Interdisciplinary Research Collegium in Advanced Maritime Systems Design

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Summary

- The education of naval architects, marine engineers and others who are the active contributors to the ship design processes is heavily focussed on engineering fundamentals, often aligned with traditional university course constraints.

- The concept of a research collegium is described whose aim is to provide an environment where young people in their formative post-graduate years can learn and work in a small, mixed discipline group drawn from the worldwide maritime community to develop their skills whilst completing a project in advanced ship design.

- The brief that initiates each project sets challenging user requirements which encourage each team to develop an imaginative solution, using their individual knowledge and experience, together with learning derived from teaching which form a common element of the early part of the collegium.
Contents of talk

• Concept of The LRET research collegium

• Carbon capture and storage (CCS)

• Ideas emerging from the research collegium
1. LRET RESEARCH COLLEGUIM CONCEPT
Motivation behind the collegium concept

• Successful ship and maritime systems design depends on the collaborative application of a broad range of engineering competences as the drive for improved efficiency and environmental performance places greater demand on the design community.

• The education of naval architects, marine engineers and others who are the active contributors to the ship design processes needs to be broadened from a focus purely on engineering fundamentals to other disciplines in sciences, social sciences, human sciences, humanities, etc.

• The LRET Research Collegium addresses this latter aspect.
Aim

• The aim of the research programme is to provide an environment where scholarly young people in their formative post-graduate years can learn and work in a small, mixed discipline group drawn from the maritime community to develop their skills whilst completing a project in advanced maritime systems design.

• The project brief will set challenging user requirements which will encourage each team of Scholars to develop an imaginative solution, using their individual knowledge and experience, together with learning derived from teaching which will form a common element of the early part of the programme.
Format

• The programme format provides adequate time for Scholars to enhance their knowledge through a structured programme of taught modules which will focus on the design process, advanced technologies, emerging technologies and novel marine solutions, regulatory and commercial issues, design challenges (such as environmental performance and climate change mitigation and adaptation) and engineering systems integration.

• Guest Lecturers are drawn from academic research and industry to provide a mind-broadening opportunity for the Scholars, whatever their original specialisation.
Outputs

• A scholarly report for free circulation

• A technical paper from each group suitable for publishing in a reputable, peer reviewed forum

• A group presentation to an invited audience of academics, industrialists, young engineers and students, in Southampton

• Individual presentations by attendees in their respective institutions and countries

• An article written for the man-on-the-street.
Outcomes

• Promotion of the collegium subject as widely as possible

• Recognition of the achievements of the young scholars

• Contribution to and influencing policy making/forming forums

• Acknowledgement of The LRET’s charitable contributions to education
An old idea revisited...

- Following 1980 Finniston report, Southampton part of first wave (1981) of UK integrated Master of Engineering (MENG 2+2)

- Novel feature was emphasis on group working with 50% of final year assessment based on a
  - Group Design (and build) Project
  - Multidisciplinary Project (MDP)

- LRET Colleguim took MDP and structured for a worldwide group of scholars to work towards a common goal over an extended period with support from leading thinkers in that area
Educational Aims

• Gaining experience of working as part of a team with different experiences and skills
• Tackling a new subject and finding a solution to a problem within a time-, human resource- and finance-constrained situation
• Tackling a real need/problem with industrial and commercial links
• Learning to meet both personal and group objectives
• Working and dealing with people from different cultural, social and educational skills backgrounds
• Handling organisation and administration for a project
• Developing communications and presentation skills
Project Brief 2011 Carbon Capture & Storage

(a) quantification of the environmental challenge;

(b) understanding of the geo-political legal-social context;

(c) possible techniques for sequestration;

(d) one engineering system to achieve CCS;

(e) economics and logistics challenges.

While all the groups/teams examined items (a) to (c), each team focused on just one (engineering) system in dealing with items (d) and (e).
The 2011 Collegium

• From 11 July till 2 September

• 19 scholars from universities in Yokohama, Harbin, Seoul, Pusan, Singapore (NUS and NTU), Aberdeen, Cardiff, UCL, Steven Institute of Technology and Southampton and Lloyd’s Register attended

• Scholars split into three teams of five and one team of four
## Project Supervisors and Student Mentors

### Project Supervisors

<table>
<thead>
<tr>
<th>Group</th>
<th>Supervisors</th>
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<tbody>
<tr>
<td>Group A</td>
<td>Professor Philip Wilson and Professor Stephen Turnock</td>
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<tr>
<td>Group B</td>
<td>Dr. Dominic Hudson and Professor Philip Wilson</td>
</tr>
<tr>
<td>Group C</td>
<td>Professor Ajit Shenoi and Dr. Dominic Hudson</td>
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<tr>
<td>Group D</td>
<td>Professor Stephen Turnock and Professor Ajit Shenoi</td>
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</table>

