AMPLIFIRE

Amplifying Future Internet Research and Experimentation for a Sustainable Future

AMPLIFIRE

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D1.2 FIRE FUTURE STRUCTURE AND EVOLUTION REPORT

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Executive Summary

One of the key tasks of the AmpliFIRE Coordination and Support Action is to identify strategic directions for the FIRE programme in order to make recommendations to the European Commission and establish common ground within the FIRE community. This document presents our findings until March 2014. Building on former work regarding the FIRE vision and scenarios, it centres around the concept of the *FIRE Ecosystem* and identifies strategic options for further evolution of the FIRE Ecosystem towards 2020. The document proposes a mission statement, a set of strategic objectives and an overview of strategic actions in domains such as: FIRE infrastructures and facilities, services, collaboration, and ecosystem building.

We highlight some of our findings, with a view towards the work in the next period within AmpliFIRE and with the FIRE community.

- The SWOT analysis revealed the strength of FIRE in terms of a large, diverse portfolio of experimental facilities, increasingly federated and supported with tools, and responding to the needs and demands of a large scientific experimenter community. We also identified weaknesses in terms of a lack of sustainability of facilities after project end, limited industry and SMEs involvement, and a not well developed ecosystem given the present challenges. A threat is the possibility of diminished EC funding after 2015.
- We also see a lot of opportunity as regards continuing federation, laying the basis of strong collaboration among facilities and providing more easy access to users. Opportunities are also in connecting with and enabling related Future Internet initiatives and Smart City initiatives. Developing a full service approach addresses the gaps between ecosystem layers, increases FIRE's visibility and addresses integration issues that are only now coming up in other Future Internet-funded projects.
- A challenge is to expand the nature of FIRE's ecosystem, from an the offering of experimental facilities towards the creation of an ecosystem platform capable to attract market parties from different sides that benefit from mutual and complementary interests.

An analysis of FIRE's position leads us to several conclusions regarding the future direction of FIRE. In particular, FIRE strategy should address the following interlinked aspects.

- Achieve longer term financial sustainability, becoming less dependent on the Commission funding.
- Expand the community, from mostly experimenters in academic and research institutes towards a wider spectrum of actors in a growing FIRE ecosystem, including large businesses and SMEs, and other initiatives or programmes that may use the solutions being experimented with such as Smart Cities and other customers.
- Develop collaborative links to related Future Internet initiatives, aimed at sharing knowledge, technologies and facilities, and at creating new services for a wider range of customers.
- Reformulate the FIRE value proposition, including FIRE's service portfolio, the range of target groups to whom the service portfolio is delivered, and the access channels or platforms for delivering the service in a customized manner. Also the concept of Testbed as a Service needs to be further developed in close collaboration with the FIRE existing and potential users to be able to serve a wider user-base. FIRE for and by the FIRE users!

FIRE's current mission and value of is to offer an efficient and effective federated platform of core facilities as a common research and experimentation infrastructure related to the Future Internet; this delivers innovative and customized experimentation capabilities and services not

achievable in the commercial market. For the future, FIRE should expand its facility offers to a wider spectrum of technological developments in EC programmes e.g. in relation to smart cyber-physical systems, smart networks and Internet architectures advanced cloud infrastructure and services, 5G network infrastructure for the Future Internet, Internet of Things and platforms for connected smart objects. In this role, FIRE delivers experimental testing facilities at low costs based upon federation, expertise and tool sharing, and offers all necessary expertise and services for experimentation on the Future Internet part of H2020.

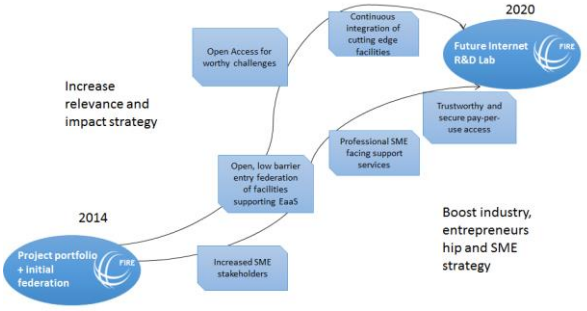
In the medium term, FIRE's mission and added value is to support the Future Internet ecosystem in building, expanding and continuously innovating the testing and experimenting facilities and tools for Future Internet technologies. In this way FIRE is able to continuously include novel cutting-edge facilities into this federation to expand its service portfolio targeting a range of customer needs. FIRE will also include "opportunistic" experimentation resources, e.g., crowd sourced or citizen or community provided resources. In the longer term, FIRE's positioning is to become the R&D&I environment, or "accelerator" within Europe's Future Internet innovation ecosystem, providing the facilities for research, early testing and experimentation on the Future Internet and accelerating Future Internet technology-induced innovation cycles resulting in advanced applications and business support, and eventually the creation of new business. The overall strategic objective for FIRE is to become a sustainable 'R&D lab' like facility for research in the Future Internet; supporting researchers and the community to tackle important problems, and acting as an accelerator for industry and entrepreneurs to take novel ideas closer to market.

FIRE is Europe's open lab for Future Internet R&D&I. FIRE is the accelerator within Europe's Future Internet innovation ecosystem. FIRE is sustainable, part of a thriving platform ecosystem, and creates substantial business and societal impact through resolving societal challenges.

The strategy to realize this future role is multidimensional and this report proposes a set of strategic objectives aimed at 2020, and a range of activities to realize the 2020 objectives. The strategy includes the following recommendations:

- Establish an easily accessible network of open and shared experimental facilities and platforms and create partnerships with other Future Internet initiatives to realize this.
- Target industry and SME innovators by establishing an "accelerator" functionality, starting with creating a market interface aimed at aligning demands and offers.
- Increase the number of experiments and experimenters using FIRE, attracting new user / stakeholder groups such as large ICT companies, developer companies, SME innovators, Smart Cities and regions, and other EC programmes.
- Target business innovator needs related to accelerating product and service innovation and go-to-market, addressing the needs and demands of companies in different stages of their development lifecycle. Work together with innovation intermediaries.

The report proposes a strategic direction for FIRE in a high-level roadmap of strategic milestones. This will be further elaborated during 2014 in AmpliFIRE's FIRE Roadmapping initiative.



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1. Introduction

1.1 Objective and context

One of the key tasks of AmpliFIRE as a Coordination and Support Action is to identify strategic options for the evolution of the FIRE ecosystem, making recommendations to the European Commission and establishing a shared perspective within the FIRE community. This D1.2 document presents our findings until M15 (March 2014).

The work on FIRE strategy has evolved from the FIRE vision and scenarios development (D1.1, M6) and the already issued FIRE Strategy White Paper in M10 (October 2013). It also relates closely to the FIRE Roadmapping activity in T1.3 which has started recently. Fig. 1 visualises that whereas the FIRE Radar is organised into three key activities of vision and scenario building (T1.1), strategy development (T1.2) and strategy implementation (T1.3), the FIRE strategy work is strongly connected to and integrates aspects of several tasks in other work packages, in particular T2.1 (capabilities and resources), T2.2 (Experimenter demands), T3.1 (Collaboration) and T3.2 (Service portfolio).

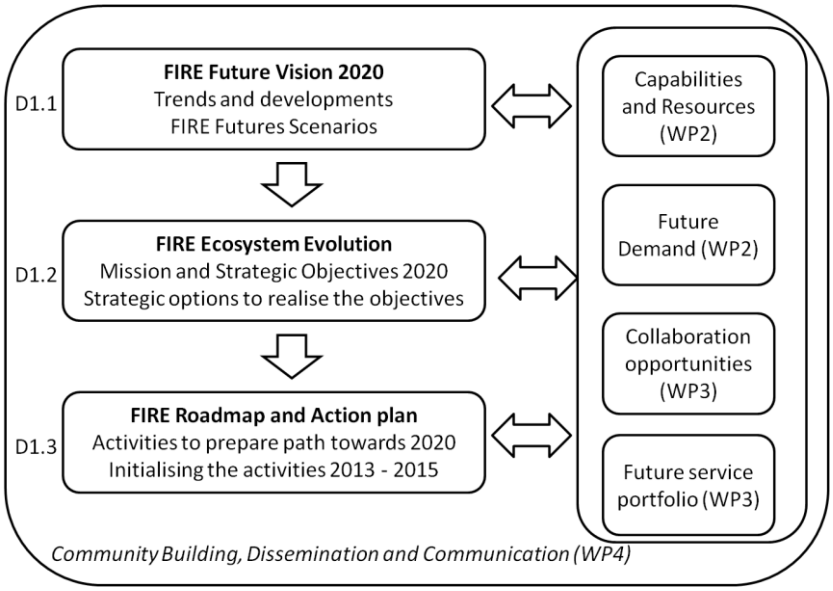

Fig. 1: Context of FIRE Strategy within AmpliFIRE

The work on FIRE strategy has evolved within the context of the FIRE community discussions as well. FIRE strategy discussions began at the 1st FIRE Forum and Board meetings held in October 2013 and continued at the 2nd FIRE Board in January 2014. A FIRE Strategy Working Group was set up, involving experts from both within and outside the traditional FIRE community. Starting in April 2014, a FIRE Roadmapping activity has been initiated, to be supported by electronic polls.

An important element of the context of FIRE strategy work is the vision of the FIRE unit E4 as regards the longer term objectives of FIRE. Regarding the long-term evolution of FIRE, the E4 unit states[1]: *"Our vision is to find long-term solutions for the sustainability of the experimental platforms in terms of funding and operations; and at the same time to extend and link them to a broad range of Member States or non-EU experimental facilities. The aim is to build progressively a strategic infrastructure of shared experimental facilities and platforms, at the service of the European economy at large".*

[1] http://ec.europa.eu/dgs/connect/en/content/future-internet-research-and-experimentation-long-term-evolution

And the unit defines as a priority: *"Our priority is to encompass novel concepts like Experimentation-as-a-Service, pan-European set ups and virtualisation of networks".*

With the current Horizon 2020 LEIT Work Programme, FIRE's foreseen evolution has been defined until 2015 (FIRE+). Our strategy work in AmpliFIRE aims at working closely with the FIRE community and the European Commission to prepare for the period until 2020, starting with the Work Programme 2016-2017 which will be prepared in the course of this year.

1.2 Approach and activities

FIRE Strategy's domain of work is the FIRE ecosystem: the actors and their interactions, programme structures, projects, funding models and other determining elements that comprise FIRE as an ecosystem. This ecosystem changes over time as a result of both external drivers and internal developments. FIRE strategy aims to identify the options and steps that result in or contribute to a future viable FIRE ecosystem.

The approach we take to FIRE Strategy can be summarized in terms of "substance" and "process". In terms of "substance", the FIRE vision and scenarios from the D1.1 [M6] give us the background and starting point in order to rethink and make precise FIRE's mission, objectives, positioning and strategy for the future. The D1.1 [M6] scenarios gave us alternative FIRE futures to explore and discuss within the FIRE community, but not yet a clear formulation of FIRE's mission and added value. The objective of D1.2 is to facilitate agreement within the FIRE community on a pathway towards the future. This path will be debated for some time and in this respect the current D1.2 [M15] must be considered as work in progress and definitely not final.

In terms of "process", AmpliFIRE deployed a range of activities to discuss aspects of FIRE Strategy within the FIRE community and to align with the Commission views. These include:

- FIRE community workshops in which elements of FIRE strategy are discussed. In particular the pre-FIA workshop in Athens discussed aspects of FIRE strategy as regards capabilities and resources, collaboration, and FIRE's future evolution (March 2014).
- Creation of the FIRE Forum as a community bringing together the "wider" FIRE community, including representatives from FIRE projects but also organizations and initiatives such as EIT ICT Labs, FI-PPP, 5G-PPP, Living Labs, Smart Cities and other. The FIRE Forum so far has convened once, in October 2013.
- Creation of the FIRE Board and a Working Group on FIRE Strategy. The FIRE Board convened twice, in October 2013 and January 2014. On both occasions, FIRE strategy was discussed. The Board established a FIRE Strategy Working Group, which held two meetings, 27th January 2014 and 14th April 2014.
- In the context of FIRE's future vision, setting up electronic polls to communicate with the wider FIRE community. This is to start in April 2014.
- Use of LinkedIn and Futurium to discuss FIRE vision and strategy issues. This also is to start in April 2014.
- Setting up a FIRE Roadmapping initiative as shared concern of tasks T1.2 and T1.3. This initiative was started during FIA 2014 (March 2014) with an interactive workshop session.
- Writing two White Papers to stimulate discussion: one white paper on "FIRE Strategy", another (in draft) on "FIRE Positioning". The material of both is included in this deliverable.

As Fig. 2 visualises, developing the FIRE strategy towards 2020 is part of an iterative process starting with mission and vision development, determining the strategic objectives of FIRE, and eventually proposing the strategic activities to realize the vision. The role of the FIRE strategy process is not to prescribe a rigid course of action. FIRE strategy development, grounded in a vision and mission, is based on understanding the uncertainties surrounding FIRE and identifying (and nurturing) the various future options available, to (re-)define FIRE's high-level strategic objectives, and to set out a basic plan to achieve these goals where the need is foreseen to anticipate to uncertainties and opportunities and to adapt and anticipate to upcoming changes in the environment.

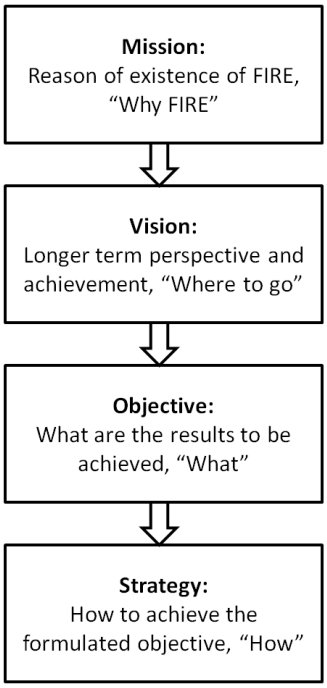

Fig. 2: Strategy development process

FIRE strategy comprises different aspects of FIRE's ecosystem such as service provision, facility development, funding base, knowledge base development, collaboration, customer strategy, internationalisation and others. Our goal is to define a broad, longer term strategic plan for the period 2016 – 2020. The strategy activity aims to support the European Commission and FIRE stakeholders to build consensus on such plan, preparing for joint collaborative activities regarding FIRE that can be part of the next Work Programme 2016-2017. The FIRE Strategy activity will also lay the groundwork for a future "FIRE Business Plan and Roadmap to Sustainability".

1.3 Structure

Clearly the D1.2 is work in progress and at this point the report is set up as input for further discussions within the FIRE community. Several issues are in discussion, notably collaboration strategy with other Future Internet initiatives, FIRE's internationalisation, customer and user strategy and other. This also means that there are several open issues.

Chapter 2 presents the points of departure. In particular the current view of the European Commission regarding FIRE's mission and evolution, the discussions concerning sustainability, and the position of FIRE in the overall Future Internet landscape in relation to other initiatives.

Chapter 3 on FIRE's mission and strategic objectives can be seen, together with Chapter 4, as the core. Taking the departure in the Future scenarios of D1.1, the chapter proposes a definition of FIRE's mission, strategic objectives and added value based.

Chapter 4 elaborates the overall strategic direction for FIRE and formulates several recommendations. Chapter 5 provides some further exploration of FIRE strategies in specific domains such as collaboration, services, infrastructure and ecosystem.

Chapter 6 brings some of the former analysis in context as it reflects on FIRE's future business model. Finally, chapter 7 provides a concise outlook to the follow-up activities.

2. FIRE's Current Position

2.1 Overview

This chapter presents the points of departure in rethinking FIRE's mission, objectives, positioning and strategic options. We start with some thoughts about the FIRE ecosystem and FIRE's current position in the Future Internet landscape. Thereafter we address FIRE sustainability and business model, the European Commission Unit E.4 current vision regarding FIRE, and we give a short assessment of FIRE's international position. The chapter ends with a SWOT summary of strengths, weaknesses, opportunities and threats.

2.2 FIRE and the Future Internet ecosystem

The FIRE ecosystem comprises the actors and their interactions, programme structures, projects, infrastructures, knowledge platforms, funding models and other determining elements. The interactions between them shape FIRE as an "ecosystem". Fig. 3 visualises a conceptual, analytical view of the FIRE ecosystem[2] that is aimed at helping us to bring more structure in the strategic options for future evolution of the Ecosystem. It points to both "FIRE internal" developments as well as to "external" factors potentially affecting the FIRE ecosystem[3].

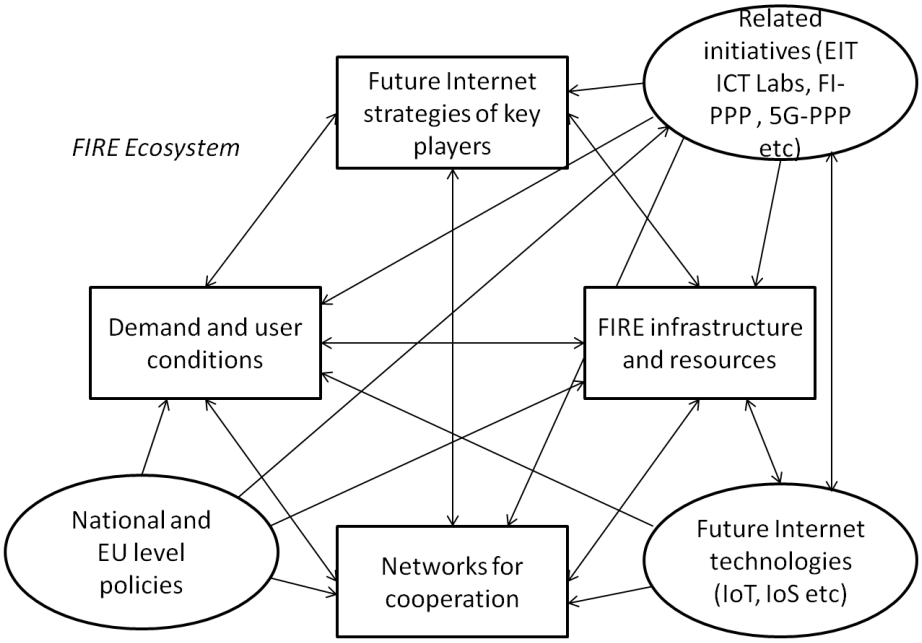

Fig. 3 FIRE's Ecosystem, a conceptual view

Our main point here is that FIRE ecosystem's future evolution depends not only on its own internal evolution as a programme, but (also) on how it will relate to other actors, initiatives and facilities and **how it will evolve as part of the wider "Future Internet Ecosystem"**. How will FIRE develop relations with other Future Internet initiatives, how will it be part of a wider policy agenda, how will it benefit from and contribute to a wider set of technological innovations, how will it create a platform ecosystem are key questions from this perspective.

[2] Inspired by M. Porter's „Diamond" approach for modelling the attractiveness of clusters and competitiveness of nations and regions. In turn, Porter's work derives from innovation systems thinking brought forward by Freeman, Lundvall and others.

[3] Further details are in the FIRE Strategy White Paper (October 2013).

