6G Infrastructure Association
Vision and Societal Challenges Working Group
Societal Needs and Value Creation Sub-Group

What societal values will 6G address?

Societal Key Values and Key Value Indicators analysed through 6G use cases

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Abstract

As we now embark on 6G development it is important that outstanding societal challenges are considered, and that value creation is ensured. This White Paper outlines how a technology development driven from the perspective of societal values can complement the usual performance-driven perspective. A set of use case areas, representing new possibilities in 6G, are identified from published sources mainly from EU funded ICT-52 research projects. These use case areas are then analysed with respect to societal key values that can be impacted by future technology developments. This entails defining Key Value Indicators (KVIs) that can be used for monitoring and validating the impact on key societal values, and vice versa, for studying how societal Key Values can be enabled by impacting the technology development in certain directions.

We find that the studied use case areas can indeed be connected to societal key values that can be enabled by future 6G networks, and that it is possible to define KVIs to estimate this value impact. We propose a continued development of this analysis involving relevant subject matter experts and the application of this analysis on upcoming 6G research projects.

Executive summary

In this paper, a societal value-driven approach to technology development building on the concept of KVIs is outlined, which complements the current performance-based approach using KPIs. KVIs are indications of a relevant societal KV that can be enabled or is in some way impacted by future technology, specifically the novel services of 6G.

6G is set to support various novel as well as evolved use cases and application domains that shall meet important societal needs and create value in multiple ways. New interactions will be made possible, between humans and machines, which are expected to benefit citizens, societies, and industries. These benefits are to be maximised, and at the same time risks are to be monitored and mitigated.

Using KVIs when developing 6G serves two purposes:

- to demonstrate and validate that 6G would contribute to meeting societal needs, and
- to impact technology development in a value-benefitting direction.

A KVI analysis which can be used as a framework for including value concerns into the technology development has been outlined, and a first evaluation that can serve as starting point has been made. The proposed KVI analysis should preferably involve relevant experts for relevant formulation and evaluation of KVIs. This is especially important to avoid inflation of societal value terms, which would lead the industry into a sort of unwanted “value-washing”.

Observing the use cases described and beyond, including reference projects and undertakings, it becomes a well recognisable trend that the aim for offering sustainable services within European cities and metropolitan regions is being recognised by most relevant stakeholders, and simultaneously the needed systematic approach is not yet existing. This White Paper aims to fill that gap with a toolkit for use case assessment in terms of added value and feasibility. Especially applying the KVIs as a method for deep understanding of novel technology-based solutions aimed at citizens’ needs, having been served until now by applying old-fashioned and less resource efficient methods, is a helpful methodology the current publication is aiming to transfer to a broad public.

The framework for defining value creation and increase within the context of 6G integration and operation in the field of smart services in cities and metropolitan areas, elaborated here, is to be tested and applied in future strategic and applied research undertakings. This White Paper is presented as a trigger and invitation for further discussions and collaboration to improve this analysis. The framework and methodology are also relevant for evolved 5G, and interaction and results transfer between the more near term (higher TRL) and the long term (lower TRL) analysis can be considered.

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1 Introduction

The development of the 6th generation of cellular communication networks (6G) has been gaining momentum since 2020, culminating in several large research projects ongoing in Europe and other regions [1]. A proposed timeline for 6G is commercial availability around 2030 based on standardization from about 2025 onwards, with regulatory activities starting already now.

In preparing for 6G, the Smart Networks & Services (SNS) Joint Undertaking [2] between 6G-IA and the European Commission has launched an ambitious work programme based in a European vision of 6G [3], which will fund a wide range of coming 6G research projects. The 6G-IA vision of 6G is based in an analysis of the future network needs and highlights three areas that the 2030 network should address:

- Societal values as mentioned by the UN Sustainable Development Goals (SDGs) [4] and the European Green Deal [5].
- Strategic autonomy and technological sovereignty reflecting European values [6].
- A human-centred approach to innovation that negotiates corporate and social value.

The position of this White Paper is that 6G will be an integral part of the future society, and innovators should *aim at addressing societal challenges, pain-points, and needs, creating value for society*. This means complementing a performance-based approach to 6G technology development, implementation, and operation, with a societal value-based approach. In addition, this document provides guiding material to justify and support the development of 6G.

