The Alliance for Internet of Things Innovation (AIOTI)

Innovation Ecosystems

Report from Working Group 2

Innovation Ecosystems

Contents

Executive Summary

Working Group (WG) 2 of the Alliance for Internet of Things Innovation (AIOTI) has been working from spring till October 2015 on recommendations to stimulate the development of Open Innovation eco-systems for Internet of Things (IoT) innovation in the EC. The IoT ecosystem will flourish only when many stakeholders work collaboratively together with open standards, platforms and interfaces and when data flows. AIOTI's WG2 developed a set of broad ranging recommendations in five areas, which are summarized below:

Creating horizontal platforms across vertical application areas **and linking them with vertical platforms** is essential, e.g. by encouraging the transversal application of APIs, GUIs and TUIs developed by either industry stakeholders or toolkits derived from academic research.

Agile Pilots enable and encourage hands-on experimentation projects which allow learning of best practices. They are characterized by having openly accessible, data-rich and pilot (demonstrator) sites either at scale, or scalable, embedded in operational environments. They should not just test technologies but rather business models and processes, adoption and performance (economic, technical, social, environmental) and including case studies for privacy, security and social implications.

Stakeholders need to be identified and recognised in IoT innovation programs and projects. Engagement of all relevant stakeholders in pilots and demonstrators is required, as the success of IoT only partly depends on technology. Problem owners, end users, innovators, representatives of the public sector and often even regulators and policy makers need to be engaged during the lifecycle of pilots and not as an afterthought.

Guidelines and project assessment criteria need to be adapted to the needs and dynamics of digital innovation. New sets of guidelines which assess levels of risk, data, openness, early adoption and stakeholder involvement are required to drive EC IoT innovation programs.

Funding mechanisms need to be reformed to account for shorter development timelines and faster deployment. The current R&D funding models require upfront definition, specification and partners for what is generally a long term project, which is not compatible with the ambitions of IoT Innovation. Besides introducing more frequent assessments with cascade funding mechanisms and fewer resource diversions for successful project teams, new approaches need to be developed to evaluate proposals based on the innovation potential and the impact in the innovation ecosystem.

1 Introduction

1.1 The Internet of Things and AIOTI

The Alliance for Internet of Things Innovation (AIOTI) was formed early 2015 following an initiative by the European Commission, DG Connect. The insight driving this initiative was the insight that stimulating innovation for economic development in the Internet of Things (IoT) requires a structurally different approach than the conventional practice followed until now.

To deliver both innovation and economic outcomes for Europe, different criteria, timelines and practices are required for innovation projects and EC stimuli (such as Large Scale Pilots (LSPs))

The traditional view of the linear value-chain cannot be applied to the innovation solutions based on IoT. Those solutions rely on the interaction, frequently simultaneous, between complex systems that collect, store, analyse and act upon data and the organisations that own them. They can only operate if there is a communication infrastructure available. They are often built upon software and hardware platforms (including sensors and other devices). Their design, development, implementation and operation requires access to virtual and physical components, some of which are purchased, some of which are “merely” accessed. IoT projects and pilots also need to be embedded in real world environments and business processes. It is therefore essential that those individuals and/or organisations that own “the problem” (and who may or may not be the end users) are fully involved end-to-end: defining, validating and testing the real-world requirements, hosting deployments, testing the business value and outcomes, and eventually investing or becoming buyers of solutions.

Although the "Internet of Things" appears to emphasise the role of "things" over that of human agency, it is worth remembering that things (and data) acquire meaning through their use. Human agency is not just another passive node in the network which simply collects data about user habits but enables interaction with and contribution to the environment (through things, places and activities).

Ultimately, the success of IoT innovation can only be measured against its commercial and social adoption in the market. This represents a more extended than usual open innovation value chain in which stakeholders and funding sources may change over time. EC (AIOTI) can facilitate a common distribution and connected platform even with crowdfunding and crowd-making off a common platform.

1.2 Policy and practice, Working Group 2

The Alliance for Internet of Things Innovation is a policy and dialogue support mechanism that brings the stakeholders in the Internet of Things (IoT) ecosystem closer to the European Commission. Building on the Internet of Things Research Cluster (IERC) it expands activities towards innovation within and across stakeholders. The Alliance will help the Commission prepare future policy, standardisation and research and innovation programmes for IoT through several working groups:

- WG1: IoT European Research Cluster: bringing together EU-funded projects.
- WG2: Innovation Ecosystems: stimulating the ecosystem
- WG3: IoT Standardisation: analysing IoT standards and the routes to interoperability
- WG4: Policy Issues (Trust, Security, Liability, Privacy): identifying barriers to uptake and how to overcome them

Other AIOTI working groups have been focusing on application domains relevant for IoT innovation. Over the past few months, each working group has gathered the expertise of its members and engaged in discussion to contribute to the ongoing policy discussion on the IoT innovation.

WG2 has been focusing on what actions are needed to develop innovation ecosystems by stimulating start-ups, the use of open IoT platforms and enabling linking up between large and small companies. This is a broad subject and, after widespread consultation, it was further broken down into the following topics:

- Linking vertical with horizontal platforms: how to set the right conditions for enabling cross-company use cases, how to establish (horizontal) cross company platforms and how to enable participation of small and medium enterprises
- Large scale pilots with hands-on experimentation: How to organise as a key element in IoT innovation, large scale pilots under close-to-market conditions
- Stakeholder involvement: how to secure timely involvement of a variety of stakeholders in the IoT innovation projects (along the value chain), including future end-users of value propositions

- Guidelines for establishing market adoption readiness levels: how to transform the conventional Technology Readiness Levels (TRL) to Market Adoption Readiness Levels (MARL) with more applicable criteria for IoT innovation projects
- Adapting funding models: How to apply EC and National funding models to stimulate the right practices, mind-sets and ownership over time

Each topic is introduced in a dedicated section while the recommendations for creating an IoT eco-system in Europe are listed per topic in section 7.