In this respect, the relatively new concepts of **platform ecosystem** and multi-sided platforms are crucial[4]. The main point is that, unlike traditional notions of the firm's value chain and supply chain where a firm receives inputs from suppliers to produce products and services delivered to its customers, a (multi-sided) platform-based activity brings together and enables direct interactions within a value network of customers, suppliers, developers and other actors. Similarly, the range of FIRE facilities and services can be seen as constituting a platform ecosystem facilitating multi-sided interactions. For example, developer communities may use the FIRE facilities to directly work with business customers on technology and product development, whereas the current FIRE service model focuses on giving researchers and experimenters access to FIRE facilities.

The question is then to what extent the current FIRE ecosystem realizes its opportunities and what the strategic options are to extend the current FIRE model to a platform-based ecosystem model. This issue deserves further attention in AmpliFIRE.

We can think of the wider Future Internet ecosystem (or landscape) at different levels of description. The first two will be dominant in this report.

- **Actor level**. The level of Future Internet actors and their roles, interests and interactions. This level is including those actors that shape the Internet as a technical ecosystem (actors involved in policies, standards etc). However our focus is predominantly on the FIRE value network actors such as research institutes, facility providers, business users, developer communities and other.
- **Programme level.** The level of Future Internet research and innovation initiatives, programmes and projects, including the processes and procedures for programme governance (led by the European Commission).
- **Technical level**. The level of the Internet as a technical system, of protocols and standards, networks, components, services, data etc. including the organizations that are responsible for naming, addressing, standards development and other activities[5].

Fig. 4 presents a view of the Future Internet landscape[6]. The different layers represent some of the key activities such as Future Internet research, clustering and collaboration, networking and industry involvement. A drawback of this picture is that FIRE as a programme and infrastructure of facilities is not very well visible as such and also the various activities and initiatives in the Future Internet research, experimentation and innovation cycle are not well visible.

However the picture serves an initial goal to create awareness of the special role of FIRE in this ecosystem. FIRE is at the forefront as it comes to testing and experimenting on technologies that shape the Future Internet and has created a range of facilities and projects that enable such experimenting on the Future Internet.

[4] See: D.S. Evans, A. Hagiu and R. Schmalensee, "Invisible Engines. How Software Platforms Drive Innovation and Transform Industries". MIT Press (2006). Also: M. Cusumano, A. Gawer, „The Elements of Platform Leadership" (2002).
[5] For a detailed description of the Internet Ecosystem from this perspective see: ISOC (2010)
[6] Source: Didier Bourse, Alcatel-Lucent.

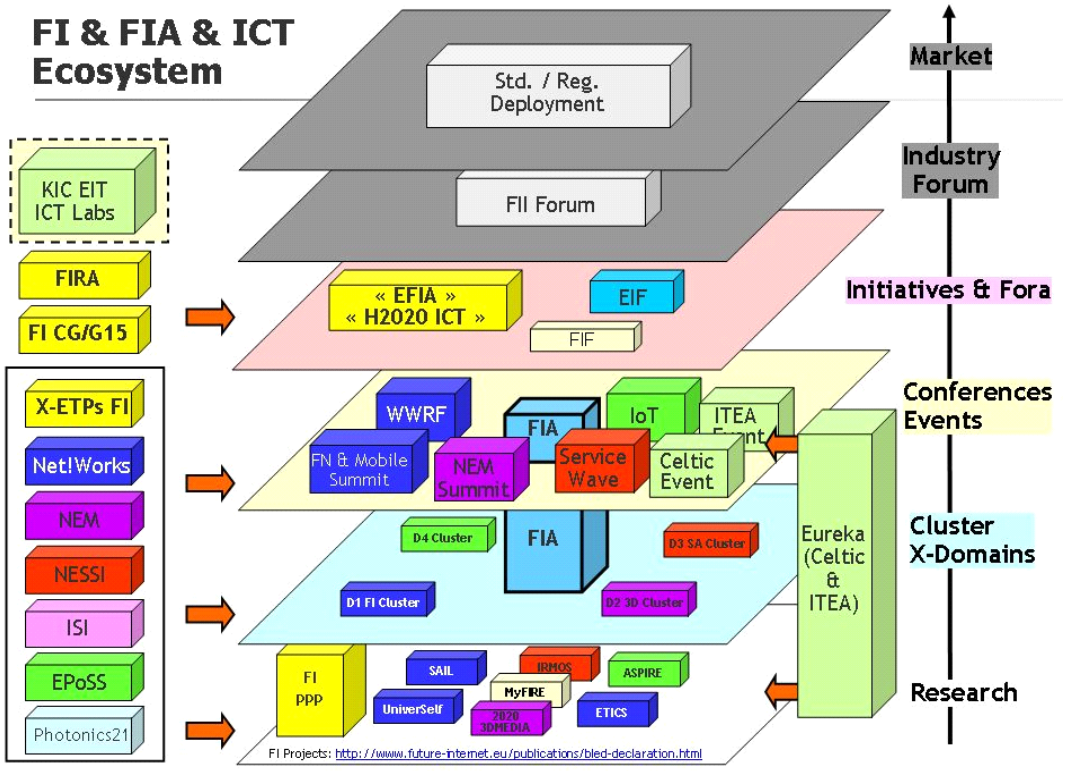

Fig. 4 Future Internet Ecosystem (author: D. Bourse)

Some points of departure for positioning of FIRE within the Future Internet landscape:

- We foresee a layered Future Internet infrastructural and service provision model where a diversity of actors bring in their resources and services e.g. providing connectivity, offering testbed and experimentation facilities, provision of research and experimentation services, business support services and more. Bottom-up experimentation resources are part of this, e.g. crowd sourced or citizen or community provided resources. Each layer is transparent and offers interoperability.
- Research networks NRENs and Géant are providing the backbone networks and connectivity, to be used by FIRE facilities and facilities of other providers.
- FIRE's key asset is to provide and maintain sustainable, common facilities for Future Internet research and experimentation, and to provide customized experimentation and research services. In doing so, FIRE will work together with actors providing complementary facilities and services. FIRE is longer term oriented, thus needs to be able to invest to modernize and innovate the experimental infrastructure for tomorrow's demands.
- FIRE delivers experimental facilities and services to a range of users. FIRE's traditional user category is scientific research institutes. Users include other initiatives related to the Future Internet, e.g. FI-PPP, which is market oriented, 5G-PPP, IoT initiatives, as well as EIT ICT Labs. FIRE also serves commercial enterprises and SMEs.
- FIRE could make use of, or collaborate on offering, services and facilities of other players e.g. EIT ICT Labs as regards education and business support.

The positioning of FIRE within the landscape gives rise to a number of opportunities regarding collaboration and ecosystem building. This will be covered in later chapters.

2.3 FIRE's positioning vs. related initiatives

Fig. 5 visualises the areas of relevance for FIRE in the context of the mentioned initiatives. The next paragraphs identify the positioning of FIRE vs Géant, EIT ICT Labs, FI-PPP, Living Labs and Smart Cities initiatives.

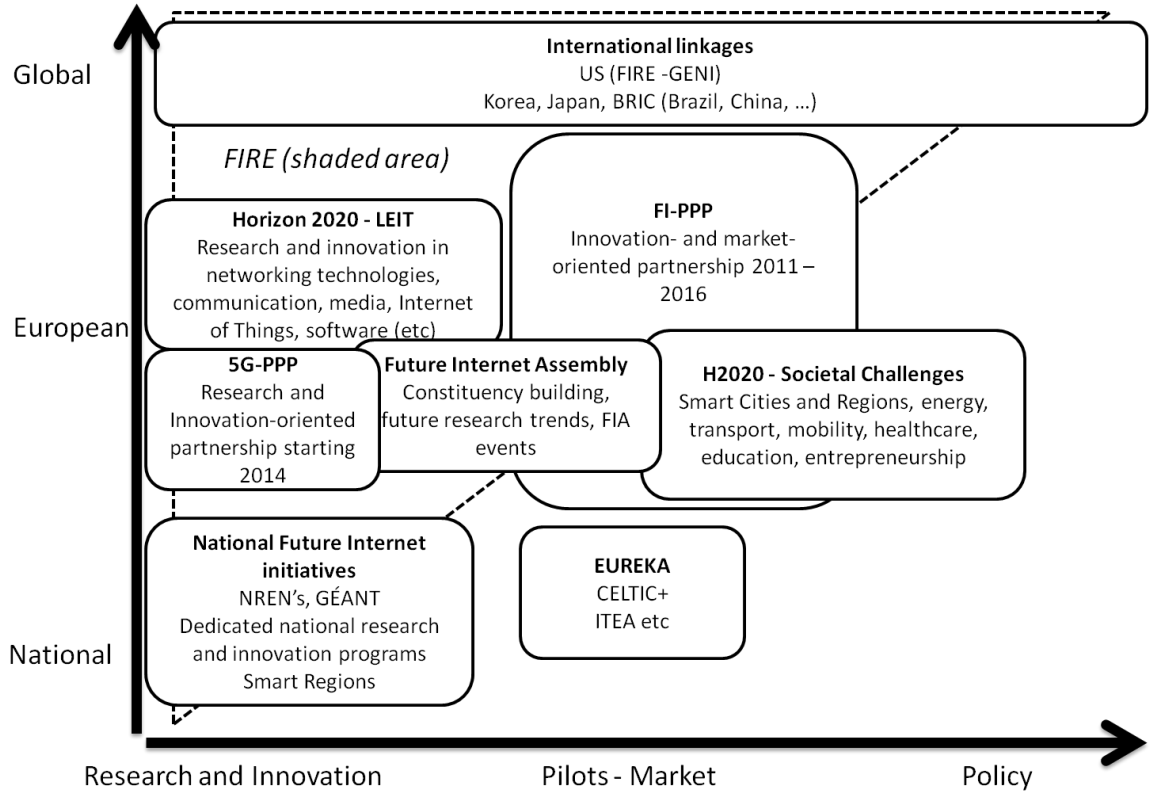

Fig. 5: Positioning of FIRE versus related initiatives[7]

2.3.1 FIRE and NRENs, GÉANT

Géant, linking NRENs, manages the pan-European networking infrastructure for research and education and provides connectivity to research infrastructures. It also acts as a testbed for new technologies, and plans to offer Testbed-as-a-Service. Although primarily working with research institutes it is also working with enterprises. Activities it aims to work on for Horizon 2020 comprise network architecture, technology testing for service specific applications and other.

Positioning. FIRE and Géant are complementary. Géant can offer high-bandwidth connectivity between multiple sites across Europe for inter-connection between testbeds. This has already been explored by existing FIRE initiatives: CONFINE, BonFIRE, FEDERICA, OpenLab, and NOVI. FIRE facilities are users of Géant buiding blocks, adding services such as testbed access. FIRE aims to increase that use in the years to come as described in H2020-LEIT. Géant is mostly working with (national) research institutes whereas FIRE (in principal) addresses a wider range of customers. Both FIRE and Géant are there for the longer term and could bring collaboration based on complementary assets on a higher level.

[7] This picture is an AmpliFIRE adaptation of an earlier picture from the European Commission DG INFSO.

Collaboration. Collaboration between FIRE and Géant currently includes FIRE projects OFELIA (Open Flow based SDN solutions) and Fed4FIRE, and earlier FEDERICA (Federated infrastructure for Future Internet research). Collaboration will enable the provision of a wide range of experiment services besides connectivity for core facilities of FIRE and bandwidth-on-demand. Géant Open Calls to make use of its facilities are interesting for the FIRE community. For FIRE, this is a chance to access more experimental infrastructure at a lower level, which is vital to FIRE and to better serve full-scale operation capacity of testbed facilities. For the purpose of advanced networking experimentation in FIRE, Géant would need to provide cutting-edge technologies in collaboration with FIRE. For obtaining Géant access, there must be a linkage to research and education – a condition that FIRE projects usually fulfil.

2.3.2 FIRE and EIT ICT Labs

EIT ICT-Labs is an initiative aiming at a wide spectrum of ICT innovation, linking education, research and business and stimulating entrepreneurship across Europe. Through its partner nodes, EIT ICT Labs has access to a variety of local testbed facilities[8]. Several FIRE partners are also partner of EIT ICT Labs. At the moment there are initiatives to explore FIRE facilities for industry by establishing a testbed brokerage service as part of EIT ICT Labs. The first step is to offer services from Onelab (www.onelab.eu) and the FUSECO facility

Positioning. FIRE and EIT ICT Labs are highly complementary. The fact that several stakeholders are in both initiatives increases the prospects for future collaboration based on mutual advantage. FIRE offers a range of (federated) testbed facilities and experimentation services that can be of use for EIT ICT Labs. FIRE will benefit from the EIT ICT Labs business driven and entrepreneurial approach to go beyond mainly targeting research and experimentation and to also serve business growth and innovation take-up. Currently FIRE lacks the impact of directed business outreach that EIT performs. FIRE can also learn from EIT as regards education, although interesting activities have started under the new STREP project FORGE.

Collaboration. The goal of collaboration could be to realize efficiency and new services in sharing of infrastructures (FIRE), node facilities (EIT ICT Labs), exploitation capabilities (EIT ICT Labs), educational platforms (EIT ICT Labs). The win-win is that FIRE can add exploitation capability and attract business interest while EIT ICT Labs may widen its set of available testing and research infrastructures, also for educational purposes. The CI-FIRE CSA has the task to specify the collaboration opportunities between FIRE and EIT ICT Labs. AmpliFIRE would use the results as input to an over-all collaboration agreement framework.

2.3.3 FIRE and the Future Internet PPP's

FI-PPP is a large-scale market and innovation oriented Future Internet research partnership. Key projects are FI-WARE (Future Internet platform) and FI-Lab, XIFI (infrastructure) and Use Case projects addressing various sectors. The FI-PPP concludes in 2016. The 5G-PPP is a new initiative, addressing advanced 5G network infrastructure.

Positioning. Within FI-PPP, in particular, XIFI and FI-WARE are relevant projects, facilitating large scale experimentation and testing for Future Internet projects, applications and service developments. Linkages with FIRE already exist and FI-PPP offering includes the exploitation of FIRE experimental facilities, services and experiments to the larger scale and

[8] To be checked is whether these are also in FIRE, e.g. GRID 5000 is part of the Paris node and also part of BonFIRE and FED4FIRE, but they could be completely separated entities under the Grid 5000 umbrella.

industry-oriented FI-PPP facilities. For this to happen FIRE facilities should meet the FI-PPP demands and requirements such as migration and interoperability issues, to ensure an appropriate scaling up and to investigate the partnership requirements from the federation and distribution concepts of FIRE (multiple partners (infrastructure owners) are involved and therefore the relationship among them in the value chain needs to be investigated for understanding what is the best possible business model in such a situation).

Both at the technical and business levels there are differences to consider between FI-PPP and FIRE. The two target different stakeholders at present: research (FIRE) versus business and SMEs (FI-PPP). This also explains the technical differences. FI-WARE and XIFI offer a service composition model (web-based technologies) while FIRE is predominantly based on experimental testbeds (e.g. OMF technologies). The transition of users from one to the other is not trivial. So far FI-WARE and XIFI have not explored this to the full extent. The FIRE Forum (October 2013) made clear that there is a limited understanding between the communities. This is definitely an issue that AmpliFIRE should take up.

Regarding the new 5G-PPP, FIRE's potential contribution should be assessed in more detail.

Collaboration. A goal of collaboration between FIRE and FI-PPP could be, in the XIFI Open Call, to exploit the potential for using FIRE testbeds in FI-PPP Phase 3 Generic Enabler pilot trials. Although this currently seems unlikely, this would in turn prove the possibility of creating an overall end to end Future Internet innovation ecosystem, which goes from the early technology experimentation phase (FIRE), to the large scale industry and commercial oriented service phase (FI-PPP). This way the XIFI Open Call potentially could provide a collaboration opportunity as experiments with FI-PPP Generic Enablers could be conducted on FIRE testbeds. Scaling up from small-scale experiments to large trials might then be another area of collaboration. However we see only limited interest to make this happen.

Other issues of common interest could be explored such as AmpliFIRE's FIRE Radar activity, the issue of facilities' sustainability, the challenge of attracting SMEs and other. FIRE could also learn from FI-PPP how to attract SMEs to the programme[9]. Opportunities provided by FI-WARE technologies and FI-Lab could be taken up by FIRE after FI-PPP ends.

2.3.4 FIRE and Living Labs

Living Labs are facilities for human-centric open innovation. The European Network of Living Labs (ENoLL) brings together a large number of such facilities, however only few meet professional standards in terms of methodologies and professional organization. Some of the facilities explicitly address Future Internet innovations for example in city contexts.

Positioning: FIRE and Living Labs can be highly complementary and synergetic. In several FIRE projects, user-oriented open innovation plays a role. TEFIS and BonFIRE have worked with Living Labs (see D1.1). EXPERIMEDIA (Experiments in Live Social and Networked Media Experiences) carries out interesting user-experience experiments. 3D LIVE is also oriented to user experience. The SmartSantander project involving FIRE experiments with the use of sensor networks in user-centric city environments. In some ongoing STREPs end-user involvement is a significant component when running experiments including FIRE testbeds (examples are in EAR-IT, IoT Lab etc) Generally, FIRE is positioned to provide testbed facilities for technology testing whereas Living Labs projects experiment on applications and services. An area of synergy is where technologies and applications are being both developed, prototyped and experimented in real-live environments such as urban areas (Smart Cities) or

[9] Results of the FI-PPP phase 3 bids will be available in the next few months to start in September 2014.

when technology might have an impact on privacy and where the principle of Privacy by Design including user-insights is needed to develop sustainable innovations.

Collaboration: So far the collaboration between FIRE and Living Labs is more of a task-force oriented relation where some Living Lab actors and testbed providers have joined forces to support innovative experiments involving useful assets from each facility and by this exploit the potential of the mixture of Living Labs and testbeds. Projects like TEFIS and SmartSantander and also EXPERIMEDIA have explored this setup. The potential synergy in the longer term for such collaboration is to attract more users to exploit the added value from the combinations and by this to cover more phases of the experimentation lifecycle. This could also lead to a more agile and demand-oriented methodology for Future Internet experimentation and by this create a shorter time for take-up and more innovations to succeed on the market by users and technology evolving together. Increasingly this is a key direction to go for FIRE in parallel with the more traditional facility- and service-oriented streams.

2.3.5 FIRE and Smart Cities

Smart Cities are environments in which new technologies and applications for the benefit of cities and citizens are tested in real-life user environments, using some form of "Living Lab" methodologies empowering the role of users (citizens). Examples of Smart City projects related to FIRE are SmartSantander, and a large number of pilots in the CIP ICT-PSP. The Smart City environments themselves are also real life Smart City experimentation facilities serving the requirements and challenges of the city context by involving the city actors as key partners for new innovations.

Positioning. FIRE is the provider of testbed facilities and experimental methodologies for technologies testing in Smart City environments.

Collaboration. See the former section 2.3.4 about FIRE and Living Labs. The various Smart City pilots within the CIP ICT PSP have experimented in using the Living Lab concept for the urban domain. As several FIRE projects already demonstrate, Smart Cities can be very well considered as experimentation environments for the Future Internet and good examples are SmartSantander as well as several projects in the FI-PPP programme (SafeCity, OUTSMART, FINSENY, FINESCE and other). AmpliFIRE's "social innovation ecosystem" scenario provides a good background to the opportunities foreseen for upcoming years. Currently, however, there are still only few Smart City initiatives that provide a user-centric environment of experimenting on Future Internet technologies. In any case it would be interesting to consider how FIRE could transfer technologies e.g. lessons learned in SmartSantander to new Smart City deployments.

