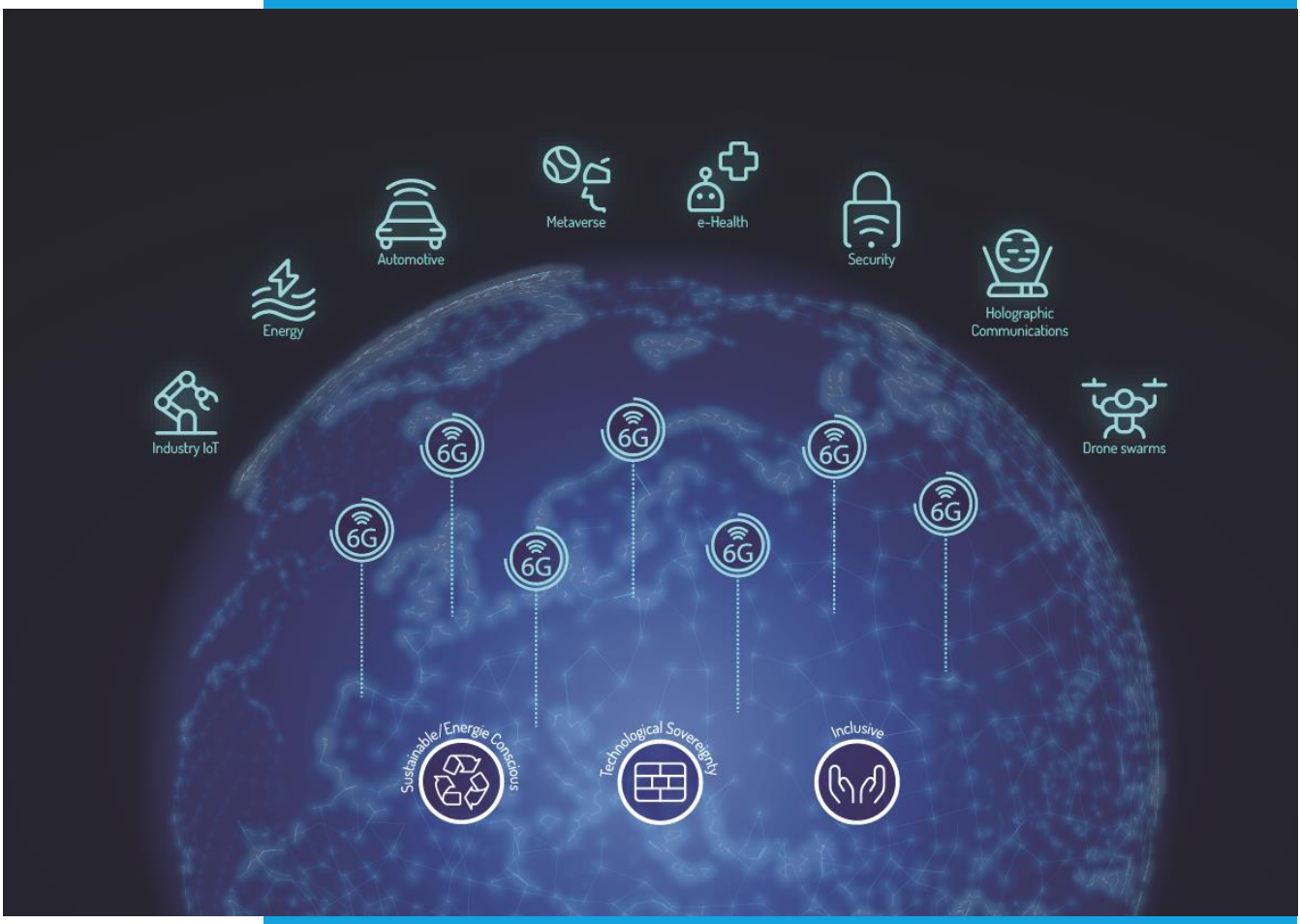
6G Smart Networks and Services Industry Association
(6G-IA)



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White paper

5G AND BEYOND 5G ECOSYSTEM BUSINESS MODELLING

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EXECUTIVE SUMMARY

In the telecommunication sector, the evolution of service delivery models in the 5G era was triggered by two technology-driven trends. The first pertains to the industry transformation needed as a means to overcome poor cost efficiencies and low flexibility in delivering services covering a wide range of requirements as defined by the new service classes introduced by 5G: enhanced mobile broadband (eMBB), ultra-reliable low latency communications (URLLC) and massive IoT (mIoT). The second trend relates to a technological paradigm shift towards full softwarisation of network functions and network architecture disaggregation thereof.

These trends provoked a transition from linear value chains, with simple relationships between vendors and operators, to complex value networks, which imply a multitude of relationships between several enterprises to formulate and deliver a value proposition to the customer. We use value networks to model ecosystem-based value creation in these complex systems. We differentiate between a provisioning ecosystem catering to developing and delivering 5G and beyond 5G services and a vertical ecosystem, which uses 5G and beyond 5G services in combination with other technologies to deliver applications to vertical customers.

Although these trends promote innovation at various levels, they also pose challenges for enterprises in identifying their position in the value network of the relevant ecosystems and formulating their business models. Business modelling is generally well understood as a conceptual structure that explains how an enterprise operates and intends to achieve its goals towards creating value for its customers and monetising on its activities. However, in the new context of business activity in the new 5G ecosystem, the business models of different enterprises are interdependent. This becomes more of a challenge especially when markets are immature, and the business relationships are not well-established and thus there are multiple configurations of how an ecosystem can be realised.

Enterprises in 5G and beyond 5G should follow an *ecosystem business modelling* approach that considers all potential configurations of how an ecosystem can be formed, i.e., potential business models that will be adopted by other players and the resulting network effects. The inherent ecosystem dynamics induce an iterative process for enterprises to continuously adjust and optimise their initially formulated business models following the interactions with other ecosystem actors. The necessity for continuous adjustment calls for business modelling tools that help them to streamline this process. Furthermore, in order to ensure an alignment with the ambition of 5G and beyond 5G technology vision to meet sustainability goals - as defined by the United Nations Sustainable Development Goals (UN SDGs) - enterprises must adapt their understanding of how business models are developed and can evolve.

With sustainability in mind, business models should prioritise long-term values over short-term interests and gains and combine these with the definition of extended values that consider societal and environmental sustainability targets along with economic outcomes. A sustainability-oriented business model ensures that value creation, delivery, and capture allows an organisation to contribute to tackling sustainability challenges and promote sustainable development. Furthermore, embracing systemic thinking allows bidirectional

interactions with internal and external actors to reflect upon potential outcomes and capture capacities through stakeholder integration.

Aiming for the development of sustainability-oriented business models in the context of ecosystems, we propose an iterative ecosystem business modelling methodology composed of five steps named the “expand”, “focus”, “design”, “business case development” and “iteration” steps.

1) "Expand" step: an enterprise identifies the scope of the ecosystem, including the potential number of relationships with other actors and the potential frequency and extent of changes in the relationships. In this step, the enterprise also identifies possible other ecosystems it could be part of with its defined business model.

2) "Focus" step: an enterprise settles its value proposition, including economic, societal, and environmental value, and identifies the necessary capacities to deliver value. In this step, it formulates the activities in the ecosystem that best fit its strategic goals, considering the ecosystem dynamics and identifies potential disruptive factors.

3) "Design" step: the specific enterprise business model is analytically defined, using established advanced tools that consider sustainability-oriented business modelling elements. The challenge here is to model and compare multiple business models in the context of varying relationships with other actors as part of the dynamics of the ecosystems. This calls for a new generation of modelling tools that can logically associate possible business models and analyse and compare the outcomes.

4) "Business case development" step: an enterprise can follow existing approaches on sustainability-oriented business and revenue models, with which it can estimate and compare its market opportunities.

5) "Iteration" step: defined as a step in its own right to cater for the importance of the necessary adjustment and optimisation of the business models introduced above.

The practical application of ecosystem business modelling can imply the segmentation of an ecosystem into smaller sub-ecosystems as a means to handle complexity. It employs the aforementioned concepts and tools to comprehensively analyse the potential of an enterprise to engage in the ecosystem and its sub-ecosystems. This potential is evaluated through an sustainability-oriented ecosystem business model assessment, which ideally is substantiated by concrete turnover/cost/revenue models and the ability to compare the viability of different assumptions made along the entire modelling process.

We provide several examples from recently concluded 5G PPP projects. The list does not claim completeness but rather serves as an indicator of the inherent complexity of properly defining an ecosystem business model, along with individual business models of enterprises that are part of the ecosystem. A closer analysis of the projects' different approaches reveals the intensive engagement of ICT actors with vertical ecosystem actors in an attempt to form a detailed understanding of how they can generate value in the associated ecosystem and where to position their enterprises in the value network. The examples also illustrate the similarities between the applied business modelling tools and steps taken and the ecosystem business modelling approaches presented in this white paper.

Concluding, this white paper provides a methodology as a recommendation for sustainability-oriented business model innovation and development based on five steps and describes practical implementations of this methodology. As evidence of its applicability, it illustrates how 5G PPP projects have used a multitude of modelling tools to tackle the problem of positioning a viable business in the value network and formulating a desirable value proposition for their customers.

CONTENTS

1. INTRODUCTION

The Ecosystem Business Modelling Challenge

We could claim that the business models in the 5G and beyond 5G era are not more complex than they were during the launch of 4G or 3G. This would be the case if we assumed a simple continuation of service delivery, revenue generation and profit models. However, 5G and beyond network technologies introduce fundamental technological transformations compared to earlier generations. The resulting technologies allow for a much more open market, and as a consequence dramatically increasing the number of alternative business models available and driving the market towards emerging business ecosystems. Although ecosystem-based markets can be highly beneficial for participants [1], they create significant complexity in deriving appropriate business models that ensure profitability for each of the enterprises involved while delivering the expected value to customers.

As expressed by many experts in the SNS Smart Networks and Services Industry Association (6G-IA) [2] sub-working group on Business Validation, Models, and Ecosystems (BVME), the resulting difficulty that arises when designing business models in the context of 5G and beyond 5G ecosystems, is effectively summarised in the following (fictitious) statement:

"As an enterprise in the 5G ecosystem we struggle to define our sustainability-oriented business model because there are so many key partner enterprises we do not control, and so many alternative combinations."

The challenge is highlighted if we consider a single enterprise operating in a traditional (linear supply-chain) market. In such a situation, the business model definition ideally evolves as a result of a nested process, as illustrated in Figure 1. The process starts from an enterprise's strategic plan that explains which specific long-term goals an enterprise expects to achieve and how. From its strategic plan the enterprise derives a business strategy, which sketches the steps needed to achieve its long-term goals. The next step in the process is defining a business model that identifies how the enterprise creates economic and societal value. It also provides concrete steps to deliver this value and capture the associated revenue. Embedded in its business model, each enterprise will define one or more business plans and formulate associated business cases that support the execution of the business strategy.

Figure 1: Nested process for the evolution and development of a business model

However, this ideal and sequential process is challenging to apply for an enterprise that struggles to catch up with the pace of technological development and the need to reposition

itself in a dynamically changing ecosystem. This effect is particularly evident in the 5G and beyond 5G market environment, which is evolving rapidly with a plethora of emerging new products and services, as illustrated in Figure 2. Enterprises are in urgent need of tools to help them quickly adapt to competitive pressures through sustainability-oriented business models.

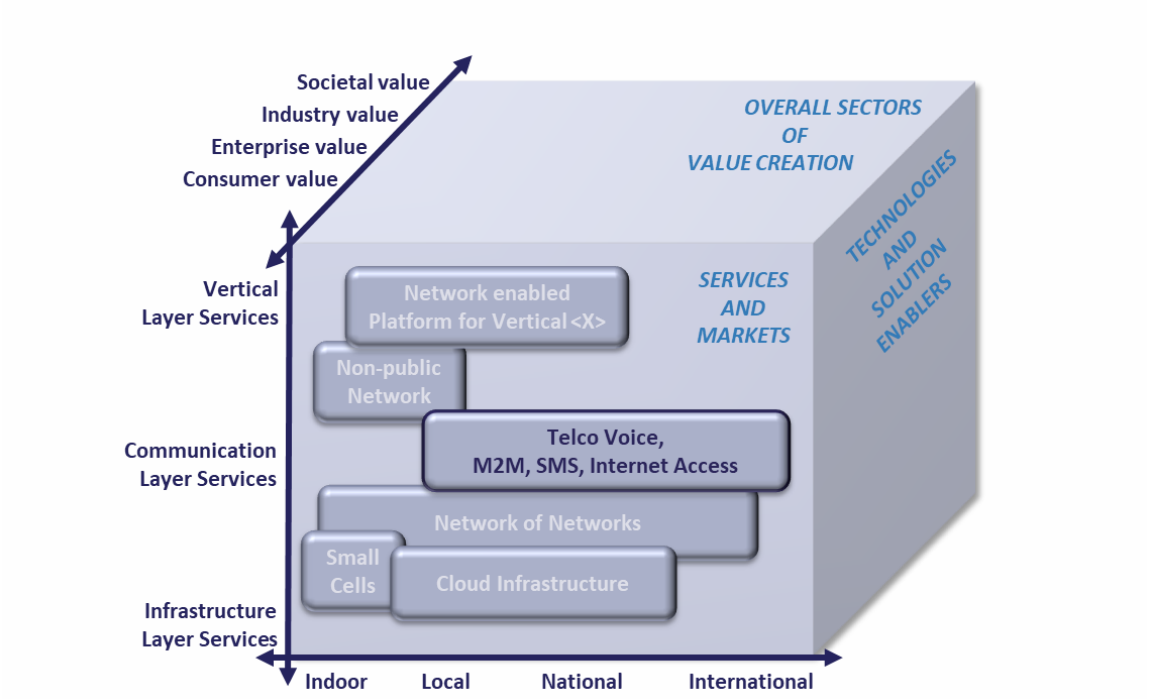

Figure 2 Plethora of traditional and new services, across multiple domains

To support the discussion, we need to clarify the conceptual background of ecosystem. [1] defines a 5G ecosystem as a complex network of interacting cross-industry actors who work together and depend on each other to define, build, and deliver value-creating customer solutions. The depth and breadth of potential collaborations among actors characterise the ecosystem, with each actor delivering a piece of the solution and thus contributing to the strength of the overall ecosystem. The power of the ecosystem comes from the fact that each actor can derive profitable returns without the need to own or operate all components of a solution. In a *business ecosystem,* the relationships can transition from transactional to strategic, and the business model impact changes from incremental to disruptive, as depicted in Figure 3. The intention is not just to aggregate value (1+1=2) but to generate additional value (1+1>2). Thus, all enterprises in the ecosystem should acquire more value than they would capture independently.

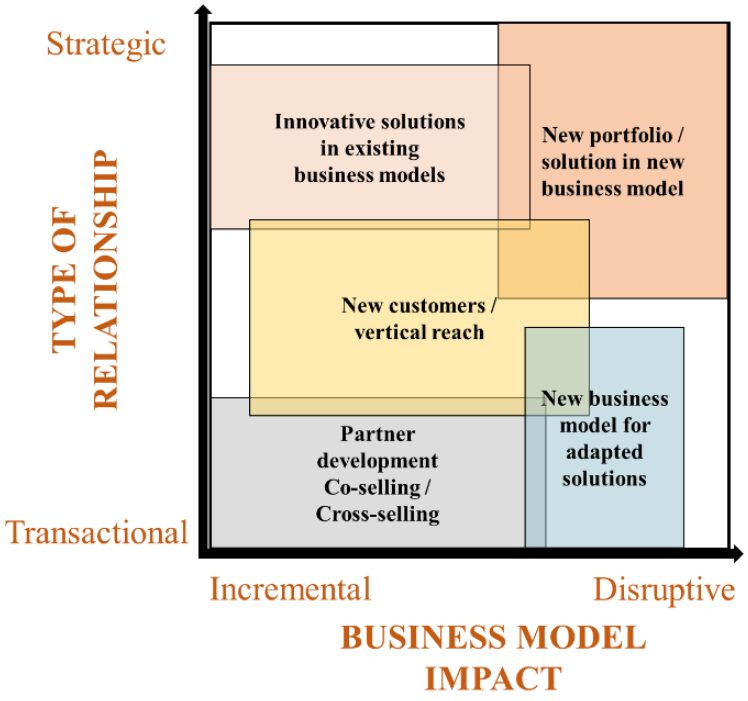

Figure 3: Ecosystem collaboration ambition

In the context of 5G PPP [3] projects, the white paper on *Business Validation in 5G PPP vertical use cases* [4] proposes a flow of business development activities in 5G and beyond 5G ecosystems. These activities guide the enterprises participating in these projects in positioning themselves in the ecosystem value network. Lean Start-up methodologies inspire the business development activities, which are divided in four phases: Customer validation, Solution alignment, Business Model, and Growth Trajectory.

Similarly, following the argumentation in [4], we assume that no enterprise operating in the 5G and beyond 5G ecosystems could individually deliver on the full value proposition to the customer. Therefore, before designing a business model, it is necessary to align understanding with partner enterprises on how to jointly present a value proposition and deliver a solution which properly meets customer's expectations. Therefore, when starting to design an ecosystem-based business model, each enterprise must acknowledge its dependency on other enterprises and rule out the possibility of serving the customer alone.

New Market Dynamics Driven by Technological Transformation

Although it is often argued that complex ecosystems existed with previous-generation telecom networks, the business models that eventually emerged were much simpler, in most cases, exhibiting a linear one-to-one cooperation flow. As illustrated in Figure 4, previous business models tended to be linear. In contrast, today's cooperation tends to be more circular and cooperative, building upon multilateral cooperations based on the skills and capacities of each interacting enterprise in the ecosystem. As a result, ecosystem-based value creation can be modelled and presented by means of value networks.

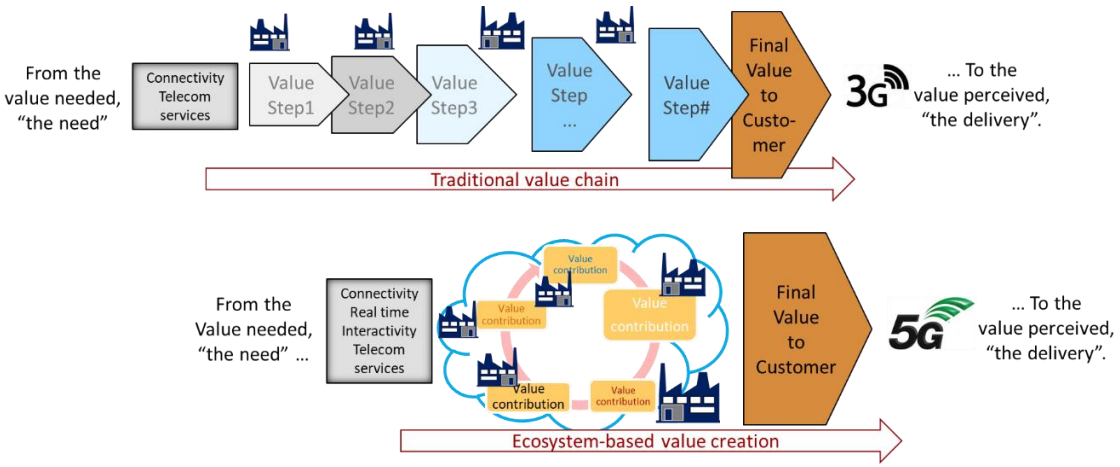

Figure 4: Transition from linear value chain to ecosystem-based value creation

An example of this is seen from the past 3G era, where the association between a vendor and an operator was a simple linear relationship of order-delivery and was enough to deliver telecom services to the market. The emergence of 4G and, more notably, 5G evidenced the need to establish more complex cooperation arrangements. One trigger of this need was the softwarisation of the telecom infrastructure, which implied a transition from pure telecom technologies to information and communication technologies.

The ongoing softwarisation and disaggregation of telecommunication technologies induce the relevance of the ecosystem approach to 5G and the forthcoming expected 6G markets [1]. This transformation in the 5G ecosystem is *intentional*, meant to mitigate current poor cost efficiencies and low flexibility, as well as *enforced* upon the industry by customer demand and competition. The different facets of this technological transformation include the transition from:

- equipment-based solutions to a platform-based foundation for the delivery of services
- "silo" network deployments to multi-domain, interoperable networks
- "closed" networks to open systems which expose network capabilities for customers and partner enterprises alike to innovate upon.

The disaggregation of technologies promotes interoperability and innovation, lowering barriers for new entrants. This technological transformation also facilitates new contenders to promote and develop disruptive business models while supporting the interaction of multiple ecosystems, such that value providers can cooperate and compete and where customers may choose among alternative offerings. The accessibility to the technologies enabled by open and interoperable systems creates multiple ways of addressing the market needs based on different business model formulations among suppliers, developers, integrators, service providers etc.

5G Non-Public Networks (NPNs) [5] are an illustrative example. A customer may ask an operator for an end-to-end solution or directly delegate the implementation of the private network to an equipment vendor or integrator. The traditional telecom operator is relegated to just connectivity. These multiple scenarios, occurring in different markets and all their

variances, will instigate alternative business models. In each model, the contribution of a single enterprise will be different, and therefore the resulting profits will be redistributed differently.

To address the complexity described above, the white paper *5G Ecosystems* [1] partitions the ecosystem into a *5G provisioning ecosystem* and a *5G vertical ecosystem*, which are complementary to each other. The *5G Provisioning Ecosystem* caters to developing, delivering, and providing 5G services while the *5G Vertical Ecosystem* applies 5G services in combination with yet other technologies and offers them to vertical customers and users (see Figure 5).

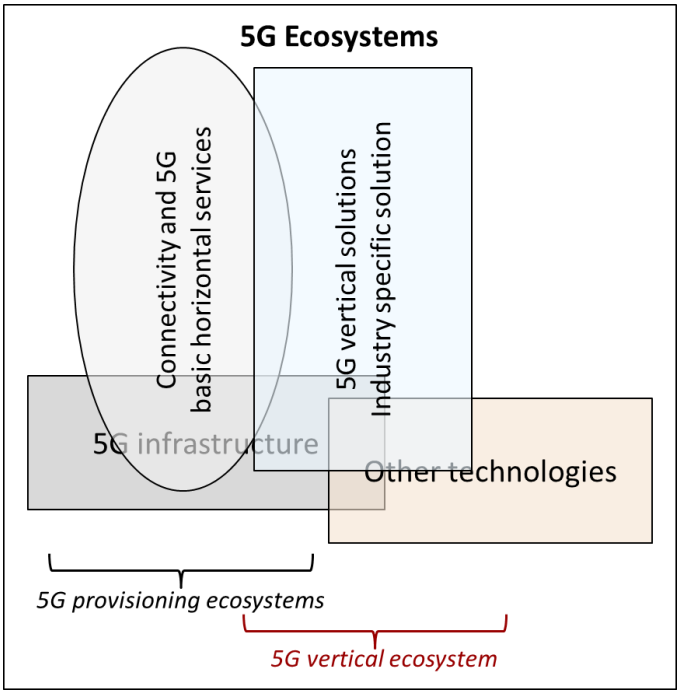

Figure 5: Partitioning of the 5G ecosystem

The roles in the 5G provisioning ecosystem include, among others, Service Providers, Network Operators, Hardware and Software Suppliers, Cloud providers, Datacentre Providers and Solution integrators. The roles in the 5G vertical ecosystem include, among others, Software Providers, Data Processing and Hosting Providers, Service integrators, Computer Consultancy, as well as vertical sector-specific roles from sectors such as industrial automation, healthcare, or automotive. The enterprises that are assuming the aforementioned roles may vary. Therefore, this white paper addresses the needs of a wide diversity in mind, from incumbent enterprises to new market entrants, from large corporations to small and medium enterprises.

Inherent Uncertainties of Ecosystems

Previous work of the 6G-IA working group on Business Validation, Models, and Ecosystems (BVME) has presented a detailed discussion on how current trends in the 5G market demonstrate ecosystem characteristics [1]. As discussed earlier, the ecosystem approach has significant benefits. The enterprises depend on each other and aggregate value from each other to deliver value to their customers, drive innovation and grow the market beyond what a single enterprise alone would be capable of.

However, ecosystems suffer uncertainties and tensions as the business models mature because cooperating enterprises compete for market share and continually refine their business strategies. This often causes changes in the role they play and impacts the business models of others in the ecosystem.

Such uncertainties stem from the dynamic nature of ecosystems, where an enterprise's contribution to the market can become less relevant, less effective, or even obsolete, or its market share can rapidly erode. This erosion can be caused by other, potentially more dominant enterprises that expand investments within the roles they assume or that invest to position themselves in new, competing roles within the ecosystem. Despite these challenges, operating in an interdependent ecosystem is still in the best interests of all 5G stakeholders for maximising value creation and associated revenues and thus promoting innovation and market growth.

Framework to Mitigate Ecosystem Challenges

To help reduce the challenges arising from the inherent ecosystem dynamics described above and to support enterprises in making informed business decisions regarding their engagement in the 5G market, this document aims to provide a detailed overview of effective 5G business modelling tools and frameworks. It will support all stakeholders in the 5G and Beyond 5G ecosystems to make more informed investment decisions, encouraging market growth.

We take learnings from the complex 5G ecosystem sketched so far, where we infer that there is no single business model but rather a plethora of different interrelated business models at play. Due to the large number of business model formulations, we cannot emphasise one 5G business model but rather derive different business models for the numerous opportunities that 5G facilitates. This calls for a framework to address the gap between a single enterprise's business model development and the complex mixture of business models for the many other enterprises in a 5G ecosystem. The overall goal of a framework is to allow each enterprise to reap value and profit from innovation and market growth.

The overall partitioned 5G ecosystem described above further stresses the necessity for such a framework. Even in cases that allow for finer-grained segmentation, considering, for example, network creation, horizontal services, vertical applications etc., we can employ the framework to describe for each of the finer segments a specific ecosystem and associated business models for each participating enterprise. Most likely, every enterprise can participate in multiple ecosystems simultaneously, with a separate business model in each, and their aggregation will contribute to the execution of the enterprise's business strategy. It is interesting to note that the ambitions of an enterprise's business model will condition and influence the overall ecosystem.