Clearly, many topics are interrelated and feed into each other. Nevertheless and for the purpose of providing a clear view of specific recommendations to the EU, each is afforded a distinct section in this report which covers a brief introduction into the topic and the main considerations that should be taken into account in the context of the forthcoming calls for EC supported IoT projects, and particularly Large Scale Pilots. Recommendations for policy action are proffered in the final section.

Before moving onto the report, we would like to re-assert the commitment of AIOTI members to the common interest and the belief that this should be a founding principle for any publicly funded IoT initiative. In addition to competent and well-informed EC reviews of proposals, the cultural values of collective IoT intelligence are qualities that we must all strive to preserve. Collective IoT intelligence is the driver behind IoT Innovation Ecosystems.

2 Linking Vertical and Horizontal Platforms

2.1 Basic premises

The Internet of things (IoT) will proliferate both vertically and horizontally. In this report context, "Vertical" deployment refers to the fact that the applications belong to a *single* domain (e.g. traffic management, logistics tracking and tracing, home automation, wearable medical devices). In these cases, the entire scope of technology (hardware and software), products, applications and services is orchestrated within a rather closed vertically aligned group of companies or sometimes even by a single vertically integrated company. Such vertical applications of IoT are driven by existing commercial models and generally do not require a specific stimulus by the European Commission.[1]

The horizontal proliferation of IoT has two distinct forms (with strong technical commonality):

- Establishing new use cases (applications) across verticals, usually combining information from individual vertical platforms in the data domain, establishing new SW tooling and eventually leading to combined business models. For example, using local weather and air pollution monitoring information for rerouting traffic streams.
- Enabling third parties, especially small and medium size enterprises (SMEs) and start-ups, to create new applications on platforms of verticals establishing extensions or even horizontal platforms that can add a lot of value to the eco-system. For example, having start-ups creating apps on a third party platform via an open API. The massive impact of 'Apps' on mobile phones with Android or IOS is a clear example.

While this horizontal proliferation is very relevant for new economic value creation, putting it into practice is neither trivial nor self-propelling and in general will require specific stimuli by the EC, considerably beyond providing interface standards.[2]

Horizontal IoT applications can only proliferate through the establishment of platforms, well-managed, consistent sets of building blocks with defined functionality and interfaces

[1] Note that multiple views can exist on vertical and horizontal platforms, such as a technology (HW/SW) view, standards view or an ecosystem (ownership/responsibility) view. In this document we will refer to the ecosystem view unless noted differently.
[2] Being a necessary but not sufficient pre-condition.

that support a range of applications (products and/or services). This implies a great deal of standardisation, decoupling and above all, organisational discipline and commitment.

Platforms are not static. Well managed platforms enabling rapid innovation in both constituting components and in platform applications are critical factors for IoT innovation.

The critical factor is not the availability of building blocks today, but securing their availability and consistency for the future, enabling a market uptake with other players and stakeholders that are becoming dependent on it in horizontal applications.

In general, the creation and maintenance of a (vertical) platform requires significant effort and carries liabilities that could go beyond the capabilities of small and medium enterprises. It often needs the involvement of (large) vertical companies to establish such platforms, establishing the foundation of horizontal IoT application platforms.

While the technical components (API's, middleware, standards…) may be provided by a community, most horizontal platforms in sustainable, professional applications are not possible without the infrastructure, data and vertical use cases of the vertical platforms carried by large players.

In addition to the necessary interactions between verticals for the establishment of horizontal platforms across them, multiple intersections will occur at different levels between verticals. Fig. 1 provides a schematic representation of these several interactions.

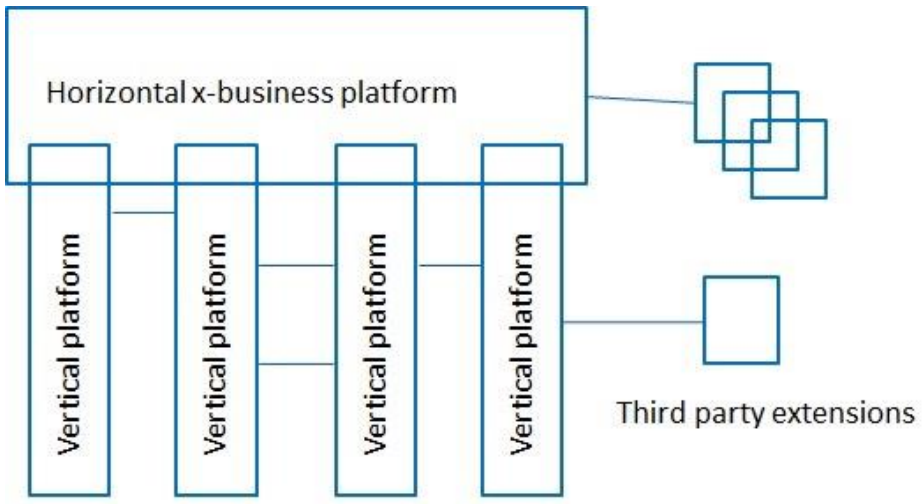

Fig. 1 schematic representation of vertical and horizontal platforms with application extensions to platforms by third parties and cross links on middleware levels

From the above, it might appear that the vertical platforms are only beneficial to the horizontal platform and to third party extensions (e.g. Apps by start-ups) and there would not be a self-interest to go beyond the pillar. In fact, there could be a strong mutual interest:

- Many players (specifically SME's) need platforms to build new applications on, vertical as well as horizontal. Clear examples are Apps leveraging mobile phone operating system standards or IoT applications that leverage communication networks and protocols.
- New economic development in IoT for all stakeholders (verticals, SME's, government, society) will increasingly be based on cross-business (data driven) use cases which requires a cross-vertical (horizontal) platform
- Those new horizontal use cases (often by SMEs and start-ups) will increasingly contribute to the justification and cost coverage of the vertical platforms and the associated horizontal platform and even create new economic value and new revenue streams
- If the interfaces (physical, logical, data) of the vertical platforms on top level are well defined and preferably standardized, the integration of the horizontal layer across will require relatively low effort (but professional management and maintenance will be an ongoing requirement).