Echoing the development and deployment of 5G technologies, various stakeholders will be impacted and involved by 6G: end users, community groups, society, and businesses. 6G innovators must anchor in their solutions in their perspectives, demonstrating *the added value 6G will bring to our lives*. This is of course important from the 6G industry's point of view since these developments represent value propositions for new technologies, ecosystems, and business models. Further, it is of key importance for understanding the demands from social acceptance and adoption, and the wider social responsibility expected of the 6G industry. Impact will not always be positive, and innovators need to identify potential risks that their solutions pose. This is especially important for 6G in its role as critical infrastructure.

In this White Paper, the societal Key Values (KVs) that 6G can address are presented along with a roadmap for identifying societal impact and human needs, and towards measuring the value of 6G solutions in the form of Key Value Indicators (KVIs). To study how 6G can create value and meet needs, use cases from published research sources have been considered, and clustered in representative societal, personal, and business use case areas. The purpose of this strategic outlook analysis is twofold: (1) to identify potential social and societal values of 6G technology development, and (2) to provide examples of a societal value-driven approach to technology and system design. The former ensures social acceptance of future technology and draws attention to societal value in research and innovation work, whereas the latter steers technology design and development.

Understanding value in the 6G era requires an understanding of ecosystem dynamics. Where stakeholders collaborate and bring resources for a 'greater good', a value proposition is needed for these investments [7]. A mindset extension is required, to frame business objectives in terms of societal objectives. Societies struggle to balance fast-paced decision-making, stakeholder engagement, and a commitment to democratic values [8]. This is why identifying KVs and leveraging KVI analysis is a way to ensure that these priorities are consistent over time. The way we do business in Europe is changing, and being able to empirically demonstrate the value of solutions will be essential criteria [8][9]. By underlining the societal value-based ambition behind 6G development and by proposing a framework for future assessment of value, this work can serve as a guide for coming European 6G research projects and strategic undertakings.

2 Key values

The UN SDGs [4] provide a versatile framework for societal values as covered by the related three areas of *Environmental sustainability*, *Societal sustainability*, and *Economic sustainability*, as illustrated in Figure 1. The 17 SDGs are mapped to a set of 169 targets on which the goals can be assessed.

However, as these are formulated for states, they need to be interpreted for the ICT industry to study its impact. Further, it is useful to separate between two forms of impact: a *direct* impact where the cost of building and operating networks is studied through e.g., material and energy consumption; and an *indirect* impact where positive and adverse effects caused by the usage of networks are studied. The study of the direct impact is often done under the aim for "Sustainable ICT", whereas the indirect impact is often referred to as "ICT for sustainability" or the "enabling effect" [10]. This paper will focus on the indirect impact of 6G networks, considering their role and stakeholders within existing and novel use cases.

Graphics by Jerker Lokrantz/Azote

Figure 1. Illustration of the UN SDGs ordered in three areas (based on [4][11])

Along with the UN SDGs there are naturally other societal values that 6G can address. Current European strategy describes a need to reconcile social and market interests under a "social pillar" [9]. Professional bodies also provide motivation; the Next Generation Mobile Networks Alliance (NGMN) recently advised that future technology development must demonstrate benefit to society and end users, as well as creating value for mobile network operators (MNOs) [12]. Existing projects are also starting to identify societal values that they are able to support as part of their work. In many cases these additional values are partly covered by the SDGs, but less pronounced. 6G should offer services to human end users, to enterprises and industries, and to stakeholders in many sectors of society. Beyond sustainability, these end users may further expect technology to directly improve their lives, through providing access to things we want and empowering us in society, and in private and work situations.

For the purpose of the analysis in this White Paper, we define societal KVs to mean values important to people and society that may be directly addressed or indirectly impacted by future network technology, and to specifically be considered for 6G. Table 1 contains a set of example KVs that will be considered in the following chapters, along with an indicative mapping of them to the UN SDGs and EU strategic goals, and additional (non-exhaustive) definitions. For each KV an indication is given of how the value can be assessed.

