Business Value and Social Acceptance for the Validation of 5G Technology

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***Abstract* — User experience, Social disruptiveness, Value impact, and Trust are fundamental dimensions to be considered for a disruptive technology as 5G promises to be. Indeed, while the race of 5G is moving towards the deployment all over the world, more and more opinion of citizens on this technology is demonstrating lack of awareness in terms of benefits (as well as risks) on 5G technology, and often this results in raising barriers and hindering the local deployment. This definitely impacts on development and business plans as well. To this extent, it plays a main role in how these four dimensions are defined, evaluated with the relevant stakeholders, prioritized and finally validated. This paper describes the on-going experience that the 5G-SOLUTONS project is performing with respect to the business validation of 5G technology, by adopting and improving a structured and holistic methodology, where the Social Acceptance of Technology (SAT) provides a conceptual framework for modelling social concerns related to technology acceptability. 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.**

Keywords* — *5G Technology, Business Validation, Social Acceptance of Technology, Trust, Quality of Experience

I. Introduction

The "fifth generation" of telecommunication systems (5G) is destined to be one of the founding and enabling elements for the worldwide economy and digital society of the next decade, interconnecting billions of devices and individuals with unprecedented performances. While this claim remarks technological and business advantages that have been properly perceived by the public opinion, on the other hand it is not clearly presenting benefits from other different perspectives (e.g. societal) that might contribute to trigger wider interest from citizens, facilitate awareness and mitigate distrust. Indeed, part of the public opinion is perceiving 5G as a disruptive technology that might harm human beings, debating that 5G networks will use higher band frequencies (such as millimeter wave) and that new networks require a wider deployment of radio base stations and antennas, with a consequent greater exposure to electromagnetic fields. To this extent, in the last years Europe has seen an increased number of nationwide protests against the 5G technology and its deployment. However, 93% of European citizens own a personal mobile phone in 2017 [1], and 73% of European citizens used a mobile device to connect to the internet in 2019 [2], and the numbers are constantly growing. Leveraging on these contradictory behaviours, the main actors in developing the 5G network should move, driven by a number of social dimensions and including – inter alia - uncertainty in the communication of technology and dissonant perceptions. So, while campaigners exploit the uncertainty on harmfulness of 5G for raising barriers and debating official reports from the World Health Organisation, on the other hand, it is increasingly becoming a social priority to ensure sustainability to future generations.

Europe has a relatively high attributable per capita mortality rate (about 130/year per 100,000) that is explained by the combination of poor air quality and dense population, leading to exposure that is among the highest in the world [3]. The world's population will reach 8.5 billion by 2030, with the number of people living within cities rising to 5 billion [4], and European cities will account for 75% of the population, consuming 80% of the EU's energy. In such a scenario, European and worldwide society might have the opportunity to revise its economic growth with a more sustainable green innovation path and redesign smart cities and infrastructures for the next decades. 5G technology promises to overcome the limits of current infrastructures, designed decades ago for a smaller number of urban dwellers, and enable new capabilities for addressing the needs of future generations. COVID-19 pandemic has definitely amplified the need for rethinking our daily lives and boosting the acceleration of sustainable development goals. Communication networks are a fundamental block for implementing this revolution, and for this reason it is important to design and evaluate them with all the relevant stakeholders, by introducing an innovative structured and holistic methodology, including the business validation and the social acceptability of technology as well.

The analysis described in this paper turns out to be particularly original not only because it combines the business validation process with a social acceptance study, but also because it was conducted within a cooperative project (H2020

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5G-SOLUTIONS – https://www.5gsolutionsproject.eu/) in which there are actors with different roles in the development of the 5G (Network operators, start-ups, small and medium enterprises, universities, corporations) guaranteeing the independence and completeness that a study conducted by a single player would not achieve. In more detail, the next chapters present the Business Validation Process (chapter II) and its underlying methodologies (i.e. LEAN Start-up and Social Acceptance of Technology). A special focus will be given to the model defined in the Social Acceptance of Technology (chapter III) for describing the relationships among social concerns and disruptive technologies. The validation methodology requires the comparison of development targets with feedback from external stakeholders, consequently the engagement of stakeholders plays a main role and it is described in chapter IV. While chapter V presents how the analysis of feedback contributes to improve the development and business plans, and the paper is closed with considerations on next steps (chapter VI).

