5G IA
INFRASTRUCTURE ASSOCIATION

Boulevard Saint-Michel, 47
1040 Brussels
Belgium

www.5g-ppp.eu, www.5g-ia.eu

**5G Infrastructure Association
Vision and Societal Challenges Working Group
Business Validation, Models, and Ecosystems Sub-Group**

Business Validation in 5G PPP vertical use cases

June 2020

Date: 2020-06-09   Version: 1.0

Abstract

Expectations are high for 5G, as it promises many benefits and new business opportunities for all stakeholders engaged in the creation and use of future networks and services. The 5G PPP continues to invest considerable resources into researching and developing the technological side of 5G systems. A relatively recent development is the additional challenge to EU research projects to validate claims about business opportunities through business validation analysis. The challenges for business validation involve using an appropriate analytic approach, as well as the identification of the critical ingredients used for the analysis. Business validation must encompass value propositions for vertical industries, the identification of stakeholders, the emergent roles in the value system, as well as the identification and visualisation of the complex ecosystems that are expected to emerge.

In the late fall of 2019, the Working Group "Visions and Societal Challenges" of 5G Infrastructure Association (5G IA) took the initiative to establish the "Business Validation, Models, and Ecosystems" Sub-Group (BVME-SG). On the 25th February 2020 BVME-SG was formally constituted and started a series of meetings to refine the scope and processes of the group.

This positioning paper has been collaboratively developed by BVME-SG participants to summarise the findings of those initial meetings. It formally establishes the scope of the group, and key working processes. We draw on some example projects in the 5G PPP portfolio of projects; however, the BVME-SG welcomes new participants from any of the 5G-PPP projects to share knowledge on their project approaches, the challenges, insights and findings so a view on the diversity of approaches can be formed. Future work of the BVME-WG will systematically capture and characterize the methods used for business related considerations of the 5G PPP projects and eventually also capture market estimates, business models and business cases.

Table of Contents

1 Introduction

The BVME-SG focus is aligned to the European 5G Vision of "**5G empowering vertical industries**" which also encompasses public sector users. A consequence of framing benefit analysis in the terms of the vertical is that the supply side of the telecoms sector and its traditional supply chain is not the predominant focus. A great deal of business validation is to understand what enables verticals, and how this is articulated through market expansion models, business and society benefits. Once the BVME-SG has established an understanding regarding how vertical value propositions and business models can be enabled, a secondary supply side beneficiary in terms of the designing, building, maintaining and operation of a network may be apparent and could be identified. However, supply side-oriented thinking regarding mobile network operator product and service is not to be the primary focus.

The BVME-SG carried out an initial survey of various 5G PPP projects with the objective of finding common approaches and processes to business validation. A short summary of some of the projects can be found in the Annex and it is already clear the group sees practises emerging that address challenges shared by many projects, drawing on customer oriented entrepreneurial approaches.

This information helped form an initial view on the purpose of business validation and helped to identify challenges that appear to be common across a number of the 5G-PPP projects. Whilst it is not the intention of the group to form a view on the "best" solutions, and it was certainly not the objective to do so in the time frame of this paper development, the expectation is that as we progress further, we may find commonality amongst projects that focus on common verticals or technology layers.

Section 2 is a short introduction to the purpose of business validation for 5G PPP vertical use-cases and the importance of embracing some coherent approach to the process. Four key stages to the business validation process are discussed; customer validation, solution alignment, business model selection and financial analysis and projections.

Section 3 summarises a number of challenges that have been discovered by several of the projects as they have developed and executed their approaches to business validation. The list that has been created is not thought by the group to be an exhaustive list; indeed, it is highly likely that the list of challenges will grow.

In Section 4 we provide concluding remarks and next steps. Whilst developing the initial views of the group has proved invaluable to create a common terminology, we capture an initial list of terms used by the group as this also helps with establishing the scope of the group in Section 5.

2 The purpose of Business Validation

Turning brilliant research into successful commercial products is a complex task with many failures. Most failures occur because there is a lack of Product/Market [1] fit or to put it simply, the product or solution that is built is not what the customer wants to buy in sufficiently large amounts to sustain a business. This is a particularly big risk in the fledgling 5G verticals market where so much has already been invested and committed to the infrastructure. This raises the risk that solution providers may propel towards creating solutions for a problem that does not exist in sufficient scale, or can be more cost effectively solved with alternative solutions. To help avoid this, many early ventures in new markets use a Lean Start-up Methodology [2] as the preferred method to guide their journey to early viability. The Lean Start-up paradigm envisions a new proposition being created based on a new product or service that will be embraced by a market [3] because **it solves the customer's urgent problem**.

While a Lean Start-up Methodology is the accepted option for creating founder-driven, investor-oriented start-ups, there is strong evidence [4] that adopting a similar approach in the research domain can lead a project to better enable: i) the commercialisation of better products and services, ii) while being faster to the market, and iii) with sustainable business models.

Figure 1 Approach to business validation for H2020 vertical use-cases

Figure 1 illustrates four phases that are almost always present in some form of business validation process. The first phase, customer validation, is arguably the most important as it helps to establish the specific business problems that a potential customer wants to solve and is willing to invest money to gain the benefit they need. Development of business models, technology roadmaps and revenue plans are important activities in later phases, but they have a higher likelihood of failure if not consciously and continuously grounded in support of specific customer pains. The figure also illustrates that technological validation, the other pillar of validation in 5G PPP projects, is a parallel activity to business validation and the processes are intertwined and complimentary. We shall see in the next section that 5G PPP projects report challenges in all business validation phases. However, there appears to be a consistent view that if vertical customers' real pain points are not adequately understood and placed at the centre of the validation process, the future uptake of 5G amongst verticals will be significantly retarded.