Well-defined interfaces are consequently very important for designing effective systems in terms of policy, security, openness, and interoperability, discovery and consistency aspects, among others.

2.2 Key considerations

The final section of this report outlines our main policy recommendations to stimulate the linkage of horizontal and vertical platforms. But these recommendations assume a number of starting points to be in place before they can be successfully implemented.

- While this is not an easy task, there has to be a strong platform commitment with the involved parties. This implies constraints and mutual commitments (governance and change control) in order to benefit from such a platform.
- The interface definition for the vertical extensions can mainly be left to the verticals and their partners. There are already good examples of such interfaces and common service layers. But orchestrated effort is required to define or select

clear interfaces for a true horizontal platform on the top level (ESB, data formats etc.), across verticals.

- Such interfaces should use open standards and specifications, but that does not imply that all the data or platform functionality is open to everyone. This is still a responsibility of the 'data owner', which will increasingly be the individual citizens and customers for personal data and the respective company or organisation for systems data.
- If no data exchange is enabled at all, one cannot participate in the horizontal platform (or in an AIOTI perspective) nor if one has no intention to actually exchange data for certain use cases even when it is enabled.
- It is quite likely that the horizontal platforms will be mainly focused in the data domain, and therefore be determined by software for data management and communication interfaces. This will bring clarity on the interactions between stakeholders and also the specification of conditions on data usage and general cooperation (such as business models) on horizontal platforms.
- Finally, although theoretically there could be a *single* horizontal platform (standard), it is quite likely that there will be multiple but preferably just a few of them. The diversity of IoT applications in various domains (Smart Home, Smart City, Smart Energy, Healthcare…) and the legacy in vertical platforms makes it unlikely that one will serve all. A common interface on all of these can enable a horizontal platform of horizontal platforms.

3 Large-scale pilots: hands-on experimentation

3.1 Basic premises

IoT innovation requires scale and, while companies (particularly large ones) are very capable in terms of incremental innovation or in developing strong, closed, vertical platforms, there is an opportunity to broaden the value generated by IoT innovation through the involvement of other stakeholders, including specialist SMEs and start-ups.

Large scale pilots (LSPs) are essential to drive forward propositions that need to be proven in complex realistic settings because they encompass technical and numerous non-technical dimensions (legal, social, economic, policy related, etc.) and need a significant number of players to come together to work out solutions and move industry forward. Particularly SMEs and start-ups need to be integrated in the horizotal eco-system in a sustainable way (which requires considering legal aspects, IP and knowledge protection, RAND licensing, regulation, certification, standards, among other things).

This is particularly true of the IoT, which is still in its early stage of development, is complex, requires a systems (and systems of systems) approach and where business cases and benefits can only be realised with deployments along the value chain of various players/ stakeholders at scale.

Large Scale Pilots/Demonstrators should provide the opportunity to demonstrate actual IoT solutions in real-life settings and make it possible for stakeholders to test business models and integration modalities through direct experimentation with users. This could also help clarify the need for complementary actions around notably standardisation, interoperability and other policies like trust and security, and provide also an environment where to test data management and analytics tools at scale.

In essence, a Large Scale Pilot/Demonstrator environment is a large stable environment with sufficient technology, support and service underpinning to allow a variety of close to market products and services to be trailed and tested with real consumers. It can be in one or more physical locations and is designed to provide full stable services to Platforms, Products and Services running on it. It can run TRL3-7 propositions (see section 4).

A pilot that has successfully involved start-ups, SMEs and/or larger companies will have enabled these companies to take the product or service to many markets and scale with a 'turnkey' implementation based on the reputation, learning and insight gained from the LSP/demonstrator experience.

3.2 Key considerations

IoT demonstrator environments can be technology implementations performed in civic or metropolitan environments, or "simply" be performed in networked environments that enable data transfer or simulation in specific local environments like homes or vehicles.

There is a blurry line between testbeds and pilot environments (which prototype new and experimental technology in the platform and allow an opportunity for companies in an early product development stage to connect and test against) and real LSP/demonstrator environments. A good quality large demonstrator often includes testbeds, pilot environments, simulation, innovation centres and other resources to support an R&D and innovation, market development and SME community.

Given the typical timeframes and TRL IoT innovation takes place in, there is an ongoing debate on whether demonstrator environments should include novel technology or be representative of typical deployment environments within which companies involved can deploy their solutions. In any case, the consensus position is that:

- Large Scale Pilots should provide a context and an opportunity to demonstrate the benefits of IoT through deployment of solutions close to market, not (just) R&D.
- They should aim for 'scale of deployment' (ambition, complexity), not scale of the project (e.g. geographical scope, technology development budget); scale is essential for critical mass, 'network effect', meaningful evaluation of impact and sustainability.
- LSPs should have multiple problem owners fully and deeply engaged in the project - far deeper than in ordinary projects since they are essential to deployment, testing and market adoption (see section 4).
- The portfolio of LSPs should independently strive to achieve their objectives without top-down planning; however coordination is essential to promote interoperability, scalability and critical mass; this includes co-ordinating users, tracking changes, and documentation to make sure that replicability is easy.
- LSPs, in various measures depending on target sector and application, should involve large numbers of users.

- Data is what makes LSPs come alive with applications, delivering business and citizen benefit. LSPs should be open access and data-rich and based on open standards and interoperability principles.[3]
- LSPs should aim to become platforms for innovators, with spill over benefits that exceed the consortium boundaries – this may require having specialist partners who are dedicated to this role, but more importantly the pilots have to be designed with this in mind.

[3]The approach used by the Hypercat investment in the UK, which was embedded in the funding contracts, is an example of how this could be enabled;

4 Involvement of Stakeholders in Large Scale Pilots

4.1 Basic premises

Internet of Things innovation is enabled in practically any domain, through the availability and ubiquity of connected technology but wide-spread adoption will only take place if and when stakeholder needs are addressed.

