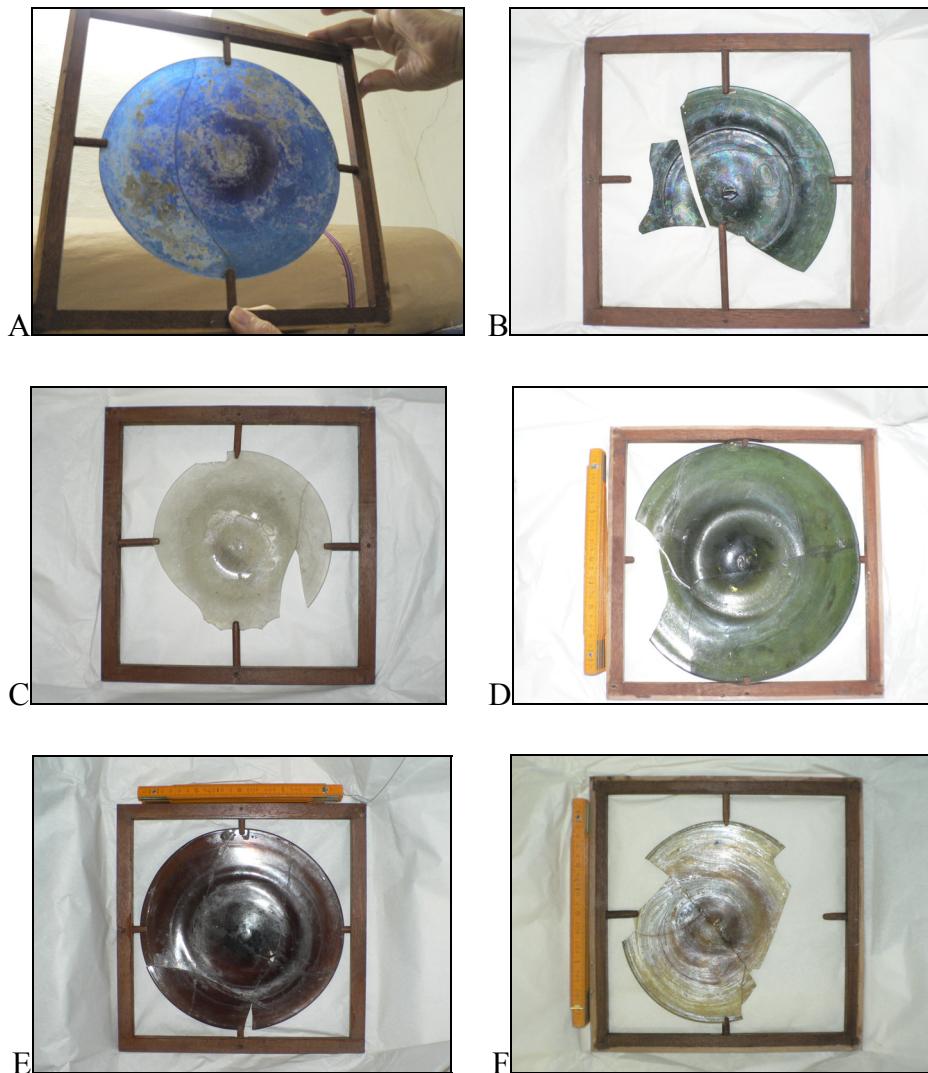
Figure D.1.2: San Vitale glass window '*tessere*'; a selection of the variety of colours (Garagnani 2008).

Aside from these numerous plain coloured discs, there is one example, which is painted (Figure D.1.3 below). Not shown in Azzaroni's drawing is the beginning of the *Omega* with cross above, as can be clearly seen in Figure D.1.4.