Regardless of whether the business validation process follows a strict Lean Methodology or some variations thereof, the general approach is the same as with all research methods – create a hypothesis that can be tested, and allow for agile re-adjustment before investing time and effort in outcomes that cannot be successful. This is a fundamental underpinning for the technical

research process and a comprehensive business validation process should encompass a similar disciplined approach to assessing if a viable business can be created that delivers value to the stakeholders involved.

Business validation therefore is much more than a desk-based research that estimates potential revenues and market sizes. The process must always be grounded with an objective and detailed understanding of customer needs (Customer Validation) and develop robust assumptions about solutions that future customers will actually use.

It should be noted that business validation is better carried out in an iterative way with openings for feed-back and learning loops. Aspects such as willingness to pay, market size, routes to market and business model calibration can be addressed in subsequent phases of business validation whilst constantly revisiting and recalibrating that the business is creating a solution that sufficient customers will want to buy. There are many challenges also in later phases of business validation, as noted by 5G PPP projects (see section 3 and Annex A). Later BVME-SG white papers will also explore appropriate approaches to challenges with complexity in value systems, ecosystems, roles and stakeholders, and business models for both verticals and 5G providers.

3 5G PPP projects and Business Validation: status and challenges

The BVME-SG has carried out an early examination of an indicative set of 5G PPP projects starting from more mature Phase II and Phase III projects to projects conducting advanced 5G validation trials across multiple vertical industries (see Annex A). In summary, all projects put significant efforts into business validation with a varied set of approaches. They form a group of domain specific insight and experience, with huge potential for knowledge sharing and development for innovating with 5G. The projects use classical approaches to business aspects such as providing exploitation plans and less frequently, techno-economic analysis of costs, revenues, and market evolution. The business model canvas (BMC) recurs in most projects as a basis for identification of provisioning roles and stakeholders, business opportunities, and market estimates. The projects typically examine hypotheses related to the value of services and business models through peer group exploration, small sample surveys or workshops. Additional notable approaches use tools to explore the problems customers and users need to solve, and the use of design thinking tools such as customer journeys and storyboards.

On this basis, some key challenges are consistently emerging, mainly associated with the identification of customer/vertical "pain points", the benefit analysis of 5G enabled products and services, and the usage of ecosystem driven approaches to the definition and creation of sustainable solutions. As illustrated in Figure 2, some of these challenges are emerging in early business validation phases and may affect the success of the subsequent process. Thus, addressing them is vital and has been the main driving force for the creation of BVME-SG.

Growth Trajectory
-Availability of information for performing accurate Techno-economic analysis (esp. at early R&D phases)

Customer Validation
- Vertical industry value proposition enhancement vs dependability
- Gap in demand and supply

Technical Research and Validation

Business Model
-Complexity of existing and new supply chains (business relationships)
-Need for representative analytic models and visualisations to overcome limitation of existing business modeling tools

Solution Alignment
-Emergent roles in the value chain and candidate stakeholders
-Complexity in mapping stakeholders to roles & length of value chains to deliver solution

Figure 2 Typical challenges with business validation of vertical use-cases

Vertical industry value proposition enhancement vs dependability: Today, many vertical industries rely totally on Mobile Network Operators (MNOs) for their internal telecommunication needs. However, some large industry sectors, such as the railways, have come to regard the network as part of their business infrastructure. 5G can bring together traditionally separated industries with common value chains, while the market position of many vertical industries can be empowered by including 5G enabled enhancements in their core business unique proposition(s). However, no matter the promised enhancements and business viability, vertical industries can be strategically reluctant to rely on MNOs for their core business propositions (and engage them in their value chains) or hesitant to include additional network operations in their business processes.

Gap in demand and supply: A common challenge encountered is bridging the communication and knowledge gap between potential customer demand and provider solutions. Specialists in the telecommunications industry may have only partial understanding of vertical industry requirements and the limitations imposed in their business activities; specialists in the vertical industries have a partial understanding of what 5G can bring in their domain. Both domains have even less understanding of the required transformations in respective business processes. At a certain level, this stems from the fact that stakeholders do not share common vocabulary, concepts, visions and missions. Thus, appropriate tools for business validation purposes may also serve as a translation layer between stakeholders.

Emergent roles in the value chain and candidate stakeholders: 5G advancements in network deployment, operation and services provisioning can accelerate transformation of the complete value system of the telecom and vertical industries business, both in terms of new emerging roles and in terms of roles shared between existing and emerging stakeholders. For instance, network deployment and telecom services provisioning is currently the core business role of telecom operators; in future value systems, stakeholders from vertical industries may emerge as small scale telecom service providers or non-public network (NPN) providers. They could develop from a different starting point in the value system, taking advantage of 5G capabilities to rapidly overtake traditional providers. An indicative case could be the Railways, specifically in relation to the advent of Future Railway Mobile Communications Systems. Therefore, mapping of a business role with stakeholders will become less straightforward; several of the 5G PPP projects have responded by employing tools to analyse and visualise new value chains and ecosystems.