Their involvement must not take place at the point of pre-market testing but must be adequately planned and be iterative, spanning all development activities from design to final launch and beyond. This user-centric approach marks a departure from the previous R&D and innovation norm in which the concept was developed and proved in a controlled space (normally a laboratory) and then validated in a simulated environment, such as a factory floor.

Where the domain has a strong supply chain/value network nature (e.g. food or logistics), critical players from each stakeholder group in that process need to be involved. For instance, for food security, an effective end-to-end pilot could involve a farm, a distributor and a supermarket to test the viability.

As has been outlined earlier, IoT platforms can be also horizontal, in effect working as enablers and demonstrators. Even so, clear mechanisms and incentives for engaging problem owners during the projects are essential.

One of the greatest promises of the IoT innovation is not just providing a market opportunity to large system integrators but that it can facilitate the emergence of ecosystems of SMEs and start-ups that can work locally, while learning, growing and improving their products and selling globally.

Market and business models are also changing. The role of what has previously been known in many industries as a customer is broader. Users of the solutions may not be purchasers. This increases the importance of trying to understand how business is done rather than just focusing on how technology can be integrated.

Cybersecurity including aspects of privacy and trust has been widely identified as a major issue in IoT, both in terms of privacy and public perception of risk.[4] An energy consumption sensor in building could be used (or hacked) to detect presence and data from an environmental sensor in a road can severely affect somebody's real estate market value. These issues are magnified once actuators are included. The examples are limitless.

[4] In preparatory studies in the UK in 10 different IoT applications in 2012 and more recently in a review commissioned by the UK's Prime Minister, privacy and trust issues are pervasive in the IoT.

The fitness-for-purpose, reliability, security and safety and ultimate sustainability of the solutions relies on being able to correctly identify and involve the stakeholders involved in the many moving parts that constitute not just the solution, but also the ecosystem in which it will be deployed.

4.2 Key considerations

IoT projects must start with a clear definition of the scope of the project, particularly when it involves a Large Scale Pilot (LSP, see section 5), geographically and technologically. This is a first step towards identifying which stakeholders need to be involved. The categorisation of stakeholders will be a way to visualise whether the IoT ecosystem is represented in the project; a generic classification is probably possible and could help LSPs to design their ecosystem in a meaningful way. A first, simple way to categorise stakeholders might be:

- Problem Owners: who has the need for the LSP? This is a broad category that may include users and purchasers, but is not necessarily equivalent to them.
- Users (end-users) with specific needs
- Innovators: essentially the organisations that provide the solution (technological and other).
- Enablers: this includes technological enablers but also other parties that are a necessary part of the provision of a solution, for instance, the providers of infrastructure on which the applications need to run, the content creators or the data owners.
- Others: this may include regulators, in the case of more heavily regulated domains, standards agencies or other organisations that can ensure greater impact.

Clearly defined stakeholder needs are a prerequisite for long-term take up and success. Why is the LSP necessary? What benefits does it bring over existing solutions? How does its design and functionality adequately address the specific needs that have been identified? What are the roles they play? How are they represented in the LSP?

Different stakeholders may need to participate at different times in an LSP. Some may need to play an iterative part in the project whereas others may only have a relevant but time-bound role. Equally, the fact that they are close to market will affect their commitment and how they interact.

The very ambition of LSPs means that they should not be used for the purpose of developing new technologies but for stimulating integration and adoption, testing technology in new applications and providing the "glue" that enables each component part to perform as required. In order to address the long term viability of the LSP it must address the business model and how each of the stakeholders get a return for their contribution to the eco-system.

In turn, this requires a clear vision from the start of which stakeholders are necessary to demonstrate the expected outcomes (beyond technology) and how they will be engaged. In many use cases, such as assisted living, personalised transport, particularly in cases where the use case is consumer facing, a sizeable population of users/early adopters is essential. They can help refine solutions and force a user-centric design approach, provide initial proof points and become magnets for innovators and applications developers (real people with real problems and real data to help solve them), hence helping to ignite ecosystems.

Effective communication between stakeholders is essential. The language employed is understood by the stakeholders so that they are able to input. It may be difficult for a highly technical solution provider to communicate effectively with a small retailer. On a technical level, effective communication also includes dealing with semantic and other interoperability. Although the IoT can operate in different domains, communication may need to be domain specific.

There are also more technical considerations:

- Identification of parts of the system that need to be open (all stakeholders own and modify) vs. those that need to be closed (personal and payment transfer modules for instance). This is both a business and a technical endeavour.
- Clarity on how data is held by stakeholders and is to be used and accessed in the process (e.g. an LSP may require access to environmental data held by local environmental agencies; how will you ensure that is machine readable and can be accessed by open APIs?).
- Quadruple trust[5] (protection, security, privacy and safety) must be guaranteed throughout the ecosystem (perimeter defences?). The large scale pilots should embed trust, privacy and user-centred, safety-focused design throughout their development. By ensuring that the ecosystem is adequately present in the LSP,

5 IEEE-SA IoT Ecosystem Study (2015) IEEE Standards Association

there is an opportunity to make it a beacons of best practice with end-to-end use cases, stress tests and use cases for industry and the public sector.

Scalability also needs to be considered; for instance, SMEs can be valuable partners providing specific expertise, but what happens when the pilot scales? How can they be supported in this? What are the implications/limitations of the LSP scaling worldwide?

What happens if something goes wrong? A working model for understanding where the risks lie and where legal liability might reside will help stakeholders understand the full implications of their involvement (e.g. one's credit card details may be compromised through a smart home solution designed to lower energy consumption and spend).

Traditional business models may need to be decomposed, analysed, adapted and relaunched; the purchaser may not be the user of the solution and the point at which payment is collected may not be the point at which value is created or enabled.

This is also an opportunity for input from stakeholders to feed into efforts for the development of standards (whether de facto o de jure) and develop use cases to stimulate take-up and innovation.

In terms of impact, the LSPs should have a multiplier effect, seeding application ecosystems. In some cases they have a demand pull effect for innovators upstream, such for components or middleware or data innovation when 'big data' is made available.