A critical element to consider in the creation of viable business models is the increasing focus on how enterprises can extend their value contributions to society beyond shareholder and economic value by addressing social and ecological sustainability alongside economic sustainability. This focus also addresses goals as formulated, for example, in the United Nations Sustainable Development Goals (SDGs) [6] and the European Green deal. In order to comply with these normative frameworks, this paper combines 5G ecosystem business modelling with approaches to model sustainability-oriented business model design. After introducing the

relevant business modelling approaches, we extend the focus to sustainability-oriented business modelling, before adding the ecosystem perspective.

To address the targets outlined in this section, the remainder of this white paper is structured as follows: Section two distinguishes between deriving business models for one company versus business modelling of the wider ecosystem. Section three describes a framework proposed by the 6G-IA working group on Business Validation, Models, and Ecosystems, building on its experts' insight, and opinions aggregated from many 5G PPP projects and 6G-IA members. Section four provides alternative examples of how a business model can be designed in an ecosystem context, catering for the interests of the many different enterprises. Section five provides concrete examples from 5G PPP projects and discuss them in light of the provided framework. Finally, section six summarises the paper and suggests recommendations.

2. BUSINESS MODELLING APPROACHES

Commercial exploitation of technology developments implies that someone seeks to position a product in the market with a defined business model. As the term suggests, "business *model*" is a model of the business one is running or plans to run. A business model is usually developed from the perspective of one enterprise. With the emergence of interdependent 5G and beyond 5G technologies and solutions, we need additional means to develop business models that work for the many enterprises creating value together in 5G and beyond 5G ecosystems. Note that we assume that enterprises are actors with intent and agency, that is, they are entities with specific objectives and the power and resources to fulfil them, thus can aim at a specific future and take actions toward it. We implicitly assume that such entities can intentionally form ecosystems. Thus, we do not elaborate on the case that ecosystems and markets may well evolve in a more accidental way.

2.1. BUSINESS MODELLING FOR THE SINGLE ENTERPRISE

The typical interpretation of the term "business model" refers to *one* "enterprise's plan for making a profit. It identifies the products or services and the business plans to sell, its identified target market, and any anticipated expenses." [7]. Another typical, though broader, definition is the following: "A business model is a conceptual structure that explains the flow of the business, how a business operates and intends to achieve its goals. It supports the viability of the business and provides a description of what and how a company creates value for its customers and delivers it to the market and most importantly, how it will make money" [8]. Thus, the business model concept can be used to capture how existing business is carried out and to plan for a desired business opportunity (see also [1] and [9]). Or, as the organisational theorist David Teece defines it, a business model "describes the design or architecture of the value creation, delivery, and capture mechanisms [an enterprise] employs." [10].

From the perspective of one enterprise's operation, any mode of presentation helping the comprehensive identification of all pieces influencing the company's business positioning would be valid. Figure 6, illustrates a meta-model of the most common business model canvas definitions [11]. For further information, please refer to [12], [10], [13], [14].

2.1. SUSTAINABILITY-ORIENTED BUSINESS MODELLING

Besides the commercial and pecuniary focus of business modelling, there is increasing emphasis on how businesses of any scale or constitution are directed towards values of sustainability as normative goals from global frameworks and agendas. In traditional economic theory, companies create benefits for their customers, financial returns for their shareholders and investors, generate income for their employees, and taxes to the state. However, this constellation is not alone sufficient for creating sustainability-oriented business

and adhere to new norms. It does not account for environmental costs and potentials for value creation, nor does it consider the interests and values of other stakeholders [15] that are affected by this business and that may contribute to its failure or success.

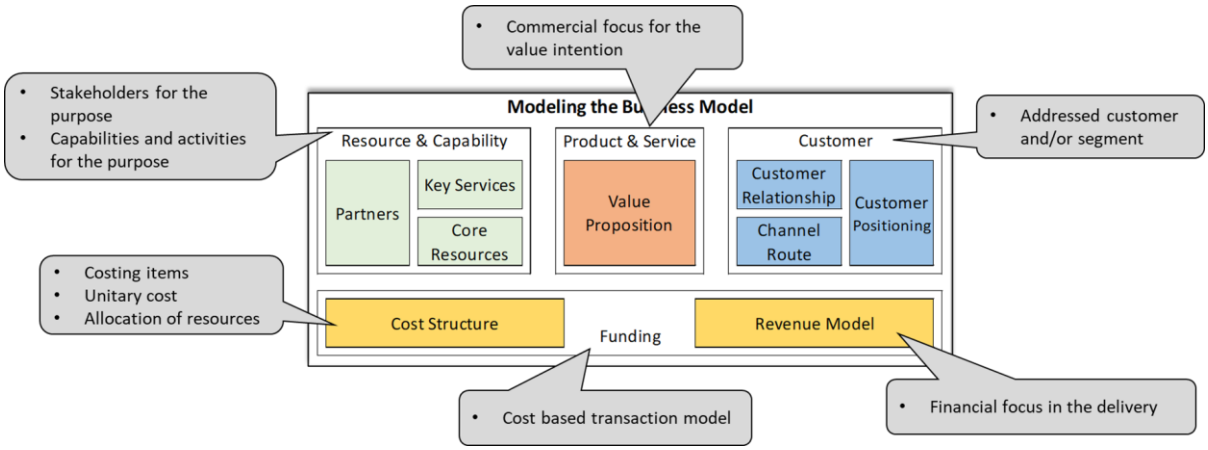

Figure 6 Metamodel of prevailing Business Model Canvas Definitions [11]

Even associations like the Business Roundtable of more than 200 CEOs of major US companies are moving beyond this conventional view on value creation and stakeholder commitments and claim that companies should serve all their stakeholders [13]. Normative frameworks such as the United Nations Sustainable Development Goals (SDGs) [6] and the European Green Deal require new business in general to comply with increased sustainability standards. These frameworks are further reinforced by the EU Taxonomy [16], [17] and the Corporate Sustainability Reporting Directive [18], [19] that requires even mid-sized companies from 2023 to professionalise their sustainability reporting and in many cases to innovate their business model in a sustainability-oriented manner.

A sustainability-oriented business model introduces value creation, delivery, and capture which allows an organisation to contribute to tackling sustainability challenges and promote sustainable development. Or, in the language of global sustainability governance frameworks, sustainability-oriented business models contribute to reaching the United Nations SDGs.

Integration of additional types of value and further stakeholder relations constitute sustainability-oriented business. Sustainability-oriented business model development applies at least four guiding principles, namely sustainability orientation, extended value creation, systemic thinking, and stakeholder integration [20]. **Sustainability orientation** refers to prioritising values of sustainability over short-term interests and, for instance, expressing "purpose, vision and/or mission in terms of social, environmental, and economic outcomes" [21] p. 121). **Extended value-creation** considers different types of (monetary and non-monetary) value being created or, in some cases, being destroyed or missed [14]. In addition to economic value, social value, and ecological value are not just side-effects but essential components of a business model (e.g., in terms of inclusive participation, energy saving, or positive contributions to the strengthening of ecosystems). **Systemic thinking** emphasises social interactions to integrate external and internal resources and bidirectional relationships between actors, including the necessity to reflect upon potential outcomes. Finally, **stakeholder integration** acknowledges the crucial role of market and non-market actors in

accessing and acquiring resources and capacities necessary for developing and implementing business models [20], [22].

Stakeholders such as regulators or communities embedding new business are not just affected by business activities but can also play a crucial role in contributing to its success and therefore resemble ecosystem partners in a business ecosystem. Still, just like the principle of extended value creation, additional stakeholders add further complexity to the already wide range of distinguishable parts and potential connections in modelling new business.

The key challenge here is to find viable paths to deal with this complexity of different business model components or activities, different types of (economic, social, and ecological) value creation and different stakeholders, including ecosystem partners, being involved without running into an overwhelming complexity. The good news is that much of this complexity stems from considering numerous options that are only theoretically relevant, whereas in each real case, the range of alternative constellations and development paths is quite limited. What we need is a business modelling methodology that integrates sustainability orientation consistently in each of the steps and that ensures that sustainable value creation is considered from the outset, and not just as "end-of-the-pipe" assessment.

Useful resources are already available, including the *EU Taxonomy* [16] to trigger and direct private investment in environmentally sustainable economic activities, a taxonomy of business model design patterns accounting for economic, social and ecological value creation [23], [24], practically proven tools to model sustainable business [20], and a generic process model developed and applied for 5G vertical business ideas in projects, such as in [25], including examples of sustainability-oriented 5G business models. An approach for integrating a societal value perspective in the process of 5G and beyond 5G development, which may also provide insights for business modelling, is suggested by the concept of value indicator analysis, as outlined by the 5G IA Societal Needs and Value Creation Sub-Group of the Vision and Societal Challenges Working Group [26].

2.2. BUSINESS MODELLING IN ECOSYSTEMS

As discussed earlier, the market formulations for 5G and beyond 5G service provisioning has shifted from the "value chains" of earlier-generation telecom networks to exhibit more complex ecosystem characteristics. A brief report on this shift and details on the early identification of various potential ecosystem formulations can be found in [1].

The evolution of an ecosystem is shaped by how individual business models form and vice versa. The factors influencing the ecosystem formation throughout its life cycle are multi-faceted [1] . In the ecosystem formation phase, interactions and dynamics among the collaborating enterprises will go through adjustments to optimise benefits and remunerate enterprises as per their contribution. At this point, enterprises iterate and refine their business models until the ecosystem reaches stability. An enterprise designs a specific business model and seeks to position itself in a business ecosystem. However, the first iteration is probably not the final one. The trials and errors of one enterprise iterating key activities in its business model affect other companies and, in turn, trigger changes in the ecosystem. At this point, the single enterprise in its planning would need to revise its business modelling to capture its interaction

with all the actors in the ecosystem and their business models, as well as the ecosystem dynamics [9] and to promptly develop a viable operational business model. For this purpose, it becomes necessary to have business modelling tools which are able to evidence those changes and the implications for the single enterprise and the ecosystem.

The ecosystem formation phase is depicted in Figure 7, the left showing multiple independent or overlapping enterprises that will enter into ecosystem collaborations. The right side of the figure shows how each enterprise has formed new business models influenced by all other business models. The ecosystem business model emerges in this formation phase based on how the ecosystem actors perceive their roles, key activities, and contributions, and consequently, the distribution of risks and profits between them. The resulting ecosystem business model will be different from the business model of each of the enterprises but will be affected by them.

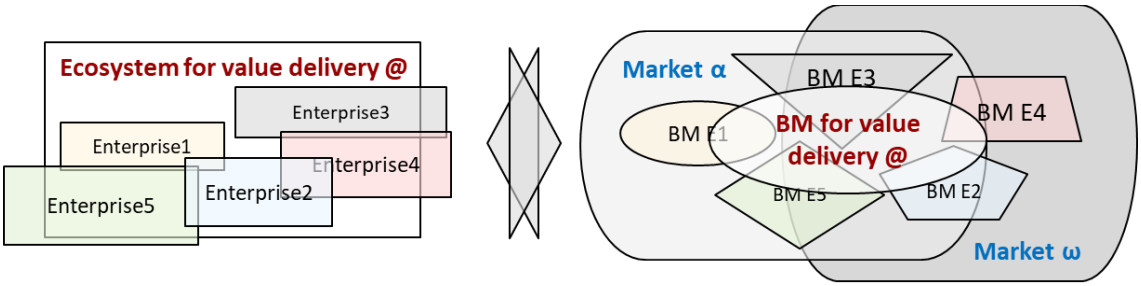

Figure 7 Iterations of enterprise business models into a stable ecosystem

Consequently, a shift from single enterprise business modelling to ecosystem modelling is mandated by:

- the evolution of technology and customer needs that require increased collaboration by independent companies, thus implying increased interdependency (also in [27], p. 414]) and
- by the fact that financial reward and market growth will only be unleashed simultaneously by collaborative aggregation of value contributions.

In other words, in the cases where a single enterprise aims to become part of an ecosystem to address customer needs, the conventional business modelling for one enterprise becomes less helpful - although useful in the case of a Leading Product Portfolios or of Short Portfolio solutions and simpler market environments. It provides insufficient modelling of interfaces and interactions, complementary benefits, as well as risk, liabilities and revenue sharing constellations. Neither can it sufficiently capture an end-to-end solution for a customer or industry. Moreover, conventional business modelling provides limited capability to maintain consistency and cross-validate business models for partnering enterprises; thus, it makes it practically impossible to capture the impact of changes of partnering enterprises' business models changes onto the enterprise's business model.

Instead, ecosystem business modelling aims to address these gaps, to model innovative complex offerings associated with complex partnerships in a more precise way and shed light on the transformation of the core business of a company. In such cases, business models can be platform-based, value-contribution based and can present multiple facets towards the

customer, while balancing risk-sharing aspects. In this context, ecosystem business modelling aims to capture positions and interfaces towards end-customers, including the escalation approaches in the Customer Relations Management pyramid, interactions and interfaces with other ecosystem roles, and implicit benefits that can be derived from collaboration. The activities/ operations/ services and key capabilities of adjacent stakeholders can be captured and a better-balanced profitability model (possibly capturing complex revenue streams) for all relevant roles and actors can be designed. Moreover, the process of ecosystem business modelling can help in the early identification of and response to disruptive market initiatives by capturing and maintaining an updated view of the market dynamics.

To complement this, embracing the aforementioned sustainability perspective, 5G and beyond 5G ecosystem business modelling can address the sustainability challenges of individual companies and their customers and enhance the sustainability performance of the whole ecosystem. Just like business models of an individual enterprise can be re-framed to ensure their contribution to support societal values and normative goals for sustainable development, 5G and beyond 5G ecosystems can be framed to consider and create likewise economic, social, and ecological benefits. To this end, sustainability-oriented business ecosystems comprise the co-creation of customer value, benefits for participating actors and stakeholders being affected, and contributions to sustainability challenges of customers or participating actors.

Apparently, ecosystem business modelling is more complex than conventional business modelling as it implies good knowledge of the business environment, of the complementarities and of the overlaps of strategic goals between partnering or competing enterprises. It also has an evolutionary character; thus, sustainability-oriented business modelling comes to the foreground. All these aspects need to be reflected in the methodologies and tools to be used for its development. In this context, the next chapter proposes a stepwise approach to ecosystem business modelling and (non-limiting) implementation methods.

3. SUSTAINABILITY-ORIENTED ECOSYSTEM BUSINESS MODELLING IN 5 STEPS

Based on the experience of its members and methods aggregated from across many 5G PPP projects and 6G IA members, the BVME WG suggests that ecosystem business modelling can be effectively performed by diving the action in five steps (see Figure 8). The five steps embrace the ecosystem's evolutionary character as a whole and acknowledge the ambition to accurately model all ecosystem participants. The steps are: Expand, Focus, Design, Develop business cases, and Iterate. The five steps address different challenges in business modelling analysis. The sequence of steps reflects the processes that are needed for the analysis and development of an ecosystem business model.

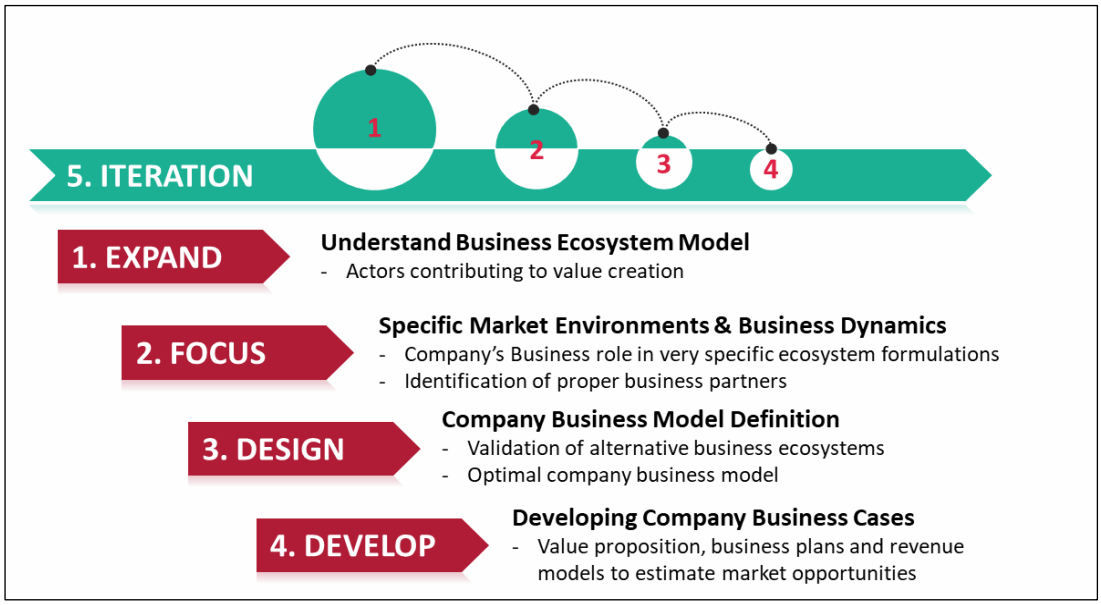

Figure 8 Five steps for ecosystem business modelling

The proposed five steps are well aligned with recent business model innovation concepts that suggest a process perspective on business model development including the processes: observe, synthesize, generate, refine, and implement [28]. From this point, we go a step further by suggesting that iterations of these steps are needed both in the theoretic planning and the business model implementation phase.

3.1. STEP 1 – EXPAND

A first step in developing business models in an ecosystem context is to **expand** the scope and view towards understanding and modelling potential ecosystems [29]. We assume that the customer value proposition is already identified based on customer and user pains and gains [1]. It is understood that the value proposition is best served by an ecosystem which consists of many and different actors. The challenge addressed in Step 1 is to envision and grasp the potentially vast room of alternatives for ecosystem formation, i.e., how different actors relate in

a context where alternative combinations of many actors and the various necessary roles they assume lead to different ecosystem business model formulations [30]. Thus, *all main actors* contributing to value creation and delivery in the ecosystem should be identified. Next, the potential *relationships* between the actors should be sketched based on their relative position in and contribution to value creation and delivery. In this process, the sustainability values, preferences, and interests pursued and shared by different actors should be explored and acknowledged. Some shared values call for actors to align motivations and collaboration, e.g., sustainability and resilience of the ecosystem, accessibility, and end-user experience.

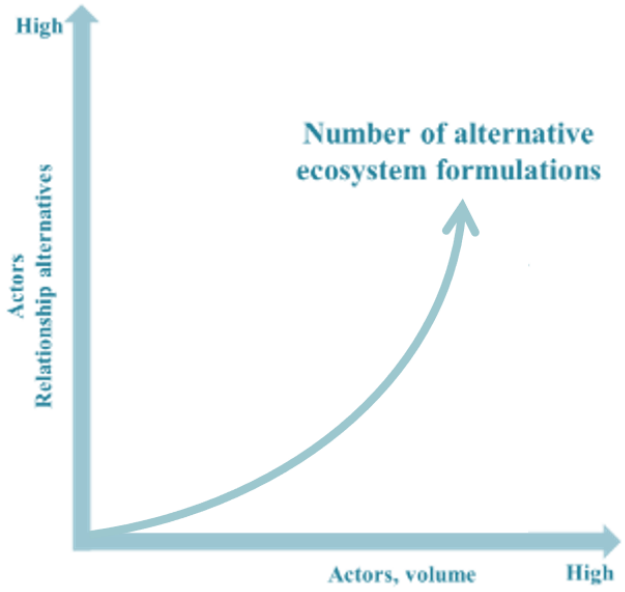

Figure 9 Number of Ecosystem formulations in relation to the number of participating actors

This exercise should reveal the multiple alternative configurations of an ecosystem business model. From the perspective of partner activities, the ecosystem configurations could vary according to the ways actors perceive and handle customer relationships, the core resources they possess [1], existing market positions and partnerships [29], as well as the cost structures and specific values actors rally around (see also Figure 6). Besides business, technological factors such as the state of technology disaggregation play a major role.

According to the analysis in [1], the number of ecosystem formulations to be examined can become very high, as it increases with: 1) the number of actors in an ecosystem, and; 2) their alternative relationships, as illustrated in Figure 9.

Besides the number of ecosystem formulations, potential changes throughout their life cycle add complexity and unpredictability to the initial part of the evolution. In addition, a single enterprise may sometimes assume roles in multiple concurrent ecosystems. Thus, the methods used for ecosystem business modelling must handle this complexity.

3.1.1. ACTORS – NUMBER AND RELATIONSHIPS

The number of possible ecosystem formulations increases with the number of actors and how they can be related. Consider three actors (X, Y, Z), that collaborate in various forms (i.e.,

undertake different roles and activities) to provide a customer (C) with a value proposition. For instance, in a simple three-actor ecosystem, a system integrator, a communication service provider and a hardware provider (telecommunication vendor) may undertake various roles and activities to provide a 5G and beyond service to a customer. An extensive set of collaboration models to be examined is illustrated in Figure 10. Besides considering linear supply chain and full mesh collaboration in delivery as two extreme alternatives, there are many and all the other potential alternatives. In theory, an enterprise could consider up to 19 combinations (indicatively as shown in Figure 10). Although some collaboration aspects may be well known a priori and may significantly narrow down the number of potential formulations, such an exercise could be used to open up the possibilities and warn against preferring or predicting some alternatives too early.

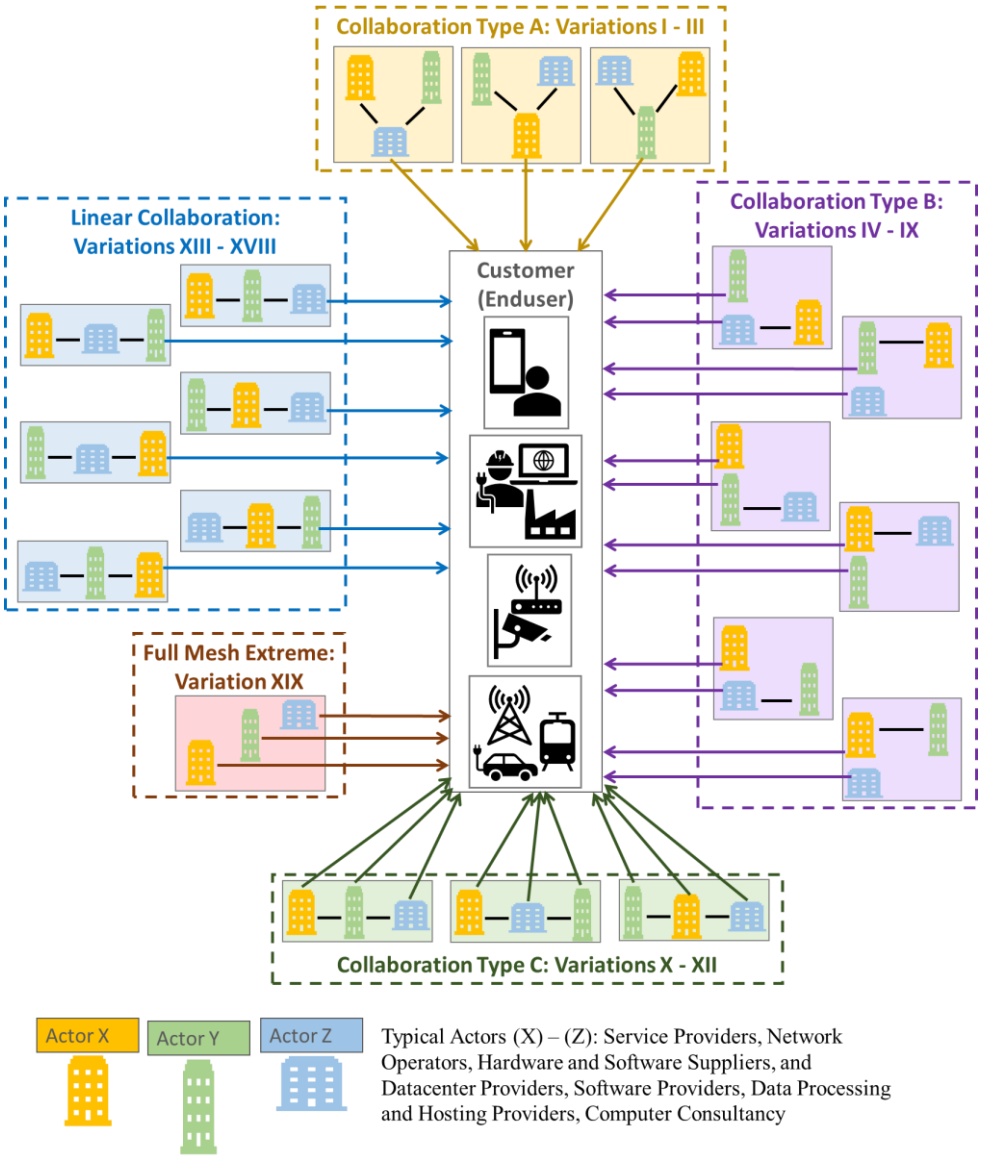

Figure 10 Three-actor example illustrating potential ecosystem formulations

3.1.2. ACTORS – RELATIONSHIPS AND CHANGES IN BUSINESS MODELS

The multiple actor combinations presented in Figure 10 introduces different potential formulations of the complete ecosystem business model. Each actors' business model should be sketched in the different formulations relevant for an ecosystem. This step also includes defining each actor's core goals and values to define and make explicit the values shared with other actors in various constellations. Depending on their individual business models and relationship characteristics, attributes such as cost, and profit distribution vary.