Complexity in mapping stakeholders to roles: Considering the aforementioned value system transformations, whilst the beneficiary stakeholder/vertical and their need may be easy to identify, the mapping of contributing stakeholders to deliver a potential solution can be more complex. For the latter, a mapping between required roles in the value chain and stakeholders to undertake them depends on the market environment and the stakeholders' associations in it, and can be a burden, no matter the business benefit and validation of the solution from the beneficiary side. Thus, business validation would require methods of analysing these relationships in a holistic way.

Complexity of existing and new supply chains: The complexity in mapping stakeholders to roles for the delivery of a solution increases in markets with multiple stakeholders, as a considerably high number of business relationships/associations could be required, along with a proportionally high number of complex contractual arrangements between them; actually constituting a hurdle to the evolution of the market. This complexity of supply chains is not easily depicted with current business modelling tools and can be a challenge from the vertical industries side.

Representative analytic models and visualisations: The Business Model Canvas (BMC) is a commonly used method presenting a business model of a value proposition for a specific customer segment. However, in early business validation phases, it is beneficial to also capture aspects related to the role(s) and the level of transformation of their current business activities that the beneficiary stakeholder/vertical is willing to perform plus aspects that are specific to the stakeholder and market environment. In addition, aspects related to the market environment (e.g. regulatory or competition specific), to potential social impact and acceptance, may severely impact the sustainability of a solution even if the innovation/product economic viability is validated. For these purposes, tools mapping the whole socio-technical system could be valuable.

Availability of information for accurate Techno-economic analysis: Although experts in the 5G community conduct technical analyses and accurately define suitable solutions/deployments for specific verticals, the economic evaluation of solutions is challenging and adds to

uncertainty in evaluating the overall hypotheses. This is because the parties developing the technology cannot disclose economic data at early R&D stages, and thus, key financial metrics like volume vs. price, price decreases over time, and many others are not available to support accurate financial modelling for the verticals.

4 Concluding remarks and next steps

Starting from this white paper, the BVME-SG will systematically review how 5G PPP projects address business validation. The group will facilitate and promote sharing of practises through regular meetings and documentation. Eventually, this will lead to a full cycle of business validation beyond customer pains, into business models and ecosystems. The ultimate goal of the BVME-SG is to establish guidelines on best practice and approaches for business validation across all 5G-PPP projects to facilitate a sustainable evolution of the 5G market.

In this white paper we introduce, and direct our fellow 5G PPP projects, to well-known business validation approaches such as the Lean Start-up method. Pivotal to this and similar approaches, is the emphasis on **solving the customer's urgent problem**. Translated into the context of 5G and verticals, it is essential to explore and validate vertical customers' real problem early. This lays the ground for finding out if and how 5G capabilities can solve the identified problems and facilitate the development of sustainable business models, ecosystems, and business cases.

An analysis of a subset of 5G-PPP projects indicated that most employ some methods for examining the customer pains and value propositions. Nonetheless, the projects also reported that a number of challenges had emerged in the process of business validation, spanning from the initial customer validation and value proposition identification to the definition of suitable win-win business models for all stakeholders in the value system. Typical challenges in the early phases of validation were associated with the alignment between the customer expectations, the technology, and value proposition capabilities. In later phases of business validation, challenges concern (i) the identification and distribution of roles in the complex value system of the future 5G ecosystem, and (ii) the associated complexity of existing and new supply chains. These challenges call for the development of representative analytic models and visualizations to overcome limitations of existing business modelling tools.

To summarise, 5G PPP projects share some common views on business validation challenges and which methods are more appropriate to support the business validation process. While these methods are easy to describe it is still demanding to put them into practise in the 5G community. This white paper suggests with confidence that 5G PPP projects exploring vertical use cases should cater to customer problems in early stages of business validation. Beyond that, the projects will benefit from sharing and learning between them, and forming new and best practises for business validation for 5G technology and markets.

This white paper is a standing invitation to all experts whose subject of work is the business validation in their respective 5G PPP projects. Please join the effort of the BVME-SG in systematically reviewing, analysing, and sharing best practices towards the development of sustainable business models for all stakeholders in the 5G ecosystem.

5 Terminology

In the context of Business Validation, Models and Ecosystems there is a high risk of confusing and inconsistent terminology. This results from the fact that many different teams which are working to address the pertinent challenges are coming from different backgrounds. Relying on sources external to the 5G PPP community does not help, because literature diverge on the definition of terms like business model, business case etc. Often terms are used loosely and certainly are not formally defined. From a pool of available and used definitions we have made some choices that approximate the intended meaning in this white paper or have found a minimum consensus among the members of the working group.

Concerning the definition of the 5G PPP community, we rely on previous published work by 5G PPP that illustrates [5] and defines the main target stakeholders. All members of the stakeholder groups defined in [6] constitute the **5G PPP community**. The community has introduced the term **Ecosystem** to signal an expansion of involved stakeholders in 5G value creation, innovation and new growth [7], [8]. The term **ecosystem** can be qualified and refer to a **5G business ecosystem** that describes self-organising, business-oriented socio-technical communities regardless of their location and structure, which are enabled by the 5G system.

A **platform** in an ecosystem is defined as products, services or technologies developed by one or more firms, and which serve as foundations upon which a larger number of firms can build further complementary innovations and potentially generate network effects.