Table 1. Examples of societal KVs to be targeted by technology and how to assess

Key value	Societal added value and relation to UN SDGs	Assessment
Environmental sustainability	KV related to SDGs #6, 13, 14, 15	Objective evaluation by experts
Societal sustainability	KV related to SDGs #1, 2, 3, 4, 5, 7, 11, 16	Objective evaluation by experts and representatives
Economical sustainability and innovation	KV related to SDGs #8, 9, 10, 12	Objective evaluation by experts
Democracy	KV related to SDGs #5, 10, 16, as well as linked to securing “Political equality in a pluralistic, liberal society” and to “Protecting EU democracy from external interference” [6]	Objective evaluation by experts and representatives
Cultural connection	KV related to SDG #10, 11, 16, linked to fostering production and access to cultural products (e.g. art - movies, music, literature-, history, trends/new culture domains, e.g. games)	Subjective evaluation by representatives
Knowledge	KV related to SDGs #1, 4, 5, 8, 10, 17 especially referring to access to quality education systems and equal educational opportunities	Objective evaluation by experts
Privacy and confidentiality	KV related to SDG #16; as privacy is an institutionally protected value related to the claim of individuals or institutions to decide on if, when, how, and to what extent information about them is communicated to others. and at the same time ”the appropriate use of data relating an individual to a context” [13][14]	Subjective evaluation by representatives
Simplified life	KV reflecting UN SDGs #3 (primarily), #9, #11	Objective evaluation by experts and representatives
Digital inclusion	KV reflecting partly UN SDG #10, in people being part of the digital world [6][15]	Objective evaluation by experts, and subjective evaluation by representatives
Personal freedom	KV referring to a positive freedom of an individual to control and impact you’re his/her own life	Subjective evaluation by representatives
Personal health and protection from harm	KV related to SDGs #2, 3, 6, 13	Subjective evaluation by representatives
Trust	Feeling of confidence, faith and explainability in the way that advanced systems (e.g., AI-driven decision making) may impact humans	Objective evaluation by experts, and subjective evaluation by representatives

3 Key Value Indicators

KVIs offer one way for innovators to stimulate and enable societal KVs while building new solutions, representing a strategic shift towards “Big Democracy” rather than “Big Tech” [16]. KVIs differ from Key Performance Indicators (KPIs) in that they provide deeper insight into human-related factors and can require conversations and creativity to emerge [17]. They are similar to quality standards that encourage a ‘top-down’ approach where project goals are clarified before metrics can be assigned to them [17].

KVIs are all about understanding the context within which technologies must operate, and identifying the resulting societal value these developments offer. To understand such environments, feedback must be sought from the different stakeholders active within them; a human-practice approach that seeks expertise from people can be particularly useful where there are substantial ethical and legal challenges [18], which may be unknown. KVIs draw from a model of “societal readiness” [19] that asks whether technologies are ready to be integrated into society, rather than whether society is ready for a new technology. Under the societal readiness model, a technology is valuable if it is practical, effective, augments innovation in practice and supports systemic change to society’s benefit. A solution that operates in isolation is of less value.

A technology is valuable for society if it enables KVs, and KVIs are useful because they provide metrics to demonstrate this value. Methodologically, this is an opportunity to use methods that are often recommended in technology development, e.g. use of interviews or focus groups to test user reactions to a prototype. These methods produce qualitative data that can be useful and provide specific insights. This data can be difficult to quantify if a team is unused to working with such data. KVIs offer a way to collect broader perspective, contextual information and human insights or expertise [20], and leverage qualitative and quantitative metrics to illustrate value.

One way to identify KVIs for societal KVs is to ask how to measure success of addressing a pain point with a solution. This is a common question in business when delivering to address users and customers’ needs. For KVIs, the question must be extended to ask how to measure that a stakeholder has achieved the anticipated societal value. For instance, Public Protection and Disaster Relief (PPDR) stakeholders may hold that improved time and accuracy for incidents is a KVIs. The causal chain from a technology to KVIs are usually not straightforward, not the least because societal challenges often are so-called wicked problems [21]. Even though the indicator can be easy to measure, the causality should be qualified by domain experts.

Currently, KVIs are being sought to demonstrate that 6G innovation projects are considering societal impact, and as a first step in wider conversations with society regarding the impact of new technologies [2]. They are also used as evaluation criteria within 6G network design [15].

3.1 Defining and evaluating KVIs

A KVI should be a measurable quantity or requirement that in some form provides an estimate of an affected KV. It should thereby be possible to formulate targets using KVIs, e.g., in the form of *number of users of a service fulfilling a condition* or *perceived fulfilment of required value using a service*. A specific KV could be estimated through multiple KVIs.