Furthermore, if key activities in the business model of one actor change, this will affect the relationships among other actor roles as well. For instance, when one partner changes its focus on a key activity, e.g., customer or user support, activities need to be redistributed among actors. Other actors must reconsider their customer support capabilities and how those affect their potential business models. This leads to a redistribution of the ecosystem's value creation, delivery, and profits. Any actor who considers such changes must capture the consequences in its analysis. Such changes may also force the actors into an alternative ecosystem formulation, where e.g., actors' positions relative to the customer and users are changed. The dynamic in the ecosystem caused by such changes will continue till the ecosystem reaches a stable stage.

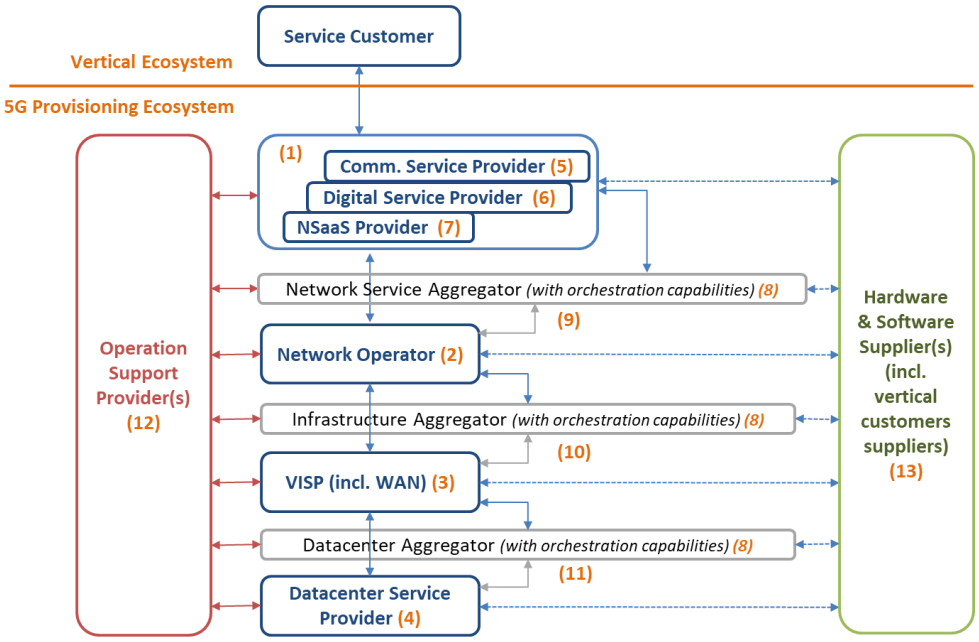

Figure 11 Roles in provisioning ecosystem [1]

For instance, the case of 5G provisioning ecosystem, Figure 11 [1], shows many actor roles and their relationships: Service Provider (SP) (1), Network Operator (NO) (2), Virtualisation Infrastructure Service Provider (VISP) (3), Data Centre Service Provider (DCSP) (4) (collectively referred to as Infrastructure Providers), Communication Service Provider (CSP) (5), Digital

Service Provider (DSP) (6), Network Slice as a Service (NSaaS) Provider (7), various aggregation levels (8) and the relevant service provisioning interfaces (9), (10), (11). In the provisioning ecosystem, the resulting ecosystem formulation(s) can be different from this depiction.

3.1.3. ACTORS – PART OF PARALLEL ECOSYSTEMS

One actor can be part of several related and parallel ecosystems. Consider the example of a carrier and a vendor illustrated in Figure 12. In a value chain view (left side of Figure 12), a vendor provides 5G equipment to a carrier (network operator). In reality, both the vendor and the carrier have relationships with more competitors, customers, suppliers, and partners - as depicted on the right side of Figure 12. One carrier will most likely be participating in other ecosystems with other vendors to realise its 5G goals. At the same time the 5G service goals need to be coordinated with other actors' service ambitions.

Similarly, the vendor will be participating in many other ecosystems, possibly with other carriers providing the same and other products and services and/or addressing other segments. This multiplication of ecosystems in which an enterprise participates, possibly assuming different roles in different ecosystems, in turn, requires the enterprise to maintain multiple business models. In each case, the enterprise must ensure the viability of the business models and guarantee that they all contribute to the actor's goals.

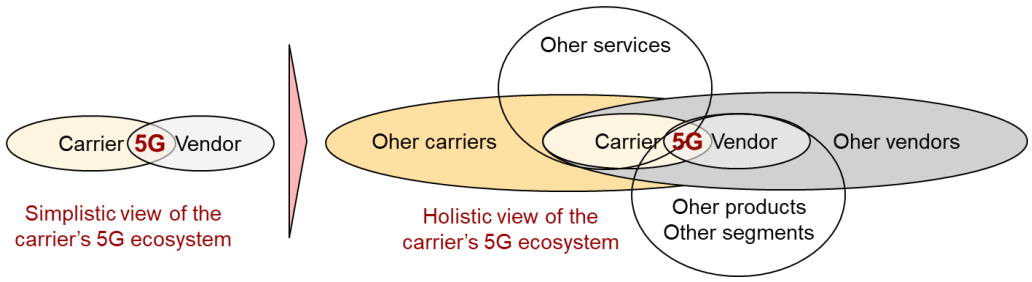

Figure 12 Actors taking part to several ecosystems

Similarly, it is difficult to work with a single business model for a vertical actor in a vertical ecosystem, e.g., the healthcare vertical. Usually, the business model of an actor / vertical implies the aggregation of multiple business models, each supporting vertical services with the help of a set of partners. Altogether, they may constitute multiple vertical ecosystems in which the healthcare vertical participates.

Figure 13 simplifies this with the case of a hospital. When the hospital tries to implement services such as tele-diagnoses, remote surgery, or digitalisation of the hospital facilities, it must participate in multiple ecosystems. Each of these ecosystems delivers a service and has its own business model. The aggregation of all ecosystems and their business models will shape the business model for this particular hospital. The established relationships could be different for any other hospital, even with the same partners.

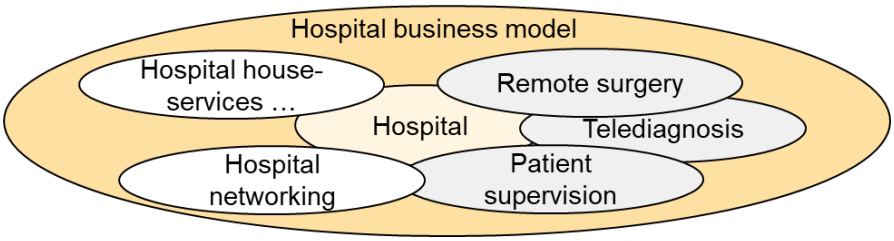

Figure 13 An example of a provisioning ecosystem surrounding a hospital

3.2. STEP 2 - FOCUS

Ecosystems will eventually evolve into more stable formations and business models that require different value contributions from participating companies. Thus, for a company to properly position its activities, it needs to **focus** on its specific market environment by identifying the formulation(s) that suits the focal company's business dynamics**.** Step 2 addresses the following challenge faced by companies: "to rule out non-durable alternatives at an early stage and carry out more extensive analyses of a subset of more appropriate formulations". Each enterprise decides criteria and explanations for why some alternatives are more attractive than others.

This stage refers to building an enterprise's business model. This includes focusing on an identified subset of the most important/relevant roles directly related to the enterprise's activities and strategic goals. It also includes an analysis of how other different enterprises can fill these roles and how the focal enterprise can fill in a particular position. At this early stage, potential reallocation or disruption of current market positions should be identified. The design of the business models should be subject to several iterations, validating their viability and sustainability – see also the description in 3.1.2.

A key outcome of this stage is settling the enterprise's value proposition, which lies at the core of the business model rationale. The value proposition includes economic value, social value, and ecological value (extended value-creation). It is crucial to ensure the engagement of proper partners that can provide the necessary skills to efficiently allocate the value creation and delivery activities, avoiding gaps and/or overlaps that can cause extra costs, negatively impacting the business results and profits. The early identification of any kind of weakness shall lead to adjustments in the business model structure.

All actors, but in particular a lead partner, should consider their own and others' key capabilities and reflect on if and how others are in a better position to exploit capabilities. Subsequently, other parties must be mobilised to take on relevant roles. Revising and redistributing activities between the parties can lead to changes in their individual business models.

The process of focusing in this step entails excluding groups of stakeholders, in particular non-market stakeholders, from the immediate focus. While this is a necessary step, given the importance of integrating all stakeholders for sustainability-oriented business modelling [20] care should be taken to explicitly acknowledge the existence of stakeholders excluded from the focus in this step. These stakeholders must be again taken into consideration in later steps once the basic actor configuration is fixed.

In case the market is mature enough, the alternative combinations are fewer, and a company's business modelling may start from this second step, given the established ecosystem formulation(s). Also, in the second step, various tools can be used for illustrating a company's business role in very specific ecosystem formulations such as: value (sub-) networks in 5G ESSENCE [31], MATILDA model [32], and the V^2-PARK model (section 4.2).

3.3. STEP 3 – DESIGN

Upon focusing on a specific enterprise business model, the third step will be to analytically **design** and **validate** alternative ecosystem business models depending on the level at which the enterprise can assume a role. The challenge addressed in Step 3 is to carry out the actual complex business model designs, and through iterative analysis, identify the optimal one(s) against specific criteria such as value delivery, sustainability, minimum cost, etc. This step goes hand-in-hand with the product/ service/ value-proposition -based business modelling. Also, in this step, there are many ways to represent the devised models, the most common being the Value Proposition Canvas [33], the Lean Canvas [34], and the V^2-PARK model (section 4.2).

To ensure sustainability orientation in Step 3, companies need to use business modelling tools that have sustainability concerns embedded within them. Tools like the popular Business Model Canvas [11] blend out social and environmental concerns and fall short of facilitating sustainability-oriented business model development. Thus, distinct tools have been developed to better model and create sustainable business [29].

Some of these tools explicitly extend the Business Model Canvas to include sustainability aspects. Examples are: the 'Flourishing Business Canvas' (FBC), which proposes a modelling technique for stakeholder-oriented design of enterprises that enable 'flourishing' across living ecosystems and organised social systems [35], [36], [37], [38]; the 'Sustainable Business Canvas' (SBC), which was developed within the context of the StartUp4Climate initiative [39]; the 'triple-layered Business Model Canvas' (triple-layered BMC) [40], [41]; and the 'Business Model Canvas extended for infrastructure' (BMC infrastructure) [42], which is specifically geared towards designing infrastructure business models that incorporate economic, social, and environmental value streams and propositions.

Other approaches include the 'Value Mapping Tool' (VMT), which was developed to help companies and their wider stakeholder networks design value propositions as a part of sustainability-oriented business modelling [14] and the 'Business Innovation Kit' (BIK) and its extension, the 'Sustainability Innovation Pack' (SIP), which take a values-based, didactic approach to modelling new and sustainability-oriented business models [43], [44], [45], [46]. The latter has been widely used in sustainability-oriented business model design with the help of design patterns [23], [24].

All these tools are widely used and proven in practice. They facilitate integrating the four guiding principles of sustainability-oriented business modelling: sustainability orientation, extended value creation, systemic thinking and stakeholder integration, in the process of business modelling. This allows actors to avoid potential harmful consequences for sustainability and comply with sustainability standards, and also enables them to actively

contribute to solving sustainability challenges and creating value that exceeds benefits for customers and shareholders.

In Step 3, it is possible to develop business model canvases for each of the actor roles in the whole ecosystem and identify the actors in those roles. However, the ability to compare and analyse may get lost in the details. In this complex environment with multiple "business model possibilities", we need a superset of modelling tools/representations that are logically associated and can provide "the ability to compare and analyse". To address this challenge, new approaches in business modelling suggest how alternative business models can efficiently be represented and compared for a focused part of an ecosystem. However, we must take care to attend to the ecosystem end-to-end vision to ensure the compatibility of the ecosystem business model with the individual actors' business models. While the ecosystem as a whole can be profitable, its profit distribution among actors should be fair and attractive enough to be able to mobilise participation. Only the holistic and stable business model design for the ecosystem will ensure the stability of the individual business models and, with that, the sustainability of the business. In Section 4.1, 4.2 and 4.3, we elaborate on approaches for such analyses.

3.4. STEP 4 – DEVELOP BUSINESS CASE

Eventually, the company can develop a business case based on its specific value proposition, business model, and business plan (see Figure 1 as a reference for the flow). It can follow existing approaches on sustainability-oriented business and revenue models, with which the company can estimate and compare its market opportunities. The challenge addressed in Step 4 would be to estimate the specifics of both costs and revenues and specify how to realize sustainability potentials in emerging markets and ecosystems. Such cost estimation and revenue generation go hand-in-hand with performing a techno-economic analysis of the alternative implementations. Although in this White Paper we do not elaborate further on business case tools, concepts in ecosystem business modelling need to be propagated in the business case development step also.

3.5. STEP 5 – ITERATE

As discussed in [1], ecosystem emergence and resulting formulations are subject to uncertainties borne from their dynamic and non-linear nature. This implies **iterations** of the four steps as companies carry out ecosystem business modelling. The challenge addressed in Step 5 is to minimise the risks of moving forward with initial suggestions instead of taking the chance to identify improvements and changes early and with fewer costs incurred.

As noted earlier, ecosystems are not static formulations. Instead, they suffer tension or encounter opportunities as a consequence of multiple possible factors: the market itself matures, customer demand changes, or competing actors appear and deliver the same value. Any of these factors can disrupt an actor's initial position in the ecosystem and its business model. Therefore, iterations should continue when the business models are deployed in the market. Companies must consider if their contribution to the ecosystem can become obsolete, their market share can rapidly be eroded by dominant enterprises, to expand within their

existing role(s), or to take new roles within the ecosystem. In practical terms, a fifth step in the business modelling process is required to address the need for continuous (pro-active or re-active) adjustment of the ecosystem and enterprise business models. This could result not only in role changes of the actors in the ecosystem but also of the stake of each enterprise in the profit model, the sharing of risk and liabilities, etc.

The initial version of an ecosystem business model and the associated business models of the enterprises involved are created in a first implementation phase of Steps 1-4. At this point, the business models should be subjected to stress-tests to validate their robustness, as suggested by [47]. A stress-test will start with identifying stress factors, typically uncertainties mentioned above, with high effects on the business models' probability for success. Thus, companies should reconsider how to iterate the ecosystem business models to ensure continuity and reach some stability as a profitable and sustainable contributor to ecosystem value creation and delivery.

The iteration step can be realised in three phases: 1) business model adjustment phase, 2) business model redesign phase, and 3) business model re-creation phase. The focus of the business model adjustment phase is to perform iterative optimisation of the business model by assessing early results, market developments and current facts and fine-tuning the positioning of the enterprise(s), the processes, the relationships, and the profit/value models. In case adjustments do not prove effective in improving the viability of the business model, the re-design phase is triggered, leading to the business model re-creation phase. In the latter, Steps 1-4 are repeated.

4. PRACTICAL IMPLEMENTATION OF ECOSYSTEM BUSINESS MODELLING

The previous section provided an introduction to five steps that, when combined, outline an effective process for assessing complex ecosystems and deriving viable business models for the various actors involved. To develop this discussion, this section aims to move from the higher-level description in Section 3 and guide the reader in more detail on how to practically implement the full range of steps introduced there.

The approaches discussed are taken from previous 5G PPP projects and derived from industrial expertise from within the BVME WG. These approaches aim to clearly outline the best practices that companies can follow to assess the wider ecosystem in which they operate and their role in it. As discussed in Section 3, the goal is to identify feasible roles and business opportunities for each company involved, thus enhancing the potential for success of the overall ecosystem.

In Section 5, we broaden the discussion to examine a wider set of recent projects and investigate the various approaches taken to articulate the business opportunities created by those projects.

4.1. VALUE NETWORK-BASED APPROACHES AND RELATED METHODS

Value network-based approaches have been widely used to capture the complexity of telecom business contexts, which involve many interacting enterprises with non-sequential relationships across markets [1]. A value network [48] is a network of relationships that generates economic and other types of value through dynamic exchanges between two or more participating players. The exchanges may be of tangible or intangible nature. Some examples and a general actor role model for 5G ecosystems are provided in [1]. In these examples, it has been crucial to understand and design the interrelation and the exchange of value between one company and all the other companies that are involved in the specific company's ecosystem or value network. The value networks can be visualized with a mapping tool showing nodes/ellipses (representing actor roles) and connectors/arrows (representing relationships). The actor roles can cover customer, aggregators, and providers of support, software, spectrum or infrastructure, and interest groups. Actor roles will be populated by companies and also persons.

Figure 14 provides an example of a value network of an operator in a small cell network [49], where the ellipse represents an actor role that can contain several actors and one actor is depicted in a rectangular box within the ellipse.

The value that is exchanged in relationships can be monetary gain, a product, a service, data, but also reputation, or access to a market. In a graphical representation, these relationships are visualised with different legends which must be explained. See also [50] for an elaboration of different flows in business models.

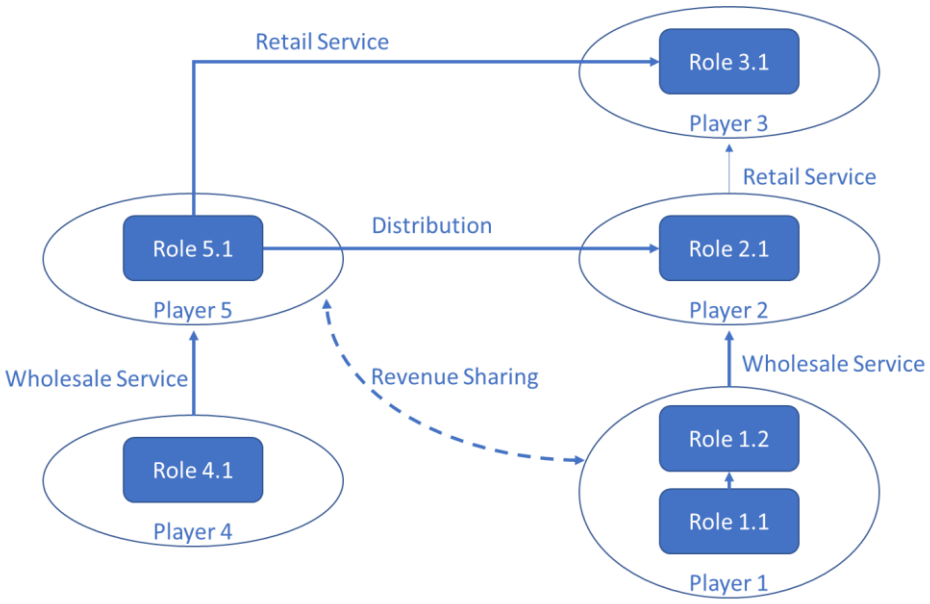

Figure 14 Value network depiction of a small cell ecosystem [51]

In Figure 15, the direction of the full arrows in the model represents the direction of service flow. Revenue flows are considered to be in the opposite direction. In some cases, revenue sharing exists between two actor roles, resulting in a bidirectional flow, such as the dotted line between Role 1 and 5. In an ecosystem, service and revenue flows can also be between very different actor roles. Thus, a value network depiction can be complex and will probably not capture the real complexity. [1] suggests aggregating and even omitting some details depending on the purpose and scope of the analysis.

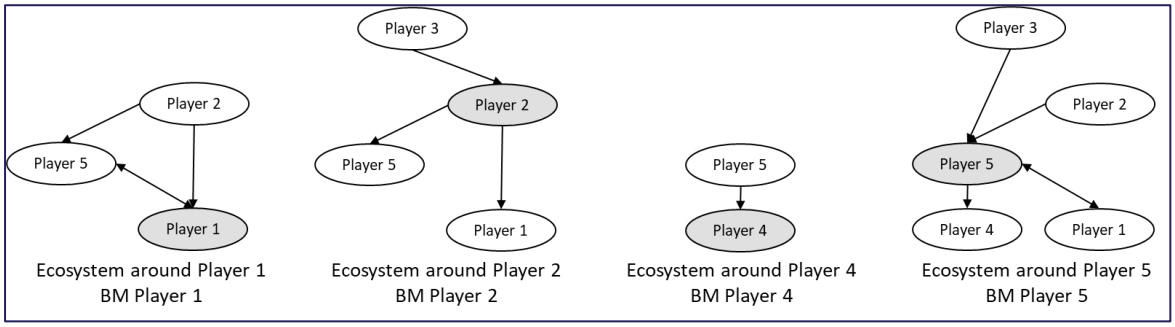

Figure 15 Segmenting an ecosystem sub-ecosystems and business models

The intricate business model of a complex ecosystem can be segmented into different simpler sub-ecosystems, each from the perspective of one player (Figure 15). The point is that all these simpler business models need to work together and be compatible in order to make possible the seamless working of the complex ecosystem (like different gears in the same machinery). The business models activated in these different sub-ecosystems intend to serve the customer, i.e., a retailer denoted Player 3 in Figure 15. The realisation of this customer's business will only be possible if its business model is compatible with the business models of its providers, i.e., Player 2 and Player 5.

The value network and BMC methods have been employed in the 5G-VINNI project [52], [54] to introduce and explore alternative business models for a business case for 5G Experimentation as a Service (EaaS). In addition, the project used new analytic tools to better assess and compare the viability of different business models in different value network instances (ecosystems). We will not repeat the business case example here, rather elaborate on the overall approach and the method.

The method is generic and can be applied to define and evaluate different business models for business cases in the 5G ecosystem. The approach is an alternative to the one followed in [51], described above. We briefly describe the different methodology steps that were followed in [54] to define and assess the 5G EaaS business case (presented in Figure 16). Also, we identify the alignment of this method with the 5 steps presented in Section 3.

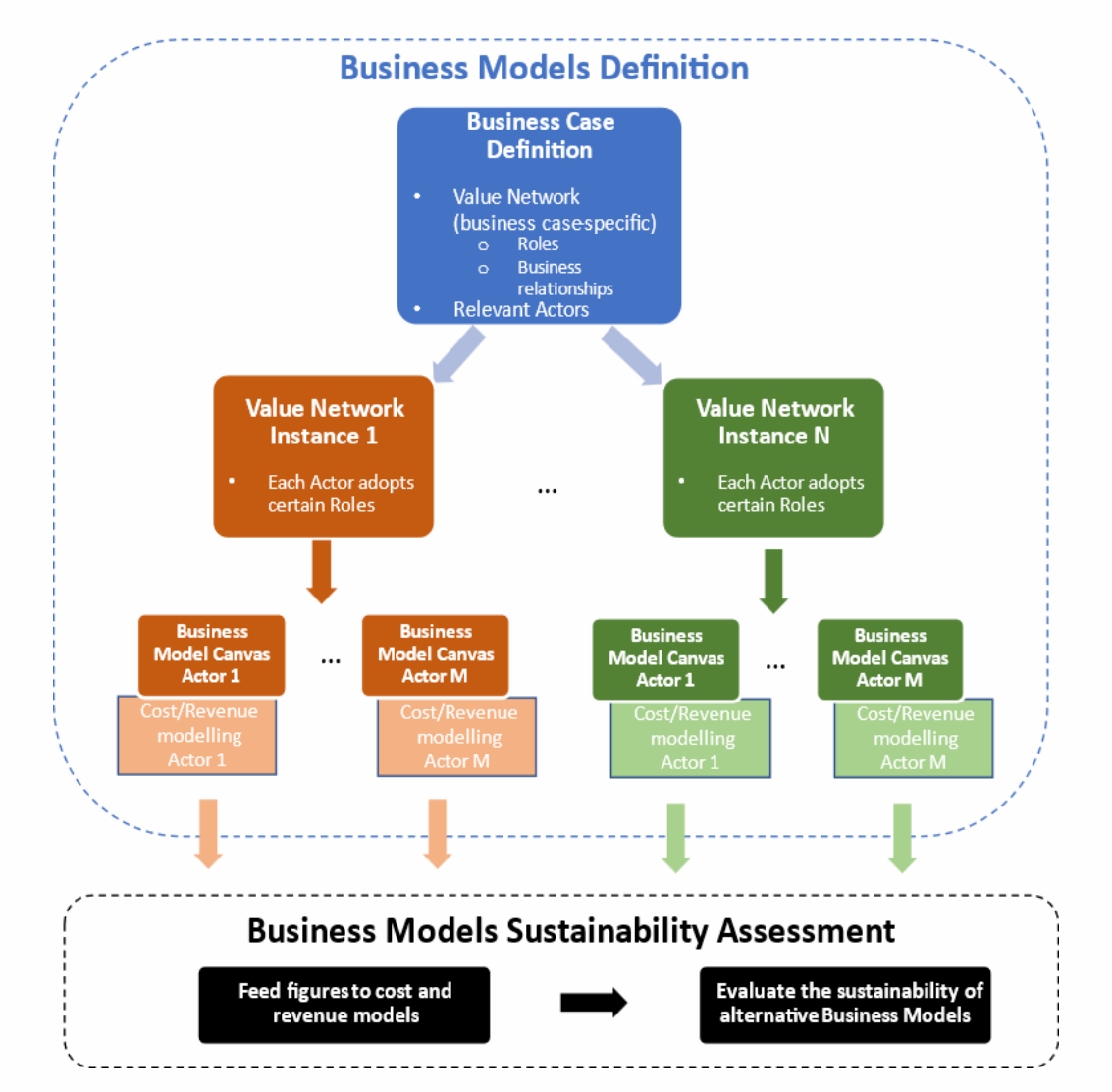

Figure 16 Methodology for definition and evaluation of business models in value networks

A. Following a similar logic to the one presented in Figure 14, the method suggests that a value network for the 5G EaaS business case is constructed by selecting only the relevant roles from the generic 5G value network [1]. This is a simplification of the value network that can be done for a particular analysis. Beyond the definition of the value network that is specific to a business case, some actors are identified, who are relevant to this business case and who may adopt one or combine a sub-set of roles. For instance, actors relevant to the EaaS business case are the Experimentation Infrastructure Operator (adopting the Network Operator role) and the Experimentation Support Provider (adopting the Customer Support Provider role).