In this context a **5G value network** is defined by way of a 5G ecosystem as a complex network or interconnected system, with focus on how 5G services are provisioned seen from within (introvert view) [9]. Such models reveal the internal complexity of a platform, and hide the complexity of the interaction with customers and external partners. The introvert view refers to a team or group directly engaged in the construction of one or several 5G systems. In contrast a **5G platform ecosystem** is an interconnected system, where the focus is on how one 5G platform interacts with external stakeholders and customers. Such a model hides the internal complexity of a platform, and reveals the complexity of interactions with external stakeholders and customers that can belong to other industry sectors (extrovert view) [9]. The complex relationships in value networks and platform ecosystems deviate from the idea of a **Value chain**, which models sequential relationships between value producing activities in control of one organisation. [9]

Business Validation is the process to assess whether or not a certain system design is appropriate for the purpose and meets the business requirements within given constraints. Business requirements are the characteristics of the system from the end-users' and customer's point of view and expressed in the customer's vocabulary. Constraints are external factors that impact and limit system design and can be technical, financial or regulatory of nature. It is here understood that business validation embraces everything from ideation, through development of robust value propositions, to estimating market sizes, designing business models and carrying out business case analyses.

A **Business model** describes qualitatively how one organisation endeavours to create, capture, and deliver value in an economic or societal context. A business model is used both for the description of how entrepreneurs create growth opportunities, as well as how established organisations identify new commercial opportunities.

A **Business case** is the identification of a business need that can be satisfied by the introduction of new or adapted existing products and services. It provides a systematic reasoning and argumentation about the assumptions, target market situation, benefits and risks, needed investments, as well as projected cash flow when an organisation plans to satisfy the business

need. It typically includes also the opportunity cost and mostly expressed in quantitative terms in e.g. an Excel Book.

A **"pain point"** is a real or perceived user or customer problem. A solution that relieves the pain point for the user or customer is creating an opportunity for creating value in the ecosystem and the foundation for a value proposition seen from the provider's point of view. The challenge is identifying the pain points that have a high potential in creating business value through wider market adoption.

A **stakeholder** is a party that holds a business interest or concern in the ecosystem, while **role** (also **business role**) is the expected function performed by a stakeholder in the ecosystem. Therefore a business role can be mapped onto a stakeholder, whereas a stakeholder can perform one or more business roles. This relation can be better explained by introducing the business **administrative domain** that is defined by the requirements of one or more business roles and is governed by a single business objective. A stakeholder may own one or more business administrative domains. Finally, the association between two business roles can be defined as the business **relationship** that is manifested through a **contract**, which in turn specifies the context and constrains for the business relationship. In the context of an ecosystem, a contract should also be understood as mutual expectations between roles that are interdependent, however, do not directly control the other party. It should be noted that 3GPP in TR 28.801 is using the term **actor** to denote a similar concept to stakeholder. Leveraging this 3GPP definition the 5G PPP white paper on architecture [10] defined a model for stakeholder roles in the 5G ecosystem that finds general consensus among many project of the 5G PPP.

6 References

[1]   The Top 20 Reasons Startups Fail, CBINSIGHTS [Online]. Available: https://www.cbinsights.com/research/startup-failure-reasons-top/

[2]   The Lean Startup Methodology, [Online]. Available: http://theleanstartup.com/principleshttps://www.5gsolutionsproject.eu/

[3]   Ries, E., 2011, The Lean Startup, New York: Crown Business, ISBN 9780307887917, eBook https://books.google.de/books?id=tvfyz-4JILwC

[4]   Still, K. 2017. Accelerating Research Innovation by Adopting the Lean Startup Paradigm. Technology Innovation Management Review, 7(5): 32-43. http://doi.org/10.22215/timreview/1075

[5]   Revised 5G PPP target stakeholders picture, April 2020 [Online]. Available: https://bscw.5g-ppp.eu/pub/bscw.cgi/d347354/5G%20PPP%20Stakeholder%20Picture%202020-04.pdf

[6]   The 5G PPP Stakeholders Glossary, April 2020 [Online]. Available: https://bscw.5g-ppp.eu/pub/bscw.cgi/d347361/5G%20PPP%20Stakeholder%20Glossary%202020-04%20v3.pdf

[7]   5G PPP, 5G – empowering vertical industries, February 2016 [Online]. Available: https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf

[8]   5G PPP, 5G – innovation for new business opportunities, March 2017 [Online]. Available: https://5g-ppp.eu/wp-content/uploads/2017/03/5GPPP-brochure-final-web-MWC.pdf

[9]   D5.1, Ecosystem analysis and specification of Business and Economic KPIs, project 5G-VINNI, July 2019 [Online]. Available: https://zenodo.org/record/3345665

[10]   5G PPP Architecture Working Group – View on 5G Architecture, Version 3.0, white paper [Online]. Available: https://doi.org/10.5281/zenodo.3265031

[11]   5G PPP Phase 2 projects [Online]. Available: https://5g-ppp.eu/5g-ppp-phase-2-projects/

[12]   5G PPP Phase 3 projects [Online]. Available: https://5g-ppp.eu/5g-ppp-phase-3-projects/

[13]   MATILDA project website [Online]. Available: https://www.matilda-5g.eu

[14]   5G-VINNI project deliverable D5.1, Ecosystem analysis and specification of B&E KPIs, July 2019, https://doi.org/10.5281/zenodo.3345665