### Student Mentors

Messrs. Jonathan Gravina, Tom Lloyd and Matt Streeter
<table>
<thead>
<tr>
<th>Time</th>
<th>Monday, 11/07/11</th>
<th>Tuesday, 12/07/11</th>
<th>Wednesday, 13/07/11</th>
<th>Thursday, 14/07/11</th>
<th>Friday, 15/07/11</th>
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<tbody>
<tr>
<td>0900-0950</td>
<td>Welcome LRET</td>
<td>Lecture, Reeve &amp; Melin Overview, LR</td>
<td>Library familiarisation</td>
<td>Lecture Tsimpolis</td>
<td>Lecture Wu</td>
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<tr>
<td>1000-1050</td>
<td>Group introductions</td>
<td>Lecture, Reeve &amp; Melin Overview, LR</td>
<td>Library familiarisation</td>
<td>Lecture Tsimpolis</td>
<td>Lecture Wu</td>
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<td>1110-1200</td>
<td>Group introductions</td>
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<td>Computing familiarisation</td>
<td>Library search and reading (Individual)</td>
<td>Project Discussion (groups + mentors)</td>
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<tr>
<td>1210-1300</td>
<td>Introduction to Collegium</td>
<td>Lecture, Reeve &amp; Melin Overview, LR</td>
<td>Computing familiarisation</td>
<td>Library search and reading (Individual)</td>
<td>Project Discussion (groups + mentors)</td>
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<td>1300-1400</td>
<td>Lunch</td>
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<tr>
<td>1400-1450</td>
<td>Introduction to mentors</td>
<td>Project Discussion (groups + mentors)</td>
<td>Library search and reading (Individual)</td>
<td>Project Discussion (groups)</td>
<td>Presentations of progress (group wise)</td>
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<tr>
<td>1500-1550</td>
<td>Registration formalities</td>
<td>Project Discussion (groups + mentors)</td>
<td>Library search and reading (Individual)</td>
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<td>1710-1800</td>
<td>Meet with FSI (wine and nibbles)</td>
<td>Project Discussion (groups)</td>
<td>Library search and reading (Individual)</td>
<td>Project Discussion (groups)</td>
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<td>Lecture Arai</td>
<td>Lecture Bruno</td>
<td>Lecture Bucknall</td>
<td>Private study and reading (Individual)</td>
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<td>Lecture Arai</td>
<td>Lecture Bruno</td>
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CLIMATE CHANGE
Climate change

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years – sometimes used to refer specifically to climate change caused by human activity, as opposed to changes in climate that may have resulted as part of Earth's natural processes.
Consequences of climate change

• Over the last 100 years, the average air temperature near the Earth’s surface has risen by a little less than 1ºC
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• Projections from IPCC indicate that global surface temperature will probably rise a further 1.1° - 6.4°C during the 21st century

1.1° - 6.4°C does not seem to be much!

Consider this: at the end of the last ice age, when the northern part of American continent was covered by more than 3,000 feet of ice, average temperatures were only 5 to 9 degrees cooler than today.
Consequences of climate change

• Over the last 100 years, the average air temperature near the Earth’s surface has risen by a little less than 1°C

• Projections from IPCC indicate that global surface temperature will probably rise a further 1.1° - 6.4°C during the 21st century

• During the 20th century, sea level rose about 15-20 cm (roughly 1.5 to 2.0 mm/year), with the rate at the end of the century greater than over the early part of the century
Consequences of climate change

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- Projections from the Intergovernmental Panel on Climate Change (IPCC) indicate that Earth’s temperature will probably rise a further 1.1º – 6.4ºC during the 21st century.

- During the 20th century, sea level rose about 15-20 cm (roughly 1.5 to 2.0 mm/yr), with the rate at the end of the century greater than over the early part of the century.

- Over the 21st century, the IPCC’s Fourth Assessment projected that thermal expansion will lead to sea level rise of about 17-28 cm (± 50%).
Consequences of climate change 2

- Melting of Glaciers and Ice Sheets
- Ocean Acidification
- Thermohaline Circulation

Historically, ocean pH has averaged around 8.17, meaning that ocean waters are slightly basic. But with the rising CO₂ concentration causing acidification, today the pH levels are around 8.09, edging the waters closer to neutral (i.e. 7).
Causes of climate change

• According to DirectGov (a UK government website): *There is very strong evidence that people are changing the climate with actions that create emissions of greenhouse gases like water vapour, carbon dioxide, methane, SOx, NOx, etc.*

• The greenhouse gases trap heat near the Earth's surface.
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• The greenhouse gases trap heat near the Earth's surface.

*Collegium focus was on mitigation of one facet, namely CO$_2$*
CO$_2$ in atmosphere

• The concentration of CO$_2$ in the Earth's atmosphere is approximately 391 ppm by volume as of 2011 and rose by 2.0 ppm/yr during 2000–2009.