B. Figure 17 describes how the "reduced" value network for the 5G EaaS business case can generate different instances. In other words, how different instances of the same value network can realise the 5G EaaS business case. Each instance of the value network reflects the assumption of different combinations of roles by the involved actors and, thus, business model configurations. Figure 17 presents the approach followed in [54] for defining different instances of the same value network. In particular, a role appears once in the value network and actors that adopt this role are represented with different colours. Arrows represent the business relationships (money and service flow) among the different roles. Arrows should not appear between roles that are adopted by a single actor. Two of the actual value network instances that were evaluated in [54] for the case of 5G EaaS are presented in [30]. The different instances of the value network in fact implement the concept of the *Expand* step presented in Section 3.1.

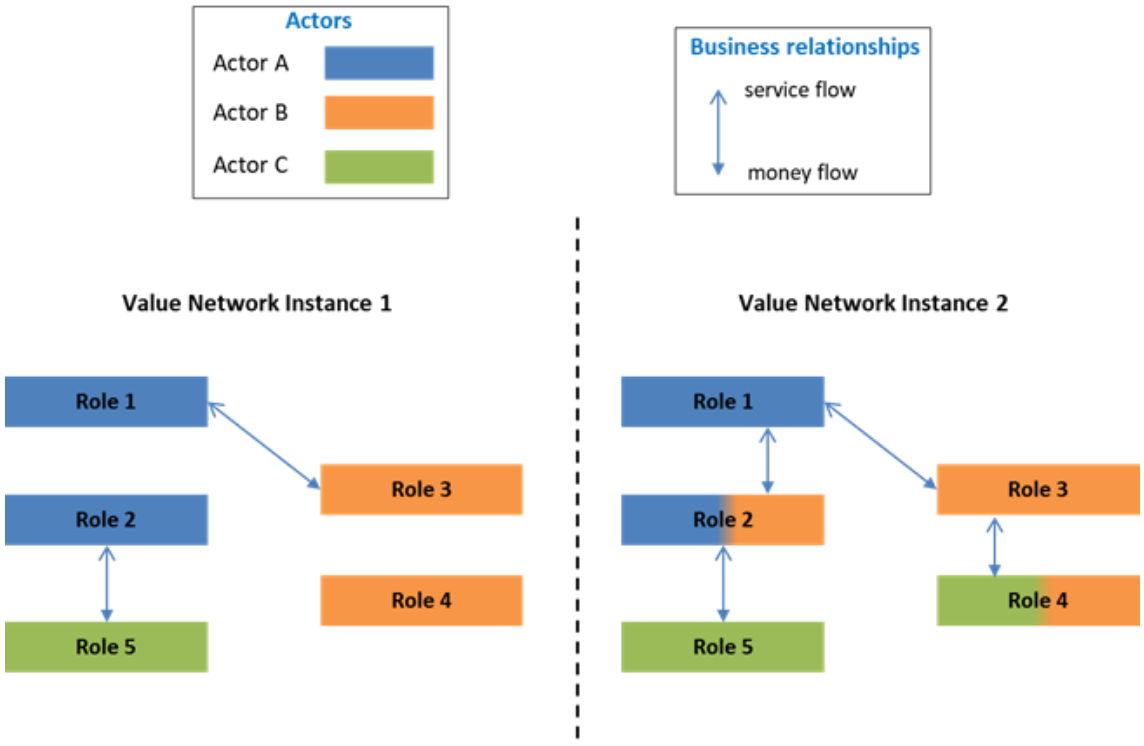

Figure 17 Value Network Instances in 5G-VINNI approach

C. In one value network instance, the well-known BMC [11] method is used to develop business models for each actor, which may adopt one or more actor roles. This per-

actor business modelling process implements the *Focus* step presented in Section 3.2. The combination of the BMC of the different actors defined for a value network instance is, in fact, one *ecosystem business model* for the EaaS business case. The BMC of each actor is further extended with the modelling of costs and revenues for the different actors based on their business case-specific (EaaS) and value network instance-specific costs and revenue streams. This implements the *Design* step presented in Section 3.3. When considering the revenue streams and cost structure of a business case, the revenue streams come from different service offerings (in the context of the business case) that may share cost. Our example of sharing resources and costs is illustrated in Figure 18. Therefore, appropriate models should be developed for associating costs with revenues, especially when revenues come from the cost-based pricing of services/products.

D. In order to assess the long-term continuation of the defined business models under different value network instances, i.e., the *alternative ecosystem business models,* figures for the identified cost and revenue items need to be fed into the models that have been developed for the costs and revenues of the different actors. These figures should capture the cost and revenues of the different actors for certain scenarios of infrastructure deployments and market conditions for the considered business case. It may be the case that different instances may be preferable under different market scenarios. The outcome of such an assessment for each actor will affect how they negotiate their role in an ecosystem and the ecosystem's further shaping. These activities implement the *Develop* step presented in Section 3.4.

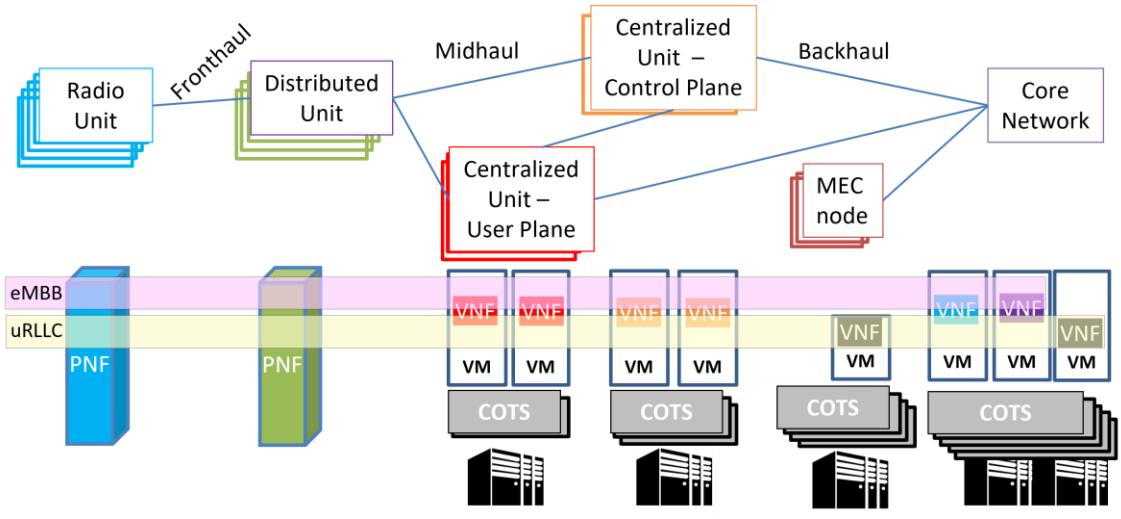

Figure 18 Example of two network slice services, namely eMBB and uRLLC, sharing resources and cost in the context of EaaS business case [54]

The above steps A-D are subject to iterations for capturing the ecosystem dynamics and for converging to business models that are beneficial for all actors in the ecosystem.

The *key message* of this section is that the value network analysis approach presented here is valuable for capturing the complexity of ecosystems with multiple potential configurations. We suggest that it is complementary to the BMC and other techniques of business modelling for capturing the interdependencies in the 5G market and co-creation of services.

4.2. THE V² PARK APPROACH TO ECOSYSTEM DYNAMICS

It is not new to struggle with the one-actor BMC in a complex multiple-actor ecosystem, and there are existing and available approaches we can build on. An insightful alternative approach for business modelling in complex multi-actor ecosystems is the one suggested by the V²PARK[1] business modelling system. Drawing on extensive industry expertise and market cases, V²PARK serves the following purposes:

- reflects a comprehensive viewpoint on ecosystem business modelling
- gives insight into concrete applications of business modelling and ecosystem literature

The V²PARK approach and methodology aim to better reflect the dynamics in the 5G and beyond 5G business models and ecosystems. It is a helpful approach to capture, from the initial definition of the aimed value proposition, the interdependencies between different factors and actors, who can be active in an ecosystem in its formation phase and to capture how the ecosystem matures with the maturity of the market and/or of the members.

We will here introduce the approach and comment on how it can support and extend the analysis in the five steps described in Section 0.

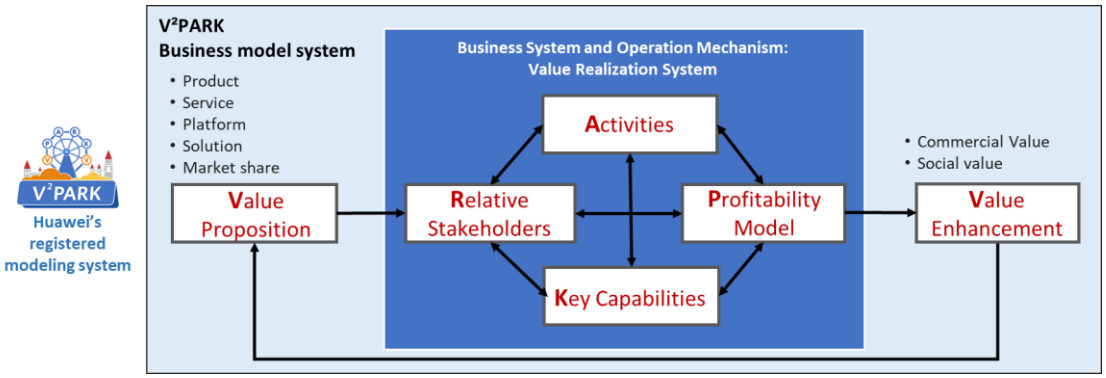

Figure 19 V2PARK's six building blocks

The starting point for V²PARK – depicted in Figure 19 – is a structure made of the six building blocks. These are interconnected and work together as a mechanism that rules the behaviour of the business ecosystem. In this case, the blocks operate on an ecosystem level, and not on the individual level of actors (i.e., stakeholders in the figure). One of V²PARK's key contributions is to identify, aggregate, and isolate key factors in an ecosystem as blocks and suggest how they are related and how they affect each other, i.e., to explain the ecosystem dynamics.

[1] V²PARK is Huawei's registered trade-mark for business model modelling system. Since May 13th 2022, Mark and Logo EU registration numbers are 18598713 and 18598723, respectively.

The interconnections and interdependencies between the blocks capture the fact that any change in the conditions of any of the blocks may eventually trigger the need for adjustments in all the other five blocks. Subsequently, a change in one block could lead to a new ecosystem iteration in the formation phase or, eventually, a final stability and arrangement of business model for the ecosystem and all actors involved.

Figure 20 indicates the meaning and content of the distinguished six blocks, their goals on the ecosystem level, and how they may affect each other. The block *value proposition* concerns the ecosystem as a whole, e.g., existing or new product, services, and platforms. A validated value proposition, i.e., a clear business goal, is a prerequisite for the ecosystem definition and the business modelling.

The four blocks in the middle of the model ("the value realization system") constitute together the mechanism that addresses and realizes the value proposition as an ecosystem. *Stakeholders* are all the actors that are taking part in the ecosystem, including the relationships between them. The goal for the block is to always mobilise the actors who can best contribute to the ecosystem delivery at an acceptable cost-level. Passive actors influencing the business must be considered as well (e.g., regulators in the telecom business). *Activities* is a concrete description of the content and boundary of the transactions carried out in the ecosystem on the actor level. The goal is efficient operation and delivery. *Key capabilities* keep track of the presence and state of the ecosystem's resources and capabilities, enabling the execution of the needed activities. The goal is to optimise the use of resources and avoid gaps and overlaps (i.e., avoiding extra costs). The *profitability model* details status, levels, and distribution of revenues and cost flows within the ecosystem and among actors. The goal is cost efficiency and revenue growth, setting the model that ensures fairness for each stakeholder.

Value enhancement is the block to the right in Figure 20 and accounts for the ecosystem's creation of commercial, pecuniary, and social value. Its goals concern such aspects as market growth expectations, company market value, social engagement and contribution, and actors' level of satisfaction with the current status of the ecosystem.

As an analytic tool, V^{2}PARK and the six blocks are complementary to all five steps of the ecosystem Business Modelling as introduced in Section 3. It is an iterative process to populate the V^{2}PARK business model system with, e.g., concrete activities, stakeholders, and capabilities which fulfil the value proposition. The populating process of one V^{2}PARK instance will have its counterpart in a systematic identification of all possible combinations of stakeholders and their relationships and the design of business models for a set of actors that may be part of the ecosystem. Each of the multiple combinations of stakeholders establishes potentially different interpretations of the total ecosystem's business models. With a more mature design of a single actors' business model, it would, in turn, be possible to investigate how changes in these would affect the ecosystem. From the different contribution arrangements, profit distribution will be different and so on. V^{2}PARK enables the study of change effects arising both on the actor level, and the ecosystem level.

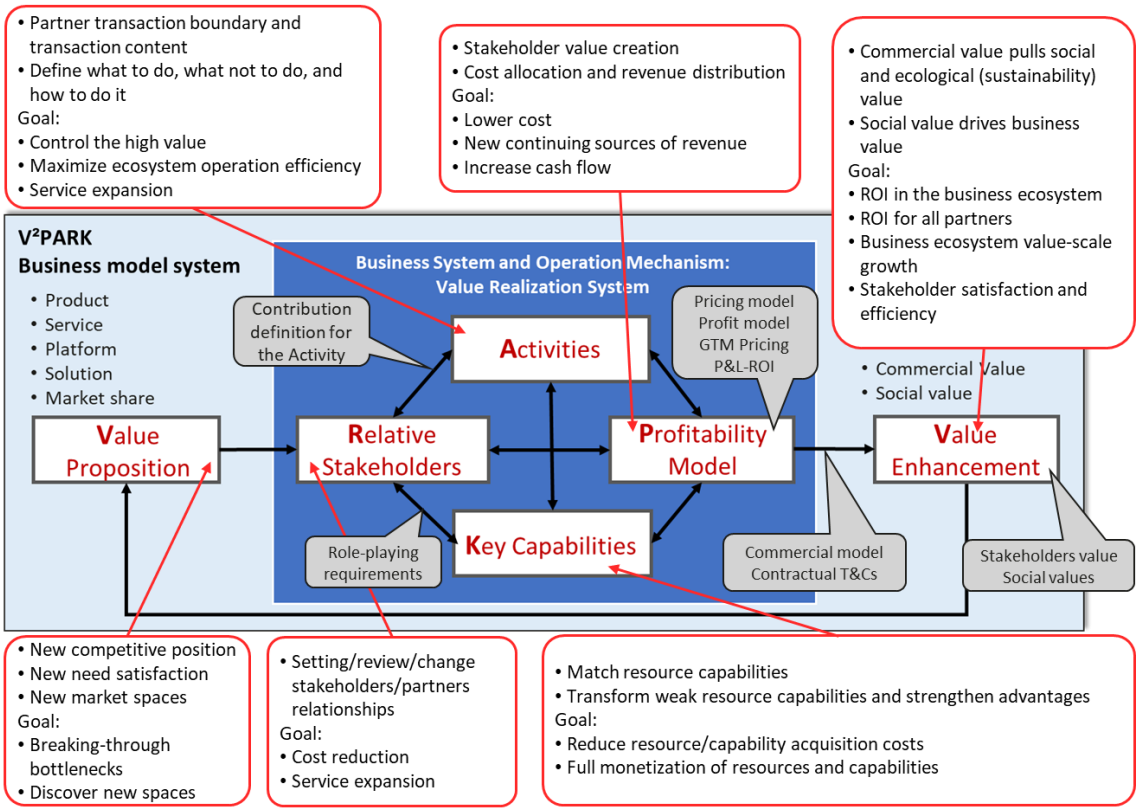

Figure 20 V2PARK's building blocks described

For instance, Figure 21 depicts a potential chain of effects. We assume that the ecosystem's value proposition is stable. One actor could then change one of its key activities for the ecosystem, e.g., customer support, leading to a redistribution of activities among stakeholders (1). A reassessment and potentially a redistribution of the ecosystem capability in this respect must then be carried out. Next, each actors' BMC should be visited (2) to identify who could take on customer support, potentially mobilising new actors into the ecosystem. This would lead to a reorganization of the "support included" pricing model (3). All lead to a repositioning of the final value delivery (4).

With the bird's eye view of the ecosystem, the status of the ecosystem's ability to deliver on the value proposition can be assessed. Are the proper actors with the necessary skills mobilised, and can they efficiently carry out activities without negatively impacting the business results and profits? The early identification of any kind of weakness shall lead to adjustments in the ecosystem structure. For instance, for the aimed value delivery, a critical key capability not yet covered in the ecosystem can be identified, for instance, digital 3rd party support. Figure 22 depicts how this could lead to a revision of the activities to include such support (1). Each ecosystem actor needs to consider if it has the key capability documented in its BMC and if it can and should take on the role (2). Again, a change of the profit model (3) is taking place, and the final value delivery can be repositioned (4).

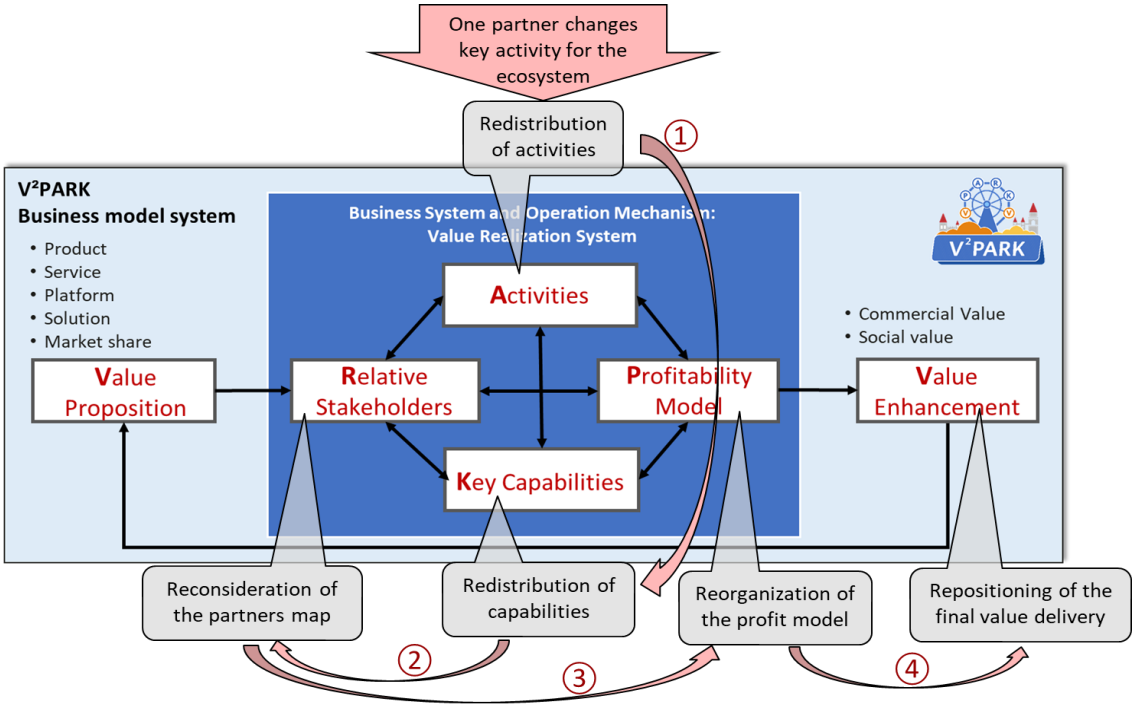

Figure 21 Example of how a change in actor key activity affects a business ecosystem

An ecosystem suffers from tensions and external influence in its formation phase as well as when it matures and stabilises. Depicted in Figure 23, different events could affect the dynamics in the ecosystem: market matures, customer demand changes, new competitors appear, cooperating enterprises compete for market share and continually refine their business strategies, or new enterprises challenge the existing ones. Any of these events could create disruptions in the ecosystem. The V²PARK business model system enables analysis of where and how such events would take effect and how to work on the ecosystem level to mitigate disadvantageous effects, especially in the advanced iterative stages of ecosystem business modelling (see section 3.5).

The described modelling of an ecosystem and its business model can also be applied to estimate and simulate the business model of individual addressable customers in a targeted market. Customers using 5G networking solutions and deploying 5G-oriented solutions enter themselves into complex business scenarios requiring significant investments, which need to respond to a well-defined customer business model to make a profitable customer business case. The knowledge of the customers' requirements, pain points, and business goals is essential for the cooperating enterprises to properly define the ecosystem's business model that ensures success and achieves the expected results.

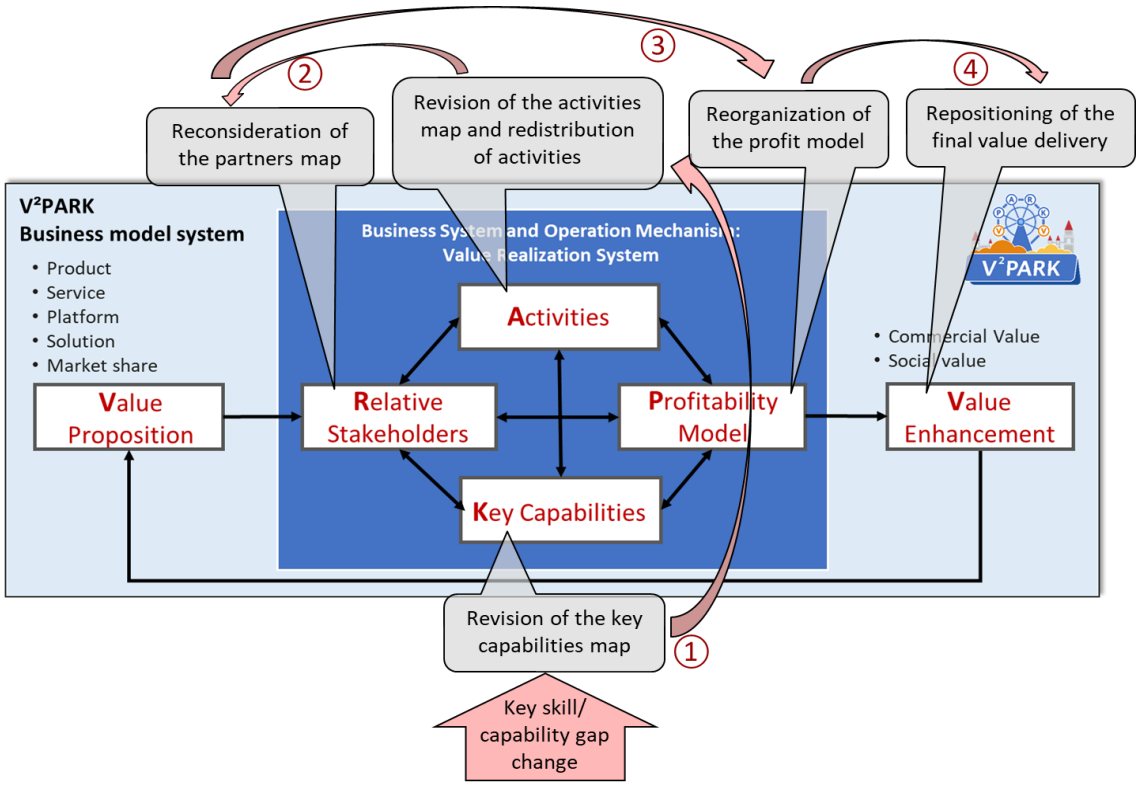

Figure 22 Example of how an identified gap affects the business ecosystem

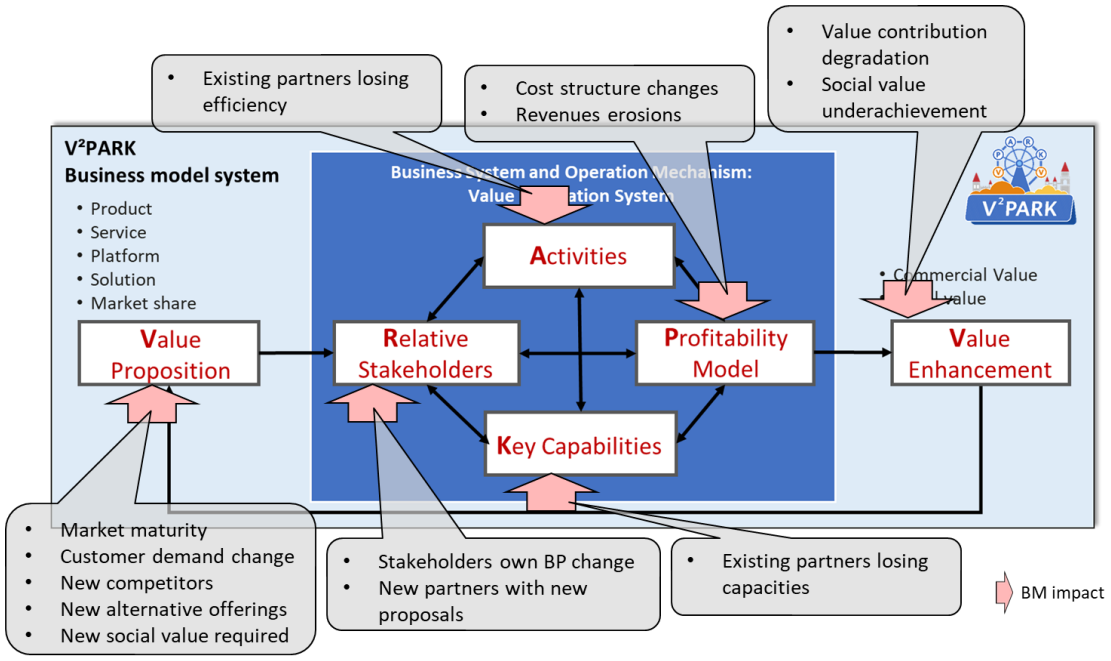

Figure 23 Example of internal and external events affecting the ecosystem

4.3. SUSTAINABILITY-ORIENTED AND VALUES-BASED ECOSYSTEMS BUSINESS MODELLING APPROACH

Requirements for business to comply with environmental and social standards are becoming stricter. At the same time, many companies are trying to get ahead of regulation and integrate sustainability-related values in their strategies and in their normative management frameworks and associated vision, mission, or purpose declaration. We can distinguish between the strategic and normative management dimensions of business organisations and ecosystems they participate in.