[15]   5GCroCo project deliverable D5.1, Description of 5GCroCo Business Potentials, Sept. 2019, [Online]. Available: https://5gcroco.eu/images/templates/rsvario/images/5GCroCo_D5_1.pdf

[16]   5G-TOURS project website [Online]. Available: http://5gtours.eu/

[17]   5G-CroCo project website [Online]. Available: http://5gcroco.eu/

[18]   5GROWTH project website [Online]. Available: http://5growth.eu/

[19]   5G-VINNI project website [Online]. Available: https://5g-vinni.eu/

[20]   Full5G project website [Online]. Available: https://5g-ppp.eu/full-5g/

[21]   5G-HEART project website [Online]. Available: http://5gheart.org/

[22]   5G-SOLUTIONS project website [Online]. Available: https://www.5gsolutionsproject.eu/

[23]   5G-PICTURE project website [Online]. Available: https://www.5g-picture-project.eu/

[24]   MATILDA project website [Online]. Available: https://www.matilda-5g.eu/

[25]   ICT-19-2020 Advanced 5G validation trials across multiple vertical industries [Online].
       Available: https://ec.europa.eu/info/funding-
       tenders/opportunities/portal/screen/opportunities/topic-details/ict-19-2019

[26]   5GCAR project website [Online]. Available: https://5gcar.eu/

[27]   Turetken, O., Grefen, P., Gilsing, R. et al. Service-Dominant Business Model Design for
       Digital Innovation in Smart Mobility. Business & Information Systems Engineering 61,
       9–29 (2019). https://doi.org/10.1007/s12599-018-0565-x

[28]   5G EVE project website [Online]. Available: https://5g-eve.eu

[29]   5GCity project website [Online]. Available: http://www.5gcity.eu/

[30]   5G-PHOS project website [Online]. Available: http://www.5g-phos.eu/
       https://www.5gsolutionsproject.eu/

7 List of Contributors

Name	Affiliation	Project
Editorial team		
Patrick Durkin	Inlecom Systems	5G-SOLUTIONS
Simon Fletcher	Real Wireless	5G-TOURS
Anastasius Gavras	Eurescom	5G-VINNI
Hanne Kristine Hallingby	Telenor Research	FULL5G, 5G-HEART, 5G-SOLUTIONS, 5G-VINNI
Ioanna Mesogiti	Cosmote	5G-VICTORI
Contributors		
Sergi Figuerola	i2cat	5GZORRO, 5G-CLARITY, 5GCroco, 5G-VICTORI, 5GCity
Esther Garrido	Atos	MATILDA
Dirk Hetzer	T-systems	5GCroCo
Alexandros Kaloxylos	5G-PPP	Executive director 5G Infrastructure Association
Eirini Liotou	Fogus	5GENESIS
Diego Lopez	Telefonica	5GROWTH
Meng Lu	Dynniq	5G-HEART
George Lyberopoulos	Cosmote	5G-PHOS
Håkon Lønsethagen	Telenor	5G-SOLUTIONS, Full5G
Ioannis Markopoulos	Forthnet	5G-SOLUTIONS
Iaonnis Neokosmidis	Incites	5GCity
Per J. Nesse	Telenor Research	5G-SOLUTIONS
Roland Nolte	IZT	5G-VICTORI
Eunice Ribeiro	i2cat	5GZORRO, 5G-CLARITY, 5GCroco, 5G-VICTORI, 5GCity

Theodoros Rokkas	Incites	5GCity
Richard Stevens	IDC	5G-EVE
Elina Theodoropoulou	Cosmote	5G-PICTURE
Ioannis Tzanettis	Wings ict solutions	5G-HEART

Annex A Maturing approaches to business validation employed in 5G PPP projects

The following is an account for the approaches to business validation in some 5G PPP phase 2 [11] and phase 3 [12] projects. We observe that the topic of business validation is addressed by all, however, with a lot of variance. This reflects that there are many applicable business validation methods. We argue that the variance also signals that there is room for sharing, learning, and consensus about well-functioning methods in order to explore and succeed with 5G both from a vertical and provider point of view.