The formulation of KVIs should preferably be done together with subject matter experts relative to the KV, e.g., from social or human sciences for KVIs related to social sustainability or personal values, or from the natural sciences or technical domain for KVIs related to environmental and economical sustainability, and from medical sciences for health related KVIs. In addition, the relevant stakeholders, representing end users and parts of society, should be involved in defining KVIs. That said, provisional KVIs formulated by experts from the ICT domain serve as starting points at early Technology Readiness Levels (TRLs) [22] that could be updated at a later stage.

It is a key quality for the KVIs defined for a KV that they should be measurable or estimable in some form. The method and time for doing this would depend on the nature of the KV. Some KVIs are assuming a deployed network with established use cases, and these can therefore only be measured or estimated at a later time, i.e. at a later period of technology development at higher TRLs. Still, these can provide useful proof-points for early-stage development and be used for setting long-term objectives. Other KVIs are based on personal experiences and should be possible to estimate through interviews, questionnaires, trials, or similar at lower TRLs. Still others may require analysis by subject matter experts, which in some cases can be performed at lower TRLs and therefore impact the early development. The options for evaluation of KVIs are summarized in Table 2.

Table 2. Methods for evaluating KVIs

Assessment type / phase	**Lower TRLs (early in the technology development)**	**Higher TRLs (later in the technology development)**
Subjective assessment	Trials, experiments, interviews	Questionnaires, interviews, focus groups
Objective assessment	Assessment by subject matter experts	Measurements on deployed networks

3.2 KVI analysis

As was outlined in the introduction, the purpose of a KVI analysis is twofold: (1) to be able to point at expected value benefits from technology usage, and (2) to provide a basis for a value-driven design of technology. The proposed KVI analysis consists of four steps, outlined in Figure 2, that moves from the defined KVs to KPIs that can be used to provide measures on how to enable these KVs. It is important to underline that the KVI analysis is meaningful when performed for a specific use case area, and the resulting KVIs are therefore to be seen in this context.

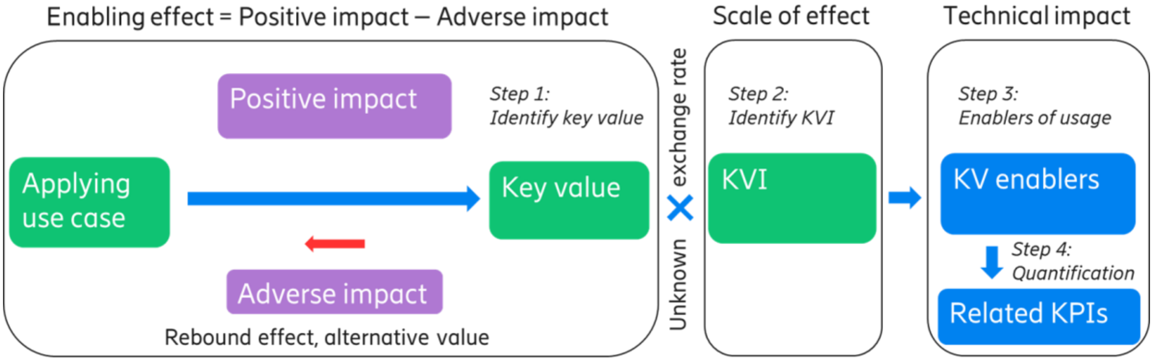


Figure 2. Overview of the KVI analysis in four steps.

The methodology steps are further elaborated below, using a *Global e-health service* (Section 4.3) use case as an example of how it can be applied.

Step 0 – Identifying societal pain points

For a use case, this step includes an analysis of the pain points or problems stakeholders have. Key aspects of the analysis are “How they are currently addressing these points”, and “what value they could gain from having these pains solved”. In the *Global e-health service* use case example: *Hospital/health authorities*: hospital care is expensive, especially in rural areas; *Person*: does not trust technology – feels safe only when taken care of in hospital; *Society/all*: health care is not delivered fast enough or cost-efficiently.