II. Business Validation Process

The 5G-SOLUTIONS consortium is an ecosystem of public and private actors involved in joint research and innovation in 20 use cases within four verticals/Living Labs (LLs): Factory of the Future, Smart Energy, Smart Cities/Port, and Media and Entertainment. 5G-SOLUTIONS applies a business validation methodology that guides the development of the product and service solutions in these use cases with respect to user and commercial aspects. The method is executed hand in hand with the method for technological research and validation with feedback loops based on results from technology and business trials. The business validation process follows four steps and is adapted from Still [5], see Fig. 1.

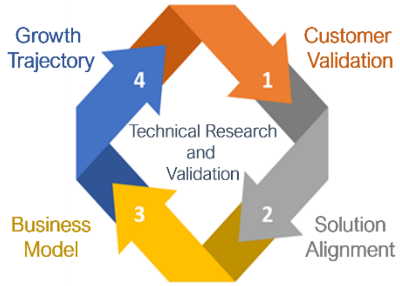

Fig. 1. Business validation in 5G-SOLUTIONS project

The integrated business-technological validation methodology is built on state of art innovation process principles such as design thinking, lean start-up/agile way of work with build-measure-learn (develop, prototype and test) feedback loop on a minimum viable product (MVP) in order to speed the process of learning as quickly as possible how to develop a product or a service that meets the customers' needs and desires [6]. The methodology has been disseminated broadly across other 5G EU Research projects and discussed as a basis for best practice for business validation in 5G vertical use cases [7].

A. Stage 1 - Customer validation

This stage involves description of personas (vertical industry application and content providers, end user subscribers and other stakeholders), their needs/problems/pains, their task constraints and how these pain points are solved today. A tentative 5G based solution is described and presented to the customers. The expected willingness to pay for this solution is based on the benefits it can provide for the stakeholders/personas after launch and implementation. These benefits and opportunities are evaluated through key performance indicators (KPIs) that arise from the 5G solution, e.g. reduced cost (CAPEX and/or OPEX), revenue generation from new products/markets, time saved from removal of specific tasks in an existing process flow, improved safety from early warning of potential risks/problems in assets, improved accessibility from more users that can access a critical service, and improved quality of experience e.g. on a mean opinion score (MOS scale) [8] with no interruptions.

B. Stage 2 - Solution validation and alignment

It involves testing of whether the developed MVP actually meets the personas' expectations and solves the pain points in the different use cases. The degree of social acceptability of this new technology is included here, to evaluate expectations from the social perspective and considering dimensions such as environmental footprint, social justice, and trustworthiness. Moreover, the test pilots of the MVP solution validate the predefined business KPIs. If the solution does not meet these KPIs, a new MVP has to be developed based on updated specifications via a feedback loop. A subset of use cases solutions within the different industry verticals/living labs will be clustered/aligned around a joint solution that consortium actors can commercialize in the vertical marketplace.

C. Stage 3 - Business model

This stage involves selecting a business model for the 5G solution being developed. This means describing how the commercialization actor(s) and their network of sub providers/partners creates, markets, and delivers a profitable 5G solution to one or several customer segments [9]. This work will be using qualitative value proposition and business models canvas frameworks. Other key tasks carried out during the business model stage analyse the "Strengths, Weaknesses, Opportunities, and Threats" (SWOT), product and service portfolio, patent alignment and competitors. A total cost of ownership framework can be applied here to identify the costs related to technology development and operations (including training) of products and services as well as costs to replace or upgrade at the end-of-life cycle. In addition, in-depth information will be gathered through interviews, focus groups and surveys verifying satisfaction and usability of the solutions offered, e.g. Quality of Experience (QoE).

D. Stage 4 - Growth trajectory

The final stage includes the articulation of a business plan for growth and sustainability and specify operational roadmaps, financial, people, marketing and sales for the chosen 5G product solution. The business plan will further explore the business models with indeterminate parameters, prices, costs, sales volumes etc. For those verticals close to exploitation, each commercial solution/service will have a lead commercialization partner, who has experience and expertise in bringing solutions to market within their respective vertical industry, and he/she will own the execution of the business development plans that are created within 5G-SOLUTIONS project. Other value chain/ecosystem stakeholders from the 5G consortium will function as sub suppliers etc., based on their roles and deliverables of the value chain. PESTEL analysis tool supporting the barriers for implementation and launch of the clustered 5G solution in selected industry vertical/market segments are also used.