Based on sections 2.3.4 and 2.3.5, it can be concluded that FIRE does not yet sufficiently take advantage of the opportunities to strengthen the relation with the user side, in particular Smart Cities and Living Labs, and possibilities to work with SMEs. It would it be interesting to consider how FIRE could transfer technologies e.g. lessons learned in Smart Santander to new Smart City deployments and to foster innovation take-up. To better attract SME´s FIRE could also emphasize to include the entire value-chain in the experimentation lifecycle and by this better foster business-growth. This would require the collaboration with complementary actors from different sectors and to extend the FIRE community with additional actors who could represent the future market and the actor-network of the solutions being experimented.

2.4 FIRE's international position

FIRE is building up a collection of advanced infrastructures. The FIRE Community has already engaged in international collaboration and co-operation, but how could we strengthen those relations and what for? What are the objectives and how to proceed?

This section addresses the question how FIRE positions itself with respect to other initiatives globally: in particular the US (GENI), South-Korea, Japan, China, BRIC countries. A good level of exchange and collaboration has developed over the years between FIRE and other initiatives (e.g. GENI), and other collaborations are developing[10]. The recent Call 10 included two joint calls: EU-Japan and EU-Brazil. Within this context FIRE's role will be developing and widening. To start with, the following table presents the current level of collaboration and exchange.

Country	FIRE's current collaboration
USA	A series of FIRE-GENI collaboration workshops took place in October 2013 (coordinated by Fed4FIRE): Savi funding is available to send US researchers to Europe FIRE meetings. FIRE is building upon the FIRE-GENI interaction: during the 1st year H2020, there is a call for a CSA to look into collaboration with US and other partners around the world, how to organize joint experiments, progress on standardization and interoperability. In this regard, the GENI project has an API used in every testbed. The main outcome of this is a common interface. GENI use is for free whereas EU testbeds determine who uses what. Partners from the US are also present in some FIRE projects. Stanford will participate in the Fed4FIRE via the MoU (facilities will be available for experiments). The CONECT project counts the University of California (Berkeley and Los Angeles) among its partners. In the past, the University of California was also a partner of OFELIA, which also included in its consortium Stanford University.
Japan	A coordinated call is planed with Japan late 2014 (4 experimentations on federated EU/Japan testbeds). Currently, the FELIX project (FEderated Test-beds for Large-scale Infrastructure eXperiments; www.ict-felix.eu) is a joint effort of two independent consortia (i.e. FELIX-EU in Europe, FELIX-JP in Japan). It builds strong foundations for a federation framework by investigating emerging technologies and Software Defined Networking control frameworks (e.g. Open Grid Forum's NSI and OFELIA OCF). The primary objective of the FELIX project is to create a common framework in which users can request, monitor and manage a slice provisioned over distributed and distant Future Internet experimental facilities in Europe and in Japan. In the past, FIRE STATION was involved with Japan through EU-Japan events. The 3rd EU-Japan Symposium on Future Internet and New Generation Networks (NWGN) in Tampere in October 2010, and in January 2012 the 4th Symposium in Tokyo which focused on topics that require joint research efforts from Japanese and European researchers. An important related outcome of this 4th symposia was the intention to issue a coordinated call between EU and Japan for joint projects in the above areas. FIRE STATION also attended October 2011 Information Day organized by the European Commission for Japanese researchers on the ICT Call 8. H2020-LEIT will promote further research and development cooperation with Japan, for FIRE in EUJ4-2014 (€ 1,5 mln): experimentation and development on federated Japan-EU testbeds. The goal is to connect, federate and share experimental platforms and testbeds in Europe with NICT's orchestrated Smart ICT testbed in order to carry ot global large-scale experimentations.
South Korea	The SmartFIRE STREP is a collaboration project between Europe and South Korea testbeds, to enable SDN across the two continents. The Korean partner NIA is a member of the Fed4FIRE project. Future Internet related events have been organised jointly. In the past, FIRE STATION participated or was represented in several events in Korea : - Conference on Future Internet 2012: 11-12 September 2012 and Global Future Internet Summit: 13-14 September 2012

[10] See http://www.ict-fire.eu/home/international-cooperation.html

	- the KOREN workshop which took place in May 2011 in Seoul - the AsiaFI Forum Summer School which was held in Daejeon, Korea, from 8 to 12 August 2011 - EINS KOREN AsiaFI Forum: The Call 7 Network of Excellence EINS has also a Korean Partner.
China	Call 10 funded a CSA for developing partnerships between China and EU organizations regarding Future Internet and IPv6. Exploring EU-China joint research efforts on the future Internet by developing interoperable solutions and common standards. Federation of test beds will be explored and interoperability initiatives will be undertaken. With China, the ECIAO CSA project tries to create a bridge between EU and China on Future Internet Experimental Research (FIRE) and IPv6: developing interoperable solutions and common standards, reinforce academic and industrial collaboration, share good practices for IPv6, and reinforce the links for future collaborations. Also, Onelab has signed a MoU with the Institute of Computing Science Chinese Academy about joint experiments, development of joint vision and the Call 7 Network of Excellence EINS (European INternet Science) also has a Chinese partner (the Institute of Computing Technology, Chinese Academy of Sciences). In the past TEFIS and MyFIRE involved a Chinese partner in their consortium.
South Africa	A joint event was planned in September 2012 at the EU Information Day for **Call 10, which call 10 funded a STREP on** cooperation on Future Internet experimental research and testbed interconnection (STREP, up to 1M €). The TRESCIMO project was subsequently funded.
Canada	Collaboration is very limited. The Call 7 FIRE project OpenLab has a Canadian partner in its consortium (ETS/SYNC - Ecole de Technologie Supérieure) and the University of Waterloo is a partner of EINS. No visible collaboration with CANARIE.
Brazil	So far limited collaboration. . Call 7 included a joint EU-Brazil Call for proposals. One project with a small budget has been retained as part of FIRE: FIBRE, which consortium included nine partners from Brazil. Both the MyFIRE and the TEFIS projects had in their consortium a partner from Brazil. H2020 strengthens international collaboration with Brazil in advanced cyber infrastructure such as cloud computing and HPC but also experimental platforms (EUB3-2015, € 1,5 Mln) aiming at federation of experimental resources in Brazil and Europe. A new coordinated call with Brazil is planned for late 2014.
Russia	Limited collaboration. In the past, MyFIRE had a Russian partner.
India	Low level of collaboration. MyFIRE had an Indian partner.
Australia	Several FIRE projects include an Australian partner (NICTA) in their consortium. And, the Australian research institute NICTA (National ICT Australia) is involved in three projects: OpenLab, FIBRE and EINS.

Table 1: FIRE international collaborations

Continuing from FP7-ICT, the H2020-LEIT Work Programme sets out some directions for international positioning of FIRE within the vision of a Strategic Experimental Infrastructure for Future Internet Research and Experimentation (FIRE+). New INCO activities in the scope of FIRE are specifically announced for Brazil and Japan only (GENI not mentioned). However for the future we may expect the Commission Unit E4 to concentrate on 1. The US (GENI) which plays a strategic role, 2. Korea and Japan.

Elements of a future positioning of FIRE/FIRE+ within INCO context should be further elaborated, where two directions can be taken into account:

- FIRE and FIRE+ may become part of a future backbone of a connected European research and innovation ecosystem (research, companies, government institutions, SMEs, end-users). As such it forms an attractive environment with high level of demand-side requirements for testing of new technologies. Such research and experimentation ecosystem is an attractive environment for advanced initiatives such as those in Japan, Korea and US to collaborate with European counterparts.

- FIRE could exploit experiences from such advanced environments and strengthen the knowledge and technology base through shared research and experimentation. In this context it should be considered where Europe wants to lead (unique technologies and testbeds) and where to follow (learning from similar or even more advanced initiatives elsewhere, and get inspired in terms of governance, in terms of exploiting synergies, saving costs, enabling faster exploitation and an innovative use of experimental facilities).

In relation to international development of FIRE, AmpliFIRE's mission is to increase FIRE's impact and increase its value: taking advantage of new market and technology opportunities at an international level, with the development of sustainable value networks around the FIRE facilities collaboration (e.g. partner agreements, access and sharing mechanisms, service agreements, links with international communities of users and experimenters). International collaboration generates further benefits through creation of a larger market for FIRE facility services. In this respect we propose to:

- Tie links with initiatives in industrial countries and emerging economies, to enlarge the FIRE community on the users and experimenters. An analysis of industrial relationships in international projects will give inputs in terms of best practices and potential connections within FIRE (e.g. DAIR's relations with SMEs, Brazilian's experience in collaboration between their platforms and industries, analyze GENI's standardization models in order to exploit synergies, etc.)
- Trainings, webinars and thematic Working Groups on international relations could be proposed to the FIRE Community to help building international collaborations, e.g.: the needs of the car industry regarding experimentation, how have they been working so far with existing FIRE facilities or facilities outside Europe; what have been the benefits and the challenges, what collaboration could be beneficial in a win-win situation.
- Keep on organizing cross countries events to facilitate links both at the project level and at the level of the organizations, industries, partners, testbeds themselves.

Two International Cooperation workshops were planned between EU and Asia/Pacific and the Americas.

One EU-Japan symposium is being planned in October 2014 and will be collocated with the FIRE Forum. This Forum might be focusing on:

- FIRE's international development: it might be the occasion to invite initiatives from other countries e.g. Korea, Brazil, and of course some of the Japanese partners.
- But also on the FIRE Community's extension to engage communities that have not necessarily been involved so far (such as car or health industries, education, etc.) and keeping the attraction for the communities that are already interested or have already been involved.

Also Fed4FIRE is organising the 3rd GENI-FIRE workshop in November 2014 (potentially the week of 17 November, in Paris).

We should identify strategic objectives in the collaboration between FIRE and international initiatives. Beyond exchanges and collaboratively working in projects, what does the Commission want to achieve with INCO? What are the priorities? How to measure the benefits?

2.5 Sustainability of FIRE's experimental facilities

Sustainability, which is the capability for continued funding of FIRE experimental facilities, has been a topic in FIRE over the last years. The D1.1 [M6] has reviewed the recent discussions, which were organised in the context of the FIRE STATION support action. In particular it can been observed that:

- Sustainability of FIRE facilities is not guaranteed, as facility projects are limited in terms of duration. Facilities are normally no longer available after end of project.
- Sustainability of the FIRE experimental facilities is in the interest of all stakeholders.
- EU funding is critical for FIRE facilities' sustainability. Other initiatives in ICT research infrastructures demonstrate higher amounts of national funding or even business funding.
- Involvement of industry as experimenter is limited, but has potential especially for SMEs.
- Involvement of Smart Cities and other attractive and promising initiatives related to societal challenges is emerging but not exploited to the full possible extent.

This raises questions concerning the vulnerability and viability of FIRE's business model. Creating more flexibility and resilience in FIRE's business model aimed at enhancing the future sustainability requires the consideration of all elements of the business model in the context of the changing Future Internet landscape. Elements to be considered include FIRE's service portfolio, its federation strategy to provide more easily access for users, its strategy towards expanding the user base (industry, SMEs, Smart Cities), its collaboration with other initiatives and actors, and its financial base.

Sustainability is also an issue for the FIRE programme as such. Most probably, continuation of the present level of EU funding for FIRE will be dependent of the business and societal impact that FIRE is able to achieve and the business interest it is able to attract.

At facility level, there have been some promising recent developments to ensure sustainability e.g. creation of the BonFIRE and OFELIA foundations. These experiences must be studied carefully to see if this can be stimulated in next calls.

Overall given the vulnerabilities there is a need to redefine FIRE's business model both at facility and programme level in order to ensure future sustainability.

2.6 Unit E4 vision on the longer term evolution of FIRE

FIRE as a programme, as a portfolio of projects and experimental facilities, and as a body of knowledge is what it is today thanks to the long term availability of EC funding for FIRE facilities and experimental research projects. For the near future, FIRE has also gained an important place in the Horizon 2020 LEIT Work Programme for 2014-2015:

- ICT11 FIRE+ (2014) is about developing the Strategic Experimental Infrastructure for Future Internet Research and Experimentation.
- ICT12 Integrating experiments and facilities in FIRE+ (2015) is about further integrating experimental facilities, testbeds and laboratories into FIRE+.

The FIRE programme is part of the EU Unit E.4 vision to shape the Future Internet in collaboration with other regions of the world. The strategy for that is to provide testing environments for experimental research beyond the state of the art and for increased competitiveness. The FIRE programme is aimed at building a centre of excellence for advanced networking experimentation, integrating multiple technologies, creating platforms and tools for application and service development for the benefit of users. The ultimate aim of

experimentally driven research carried out in such facilities is to boost the innovation of products and services by industry. Table 2 provides an overview of the nit E4 vision.

	Experimental platforms	Experimentally driven research	FIRE long-term evolution
Vision	Shape the Future Internet	Facilitate integration of research by industry into new products and services	Long term sustainability of experimental platforms
Strategy	Provide advanced testing environments Build centre of excellence for experimentation	Promote experimentally driven research	Build a strategic infrastructure of shared experimental facilities and platforms serving the European economy
Priorities	Create and maintain experimental platforms; support experimentation in realistic environments; promote federation and sustainability of the platforms	Foster demand for experiments; ensure demand-driven experiments; ensure value to actors involved	Novel service concepts such as EaaS, network virtualisation
Outputs and impact	Enlargement of facilities' coverage Stimulate open calls Stimulate open access Sustainability	Number of experiments on FIRE facilities Attract new users in particular from the private sector Increase new applications and services	Federations among FIRE, Member States, regional and global facilities, and integration with NRENs Alignment of FIRE with non-FIRE facilities Sustainability of experimental facilities

Table 2: Summary of the Unit E4 vision on the FIRE programme

While FIRE creates an open research environment, it considers that other regions of the world (US, Japan and other) have built comparable large-scale experimentation facilities. This FIRE programme also plays a role in strengthening the European research and innovation ecosystem worldwide.

As such, FIRE is part of a wider range of European Future Internet initiatives, including Géant and NRENs, EIT ICT Labs, priorities in the H2020-LEIT related to networking infrastructures and platforms (including the FI-PPP and the new 5G-PPP), as well as initiatives regarding Smart Cities and Living Labs.

Although a full evaluation of the strategic impact of FIRE has not been carried out yet, the Commission has some concerns regarding the impact of FIRE in terms of industry and SMEs involvement. Also, the sustainability of FIRE as a programme is an issue, which means that on the longer term, EU funding for FIRE is uncertain.

The Unit's vision and strategy, implemented by the WP2014-2015, can be considered as adequate for the next years to consolidate the achievements and guide FIRE's evolution towards a higher level of professionalism.

For the somewhat longer term there is a need to anticipate to the increasing importance of the demand side beyond traditional experimenter groups, to the increasing need to attract industry and SMEs interest, to the collaboration opportunities that exist with related Future Internet initiatives, to the uncertainty as regards the sustainability of FIRE as a programme, and to the different evolution paths that seem possible for FIRE in terms of customers, services, infrastructures, governance models and overall role in the European research and innovation

ecosystem. It should be dealt with the main uncertainties on the longer term, surrounding FIRE, which can be summarized as:

1. FIRE's sustainability as a programme. Will EU funding continue at the present level?
2. Capability to attract business interest. Will FIRE evolve into a facility offering services that add value to business users?
3. Positioning and role within the wider Future Internet ecosystem. Will FIRE be capable to arrange beneficial collaborative relations with related initiatives (e.g. in sharing facilities)?
4. Evolution of collaboration among researchers and experimenters. How will experimenters collaborate, as community-based collaboration or as individual stakeholders?
5. Evolution of interworking among facilities. Will facilities remain fragmented or integrated?

D1.1 has started the process to develop a vision and scenarios regarding the FIRE future targeting the longer term (2020). Uncertainties 4 and 5 were addressed, leading to a set of scenarios. In this D1.2 we take that as a starting point to revisit the mission and strategic objectives.

2.7 FIRE strengths, weaknesses, opportunities and threats

Table 3 presents a summary of strengths, weaknesses, opportunities and threats based on previous considerations. In this form it will be further discussed and validated within the FIRE community.

Strenghts	Weaknesses
• Large, diverse portfolio of experimental facilities • Increasingly connected, federated, supported with tools, and well accessible • Experimenter community	• Lack of sustainability of FIRE's facilities after project end • Limited involvement of industry and SMEs, high entry barriers • Ecosystem not well developed
Opportunities	**Threats**
• User support: Shortening time to market, user tools, service concepts • Benefits and enabler to Smart Cities and industry • Ecosystem development based on collaborative relations with related initiatives • Global collaboration • More balanced funding mix (industry, national, EU, users)	• Declining programme funding by the EU after 2015 might be a possibility

Table 3 FIRE SWOT analysis

2.8 Direction of change

The FIRE position analysis in this chapter leads us to several considerations regarding the possible future direction of FIRE. In particular, FIRE strategy development could address the following interlinked aspects.

- **Achieve longer term financial sustainability**, becoming less dependent of the Commission funding.

- **Expand the community of stakeholders,** from mostly experimenters in academic and research institutes towards a wider spectrum of actors in a growing FIRE ecosystem, including large businesses and SMEs as users, developer communities, and other initiatives or programmes that may use the solutions being experimented with such as Smart Cities and other customers. Thinking in terms of "multisided platforms" in the Future Internet ecosystem may provide a new perspective on how FIRE could benefit from network effects.
- **Develop collaborative linkages** to related Future Internet initiatives, aimed at sharing knowledge, technologies and facilities, and at creating new services for a wider range of customers.
- **Reformulate the FIRE value proposition,** including FIRE's service portfolio, the range of target groups to deliver the service portfolio, and the access channels or platforms for delivering the service in customized manner. Also the concept of Testbed as a Service needs to be further developed on close collaboration with the FIRE existing and potential users to be able to serve a wider user-base. FIRE for and by the FIRE users!

3. FIRE mission and strategic objectives

3.1 Overview

Continuing from the analysis of FIRE's position, this chapter proposes a reformulation of FIRE's mission and strategic objectives. With the FIRE position analysis of the previous chapter in mind, we reconsider the D1.1 scenarios, and propose an **integrated scenario** while recognizing alternative options, and focus on the strategic implications of this final scenario in terms of FIRE's mission and strategic objectives. Figure 6 presents our methodology. We start by summarizing the initial views from the FIRE community and beyond. Alongside the inputs from the scenario analysis we produce a clear definition of the FIRE mission statement which we use to conclude the chapter with a statement of the FIRE strategic objectives.