Step 1 – Identifying relevant, positively affected KVs

For a use case, this step requires to analyse which KVs could be potentially impacted / affected net positively. This can be simply to associate a set of KVs with the use case and assess if the effect of one usage instance would enable a mainly positive impact, taking into account also adverse impacts such as rebound effects. The enabling effect on a KV can be described as the positive impact minus the adverse impact. But, quantifying the impact is very challenging, and outside the scope of this analysis. It is enough to understand if it is net positive or negative, which should suffice to fulfil the first target of the KVI analysis; to be able to point at expected value benefits from technology usage.

Positively impacted KVs in the *Global e-health service* use case example: *Societal sustainability; Personal health and protection from harm.*

Step 2 – The scale of effect – identifying the KVI

For a use case, this step refers to finding a measure on how successful it has potential to be, how widespread the usage would be. The usage would depend on a use case's popularity and availability, which would in turn determine the scale of effect. How large part of a population, of a society sector, or of an industry could realistically be served or affected through this use case? The basic rationality here is that there is a *multiplicative effect* at hand; more of a use case with positive effect on value will lead to more of the impacted value. This measure of the scale of effect yields what the multiplied factor to the net positive effect of step 1 is. The measure of this scale factor is then the KVI. It is important to stress that a precise relation between the KVI and the enabled effect is not within reach – the *exchange rate* is unknown - as there is some unknown factor determining how much value each usage of a use case enables. However, for most purposes it should be enough to consider the multiplicative effect on the enabled value.

KVIs in the *Global e-health service* use case example: *Number of active e-health users*; *Average gain in health care access; Decrease in number of hospital stay-overs,* etc.

Step 3 – Determine the enablers and blockers of usage – the KV enablers

For a use case, this step will aim to analyse what would determine its usage, meaning its popularity and availability. What are the key factors that would spread a use case and scale up the enabled value, or block its further establishment? These factors are usually related to fulfilling the technical requirements, ensuring the service coverage, adapting to existing ecosystems, and having an attractive value proposition to the end user. These are thus KV enablers. The important idea is that improving KV enablers should eventually create value, without specifying exactly what the exchange rate is. Since the KVI should be an indication of value it can only be measured once networks have been deployed and use cases have been established. Therefore, KVI can be used to demonstrate value but cannot be directly used to design for value. In contrast, the KV enablers can be used exactly for impacting the technical design of future networks.

KV enablers in the *Global e-health service* use case example: *Global service coverage for basic MBB*; *Low cost of connectivity*; *Availability of secure cloud services*; *Availability of subsidized devices,* etc.

Step 4 – Quantification of KVIs with KPIs

For a use case, this relates to analysing which KPIs would provide useful estimates of the related KVI. Depending on the KVI, this may not always be possible or meaningful. With KPIs it should be clear how and to what extent a certain KVI is improved, such that if a KPI is improved this should eventually enable value, again without specifying the exchange rate. The KPIs can be used as set technical numerical targets for future networks in order to enable KVs. Finally, this step should be able to fulfil the second aim of the KVI analysis; to provide a basis for a value-driven design of technology.

KPIs in the *Global e-health service* use case example: *User monthly cost of service*; *Fraction of world population covered by e-health service*; *Energy consumption of devices,* etc.

4 Use case analysis

To study the indirect impact from future networks, a set of technology-based service application scenarios – use cases – have been identified from published sources, these being mainly research projects within Horizon 2020, as well as 6G vision documents. These use cases, of more narrow scope, have been clustered into six larger use case areas, presented in Table 3. The areas are intended to focus on the 6G impact from three main perspectives: a *societal* perspective to capture the interests of communities; a *personal* perspective to illustrate the interests of individual users; and a *business* perspective to represent the interests of industries and vertical applications. In addition, the use case areas are selected to reflect the KVs defined in Chapter 2.

Table 3. Selected use case areas

Perspective	Use case area	ICT-52 project or other sources
Societal	1: Emergency response & warning systems (Section 4.1)	BroadWay [23], GSMA [24]
	2: Smart cities with urban mobility (Section 4.2)	AI@Edge [25], Hexa-X [26], Airmour [27]
Personal	3: Personal health monitoring & actuation everywhere (Section 4.3)	Hexa-X [26], Reindeer [28]
	4: Living and working everywhere (Section 4.4)	Hexa-X [26]
Business	5: Assistance from twinned cobots (Section 4.5)	Hexa-X [26]
	6: Sustainable food production (Section 4.6)	6GBrains [29], Hexa-X [26]

The method used in this white paper starts from the selected use case areas in Table 3. Each use case area can be analysed in two directions, as illustrated in Figure 3.