In a *strategic management dimension*, companies and ecosystems strive for competitive advantages. They need to find out which business models to apply and, possibly, which kinds of economic, social, and ecological value to create. For instance, in order to comply with the EU taxonomy [16], business activities should fulfil minimal social standards, not cause significant harm and contribute to at least one of six environmental goals [55], including, among others, climate change mitigation, sustainable use and protection of water and marine resources, and the transition to a circular economy. Ecosystems of interdependent and co-creative actors should even more powerfully prioritize social and ecological value to not just create benefits for their customers and clients but also for a wider range of stakeholders – the EU Taxonomy already contains numerous topics for such strategic innovation.

In a *normative management dimension*, companies have company-specific values and normative orientations, typically expressed through vision, mission, purpose, or values statements ([46]; based on [56]). They align with yet other companies. A process of value definition and prioritisation is also a prerequisite for developing networks among different organisations forming an ecosystem. Business-related notions of sustainability, standards of social conduct, thresholds of environmental performance, and business outcomes in terms of ecological, social, and economic benefits need to be defined and prioritised. Accordingly, shared values and normative orientations (e.g., towards sustainable development goals of the UN or the EU Taxonomy) constitute a nexus, reference and generative force for network development ([45], [46]). As shown in Figure 24, business models of different actors and their shared or distinct business model components constitute a values-based network, usually evolving through an iterative exploration of common values and formulation of a shared vision to be realised through cooperating business models and actors (Figure 25).

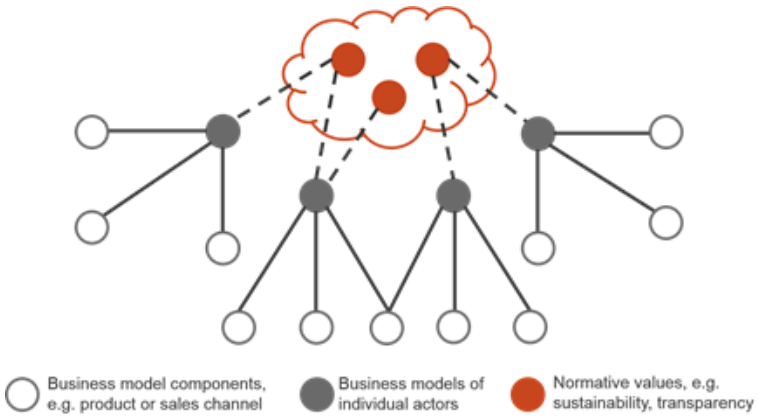

Figure 24 Illustration of an ecosystem or network with shared (sustainability-oriented) values among the participating business models and actors

The joint elicitation, exploration, and elaboration of values and normative orientations can be used to re-frame and expand existing innovation methods and frameworks and build shared sustainability values that all ecosystem stakeholders commit to. In turn, stakeholders build their business model on top of this basic framing, as visualised in Figure 25. The re-framing of actors' business models and the ecosystem as a whole happens in an iterative process. Once defined and stabilised, such shared values and normative orientations can inform the search for attractive business models (e.g., use-oriented services [24]) and business model components (e.g., a green freemium revenue modal to privilege green modes of using, for instance, mobility services).

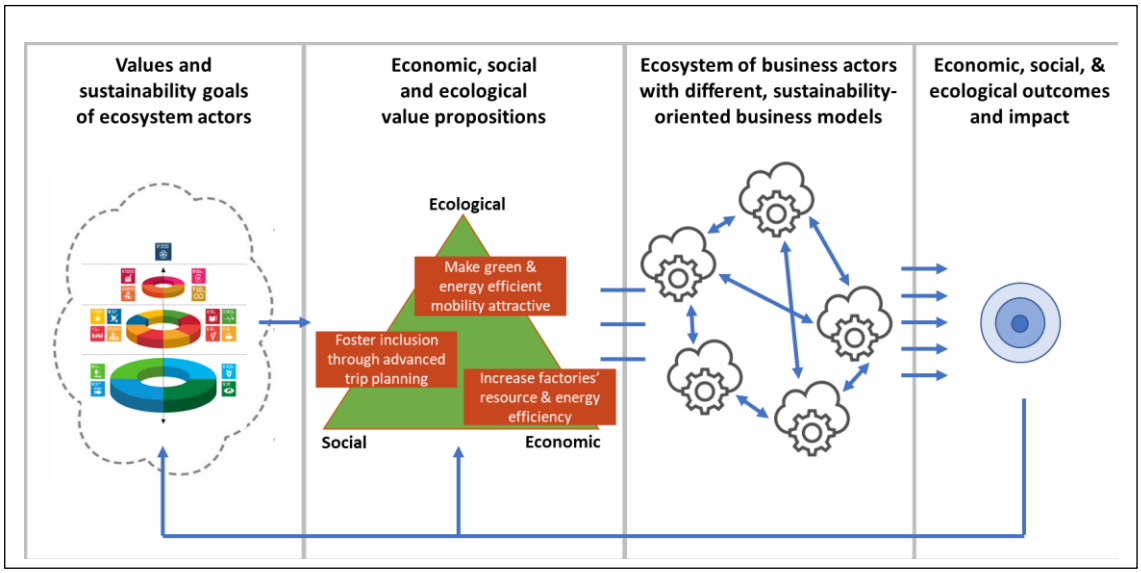

Figure 25 Shared values realised through cooperating business models and actors

Several facilitation methods have been successfully applied to values-based ecosystem development, including Future Workshops [57] or Future Search [58], to create a shared vision and plan its realisation with all relevant stakeholders of a business ecosystem. The methods can be applied in conjunction with values-based collaborative business modelling using a business innovation toolkit [45].

A Future Workshop [57] typically involves a small group of participants in seeking new approaches to joint, problem-solving action. It proceeds through three stages of critically reviewing the problem, creative projection of utopian solutions, and translating aspects of the projection into realistic plans for action. It allows participants from different firms in an ecosystem to agree on common values and to create ambitious visions beyond single firms and incremental improvements of their core businesses. Another way to do so is Future Search, a large group facilitation format that brings all relevant stakeholders in an ecosystem together to create a shared vision and ensure the commitment to turn it into action.

Common values and shared vision can then be applied to drive innovation in the distinct business models of the participating actors. Different sustainability-oriented and values-based business modelling tools [20] support this second step of the process. In particular, the Business Innovation Kit [59] was developed exactly for this purpose. It takes a small group of participants from understanding the fundamental values and normative orientations of a business or business idea to considering different value propositions, and on to ideation, selection, and recombination of suitable business model components, including stakeholders, capabilities, revenue models, and cost structures. An exemplary walk-through of the Future Workshop and Values-Based Business Modelling sequences has been demonstrated [45] for the development of a sustainable energy region and its ecosystem of providers.

The success of the model must be demonstrated not only by the output in terms of economic key figures but also by the outcome in terms of social and ecological value creation and, ultimately, the impact on values-based and normative (e.g., sustainable development) goals that motivate and provide the basic framing for the ecosystem.

5. BUSINESS MODELLING INSIGHT FROM 5G PPP PROJECTS

The purpose of this section is to provide insight to the reader on how the topic of business modelling has been approached across a variety of 5G PPP projects. Collectively, these projects can be viewed as segmenting the 5G and beyond ecosystem discussed in previous sections. Therefore, this section provides a more granular view of effective analysis methods used to articulate business value within the 5G and beyond ecosystem.

More specifically, it is seen in many cases that the 5G PPP projects focus attention on particular vertical industries. By examining how business modelling was approached in these projects, enterprises engaging in such vertical markets can acquire a detailed understanding of how value can be extracted and how to position themselves within the associated value networks.

This section analyses a selection of these projects and reveals a common emphasis on articulating the business value of the 5G and beyond technologies and/or solutions being developed. This is understandable, considering this is an essential question to clarify in order to maximise investment in 5G and beyond networks and the associated technologies and services. Understanding the commercial potential arising from these projects provides crucial information that is being sought by all stakeholders engaged in the industry.

The non-exhaustive set of 5G PPP projects presented in this section show that similar business modelling tools are applied across the different projects, many aligned with the business analysis steps described earlier in Section 0. The project descriptions, therefore, provide further examples of how such approaches are effective in analysing available business opportunities in the 5G and beyond ecosystem.

The content in this section is not intended to represent the entire scope of business modelling work carried out by the projects discussed. Instead, the authors have drawn examples of business modelling approaches from a broad range of projects that provide the reader with a strong understanding of the categories of applied methods. These examples have been examined and generalised to provide a shortlist of business modelling approaches that have been effectively employed by the 5G PPP projects to highlight business value across a broad variety of vertical industries.

5.1. BUSINESS MODELLING COMMONALITIES ACROSS 5G PPP PROJECTS

The generalised categories of business modelling approaches discussed in this section are:

1. Identification of impacted roles and stakeholders
2. Analysis of business requirements and benefits for each of the affected stakeholders (incl. regulatory)
3. Business relationship mapping (i.e., inter-role service and revenue flows)

4. Description of value propositions / Value Proposition Canvas (VPC) for technology / solutions being developed
5. BMC / Lean Canvas
6. Criteria-based evaluation of business models
7. Techno-economic analysis of project pilots
8. Go-to-market proposals of commercially-viable assets
9. TMOG (Technology, Market, Organisation, Governance) frameworks
10. Business Innovation Kit (BIK)
11. Evaluation of indirect benefits to economy and/or society of business cases/ Social Acceptance of Technology (SAT) framework
12. Planning for business growth and longer-term economic sustainability

With reference to this list, Table 1 is provided to aid the reader in understanding the vertical domains where the generalised methods have been applied, thus helping the reader navigate the ecosystem to find focus areas of interest and related projects.

Table 1 Business modelling approaches discussed in this white paper and the example vertical domains and projects in which they have been applied

Vertical Domain(s)	Example Business Modelling Approaches Applied in Verticals	Example Projects Applying the Referenced Business Modelling Approaches
Industry 4.0	1 to 6, 10 to 12	5GROWTH; 5G-SMART; 5G-VICTORI; EVOLVED 5G; 5G-SOLUTIONS
Automotive / CCAM	1 to 8, 12	5G-CARMEN; 5G-HEART; 5G-ROUTES; TeraFlow
Transport &Logistics (T&L)	1 to 9	5GROWTH; 5G-TOURS; 5GENESIS; 5G-HEART; VITAL-5G; Int5Gent; 5G-VICTORI
Energy	1 to 6, 10	5GROWTH; 5G-VICTORI
Smart Cities & Utilities	1 to 7, 9, 11, 12	5G-TOURS; 5GENESIS; 5G-SOLUTIONS
Smart (Air)ports	1 to 9, 11, 12	5G-TOURS; VITAL-5G; 5G-SOLUTIONS
eHealth	1 to 7, 9	5G-TOURS; 5G-HEART
Media & Entertainment (M&E)	1 to 12	5G-TOURS; 5G-RECORDS; 5GZORRO; 5GENESIS; 5GMediaHUB; 5G-VICTORI; 5G-SOLUTIONS
Governmental Agencies	1 to 4	5GZORRO
Public Safety / PPDR	1 to 4, 7	5GENESIS; Int5Gent
Agriculture & agrifood	1 to 5	5G-HEART

It is observed that although there is variability in the subject areas examined by the projects, there is the common theme of examining the perspectives of the wide diversity of impacted stakeholders. Their positioning in the ecosystem and applicable business models can therefore be better understood. In this way, the shortlist of business modelling approaches can be seen as effective in articulating the business opportunities arising from the projects' work and the commercial value for the different stakeholders involved.

Table 2Table 2 provides a summary of the example activities reported in this paper from across the projects and gives the reader more insight into how the shortlist of business modelling

approaches were applied in the various projects. Section 5.2then elaborates on the content of this table by providing further details from the various projects examined.

Table 2 Business modelling-related methods applied in selected 5G PPP projects

Project	Vertical Domain(s)	Summary of Business Modelling Approaches Discussed in Section 5.2
5GROWTH	Industry 4.0; T&L; Energy	• Analysis of business requirements and benefits for each of the project's pilots • Identification of pilot roles and stakeholders, including partner mapping • Pilot-specific business relationship mapping • Stakeholder-focused BMCs for each pilot • Specific value proposition for each of the stakeholders • Technoeconomic analysis of project pilots
5G-TOURS 5G-TOURS cont.	T&L; Smart Cities & Utilities; Smart (Air)ports; eHealth; M&E	• Holistic multi-stakeholder value proposition analysis • Value examined across 5G ecosystem in terms of economic, social, and cultural impact • TMOG (Technology, Market, Organisation, Governance) framework, to identify project innovations with potential for highest demand • Use case-specific roles / stakeholder analysis • Examination of costs, socio-economic factors and return on investment • BMC for the project use cases • Return on investment analysis specific to the different wireless deployment strategies required by project use cases
5G-SMART	Industry 4.0 (Non-Public Networks – NPN)	• Relationship analysis of interdependent stakeholders in Smart Manufacturing ecosystem • Stakeholder / role mapping • Numerous relationship models highlighting value proposition and revenue flows between 5G-NPN stakeholders, considering variations in the roles occupied by different stakeholders • Evaluation of business dynamics associated with each relationship model, based on comprehensive set of criteria • Business relationship models evaluated from perspective of MNO and of NPN user
5G-RECORDS	M&E	• Analysis of specific commercial objectives of Programme Making and Special Events (PMSE) industry • Description of value proposition of the different actors in PMSE ecosystem • Analysis of business value in terms of costs savings and efficiencies in how media content is produced
Global5G	Multi-Vertical	• Analysis of impact of 5G adoption, rollout strategies, and standardisation on vertical industries and small cell deployments • Highlighting potential roles in 5G ecosystem for incumbent companies and new market entrants • Discussion on value proposition and challenges brought on by 5G for various members of ecosystem, covering different verticals, telecom operators and government regulators • Posed key questions for developing commercial understanding of 5G ecosystem in terms of end user value, understanding actor roles, and identifying actor/role relationships
5GZORRO	M&E; Governmental Agencies	• 5G ecosystem business stakeholders analysis • Assessment of interaction between stakeholders

Project	Vertical Domain(s)	Summary of Business Modelling Approaches Discussed in Section 5.2
		• Identification of business opportunities from the different perspectives of the various stakeholders • Assessment of potential value proposition arising from 5GZORRO technology across multiple verticals • BMC • Technoeconomic analysis
5GENESIS	T&L; Smart Cities & Utilities; Public Safety; M&E	• Business value assessment of project's exploitable outcomes • Value Proposition Canvas (VPC) for different potential customer types • Lean Canvas • Cost v revenue analysis to highlight potential business performance
5G-HEART	Agriculture &agri-food; Automotive; T&L; eHealth	• Identification of network requirements to address business needs • Analysis of various provider / customer relationships • Discussion of multiple business models associated with different provisioning scenarios • Analysis of 5G business models for CSPs
VITAL-5G	T&L; Smart (Air)ports	• Commercial assessment of vertical services being developed • Definition of key customers of various project assets • Value proposition canvases, focused on vertical services • Discussion on key commercial considerations affecting delivery of service to market • BMC • Go-to-market proposals
5GMediaHUB 5GMediaHUB cont.	M&E	• Commercial assessment of experimentation as a service business model based on platform developed in project • Commercial stakeholder analysis, outlining ecosystem of companies involved in the provision of advanced media-related services • Definition of value proposition of experimentation facility • BMC • Definition of go-to-market strategy • Analysis of various deployment options for the experimentation facility in the ecosystem and associated business models
Int5Gent	Railway; PPDR	• Review of 5G technology roadmap and positioning of project's technologies • Review of relevant 5G business modelling practices and identification of competing stakeholders, both present and future • Analysis of 5G ecosystem formulations for project's use cases • Analysis of ecosystem roles / stakeholders based on advanced PPDR service needs • Value Proposition Canvases • Technoeconomic evaluation, providing TCO of 5G service provisioning layers
5G-CARMEN	CCAM	• Identification of key stakeholders and mapping to business roles in complex cross-border CCAM 5G ecosystem • Proposal of new business models from MNO perspective, based on network slicing (collaboration-based, non-collaborative, and Slice-as-a-service • Assessment of challenges associated with proposed business models
Smart5Grid	Energy; Smart Grids	• Identification of key stakeholder groups and business roles in the 5G Network Applications ecosystem, deploying solutions for the energy vertical • Proposal of different business models (solution partners, open ecosystem, collaborative ecosystem, directed ecosystem), based on

Project	Vertical Domain(s)	Summary of Business Modelling Approaches Discussed in Section 5.2
		leveraging 5G network programmability for serving various vertical use cases • Assessment of business, technical & organizational challenges associated with proposed business models
5G-VICTORI	Industry 4.0; T&L; Energy; M&E	• Values-based approach, focusing on stakeholder values as enablers and drivers of sustainable business model innovation • Business Innovation Kit (BIK) • Roles / stakeholder analysis of future 5G provisioning ecosystems • (Values-based) BMC • Technoeconomic evaluation, providing TCO of 5G service provisioning layers
EVOLVED-5G	Industry 4.0	• Identification of business roles and stakeholders involved • Business models and value networks development • Business case viability study, supported by a TCO model for various performance-v-cost trade-offs • Investigation of impact of innovative technology on the business case • Evaluation of indirect benefits to economy and/or society of business cases
5G-ROUTES	CCAM	• Detailed examination of the key personas in each use case and the expected benefits for each • Identification of products and services suitable for potential commercialisation, aligned with partners best suited to lead that process • Focused marketplace and positioning analysis specific to selected products and services • Value Proposition Canvases and BMC • Assessment of most appropriate routes to market and developing the strategies for enhancing growth and product innovation over time • Evaluation of business opportunities and their ranking using a Multi-Actor Multi-Criteria Analysis (MAMCA) methodology • Cost-Benefit Analysis (CBA) for the selected business cases
5G-SOLUTIONS	Industry 4.0; Smart Cities and Ports, M&E	• Identification of personas affected by use case solutions and their needs • Benefits and opportunities of use case solutions for stakeholders affected by use case products / services • Social Acceptance of Technology (SAT) framework to assess the degree of acceptance from ethics and social perspective of use case solutions • Value proposition and business model development • Defines business plan for growth and economic sustainability for selected 5G services
TeraFlow	Network Operators	• Investigation of business modelling enabling specialized connectivity across network operator domains • Exploration of current operational and regulatory issues impacting the provision of specialised connectivity services and highlighting means of mitigating the issues • Identification of different service-level concepts applied to different market segments • Relationship analysis of interdependent stakeholders covering four options of increasing complexity

5.2. OVERVIEW OF EXAMPLE BUSINESS MODELLING APPROACHES FROM 5G PPP PROJECTS

5.2.1. 5GROWTH

5GROWTH (https://5growth.eu/) focused on AI-driven automation of 5G E2E solutions for vertical industries that optimise network performance for a diverse range of service requests. The project involved a series of vertical-specific pilot deployments of 5G solutions to support the technical and business validation of 5G technologies from the verticals' perspective.

The project's business assessment involved the identification of the business requirements and benefits for each pilot deployment. The stakeholders and roles involved in the pilot deployments were also highlighted and project partners were mapped to those roles. Using this information, the project provides a clear example of the implementation of Step 1 by identifying the business relationships (service provision and revenue flows) between each of the partners, which are specific to each of the pilot deployments.

The pilots were well defined by the project, minimising the requirement to analyse different permutations of the relationship models, where different companies fill the various roles (as per Step 2). Instead, the relationship models provided were used as the basis to develop BMCs for each pilot, from the perspective of each stakeholder . This allowed the project to report on the specific value proposition for each stakeholder and elaborate the details of the proposed business model applicable to each actor. Such an approach can be seen as a focused application of Step 3.

The project also evaluated the economic benefits derived from the pilots through a techno-economic analysis. This was presented to validate the potential profitability of each pilot, and could be useful for developing the business case described in Step 4. The analysis provided an understanding of possible savings and other economic impact of implementing the 5G-enabled use cases based on certain assumptions, and focused on CAPEX savings, OPEX savings and new revenues for the project stakeholders.

5.2.2. 5G-TOURS

5G-TOURS (https://5gtours.eu/) focused on improving city life for citizens and tourists, through increased efficiency of mobility services, improved safety and enhanced visitor experiences. The project concentrated on demonstrating concurrent support of multiple use cases on the same 5G infrastructure. Three themes were examined, namely, 1) employing 5G to enhance visitor experience in museums and other city attractions, 2) enhanced mobility within cities, particularly for airport operations, and 3) 5G for enhanced safety through assisted healthcare.

A very extensive analysis of the project's use cases was carried out to establish the justification for commercial investment, both from the perspective of the companies supplying 5G infrastructure and the verticals driving demand for the 5G services. This analysis was both

quantitative and qualitative in order to demonstrate the potential value generating capabilities of the use cases.

In line with Step 1, the commercial assessment described how the organisations involved could derive value from and deliver value within a variety of contexts, and examined value in terms of economic, social, and cultural impact. The ultimate goal of this activity was to clarify the roles of the stakeholders in the use cases and support their commercial exploitation strategy development. 5G-TOURS highlights that there is substantial value in the 5G ecosystem that can be unlocked by maximising the infrastructure capabilities, ensuring 5G connectivity is widely available and costs are shared equitably among beneficiaries. The analysis involved an examination of costs, socio-economic factors and return on investment, which were reported across multiple project deliverables.

Within the vertical industries analysed, the project emphasised that considering multiple perspectives is important because there is no one-size-fits-all for operating and sustaining demand for 5G solutions in an economically viable way across all industry sectors. The project highlighted how vertical industries are less interested in the details of technology innovations and more in the associated business outcomes, and so articulating the value of 5G is key to maximising investment in this network technology. This insight on value creation is well aligned with the motivation driving Step 1.

The project employed the BMC to assess new value creation opportunities for the project's use cases, as a first step towards developing the overall business case. Output from this was seen as important for helping to develop the project partners' exploitation plans. The project also highlighted the need for tools to assess the commercial value of the specific innovations being developed in the project, particularly for those relating to more nascent markets. Such tools can be helpful in evaluating the value creation more widely across the 5G ecosystem, which would therefore be useful for the analysis recommended here as part of Step 1.

Those tools helped to uncover the viability of the innovations from a commercial perspective, helping to inform decision makers on resource investments. The project took the approach of developing a holistic framework that considers the needs of verticals and those supplying wireless connectivity. The tools are comprehensive and consider the technologies involved, the markets, organisations impacted, along with environmental, social and governance factors involved in the proposed use case solutions. This resulted in what was called a TMOG (Technology, Market, Organisation, Governance) framework, the application of which highlighted project innovations where demand would likely be the highest. Such an approach can help to focus company activities as part of Step 2.

By focusing on the perspective of CSPs, 5G-TOURS was able to begin to design and evaluate different business models, providing an interesting application of Step 3. The project reported on a detailed cost assessment of various infrastructure deployments required for implementing the project's use cases, which varied in nature due to the different use case environments (airport, museum, healthcare setting). The project examined different evaluation use cases to determine the revenues and potential return on investment of the different wireless deployment strategies. One of the benefits of working through the cost assessments was to highlight the economies of scale that could be achieved should a wider ecosystem of

verticals take advantage of the deployed infrastructure. Such insight can help to verify investment strategies and determine appropriate revenue models.

5.2.3. 5G-SMART

5G-SMART (https://5gsmart.eu/) investigated the use of 5G non-public networks (NPN) [5] by vertical industries, which is seen as a route to creating competitive advantage for industrial players engaging with 5G technology. As part of the project, the relationships between the various actors in the Smart Manufacturing ecosystem were considered and challenges to fulfilling the needs of industrial end-users were examined.

It was recognised that the stakeholders involved in providing 5G products/services and the industrial players are interdependent as the required technologies, expertise and resources to deliver NPN solutions are not wholly under the control of a single industrial 5G ecosystem actor. It was highlighted that the provision of 5G NPNs is also complex and costly, requiring each involved actor to evaluate different NPN technical solutions from a business perspective.

To achieve this, the project proposed a methodology where the NPN ecosystem is analysed and stakeholders are mapped to business roles. Relationship models were then employed to visualise the value proposition offered between the stakeholders/business roles and the associated revenue flows. This approach is an excellent example that can be viewed as an illustration of Step 1 and results in a clear understanding of the business relationships in the 5G NPN ecosystem. The project then examined the pros and cons of the different relationship models using a set of criteria that helps identifying the most suitable use cases and users for the different relationship models. This can be viewed as an instance of applying the focusing activities described in Step 2 and results in a deeper understanding of the business dynamics associated with each relationship model and the actor roles involved.

5.2.4. 5G-RECORDS

5G-RECORDS (https://www.5g-records.eu/) focused on the impact of 5G connectivity on the performance of professional media content production. 5G is expected to develop in its capabilities to support the use of wireless production tools in the Programme Making and Special Events (PMSE) industry once appropriate features are implemented in 5G networks.

The project highlighted that 5G will likely be used in different ways in the PSME industry because different 5G network configurations will be needed to address all production use cases (e.g., best-effort public mobile networks, SLA-based private networks, etc.). It is also noted that the diversity of actors involved in each of the use cases examined leads to the need to analyse the different business perspectives within the PSME ecosystem. From a commercial point of view, each of these actors will have specific business objectives and the use of 5G in the different areas of the PSME industry will be driven by the ability of 5G to create value for the various stakeholders involved. For this reason, the project focused on analysing the value proposition of the different actors, and so provided an example of the implementation of some of the key elements of Step 1.

Ultimately for the PSME ecosystem, value is expected to be based on costs savings and on the new opportunities offered by 5G, enabling innovations in how media content is produced.

There is also a recognition that suitable business models are required to articulate the value of 5G and the ability to provide the details behind these models is likely to develop as network roll-out increases and network capabilities improve.