The technological validation of the MVPs is performed in relation to predefined trial cycles during the 5G-SOLUTIONS project using 5G facilities established in Italy, Norway and Greece. Trials for user and business validation are performed in the same cycles' providing feedback on the MVPs using methods such as interviews, focus groups, webinars and surveys. Here the use cases solutions are presented, e.g. for smart city use cases [10] with the opportunity to provide initial qualitative in–depth insight into the balance of need vs. product feature vs. benefit. As a follow up, a more comprehensive quantitative survey with questions and defined scores can be distributed for confirmation of whether the initial results also comply for a larger sample of customers.

III. Social acceptance of technology

A. *The conceptual model and its four bubbles*

The Social Acceptance of Technology (SAT) is a methodology that has the ambition of evaluating the degree of social acceptability of novel and potentially disruptive technologies, as 5G promises to be, by considering the legal, ethical, and societal perspectives, and to become the best practice for thorough yet feasible research on the topic. The methodology combines qualitative and quantitative tools and techniques, and takes into account the acceptability perceived by all the stakeholders involved in the development, validation and adoption of a technological innovation process. SAT is the evolving result of research experiences carried out by the research and development department of CyberEthics Lab., where reference models of social acceptance have been considered. Most of these models are considering acceptance from specific perspectives, such as usability [11], while others try to build models from different dimensions, such as the "unified theory of acceptance and use of technology" [12]. This last is focused mainly on users' behaviour and acceptability on the user-experience side, without considering the systematic aspects of social impact.

However, the several forms by which a given technology is designed, communicated, and perceived by stakeholders have to take into account the socio-economic and political aspects on which technology itself is deployed and will likely impact. As a matter of fact, by considering the socio-technical systems [13], society and technology are strictly linked and shape one another, defining a common and parallel evolution path, where impact of cultural values on technology acceptance might play a relevant role [14].

The assessment of all these aspects, in a holistic process as the one defined in 5G-SOLUTIONS for the technical-business validation, can provide a complete synoptic for comprehending the social acceptability of a technology.

The modularity of this methodology, agnostic with respect to the specific analysed technology, ensures a high scalability and flexibility, making feasible its application on a wide range of technologies, allowing *i*) technology providers to get insights on issues impacting the social acceptability and value impact of their technologies, since the design phase and enabling a co-design process; *ii*) policy makers and public entities to early capture more or less likely issues of public perception.

Four building blocks, called "bubbles" and representing the fundamental areas of evaluation, lay the foundation of the conceptual model of the methodology, i.e.: User-Experience, Social Disruptiveness, Value Impact and Trust.

User-Experience (UX): This first bubble aims to understand how the user interacts with the technological product, also considering the content conveyed by brand communication and marketing. It analyses and describes the subjective and psychological factors that characterise the experience of individuals with respect to a new technology. Users' subjective perception of uses, benefits, and risks affects their degree of satisfaction and acceptance of a technological object, process, or infrastructure. Benefits deriving from the technology's usage, addressed needs, enabled capabilities, as well as technology constraints and potential risks are defined during the design phase. These are relevant parameters of the three evaluative structures, and a poorly executed communication process of the technology can definitely impact these parameters, distort users' perception, and raise dissonant expectations. Users' subjective perceptions can be aligned with design intentions through the identification and engagement of all the interested stakeholders since the concept design of the technology, as recognised by best practices [15].

Social Disruptiveness: This bubble investigates how and to what extent the technology under consideration reframes internal societal relations, from the perspective of impact both on production and socio-political processes and relations. It is aimed at measuring, evaluating, and predicting the combination of three factors: the expected spread of a technology; how much it will lead to a significant change from the point of view of production processes; and how much it will impact on society as a socio-technical system, changing societal dynamics. Social expectations (measured by socioeconomic indicators) and institutions/policies (assessing the supportive or hostile behaviour of institutional players, civil society to technology adoption) are two fundamental evaluative concepts, as well as the novelty of technology and environment readiness.

Value Impact: This bubble evaluates the extent to which the technology concerned and – perhaps even more importantly – the company producing it, comply with shared social values. This bubble considers not only cultural values, but also those value-sensitive aspects that determine impacts on the market, as well as specific needs and beliefs of specific stakeholder groups (e.g. citizens, scientists, policy makers) in society, such as knowledge sharing (e.g. transparency), social justice (e.g. rights and attention to vulnerability), business (e.g. distribution and fiscal policies).