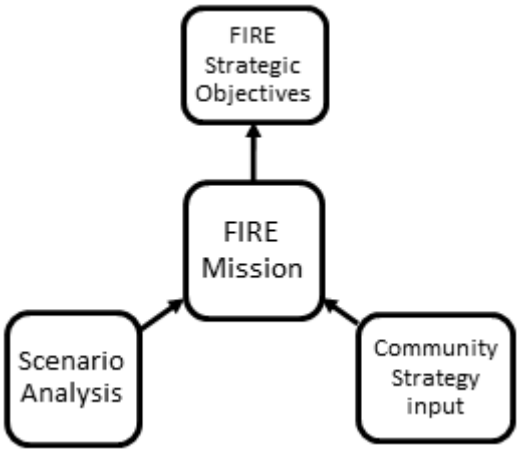

Figure 6: Methodology for creating an integrated scenario

3.2 Community discussion of FIRE's vision and strategy

We discussed the FIRE future scenarios, vision, mission and strategy within the FIRE community, and beyond with other stakeholders in the Future Internet landscape. This is an ongoing process of workshops, community interaction and meetings of the Strategy working group; continuing these discussions will be a key priority of the remaining period. Table 4 summarizes some of the inputs received from our interactions with the FIRE community and beyond (source: interviews and workshop discussions).

Willem Jonker, CEO of KIC EIT ICT labs	Europe needs ICT industry strategy 2020. FIRE vision strategy should be part of an overarching ICT industry strategy. FIRE needs business model ensuring sustainability. Sustainability and governance are critical in order to do business with FIRE. FIRE needs a "platform strategy": FIRE includes: infrastructure, services, but also exploitation, maintenance, business development, governance, community of attracted businesses. How to attract business so that FIRE becomes viable? What is the business model? What happens if projects are ending, what ensures continuity? The legal and organisational model seems not to exist. Is FIRE able to offer service contracts? Collaboration of FIRE with EIT ICT Labs is attractive, but the win-win should be made clear. EIT ICT Labs works a lot on exploitation, business creation, education so there are opportunities. Also the governance and sustainability issues must be clarified. Ensure IP management and models where work can be subcontracted and FIRE remains owner of IP. Ensure professionalization of FIRE.

Dave Carter, Manchester MDDA and Connected Smart Cities	A key aspect of the FIRE vision is that there will be a new landscape where different actors and initiatives will need to find new collaboration models. It is unclear to what extent FIRE is a stable sustainable organization. From collaboration point of view it helps if longer term sustainability is ensured. What are the needs of Living Labs that are already working with FIRE?
Jarmo Eskelinen, ENoLL and Forum Virium Helsinki	There is a lack of entrepreneurship within Future Internet initiatives. Programmes such as DAIR could be interesting for FIRE and other Future Internet programmes. FIRE and other initiatives should support multiple domains. An important new domain also FIRE is content and media, e.g. in the area of gaming. This area is also expected to make money and attracts business creation activities. Besides gaming, also applications in the domain of open data will be relevant. Supporting creative freedom may be one of the challenges for FIRE as well. Living lab facilities and FIRE facilities may interact, however concrete models should be developed. There are some examples in the IoT area. Living Labs generally are not that professional and mature but some have mature level. Living Labs domain could bring interesting test cases also combined with urban development aspects. Smart Grids provides a new business model not just covering energy. FIRE may also need more attention to business model innovation, in relation to the domains it could support. For cross-border collaborations it should be addressed the need for policy harmonization (e.g. in health, or privacy, access to data etc). National policies are often hindering collaboration and business models operating across border.
Yrjö Neuvo, Aalto University, former member of Future Internet Advisory Board	More and more the Future Internet initiatives that are currently organised ads vertically integrated "stovepipes" will become horizontally layered and integrated. Different horizontal layers will emerge, where facilities, services and applications offered by a range of different providers will be able to interoperate. This will enable the user driven tailored creation of experimental spaces.
Mauro Campanella, GARR	Collaboration is a way of optimizing the use of the resources. It helps both to reach their goals. It helps to optimize the product and it´s a way for sustainability. We need to decide to move along the same roadmap. Collaboration is essential. Why FIRE? FIRE is the only environment to merge different perspectives together The value is the ecosystem itself and to force experimentation. In these environments you have the right mixture. It´s half between research and the commercial environment.
Josep Martrat, ATOS Origin and coordinator of BONFIRE	FIRE needs to establish links between industry and academics. For this, we need controlled data, privacy, which industry requires moving towards the left. Industry will not come without features – what are the requirements? Choices must not be contradictory. We need to analyse what the facilities need to provide beyond Fed4FIRE. This needs information about the scenarios, details rather than abstract. There should be a value for FIRE.
Maurizio Cecchi, Telecom Italia and XIFI (FI-PPP)	We are interested to use the FIRE facilities as a next step from "research testing" to "industrial level testing". For the future value could be increased by joint initiatives towards the 5G-PPP Programme.
Theodoros Michalareas, George Aristomenopoulos and Panagiotis Vlahopoulos, VELTI	Sustainability and maintenance of facilities are of key importance for the attraction of industry. Testbeds must work on "commercial level" to be interesting for industry. The communication about what to be achieved from using the testbeds are lacking. Organize FIRE in categories: FIRE for networking, FIRE for IoT, FIRE for UX etc so experimenters don´t need to be experts in the testbeds themselves.
Nuria Delama, Atos Origin	There is not enough collaboration between FIRE projects. The existing FIRE facilities should be used more. For me to consider potential FIRE collaboration a strategy is needed. I don´t know what FIRE do. There is a need to establish collaboration between FI-PPP(XI-FI) and FIRE. Now there are parallel actions: what is FIRE and what is XIFI, and to create this link. The risk is that we end up in developing component twice. The ROI of FIRE is not clear. There is a need to clear how to use FIRE outside the research community.

Henrik Abramovicz, Ericsson	FIRE in the early days was focusing on the FUTURE Internet, a clean slate, but that is history now and reality indicates FIRE is to close to "reality" i.e now. Not in the future anymore. FIRE has to reclaim the position as being even beyond the future again. Be sure that the testbed exist! Today you can build a testbed but what about maintenance after project ending? This creates uncertainty and risks and lt hereby less interest to use, to plan for. Maintenance of testbeds after project ending should be of responsibility of another EC Unit.
Philippe Cousin, EAR-IT	It is important to gain experience through experiments, exploring IoT and at the same time developing testbeds and working with other actors. The main issues are the following: How can FIRE stimulate more innovation? The solution is to bring them to the market. How to explore other programmes "FI-PPP"? FI-PPP Phase 3 integrates SMEs. Testbeds for data.
Dimitri Papadimitriou, EULER	FIRE should be attractive for scientist in the outside world to cross boundaries. Dimitri insisted on the experimentation chain and the conditions to meet, scalability and the technical researchers view. The most important challenges for the future are Measurement methods (there's also a publication on this); Scalability; Heterogeneous technologies: e.g. I need both wireless and wired at the same time, because TCP is end-to-end.
Donal Morris, RedZinc and FUSION	FIRE should be closer to real users (it's too academic), more users driven than infrastructure driven, more flexible, with a more open and rolling access. There should be thousands of users connected to FIRE (hospital, PPP…). SMEs and startups move fast and need short term results, they need product validation and testing more that experimentation, they need User Experience Testing more than just infrastructure, simplified management and services, they need to asses market acceptance risk not only technical risk.

Table 4: Viewpoints concerning FIRE vision, mission and strategy

These viewpoints, although diverse and different, are considered as highly relevant, and we have taken them into account for developing the FIRE vision, mission and strategy. These viewpoints coming both from FIRE as well as beyond FIRE are being collected by AmpliFIRE on continuous basis.

3.3 Future scenarios and their implications

AmpliFIRE's Vision and Scenarios 2020 report (June 2013) reflected upon the key uncertainties for FIRE (the FIRE ecosystem; not the FIRE Work Programme), and explored different future scenarios in order to investigate the possible implications of such uncertainties.

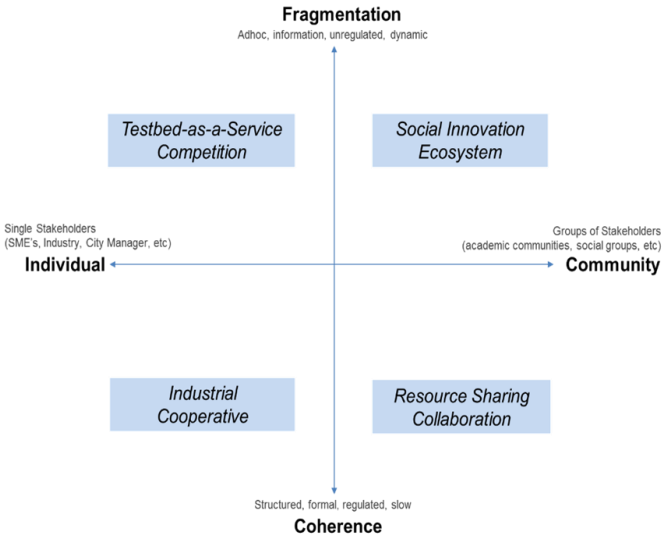

Fig. 7: Framing future FIRE scenarios (AmpliFIRE D1.1, 2013)

Scenarios were framed around two selected uncertainty axes: 1) Structure and facilities: coherence versus fragmentation - how will collaboration in research and experimentation be supported and governed in terms of fragmented or integrated facilities; 2) Collaboration: individual versus community - how will researchers and experimenters collaborate, as community-based collaboration versus competitive individual stakeholders. Four scenarios for FIRE futures were identified and these are illustrated in Fig. 7. As presented in Fig. 2 in the previous chapter, an important part of the strategy development process is the identification of the objectives that we want to achieve in order to realize the postulated vision. Hence, we now explore each of the four scenarios individually and identify an initial set of objectives and potential strategies that may realize the scenarios.

The four scenarios can be considered as extreme future worlds that are polarized because they are framed on two uncertainty axes; hence they do not represent desirable or probable futures. Addressing and understanding the forces that are shaping each of these different worlds and the different pathways leading to them enables us to frame their objectives and opportunities and minimize negative effects, and to further examine how to handle the specific situations visualized in the scenarios, and eventually leads us back to the current state of affairs as regards FIRE and developing appropriate strategies for the future development of FIRE. Table 5 summarises the scenarios including their threats and opportunities, and briefly points out their strategic implications.

	Testbed as a Service Competition	**Industrial Cooperative**	**Social Innovation Ecosystem**	**Resource Sharing Collaboration**
Characterisation	Individually competing testbeds providing facilities as pay-per-use service to segmented customers	Cooperating, federated FIRE facilities offering services to target customers	Diverse collection of open accessible facility resources, targeting societal innovation	Cooperating, federated facilities based on standards for integration, used by communities e.g. RTD projects
Threats and challenges	FIRE as a programme may not be publicly funded in a full testbed service market	Diminished justification of public funding of FIRE as it is considered a commercial infrastructure. Higher level of governance required	Dependence on public funding Realising openness (vertical – horizontal) and composability as precondition	Dependence on public funding Technical challenges (federation support, dynamic service distribution across diverse platforms) Need for governance, trusted environments Sustainability of federated facilities
Opportunities	Testbed market creation for specialized services	Strong collaboration among facilities and offers, integrated service offering Commercial market development and service offering Lower cost, efficiency and effectiveness	FIRE as driver of societal innovation, e.g. social computing Creating dynamic innovation ecosystems based on customized access and integration of resources / services (testbeds, Living Labs)	Providing the testbed infrastructure for supporting research into large-scale software and service development
FIRE strategy implications	Emphasis on cost efficiency and operational excellence Business model as pay-per-use	Operational excellence Push flexible federation of facilities and integrated offer of services to target customer segments	Flexible and heterogeneous resources offering broad range of services; openness strategy Targeting large-scale societal innovations	Governance of federated facilities Need to develop sustainability approach targeting dedicated communities (R&D)

Table 5: Future Scenarios and implications for FIRE strategies

Testbed-as-a-Service Competition

In this scenario, FIRE is conceived as a set of fragmented single-purpose testbeds providing their facilities via a pay-per-use service. Hence, FIRE provides a marketplace for paying commercial and non-commercial experimenters to search for and leverage future Internet experimental facilities and services. The scenario embodies a world lacking collaboration. Testbeds stand on their own, serving individual customers who pay to use individual facilities directly within a FIRE branded marketplace. The issue comes up if FIRE could survive in this scenario and in what form. If FIRE survives in this future it will probably be because of aggressive marketing and offering quality services, or because of being able to deliver low cost services. However, it is not yet clear who are the customers in this future, and if it is realistic to expect paying research institutes or large companies as customer segments. It is also unclear what the perspectives are for continued EU funding of testbed facilities. The scenario seems to describe a mature business of individualised commercial testbed service provision, not dependent on FIRE, delivered to customers with specialised needs. This future may also embody a mature testbed market segment, one among different segments, which co-exists with other testbed futures or market segments where FIRE keeps playing its role as public service.

The key high-level objectives within this particular scenario are:

- To ensure the sustainability of FIRE with significantly reduced funding from the EC research budget.
- To increase the economic impact (benefits, operational excellence) of FIRE.
- To lower industry barriers.
- To promote alternative revenue streams and pay-per-use experiment as a service within a global research and development marketplace.

Example strategies to make this happen:

- FIRE funds an innovative facility in terms of its transfer to the FIRE marketplace (e.g. using incubation loans)[11].
- FIRE funds innovative commercial and non-commercial experimenters that can be used to pay for Future Internet facilities.

Industrial Cooperative

FIRE becomes a resource where experimental infrastructures and Future Internet services are provided by co-operating commercial and non-commercial stakeholders; these converge towards a common facility to provide the resources for large-scale scientific experiments and commercial trials. The key value proposition of convergence is to provide a service that cannot be replicated by facilities competing in a marketplace—and as such lower industry barriers further and speed up the innovation chain from invention to market. Collaboration on the testbed facility supply side is strong, resulting in federated facilities, integrated offerings and serving highly individualized customers with specialised needs. This scenario thus describes an integrated and professional FIRE service offering, customized to changing demands from individual industry customers. This implies that FIRE should be organised professionally to attract a high level of business commitment. At the same time the realism of this business commitment is not clear. FIRE would need a "testbed service platform strategy" to achieve this future. It is unclear whether there would remain a need for public funding for

[11] See also AmpliFIRE's White Paper on Incubation.

FIRE in this scenario given that it targets specific industry interests, and whether public funding would be justified. Over-all in the two scenarios mentioned we would expect the current publicly funded FIRE programme to be less viable or justifiable.

The key strategic objectives within such a FIRE scenario are:

- To support experimenters to perform complex experiments that use multiple, geographically distributed experimental testbeds via a common converged service (one stop shop).
- To reduce experiment costs through large scale service and reusable tools, software and training utilized by individual facilities.
- To lower industry barriers by supporting and funding commercial trial activities, and thus speed up the transfer to market.
- To increase the economic impact and operational excellence of FIRE.

Social Innovation Ecosystem

FIRE is a collection of heterogeneous, dynamic and flexible resources offering a broad range of facilities e.g. service-based infrastructures, network infrastructure, Smart City testbeds, support to user centred Living Labs, and others. The divergence of resources means to support cutting edge research ideas and have a broad social and economic impact. FIRE remains at the cutting edge of future Internet research; providing the research community access to perform experiments on the latest technologies. This scenario pursues a public need as driver of innovations for society. FIRE facilities, becoming a collection of a diverse, cutting edge set of resources, are jointly acting as a public service infrastructure, and FIRE funds the continuous creation of additional advanced testbed facilities and services. Given its societal nature it would be difficult to envisage the survival of such facilities under market circumstances and in this scenario there is a relatively high dependence on continuation of public funds. The testbeds would have different customers and these would require open access to all testbeds with the goal of performing scientifically challenging and societally impacting experiments. Openness of facilities and testbed services, and the ability to access, compose and customise services as needed are key criteria for success.

The key strategic objectives of such a FIRE scenario are:

- To increase the socio-economic impact of FIRE-allowing innovation that provides gains to society.
- To be highly adaptive to changing research and technology trends in order to provide a cutting edge experimental facility.
- To offer increased functionality and diversity of experimentation platforms.
- To attract a wider range of experimental platforms (including Smart Cities and Living Labs) to then in turn attract a broader customer base.

Resource Sharing Collaboration

FIRE becomes a set of federated infrastructures that provide the next generation of testbeds, integrating different types of infrastructures within a common architecture (in similar fashion to the industrial co-operative). The supports and open, single-stop facility to directly support collaborating researchers tackling the latest problems. Sustainability and governance of such infrastructures are among the main challenges of this scenario. The scenario has similar objectives to the Social Innovation system as a driver of technology, scientific and societal research; however the driver is collaboration and federation to tackle larger scale problems

and grand challenges. Hence, such a scenario can be seen as closer to market, i.e. the experimental R&D facility where ideas can be tested in advance of a market trial. Like Social innovation, openness of facilities and testbed services, and the ability to access, compose and customise services are key criteria for success; in addition, federation of services, single portals for experiment-as-a-service are also key to allow experimenters minimal overhead towards using such heterogeneous services.

The key strategic objectives of such a FIRE scenario are:

- To increase the socio-economic impact of FIRE-allowing innovation that provides gains to society.
- To support experimenters perform complex experiments that use multiple, geographically distributed experimental testbeds via a common converged service (one stop shop).
- To reduce experiment costs through large scale service and reusable tools, software and training utilized by individual facilities.
- To ensure the sustainability of FIRE with significantly reduced funding from the EC research budget.

Other opportunities to consider

In addition to these scenarios there are also other opportunities with their main background from discussions with industry.

The business web scenario: FIRE as a multi-enterprise network driven by the users. In this future scenario FIRE is an ecosystem of producers, researchers, service providers, suppliers, infrastructure companies, and customers. In this scenario the experimenters outsource experimentation to the testbed-providers. In this scenario the experimenters are the drivers and they drive the market for testbeds. They "put out" testing services and the testbed-providers are the labour sources. By this the experimenters use testbed networks to source external labour and to harness expertise. This builds on a model where testbed providers capitalize on expanding the range of their services in cooperation with other testbed-providers but driven by the request from experimenters.

FIRE as a Centre of excellence (COE) – the formal legal FIRE. In 2020 FIRE has become a centre of excellence. "A centre of excellence is a premier organization providing an exceptional product or service in an assigned sphere of expertise and within a specific field of technology, business, or government, consistent with the unique requirements and capabilities of the COE organization." The centre is composed of networks of existing businesses, research institutes and education institutions or universities which work together to provide excellence in Future Internet experimentation. In this scenario the institute key mission will be to Experiment the future Internet. The FIRE CoE may comprise a functional or cross-functional team looking both inside and outside the organisation to capture new knowledge and practices. It has a permanent status and the sustainability model incorporates public funds, private investments as well as grants from customers when accessing services. Projects are tools for development and to stimulate the evolution.

3.4 Implications for FIRE's mission and strategy

From the scenarios we try to extract a high-level view concerning the future evolution of FIRE, while at the same time keeping development options open as to be flexible with changing views and circumstances.

The scenarios embody important implications for FIRE as a programme but also for FIRE's positioning within the landscape of Future Internet initiatives and programmes. In general the

scenarios are located at the extremes of the uncertainty axes and individually offer clearly important objectives for the future of FIRE, whether that be through achieving sustainability, relevance or industry support. In examining the strategic objectives underlying each of the FIRE scenarios individually (former section) we collected a range of strategic options.

Vision and scenario building on the one hand and strategy development on the other interact, as in further developing the FIRE strategies we may identify or reshape those scenarios (or combinations of elements of different scenarios) that we consider as desirable, robust, probable or viable. Here we need to keep in mind that "desirable" scenarios represents a community consensus in terms of priorities and objectives; whereas robustness and viability are concepts based more easier on neutral analysis (as far as this is possible).