MATILDA [13] demonstrators have been devised to prove the applicability, usability, effectiveness and value of the MATILDA framework for vertical industries: 5G Personal Assistant during Crowded Events (user moving around a crowded venue can share high quality media contents with peers and receive personalized recommendations based on current location and preferences), Distributed System testing (providing means to have secure access to test data, both for quasi real time monitoring, as well as for data stored in remote databases), 5G Emergency Infrastructure (real time intervention monitoring and critical infrastructure protection), Industry 4.0 Smart Factory (enabling 5G for logistics and real time distance calculation in human-robot collaborative production environments) and Smart City Intelligent Lighting System (fully automates deployment and in life management of lighting solutions). MATILDA has taken the classic approach to validation of claims regarding business opportunities as a result of technology oriented research activities. These approaches are project partner centric and focus on their business intentions beyond the end of the project. Workshops are organised that identify exploitable results and how they map into technical architecture layers along with IP ownership knowledge. The mapping of the innovations into the business model canvas (BMC) template, and in particular the value proposition dimension helps with defining the opportunity. Questionnaires are provided to attendees of events (not only project partners) probing on issues relating to the 5G and NFV. Peer review of proposals in standards bodies is taken as an indication of validation as the intent of standard bodies is to create a standardised product ecosystem. The project partners are expected to declare how their exploitation intent maps to their business and concretely define next steps on the pathway to exploitation.
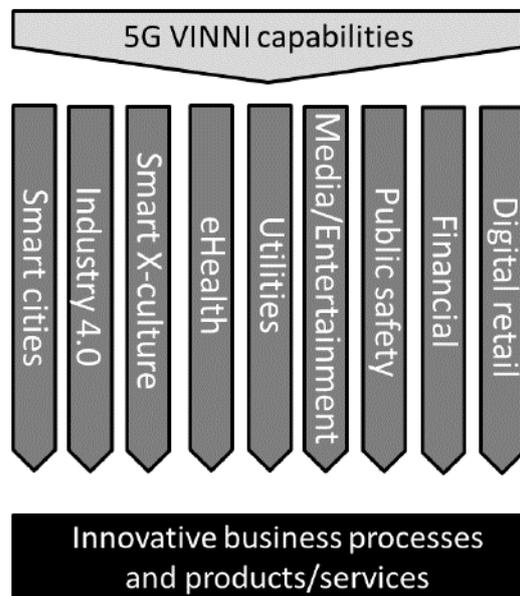
5G-VINNI [19] is developing an E2E 5G facility that can be used to first demonstrate the practical implementation of infrastructure to support the key 5G KPIs, and then to allow vertical industries to test and validate specific applications that are dependent upon those KPIs. An emphasis on the validation of the sustainability of the facility [14] results in

Figure 3 5G VINNI business approach

approaches such a value network analysis and SWOT that are custom built for each of the verticals (Figure 3) and that can be used to direct emphasis on future activities to enable the business of the PaaS model for the trials facility.

5GCroCo [15] utilises the BMC as a method to capture Cross-Border 5G Trial benefits. They place emphasis on the CCAM Ecosystem and its visualisation to enable the analysis of the

opportunities and solutions for automated driving as illustrated in Figure 4. This provides a summary view of multiple beneficiaries. Strategic Market analysis techniques for dimensioning of market size and value chain analysis are also used to determine business model aspects. Figure 5 from 5GCAR serves as inspiration to how traditional value chains can be translated into ecosystems configurations.
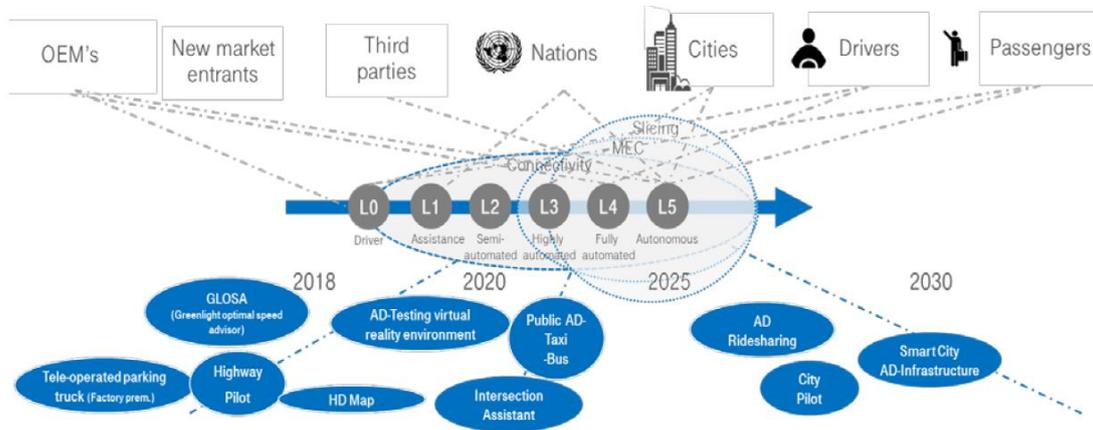

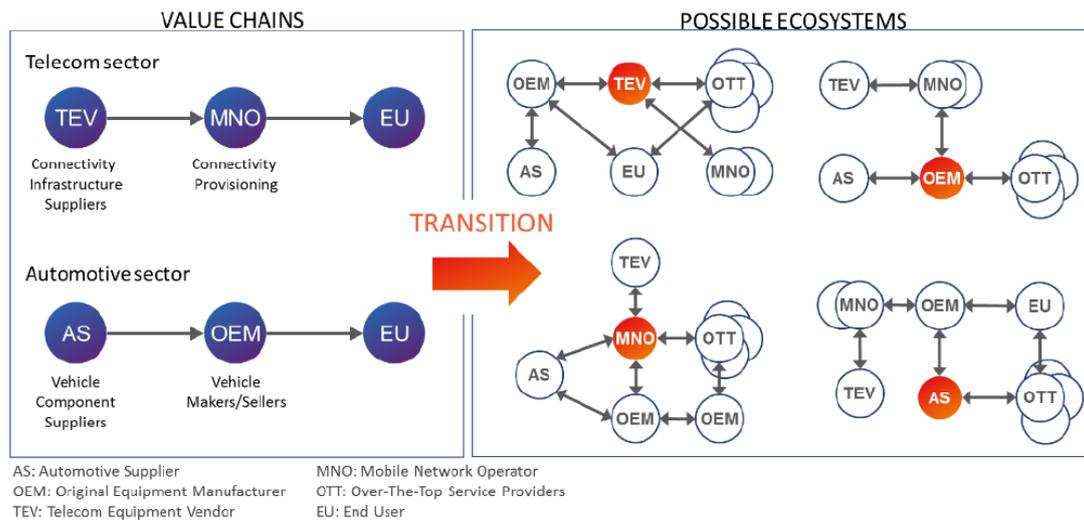**Figure 4 5GCroCo illustration of an emerging CCAM Ecosystem**