Trust: The final bubble evaluates the extent to which the technological tool is considered reliable according to the individual user and to society as a whole. Trust can be defined as an evaluation of facts, circumstances, and relationships that allows someone to rely on their own or others' capabilities, and which generally produces a feeling of security and serenity [16]. Since reliability is influenced by elements included in the other constructs, the Trust Bubble takes into account elements from the other bubbles as well. Trustability (e.g. political and human-in-the-loop) and societal impacts (e.g. legal compliance) are relevant concerns evaluated in this bubble. Trustability is a fundamental issue for the spread and the acceptance of a technology.

An important point to underline is that SAT does not evaluate the objectiveness of the parameters: for example, the benefits that an object could bring in the users' life. SAT remains on the perceptual level measuring what users and stakeholders think about the usefulness of the technological object. The same goes for the value-related evaluations: SAT is not concerned with judging the rightness of the values conveyed by a technology, instead measures the users' perception of the value impact. Each evaluative bubble of the SAT model is structured in three levels, according to a data processing schema: *i*) evaluative structures, *ii*) contextualizer, and *iii*) bubble score. These levels are shown in Fig. 2, where the UX bubble is modelled.

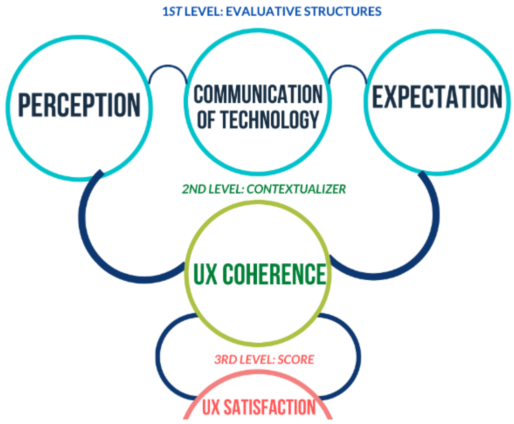

Fig. 2. UX bubble and its three-levels conceptual structures

The first level "evaluative structures" contains conceptual constructs that model and measure specific aspects considered in the bubble, e.g. in the "User Experience" bubble, one of the evaluative structures is considering the "Perception" dimension. Each evaluative structure contains parameters for measuring the specific dimension (e.g. "Risk Perception" is a parameter of "Perception"). Each parameter will use a qualitative or quantitative evaluation method (such as the intersectional method or a composite index). The rationale behind the first level of each bubble is that it offers a priori acquisition and assessment of the elements considered relevant to evaluate SAT, but without contextualizing them on the basis of the involved users or the stakeholder groups.

In the second level of each bubble, it is added a contextualizer. This is an evaluative structure, similar to the ones in the previous level, but with a different goal: to check if (and in what way) the considerations expressed in the first level are relevant for the user or the group of stakeholders involved.

For the sake of clarity, it could be considered an example for the "disruptiveness" bubble. Supposing to evaluate the disruptiveness of a solution based on 5G technology enabling a huge number of persons to interact with one another during a live event (e.g. concert, sport event or a manifestation), by producing, sharing and consuming high-definition media contents in real-time. While the first level evaluates and suggests if this technology is a true social game changer, the second level and the contextualizer will lead us in answering to questions such as "Do the network and computing infrastructure, the legal and regulatory framework around privacy, users' skill-levels, allow this 5G technology to spread and be properly used?". To this extent, the contextualizer allows to evaluate if an awe-inspiring technology might be essentially disruptive and be supported by the current socio-technical environment.

On the side of the "value impact" bubble, the sensitivity of a given society with a given culture must be considered as a "contextualiser", in order to understand if the impact on a certain set of values will be perceived as relevant by the stakeholders.

Finally, the third level contains the construct of bubble score, which will indicate for each bubble *i*) whether a technological product, service, or process produces user satisfaction (UX bubble score); *ii*) whether we expect product, service, or process to be disruptive (Social disruptiveness bubble score); *iii*) whether we believe it has a strong impact on social values or on a specific community of stakeholders (Value impact bubble score); and *iv*) whether it is considered trustable by individual users and communities (Trust bubble score).

Being technology-agnostic, the SAT methodology is built on a wide set of evaluative structures and properties in order to theoretically address the social acceptance assessment of any technology. However, the SAT methodology offers modularity, scalability and flexibility so that it can be applied incrementally and iteratively following an agile process, such as integrated business-technological validation process defined in 5G-SOLUTIONS. For this reason, a preliminary stage to the application of the methodology, called "SAT test drive", is setup. Essentially, this is an initial screening to narrow down the SAT elements to utilise to those with greater relevance for the technology being assessed. The test consists in the creation of an extremely focused pilot study regarding the application of the technology in question. Based on this pilot, the constructs and parameters of the model will be processed and qualitatively and quantitatively determined, giving a contextualized evaluation.