Abb. 82. 83. Scheibe der Fensterverglasung mit thronendem Christus (Photo und Zeichnung A. Azzaroni)
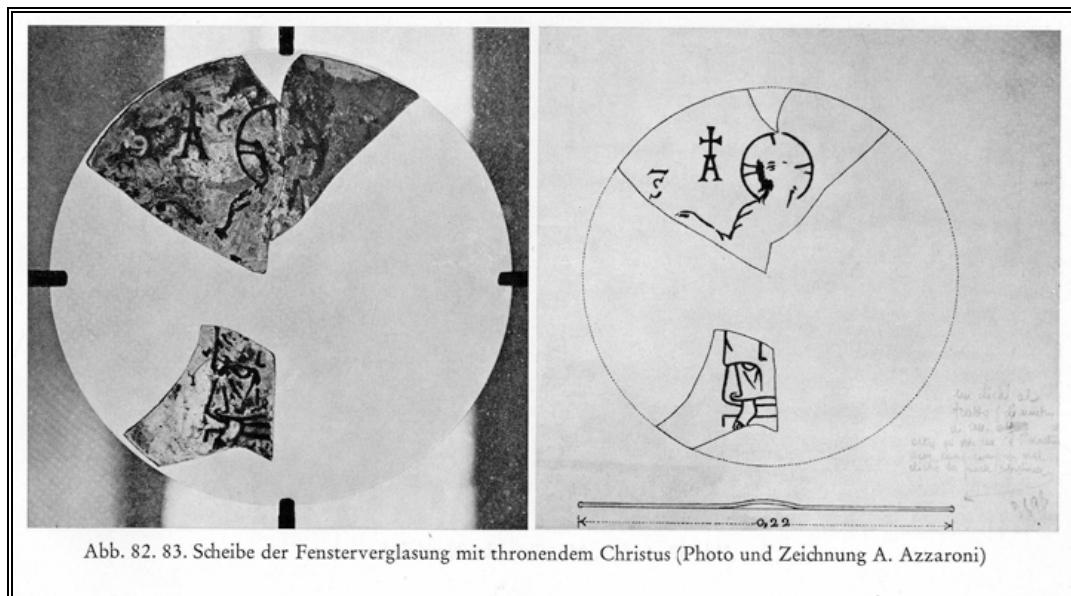
Figure D.1.3: Glass disc with Christ, Alpha & Omega (Deichmann 1989; from Azzaroni's former photograph and drawing).

Figure D.1.4: San Vitale glass window disc with Christ and the Alpha and Omega[16] (Garagnani 2008).

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[16] The letters at the left edge may be a variant of the IHS, the Latin monogram for *Jesus*, from the Greek *IHΣOYΣ* (Child & Colles 1971:20). For future consideration, the Chi Rho monogram characteristic to Ravenna may have some significance to geometric spatial symbolism. A starting point would be Frantz 1929.

In addition to these glass discs there are other rectilinear shapes from the San Vitale windows:

<center>A   B</center>

Figure D.1.5: San Vitale window glass; rectangle and diamond (*A*) and irregular shards (*B*) (Garagnani 2008).

Figure D.1.6: San Vitale window glass; irregular shards with central circular small disc (Garagnani 2008).

San Vitale has a total of fifty windows that would have been adorned with these and many more, now presumably lost, glass discs and other shapes[17]. Relatively recently,

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[17] At the time of Giannakopoulou's dissertation deadline, the above photographs of the original windows were not available; hence her light renderings could be amended in the future.

thin alabaster panels, akin to those within the *mausoleum* of Galla Placidia (Figure D.1.7 below), were placed into the majority of San Vitale's windows.

A   B
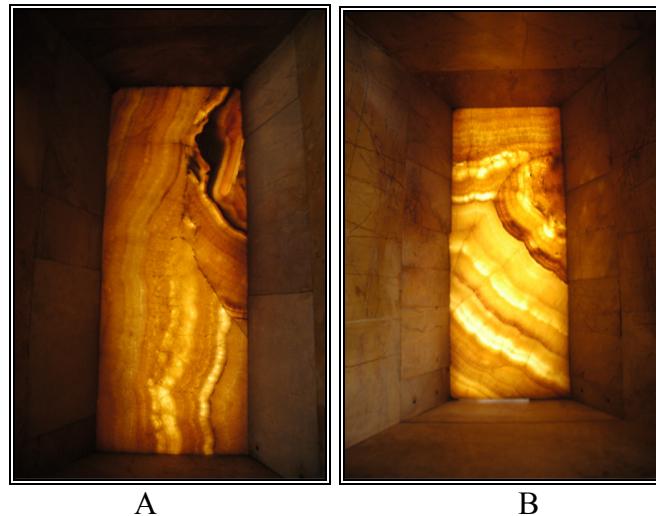
Figure D.1.7: Alabaster panel windows in the *mausoleum* of Galla Placidia (Knight 2006).