Where should FIRE development strategy concentrate*?* The Testbed-as-a-Service and also the Industrial Cooperative scenarios of FIRE will likely not be viable as a publicly funded programme. FIRE will have its development potential in the right-hand scenarios in the first place. FIRE should converge on a federated platform of core facilities (cf Fed4FIRE) offering experimentation that is not achievable or reproducible in the market. Combinations of testbeds offer optimization of resources as well as support meeting the future technology experimentation needs e.g. large scale cyber physical systems. However, it should also target the incubation of new cutting edge facilities into this federation. Different strategic directions for FIRE should be further, and jointly, explored in terms of achieving operational excellence (cost efficiency, effectiveness), targeting a wider range of customers (both industrial customers, small companies, and dedicated communities), creating a governance model that is capable to anticipate uncertain developments.

How should FIRE address its transition over time*?* The scenarios are not fully excluding but parts of the scenarios could co-exist or could be part of a transition path towards 2020. The FIRE programme could enable spin-offs in terms of Testbed-as-a-Service while still working on realizing the industrial cooperative model or transforming into an infrastructure to support societal innovations. In concentrating on the left-side scenarios there might be less scope for FIRE as a publicly funded programme although in the Industrial Cooperative scenario there is still a need for governance and management across facilities. FIRE's primary role would lie on the right-hand side, however continuing in this direction may spell the end for FIRE. There has been limited evidence of sustaining these facilities or demonstrating overwhelming need so far. Hence FIRE requires strategies to significantly increase the customer base to justify further funding. Again this might be an argument to pursue different, co-existing models. FIRE's role might be towards the middle: providing the facilities for R&D but also with clear collaborations such that there is value for industry to leverage FIRE as their starting point too. However FIRE's role may shift over time, it might become more mature in realizing Industrial Cooperative shaping the market for testing and research, and at the same time focus on the public innovation service and keep that focus in the future, spinning off those activities aiming at professional commercial services. A phased strategy for FIRE would address these different market structures, maturity phases and opportunities. A phased approach might be difficult to realize as a plan as there are no clear indicators to move from one phase to another and shifting customer needs need to be recognized in time. This means that phasing strategy will be appropriate that creates "options" for acting later in specific directions, while showing increasingly focused offerings, growing industry control, and requiring less funding over time, which is probably in-line with the EC's direction for FIRE.

In elaborating the implications for FIRE's longer term vision we emphasize the levels of analysis. FIRE's future is not only addressing excellence and further advancements in service offering and facility infrastructure (and other aspects of FIRE's concrete business model).

FIRE's future is also about the future strategic ambition of FIRE within the Future Internet ecosystem. Both views are represented in the Table 6.

Level	Vision and Mission
Strategic	***FIRE Vision - where to go in the longer term*** • FIRE is an orchestrator of testing and experimenting facility and tools for Future Internet technologies • FIRE is "the R&D lab of the Future Internet innovation ecosystem" ***FIRE Mission - why FIRE*** • Provide the early testing and experimentation facility for the Future Internet innovation ecosystem to accelerate research and innovation cycles and eventually boost entrepreneurship
Excellence	***FIRE vision – service concepts and infrastructures for the longer term*** • Anticipate Future Internet technologies • Facilitate research and experimenter collaboration in diverse forms • Develop and implement advanced service offerings e.g. Testbed as a Service (and other) • Decrease time to market from technology testing to integration and use ***FIRE mission – Why FIRE*** • Create innovative service and facilities concepts and organizational environments for testing and experimenting Future Internet technologies

Table 6: Longer term strategic vision of FIRE for 2020

Thus we distinguish between the "excellence" vision which is concrete, technical and specific in terms of FIRE services, facilities and business model, and the "strategic" vision which reflects on the reason of existence and uniqueness of FIRE and its future value creating role within the wider ecosystem and based on cooperation with other key players and communities within the ecosystem. In the latter context, the FIRE vision can be summarized as below.

FIRE Vision

In 2020, Internet infrastructures and testbeds, services and applications form the backbone of connected regional and urban innovation ecosystems across Europe. Researchers and innovators, SMEs and other organizations collaborate seamlessly across borders to experiment on novel technologies, services and business models to boost entrepreneurship and new ways of value creation.

The FIRE programme provides the tools, facilities, community support and cooperation models to facilitate such value creation, thus strengthening the FIRE ecosystem. In this sense the FIRE programme has a crucial role to fulfil in becoming the "engine" of the Future Internet research and innovation ecosystem. In analogy to a company and its R&D department, FIRE acts as the research and experimentation lab of the Future Internet innovation ecosystem.

3.5 Statement of FIRE's mission and value added

FIRE's current mission and value of is to offer an efficient and effective federated platform of core facilities as a common research and experimentation infrastructure related to the Future Internet; this delivers innovative and customized **experimentation capabilities and services** not achievable in the commercial market.

Beyond this, FIRE may expand its facility offers and services to a wider spectre of technological developments addressed in the **H2020-LEIT Work Programme**. Examples of where FIRE facilities could already be valuable, and further developing their experimental

approaches and services, are: Smart Cyber-Physical systems (ICT1), Smart networks and novel Internet architectures (ICT5), Advanced cloud infrastructure and services (ICT7), Advanced 5G Network infrastructure for the Future Internet (ICT14), Internet of Things and platforms for connected smart objects (ICT30). In this role, FIRE represents and offers all necessary expertise and services for experimentation on the Future Internet part of H2020.

FIRE has a role to **support the Future Internet ecosystem** in building, expanding and continuously innovating the testing and experimenting facilities and tools for Future Internet technologies. This way FIRE is able to continuously include novel cutting edge facilities into this federation to expand its service portfolio targeting a range of customer needs. FIRE will also include "opportunistic" experimentation resources, e.g., crowd sourced or citizen or community provided resources.

In the **longer term,** FIRE's positioning is to become the R&D&I environment, or **"accelerator" within Europe's Future Internet innovation ecosystem**, providing the facilities for research, early testing and experimentation on the Future Internet and accelerating Future Internet technology-induced innovation cycles resulting in advanced applications and business support, and eventually the creation of new business.

Apart from its value added and core role to support advanced scientific research on the Future Internet, FIRE's experimentation infrastructure will become **more easily and publicly accessible and useable for user-centric research and innovation**, e.g. in Smart Cities contexts.

3.6 FIRE strategic objectives

The next step is to use the vision and scenario framework to formulate a set of FIRE's strategic objectives for the transition to 2020: in terms of what the results to be achieved by FIRE are. FIRE's mission and vision should be translated into "measurable" objectives, as the basis for developing the strategy towards 2020. FIRE's strategic objectives should anticipate or respond to clear challenges represented in the vision, mission and scenarios. However, first we look into some of the recent discussions of FIRE's needs, ambitions and objectives within the Horizon 2020 context, then we will discuss the need for renewal of these objectives.

Recent discussions

FIRE STATION's Architecture Board position paper "FIRE in Horizon 2020" (2012) considered the questions "what can FIRE bring to H2020?" This maybe does not explicitly reflect on a 2020 vision, rather it extrapolates the existing development pattern of FIRE. However the proposed developments are of great use as part of a FIRE 2020 strategy. Another FIRE STATION's Architecture Board's position paper "Sustainability" makes concrete proposals for FIRE's development and is of great use in defining FIRE strategy 2020 (for that, next sections).

The OSIRIS conference "The Role of ICT Infrastructures in Horizon 2020" (2012) emphasized several desired developments such as: the role of collaboration across countries in the new ICT infrastructures, the need for more interoperability between the existing ICT infrastructures, the need for new services, the further development of the role of ICT infrastructures to change the way research is done, the creation of open innovation partnership models, the need for sustainability of ICT infrastructures, the role of governance models, e.g., in Géant. Such points might be specific for ICT infrastructures but also contain lessons for FIRE. Piet Demeester (iMinds, chair of this conference) presented FIRE and stated that its focus so far has been mainly on networking related infrastructures and less on services and applications, and that industrial involvement including SMEs is still limited. FIRE would work on powerful tool chains covering the whole experimentation lifecycle and on providing

seamless access to facilities and sites in a trusted environment. It is also stated that the funding mix should be balanced from European, national and industrial sources. The 2020 objectives would focus on experiment and experimenter support, and on the provision of high quality facility services.

FIRE STATION's FIRE Roadmap on Sharing, sustainability, federation and interoperability (2012) goes into extensive detail about further developing the technical strategies to enhance the FIRE offering, addressing issues like experiment life cycle experiment support, sustainability, trustworthiness, and shared support services. It looks in detail after financial and organizational issues of federation. It also calls for understanding and facilitating the synergies between the various programmes. Different from FI-PPP and the CIP, FIRE's role is to cover the spectrum from relatively short term to long term evolution of the Future Internet, in terms of large-scale experiment support, novel technologies and experimenting of new media applications or advanced radio technologies. FIRE also works across technology areas in experimenting new infrastructure technologies combined with new service platforms and new types of applications.

The European Commission's position on FIRE (in a workshop on Future Internet Research and Experimentation in Horizon 2020, in 2012) was formulated in the Work Programme of Horizon 2020 that was published end of 2013. Important directions extracted from several presentations are to stimulate demand-driven open federation of facilities, massive stimulation of users/experimenters, and expanding the scope beyond networking. Smart Cities are considered as open innovation environments for experimenting Future Internet-enabled services. The EC mentions objectives in the scope of experimental infrastructures to support faster testing and validation as well as faster standardisation and interoperability and take-up of results; also to act as a platform for end-user involvement. Keywords as regards 2020 are more users projects and industry, sustainability over time, federation towards a European experimental infrastructure, and advanced networking experimentation cooperating with Géant.

The European Commission Unit E4 has coordinated a discussion on FIRE performance indicators. For the longer term evolution of FIRE, the Unit's priority is to encompass novel concepts such as Experimentation-as-a-Service, pan-European set ups and virtualisation of networks. The vision is to find long-term solutions for the sustainability of the experimental platforms in terms of funding and operations, and at the same time extend and link them to a broad range of member states or non-European facilities. The aim is to build progressively a strategic infrastructure of shared experimental facilities and platforms at the service of the European economy.

Strategic objectives

Combining the elements and formulating them in terms of a consistent set of objectives results in the following FIRE objectives framework presented in Table 7. The strategic objectives distinguish between *high level objectives* and *excellence objectives*, and for each of the thematic areas needs and ambitions are being formulated to which objectives and achievements for 2020 are attached.

Strategic objectives	Theme Area	Needs and ambitions	Objectives and achievements 2020
High level objectives	Economic and societal impact of FIRE	FIRE should have tangible economic and societal impact	FIRE creates substantial business and societal impact, resolving societal challenges (highest level)
	Positioning FIRE in the FI landscape	Collaboration with national research facilities and complementary Future Internet initiatives	FIRE establishes network of open, shared experimental facilities and platforms jointly with other initiatives (ICT Labs, FI-PPP, 5G-PPP, Géant etc)
	FIRE as accelerator within the FI Ecosystem	To facilitate startups and SMEs' research and innovation	FIRE establishes an accelerator functionality, develops services and facilities to enable SME research and innovation
	Exploitation of FIRE	To make more efficient and effective use of FIRE assets. Lower industry barriers. Shorten time from experiment to market Attract wider customer base	FIRE's facilities and services will be used seamless and in trusted environment. Introduce professional access and interaction models. Develop Experiment-as-a-Service models
	FIRE sustainability	Ensure future sustainability of FIRE	FIRE's ecosystem, infrastructure services, governance and customer base are sustainable. Implement channel approaches, customized service offerings, payment models. Users of technology represent a new actor in the FIRE ecosystem
Excellence objectives	Experiment and experimenter support	Need for more flexible, adaptive on demand service concepts	Experimentation-as-a-service concept is introduced. Support new, nomadic, large-scale complex experiments on demand in professional supported environment
		Need for life cycle support of experiments	Tool chain for experiment lifecycle support
		Need for systematic experimentation approach	Systematic experimentation methodologies
	Facility service offering	Need to support complex experiments on demand	Capability to support complex experiments on demand including consultancy services for those in need of support when using testbeds
		Cover simulated environment and real monitored environment	Capability to cover simulated environment and real monitored environment
		Provide Smart City experimentation facilities addressing major societal challenges	Capability to provide experimentation facilities (e.g. Smart City environments) addressing major societal challenges
		Involve end-users and communities as engaged experimentation actors	Capability including methods and tools, to engage end-users and communities as experimentation actors
		Need to offer increased functionality and diversity of experimentation platforms	Offer broad functionality using de-facto standard platforms
		Reduce experiment costs	Reduce development and maintenance costs
		Offer services to large partner base using different business models	Offer services to large partner base using different business models
	FIRE facility and technology advancement	Integrate advanced technologies	
		Connect with related infrastructures Géant, ICT Labs ..	Create effective collaboration models
	User base	Widen customer base of FIRE, attract industry users and user communities e.g. Smart Cities, experiment on demand, large-scale user groups	Widen the customer base of FIRE
	Business model	Services, funding, payment model, governance, customer relations	Develop sustainable business models

Table 7: FIRE Strategic objectives

Table 7's presentation of strategic objectives distinguishes between broad high level objectives and specific technical, excellence oriented, objectives. Achieving the excellence oriented objectives contributes to achieving the high-level objectives. It should be noted that several of the area items are part of the CANVAS approach to sustainable business modelling, and we see development of a new FIRE business model as part of FIRE's strategy development (see below). In summary, the most important strategic objectives (or at least strategic themes) of FIRE to be achieved in 2020 seem to be the following:

MAIN STRATEGIC OBJECTIVES FIRE TOWARDS 2020

- FIRE creates substantial business and societal impact, resolving societal challenges (= overall objective)
- FIRE is accelerator within Future Internet ecosystem, boosting startups and SME's innovation capability
- FIRE is partner in collaborative network of open shared network of facilities and platforms
- FIRE ensures full, seamless, trusted exploitation of its facilities, services and know-how
- FIRE establishes sustainability of the ecosystem of facilities and users.

4. FIRE Strategic Direction Towards 2020

4.1 Overview

This chapter focuses on the over-all strategic direction of FIRE in terms of activities and steps to be taken, given the previous analysis of FIRE future scenarios, proposed mission and strategic objectives.

4.2 Strategic direction implementing the strategic objectives

The FIRE strategy focus is on how to realize the vision and how to achieve the strategic objectives stated for 2020. We argue that excellence oriented technical objectives are a necessity but they are not sufficient on their own as FIRE also needs strategic positioning in terms of how it achieves sustainable value creation activity and how it collaborates with other initiatives. The long-term goal of FIRE is to realize a sustainable, connected network of Internet experimentation facilities providing easy access for experimenters and innovators across Europe, and offering advanced experimentation services. This way FIRE acts as an "accelerator" of research and innovation of the Future Internet ecosystem. In Table 8, the key elements of the FIRE strategy towards 2020 are formulated in terms of the activities needed to achieve the objectives and achievements proposed for 2020.

Activities to realize objectives 2020	Strategic objectives 2020 (see Fig. 4)	Overall strategic objective
• FIRE establishes a network of open, shared experimental facilities and platforms • FIRE creates partnership with other initiatives (ICT Labs, FI-PPP, 5G-PPP, Géant etc)	FIRE establishes a network of open, shared experimental facilities and platforms jointly with other initiatives (ICT Labs, FI-PPP, 5G-PPP, Géant etc)	FIRE is the Future Internet R&D Lab FIRE is sustainable and creates substantial business and societal impact, resolving societal challenges
• FIRE establishes accelerator functionality, • FIRE develops services and facilities to enable SME research and innovation	FIRE establishes accelerator functionality to enable SME research and innovation	
• FIRE's facilities and services will be used seamlessly and in a trusted environment • Introduce professional access and interaction models • Develop and implement the Experiment-as-a-Service concept • Support new, nomadic, large-scale complex experiments on demand	FIRE's facilities and services will be used seamlessly and in a trusted environment, for a widened partner base, to enhance FIRE's exploitation, and based on advanced experimentation concepts	
• Implement channel relations approaches • Customized service offerings • Customized payment models • Facility and service provision cost management • Implement the prosumer-model among users and providers	FIRE's ecosystem, infrastructure services, marketing, governance and partner base are sustainable.	

Table 8: Strategic activities to realize FIRE objectives

Earlier in sections 3-4 we presented and elaborated a set of key strategic objectives for FIRE. We have identified in Table 5 that the overall strategic objective is for FIRE to become a sustainable 'R&D lab' like facility for research in the Future Internet; supporting researchers and the community to tackle important problems, and acting as an accelerator for industry and entrepreneurs to take novel ideas closer to market. Here we explore potential strategies that could be employed to achieve these objectives.

Strategic direction 1: FIRE is a core element in solving tomorrow's grand challenges

Objective:
FIRE creates substantial business and societal impact, resolving societal challenges.

Recommendation 1: Increase the number of experiments and experimenters using FIRE

- Offer facilities that experimenters want, and that are up-to-date with research trends.
- Broaden the FIRE community with experimenters not centred within the FIRE community. Attract experimenters without using funded experiments based on service usefulness and support quality.
- Fund the creation of new experimental facilities that meet both research trends and experimental demand. Proposals must demonstrate an expected growth in demand during and after the project completion.
- Within the lifetime of the project, facilities should plan for robust delivery of open services that will be useable and trustworthy such that industry and the public are attracted to FIRE. A funded facility project proposal must plan for open-access.
- Prioritise projects with a strong set of external stakeholders beyond computer science researchers.

Recommendation 2: Increase the number of high-level research publications for experiments that have employed FIRE facilities

- High quality computer science publication venues require rigorous and repeatable hypothesis evaluation typically involving real-world experiments. FIRE should be promoted as a facility to provide a recognized platform for such evaluation.
- Further FIRE research into repeatability and reproducibility. The next challenge beyond federation. Projects should include reproducibility as a feature of an experiment-as-a-service platform.

Recommendation 3: Increase the number of projects and experiments that lead to resolving societal challenges

- Increase community involvement as opposed to i) singular experimenters, and ii) academic and industry participants including customers of Future Internet solutions. Bring end-users into the FIRE community such that they can also innovate for the social good. Promote open source community building methods such as hackathons and open source code.
- Promote FIRE as an important R&D facility in the quest to solve tomorrow's grand challenges. Increase collaboration globally and within Europe.
- Promote FIRE as a collaboration environment to support high-quality cross-disciplinary societal research.

Strategic direction 2: FIRE is the Future Internet R&D accelerator

Objective:
FIRE is the accelerator within the Future Internet ecosystem, boosting startups, entrepreneurs and SME's innovation capability.

Recommendation 1: Increase the number of start-ups and SMEs leveraging FIRE

- FIRE directly supports incubation of SMEs and startups (e.g. using initial funding via refundable loans).
- Provide a professional, highly supported facility that will attract commercial partners. Fund activities in terms of improving the service offering. Follow industry standards for service management.
    - Drastically reduce the learning time and start-up time for using facilities
    - Provide open access to trial FIRE i.e. to discover if fit for purpose
- Prioritise projects that consider wider engagement with industrial activity. Not as project partners, but through direct and hassle free engagement mechanisms: tailored open calls and open access, point of contact, professional service delivery.