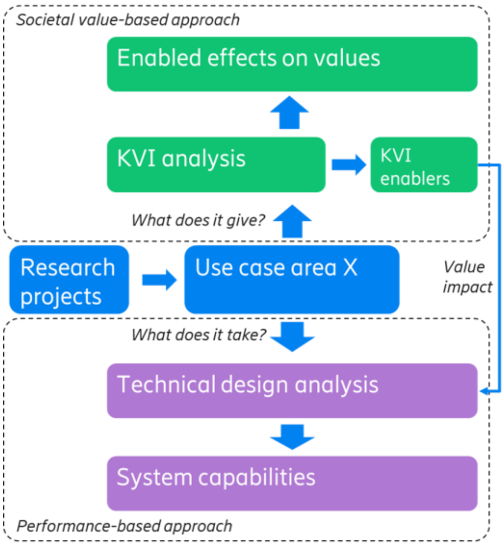


Figure 3. Use case analysis

A societal value-based approach - "*What the use case area enables", or "What does it give?"*. This is the KVI analysis expanded on in this White Paper (Section 3.2), looking at effects on KVs from a service delivered by a 6G network. KVIs would point to an impacted KV, and in turn KPIs can be used to estimate KVIs.

A performance-based approach – "*What the use case area requires*", or *"What does it take?"*. This is a *technical design analysis* pointing at what the capabilities of a 6G network should be from the starting point of the services it should deliver.

The performance-based approach is the business-as-usual one and is of course still valid and important. This should now be complemented with the value-based approach proposed in this paper. When it comes to both enabled value and required capabilities, an initial understanding of these perspectives is often part of the use case description provided by the research project sources. These different perspectives are further related in that KPIs that estimate KVIs – technical measures indicating enabled value – can provide a *value impact* on the technical design. If we want 6G to enable a certain KV, the KPIs coming out of a KVI analysis can be included in the wanted 6G capabilities. This way, use cases are used as tools to understand in which direction to develop 6G technology.

4.1 Use case area 1 - Emergency response & warning systems

4.1.1 KVs and related KVIs

The Public Protection and Disaster Relief (PPDR) services represent the societal safety net against various natural disasters, accidents, and crimes [30] such as rescue operations (e.g. barge of migrants, motorway accident), natural disasters (e.g. forest fires, floods), smuggling of people and goods, terrorist attacks etc. PPDR services rely often on horizontal integration of various technologies and involve collaboration between multiple stakeholders such as: public safety organizations (e.g. the Red Cross), rapid response teams (e.g. firefighters, paramedics), law enforcement (e.g. police), healthcare (e.g. hospitals), and government departments (e.g. intelligence services, Ministry of the Interior). This innate PPDR collaboration is often distributed at a national level, and also operates across national borders at European or international level. Examples of such cooperation include forest fires in Sweden (2018) [31], Australia (2019) [32], or Greece (2021) [33] or rescue missions in conflict areas.

The goal of PPDR is to protect the public population and society, to prevent and to contain incidents, and to relieve and to aid recovery post-incident occurrences. These objectives undergo three separate stages [24], wherein mission-critical communications are required for the stakeholders collaboration and PPDR operational management: the incident response stage (most critical phase, involving collaboration and communications with highest priority and lowest latency), the prevention phase (second most important phase, where collaboration and communication are aimed to limit or to avoid impact), and the recovery phase (least critical phase, whereby communications delays are tolerable).

Some of the critical KVs (and related KVIs) contributed by PPDR services are: *Societal sustainability* (reducing response times and increasing operational efficiency of interventions in remote partial covered or out-of-coverage areas), *Environmental sustainability* (increasing surface area of natural habitat and climate preservation), *Personal health and protection from harm* (increasing number of lives rescued and ensuring high levels of protection of PPDR personnel), *Privacy and confidentiality* (highly secure exchange of selected information among national/international agencies), and *Trust* (increase confidence and efficiency of using advanced digital devices, systems and services in critical-mission scenarios). A summary of the detailed KVs, related KVIs and potential KV enablers is presented in Table 4 in Chapter 5.