Work continues on restoring an original window scheme into the virtual model of San Vitale. The only guide is the mosaic representation of San Vitale in the apse (Figure D.1.8 below) where the dome drum windows have blue windows and the main floor windows are dark reddish-brown. However, this cannot in any way be used as an accurate depiction of the windows, not least since only one set are shown for the main body of the church, discounting the upper storey *matroneum* windows.

Figure D.1.8: Detail of San Vitale apse mosaic representing a model of the church with only two sets of windows.

Several ways of arranging the various shapes are possible based on the glass examples in the National Museum of Ravenna, but for the purposes of completing the virtual model the middle option in Figure D.1.9 below has been decided on[18]. This scheme incorporates 26 of the glass discs within a continuous border of the rectangular border elements. The distribution of the ten colours represented in the Museum collection can also have a multitude of possibilities; one is shown in Figure D.1.10 below.

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[18] I suggested the middle option to Simone Garagnani in September 2008 as the continuous border seemed to better complement other continuous borders in the mosaic scheme.
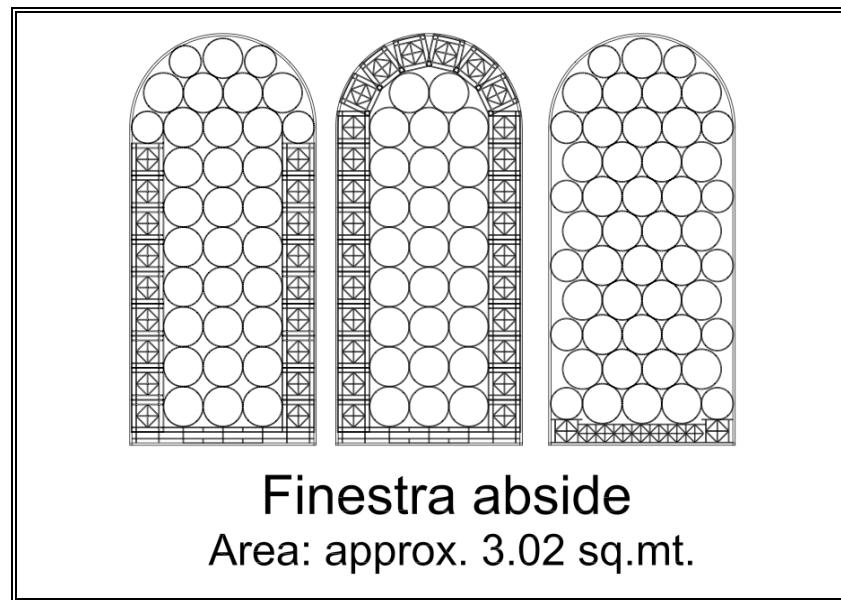
**Figure D.1.9**: Three window schematic possibilities for San Vitale (Durvilli and Garagnani 2008).
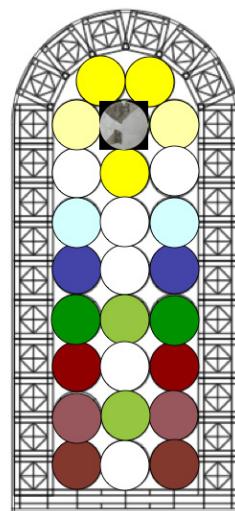
Figure D.1.10: Possible colour scheme for a window in San Vitale (Garagnani and Knight 2008).