5 Market Adoption Readiness Levels

5.1 Basic premises

Much emphasis has been placed on user engagement and early deployment for user testing of new technologies for more effective deployment in society. In most cases however, it is assumed that technologies need to be at least at the level of system prototype for demonstration in operational environments in order to be user-tested, and that the primary function for user testing is validation of the functionality of the system prototype.

In the context of IoT, greater user engagement can actually increase the value of the product through the network effect: as the number of nodes in the network increases, so does the value to users. Enabled by data-driven applications in physical space, and supported by business models which prioritise data transparency (clarity of information on availability and cost), choice (options on how and when to contribute) and trust (if the participant doesn't generate profit, the platform doesn't either), mass participation in a given IoT solution turns citizens into service providers, product makers, manufacturers, and decision makers, contributing to both business and community platforms.

In this respect it is also worth considering that business models based around ideas of Sharing Economy and Mass Participation provide the opportunity to create a new marketplace, which combines ideas of Crowdfunding with those of Crowdmaking[6]. By 2014 the iTunes App Store generated over €11bn for developers of on-screen applications, and as the Internet comes to dominate the physical space, tangible user interaction becomes the driving force of physical interaction and connectivity, with participants developing a physical applications marketplace through product upcycling, recycling, customising, 3-D printing, as well as large scale manufacturing [7].

This creativity, inclusiveness and scale can also be applied to the IoT but their stage of maturity cannot be measured with the current Technology Readiness Levels (TRLs) used by the EC guidelines for assessing the deploy-ability of proposed technologies within Innovation Actions[8]

When considering the 9 TRLs currently used, it is worth noting that this model is particularly suited to its original context, as developed by NASA in the 1980s. NASA projects bear an extremely high level of risk and they follow traditional linear innovation

[6] http://www.siliconrepublic.com/innovation/item/37296-oi2conf-we-are-now-in/

[7] *For more about the ideas of Crowdmaking see:* http://elasticengine.com/crowdmaking

[8] http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

approaches. They deploy extremely expensive technologies, tested by very few people. In order for NASA technologies to be deployable, they absolutely require TRL9.

In the case of digital innovation, and particularly in the domain of creative applications, platforms can be deployed at TRL3. A concrete example is Soundcloud, an extremely low risk, cheap to run and easy to understand platform with millions of early adopters, who even acted as an experimental proof-of-concept. For a potential investor, a large number of early adopters, and the related substantial datasets, have often proven to be sufficient incentives for investment and acquisition in early stages of development (TRL3 to TRL7).

5.2 Key considerations

Connect Advisory Forum (CAF) consultations proposed that in addition to the technology readiness levels parameter, applications which are quick and competitive economic drivers require the assessment of three further value parameters:

- users (numbers of potential early adopters and values associated with feedback loops)
- data (potential quantity and value of data generated by the system and user interactions at each stage of the process)
- the level of risk (assessment of benefits or adverse impacts of the technology on early adopters in various stages of the process).

This new set of parameters was labelled Market Adoption Readiness Levels (MARLs)[9].

One of the main MARLs objectives is to align Horizon 2020 innovation assessments with the emerging business models, user engagement and societal aspects prevalent in more recent industry and market practices. These new guidelines are required to:

- Introduce multiple parameters for assessment of innovation proposals
- Align proposals closer to business and commercial practices
- Bring awareness to the chasms of market adoption
- Cover a variety of innovation case scenarios, including products, services, industry automation, and combinations of the above

[9] http://www.elasticengine.com/marls-market-adoption-readiness-levels/ and annex.

- Establish a risk assessment relevant to business, market and investment practices
- Set anchoring points for project timelines in line with market readiness
- Establish a system which relies on feedback loops for continuous product improvement

6 Funding IoT projects in AIOTI context

6.1 Basic premises

Perhaps the most powerful of all measures to stimulate establishment of and cooperation in Internet of Things innovation eco-systems for Europe is the funding of projects. Financial support by the EC, for research projects and innovation actions, historically addresses several aspects:

- It applies to large and small companies, research institutes and academia
- The financial support enables stakeholders to put more efforts in achieving results earlier
- It drives EC priorities and policies by selective funding
- It funds the pre-competitive research phase
- It intends to stimulate later economic development by stakeholders

The intention of this funding is to stimulate activities for a *common* purpose and stakeholder commitment to this common purpose. This is a pre-requirement that is not always guaranteed upfront and/or during the projects. However, the existing funding methods are mostly based on traditional, linear innovation where conceptual work in a lab environment proves the technology and feasibility of concepts and is subsequently transferred for industrialization in another environment.

As has been pointed out earlier in this report, the traditional innovation paradigm does not apply easily to the Internet of Things innovation (or in general to digital innovation) which is more closely aligned to service innovation than product innovation and in consequence, the criteria, tempo and tools that are generally used to fund innovative project require adjustment.

6.2 Key considerations

IoT innovation differs from other technological innovation in a number of ways:

- It requires much shorter cycle times in the development stages, as well as shorter time to market (see also MARLs above)
- It often follows and requires Agile development methods (try and learn requiring a real-case environment)
- It is in general platform based, requiring platform management, API's…

- It features complex ecosystem dependencies that go beyond technology
- The innovation projects need the involvement of many stakeholders simultaneously and cannot be achieved in a step by step approach.
- The scope of stakeholders involved in projects will extend to include new ones such as local governments, data owners, users, and markets

In addition, IoT innovation happens closer to market (commercialisation) and requires upfront commercial thinking with involvement of end-users and a variety of stakeholders representing the whole value chain for the target market (beyond academics). In consequence, many of the issues that arise later in other R&D and innovation actions must be properly considered at the outset (e.g. stakeholder commitments for large scale pilots, IPR clauses, platform infrastructure and data ownership)

Traditional funding methods with 3-4 years of unconditional funding with a fixed project scope are difficult to apply to IoT Innovation. A stage-gated and flexible approach is required. It is also worth noting that cascaded funding methods still apply as subcontracting and partnerships on various levels are very likely to happen in AIOTI scope EC projects. Those structures exist today and should be evaluated.