IV. Validation Test-Drive Setup

A. *Selection of the use case for the test-drive*

5G-SOLUTIONS validation team has set up the "SAT test-drive" by selecting the "On-site Live Event Experience" use case of the "Media & Entertainment" living lab, among a first set of four relevant and mature use cases. This use case has been used as a testbed for identifying the most relevant constructs and parameters to be used for the business value and social acceptance validation.

This use case considers live events, such as sports venues, music concerts, public demonstrations or cultural exhibitions. Locations of these live events are usually characterised by a high density of users and devices requiring network access (i.e. more than 10,000 individuals per square kilometers, almost 5 times more than the density of Rome). These individual users represent proactive actors that, while are part of the event, interactively and in real-time they produce and share images, live videos and recorded clips, as well as watch other participants content or background content related to the event. At the same time, event organisers and media companies need very high performances from the network resources, for video transmissions and live television coverage, especially when dealing with high-definition (HD) media contents that require very high bandwidth and controlled latency. Moreover, Law Enforcement Agencies and Emergency Operators have to ensure security and safety for live events and their users, consequently these special operators require ad-hoc conditions (e.g. higher priorities and security constraints) for accessing network services especially in these congested areas.

Without these prerequisites and the lack of reliable network access, on-site live events might threaten its users and could expose lives at risk. However, it might be difficult to ensure expected quality of experience and live event success.

Current technologies, including 4G technology, could only partially enable on-site live events, with many unsolved limitations, including inter-alia limited support for high user density (no more than 2,000/km^2) and no guarantee on the quality of service.

For this use case, 5G technology is deputed to be the main driver with its improvements with respect to 4G, i.e. less than 10 milliseconds of latency (25 times lower), up to 10Gbps of bandwidth (100 times more), at least 10,000/km^2 of density (minimum 5 times more), support of quality of service (QoS) to provide tailored connection features (based on network slicing). This technology can ensure *i*) end-users and their user experience, when uploading/streaming/downloading high-definition quality media contents from smartphones; and *ii*) all the involved stakeholders and personas (including special operators) when requiring ad-hoc and/or on-demand specific network conditions, and primarily reliability and resilience.

B. *Identification of the key performance indicators*

For the assessment of this test-drive, the 5G-SOLUTIONS project team has identified a preliminary list of ten relevant key performance indicators (KPIs), balancing both the business value and the social acceptance of technology aspects, as well as their selection is justified by the specific interests of stakeholders engaged in the use case and its execution phase. These KPIs are called BiSa indicators, where Bi stands for Biz (business value), and Sa stands for social acceptance. The BiSa indicators are defined as:

- Bi1 – Costs and Revenues: Costs (e.g. CAPEX, OPEX) reduction and/or revenues (e.g. based on new service offered) improvement;
- Bi2 – Efficiency: Efficiency in processes (e.g. time saved, waste reduction, energy consumption reduction);
- Bi3 - Resilience: Adaptability associated to easier and faster (re)configuration of services and products (e.g. rate of reuse of same resources), even in the face of threats;
- Bi4 – Accessibility: Number of users that can access a high-value or critical service with a specific QoS (e.g. no interruptions);
- Bi5 – UX Satisfaction: Number of satisfied individuals with their user experience;
- Sa1 – Safety: Risks/threats/incidents (e.g. impacting human beings) reduction;
- Sa2 – Environmental Footprint: Improved environmental carbon footprint;
- Sa3 – Privacy and Data Protection: Improved mechanisms for ensuring that personal data is collected and processed in compliance with the EU ethics and regulatory framework;
- Sa4 – Social Justice: Social impacts related to issue of justice (e.g. impartiality, equal opportunities, inclusiveness, vulnerable groups);
- Sa5 – Trustworthiness: Improved perception of trustworthiness by the users of technology.

Each BiSa indicator can assume a score between zero and ten, according to a 5-point Likert-based scale (i.e. very low – very high).

C. *Triple evaluation phase*

For the validation assessment, the use case is submitted to a triple evaluation phase: *i*) first internal evaluation where expected targets are defined by the project; *ii*) external evaluations with stakeholders' engagement; *iii*) final internal evaluation with measurements from the running trials of the use case. Results from the triple evaluations will provide data for a comparative analysis that will produce the final validation assessment score, and feedback for improving the next development and deployment phases.