Figure D.1.11: Knight window design, Garagnani virtual construction and rendering 2008.

One can imagine, on a clear sunny day, the natural light entering San Vitale would originally have been thrown about in ever-changing ways by the swirled glass discs, bright jewels bedazzling and radiating amplified complexly variegated blurred circular patches of bright colour through the smoke of rising incense, onto the Proconnesian marble columns, mosaic floors and walls, decorative plaster-work and the reflective surface of water filling the *sacellum*. In short, the interior of San Vitale at mid-afternoon would have been a place of visually sensual colour and texture. In addition to this the long reverberation times of the acoustic space and the sonic content of music, hushed speech, perhaps even the faint sound of frogs filtering in from outside, and it seems everything was coordinated in order to overload the senses and suspend disbelief, to provide the space and time to enter another world, a heavenly kingdom structured through geometry, symbolism and representations of Empire and sacrifice[19]. Through light and sound San Vitale disarms the senses while at the same time making clear this is a specific place, a Christian church.

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[19] For the acoustics of assembly spaces see Lord & Templeton 1986.

Wood

It has been noted that San Vitale's '…central octagon…is surrounded by an ambulatory and gallery, both originally with timber ceilings'[20]. Therefore, to further augment the acoustic findings of 2006 the identification and modelling of the particular type of wood used would be of interest. The wood may have been pine[21] from the nearby *Pineta di San Vitale* (the pine forest of San Vitale). In the chronicle known as *Anon. Valesii,* Theoderic is noted as establishing himself in a fortified camp in the *Pineta* from autumn of 490 to the spring of 493, laying Ravenna under siege[22]. The *Pineta*, a pine forest which Agnellus calls *Strovilia Peucodis*, after the Greek[23], skirts Ravenna's eastern horizon 'shutting out the sight of the sea'[24]. The resonant properties of pine would need to be included into the acoustical model.[25]

Baptisteries with octagonal features

The supplemental catalogue in Appendix B of centrally planned Late Antique baptisteries with octagonal features can be continued and added to when further discoveries and identifications are made.

Polygonal Apse Exteriors

Yet another research area that requires comprehensive cataloguing are the exterior apse shapes of churches in Late Antiquity. Using Krautheimer, Roth, Poulter, Mango, Hellenkempre and Bendazzi & Ricci[26], thirty-four examples of polygonal apse exteriors, with circular interiors, were compared. Chart D.1.1 below shows the preliminary results of this comparison[27], with the majority having 8-sided polygons (octagons).

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[20] Stalley 1999:69-70.

[21] Depicted in the apse mosaic of San Vitale are representations of the cities of Jerusalem and Bethlehem with a cypress tree standing at the gate of each, whereas in Sant' Apollinaris at Classe the same cities are represented with a palm tree beneath each (cf. Hutton 1913). Walnut and cedar may also be candidates.

[22] Hutton 1913.

[23] Hodgkin 1896a:217.

[24] Hodgkin 1896a:204. Also see Hodgkin 1896b.

[25] The important work of Meiggs (1982) has already been consulted.

[26] Krautheimer 1986; Roth 1993; Poulter 1994; Mango 1974 (1986); Hellenkemper 1994 and Bendazzi & Ricci 1987.