4.1.2 KV enablers

6G must enhance 5G capabilities to support PPDR services mission-critical management and operation control towards an ergonomic, modular design enabling low-latency, extremely reliable (i.e. if possible with deterministic guarantees) data and control traffic. The types of services delivered by a 6G network are thus expected in case of PPDR to heterogeneously combine the individual eMBB, URRLC, and mMTC service categories with mission-critical service guarantees and universal coverage converging terrestrial and non-terrestrial (e.g. UAVs, HAPs, LEO satellites etc.) access networks.

The high potential of KVs impact that PPDR services provide requires strong security, ubiquitous connectivity, and an elastic network fabric capable to deliver diverse KPIs in terms of coverage, low-latency, capacity, energy efficiency, device access density and localization accuracy even outside of the context of a base station or cellular system [24]. These PPDR mission-critical support needs represent main challenges in migrating PPDR services from land mobile systems (e.g. trunked radio system) to 6G systems.

To better support PPDR 6G needs to transcend the positioning services currently available within 5G and upcoming within 5G-Advanced. A joint communication and sensing paradigm is needed in 6G [34]. The architecture is meant to provide two-fold advantages, i.e. on one hand to evolve the positioning services with sensing capabilities (e.g. radar-like sensing of objects, radio object detection, radio object identification or radio imaging), while on the other hand, to better serve the system and network in terms of reconfiguration, such as beamforming and mobility management, distributed beamforming, or even dynamic topology optimization and selection, based on the sensed environmental awareness. This would benefit PPDR services, both from an operational safety standpoint, but also from a service management perspective.

By 2030, new low-power devices and wearables are expected to emerge and support handsfree operation and AR/VR, e.g. oxygen masks with embedded AR overlay and eye tracking/hand recognition sensors. These devices are expected to be integrated within the PPDR ecosystem across various stakeholders [24], to benefit them with new ways to easily consume, provide and exchange mission-critical information. Such devices may be embedded systems integrations of some of the new 6G technologies (e.g. sub-THz transceivers, joint radio communications and sensing) to enable the first responders, and main PPDR stakeholders with operational and mission management increased efficiency.

Security of data, control, and interfaces of PPDR services is of paramount importance. The enhancement of current 5G architectures with human-centric confidentiality and privacy-preserving subsystems in a zero-trust manner is required. Furthermore, physical layer resilience as well as IT resilience of 6G system is necessary for PPDR mission-critical operations, and 6G is expected to deliver solutions for e.g. physical layer security, AI-based intrusion, anomaly detection. Consequently, the 6G platform needs to demonstrate end-to-end guarantees that the PPDR services are robust to any disturbances and available where and when needed.

The developed 6G solutions and new devices further require high energy-efficiency, and robustness to grant mobile operation in harsh environments (e.g. rugged outdoors, extreme heat, extreme cold) while maintaining similar service quality and accuracies across different conditions with manageable costs across PPDR stakeholders.

4.2 Use case area 2 - Smart city with urban mobility

4.2.1 KVs and related KVIs

In a smart city, digital technologies and solutions are integrated to the city fabric to support traditional services and infrastructure and make them more efficient and accessible. Even if common goals are better resource allocation and reduced pollution, benefits go beyond this through allowing users to directly interact with the city fabric. The city becomes responsive, in an always-running cycle of sensing and adaptation, which effects reflect in a smarter urban transport network, safer public spaces, better health support, upgraded water supply and more efficient waste disposal management and resource usage. The interaction becomes more pervasive as involved technologies evolve, and the responsiveness becomes more immediate.

The evolution of smart cities through 6G adds communication capabilities and highlights the importance of communication and sensor data gathering and integration, allowing high density of devices, the integration of different technologies and supporting the mobility of sensors. Timely accessibility to data is essential for exploiting AI and data analytics capability. The wide spreading of edge technologies allows supporting to low latency services based on AI and data analytics, helping to predict city behaviour, needs and resources.

Potential application cases of such integration of 6G technology into the city fabric are for example in road and rail transport traffic management, bringing benefits both to citizen life and reducing pollution. Urban mobility has intensified dramatically during the last century, reaching the infrastructural capacity limits. The mobility in the third dimension – the utilization of urban and metropolitan airspace by drone mobility – will become a serious alternative, as part of the metropolitan mobility systems. This, and all existing urban mobility subsystems, require rigorous coordination, as well as ensure the safety and security of all mobility modes, in all dimensions. A general benefit of involving highly advanced cellular communication systems in the smart city and particularly the mobility and transportation of tomorrow, will be the expected high level of automation and later on – autonomy – of workflows and physical processes related to urban infrastructure operation and transport and mobility in any dimension and systemic domain.