5.2.5. GLOBAL5G

Global5G (https://global5g.org/) was a 5G PPP Coordination and Support Action that examined vertical industries and small cell deployments from the perspective of 5G adoption, roll-out strategies, and standardisation. The project explored the then emerging 5G-related market opportunities, highlighting potential roles for incumbent companies and new entrants to the market, such as SMEs. The project examined different verticals and outlined the value proposition and challenges brought on by 5G (e.g., variations in spectrum allocation across borders), and also examined the perspective of telecom operators and government regulators, providing an understanding of the wider ecosystem dynamics.

The project posed some important questions that can support those carrying out the analysis described as part of Step 1. Essentially, the project examined the potential differentiation delivered by the advanced features of 5G that lead to competitive advantage for the different companies considered. The questions asked if 1) 5G could change the target customer of the companies being analysed, 2) if 5G could enhance a company's value proposition, or 3) if 5G could enhance the company's capabilities to deliver value to customers more efficiently compared to competitors. It is argued that these are fundamental questions to explore when determining the value for the end user, understanding actor roles contributing to ecosystem value creation, and identifying actor/role relationships. Such outcomes are well aligned with the goals of Step 1, highlighting the importance of exploring these questions on differentiation when exploring stakeholder relationships.

5.2.6. 5GZORRO

The motivation for 5GZORRO (https://www.5gzorro.eu/) was the growing need for telco resources, due to new envisioned use cases and new actors entering the ecosystem who do not always have easy access to these specific resources. To tackle this challenge, 5GZORRO created a platform for sharing and optimising available network resources, including spectrum, and capable to establish 5G services in an easy, flexible, automated, secure, and trustful manner. As the consortium's objective was to kick off a vibrant ecosystem around the platform, it dedicated an entire project work package to demonstrate its feasibility from three distinctive perspectives: technical, legal and business.

The demonstration of 5GZORRO platform business feasibility aimed at easing the adoption of 5GZORRO propositions. For assessment of the business model associated with running the 5GZORRO platform in different contexts (the UCs), partners used the Value Proposition and BMC templates. The problems and needs of related stakeholders were highlighted, which mainly relate with the total cost of ownership, manual cumbersome tasks and the lack of trust among parties. It became evident that the 5GZORRO platform, with its different functionalities, can alleviate these challenges addressing stakeholders' real problems and needs, thus helping the consortium in the definition of 5GZORRO unique selling point. Partners also reflected about the different activities needed to operate the platform and deliver the 5GZORRO proposition,

demonstrating that a profitable business can emerge, as costs are maintained below revenues in the different scenarios envisaged. For initial performance and cost estimates, the consortium conducted a techno-economic analysis. In this analysis, the methodology by Miroslaw Kantor [60] was adapted to the particularities of the project and the data available to use. The Kantor methodology for TEA considers three steps: Scope, Calculations and Evaluation. The process starts defining the Scope of the question under analysis and detailing the inputs for the study based on a market analysis. The second step is Calculations, making a distinction between economic calculations (estimation of costs and revenues) and technical calculations, in which the performance metrics of the proposed solution are estimated. Calculations were made based on the configuration and setup of the project results, i.e., a prototype that is technical and legally feasible, but also acknowledging 5GZORRO competitive advantage when making projections (an early adopter that is part of the consortium, directly involved in the co-development of the future product). The final step, the Evaluation, is based on the outcomes – economic and technical – of the calculations step. This step is split between investment analysis and performance analysis. The first part is an estimation of the (expected) profitability of the solution being analysed, while the second is a comparison of the different alternatives, making trade-offs of costs vs. performance. *The readiness level of a project influences not only assumptions, quality and availability of data, but also and foremost the decisions of metric and consequently results and interpretability* [61]. As the 5GZORRO platform was not expected to be a complete and qualified system at the end of the project (but a validated prototype reaching TRL4/5), to the three-step methodology considered by Kantor, the consortium adapted the three steps and added a final one that has to do with Risk and Uncertainty analysis.

As a conclusion, it can be stated that 5GZORRO platform is ready to evolve into a market ready solution in the form of a minimum viable product (MVP), as it works from a technological point of view and, equally important, complies with legal aspects and solves real problems with a reduced investment. To get to that point and impact society and European industry, partners have defined an exploitation roadmap and related activities. The work done related to business and technoeconomic models can be considered as a starting point but will need to be iterated and adapted to new circumstances as the creation of the MVP progresses.

5.2.7. 5GENESIS

5GENESIS (https://5genesis.eu/) brought together a range of outputs from 5G-related EU projects and R&D activities to create an E2E facility to validate 5G network KPIs for different use cases. The project provided an open coordination framework to enable E2E slicing and automated experiments. The project involved five European 5G facilities which provided diverse capabilities to address use cases, particularly those driven by vertical market needs.

In terms of innovation assessment, the project's exploitable outcomes were examined using a set of business modelling tools, such as the Value Proposition Canvas (VPC) and Lean Canvas. To implement the tools, a list of exploitable outcomes was first defined and the value of each of these outcomes was discussed. Of the exploitable outcomes highlighted, the most promising was selected and VPCs were presented, which provided the perspective of different potential customers. These were used to identify the most promising customer for each of the

exploitable outcomes analysed. Following this, a lean canvas was produced to provide a more detailed commercial analysis. Costs and revenue streams were presented to provide a preliminary view of the potential business performance of the most promising exploitable outcome, showing profitable returns were possible for the test case analysed.

This description of the 5GENESIS approach shows how the project's innovation assessment covered Steps 1 to 4. Essentially, the project examined the customer types and the related value proposition of each, provided an assessment of their potential market impact, which helped to focus the subject of the subsequent Lean Canvas and revenue model that were developed.

5.2.8. 5G-HEART

5G-HEART (https://5gheart.org/) was an ICT-19 project with healthcare as one vertical for studies. The project tested e.g., Remote Patient Monitoring (RPM) for transitional care, and validated the business opportunities and challenges [62].

An RPM solution is constituted of wearable devices in the form of e.g., bracelets, which must be connected to the cloud anytime and anywhere. This implies excellent coverage indoor and outdoor in one geographic domain, but also across geographic domains. 5G is ideal for outdoor coverage, but the status of ubiquitous indoor 5G coverage is a challenge. Thus, cross-border interoperability and indoor-outdoor interoperability are challenges. There are four interesting provider-customer relationships drawn from this example, illustrated in Table 3.

Table 3 Remote Patient Monitoring, provisioning example

	Provider	Customer	What	Notation
1	RPM provider	E.g., hospital monitoring patients in local market	Out of the box RPM solution Connecting device	B1-C-device
2	Global M(V)NO	RPM provider	Global connectivity	B2-B1
3	Local MNO	Global M(V)NO	Interoperability global-local connectivity, and local connectivity (roaming)	B3-B2
4	Indoor coverage, e.g., Neutral host provider and providers of connectivity according to requirements	Local MNO	Interoperability outdoor-indoor connectivity, and indoor connectivity (national roaming)	B4-B3

The provisioning of RPM in this case indicates a fully integrated solution. This could be denoted a B-B-C type of business model, a chain of relationships: B4-B3-B2-B1-C-device. Each provider would charge a price, which the next provider would need to include in its further offers, constituting the total price to the customer.

An alternative and realistic way of organizing the offerings is that the RPM provider leave the purchase of connectivity to the customer in the local market. This would give us a model where e.g., the hospital purchased the RPM solution from the RPM provider and purchased local and indoor connectivity from others. This can be described in the following way, as a set of interdependent business relationships with one customer - see below. The customer here serves as a system integrator, and/or set requirements to how the market must coordinate its offerings. This may introduce a pressure towards an ecosystem organization of the market,

also because of the need for re-combination of offerings across many providers and that providers want to retain the vertical customer relationship.

- B1-C
- B2-B3-C-device
- B3-C-device
- B4-C-device

Based on this example we emphasize three observations**:**

- The provisioning of health solutions such as an RPM solution imply provisioning models varying from an integrated supply chain, to deliveries from interdependent providers. The analysis is an example of a Step 1 procedure where multiple business model scenarios were explored. However, a complete assessment of all theoretical combinations was not carried out. [62] (too) quickly converged towards one scenario.
- In addition to different roles, interoperability between network operators was an important capability in offerings. Business models between operators increase volume and complexity in potential business models to be assessed.
- Finally, management of device connectivity (authorization) is an important capability in offerings and may constitute a new role.

We can deduce that the connectivity providers in this example are communication service providers (CSP), providing services either to a vertical enterprise customer (hospital) or other CSPs. In line with Step 2, the project sketched 5G business models for the CSP with the structure described below:

- Value proposition: connectivity in defined area, interoperability, management of devices
- Partners: other CSPs
- Resources: Network purchased as a service, interoperability agreements, programming and management resources, sales resources, customer interface (APIs and portal)
- Cost structure: lease defined network capabilities from network operator (costs are taken in chunks)/programming and operating services. Economies of scope – combine connectivity with other services/cross-selling
- Revenues: Per connection/subscriptions for RPM devices with given services included. Fixed price for managed solution with given services included.

5.2.9. VITAL-5G

VITAL-5G (https://www.vital5g.eu/) focuses on enabling 5G-enhanced transport and logistics (T&L) services by bridging the knowledge gap between the T&L sector end-users, seeking to enhance efficiency in their operations, and the telecommunication experts and application developers, who provide the technical assets and knowledge to deploy advanced T&L services. The project's use cases are guided by the T&L end users and examine industrially relevant challenges at sea and river ports, and in warehouses.

To achieve their goals, VITAL-5G engages with three 5G testbeds to provide the required 5G connectivity. The project developed an experimentation platform, which is a secure, virtualised environment that interfaces with the 5G testbeds and allows SME experimenters to readily test and validate the performance of their Network Applications on 5G infrastructure. The platform will provide third-party experimenters the necessary testing and validation tools, and secure service execution environment to allow refinement and fine-tuning of services, thus fostering the creation of new services and the evolution of existing ones. Through these methods VITAL-5G plans to showcase the added-value of 5G connectivity for the European T&L sector, while enhancing SME presence in the emerging 5G-driven logistics ecosystem.

As part of the efforts to assess the commercial potential of the assets being produced across the project, a four-stage process was employed, similar to that described in [4]. A detailed market report was produced to provide a partner-specific perspective on the market opportunities arising from the project. Once the market assessment was completed, key assets with the highest commercial potential were identified. These mainly focused on the vertical services being developed by the project. For each of these, a detailed commercial assessment was carried out, which helped to more clearly define the proposed offerings and their value to perspective customers. In activities that are broadly aligned with Step 1, the project identified characteristics of these proposed customers and developed value proposition canvases to outline customer needs and how the vertical services could provide value to the customers.

An assessment was then presented for each of the vertical services on the key considerations that would be involved in delivering the associated products / services to the market. This involved considering dependencies with other suppliers and 5G network providers in the ecosystem, costs of delivering services, requirements for licensing agreements, and benefits derived from advanced 5G capabilities. These are key considerations that can be used as input to develop Step 2. Similar to what is described for the initial stages of Step 3 above, the information discussed was collated and summarised in BMCs and initial “go-to-market” proposals were put forward to provide insight into how revenue could be generated from the proposed services by the commercial leaders developing the associated services.

5.2.10. 5GMEDIAHUB

5GMediaHUB (https://www.5gmediahub.eu/) targets the delivery of a richly featured Experimentation Facility, which will allow Network Application developers to test and validate their applications on 5G infrastructure. The project assets focus on providing solutions mainly for the media industry, however, many of the targeted outcomes are vertical agnostic, enabling the project to impact a wide variety of sectors and to broadly support the development of a Network Application ecosystem.

To achieve its goals, the project developed the required experimental tools for Network Application developers to minimise market entry barriers, accelerating time-to-market of novel services. The experimentation tools aim to provide insight into network resource utilisation, allowing developers to understand the impact of Service Level Agreement (SLA) features on the Quality of Service/Experience (QoS/QoE) ultimately experienced by their users.

The 5GMediaHUB Experimentation Facility will offer an Experimenters Portal for interfacing with a Testing-as-a-Service (TaaS), DevOps-based environment, and a rich set of Experimentation Tools, which include application validation, verification, and QoS/QoE monitoring mechanisms. The project will also offer re-usable vertical-specific and vertical-agnostic Network Application through an open-source Network Application repository that can be leveraged for rapid prototyping and application testing.

In alignment with Step 1, the market-impact potential of the assets being developed in the project were explored in a detailed market assessment, which validated the market-driven requirements for the project's assets. This supported the development of the project's exploitation strategy, which is focused on exploring the feasibility of delivering the 5GMediaHUB Experimentation Facility to the market.

An initial commercial assessment of a potential business-entity based on the facility was provided, identifying relevant commercial stakeholders and proposed the value proposition of the platform business in terms of how it will address specific customer needs. In addition, insight was provided into the wider ecosystem of companies involved in the provision of advanced media-related services though an analysis of the project partner's key exploitable outcomes. To explain this, it is considered that the project's consortium members are representative of a wider ecosystem, meaning such an analysis of the partner's exploitable outcomes provided an understanding of the actor roles and their sectorial needs.

A BMC was also presented to describe the dynamics of the proposed business, similar to Step 2, allowing an initial go-to-market strategy to be developed. At the time of writing, the project was in the process of exploring how partners could potentially interact to bring the proposed business to the market and the potential deployment models that would be most suitable for deriving revenues from the assets produced in the project. Such an investigation can be seen as an initial implementation of Step 3.

5.2.11. 5G-VICTORI

The focus of 5G-VICTORI (https://www.5g-victori-project.eu/) is to conduct large-scale trials for advanced use case verification in a commercially relevant 5G environment for multiple verticals, including Transportation, Energy, Media, and Factories of the Future. Besides use cases located in the respective verticals, several use cases include cross-vertical interaction.

The project spans 7 use cases, comprising 23 services. The use cases span widely with respect to target user groups, presumed commercial environment and novelty of the applications or services. While in some cases the goal was to enhance and replace existing functionalities, in other cases services aimed to provide new types of experiences and possibilities.

In order to support commercial exploitation strategies across the wide spectrum of use cases, business modelling workshops with professional moderation were repeatedly conducted, starting in the middle of the project's time span. In order to ensure continuous support for developing and realizing exploitation strategies and guidance in business modelling, a generic process model was developed on the basis of conducted workshops, providing guidance and resources to create and consolidate sustainability-oriented business models for 5G-VICTORI

services. It described five overarching steps and is complemented by a number of resources and templates that contain further support and instructions.

Recognizing that sustainability is a top priority for both public and private actors in the 5G-VICTORI project, the workshops aimed at facilitating sustainability-oriented business modelling. Consideration of social and ecological sustainability was embedded in all process modelling steps and considered alongside and in combination with economic sustainability and profit based objectives. To this end, the Business Innovation Kit (BIK) [59] was applied in the workshops. The BIK is a toolkit specifically designed to facilitate business model innovations that integrate and cater to stakeholder values, such as sustainability, security or privacy. This values-based approach focuses on using stakeholder values as enablers and drivers of sustainability-oriented business model innovation, rather than sustainability as a constraining factor. In addition, 45 sustainable business model design patterns with solutions to recurring sustainability challenges was used to identify sustainability-oriented business models and components that contribute to economic, social and ecological value creation [24].

In the first iteration of these workshops, ecosystem considerations were implicitly considered when addressing business model components. In the second iteration, the business modelling refinement workshops, the ecosystem perspective was integrated in a more systematic and explicit way. The potential ecosystem implications for each business idea were explicitly discussed, considering questions pertaining to different business model components. These activities constitute an application of Step 3 of the approach to ecosystem business modelling suggested in this paper. Examples include:

- **Value Proposition:** How might we accelerate ecosystem growth by making our value propositions more attractive for other actors to join?
- **Revenue Model:** How might we define a clear revenue-sharing model for all involved stakeholders/roles?
- **Partners:** How might we acknowledge and balance tensions between roles and interests of ecosystem members (e.g., based on shared values of sustainability)?

Beyond the workshops conducted with business idea owners, and in order to further map the 5G-VICTORI onto 5G Ecosystems business modelling concepts, internal workshops were organised focusing on business ideas in 5G ecosystems from the perspective of key players in the emerging ecosystem (e.g., telecom operators). In a first step, potential distributions of roles among stakeholders in future 5G provisioning ecosystems were mapped in order to reflect upon benefits created and received by each actor and to identify key issues of uncertainty for follow-up elaboration. The generic mapping was then adapted to specific contexts (e.g., railway environments and smart city environments). This suggests a procedure for engaging in Step 1 and Step 2. In light of the insights from this mapping a (values-based) BMC was then filled in focusing on the ecosystem specific challenges of the key actor (e.g., telecom operator) in one of the environments. This can be seen as a first approach to Step 3, which should be followed up on by a more detailed analysis, as well as the specification of shared values and normative directives for future ecosystem development.

An example for a novel business model combining insights from both the sustainability and ecosystem perspective assigned a key role to telecom operators on the one hand and to

municipalities on the other hand. Due to high network deployment costs municipalities may decide to foster deployments in remote areas that are not economically feasible for telecom operators, with the goal of reducing the digital divide and generate social and economic benefits. Municipalities could utilize their ownership of street furniture (e.g., benches, lamp posts, etc.) to deploy network equipment and reduce Total Cost of Ownership (TCO) (high rental costs) for telecom operators.

5G-VICTORI activities included an evaluation from a technoeconomic perspective. The technoeconomic approach that was used delivered insights of the TCO broken down to the afore 5G service provisioning layers. The purpose was to cross-validate the layered service provisioning approach and at the same time provide the necessary feedback to value-oriented business modelling activities.

A general insight from the workshops was that business ecosystems flourish based on the exchange of benefits between the participating actors. Understanding which benefit each stakeholder contributes and receives is essential for building the ecosystem and ensuring trust in a balanced exchange among the participants. In addition, potential extensions of the ecosystem can be identified e.g., by spotting benefits that additional parties could profit from, or new benefits (and associated actors) that could enhance the whole ecosystem's capabilities. This insight pertains to all of the Steps introduced in Section 0.

5.2.12. INT5GENT

The Int5Gent project (https://int5gent.eu/) focuses on delivering Beyond 5G (B5G) technology innovations across multiple network domains, segments, and layers, that will enable the E2E orchestration of 5G network functions, network and compute resources of various segments (access, transport, core) as well as application components; towards allowing the automated network and service provisioning on demand in various occasions. Int5Gent addresses key vertical industries, primarily the Railway and the Public Protection and Disaster Recovery.

Aiming to pave the way to the commercial exploitation of the project outcomes, the project includes exploitation activities that are performed in two phases. The first phase includes the review of the 5G technologies roadmap to position the technical innovations in the technology context and secure the technology–specific market potential for Int5Gent technologies. This phase includes also the identification of the 5G business environment, through the review of the 5G business modelling practices, trends and roles, along with the identification of competing (in present or future) stakeholders. 5G Ecosystems are investigated in this context, and prevailing 5G ecosystem formulations are identified for the Int5Gent use cases (aligned with Step 1 from Section 0). The second phase includes direct exploitation activities of partners towards materialising these models (similar to the business dynamics analysis of Step 2).

- More specifically, the PPDR vision creates the need for extended 5G network availability along with compute resources availability. This brings changes in the role of the traditional Network Operator to providing also compute resources, and in specific circumstances necessitates the deployment and provisioning of advanced PPDR services ad-hoc at small scale. This makes room for new stakeholders to innovate and engage. From a business modelling perspective, the project refines and applies the 5G

niche ecosystems (as subcategory of 5G provisioning ecosystems) approach (also provided in [63]) to the PPDR sector. Following a layered approach for the PPDR ecosystem-actor roles, the following roles and corresponding competing stakeholders/ players have been identified: The PPDR Infrastructure Provider role similar to DCSP/ VISPs role; which can be undertaken by Private and Public IaaS infrastructure

- The PPDR Network Provider role, similar to the NO, the CSP, the NSaaS provider roles, which provides a Telco Logical Network, a Non-Public-Network, or a 5G Slice or purposely built 5G RAN; which can be assumed by established carriers, Non-Public Network Operators, or other players such as vendors, system integrators, actors of the PPDR vertical industry such as civil protection agencies, etc.
- The PPDR Application Providers, partly similar to the Digital Service Provider role, providing MC-services for PPDR users. Apparently, the players assuming this role can be those assuming the PPDR Network Provider role or different.

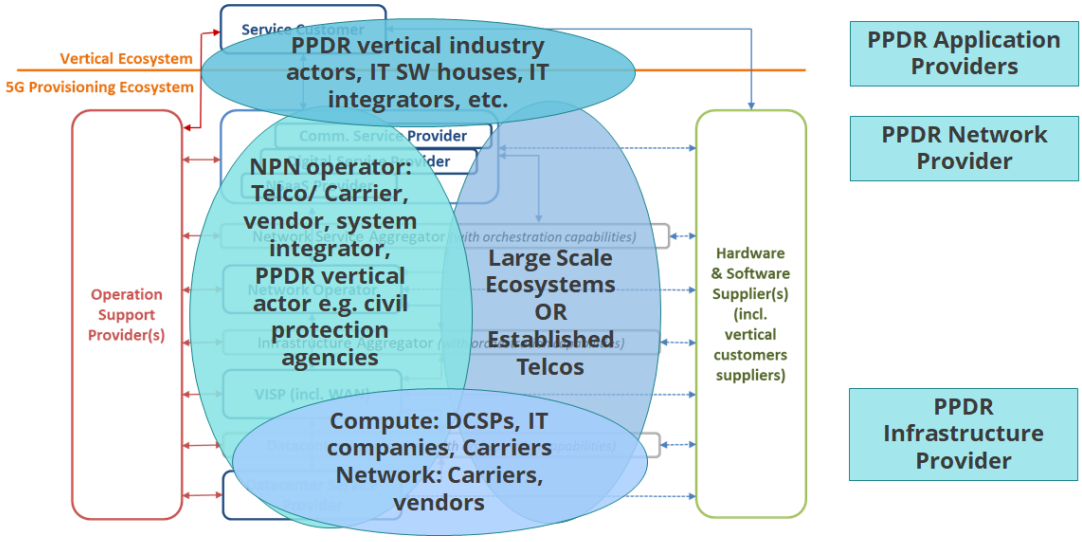

Figure 26 PPDR Ecosystem Formulations

The identification of the niche ecosystem formulations in the PPDR sector, illustrated in Figure 26, is followed by a more precise modelling of the business models for target stakeholders that are participating in the project. The tool used is the Value Proposition Canvas, which are being cross-validated between stakeholders targeting to assume complementary or competing roles (from those listed above).

In parallel, the Int5Gent E2E solution is evaluated from a technoeconomic perspective. The technoeconomic approach followed delivers insights of the TCO broken down to the aforementioned 5G service provisioning layers. The purpose is to cross-validate the layered service provisioning approach, and at the same time provide the necessary feedback on the benefits/revenues and cost factors of the Value Proposition Canvases.

5.2.13. 5G CARMEN

The 5G-CARMEN project (https://5gcarmen.eu/) was an effort to significantly drive the research, implementation, and demonstration of refined 5G solutions for the Cooperative, Connected, and Automated Mobility (CCAM). In 5G-CARMEN important European industries, academics and innovative SMEs committed to achieve worldwide impact by conducting extensive trials across an important corridor (by people/goods traffic volumes), from Bologna to Munich, spanning 600 km of roads, connecting three European regions (Bavaria, Tyrol and North Italy) across three countries. The key 5G-CARMEN innovations were centred around developing: an autonomously managed hybrid network, combining direct short range V2V (vehicle to vehicle) and V2I (vehicle to infrastructure) communications with long-range V2N (vehicle to network) communications and enabling technologies such as 5G New Radio, C-V2X (Cellular vehicle to everything), and secure, multi-domain, and cross-border service orchestration system to provide E2E 5G enabled automated mobility services. 5G-CARMEN validated a set of innovative CCAM use cases from both business and technical perspectives, focusing on cross-border 5G and advanced Automated Driving Assistance Systems (ADAS) on the way to Level 4.

Key business actors play an essential role in the proposition of new business models suitable for CCAM services. In alignment with Step 1 from Section 0, these identified business actors were mapped onto the business roles resulting in a value network configuration. Since the cross-border CCAM ecosystem is very complex, the focus of the 5G-CARMEN project was on four key stakeholders: MNO, Road operator, car manufacturer and service provider, since those four actors need to collaborate in order to 1) ensure a seamless connectivity and 2) provide service continuity across the corridor.

Three new business models from an MNO perspective were proposed building on top of the CCAM service provision business models, based on the idea of using network slicing to support CCAM services (combining activities similar to those described in Steps 2 and 3 in Section 0**).**

1. **Collaborative business model**: the involved network operators establish an agreement between them stating that they collaborate to design an E2E slice that covers the entire corridor. This slice is (or multiple slices are) designed and customized in such a way that they meet the requirements of the offered services (typically an URLCC slice for safety-related services and an eMBB slice for infotainment and video streaming services). Within the 5G network architecture, there are two types of handovers that are slice-aware, being the Xn-based handover and the NG/5GC-handover, which allow the switch between base stations while preserving the connection to the same slice. Challenges resulting from this business model are i) the definition of cost-revenue sharing models that satisfy all the collaborating parties, and ii) the identification of responsibilities for maintaining and troubleshooting the joint network slices. The sharing model here is an active sharing model where slices of the network are shared. A slice consists of computing resources and storage on the core network side, a pipe on the transport network part and a pipe on the radio resource side as well (e.g., reserved piece of the operator's spectrum).