Figure 5 Going from value chains to ecosystems (Source: 5GCAR [26])

5G-HEART [21] explore 5G by deploying innovative digital use cases in healthcare, transport, and aquaculture industries. 5G-HEART's primary approach to business validation is an extended business model canvas, the BASE/X framework (Business Agility through Service Engineering in a Cross-Organizational Setting [27]). This framework emphasises: 1) the service aspects of innovations, in contrast to hardware and products, and 2); the complex web of actors that together provide the solution and are part of the business models. With this, the framework addresses one shortcoming of the business model canvas, i.e. too simplistic assumptions about stakeholders' participation in value creation and their relationships. However, it is still a late phase tool, as is the business model canvas. Thus, 5G-HEART has introduced tools to identify stakeholder pain points and develop robust benefits and value propositions. The project observes that project participants have varying experience with such methods, and that the use

cases are on different levels of maturity with regards to validation of customers' problems and value propositions.

An approach that has been trialled successfully by 5G-HEART is the visualisation of pain points in a story board. Ambiguity is removed by analysing multiple stakeholders focussing on their pain points and any short comings in the existing solution space.

5G-SOLUTIONS [22] is oriented towards delivering a business and technical validation of 20 real-life use cases (UC) across several verticals (Factory of the Future, Smart Cities, Smart Ports, Smart Energy and Enhanced Media). To complement the technical validation of each UC, a detailed Customer Discovery questionnaire (Business Value Template) has been completed for each individual UC which is strongly focused on the specific problem that is being solved and aims to answer some key questions:

- What exactly is the business problem (not technical issue) that a customer is trying to solve?
- Who specifically (what users?) will benefit from a new solution to the problem?
- Define the benefit (e.g. in time, cost, etc.) that will accrue to the user and to the broader users ecosystem (firm, industry, city, etc.) from addressing the problem or   current shortcoming

A second step in the process (Solution Discovery) will pivot around the key commercial partners in the consortium who are best placed to address the specific problems within the UC and who also can adapt and extend their current commercial portfolio towards innovative 5G-enabled solutions. In following stages, the project will support partners to develop and calibrate their individual business models and business growth, and thus provide a pathway for other similar EU organisations to follow in growing new solutions in a 5G vertical domain.
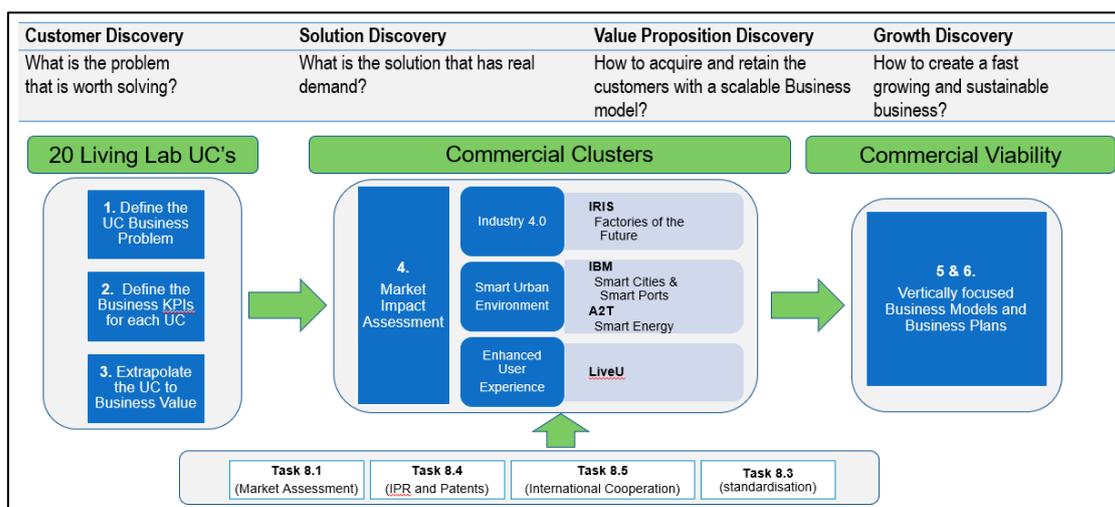