It should be noted that the *platform* aspects of IoT innovation projects may require a longer term funding commitment in order to secure the establishment and availability of it to many users.

7 Recommendations

Funded LSPs, being open and platform-oriented, should aim to interconnect across Europe to contribute to the Digital Single Market, and strive to become an exemplar of policy driven innovation in Europe.

Privacy, security and trust challenges are everywhere in the IoT – all LSPs should have privacy and trust built in by design with credible consortia members dedicated to this objective; A dedicated association to certify the platform components may be required.

Even though an LSP can start or exist in a single vertical, LSPs starting with horizontal approaches applied into one or more vertical may have a greater effect on market development and ecosystem building, e.g. drive interoperability at all levels of the stack and commoditization

LSP should become hotbeds of best practices and lessons learned. Problems that arise during LSPs in applying the new technology and new business models with new partners provide valuable knowledge spill overs for future projects and market development.

7.1 Stimulating linkage between vertical and horizontal platforms

Based on the above starting points, the following policies are recommended for the stimulating linkage of vertical and horizontal platforms.

- Demand a set of standard API's/ESB/Data interfaces to be used and enabled in each EC subsidised project or large scale pilot regarding IoT. Such interface must be open and offered royalty free for use within the large scale pilot consortium partner group and not worse than RAND conditions should apply for subsequent commercialisation activities. This enables fast experimentation without blocking commercialisation. In all cases clarity on IPR conditions for the commercialisation phase should be provided in an early stage by stakeholders and at project start for background IPR. It is worth noting that many standard interfaces exist for communicating between "Things" and Platforms as well as applications (DDS, MQTT, TR-50 to name just a few).
- Software stacks (portable) for such interfaces should be made available for integration by EC supported IoT innovation program members. Such stacks should be *maintained* with a centralised overview (for which reasonable charges may apply) and application support should be provided at competitive rates (but not for free).

- Participants in EC supported IoT innovation programs (qualifying for stimulus measures, i.e. project subsidies) should commit themselves to implement these interfaces AND develop new use cases with partners based on those interfaces, either as vertical extension or in a horizontal platform (preferred to qualify for AOITI support). Such use cases should be defined upfront.
- Participants in EC supported IoT innovation programs, and specifically the large scale pilots should be prepared to maintain the platform after completion of the program (to allow for commercial roll out and scale up) and also for further application development (either in- or outside the EC supported scope). Alternatively they may transfer the maintenance of the required platform to third parties, possibly an EC supported central organisation [10]
- Usage drives platforms and platforms drive usage. Therefore, there should be a continuous stimulus for the development of horizontal use-cases as they will justify the underlying platform efforts. EC calls and subsequently supported projects should explicitly refer to the establishment and use of horizontal platforms (e.g. in large scale pilots). As there are many parallel efforts by private and public organizations – it is worthwhile liaising with groups leveraging the broadest possible industry network and the adoption of field proven technology in use today.
- A professional maintenance organisation is required. One must anticipate upgrades and professional change control is required. The change control process should (after establishment) be in the hands of a professional organisation, endorsed by AIOTI members. If not supported by the market, IERC could play such role.
- Security must be an integral component of the proposed solution. We recommend a defence in depth layered approach starting from the hardware, through the network / transport and platform up to and including the application. An LPS platform must ensure / provide for – role based access control, active authentications and authorization data-validation, session management, data integrity / confidentiality, auditing and monitoring tools, and the ongoing education enforcing of security policies. Platforms should be ranked by their conformance to accepted standards.

10 (see RIS3 Guide on Research and Innovation Strategies for Smart Specialisation, EC)

- Market dynamics will decide which standards will be applied for the horizontal interfaces. But the EC can demand for its projects that such interfaces are defined. Some platforms may be managed by industry consortia and provided at reasonable charges to cover the cost of maintenance, as long as the interfaces themselves remain open. Vertical platforms are likely to remain with vertical companies/consortia.
- The nature/type of interfaces required should be co-defined by domain Working Groups of AIOTI (basically to verify whether special conditions apply from a specific domain such as Smart Healthcare, Smart City, Smart Transport…) but should as much as possible follow cross domain standards. The interfaces must be well defined to enable a solid implementation of system aspects such as security, openness, and interoperability, discovery and consistency aspects.
- The rigorous implementation of new requirements for EC funded projects may result in a large initial reject rate of proposals and a shock effect. This should be anticipated by providing upfront clear communication on requirements as well as an application extension to allow for corrective action. Strong orchestration between the reviewers, the EC and the AIOTI WG's is required.

7.2 Ensuring successful stakeholder engagement in LSPs

- Large Scale Pilot proposals should classify stakeholders according to the categories outlined in section 4, and also include an initial analysis of stakeholder needs that can be refined in greater detail during the course of the project.
- The precise stakeholders to be involved must be relevant to the domain in question; proposals must describe roles and detail specific actions in the work plan that involve stakeholders or their representatives.
- Proposals should also explain how the LSPs will become platforms for innovation, creating value that goes beyond large platform providers, This should be structural (vs. a posteriori) and can be achieved through organisations that access and provide support to innovator communities (innovation clusters, physical or virtual, communities of practice, networks of incubators…).
- The elements that are open and those that are closed should be very clear from the start and explicitly addressed in the proposals submitted. If it is not clear, the proposal should be rejected. The reason for keeping elements closed should be clearly stated.

- Given the difficulty and cost attached to onboarding users/early adopters, evaluators should consider the incentives proposed, as well as the appropriateness of the budgets and other mechanisms deployed to facilitate user involvement.
- Proposals should also describe the implications of a specific stakeholder withdrawing their support (can their involvement be "turned off"? can they be substituted? What is the impact on the project? What happens after the pilot?). A common table format should be sufficient.
- The risks for stakeholders should also be included in the proposals and investigated in further detail on an ongoing basis as the LSP progresses.