2. **Slice-as-a-service (SaaS) business model**: operators that intend to cover the corridor have to lease a network slice from the operators that cover different parts of the corridor where they do not have network infrastructure deployed. One of the technical challenges that the operators (who wants to provide services to the end user) face is how to establish the continuity between different slices coming from different operators. Imagine that we have the corridor that traverses Germany, Austria and Italy and an Austrian network operator wants to cover this entire corridor. In this case, this MNO needs to lease a slice from a German MNO and another one from an Italian MNO, these two slices should be integrated into its own slice to ensure the continuity of the provided services. Usually, the agreement that should be made between the involved operators should clearly state the type of the slice, the required KPIs, the QoS class, and the type of the resource allocation model for this slice (static or dynamic allocation). All these requirements can be described in a SLA.
3. **Non-collaborative model**: every network operator deploys its own network to cover the corridor independently from the others. However, the network deployment could be non-cost effective due to the huge investment needed to cover the entire corridor and the cost of the spectrum licenses that the network operator must buy or lease in all the countries that the corridor traverses. Additionally, the operator must comply with immense legal obligations and costs of operating a mobile network in an additional country, unless a harmonized European solution will be established. Besides, the roaming problem is just transferred to another place in the visiting country because sooner or later a switch between networks has to be executed.

In general, some challenges faced by the three discussed business models to be realized in the real world are i) the lack of network coverage near country borders and/or network interferences with foreign MNOs; ii) the adoption of different deployment strategies of 5G networks (in both non-standalone and standalone deployments) in the involved countries and the different timelines of these deployments; iii) the necessary support of E2E slicing by the involved MNOs networks, as well as MEC and finally iv) regulations that put restrictions on buying and re-selling portions of the spectrum.

5.2.14. SMART5GRID

The Smart5Grid project (https://smart5grid.eu/) focuses on the use of 5G technology and Network Applications as an enabler for the digitalization of the energy grids of the future.

The value network examined includes diverse stakeholders, coming from the energy vertical (TSOs, DSOs, RES producers), telecommunication service providers (MNOs, MVNOs, Private Network Operators), solution providers (TowerCos, Cloud/Edge providers, Neutral Hosts), and ICT SMEs (application developers, system integrators, consultancies).

The ecosystem approach, combining one stakeholder's offerings with those of other firms in order to better address customer's needs, helps cost-effectively and rapidly expand into new segments and markets. A critical success factor for an ecosystem is clear vision and direction, when a firm assumes the lead role with a clear understanding of customer needs.

As a first step, the potential of different groups of stakeholders to assume this 'prime' role in the development of a Network Applications ecosystem, leveraging the 5G network's programmability capabilities for serving various verticals' needs was analysed. This is similar to the activities described for Step 1 in Section 0.

Different ecosystem models were then examined, aligning with Steps 2 and 3, requiring different levels of engagement and investment, while also bringing different benefits to the 'prime' firm.

These models, in an increasing engagement order, are:

- **Solution partners**: where a firm enters into a partnership with a Solution Partner who is offering complementary services.
- **Open Ecosystem**: initiated by one large company, an open forum of firms, jointly addressing real-world challenges with innovative solutions. Relationships are formed between firms co-creating solutions, while addressing specific challenges.
- **Collaborative Ecosystem**: a firm opens up their assets through APIs, allowing their integration into member products and services to address new use cases and markets, while also benefiting from integrating their offerings in return. In a collaborative model, one leading company might provide direction.
- **Directed Ecosystem**: One company holding significant value in a certain segment, assumes the role of defining customer needs and new ways to serve them. In addition, they select new companies to enter the ecosystem and define the connections between ecosystem members.

5.2.15. EVOLVED-5G

The goal of EVOLVED 5G (https://evolved-5g.eu/) is to create new and realistic opportunities for generating competitive advantages for the European ICT sector and more specifically within the 5G market. Since EVOLVED 5G is targeting vertical industries, we are focusing on the 5G Vertical Ecosystem and the relevant roles. The roles in 5G Vertical Ecosystems include the relationship to the 5G Provisioning Ecosystem and the 5G Service Provider and are a disaggregation of the 5G Service Customer role. A first separation is between the role of the 5G Vertical Enterprise Customer, and the role which supports the Vertical Enterprise Customer to create and operate a solution in the vertical domain. From the 5G Service Provider side, the supporting role complements a 5G service and the role may be referred to as a complementor. Furthermore, this complementing role consists of many more specific roles, and therefore this main role is referred to in plural – 5G Vertical Complementors.

The 5G service provided by a 5G Service Provider is one component in such a vertical solution and can be directly purchased either by the Vertical Enterprise Customer or by the 5G Vertical Complementors. It should be noted that the complementors are not only seen as providers of components in 5G empowered solutions; in an ecosystem context, complementors are seen as critical holders and developers of knowledge, which in turn is the basis for innovation in the vertical domain.

The proposed methodology for the development of the business models consists of three steps (providing strong examples of the implementation of Steps 1 to 4 described in Section 0):

1. Business roles and business models as value networks identification: this can be achieved by firstly defining the different business roles and stakeholders involved, and secondly the interactions between them.
2. Business case viability study: A TCO model as well as revenue assumptions are used to evaluate the viability of the business cases. In addition, given the costs associated with different business models, performance-cost trade-offs can be identified, and their impact calculated.
3. Impact of new technologies on enterprises' business case: this step consists in investigating the impact of the innovative technology on the business case of single enterprises.

Step one in the EVOLVED 5G business analysis constitutes a Value network analysis (VNA), as the methodology for understanding, visualizing, optimizing internal and external value networks and complex economic ecosystems. Following this VNA analysis, EVOLVED 5G proposed four value network models for each use case [72]. More specifically these focused on:

- Provisioning of services based on Network Applications for Interaction of Employees and Machines, including a factory, chatbot application supplier, a mixed reality application supplier and an aircraft company.
- Provisioning of services based on Network Applications for FoF (Factory-of-Future) Operations including the factory, the Network App supplier, the M2M (Machine-to-Machine) platform and the vision software supplier.
- Provisioning of services based on Network Applications for Security Guarantees and Risk Analysis, which connect the network company with the Network App supplier, the SIEM (Security Information and Event Management) supplier and the transaction broker.
- Provisioning of services based on Network Applications for Production Line Infrastructure, which connects the factory with the Network App supplier, the platform and the robot supplier.

The vision of innovative and demanding applications and services is set to transform the telecom industry that will benefit from the same level of agility as what is available today in the IT world: time-to-market for new innovative services will be significantly improved, and the overall TCO will be reduced. TCO can be evaluated by means of a techno-economic analysis, which examines primary costs, benefits, risks, uncertainties, and timeframes to evaluate the attributes of technologies developed and produced. This constitutes the second step in EVOLVED 5G business analysis. The economic performance of the solutions will be calculated taking into account a life-cycle perspective, which considers initial costs, operational costs, maintenances, substitution, etc. A TCO model as well as revenue assumptions are used to evaluate the viability of the business cases. In addition, given the costs associated with different business models, performance-cost trade-offs can be identified, and their impact calculated. Finally, indirect benefits (i.e., non-monetary benefits for direct users or positive

effects on the economy or society) should be included in the business case evaluation, especially for public stakeholders.

In order to evaluate the economic viability of the selected scenarios (use cases) in the context of EVOLVED-5G a TCO model was built. The model considered both the Capital Expenditures (CAPEX) and the Operational Expenditures (OPEX), including overhead costs (e.g., marketing, helpdesk, etc.). CAPEX contribute to the fixed infrastructure of the company and they are depreciated over time. For a network operator, they include the purchase of land and buildings (e.g., to house the personnel), network infrastructure (e.g., optical fibre, IP routers) and software (e.g., network management system).

More information on the EVOLVED-5G methodology and Value Networks formulations and VNA can be found in [72].

5.2.16. 5G-ROUTES

5G-ROUTES (https://www.5g-routes.eu/) focuses on conducting advanced large-scale field trials of Connected & Automated Mobility (CAM) applications to demonstrate seamless 5G functionality across the Via Baltica-North corridor and thus accelerate the widespread deployment of 5G E2E interoperable CAM ecosystems and services in digitised shipways and motorways throughout Europe.

The business validation process in 5G-ROUTES is challenged with engaging and examining the field trials with a commercial and business lens in order to identify those solutions that are most likely to become commercially viable and can deliver the most immediate quantifiable value to the stakeholders involved in each Use Case.

The ultimate goal for the 5G-ROUTES business validation process is to create anticipatory business plans on applications for automotive, infotainment and maritime environment services. A collaborative and iterative process is applied that guides the Use Cases from initial ideas through to potential business impact and demonstrates how commercial actors supporting the Use Cases could move those outputs closer to commercial reality.

Great focus has been placed on the selection of the 5G-based products & services with high-commercialization potential. The related CAM and Transport and Logistics (T&L) markets in the context of 5G-ROUTES were analysed, giving an overview of 5G and vertical opportunities as well as the challenges to operating in the 5G ecosystem. Then a detailed examination of the key personas in each Use Case and the expected benefits to be gained from eventual large-scale uptake of the proposed scenario was carried out, with the help of technical experts, Use Case owners and related stakeholders. Furthermore, products and services suitable for commercialization together with partners who could lead that process were identified and a focused marketplace analysis and positioning analysis was carried out with a specific focus on the Baltic CEF2 Corridor. Dedicated workshops with T&L and CAM industry leaders helped arrive to Value Proposition Canvases and BMCs on applications for automotive, infotainment and maritime environment services. The final part of the commercialisation process involves deciding on the most appropriate route(s) to market for initial sales and the strategies for enhancing growth and product innovation over time. This analysis aligns well with Step 1 from Section 0 because of the focus on understanding value creation within the ecosystem.

The Business impact assessment of 5G-ROUTES is based on the analysis of the business models and value propositions through the application of the – adapted to the project needs – Multi-Actor Multi-Criteria Analysis (MAMCA [2]) methodology that will result to a broad screening of the business opportunities and their ranking, followed by a Cost-Benefit Analysis (CBA) that will evaluate in-depth the present value of the benefit streams for the selected business cases. This highlights two interesting tools that can be used in the implementation of Steps 2 and 3 from Section 0.

The involvement of the internal and external stakeholders serves a major role in the process. A first workshop focusing on the maritime domain was organised on November 29th, 2022 in Riga in conjunction to the 5G Techritory Event, under the theme Seamless connectivity over the sea and on harbours. The workshop was attended by 30 stakeholders, external to the project, stemming from Authorities, Maritime service providers and Technology developers. The final output of the workshop was the identification of the most promising services of the seamless connectivity technology for the maritime domain. The highest voted services in priority order were: 1. Rescue & Safety operations, 2. Real-time freight tracking services and 3. Fuel management and optimisation. Follow-up workshops for evaluating the identified services through the MAMCA method for each Use Case project cluster will be conducted during spring and summer of 2023, that will lead to the most prominent services to be considered for the Cost-Benefit Analysis study in 2024.

5.2.17. 5G-SOLUTIONS

The *5G Solutions for European Citizens* project (5G-SOLUTIONS, https://5gsolutionsproject.eu) aimed to validate that 5G can enable a wide range of forward-looking services with orders of magnitude of improvement over 4G. Validation has been achieved through 5G infrastructure facilities (e.g. 5G-EVE and 5G-VINNI) and twenty innovative use cases, trialled in the field across four industry vertical domains (Living Labs): Factories of the Future, Smart Energy, Smart Cities and Ports, Media & Entertainment.

5G-SOLUTIONS is unique in the context of the 5G-PPP projects by introducing a holistic assessment based on three intertwined aspects: technology; business; ethics and social.

Therefore, while measuring and assessing the technical aspects and enabling capacity of 5G networks (e.g. throughput, latency, device density), use cases were also evaluated in terms of future commercialisation potential (e.g. OPEX costs reduction, new business models) and by analysing ethics, legal, social concerns (e.g. privacy), which have an impact on the social acceptance of 5G technology, and, consequently, on its wider adoption and deployment.

5G-SOLUTIONS applied a business validation methodology that guides the development of the product and services within the Living Labs taking care of these intertwined dimensions. This methodology was carried out in iterative and incremental loops based on results from technological, business, and societal validation. The business validation process follows four steps and is adapted from the Lean Startup Paradigm [67], i.e., Customer Validation, Solution validation and alignment, Business model, and Growth trajectory. See also [3].

[2] https://www.mamca.eu/

The first step, Customer Validation, identifies and describes personas (e.g., vertical industry application and content providers) in terms of their needs, pains, task constraints and how these pain points are addressed with state-of-the-art solutions. Based on relevant concerns, new services are presented with informative material for non-experts (e.g., infographics and videos) making relevant personas aware of associated benefits and opportunities.

During the second step, Solutions validation and alignment, test and validation of the newly developed services and solutions are performed, allowing project teams to check the personas' expectations and addressing pain points in the different Living Labs. The assessment includes the Social Acceptance of Technology (SAT), a methodological framework defined within the 5G-SOLUTIONS project and belonging to the so-called Technology Acceptance Models. This methodology allows to assess the degree of acceptance from ethics and social perspectives, including user experience, value impact, social disruptiveness and trust (fundamental dimensions to be considered for a disruptive technology as 5G promises to be). This aspect is paramount for identifying potential barriers against the local deployment. This novel approach overcomes limits of current methodologies that usually focus on users' behaviour and acceptability on the user-experience side, without considering the systematic aspects of social impact. Social science tools and techniques (e.g. focus groups and surveys) are adopted for the collection and analysis of data.

The third step, Business Model, selects appropriate business models for each Living Lab through the identification and description of commercialisation actor(s), network of providers and partners, and value proposition for one or several customer segments. This step adopts tools and techniques from both business (e.g. empathy map) and social sciences.

The final step, Growth trajectory, identifies and defines a business plan for growth and sustainability and specify operational roadmaps, financial, people, marketing and sales for the chosen 5G services.

The phases of the business analysis methodology conducted in 5G-SOLUTIONS can be seen to closely follow Steps 1 to 4 discussed in Section 0. Both approaches consider similar core aspects, such as the ecosystem make-up, value propositions, business dynamics, business models, and considerations on revenue generation and costs.

This methodology was presented in many 5G-SOLUTIONS deliverables during the whole life cycle of the project, clarifying how the three dimensions are deeply necessary to perform a more exhaustive analysis of the 5G technology and its implications from the technological, business and societal perspectives. For the sake of clarity, this methodology allowed the 5G-SOLUTIONS project to assess a positive propensity of the technological solutions to be adopted (overall score 73%). Nevertheless, this methodology has potential room for improvement, especially considering some specific ethics and social dimensions.

Concerns, potential countermeasures, guidelines and policy options were collected by 5G-SOLUTIONS and presented in an updated corpus of its Research Ethics Protocol, to ensure compliance with the current and evolving legal, ethics and social framework. Based on this experience and lessons learnt, the 5G-SOLUTIONS project defined a policy brief for external communication (e.g., policy makers) entitled "Towards an ethically-driven design of 5G and beyond technology".

5.2.18. TERAFLOW - SPECIALIZED CONNECTIVITY ON-DEMAND

TeraFlow (https://www.teraflow-h2020.eu/) has hosted a discussion on principles for money flow schemes and business modelling enabling specialized connectivity across network operator domains. The work builds on the prior EU projects ETICS, 5G-Exchange (see e.g., [68] and [69]). The work-in-progress target is to develop better abstractions and business-level service concepts.

We propose a view that can be a shared base for many 5G and beyond business models. On top of this, we can build specialized connectivity services (SCS) on-demand across network operator domains. This, and the subsequent business models can be part of more complex service offerings and business models, such as the offering of Logical Networks-as-a-Service (LNaaS). To achieve inter-networking at the scale of the Internet with support for multiple modes of traffic (beyond "best-effort" Internet) is a challenge with today's tools, techniques, and business models [70]. Thus, it is important to be aware of stumbling blocks in the current operational and regulatory context that tend to predicate against providing these services. Such stumbling blocks and suggested ways to mitigate them are discussed further in [71].

[70] suggests future work on how to extend today's service concepts as producing regional network slices. The notion of "IETF network slice" is envisaged as a tool to enable and bring 5G network slices (defined by 3GPP) into an E2E use to enable and support LNaaS, in which SCS is integrated. From this, two levels of service concepts are seen, and their abstractions emerge: i) the Managed Quality Path (MQP) level deals with semi-static, but still dynamic, infrastructure-oriented topologies; and ii) the SCS level dealing with highly dynamic sessions (end-user flows or tunnels), given the already pre-established MQP level.

TeraFlow considers various service levels in different market segments for the anticipated E2E connectivity properties for 5G and beyond use case. Different traffic modes address the segments, in the context of delay performance, complemented by resilience levels.

Figure 27 [70] is an example illustration of market segments and indicates how there is already a requirement for all or most service levels. Even in the consumer segment we foresee the need for a "consumer critical" service level, e.g., in relation to eHealth. Moreover, Figure 27 suggests that some traffic modes can be shared or be common across segments (see [70] for more details.) Thus, the problem is already upon us: all market segments have demands across all service levels. Network operators must differentiate traffic in order to guarantee the different quality requirements in a scalable, resource efficient, and sustainable way, environmentally as well as economically. However, we anticipate that a smaller/limited number of traffic modes can support the requirements sufficiently in a metro or backbone transport network. Considering latency for instance, three modes may be sufficient (bounded, basic and elastic latency modes). A more fine-grained set of traffic modes may be required in the (radio) access network. These fewer traffic modes constitute the basis for inter-networking between network operators.

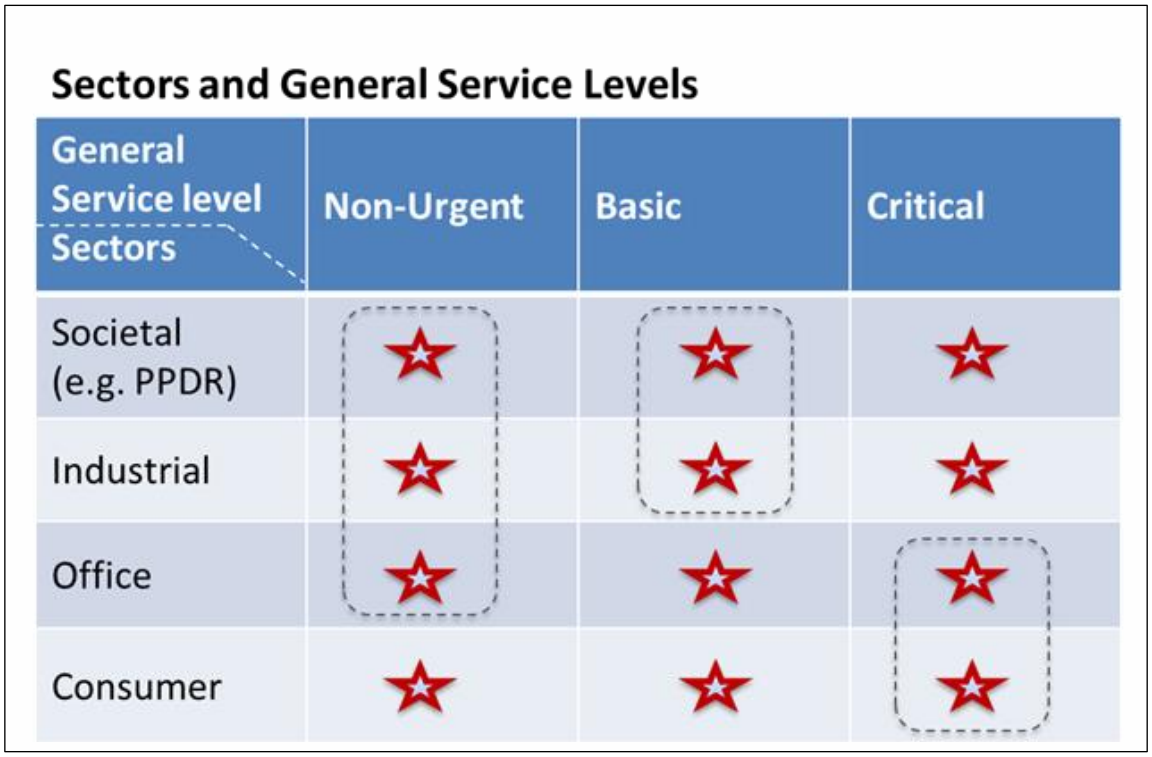

Figure 27 Exposing the Urgency of Different Service Levels According to User Type

Figure 27 and the discussion above highlight how both the ecosystem and the associated business dynamics of the various actors were analysed in this project. These are the core activities in Steps 1 and 2 from Section 0 and therefore the analysis discussed here is a strong example of how these steps could be implemented in practice.

The analysis of business dynamics was continued in the project leading to the development of a range of appropriate business models, which is fully aligned with Step 3 from Section 0. The resulting business models are described below, which is structured as follows: before we elaborate on inter-networking, we suggest business models in the simplest setting - On-net. Next, we suggest three more stages of increasing or widening complexity. If the first On-net stage can be properly solved, we predict that the next levels can follow by a natural extension of scope applying basic traffic modes.

- Stage 1: The On-net OAP case

Both Online Application Service Provider (OAP) and customer and user end-points are attached to the same Communication Service Provider (CSP), i.e., the service is on-net. The OAP service is located within the CSP, and the CSP ensures that SCS (service beyond non-urgent or basic) is provided between the OAP and the customer / user endpoint. Although a simple case, further important topics to be solved are:

(For more details, see - [70])

i. Application to Network Interaction
ii. Evolving Net Neutrality regulation
iii. APIs for service handling and support

iv. Support for several alternative money flows and business models as illustrated below.

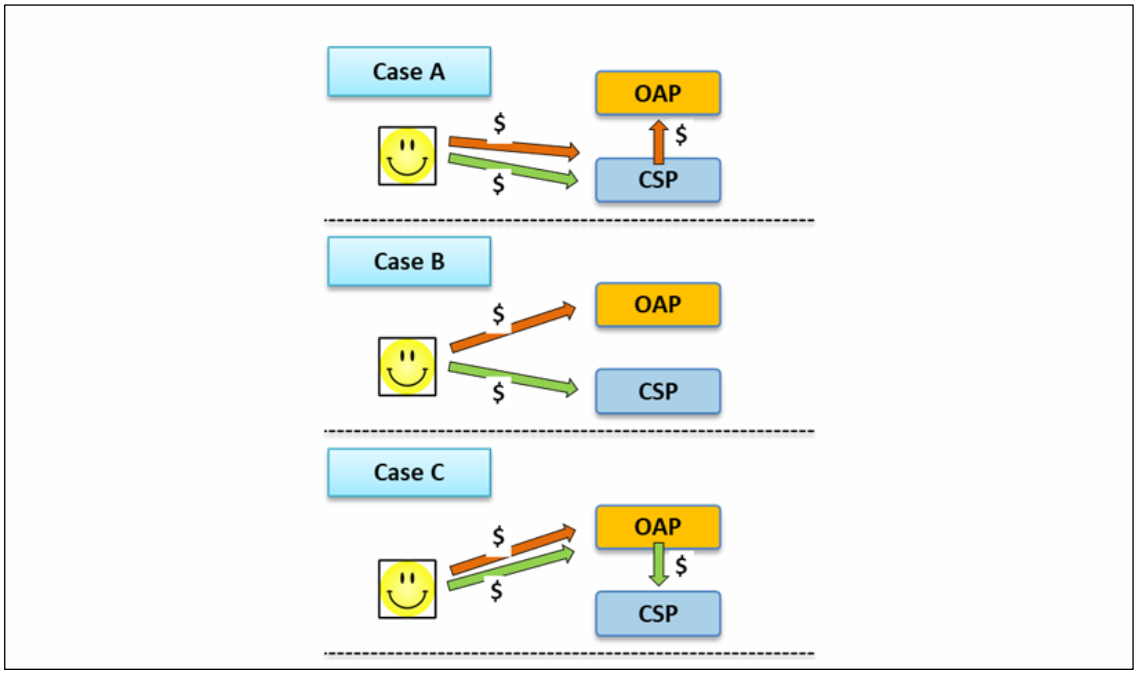

Figure 28 Customer oriented OAP – CSP money flow scenarios

As illustrated in Figure 28, several money flow patterns should be anticipated and supported. Case A allows the CSP to create additional value, and simplifications for OAPs' customer management (e.g., billing). Case B can be demanded by OAPs which require direct customer relationships. Some OAPs might prefer Case C, where the CSP sell to the OAP. Consider as well the situation where the CSP will move into an OAP role to offer Specialized Application Services complementing their own service offering portfolio.

[70] suggests the following CSP (network operator) outcomes from solving the above challenges and enabling SCS business models:

i. increased resource utilization,

ii. increased energy efficiency,

iii. predictable Quality of Experience (QoE) and customer utility

iv. unleashing a new generation of innovation potentials, in particular by SMEs that cannot offer specialized application services (SAS) by building own global backbone networks

The last point requires going beyond Stage 1, embarking on modes of inter-networking.

- Stage 2: Direct interconnection

The next stage is where the OAP wants to reach end-points in a different CSP domain where the OAP is not attached. However, the home "on-net CSP" has a direct interconnection with the remote CSP. This stage could include several sub-business models, such as: settlement free transactions; with settlement transactions (where there is asymmetry between the mutual offerings between the two CSPs); and also Initiating Party Network Pays. The latter must allow

one customer (end-point) to pay for two-way traffic. This will allow money flowing from one CSP domain into the other CSP domain.

- Stage 3: Transit NSP

The third stage is where the remote CSP is not directly connected to the "originating" CSP. This calls for services from a transit network operator (NSP). It is suggested that the transit NSP offerings are limited to the MQP level (see above). This will avoid complexity and cost related to the handling of the SCS session, which should not be required at the transit traffic exchange level.

- Stage 4: Hub-Role

Finally, a fourth stage enables further scaling and efficiency of business relationships and the supporting technical solutions. The aim is global reach and coverage, eventually evolving into global Internet scale. This can be achieved by inspiration from today's services offering in the space of Telco (public) voice and data interconnection and roaming (cf. GSMA IPX model) and the space of public Internet IP Peering and Transit traffic exchanges (cf. Internet exchange points, IXP models). In these models we see "Hub-Role"-models for SCS. Hub-role models should seek to avoid of unnecessary addition of cost and complexity.