Recommendation 2: Decrease the time to market for experimenters

- Position FIRE as the R&D lab of Future Internet technologies and services. Invention -> FIRE -> scale up to FI-PPP trials -> market.
    - Build a strategic and technological relationship with PPP initiatives to ensure that rapid transfer from idea to initial validation to trialing can occur with minimal cost to commercial participants.
    - Foster "spinouts" from FIRE experiments. Continued support of start-up e.g. further free use of facilities.

Fig. 8 visualises the proposed strategic direction in a high-level roadmap of "landing places". This will be elaborated in more detail in the FIRE Roadmapping exercise (T1.3).

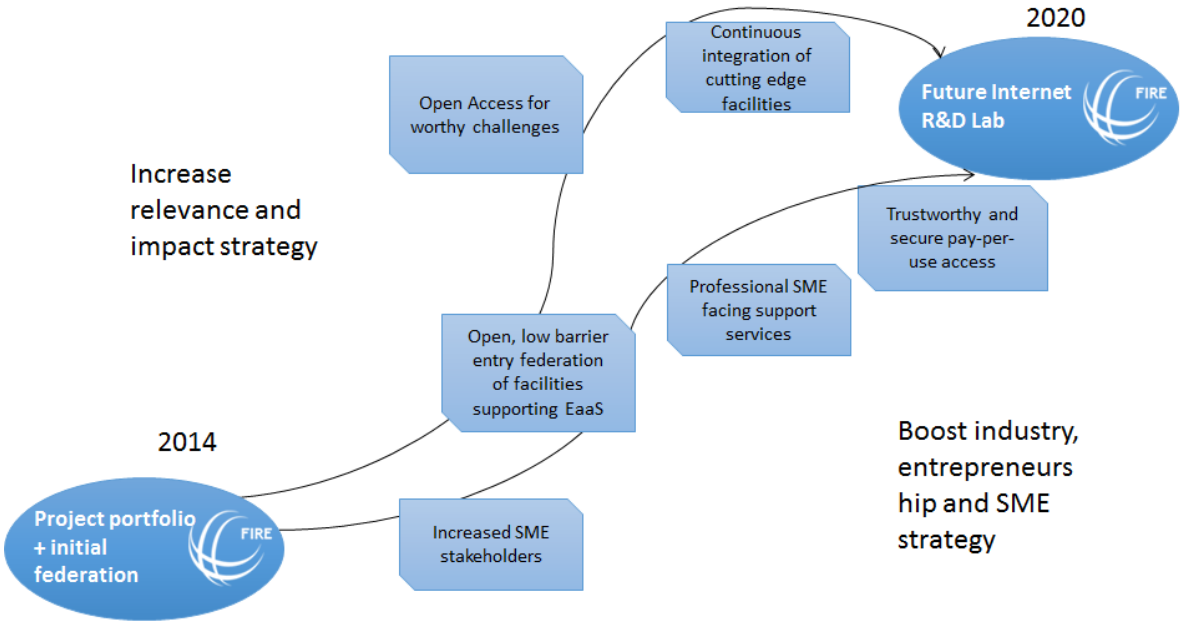

Figure 8: Overall strategic direction of FIRE

5. FIRE Domain Strategies

5.1 Overview

This chapter provides an elaboration of the strategic direction in domains of service offering, facilities and federation, EC programme relations, users and community ecosystem, collaboration, and governance. These elaborations should be considered as `work in progress` and are discussed within the FIRE community.

5.2 FIRE service offering strategy

A service is a utility or function performed by a service provider that offers value to a consumer. In terms of FIRE this is centred on the services provided by the FIRE facilities, FIRE support actions and the EC to the FIRE partners, i.e., the experimenters and innovators of Future Internet technologies. Generally, the goal of a service provider is to professionally deliver a service that adds significant value, such that customers are attracted and maintained. However, as we move towards 2020 there is also a need to increase efficiency and optimise service delivery. FIRE is now a mature programme of experimental facilities, i.e. if it is to sustain in the long term it must consider how to manage the delivery of services effectively; at present FIRE is an ad-hoc collection of facilities with **inconsistency across the programme** in terms of: i) the richness of services provided by each facility (including the level of support to an experimenter, ii) the long-term availability of facilities (if I am an experimenter will a facility sustain long enough to meet my requirements?), and iii) interoperability between the different infrastructures. Therefore, the following are a set of key objectives to consider:

(1) FIRE must remain relevant and meet future experimenter demands and be driven by the demand.

Future Internet technologies emerge quickly and the period for research and experimentation with such technologies is often short. FIRE must provide experimental facilities that underpin experiments with the latest technologies. How would such an objective be met? There are a number of strategies to employ. FIRE can support actions that assess the changing state of the art in terms of technologies and services, able to deal with current and evolving experimenter demands. Such actions must be based upon a co-creation strategy, interacting directly with experimenters, extract their requirements and uncover potential for extensions. FIRE must also collaborate globally with other experimental testbed initiatives to align with trends and share expertise and new facilities. Where major new technologies emerge these should be funded as early as possible as new experimental facilities in the FIRE ecosystem.

(2) FIRE must federate diverse facilities in a flexible way.

Ultra-large scale systems, cyber physical systems, and the Internet of Things are just some of the many technology trends that point to the convergence of Internet technologies. Systems will be cross-domain and FIRE must support experimenters who wish to perform experiments across heterogeneous testbeds. A single sensor or wireless network testbed will not be sufficient to meet the next generation of experimenter demand. To meet such an objective, federation building initiatives are required and then subsequently community building exercises around these federations (i.e. small scale projects to build and deploy added value services). There may not be a single FIRE federation i.e. there could be separate network and service testbed federations[12]. The key to each is to ensure that the federation provides a

[12] Serving different segments and domains of experimentations and experimenters.

valuable service and that a user community is built. Part of the Fed4FIRE project is to define a strategy to interconnect different testbeds, even with existing federations e.g. BonFIRE.

(3) FIRE must promote common tools and methodologies to perform experiments.

Essentially, FIRE must provide Experiment-as-a-Service i.e. an experimenter can utilise FIRE facilities from a single point using the same technologies without having to learn all the heterogeneous technologies. The added value of such a service is the reduced time to experiment deployment, which in turn will lower barriers to both the research and industrial experimenters and help grow the customer base.

In this, the role of standards is a point of discussion. One view is that the FIRE ecosystem must enforce policies and APIs / standards that facilities provide and implement such that they can join an experiment as a service platform. The key tools provided by current facilities must be identified to ensure that reuse of these is optimised. Future funded FIRE facilities would be conditioned upon the common use of the existing tools in and the convergence to a single experimenter portal. However, such tools and portal need to be maintained in the long term; hence software communities must be built around such tools and technologies. FIRE must follow open source practices in this regard. Where there is a community demand, experimenters will help maintain and create with minimal funding support from FIRE.

In Fed4FIRE, however, different standards are supported. Some should be implemented in order to provide a basic service (e.g. resource detection, reservation and provisioning), some are optional (experimentation monitoring). Who will decide what standard to use is not defined yet.

5.3 FIRE facilities and federation strategy towards sustainability

FIRE enables experimentation for the Future Internet development, by building new facilities (testbeds and tools to measure the results obtained) or by utilizing existing ones, depending on the Future Internet area that the experiments target to cover. A non exhaustive Future Internet area based categorization and analysis of the wide range of isolated facilities and experiments that can be found in FIRE is the following.

- **Networking**: experiments that use existing FIRE facilities mainly for research into networking technology, interfaces and protocols. Depending on the type of facility on which the experiment takes place we can distinguish between PlanetLab-based facilities, open Internet measurement testbeds, optical testbeds, switching testbeds, emulation testbeds, wireless LAN testbeds (Wi-Fi, Bluetooth, etc.), software-defined radio testbeds, sensor networking / embedded object testbeds, and cellular wireless testbeds.
- **Internet of Services, software and virtualisation**: these are FIRE facility building projects dedicated to research in distributed computing, data management, security, Grid and all aspects from services front-end, including architectures and virtualized infrastructures. Research towards service platforms and advanced cloud paradigms for service delivery, also by offering Platform-as-a-Service (PaaS) and infrastructure as a service (IaaS), are covered as well.
- **Internet of Things:** these usually are FIRE facility building projects covering the deployment of heterogeneous IoT infrastructures in order to run service experiments (or eventually to experiment in networking and transport as well), some of them with a direct connection to the Smart Cities area or within a city context. Furthermore, the use and operation of the applications that interact with the IoT infrastructure is also covered in these type of FIRE projects.

- **Internet of People:** FIRE facilities are used for research in Future Media Internet, networked content, internet communities and search systems, as the mechanisms to deliver social and networked media experiences to individuals and communities, i.e. to the internet users themselves. These are therefore, application and content oriented experiments that usually include research in network and content management infrastructures as well, in order to deliver guaranteed Quality of Service (QoS) and enhanced Quality of Experience (QoE) to communities that dynamically organize themselves around socially distributed, fixed and mobile content.

  Applications focus on providing enhanced personalised experiences supporting interaction or even the creation of social communities which allow people to use e.g 3D environments to communicate and interact with each other, using rich communication means similar to those used in face-to-face meetings, capture and reproduction of the real world in 3D, etc.

- **Research in Vertical Sectors**: these experiments create new or use existing FIRE facilities for research in Future Internet application scenarios in vertical sectors such as eHealth, environment, transport, logistics, energy, telecom industry, automotive or ecommerce applications. This is a wide and heterogeneous community, and therefore, usually the demand for FIRE facilities and experiments, showcases or application scenarios is represented in specific Challenges.

From the above analysis, it can be seen that FIRE, as a research infrastructure, includes a range of experimentation facilities covering many of the areas required for the development of the Future Internet, and that FIRE facilities and experimentations can be used to reduce cost and time when implementing complicated and novel systems (i.e: for prototyping), or as part of a scientific methodology. FIRE supports both these usages of experimentation.

The historical FIRE portfolio is weighted heavily towards networking research e.g. PlanetLab-like facilities, wireless testbeds etc. In the *Services, Things, and People* domain there have only been a handful of facilities in comparison (BonFIRE, EXPERIMEDIA, SmartSantander). With changing trends FIRE should continue to broaden its range, to meet experimental needs.

Moreover, currently, most of these FIRE facilities and experiments exist largely in isolation, however, ground-breaking new applications and services on the Internet are often driven by a clever combination of many innovations across the entire ecosystem. Future Internet evolution and demands show that FIRE will need to evolve from the usually single area oriented Future Internet research facilities and experiments that exist currently, to **cross-technology and cross-area facilities** which can support the combined effects and benefits of novel infrastructure technologies (wireless equipment, management of networks, new devices, new protocols, etc.) used **together with the emerging new service platforms** (Clouds, IMS, content distribution, etc.) where new applications (media, eHealth, Smart Cities, etc.) will try to influence the new underlying technologies.

This Future Internet evolution in trends and demands can be best covered by a federation of FIRE facilities that can fulfil not only the experimentation needs for using cross-technology research facilities, but also the need to run a single FIRE experiment on multiple testbeds at different locations, which can be of great value from an industry or scientific point of view. Moreover, federation is a strategy to add value to the FIRE offering and share best practices, such as sharing code, methods, resources, tools etc. and give a better value to each individual facility.

It is of utmost importance as well, to understand and facilitate the synergies between FIRE facilities and the various EC programmes, in order to evaluate the chain of developments funded by the EC (see next Section 5.4). It is equally important to recognize the value of each programme and that we cannot expect that a single programme will address all the needs.

There is a potential for stimulating the various innovation channels, identifying the common challenges and methodologies, complementary roles and success factors, from a technical and sustainability point of view.

The Fed4FIRE project has initiated the work for defining a common Federation framework for FIRE facilities, and it will be of great importance that the Federation model created includes and maintains all the necessary tools and services supporting the FIRE experiment lifecycle management (discovery, reservation and experiment control), measurement (metrics, instrumentation, data management) and trustworthiness (federated identity management and access control, accountability, SLA management). In order to develop and evolve a global FIRE Federation that allows experimenters a transparent and unified access to all available testbed resources, **the most important step is the standardization of the interfaces used for communication and information**. For example, standardized experiment descriptions will allow a single experiment to be run in different testbeds, standardized resource descriptions will allow experimenters to browse and combine resources coming from different testbeds, and common authentication and authorization policies will facilitate the crossing of administrative boundaries.

Efforts around this have been on-going, with the first steps being carried out mainly in the context of a single technology. For example, OMF and OML are proposed standards that are being developed to formalize the experiment description and monitoring data for testbeds based on the ORBIT technology, and the Slice-based Facility Architecture (SFA) was introduced as a generic distributed federation architecture focusing on authentication, authorization, and resource descriptions, though it was initially implemented around the PlanetLab testbeds.

Also, we believe that having a **monitoring service** as part of the FIRE Federation infrastructure would have many advantages, since for instance, it relieves the experimenter from having to perform such instrumentation by themselves, so they can focus on developing the core of their experiments. Instrumentation is sometimes challenging, and a monitoring service will typically be realized by more experienced people, allowing the experimenter to benefit from best-of-breed tools.

A close **integration of measurements (live measurements, historic measurements) into the experimental lifecycle** should help users to get the best out of a testbed's resources and validate their experiment results.

As mentioned before, it is important to understand that FIRE facilities can not only benefit and provide added value by following this federation model inside the FIRE programme in the future, but also it is relevant to analyse the possibility of a **facilities federation with the infrastructures provided by other EC programmes** (e.g: FI-PPP) from a technical and sustainability point of view. Several efforts in this direction are already planned to start, specifically in the FI-WARE and XIFI (FI-WARE's federation authority) projects from FI-PPP. The first FIRE experiments that have been identified by XIFI as candidates for the Federation with FI-WARE's infrastructures are Ofertie, EXPERIMEDIA and Smart Santander.

Ofertie is a FIRE project for building a FIRE facility that can be used for running several experiments on mmo gaming, and adjust the network settings according to the evolution of network condition and the number of participants in the games. Ofertie uses for its cloud the OpenStack technology, the same used in FI-WARE, so a technical federation of both infrastructures should be possible after solving any interoperability or scaling up issue.

EXPERIMEDIA is a FIRE project that uses FIRE facilities to analyse internet communities and social feeds and create Social analytics dashboards. The data context management and event processing systems used in FI-WARE are very similar to those used by EXPERIMEDIA, making it possible to consider a technical federation of both infrastructures.

SmartSantander is a city-scale FIRE project that has built a FIRE facility in order to run experiments on the Internet of Things (IoT) area, which can in turn be utilised to create new urban services for the cities. The protocols and interfaces used by the IoT management system (NGSI, Sensor ML) are the same ones used by FI-WARE, making it possible to consider the technical federation of both infrastructures.

From a sustainability point of view, federation means that **multiple partners** (infrastructure owners) are involved and therefore the relationship among them in the chain value needs to be investigated for understanding what is the best **business model** in such a situation. This situation will be different when a FIRE Facilities Federation is considered than when a federation of a FIRE facility with infrastructures from other Future Internet EC programmes is considered.

Sustainability of the federation can be ensured only by establishing an **operations centre**, which deals with all operational issues related to federation (e.g: as defined in Fed4FIRE for FIRE Facilities federation, or as defined in XiFi for federation with FI-WARE facilities from FI-PPP). Of course, it is very important that Fed4FIRE leverages the work being done by other organizations outside FIRE (e.g. XIFI) so that federation with infrastructures from other EC programmes is facilitated. In this sense, FIRE federation sustainability could be ensured by following a **pay per use model** with the relevant FIRE projects, depending on the number of facilities and use that each of the FIRE projects makes from the Federation.

A wider effort may be required for ensuring funding and the federation sustainability when projects from other EC programmes are involved in the federation, some possibilities being to reserve a part of the budget from the interested FIRE project to work on this, to request funding from other EC or national programmes or that the relevant project from the other EC programme dedicates the necessary budget to ensure the interested FIRE facility can be federated.

Another important factor in the future sustainability of FIRE facilities is **trustworthiness**. Experimenters trust that the service they require will be long-lived (they do not want to build a plan based upon FIRE, only for it to disappear). They also want the facilities to be reliable and secure, such that there is no threat to their IPR. FIRE facilities have not addressed such requirements, but must begin to do so if long-term sustainability is to be achieved.

From the legal point of view, it will be necessary to provide a **legal base for the operation of a federation of experimentation facilities** by defining all necessary legal rules for implementation of experimentation. So-called federation contracts, which might be provided in form of contract templates, should ensure a simple and clear legal procedure for joining the Federation, as testbed owner providing experimentation facilities and as customer using the federated testing services.

In conclusion, FIRE strategy in this domain should drive towards:

- A broad set of facilities that capture the complexity of the Future Internet and meet the often interdisciplinary needs of experimental users.
- Continue standards driven federation to ensure research is not constrained to so-called experimental silos.
- Align with global facilities within the Future Internet research landscape, e.g. FIRE and GENI. Ensure that transitions between one another is either seamless or simple.
- Facilities and federations within FIRE should seek to be self-sustaining (as far as possible).

5.4 FIRE Infrastructure strategy and relation with EC programmes

There are several EC programmes that dedicate all or part of their mission to provide innovative pan-European ICT infrastructures as a result of their research and experimentation activities. Some examples are FIRE, FI-PPP, 5G-PPP and EIT ICT Labs.

Currently, the main user communities for each of these programmes are different: while FIRE's primary focus has been the research and scientific community, FI-PPP's focus has been the big industry, 5G-PPP target is mainly the telecommunications industry, and EIT ICT Labs have mostly focused on the entrepreneurs, SMEs, and the individual end users themselves, as part of the society. It is important to mention that FIRE does target all these other user communities as well, however, it is also true to say that its primary focus has been the research and scientific community.

It is clear that the interests of all these user communities converge and that we therefore need to find ways to allow the FIRE programme to leverage the work done by other EC programmes in that sense. There is little value in the scientific and research community developing facilities which have little to do with what the industry community really needs or will need in the future, nor in the industry community to work on facilities for providing services that don't match what the society demands and needs, or the SMEs and entrepreneurs wasting time trying to create their own facilities which don't take advantage of the new ground breaking technologies and social demand trends that the scientific and research community identifies.

The various EC programmes are already working towards the convergence of these user communities. AmpliFIRE aims to bring together the different user communities for developing a vision of FIRE's future including its capabilities and services, and it also identifies the gaps between FIRE's resources and the user demands to ensure that FIRE facilities can continue matching their expectations in the future. Moreover, AmpliFIRE carefully follows the activities and strategic roadmaps of the different EC ICT innovation programmes in order to identify potential opportunities of collaboration with them.

From an innovation ecosystem point of view, the different EC ICT innovation programmes are also following **different approaches**. FIRE and FI-PPP dedicate more than 80% of their ICT innovation and research activities to the development of Future Internet (i.e: research in the areas of Internet of Things, Internet of Services, Internet of People/Users, Networking) and the rest is dedicated to research applicable to particular vertical industry and society sectors. 5G-PPP will be dedicated exclusively to research in the networking area of the Future Internet, while EIT ICT Labs dedicates more than 80% of their research and innovation activities to the creation of specific infrastructures and facilities to be applied on a particular vertical industry or society sector (Education, e-Health, Energy, Mobility, Cyber-physical systems etc.) .