- From a selection perspective, evaluators of proposals should not expect all projects to conform to a single ecosystem model. Whereas it may be relevant for the public sector (local authorities, energy agencies…) to be active partners in a smart cities LSP, the same may not be true for an LSP focused on well-being services. A team of evaluators with different backgrounds will produce a more rounded view of the long-term impact of the LSP.
- Finally, beyond the specific scope of LSPs and with reference to the more administrative aspects surrounding complex initiatives, the legal aspects require considerable expertise and resource. Support could be made available so that less experienced stakeholders are able to easily have access to templates or checklists.
- A further recommendation is to set up a specific working group to look at issues such as data ownership, with a view to feeding into policy measures.
- Finally, it is important to have mechanisms that enable DG Connect to evaluate and improve the LSPs as the projects progress, including but not limited to the dissemination of knowledge regarding best practices and lessons learned.

7.3 Developing Relevant Market Adoption Readiness Levels

Novel case scenarios in IoT Innovation Ecosystems are constantly emerging (many current and emerging examples can be listed here). It is therefore essential that the criteria described in section 4 are further amplified and tested in real LSP case scenarios with hands-on experiments before being finalised.

The following guidelines are proposed:

- Examine the level of risk implicit in the technology

  - Is the proposal dealing with medical technologies placing the patient at high risk, or with a creative application that can be tested on users at experimental stage?
  - Is the technology being developed by a large company with allocated resources or a start up with low resources?

- Analyse the target stakeholders and their potential for early adoption
  - Is the application aimed at "users with needs", "problem owners" or "content creators"? The definition of target stakeholders will affect their ability to adopt the tools early.
  - Is the platform adding value to the sharing economy? Low risk experimental platforms can attract a large number of Early Adopters if they are perceived as adding collective value.
  - If early adopters are reduced to small numbers (e.g. high risk medical applications), what is the estimated number of end users? An investor may justify investing in a technology which is high risk and requires TRL9 if the Estimated Number of End Users is in the millions of users.
- Assess the potential to yield data
  - How quickly can the project yield data? E.g. Early Adopters can in some cases generate a considerable amount of valuable data at early stages of deployment.
  - How high is the quality of data yield? High risk investment may be justified for scenarios where there is a high quality data yield.
  - How much valuable data can the project produce? The value of companies is often assessed as high based on its ability to gather a large quantity of valuable data.
- Technology readiness
  - Is the technology at early or advanced prototype level at the start of the ecosystem-building process?
  - How quickly can the technology be deployed? If the technology can be deployed quickly, does it already have a market (e.g. "users with needs")?

- What is the potential of the technology to create a new market (e.g. "problems we didn't know we had")?
- Does the project involve "content creators"? If so, can it rely on feedback loops for growth and market competitiveness?

7.4 Criteria for identifying successful LSP/demonstrator platforms

Successful IoT LSP/demonstrator environments share a number of characteristics. They must:

- Cover the full value chain and demonstrate integration capabilities
- Deliver open APIs and/or interoperability, and incentives to re-use technology blocks or European standards. On top, upward compatibility should also be taken into account
- Provide easy access to demonstrator environment, either directly on field or remotely through network (in case of work on data)
- Offer affordable access to the SME and start-ups who are contributing
- Guarantee the replicability of the pilot (e.g. several locations, re-use of components)
- Change the perception of the actors involved (seeing is believing)
- Adopt clear and auditable rules for privacy management and handling of personal data
- Ensure security is an integral part of the solution being built and not an "add on" post deployment
- Ensure the visibility and citizens' perception of the solutions implemented
- Adopt a multi-disciplinary perspective, involving social science experts and co-creating solutions with active involvement of user groups
- Address ecological challenges related to the IoT (e.g. energy saving technology use or eco-conception/manufacturing)

There are a number of other questions that should be considered by evaluators:

- Sustainability: what are the commitments and resources in place to ensure the environment is supported for the duration of at least the project utilising it? An

ideal platform is one with a multi-year commitment and roadmap to ensure testing and stability issues with platform are ironed out.

- Resilience: what are the processes and technology in place to ensure the uptime and reliability of the platform? It is hard if not impossible to test a new product or service in an environment which has stability issues itself.
- Concurrency: can the environment support multiple products in pilot and demonstrator phase without interference or stability issues?
- Technical Integration: are there clear guides and support for APIs, SDKs, Network and Hardware configuration to integrate with the environment? (reliability & upward compatibility)
- Commercial/Legal Integration: Are there clear guidelines and support for any commercial and legal issues around software/hardware installation, licensing and shared services? (data ownership, integrity & privacy)
- Representative Environment: Do the environmental characteristics match the environment the product will be used or sold in, in real life?
- Capacity: Does the environment support the networking, processing, number of locations or other characteristics to meet the KPIs of the product being used? Consideration should be given for special events or showcases which may have higher requirements for availability and capacity (bandwidth] than day-to-day operation
- Location and Access: Can the Client/Customer of the environment physically get to the demonstrator?
- Interoperability: Is it possible to test use cases between various products in the demonstrator environment (LSP)? This is to allow for horizontal as well as vertical compatibility testing.
- Support Services: Are support services such as Innovation Centres, Support Centres, Civic environment, Data Sources available within the demonstrator? Is there access to creative and multi-discipline resources to assist with project and outcomes?
- Data Handling: Are good quality systems and processes in place for any personal and secure data collected by the LSP environment?

- Showcase: Are there areas or features within the demonstrator which allow for potential customers and clients of the product to be shown a working version of the product?
- Funding Model: Are the direct and in-direct costs which stakeholders would have to fund themselves when engaging with the demonstrator made clear to them?

7.5 Effective stimulation of the IoT innovation through funding

Our recommendations for IoT innovation funding refer in the first instance to the full portfolio of projects that are funded in a given call, and in the second, to individual projects that apply for funding.

Portfolio of projects

- Rather than receiving a fixed, 3-4 years funding, the projects in the portfolio are conditionally funded for the full duration of the project but need to meet clear criteria, conditions before they can receive next stage funding, as shown below.