• 40 years earlier, the rise was only 0.9 ppm/yr, showing not only increasing concentrations, but also a rapid acceleration of concentrations. The increase of concentration from pre-industrial concentrations has again doubled in just the last 31 years.
Sources of atmospheric CO$_2$

Burning fossil fuels such as coal and petroleum is the leading cause of increased anthropogenic CO$_2$.

8.67 GT of carbon (or 31.8 GT of CO$_2$) were released from fossil fuels worldwide in 2008, compared to 6.14 GT in 1990.
Carbon capture and storage (CCS), alternatively referred to as carbon capture and sequestration, is a means of mitigating the contribution of fossil fuel emissions to global warming. The process is based on capturing CO$_2$ from large point sources, such as fossil fuel power plants, and storing it in such a way that it does not enter the atmosphere.
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**CCS in ocean space** was chosen as the topic for the 2011 research collegium.
LRET COLLEGUIM OUTPUTS SUMMER 2011
CCS – the coverage
Group A – Guidelines for implementing CCS in China I

Largest emitter of CO₂ and projected to continue growing

Relatively new technology in China

Government is proactive in green energy & sustainable planning
Group A – Guidelines for implementing CCS in China II

Capture
  Amines
  Membranes

Transport
  Onshore Pipeline
  Offshore Ships

Ocean Storage
  Subsea Geological
  Direct Injection

Diagram:

- **Capture**
  - Post-combustion amine separation
  - Post-combustion membrane separation

- **Transport**
  - Pipelines & Ships

- **Storage**
  - Available subsea storage space?
    - No
    - Yes:
      - Direct Injection into Ocean Space
      - Injection into Subsea Saline Aquifer
Group B – Offshore thermal power with CCS

Conventional Approach
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Offshore Thermal Power
Group B – Offshore thermal power with CCS

Offshore Thermal Power
Group C – Key to successful CCS; engaging the public

Green Town Concept

I. Air capturing facility to remove CO₂ from air
II. Captured CO₂ is transported by pipelines
III. CO₂ is stored in geological formation
Group C – Key to successful CCS; engaging the public II

How can we prove “Green Town” is a good idea?
Group C – Key to successful CCS; engaging the public III

Surveys

Objectives:
• Is “Green Town” popular?
• Does “Green Town” help to promote CCS?
• What are the best methods to promote CCS?

Table Samples Collected in Southampton and Hamburg

<table>
<thead>
<tr>
<th></th>
<th>Total Samples</th>
<th>Locals</th>
<th>Confidence Level</th>
<th>Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southampton</td>
<td>158</td>
<td>100</td>
<td>95%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Hamburg</td>
<td>366</td>
<td>248</td>
<td>95%</td>
<td>6.3%</td>
</tr>
</tbody>
</table>
Group D – Offshore Renewable Energy Powered CO₂ Injection; concept

- Pipe CO₂ gas from Drax power plant to offshore field (Audrey) in Southern North Sea gas basin

- Lay subsea electrical cable from Sheringham Shoal wind farm to platform for power supply

- Retrofit the existing Audrey platform & reconfigure for CO₂ injection
Group D – Offshore Renewable Energy Powered CO₂ Injection; systems approach
Reports

Carbon Capture and Storage in Deep Ocean Space for the 21st Century
Guidelines for Implementation in China

Elizabeth A. Livermont, Yongjie Koh, Taurai Mlambi, Matesa Bhawanis, Binbin Zhao

Offshore Thermal Power with CCS
An Alternative to CO₂ Transportation

Björn Winstein, Mingsheng Chen, Ryoji Ohamoto, Do Kyun Kim, & Elizabeth McCaffrey

The Key to Successful Carbon Capture and Storage
Engaging the Public

Ning Cheng, Meriam Firth, Michael Charles Johnson, & Zhi Yung Tay

Offshore Renewable Energy Powered CO₂ Injection
A Small Carbon Footprint Solution

Achun Feng, Eunyoung Kim, Xiaofan Li, Zeeshan Riaz, & Justin Wier
Closure

• The LRET Collegium 2011 successfully achieved two of the three outputs, namely the report and layman article, with the third output, the technical article, being work in progress.

• Tangible steps are underway to achieve the stated outcomes: of generating interest in CCS and influencing people in policy directions; of celebrating the success of young scholars from around the world; and of widening and deepening awareness of The LRET’s activities and its aims.
The Future

• Two more summer programmes are proposed in Southampton in 2012 and 2013

• Full scholarships provided via LRET for all students attending

• Applications sought worldwide encouraging both industry and academic participants. Seeking ‘the best’ and the likely next generation leaders in maritime sector. Network of LRET UTC provided many links.

• Generous support of LRET and its vision for future maritime education very gratefully acknowledged
Was it all hard work (ctrl-shift H)?

- Justin’s travels