Vertical sectors and their application scenarios related to Future Internet research are represented all across FP7 ICT Work Programme challenges (for instance ICT Challenge 5 covers the eHealth sector, ageing scenarios and new government schemes in the public sector, Challenge 7 addresses future manufacturing scenarios or we can find technologies and applications covering environmental aspects, carbon economy and climate change in Challenge 6). There are also specific research programmes for transport, logistics or energy sectors. FIRE can expect demand from major showcases or application scenarios represented in Challenges, as well as IP projects like SAIL and SWIFT about telecom industry; SOA4ALL with eCommerce applications; 2020 3D Media and LinkedTV for TV broadcasters and the 'new media' sector on the Web; COIN with cases in automotive or healthcare and related future projects.

Another potential source of demand for FIRE are the Use Case projects gathered under the FI-PPP initiative. Examples are FINSENY (energy sector), ENVIROFI (use of environmental observations), FI-CONTENT (multimedia industry), FINEST (transport and logistics sector), OUTSMART (about supply and access to services in urban areas relying on infrastructures provided by the utilities), SAFE CITY (public safety and security in cities – public sector) and SMARTAGRIFOOD (agri-food sector). Also, new "smart" scenarios like the Smart Cities supported by public administrations in the Horizon 2020 programme offer complex application scenarios that combine all angles of Future Internet.

Collaboration with the initiatives in FI-PPP that cover the different Future Internet development areas and federation of facilities (e.g. FI-WARE and XIFI) is also foreseen as key for FIRE.

Moreover, as we have seen, EIT IC Labs is also a relevant programme where collaboration with FIRE will be important for the application of Future Internet development research in the vertical sectors that are part of EIT IC Labs strategy, and that we have mentioned before. It is important to highlight that, despite not being part of the main stream of activities in EIT ICT Labs, this programme also plans to research on the cloud and networking areas of the Future Internet, so there's also a potential opportunity of collaboration with FIRE in that sense.

The 5G-PPP programme may be another source of demand for FIRE, in order to leverage the work done by FIRE in the networking area of the Future Internet.

In conclusion, we believe the FIRE collaboration model with FI-PPP, EIT ICT Labs and 5G-PPP should be the following (see also section 5.5 for a detailed presentation):

- Collaboration with FI-PPP should be focused on the initiatives from that programme that cover the Future Internet development areas as a whole (e.g: FI-WARE and XIFI), since this is in line with the proposed FIRE's facilities strategy and federation in the future (see section 5.3).
- FIRE can expect to receive demands for Future Internet research application scenarios in vertical sectors, either through FP7 specific Challenges or Use Case projects, or through EIT ICT Labs programme.
- Collaboration with 5G-PPP will be focused on leveraging the FIRE research and facilities in the networking area of the Future Internet.

AmpliFIRE should continue to carefully follow the evolution of the previously mentioned programmes in order to identify potential opportunities of collaboration for FIRE in the future.

5.5 FIRE users and platform ecosystem strategy

User and community ecosystem strategy will become a more and more important aspect of FIRE strategy and future business model. This section tries to formulate a general user and ecosystem building approach which is to be elaborated in the next period.

In previous sections we identified a range of opportunities for FIRE to attract different user segments including but also beyond the traditional research and scientific communities. Key user categories include research institutes, large industry (ICT), innovative SMEs, initiatives in the Future Internet such as FI-PPP (with a focus on large industry as well as SMEs) and 5G-PPP (focus on telecom), EIT ICT Labs and other. With some of these a more collaborative relation can be developed as distinguished from a customer relation, as we've seen is previous sections and further explored in section 5.6. As discussed in section 5.4, other EC programmes are also relevant for FIRE in terms of customer and collaborative relations.

A first point is to distinguish the different natures of the various stakeholder segments. Some segments can be clearly characterized as "user" or "customer". With other segments or stakeholder types the (potential) relation is in terms of "collaboration" which implies more than offering and consuming a service. It implies creating mutually beneficial relations over a longer time horizon: creating a **platform ecosystem around the FIRE activities**.

As was suggested in Chapter 2 we may consider that the concept of platform ecosystem and multi-sided platforms is potentially relevant for FIRE and opens new opportunities. Unlike a value chain or supply chain, a (multi-sided) platform-based activity brings together and enables direct interactions within a value network of customers, suppliers, developers and other actors. The range of FIRE facilities and services can be seen as constituting a platform ecosystem facilitating multi-sided interactions. For example, developer communities may use the FIRE facilities to directly work with business customers on technology and product development, whereas the current FIRE service model focuses on giving researchers and experimenters access to FIRE facilities. The issue is then to what extent the current FIRE ecosystem realizes its opportunities and what the strategic options are to extend the current FIRE model to a platform-based ecosystem model.

A related point is how to address dedicated user groups apart from researchers and experimenters. FIRE's potential to attract "users" has been discussed in the FIRE Forum and Board events organised by AmpliFIRE. On the one hand the discussion is about making FIRE even more attractive for scientific experimenters, meeting their demands. In this respect, important challenges for the future are: measurement methods, scalability and heterogeneous technologies[13]. Meeting these demands requires **continuity of testbed facilities**. The mechanism of "Open Calls" became an increasingly popular way of orienting running projects towards today's demand for new testbeds, new technologies and new services. The "Open Access" gives a new instrument, from which the first experience is eagerly awaited. E.g., Bonfire will continue one year after its formal ending, under this Open Access model, offering new testbeds to be partner of an ecosystem and giving the industry full control of the resources. Apart from technical continuity, **financial sustainability** comes into play as facilities need to be offered to users on a sustainable basis. Several models have been worked out by projects such a Bonfire, and organisations like iMinds. It is important to recognize that continuity and sustainability assume a critical mass of users, so user strategy is part of FIRE's future.

[13] E.g. when a user needs need both wireless and wired at the same time, because TCP is end-to-end.

User strategy is to consider the implication of SMEs, start-ups but also more industries as new users/experimenters. As the demand of such users groups are different (see above for SMEs), FIRE must create a **value proposition and service approach** that addresses a range of user categories.

At this point, the FIRE community is in the phase of developing more concrete views with respect to the approach and services with which different user categories can be attracted to FIRE facilities and services. FIRE Forum and Board have discussed the needs of SMEs and of sectors such as education, automotive and health in terms of potential importance, however work must be done to clarify the service interface that brings together demand and supply.

SMEs are one case in point[14]. The offering of experimental facilities used in FIRE projects can be tuned to match the expectation of SME target groups.

An example is the approach of iLab.t at iMinds which offers technical testing. Until 2012 the information that was shared on iLab.t was mainly distributed through scientific conferences and hidden on project websites. The message was also spread mostly to specialised engineering audiences. Typical information that was made available were listings of available technologies, the number and type of available servers, reports on technical extensions and/or a listing of available tools (e.g. "a tool to take care of mass-installation of nodes, a tool to visualise monitored data", etc.), and the interconnection of the different testbed components. However it was found that through these presentations a relatively limited amount of SMEs found their way to the testbed.

In order to attract more SMEs (as supporting the local industry and beyond is part of iMinds' mission), a specific effort was done to reformulate the iLab.t offering. While the iLab.t testbeds obviously do not at all represent the whole of FIRE, the fact that iLab.t has both wired and wireless testbeds, and is used for a very heterogeneous types of research (from hardware, over different layers of the OSI stack, to complex integrations of distributed systems) make that it also non-trivial to come up with a concise value proposition.

A new way of presenting the iLab.t activities targeted to SMEs was to almost completely take away the focus on technical aspects when explaining testbed possibilities: instead of focussing on what is available in iLab.t, the focus is now on the value that can be created for SMEs when they start a collaboration with iLab.t. This implies a strong emphasis on understanding the relevant problems of SMEs during the different phases of product design or development, and how they can be resolved. As an example, for products and services in early development stage, iLab.t accelerates the go-to-market process by providing the tools and know-how for fast prototyping, technology discovery, benchmarking of subsystems and feasibility analysis. This allows fast identification of go and no-go paths and the creation nof convincing prototypes.

Such approaches imply a departure from traditional "facility offering" based models of customer interaction. There is a need to discover appropriate user-producer processes and marketplace interfaces through which demands can be discovered and aligned with service offers and where service offers can be easily adapted to demands. To start with we need better insight in the requirements of large companies, but also in EC programmes and initiatives towards FIRE, and finding new ways in offering FIRE services. AmpliFIRE has already started an activity in the T1.3 to identify the market demand in several user segments.

[14] This was discussed thoroughly during the pre-FIA workshop 17-18 March, Athens in a workshop which was organised by AmpliFIRE jointly with CI-FIRE and FUSION.

At this point we conclude by stating the need for more innovative approaches to attract a wider range of users to FIRE facilities and services, and even more important to find innovative ways to align demands and offering.

The other direction to investigate is how FIRE could benefit from platform ecosystem development. To push this direction, network effects should be fostered by creating mutual beneficial relations among key stakeholders that collectively establish a true FIRE ecosystem. This ecosystem consists of facility providers offering open access to facilities and tools, developers and suppliers of user friendly experiment tools and services, end users (developers of products and services).

5.6 FIRE collaboration strategy

Focus and collaboration is required to position FIRE in the Future Internet ecosystem amidst other initiatives and players, but also because of the reduced budget available for FIRE in Horizon 2020 compared with FP7. Within the Future Internet landscape, FIRE aims to provide an important component to foster the development of experimentation infrastructures beyond 2020, based on its focus on research and experimentation facilities and increasingly on provisioning a range of dedicated testbed services to various categories of users.

In order to make that role possible, FIRE must create strategic and operational collaborations within the Future Internet landscape and move to next phase for collaboration models with both strong ties and loose ties collaboration (ref: AmpliFIRE Defining Collaboration model Whitepaper, October 2013). For that, we should more clearly define the opportunities and envisaged value networks for collaboration and the objectives, means and the multi-faceted values in the collaboration models. We should distinguish between:

1) **Collaboration within FIRE, between projects.** The objective of collaboration at this level lies in, for instance, development of common knowledge and skills, the sharing ad federation of testbed facilities, access to and sharing of technologies and know-how and methodologies or tools, the actual federation of facilities, and collaboration on technology development. For the important topic of federation, this is the domain of Fed4FIRE. As regards FIRE-internal community building, it is the role of AmpliFIRE to stimulate internal collaboration and coordination and to this end the FIRE Board has been created recently (ref: White Paper on FIRE Forum and FIRE Board, August 2013).
2) **Collaboration between FIRE and other initiatives or key players**. Examples are EIT ICT Labs, FI PPP, 5G-PPP, Géant, Living Labs and Smart cities initiatives, GENI. The CI-FIRE CSA works on collaboration between FIRE and EIT ICT Labs; Fed4FIRE works on collaboration with GENI. For such specific collaborations it is important to clearly define the objectives and benefits of collaboration as well as resources implied in the collaboration.
3) **Collaboration of FIRE within the wider ecosystem in a much informal and loose manner, comparable with a breeding ground.** In this context AmpliFIRE has the role to stimulate and create an open community for Future Internet research and experimentation, enabling sharing of resources and loose ties collaboration. Actually this more informal process for collaboration also involves shared norms and mutually interactions as for more formal collaborations (strong tie relationships). Creating such interexchange as part of a wider community is a breeding ground and a basis for longer term sustainability of FIRE. Part of this networking includes the development of further relations with ETPs such as NESSI and Net!Works (possibly resulting in stronger networks and community relations) and continuing international community building (e.g. Korea, Brazil, Japan and other).

FIRE collaboration strategy must be part of the future FIRE business model and result into strengthening its value network development, enabling FIRE's envisaged transition to 2020. FIRE aims to be part of a wider network of experimentation facilities across Europe and the world, being able to offer access to specific technologies and facilities to its users, This also includes a complex prosumer exchange value-network structure where providers of testbed assets also can be users and vice versa. Therefore it´s of importance for FIRE 2020 to understand the existing relationships and exchange between value-network actors as this plays an important role for the existing and future FIRE performance and sustainability. Through collaboration FIRE can capitalize on additional facilities and can become an actor of a wider value network for Future Internet experimentation. By offering its own assets and partnerships in turn, and by adding value added services for experimentation, FIRE becomes a partner of a collaborative network which facilitates multifaceted research and innovation services worldwide.

In order to develop concrete FIRE collaboration opportunities, we should start with asking some basic questions:

1. What is the goal of collaboration?
2. What is the win-win?
3. What are the assets used to enable collaboration?
4. What are the (new) services and value propositions enabled by collaboration?
5. How to invest to create effective collaboration?
6. How to define collaboration agreement frameworks for both strong ties and loose ties relations, addressing critical issues?
7. How to implement and realize the collaboration?

Very concisely some of these questions are addressed in Table 9, in the context of collaborations with other initiatives. FIRE as a programme, collection of testbed facilities, forefront use-cases and partner-network is also an actor of a wider Future Internet ecosystem of experimentation. This environment is in continuous change and equally value creation is migrating. Table 9 describes some existing FIRE collaboration relations with different actors including the potential future win-win from these existing and emerging bilateral collaborations.

Actor	Scope for collaboration in short term	Scope for collaboration in the longer term	Critical aspect to realize collaboration
EIT ICT Labs	to explore FIRE facilities for industry by establishing a brokerage service. First step is to offer services from Onelab(www.onelab.eu) and the Fuseco facility (https://www.fokus.fraunhofer.de/en/fokus_testbeds/fuseco_playground/_files/FOKUS_FUSECO_Playground_Overview.pdf)	The goal of collaboration could be to realize efficiency and new services in sharing of infrastructures (FIRE), node facilities (EIT ICT Labs), exploitation capabilities (EIT ICT Labs), educational platforms (EIT ICT Labs). The win-win is that FIRE can add exploitation capability and attract business interest while EIT ICT Labs may widen its set of available testing and research infrastructures, also for educational purposes.	The issue of sustainability of the FIRE testbeds is a crucial aspect, as is the financing of the KIC brokerage service. The model also depends on the maturity among connected FIRE testbeds and their capacity to offer "Testbed as a Service" to external actors. Other critical aspects that have been identified include security, SLA, confidentiality handling, accounting, ease of use and support for experimentation.

Actor	Scope for collaboration in short term	Scope for collaboration in the longer term	Critical aspect to realize collaboration
Géant	Géant can offer high-bandwidth connectivity between multiple sites across Europe for inter-connection between testbeds. This has already been explored by existing FIRE initiatives: CONFINE, BonFIRE, FEDERICA, OpenLab, and NOVI	Collaboration will enable the provision of a wide range of experiment services besides connectivity for core facilities of FIRE and bandwidth on demand.	All formal involvement of Geánt goes via NRENS and each FIRE initative must negotiate with their national NREN when preparing a proposal. For Géant access there must be a linkage to research and education – a condition that FIRE projects usually fulfil.
FI-PPP	To explore FIRE experimental facilities, services and experiments to the largest scale and industry oriented FI-PPP facilities.	To create an overall end to end Future Internet innovation ecosystem, from the early experimentation phase (FIRE), to the large scale industry and commercial oriented service phase (FI-PPP). Other issues of common interest can be explored e.g. the issue of infrastructure sustainability, the challenge of attracting SMEs and other. Opportunities provided by FI-WARE technologies and FI-Lab could be taken up by FIRE after FI-PPP ends.	Migration and interoperability issues; the distributed nature of the technological solutions adopted; and to ensure an appropriate scaling up. The federation and distribution concepts of FIRE mean that multiple partners (infrastructure owners) are involved and therefore the relationship among them in the value chain needs to be investigated for understanding what the best possible business model in such situation is.
Smart Cities	The various Smart City pilots within the CIP ICT PSP have experimented in using the Living Lab concept for the urban domain.	Urban areas can be considered as experimentation environments for the Future Internet. Good examples are SmartSantander as well as FI-PPP projects	Expectations from cities to find solutions for real take-up will require to tackle how to move from research to production stage. Also procurement rules for cities could have an impact on what and how they can be engaged in experimentation.
Living Labs	So far the collaboration between FIRE and Living Labs is more of a task-force oriented relation where some Living Lab actors and testbed providers have joined forces to support innovative experiments involving useful assets from each facility and by this exploit the potential of the mixture of Living Labs and testbeds. Projects like TEFIS, SmartSantander and ELLIOT have explored this setup.	Potential synergy in the longer term for such collaboration is to attract more users to exploit the added value from the combinations including crowdsourcig of end-users assets and by this to cover more phases of the experimentation lifecycle and bringing the Internet of people to FIRE. This could also lead into a more agile and disruptive methodology for Future Internet experimentation and by this create a shorter time for take-up and more innovations to succeed on the market by users and technology evolving together.	If Living Lab would become partners of FIRE this will require a different set-up for federation of resources. (“Humans are not machines”) Ethics and privacy are other critical aspects to be handled.

Table 9 Collaboration scope and required conditions

Collaboration within FIRE. The collaboration within FIRE has been developed through a number of years with support from EC investments in different projects. The collaboration is mainly based on strong ties relationships where the core group of members has a common goal and has been involved in different project constellations throughout the FIRE lifetime. Existing collaboration includes interest to solve common problems, development of new knowledge, contribution to better competiveness and innovativeness and sharing of assets. For academic partners additional collaboration interest includes development and dissemination of new knowledge and for industrial partners the interest in collaboration may also be for the development of new innovations and to build up strategic partnerships. The current FIRE collaboration has reached a stage where formal agreements between partners have been formulated. It can be concluded that the strong ties in FIRE are the fundamental base of the collaboration. However, dependencies on strong ties also has its limitations for reaching of efficient collaboration and one risk could be a limitation in recognizing opportunities from new collaboration and information beyond the existing boundaries.

In the current collaboration within FIRE the main actors are research organsations with a minor involvement of industrial actors - 28% in Oct 2013. To extend the involvement of industry will require some strategic movement of FIRE. From interviews in T 3.1 one key aspect to get more industrial actors on board is the sustainability and the construction of the FIRE partnership At the moment there is no FIRE legal entity except of the individual projects and there for it could make it difficult to attract industry.

Also the positioning of FIRE within the Future Internet ecosystem will have a big impact on the ability to attract industry – will FIRE be mainly for research and experimentation or will later phases- piloting and business development including partnerships be supported as well?

For FIRE to serve a diverse set of actors the future collaboration models will require to

1. be sustainable
2. inclusive to a wider group of stakeholders
3. handle dynamic value-creation
4. include different modalities for value-creation

5.7 FIRE society strategy

This chapter is concluded with some thoughts about the societal role of FIRE. The role of FIRE in driving a sustainable future is highly relevant for a plan aiming at 2020. Internet is the global back-bone of today. Billions of connected things and smart phones drives scenarios beyond our imagination just a few years ago. This development requesst a green responsibility from a sustainability point of view. To give some examples, up to the year 2003, about 5 Exabyte of data had been generated by mankind, this year 2014, 5 Exabyte will be generated every 10 minute. Global IT altogether makes a larger carbon footprint than the whole aviation industry. IT and datacentres consume >1,5% of all global electricity and by 2015 about 15 million people will globally work with big data.