6. CONCLUSION AND RECOMMENDATIONS

The business models in the 5G or beyond 5G era are not more complex than they were during the launch of 4G or 3G when assuming a simple continuation of service delivery, revenue generation and profit models. However, 5G and beyond network technologies introduce fundamental technological transformations compared to earlier generations, which dramatically increase the number of possible alternative business models. This creates significant complexity in deriving viable business models that ensure benefits for each of the enterprises in the ecosystem, while delivering the expected value to customers.

In the cases where a single enterprise aims to become part of an ecosystem to address the customer needs, the conventional business modelling approach for one focal firm is limited. It provides insufficient modelling of interfaces and interactions, of complementary benefits, and of risk and revenue sharing, while failing to describe E2Esolutions for a customer or industry appropriately.

This white paper is a practical guide to ecosystem business modelling in the context of 5G and beyond 5G networks. It consolidates current approaches and best practices in the field. The information herein is useful for a variety of professionals. For example, 1) business owners who have a deep understanding of their industry and market and want to recreate their business model to meet changing needs of their customers; 2) business consultants who specialize in developing sustainability-oriented business models and strategies for different types of vertical industries; 3) management consultants who work with businesses to analyse their operations and identify opportunities for improvement, including the design of new sustainability-oriented business models; 4) marketing professionals who understand the market and want to create a sustainability-oriented business model that meets the needs of targeted vertical customers.

We suggest that ecosystem business modelling can be performed in five steps. These steps embrace the ecosystem's evolutionary character as a whole and acknowledge the ambition to accurately model specific ecosystem aspects. The steps are: **1) Expanding** the scope and view of business modelling from enterprise to ecosystem by investigating alternative ecosystem formulations; **2) Focusing** on sustainable, viable business model formulations for a specific market environment, and for the focal company's business dynamics. This stage includes identifying the potential reallocation or disruption of current market positions; **3) Designing** and validating alternative ecosystem business models, carrying out the actual complex business model designs, and identifying the optimal one(s) against selected criteria (sustainability, value delivery, minimum costs, etc.) supported by tools with the ability to compare and analyse logically associated models; **4) Developing a business case** for the enterprise based on its specific value proposition, business model, and business plan; and finally **5) Iterating** the four steps over time, allowing for assessment and fine-tuning, re-designing and re-creating the business model when needed.

Three practical implementations of the 5-steps approach have been outlined. First, **value network-based approaches** tailored to the ecosystem dynamic nature are proposed. These approaches enable incremental analysis as follows: definition of alternative value-network representations of the ecosystem, segmentation of the complete ecosystem business model

into simpler sub-ecosystems, and cross-validation and assessment of the prevailing business models on the basis of sustainability. Second, the **V² PARK[3] approach** is structured around six interconnected building blocks referring to the complete ecosystem and the way it can achieve its goals: (1) the value proposition, (2) the stakeholders, (3) the activities, (4) the key capabilities, (5) the profitability model and (6) the value enhancement. V² PARK is a practical tool to implement the ecosystem steps approach and to study the effects of changes arising both on the actor level, and the ecosystem level through iterative updates of these blocks. Third, the **values-based and sustainability-oriented** approach to **ecosystem business modelling** is described. It requires some elicitation and elaboration of values and normative orientations among stakeholders to define shared sustainability values that ecosystem actors commit to. Building on this basic framing, ecosystem actors identify economic, social and ecological benefits to be created through their business models.

Several examples from recently concluded and still running H2020 5G PPP projects are provided and analysed. The analysis shows that similar approaches were applied, many of which are aligned with the business modelling principles described in this paper. These examples indicate the inherent complexity to properly define an ecosystem business model, along with individual business models of enterprises that are part of the ecosystem. However, these examples can also be used to support interested enterprises to identify focus areas of interest, and to develop a more detailed understanding of how value can be captured from a variety of vertical industries in the context of 5G and beyond 5G networks.

The paradigm shifts from linear value chains, with simple relationships between vendors and operators, to complex value networks, is inducing a significant hurdle to business model evolution. Such evolution must cater for the benefit of the ecosystem as a whole, and not only for the value proposition for a single enterprise. In fact, a business model will not succeed in the long term if it neglects the sustainability of the ecosystem in its social, economic, and environmental dimensions. Hence, we believe that sustainability-oriented ecosystem business modelling, as described in this white paper, will be pivotal for future successful business models in the 5G and beyond 5G era.

Currently, we can only guess how ecosystem business modelling will transpose into the 6G era. However, we can already assume that additional actor roles may emerge, providing new 6G applications, such as holographic communication, the metaverse, or intelligent sensing. Associated with these applications is the potential of generating new revenue streams and cost structures that can attract additional enterprises and stakeholders. In the context of the Smart Networks and Services Joint Undertaking, societal **key values** and **key value indicators** are guiding network research and innovation. Therefore, the work on business modelling must itself evolve as well, to better accommodate value-oriented design, into a continuous process of **value-** and **sustainability-oriented ecosystem business modelling.**

[3] V² PARK is Huawei's registered trade-mark for business model modelling system. Since May 13th 2022, Mark and Logo EU registration numbers are 18598713 and 18598723, respectively.

7. REFERENCES

[1] Hallingby, Hanne Kristine, Fletcher, Simon, Frascolla, Valerio, Gavras, Anastasius, Mesogiti, Ioanna, & Parzysz, Fanny. (2021). 5G Ecosystems. Zenodo. https://doi.org/10.5281/zenodo.5094340

[2] The 6G Infrastructure Association (6G-IA), Online: https://6g-ia.eu/

[3] The 5G Infrastructure Public Private Partnership (5G PPP), Online: https://5g-ppp.eu/

[4] Gavras, Anastasius, Durkin, Patrick, Fletcher, Simon, Hallingby, Hanne Kristine, & Mesogiti, Ioanna. (2020). Business Validation in 5G PPP vertical use cases. Zenodo. https://doi.org/10.5281/zenodo.3775405

[5] Mahmood, Kashif, Gavras, Anastasius, & Hecker, Artur. (2022). Non-Public-Networks - State of the art and way forward. Zenodo. https://doi.org/10.5281/zenodo.7230191

[6] United Nations Sustainable Development Goals. Online https://sdgs.un.org/goals

[7] https://www.investopedia.com/terms/b/businessmodel.asp

[8] https://meticulousbplans.com/2020/08/03/business-modelling-importance/

[9] TR3DENT, Business Ecosystem Modelling on the Rise. Online: https://www.tr3dent.com/business-ecosystem-modeling-on-the-rise/

[10] Teece, D. J. (2010). Business models, busi-ness strategy and innovation. Long Range Planning, 43(2-3), 172-194.

[11] Osterwalder, A., & Pigneur, Y. (2010). Business model generation. John Wiley & Sons

[12] Massa, L., Tucci, C., & Afuah, A. (2017). A critical assessment of business model research. Academy of Management Annals, 11(1), 73-104.

[13] Business Roundtable (2019). Business Roundtable Redefines the Purpose of a Corporation to Promote 'An Economy That Serves All Americans'. Online, retrieved 21.11.2022: https://www.businessroundtable.org/business-roundtable-redefines-the-purpose-of-a-corporation-to-promote-an-economy-that-serves-all-americans

[14] Bocken, N., Short, S., Rana, P. and Evans, S. (2013). A value mapping tool for sustainable business modelling. Corporate Governance, Vol. 13 No. 5, pp. 482-497. https://doi.org/10.1108/CG-06-2013-0078

[15] Breuer, H., Lüdeke-Freund, F. & Bessant, J. (2022). Managing Values for Innovation. Editorial paper to the IJIM Special Issue on Managing Values for Innovation, International Journal of Innovation Management Vol. 26, No. 05, 2201001, pp. 1-31; https://doi.org/10.1142/S1363919622010010

[16] EC/European Commission (2021). Research and Innovation at the heart of the EU Taxonomy. Online, retrieved 21.11.2022: https://research-and-

innovation.ec.europa.eu/news/all-research-and-innovation-news/research-and-innovation-heart-eu-taxonomy-2021-04-21_en

[17] Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance)

[18] EC/European Commission (2021). Sustainable finance package. Online, retrieved 21.11.2022: https://finance.ec.europa.eu/publications/sustainable-finance-package_en

[19] Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting (Text with EEA relevance)

[20] Breuer, H., Fichter, K., Lüdeke-Freund, F. and Tiemann, I. (2018) 'Sustainability-oriented business model development: principles, criteria and tools', Int. J. Entrepreneurial Venturing, Vol. 10, No. 2, pp.256–286.

[21] Stubbs and Cocklin 2008, p. 121 / Stubbs, W. and Cocklin, C. (2008) 'Conceptualizing a 'Sustainability Business Model''. Organization & Environment, 21(2), pp.103–127.

[22] Freeman, E. (1984) Strategic Management. A Stakeholder Approach, Pitman, Boston.

[23] Lüdeke-Freund, F., Carroux, S., Joyce, A., Massa, L., & Breuer, H. (2018). The sustainable business model pattern taxonomy – 45 patterns to support sustainability-oriented business model innovation. Sustainable Production and Consumption, 15, 145-162.

[24] Lüdeke-Freund, F., Breuer, H., Massa, L. (2022). Sustainable Business Model Design – 45 Patterns. Berlin: Self-Published.

[25] Project 5G-VICTORI: Vertical demos over common large scale field trials for rail, energy and media industries. Online: https://www.5g-victori-project.eu/

[26] Wikström, Gustav, Schuler Scott, Arianna, Mesogiti, Ioanna, Stoica, Razvan-Andrei, Georgiev, Georgi, Barmpounakis, Sokratis, Gavras, Anastasius, Demestichas, Panagiotis, Hamon, Marie-Helene, Hallingby, Hanne-Stine, & Lund, David. (2022). What societal values will 6G address?. Zenodo. https://doi.org/10.5281/zenodo.6557534

[27] Bouwman, H., de Reuver, M., Heikkilä, M. et al. Business model tooling: where research and practice meet. Electron Markets 30, 413–419 (2020).

[28] Zott, C. & Amit, R. (2015). Business Model Innovation: Toward a Process Perspective. In Shalley, C.E., Hitt, M.A., & Zhou, J. (Eds.), The Oxford Handbook of Creativity, Innovation, and Entrepreneurship, 395-406. Oxford University Press.

[29] Gartner, 8 Dimensions of Business Ecosystems. Online: https://www.gartner.com/smarterwithgartner/8-dimensions-of-business-ecosystems

[30] G. Darzanos, C. Kalogiros, G. D. Stamoulis, H. K. Hallingby and Z. Frias, "Business Models for 5G Experimentation as a Service: 5G Testbeds and Beyond," 2022 25th Conference on Innovation in Clouds, Internet and Networks (ICIN), 2022, pp. 169-174, doi: 10.1109/ICIN53892.2022.9758131.

[31] Project 5G ESSENCE: Embedded Network Services for 5G Experiences. Online: https://5g-ppp.eu/5g-essence/

[32] Project MATILDA: A Holistic, Innovative Framework for Design, Development and Orchestration of 5G-ready Applications and Network Services over Sliced Programmable Infrastructure. Online: https://www.matilda-5g.eu/

[33] Osterwalder, Alexander, Yves Pigneur, Patricia Papadakos, Gregory Bernarda, Trish Papadakos, and Alan Smith. 2014. Value Proposition Design. New York, NY: John Wiley & Sons.

[34] LEANSTACK, Lean Canvas. Online: https://leanstack.com/lean-canvas

[35] Upward A. (2013). Towards an ontology and canvas for strongly sustainable business models: A systemic design science exploration. (Masters of Environmental Studies/Graduate Diploma in Business + Environment, York University, Faculty of Environmental Studies and Schulich School of Business), 1–1116 (i–xxii). Retrieved from hdl.handle.net/10315/20777

[36] Jones P. H., Upward A. (2014, October 15–17). Caring for the future: The systemic design of flourishing enterprises. The Third Symposium of Relating Systems Thinking and Design (RSD3), Oslo, Norway, 3(1), 1-8.

[37] Upward, A., & Jones, P. (2016). An Ontology for Strongly Sustainable Business Models: Defining an Enterprise Framework Compatible With Natural and Social Science. Organization & Environment, 29(1), 97–123. https://doi.org/10.1177/1086026615592933

[38] Kurucz, Elizabeth & Colbert, Barry & Lüdeke-Freund, Florian & Upward, Antony & Willard, Bob. (2017). Relational Leadership for Strategic Sustainability: Practices and Capabilities to Advance the Design and Assessment of Sustainable Business Models. Journal of Cleaner Production. 140. 189-204. 10.1016/j.jclepro.2016.03.087.

[39] Tiemann, I. & Fichter, K. (2015). Geschäftsmodellentwicklung mit dem Sustainable Business Canvas: Moderationsleitfaden zur Durchführung von Workshops. Oldenburg, Berlin: Universität Oldenburg, Borderstep Institut.

[40] Joyce, A.; Paquin, R. & Pigneur, Y. (2015): The triple layered business model canvas: a tool to design more sustainable business models, ARTEM Organizational Creativity International Conference, 26-27 March 2015, Nancy, France.

[41] Joyce A., Paquin R. L., The triple layered business model canvas: A tool to design more sustainable business models, Journal of Cleaner Production, Volume 135, 2016, Pages 1474-1486, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2016.06.067.

[42] Foxon, Timothy J., Catherine SE Bale, Jonathan Busch, Ruth Bush, Stephen Hall, and Katy Roelich. "Low carbon infrastructure investment: extending business models for sustainability." Infrastructure Complexity 2 (2015): 1-13.

[43] Breuer, H. (2013). Lean Venturing. Learning to Create New Business through Exploration, Elaboration, Evaluation, Experimentation and Evolution. International Journal of Innovation Management. Vol. 17, No. 5 (22 pages). Imperial College Press. https://doi.org/10.1142/S1363919613400136

[44] Breuer, Henning and Lüdeke-Freund, Florian, Values-Based Innovation Framework -- Innovating by What We Care About (May 1, 2015). The Proceedings of the XXVI ISPIM Conference 2015 -- Shaping the frontiers of innovation management, 14-17 June, Budapest, Hungary, Available at SSRN: https://ssrn.com/abstract=2620564

[45] Breuer & Lüdeke-Freund (2017a). Values-Based Network and Business Model Innovation, International Journal of Innovation Management, Vol. 21, No. 3, Art. 1750028 (35 pages).

[46] Breuer, H. & Lüdeke-Freund, F. (2017b). Values-Based Innovation Management. Innovating By What We Care About. Palgrave Macmillan: London.

[47] Timber Haaker, Harry Bouwman, Wil Janssen, Mark de Reuver. 2017. Business model stress testing: A practical approach to test the robustness of a business model. Future. 89. 14-25.

[48] Allee, V. (2002). A Value Network Approach for Modelling and Measuring Intangibles.

[49] Neokosmidis I. et al. (2017) Are Small Cells and Network Intelligence at the Edge the Drivers for 5G Market Adoption? The SESAME Case. In: Boracchi G., Iliadis L., Jayne C., Likas A. (eds) Engineering Applications of Neural Networks. EANN 2017. Communications in Computer and Information Science, vol 744. Springer, Cham. https://doi.org/10.1007/978-3-319-65172-9_58

[50] Bouwman, H., Faber, E., Haaker, T., Kijl, B., De Reuver, M. (2008). Conceptualizing the STOF Model. In: Bouwman, H., De Vos, H., Haaker, T. (eds) Mobile Service Innovation and Business Models. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-79238-3_2

[51] Project SESAME: Small cells coordination for multi-tenancy and edge services. Online: https://5g-ppp.eu/sesame/

[52] Project 5G-VINNI: 5G Verticals Innovation Infrastructure. Online: https://www.5g-vinni.eu/

[53] Jorge Carapinha, George Darzanos, Costas Kalogiros, Katia Papakonstantinopoulou, Demi Karadimou, Antonis Dimakis, George D. Stamoulis, Paul Deans, Paul Muschamp, Giuseppa Caruso, Anastasius Gavras, Diego Lopez, Hanne-Stine Hallingby, Christos Tranoris, Kostis Trantzas, Zoraida Frias, & Jose Felix Hernandez. (2021). D5.4 Governance models, Sustainability analysis and Roadmap (1.0). Zenodo. https://doi.org/10.5281/zenodo.5909701

[54] George Darzanos, Costas Kalogiros, Katia Papakonstantinopoulou, George Stamoulis, George Zois, Paul Muschamp, Giuseppa Caruso, Anastasius Gavras, Maria Barros Weiss, Hanne Kristine Hallingby, Håkon Lønsethagen, Diego Lopez, & Jose A. Ordoñez-

Lucena. (2019). D5.1 Ecosystem analysis and specification of B&E KPIs. Zenodo. https://doi.org/10.5281/zenodo.3345665

[55] EC/European Commission (2021). EU taxonomy for sustainable activities, retrieved 19.04.23: https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

[56] Bleicher, K. (1994). Integrative management in a time of transformation. Long Range Planning, Vol. 27, No. 5, pp. 136–144.

[57] Jungk, R. & N. Müllert. (1996). Future workshops: How to Create Desirable Futures, 2nd Ed., London: Institute for Social Inventions.

[58] Weisbrod, M. & Janoff, S. (2010). Future Search. 3rd Edition. Berrett-Koehler.

[59] Breuer, H. & Lüdeke-Freund, F. (2018). Values-Based Business Model Innovation: A Toolkit. In: Moratis, L., Melissen, F. & Idowu, S.O. (Eds.). Sustainable Business Models, pp. 395-416. Springer.

[60] Kantor, Miroslaw & Wajda, Krzysztof & Lannoo, Bart & Casier, Koen & Verbrugge, Sofie & Pickavet, Mario & Wosinska, Lena & Chen, Jiajia & Mitcsenkov, Attila. (2010). General framework for techno-economic analysis of next generation access networks. 2010 12th International Conference on Transparent Optical Networks, ICTON 2010. 1 - 4. 10.1109/ICTON.2010.5549342.

[61] Zimmerman, A., Wunderlich, J., Buchner, G., Müller, L., Armstrong, K., Michailos, S., Marxen, A., Naims, H., Mason, F., Stokes, G., & Williams, E. (2018). Techno Economic Assessment & Life-Cycle Assessment Guidelines for CO2 Utilization. https://doi.org/10.3998/2027.42/145436

[62] E. Brandsma, H. K. Hallingby and P. H. Lehne, "A 5 G health use case calling for ecosystem strategies: Resolving technology and business dependencies necessary to kick off the market," 2021 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), Porto, Portugal, 2021, pp. 323-328, doi: 10.1109/EuCNC/6GSummit51104.2021.9482489.

[63] Janez Sterle, Ioanna Mesogiti, et. al. "A Framework to Support the Deployment of PPDR Services Across Edge and Cloud Domains". In: Maglogiannis, I., Iliadis, L., Macintyre, J., Cortez, P. (eds) Artificial Intelligence Applications and Innovations. AIAI 2022 IFIP WG 12.5 International Workshops. AIAI 2022. IFIP Advances in Information and Communication Technology, vol 652. Springer, Cham. https://doi.org/10.1007/978-3-031-08341-9_4

[64] Project ETICS: Economics and Technologies for Inter-Carrier Services. Online: https://cordis.europa.eu/project/id/248567

[65] Project 5GEx: 5G Exchange. Online: https://cordis.europa.eu/project/id/671636

[66] Lønsethagen, Håkon; Lange, Stanislav; Zinner, Thomas; Øverby, Harald; Contreras, Luis M.; Ciulli, Nicola; et al. (2022): Towards Smart Public Interconnected Networks and

Services – Approaching the Stumbling Blocks. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.19690570.v1

[67] Still, K, "Accelerating Research Innovation by Adopting the Lean Startup Paradigm. Technology Innovation Management Review," 7(5). 2017.

[68] 5G Exchange, Business and Economic Layer. 5G Exchange Deliverable D2.3, May, 2018

[69] Håkon Lønsethagen. (2019, February 19). Multi-Layer Modular Business Models for 5G. Zenodo. https://doi.org/10.5281/zenodo.3351295

[70] TeraFlow, Final requirements, architecture design, business models and data models. TeraFlow Deliverable, D2.2, Feb 2023, https://teraflow-h2020.eu/library/deliverables

[71] Lønsethagen, Håkon; Lange, Stanislav; Zinner, Thomas; Øverby, Harald; Contreras, Luis M.; Ciulli, Nicola; et al. (2022): Towards Smart Public Interconnected Networks and Services – Approaching the Stumbling Blocks. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.19690570.v2

[72] Evolved 5G Deliverable D6.2 Technoeconomic analysis and Stackeholders engaging (Intermediate) https://evolved-5g.eu/wp-content/uploads/2023/02/EVOLVED-5G-Deliverable-6.2-v1.0-final.pdf

8. ABBREVIATIONS

Abbreviation	Full text
5G PPP	5G Public Private Partnership
6G IA	6G Smart Network and Services Industry Association
AI	Artificial Intelligence
BIK	Business Innovation Kit
BM	Business Model
BMC	Business Model Canvas
BVME	Business Validation, Models and Ecosystems
CAPEX	Capital Expenditure
CDN	Content Delivery Network
COTS	Commercial Off the Shelf
CPE	Customer Premises Equipment
CRM	Customer Relationship Management
CSP	Communication Service Provider
DLT	Distributed Ledger Technologies
DOI	Digital Object Identifier
FBC	Flourishing Business Canvas
GSMA	GSM Association
ICT	Information and Communication Technologies
MNO	Mobile Network Operator
NFVI	Network Function Virtualisation Infrastructure
NPN	Non-Public Network
OAP	Online Application Provider
OPEX	Operating Expenditure
OTT	Over-the-top
PMSE	Programme Making and Special Events
RPM	Remote Patient Monitoring
SBC	Sustainable Business Canvas
SCNO	Small Cells Network Operator

Abbreviation	Full text
SDG	Sustainable Development Goal
SIP	Sustainability Innovation Pack
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SW	Software
TCO	Total Cost of Ownership
TMOG	Technology, Market, Organisation, Governance
TRL	Technology Readiness Level
UHF	Ultra-High Fidelity
UN	United Nations
VMT	Value Mapping Tool
VPC	Value Proposition Canvas
VSCNO	Virtual Small Cells Network Operator

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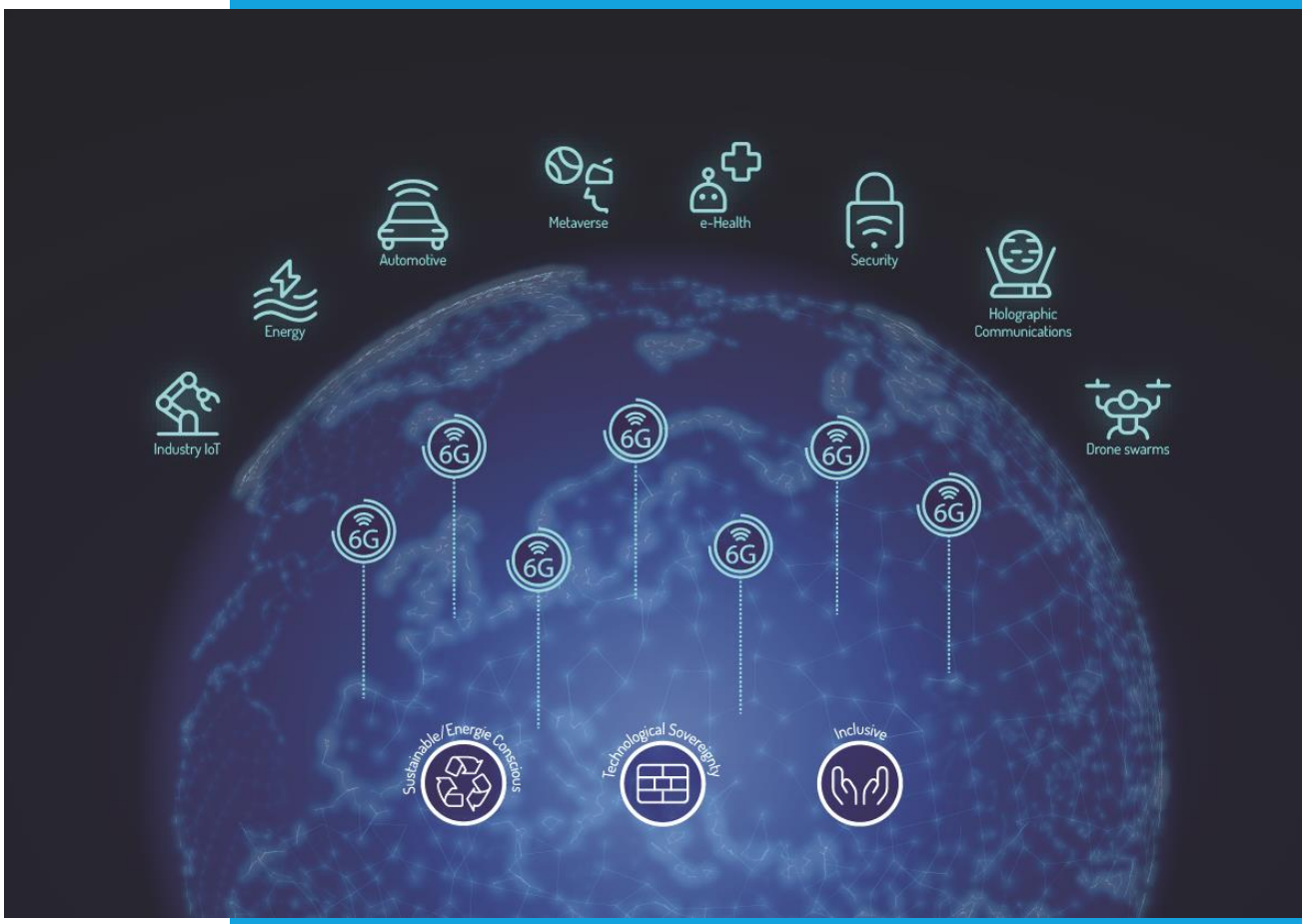

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