A first internal evaluation has allowed to obtain the BiSa radar diagram for the use case "On-site live event experience" (see Fig. 3). This diagram remarks the balanced expectations in terms of business value and social acceptance, as well as shows the margins for improvements of each KPI.

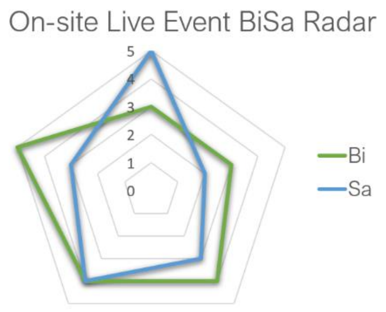

Fig. 3. First internal assessment of the use case with BiSa indicators

V. Stakeholders' Engagement for 5G Technology Assessment

As mentioned above, the stakeholders' engagement for the assessment of 5G technology is based on best practices, such as PMBOK[15]. Essentially, the engagement is performed by considering the stakeholders of each specific use case, so for the test-drive "On-site live event experience" they include individual users, event organizers, media companies, network operators, law enforcement agencies and emergency operators.

For their engagement it is necessary to identify appropriate communication tools, so that they can have a comprehensible overview of the use case in terms of context, needs, features, benefits, risks and improvements with respect to the state of the art. For this reason, the 5G-SOLUTIONS is experiencing the creation of distilled documentation and illustrative material, so called "informative material", that will be submitted to the stakeholders' groups for raising awareness on the use case background and the 5G technology.

This informative material is built by collecting text and pictures from project technical specifications and communication material, that is later peer-reviewed from the use case owners in order to guarantee accuracy of the diffused information. Technical jargons are avoided in the informative material, while brief case study sheets, presentations, videos and infographics are strongly preferred (i.e. applying the elevator pitch).

After this first phase, the validation team invites small groups (around 20 personas) with representatives of the stakeholders' group for presenting the informative material, and consequently debate and collect pain points and as-is product solutions. Finally, for gathering external evaluation of the use cases based on business and social acceptance validation methodology, specific questionnaires are submitted to the group. Reports and feedback will be used for refining the development and business plans. This process defined for the engagement of stakeholders for the 5G technology assessment is represented in Fig. 4.

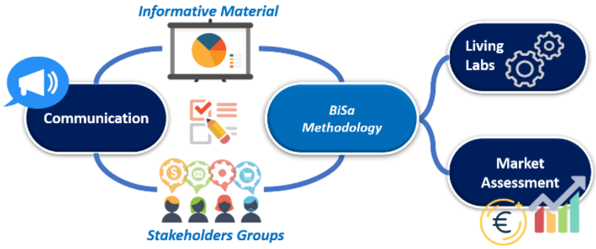

Fig. 4. Stakeholders' engagement in the assessment process

Comparing the expected internal project targets with the stakeholders' feedback and measurements from living lab experiences represents a useful tool for evaluating the dissonance between the expectations of the project team with the ones of the external world, establishing a feedback for improvements. This methodology, especially if applied since the technology conceptualisation, can allow to govern and manage a co-design process together with the stakeholders (human-in-the-loop model).

This assessment process can be reiterated recursively, by obtaining at each iteration further details from stakeholders' feedback, improvements in the informative material and finally more focused inputs for technology development (e.g. prioritization of solution improvements, update solution specification for next test cycle) and later inputs for the market assessment (e.g. commercialization activities for target users/consumers) as well. Scalability and modularity of this methodology allows to repeat the assessment by engaging wider groups with additional and new representatives, deriving benefits in terms of accuracy of the results.

VI. Conclusions

This paper presents results from ongoing work with a novel methodology for validation of business and social acceptance in 5G research and innovation project, improving methodologies and models from the state of the art. This methodology provides tools and techniques, based on project management best practices [15] as well, that allow governing and managing the whole validation process, the stakeholders' engagement, the communication, and integrating itself with the technological validation and market assessment as well.

After the test-drive, the authors envisage to proceed with the experimentation of this methodology and the validation process by considering other relevant use cases from the four living labs of the 5G-SOLUTIONS project, in order to confirm the flexibility and modularity of the methodology, i.e. applicability of selected BiSa indicators for all the use cases or their replacement with relevant indicators available from the complete model.

Results from next steps are planned to be presented in public webinars and events organised by the 5G-SOLUTIONS project, engaging representatives from the 5G Public Private Partnership (5G-PPP) as well.

Acknowledgment

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