Figure 6: Commercialisation Approach for 5G-SOLUTIONS

5G-PICTURE [23] focuses on delivering 5G solutions for specific verticals and operational environments, explicitly targeting railway transportations (in view of Future Railway Mobile Communication System), stadiums and smart cities. 5G-PICTURE's approach to business validation starts with the review of the existing value chains in the telecom industry and extends them to include more roles that seem to emerge or are enabled by 5G-networks' capabilities. To this end, a clear distinction is made between market stakeholders and roles. Next, on the basis of Value Proposition (VP) Canvases, the pain points of specific market roles are captured and along with the solutions are validated from the technology perspective with the process being followed for all standalone project innovations (i.e. pure technological products). BMC are used subsequently for the business validation of these products' introduction to the market, performed with the assumption that target customers will primarily be existing or emerging

telecom operators. In parallel, target vertical industries ecosystems addressed in the project were reviewed in terms of how 5G-PICTURE (and 5G networks in general) alter the roles that they undertake. BMCs were then used for specific target roles/business activities – rather than vertical stakeholders – in order to validate the complete 5G-PICTURE solutions targeting these vertical markets, while providing the appropriate separation from the whole and irrelevant set of the business activities of the verticals. As it was revealed, the real gap in business validation is generated (1) by the initial assumption(s) of the role(s) that the verticals would undertake – which even for the same vertical industry can be different, for different representatives, for different market environments/countries, etc., (2) by the fact that BMC does not adequately depict barriers/challenges related to the regulatory/competition environment prerequisites, necessary even if the innovation/ product economic viability is validated business-wise, (3) by the fact that BMC needs to be created on a per customer and value proposition basis, meaning that multiple BMCs for each stakeholder need to be built for a change in the value chain to capture the broader market environment change, while their dependencies are not obvious. In the context of the project these aspects were covered by relevant environment analysis accompanying the BMCs for specific markets.

5G-TOURS [16] has a focus on the three verticals (transport, health and tourism) in the environment of Cities, and builds on the 5G-EVE [28] platform. Several use cases per vertical are to be deployed. The Business Validation processes converge state of the art thinking in Business Model Innovation and City Indexes to establish the socio-economic environment within which value will be created and captured. The value to users is articulated through typical journeys or experiences of the users of the 5G systems and the potential delivery mechanisms for the services. Value chain and profit pool analysis aids in the assessment of the viability of new services, along with business research-oriented approaches to user and key stakeholder engagement through in-situ workshops as "friendly customers" or service users experience of the use cases.

Figure 7 Business Model Canvas of 5GCity Neutral Host

5GCity [29] 5GCity developed solutions focussing on Media and Entertainment services in the environment of a Smart City. The 5G neutral host platform had multi-tenancy, virtualization and edge/cloud management at its core and enabled Cities and ICT infrastructure owners a new business model for sharing 5G infrastructure. It acted as a catalyst for the telecom industry, Cities and the Media vertical enabling the provision of new media services in the city such as Live TV and news production in the city, UHD distribution and immersive reality, advanced participatory media acquisition and production. 5GCity used a series of tools towards business

validation. The first step in this endeavour was to assess the current status of the market through a market analysis. Several demographic, economic and business data were provided. Among others the evolution of population, revenues and investments as well as 4G coverage were investigated. Information about traffic growth was finally examined. After assessing the Telecom market, 5GCity Neutral Host (NH) business model was identified and described using the business model canvas (Figure 7). New players of the value chain were identified and incorporated accordingly. The relations between 5GCity actors along with the revenue streams were described in a reference network.

A global 5G population adoption curve was then estimated by combining historical data and qualitative factors that are expected to influence 5G evolution.

Following the definition of the appropriate service sets and of the business model and taking into account the forecasted global mobile technology penetration since launch, a comprehensive techno-economic model has been developed. The model aimed to simulate the scenario of a NH providing wholesale access to MNOs. The results of the model include a detailed analysis of all the investments and the cost components of the 5GCity NH, its operational expenditures, its revenues and the financial outcome as expressed by the financial indices NPV, IRR and payback period. The profitability of a NH under an immersive video use case has been presented through specific calculations.

5G-PHOS [30] project aims at developing an ultra-broadband converged FiWi PtMP fronthaul network, capable of supporting efficiently the required 5G NR densification/5G capacity issues while alleviating the need for installing fiber terminations at every Mobile Network Operators (MNO) Base Station site. In this context, the main stakeholders are the MNOs/telcos and potentially, verticals and/or infrastructure owners (municipalities, stadium owners, etc.). In addition to the solution-as-a-whole, the novel products and technology enablers comprising it and falling into the optical and the wireless domains (e.g. laser arrays, Optical Beamforming Networks (OBFNs), Reconfigurable Optical Add Drop Multiplexers (ROADMs), Indium Phosphide (InP) transceivers, mmWave mMIMO antennas) are also considered as outcomes to be validated businesswise. The validation approach adopted includes the following activities: (a) constant monitoring of the 5G evolving ecosystem, especially in the domains addressed by the 5G-PHOS so as to identify gaps, clearly position the 5G-PHOS contribution while also reassuring its innovation(s) aligned with trends both in the market and the research domain, and opportunities; (b) Conduction of a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of the solution-as-a-whole, as a preparatory step prior to the business evaluation; (c) Identification of the Key Exploitable Results (KERs) - besides the solution-as-a-whole-, including components, elements, platforms, algorithms, software applications, etc.; (d) Evaluation of both the solution-as-a-whole and the KERs considered as the most mature ones for commercialization by using the Lean Canvas model; (e) Periodic update of the partners' individual strategic exploitation plans regarding both the solution-as-a-whole and the KERs. The most challenging parts in this process have been the identification of the individual elements of the solution and even more, the techno-economic analysis, for various reasons: economic information cannot be disclosed by the vendors as long as the products are under development, volume vs. price, price decrease rate vs. time, etc. Towards a potential techno-economic analysis, a dimensioning tool has been developed, based on network architecture modelling of the different use cases envisioned by the project.