[27] Refer to Appendix B.3: Polygonal Apses.
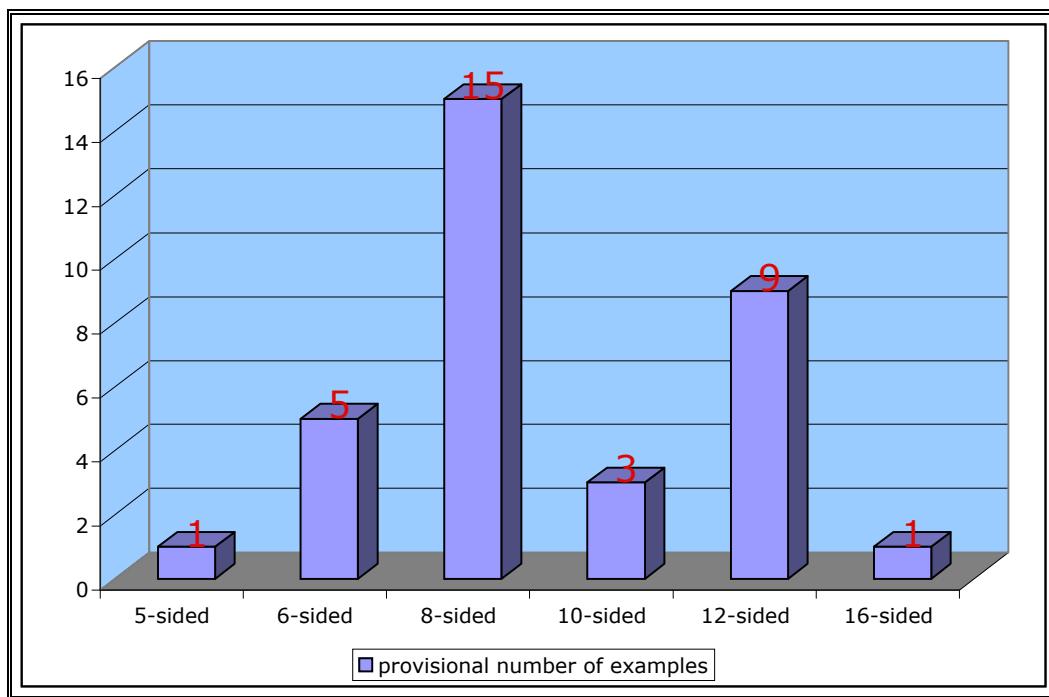
Chart D.1.1: Church apse exterior polygons from the fourth to the sixth-century (From Krautheimer 1986, Roth 1993, Poulter 1994, Mango 1986, Hellenkemper 1994, Bendazzi & Ricci 1987).

When the examples from Ravenna are extracted from the data, as in Chart D.1.2 below, it is apparent that with Ecclesius' church building there were an equal number of octagonal and 12-sided (dodecagonal) examples, and the early 16-sided (hexadecagonal) case of St John the Evangelist. No 5-sided (pentagonal), 6-sided (hexagonal), or 10-sided (decagonal) polygons have been identified from Ravenna. The continuation of this cataloguing of polygonal apses from Late Antiquity, alongside the list of centrally planned baptisteries and churches provided in Appendix B will be an important aid to archaeologists and architectural historians alike in tracing preferences for certain polygons over others.
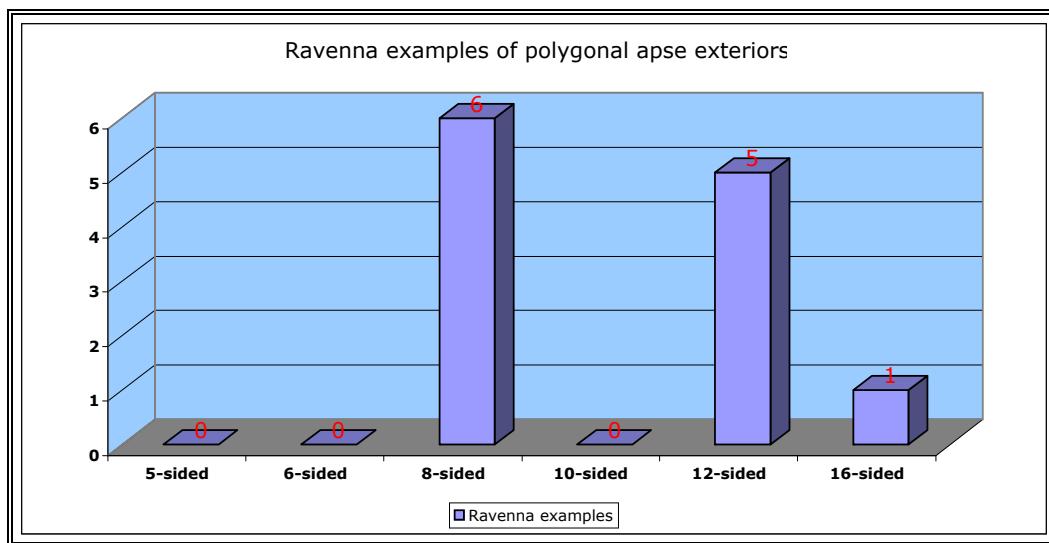
Chart D.1.2: Ravenna examples of apse polygons from the fourth to the sixth-century (From Krautheimer 1986, Roth 1993, Poulter 1994, Mango 1986, Hellenkemper 1994, Bendazzi & Ricci 1987).