These figures indicate that FIRE shall encourage and support green technologies connected to internet and take the global lead in green technologies. The environmental effect caused by ICT has to be an important parameter when experimenting and piloting using FIRE facilities. Today we can see the mega-datacentres establishing globally, and we should consider what implication and opportunities will this create for the FIRE agenda and Europe. A mega-datacentre, best in class regarding efficiency is a building size 100 m (wide) x 300 m (long) x 20 m (high) and using 40 MW in full production. One strategy (targeted by Microsoft) is to place those mega-datacentres close to the energy source, since it is more efficient to transport

digital information, zeros and ones, over distance than transporting energy over long distance to a datacentre. Some parts of the global business are not critically depended on latency but some are e.g. financial industry. A question to be explored in this context is how FIRE could contribute and adapt to this change of internet use and support European industry to develop this new technology needed.

A second question relates to the role of Future Internet in boosting Smart Cities and Regions. Experiences in projects such as SmartSantander, the Smart City pilots in the CIP, and Smart City related projects in the FI-PPP point to the important role of ICT-based infrastructure providers to benefit urban and regional development and cost efficiency. Technologies such as sensor networks and Internet of Things combined with Open Data are promising. FIRE could offer easy-to-use facilities and tools for developers to create experimental environments to design, develop and test applications based on Future Internet technologies. Startups could be enabled to use the facilities and tools to create new business.

This chapter had an aim to go deeper into the different domains where FIRE can make a difference. At this point our aim is to explore future opportunities and strategic options. Gradually in the course of work within AmpliFIRE together with the FIRE community, we will need to clarify the options and prepare choices. The FIRE Roadmapping exercise which starts April 2014 aims to support this process.

6. FIRE's Future Business Model

6.1 Overview

This chapter presents some thoughts about FIRE's future business model. This is very much "work in progress" which is to evolve with better insight in FIRE sustainability conditions and opportunities.

6.2 A view on FIRE's Activity System

The concept of **activity system** helps to evaluate the strategic role of an organization or entity. FIRE's "activity system"[15] shows how FIRE activities will create synergy and align with the over-arching vision and strategic themes. The FIRE strategy should result in a consistent activity system view of FIRE which is also connected to the CANVAS sustainable business model. An initial conceptualisation of FIRE's activity system as aligned to FIRE's strategy objectives looks is depicted in Fig. 9.

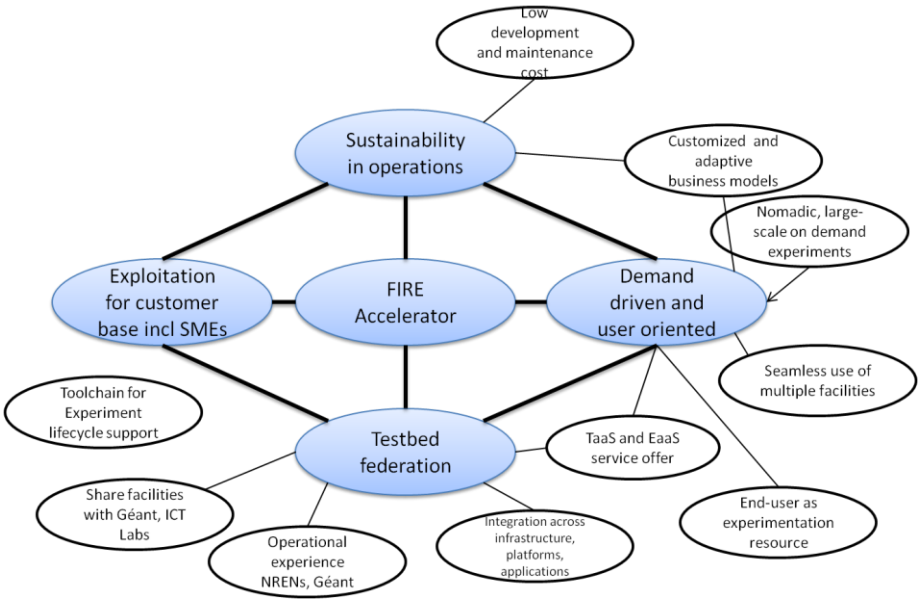

Fig. 9: FIRE's "Activity system": linking FIRE's activities and strategic themes

The activity system map can be used to examine the consistency and mutual reinforcement of activities in relation to the chosen strategy. Given the view of FIRE as "accelerator", as "R&D lab for the Future Internet", we should identify the activities and processes that implement such concepts and identify the gaps (which is undertaken in WP2). Some of these gaps can be identified e.g.

- Interface of FIRE facility services and market parties (in particular industry and SMEs) is largely lacking.
- Lack of activities aimed at customizing tools and services for dedicated user needs.

Fig. 10 presents a conceptual view of how FIRE's objectives for the future and strategic activities relate to building blocks for a revised and more future proof FIRE business model. This conceptual model will be further elaborated in the next period.

[15] The concept of Activity System in the context of Strategy has been developed by Michael Porter (1996). We apply this to FIRE.

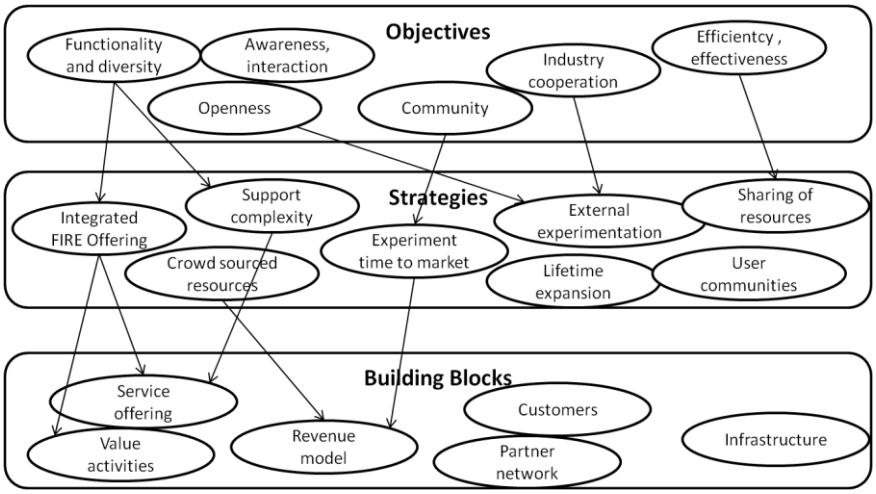

Fig. 10 From Objectives to Business Model Building blocks

6.3 FIRE business model evolution

In order to develop consistent FIRE strategies 2020, we use the CANVAS business model framework proposed by Osterwalder a.o. (see D1.1). The CANVAS framework identifies key elements of a sustainable business activity for which optional strategies can be developed. Key elements of FIRE strategy 2020 can be presented as business model elements (Table 10).

CANVAS elememts	FIRE strategy implications
FIRE value proposition, service offering	New service concepts for experimentally driven R&D on the Future Internet (maybe beyond Testbed as a Service, Experiment life cycle management); tools and services, customized and on-demand, cross-border etc. One stop shopping concept ? Tools for experiment lifecycle. Maybe also service connected to Living Labs innovation and platform for end-user involvement. Service differentiation targeting different user groups.
FIRE's key activities in its value system	Efficient federation activities and value chain including operational and management activities. Core activity on experimentation: how will it change. Seamless integration of multiple facilities and sites. Security and trust management. Maintenance of tools and services.
FIRE's key resources or "assets"	Increased functionality and diversity of FIRE Testbed facilities (see FIRE STATION); Openness of experimentation facilities (FIRE STATION). Furthermore: know-how, technologies, tools, methodologies, customer base, linkages with Living Labs, Smart Cities, user groups, community …
FIRE partner collaboration network	Relation with EIT ICT Labs, FI-PPP (and follow-up), national initiatives/ Géant. Global partner network GENI etc
FIRE customer segments	Segmentation of different customer / community groups, analysing the possibilities of attracting non-traditional customer groups (industry, SMEs, Smart Cities), needs analysis, expected future demands regarding facilities & services, technical business and legal requirements
FIRE channels	What are the channels FIRE will use to deliver its service?
FIRE customer relationships	Which relation will FIRE establish with its customer groups, now and in the future?
FIRE cost structure	Cost structure evolution. Different options to modify the cost structure (flexibilisation) and pricing structures.
FIRE revenue streams	Different exploitation models, addressing different options for federation
Legal and governance aspects	E.g. IP management, ownership, cross-border regulations Different operational models and their prospects (see FIRE STATION)

Table 10: Elements of FIRE's Business model

This presentation gives rise to the issue how FIRE's business model (including the financial model) could evolve over time. Fig. 11 and 12 distinguish the current and future business model. These conceptual views form starting point for next period discussions within the FIRE community.

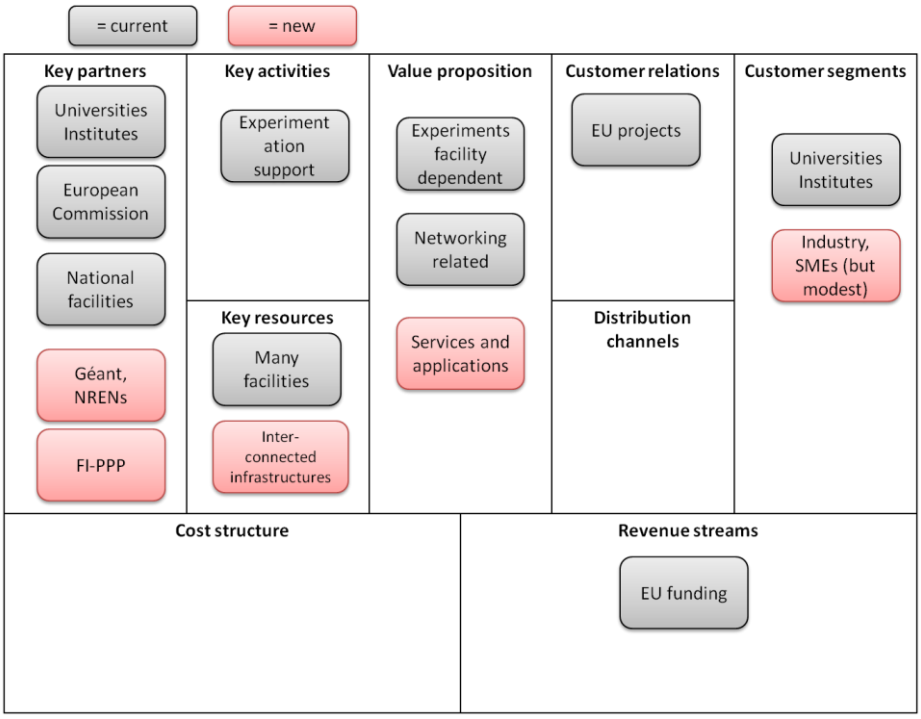

Fig. 11: FIRE's current business model

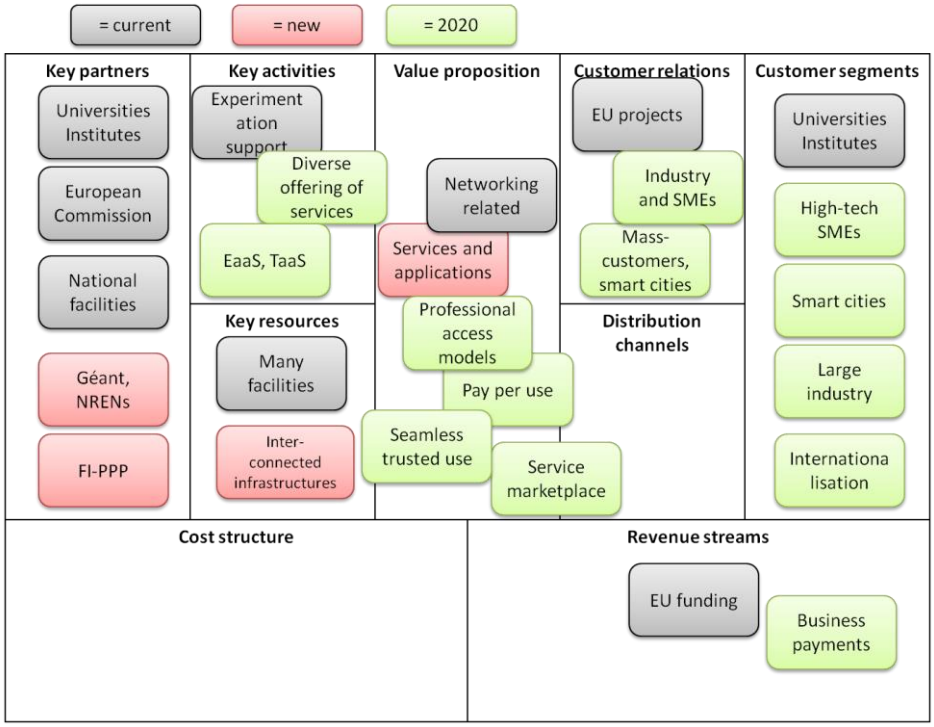

Fig. 12: FIRE Business Model towards 2020

FIRE's **current business model** (Fig. 11) is very much based on EU funding of FIRE projects, on collaboration between key partners in the domains of research and institutes, on

experiments that are facility dependent and networking related mostly. Newer aspects include the relations with Géant and FI-PPP (XIFI) and the trend towards federation.

An initial view of the **future business model** as depicted in Fig. 12 includes some important innovations, inspired by the scenario analysis and formulation of strategic objectives and strategies, as regards value proposition, key activities, customer segments and revenue streams.

7. Conclusions and Outlook

A key challenge for the AmpliFIRE Coordination and Support Action is to identify strategic directions for the FIRE programme in order to make recommendations to the European Commission and establish common ground within the FIRE community. This document presented our findings until April 2014. Building on former work regarding the FIRE vision and scenarios, it elaborated the concept of FIRE Ecosystem and identified strategic options for further evolution of the FIRE Ecosystem towards 2020. The document proposes a mission statement, a set of strategic objectives and an overview of strategic actions in domains as FIRE infrastructures and facilities, services, collaboration, and ecosystem building.

We highlight some of our findings, with a view towards next period work within AmpliFIRE and with the FIRE community.

- The SWOT analysis revealed the strength of FIRE in terms of a large, diverse portfolio of experimental facilities, increasingly federated and supported with tools, and responding to the needs and demands of a large scientific experimenter community. We also identified weaknesses in terms of a lack of sustainability of facilities after project end, limited industry and SMEs involvement, and a not well developed ecosystem given the present challenges. A threat is the possibility of diminished EC funding after 2015.
- We also see a lot of opportunity as regards continuing federation, laying the basis of strong collaboration among facilities and providing more easy access to users. Opportunities are also in connecting with and enabling related Future Internet initiatives and Smart City initiatives. Developing a full service approach addresses the gaps between ecosystem layers, increases FIRE's visibility and addresses integration issues that are only now coming up in other Future Internet-funded projects.
- A challenge is to expand the nature of FIRE's ecosystem, from an the offering of experimental facilities towards the creation of an ecosystem platform capable to attract market parties from different sides that benefit from mutual and complementary interests.

An analysis of FIRE's position leads us to several conclusions regarding the future direction of FIRE. In particular, FIRE strategy should address the following interlinked aspects.

- Achieve longer term financial sustainability, becoming less dependent of the Commission funding.
- Expand the community, from mostly experimenters in academic and research institutes towards a wider spectrum of actors in a growing FIRE ecosystem, including large businesses and SMEs, and other initiatives or programmes that may use the solutions being experimented with such as Smart Cities and other customers.
- Develop collaborative linkages to related Future Internet initiatives, aimed at sharing knowledge, technologies and facilities, and at creating new services for a wider range of customers.
- Reformulate the FIRE value proposition, including FIRE's service portfolio, the range of target groups to deliver the service portfolio, and the access channels or platforms for delivering the service in customized manner. Also the concept of Testbed as a service needs to be further developed on close collaboration with the FIRE existing and potential users to be able to serve a wider user-base. FIRE for and by the FIRE users!

On the longer term FIRE's mission and added value is to support the Future Internet ecosystem in building, expanding and continuously innovating the testing and experimenting facilities and tools for Future Internet technologies. This way FIRE is able to continuously

include novel cutting edge facilities into this federation to expand its service portfolio targeting a range of customer needs. FIRE will also include "opportunistic" experimentation resources, e.g., crowd sourced or citizen or community provided resources. In the longer term, FIRE's positioning is to become the R&D&I environment, or "accelerator" within Europe's Future Internet innovation ecosystem, providing the facilities for research, early testing and experimentation on the Future Internet and accelerating Future Internet technology-induced innovation cycles resulting in advanced applications and business support, and eventually the creation of new business. The overall strategic objective for FIRE is to become a sustainable 'R&D lab' like facility for research in the Future Internet; supporting researchers and the community to tackle important problems, and acting as an accelerator for industry and entrepreneurs to take novel ideas closer to market.

FIRE is Europe's open lab for Future Internet R&D&I. FIRE is the accelerator within Europe's Future Internet innovation ecosystem. FIRE is sustainable, part of a thriving platform ecosystem, and creates substantial business and societal impact through resolving societal challenges.

The strategy to realize this future role is multidimensional and the report proposes a set of strategic objectives aimed at 2020, and a range of activities to realize the 2020 objectives. The strategy includes the following recommendations:

- Establish an easy accessible network of open and shared experimental facilities and platforms and create partnerships with other Future Internet initiatives to realize this.
- Target industry and SME innovators by establishing an "accelerator" functionality, starting with creating a market interface aimed at aligning demands and offers.
- Increase the number of experiments and experimenters using FIRE, attracting new user / stakeholder groups such as large ICT companies, developer companies, SME innovators, Smart Cities and regions, and other EC programmes.
- Target business innovator needs related to accelerating product and service innovation and go-to-market, addressing the needs and demands of companies in different stages of their development lifecycle. Work together with innovation intermediaries.

Follow-up work in the next period will take up and specify these challenges in close interaction with the FIRE community and beyond. In particular we aim at making concrete recommendations that are aligned with and supported by the views of critical stakeholders.

References and Sources

1. AmpliFIRE (2013): D1.1 FIRE 2020 Vision and Scenarios. Version 0.9, 2013
2. EC (2013): Commission Staff Working Document. Strategy for European Technology Platforms: ETP 2020. Brussels, 12.7.2013, SWD(2013) 272 final
3. Piet Demeester (2012), Future Internet Experimental Facilities Towards 2020. Presentation.
4. D.S. Evans, A. Hagiu and R. Schmalensee, "Invisible Engines. How Software Platforms Drive Innovation and Transform Industries". MIT Press (2006)
5. Internet Society (ISOC), The Internet Ecosystem (2010)
6. TeliaSonera, The Natural Evolution of the Internet Ecosystem
7. Jorn B. Anderson, What are Innovation Ecosystems and How to Build and Use Them
8. Kurt Tutschku, The Future, Federated Internet and the Need for Designing A Sustainable Ecosystem for Future Applications – A Position Paper.
9. FIRE Station, The Future of FIRE: Horizon 2020. Annex to FIRE in Horizon 2020. Position paper from the FIRE Architecture Board.
10. Deborah J. Jackson, What is an Innovation Ecosystem? Download: http://www.erc-assoc.org/sites/default/files/topics/policy_studies/DJackson_Innovation%20Ecosystem_03-15-11.pdf
11. Michael Porter (1996), What is Strategy? Harvard Business Review, November-December 1996.
12. A. Osterwalder, Y. Pigneur a.o. (2010): Business Model Generation.