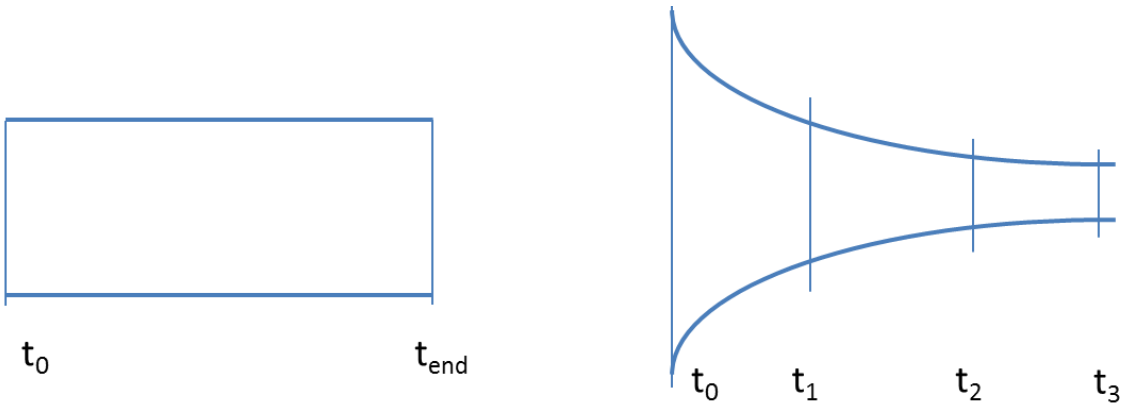

Fig. 1 schematic representation of the funding of a portfolio of projects. Instead of a fixed funding over the duration of the project (from t_0 to t_{end}), intermediate stage gates (t_1 t_2 t_3) are introduced at which some individual projects may be terminated. The resources that come available can be used to seed a larger number of projects in the initial stage while the total funding remains constant.

- Unsuccessful projects will be terminated/redirected rapidly to create room for new projects (fail cheap, learn fast for the benefit of the total portfolio). The better the quality and progress of the projects, the more the right hand curve will flatten and resemble the left hand flat funding curve. Note that the funding level of *individual* projects may increase over time.

- Those projects which are not appropriate for next stage of EU funding after some intermediate stage-gate assessment, may be stopped completely or they may find more appropriate support from National, Regional, Private Funding or Industry Partnership. Not all projects have the same progress trajectory so a flexible funding system can filter projects and funnel them into the appropriate funding schemes (e.g. ITEA).

- This approach forces partners in EC projects to continuously look ahead and collectively manage to meet the success criteria for the next phase. This also increases the chances that at the end of the project partners are still closely working together, thereby stimulating the commercialisation of the results.

- Corrective action should be allowed if one does not pass a milestone (learning). This also accommodates for the risks and objection of not having a long term coverage guarantee of resources with participants.

- Reviewing at the milestones requires new criteria and new expertise for reviewers. It is advised to involve academia/institutes/companies with expertise in innovation management and *not* involved in any of the projects itself to draft and deploy the new criteria and provide training for reviewers.

- Different reviewers and a different set of criteria may apply at the stage gates. For example in the initial phase one may apply predominantly technical criteria for the maturity of an Internet of Things platform or application and in a later phase one may apply stakeholder adoption criteria for Large Scale Pilots (LSPs). The involvement of a local government at which the LSP is run may be required to assess whether requirements are met.

- Apart from the above, there is a general need for funding of many short cyclic rapid prototypes (6-12 months) without multi-year stage gating (e.g. for Apps on platforms)

Individual projects

Clear deliverables should be upfront defined for each stage gated milestone. Note that such deliverables are fundamentally different from traditional linear innovation and go beyond technology maturity. New criteria are proposed in section 5 on MARL and TRL.

- Identified potential barriers for success (Legal, Ownership, Market…) should be addressed upfront providing also the planned way to deal with and manage possible success or failure.

- Because of the different nature and newness of IoT innovation, also the rating criteria should be clearly described upfront (questionnaire) and be 'tested' on a number of representative projects.

- One could consider the maturity representation in a 'spider diagram', where the spokes represent different vectors of maturity e.g. Market Adoption Readiness, Technology Readiness, Large Scale Pilot commitments and results, completeness of stakeholder network) with bands that indicate the minimum required levels at

each milestone. Such representation also facilitates communication to stakeholders.

- Methods can be developed using examples from existing EU initiatives which have tested stage-gate funding, as well as national initiatives such as Innovate UK which deploy regular, 3-month checks to release further funding for a project.

Policy level

- Identify and stimulate the EU nations and regions that have already invested in Innovation Ecosystems and that warrant further support for innovation by the new Committee of the Regions and that could also serve as test grounds for a large scale experiment. National and regional governments ought to be incentivised to 'keep the money' *on condition* that it is used for regional innovation ecosystem experiments within the guidelines set in AIOTI, and resulting in the regional government taking responsibility for results and infrastructures. This flexible funding model could serve to drive top down (EU) vision and bottom up (national, regional) ownership.

7.6 General recommendations

- The LSPs funded, if open and platform-oriented, should aim to interconnect across Europe to contribute to the Digital Single Market, and strive to become an exemplar of policy driven R&D&I in Europe;
- Privacy, security and trust challenges are everywhere in the IoT – all LSPs should have privacy and trust built in by design with credible consortia members dedicated to this objective; [Platform, security, reliability : One suggestion is to have an organism / association which is certifying the additional or changed technological blocks]
- An LSP can start or exist in a single vertical, but starting from horizontal approaches applied into one or more vertical may have a greater effect on ecosystem building, e.g. drive interoperability at all levels of the stack and commoditization;
- LSP should become hotbeds of best practices; not all problems will be solved by the LSPs but problems that arise in applying the technology provide valuable knowledge spill overs for future projects.
- To spur adoption and provide incentives for developers, LSP should adopt (where applicable and relevant) existing and proven technology.

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The core team of companies (around 15) is unanimous in supporting the recommendations and has provided ample review and comment opportunities to all members of AIOTI WG2 (in several telephone conferences and via the off-line review).

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