Columns

The basilica at Parenzo (Porec), Istria has ten arches and nine columns of Proconnesian marble[28] on either side, and although they are reused from an earlier Classical building the capitals 'are all worked originally for the building'[29]. One capital is similar to those used at Hagia Sophia while the rest resemble 'those at S. Vitale'[30] so closely 'they might have been cut by the same Byzantine hand'[31]. Upon their *pulvino* appears the monogram of Bishop Euphrasius who rebuilt the church, completing the project in c.543[32]. The apse is semi-circular on the inside while polygonal on the outside and has a hemicycle of seats, or *synthronon*[33], for the clergy and the Bishop's throne (*sedis*/*cathedra*) in the middle.

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[28] Krautheimer 1965:196. Proconnesos (now Marmora) was an island in the Sea of Marmora famous for its marble (Davis-Weyer 1971:50).

[29] Jackson 1913:181.

[30] Jackson 1913:181.

[31] Jackson 1913:181-182. The capitals 'were probably imported from Constantinople' (Krautheimer 1965:196).

[32] Jackson 1913:182.

[33] According to Krautheimer: 'In East Christian and Byzantine churches, the bench or benches reserved for the clergy; arranged either in a semicircle (sometimes amphitheatrically) in the apse or in straight rows on either side of the bema' (Krautheimer 1965:363).
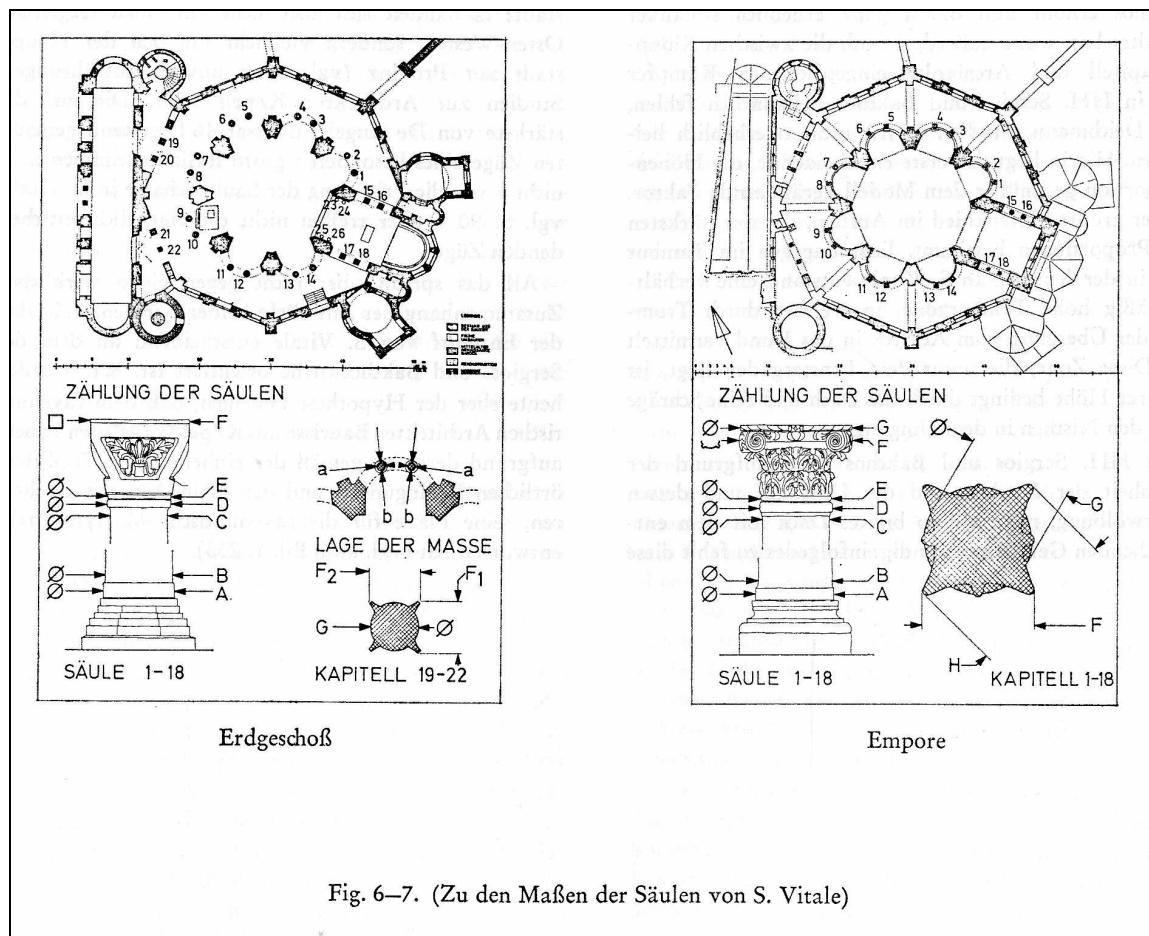
Figure D.1.12: Deichmann's plans of the different column styles in San Vitale (Deichmann 1989).

In light of the revealed distributed patterning of column base locations in San Vitale as noted in Chapter Three (Part 3.1), further spatial analysis of the column capitals (Figure D.1.12) deserves attention[34].

Amphorae

The dome of San Vitale sits upon a drum, the latter constructed of entire amphorae, and the former of terra cotta tubes set horizontally end-to-end[35]. This feature

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[34] Complementary to the pattern recognition of the various column and base details, a statistical analysis may also be beneficial. For statistics in archaeology see Drennan 1996.

[35] 'The dome is curious in that it is constructed of earthen pots fitted into each other, those in the upper part being laid horizontally, thus producing a lightness of structure which did not require the arches and buttresses found necessary in SS. Sergius and Bacchus and S. Sophia, Constantinople. This remarkable construction in pottery is protected by a timber roof, thus differing from Roman usage and approximating to the practice [page 383] which prevailed among mediaeval architects' (Fletcher 1979:380-383). The dome of San Vitale 'is in reality an eight-sided 'cloister-vault', formed out of a continuous series of clay tubes, in effect hollow cylinders of brick' (Stalley 1999:70).

has been consistently identified as a characteristic of Italian workmanship and argued as "proof" of local craftsmen executing an eastern design[36]. It is significant that the same method of lightening the weight of the dome was employed in the baptistery of Albenga and in the Orthodox Baptistery at Ravenna[37]. Despite this building method, the design of San Vitale most closely follows that of the Arian baptistery of Ravenna.

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[36] '…the execution of the building [San Vitale] was entrusted to local craftsmen, as proved, for example, by construction of the dome, which is made not of bricks but earthenware tubes laid in horizontal courses' (Mango 1978:79).

[37] Stalley 1999:70. The "lineage" of this construction method includes 'some of the barrel vaults in the substructions of Septimius Severus on the Palatine' (Platner & Ashby 1929: http://penelope.uchicago.edu/ Pg.8) and the dome of the caldarium in the Baths of Caracalla (Ibid). In Rome this 'interlocking tubular vaulting' is represented in the decagonal pavilion in the Licinian Gardens ('Temple of Minerva Medica'), early 4th century (Ward-Perkins 1981 (1990):433-438).

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