The relevant KVs within this use case are aspects of *Environmental sustainability* (footprint of urban transport of persons and goods); *Simplified life* (access and ease of use of public transport); *Personal health and protection from harm* (reducing injuries in traffic), as well as more cost-efficient mobility in all possible modes. More efficient energy use in terms of building and urban fabric operation should also be considered, from applying smart buildings, homes, streets etc. A summary of the detailed KVs, related KVIs and potential KV enablers is presented in Table 4 in Chapter 5.

4.2.2 KV enablers

The interrelation of urban environment, infrastructure and motion of goods and humans is a complex system, recently requiring higher capacities and abilities. Therefore, 6G will become a crucial success factor, enabling the safe and secure automated and later on autonomous transport of humans and goods in complex urban and metropolitan environments, often free of GNSS coverage. Especially in the case of implementing Advanced Air Mobility by drones into the urban airspace, will require reliable broadband on-demand connectivity for the vehicles, ensuring the situational awareness and vehicle-to-vehicle, as well as vehicle-to-station communication and data transfer. In this context, various novel business models involving advanced cellular communication systemic solutions will emerge and bring significant market growth. These can be prosumer-based, since a reliable dense 6G network likely requires a multi-agent system, with infrastructure embedded in the urban and private real estate fabric, and operated by users next to the network providers, which will play the role of a platform provider.

A range of new applications needs to be established, such as connectivity-based new services and business models related to smart sensing, edge computing, smart buildings and homes, situational awareness in autonomous vehicles etc; interconnectivity of transportation and mobility modes, as well as multimodal mobility hubs; improved and self-optimising scheduling for public transport; and inter-modality on much higher level thanks to better timing coordination.

High-precision in situational awareness of automated and/or autonomous vehicles is needed for higher safety and considerable reduction of accidents (mostly result of human failure), as well as GNSS-free navigation and situational awareness in complex topography and spatial environments, often needed in highly dense population and urban morphology.

Some challenges for introducing this systemic technical solution, based on 6G communication networks, will be a multi-agent prosumer-supporting network architecture where reliability can be ensured on system level; necessity of a good vertical (3D) coverage in the case of UAM, which means necessity of applying mobile network stations – drones, supporting another drones in the domain between ground and satellites; ensuring communications security in all of its aspects, embedded in the entire 6G system architecture in the context of the application systems.

The resource efficiency is to be assessed in the use cases in real environments, as well as the overall system efficiency – savings or not. A good example for this is the reliable application of 6G network solutions for safe and secure aerial drone operations in urban and metropolitan environments, where more energy efficient flight paths are possible by the smart navigation and situational awareness systems, but the on-ground based 6G communication infrastructure might consume a higher energy amount, compared to current cellular communication systems, due to the specifics of this type of communication systems high network spots density etc.

4.3 Use case area 3 - Personal health monitoring & actuation everywhere

4.3.1 KVs and related KVIs

A better and more timely knowledge of our personal health enables us to act preventively and proactively to avoid illness and to increase our wellbeing. The advancement in medical technology and medicine have led to great improvements in public, as well as personal health. At the same time, access to medical professionals and examinations is a bottleneck that delays and limits the application of modern medicine. Telemedicine can bridge this gap between the needs and solutions and establish a continuous link between patients and the medical professionals. This can be achieved with personal health devices, such as wearables, skin sensors, and even in-body sensors, that monitor our health status and report to online analysis services over the 6G network. The online medical service can formulate recommendations, connect to the general medical system, identify potentially hazardous –or even life threatening- situations and even issue commands to connected actuators, such as medicine dispensers, on and in the body in a rapid and intelligent manner [26]. Having such a connected personal health service available at all times and everywhere makes it possible to follow up on patients to a whole new level, or proactively monitor healthy people before they become patients. Achieving this would be a clear gain on a societal level, as it can prevent disease and –thus- reduce the load in the medical system. It would be possible to monitor elderly people as they continue to live in their homes, or track them in hospitals for increasing their freedom of mobility while preserving their safety [28]. On the personal level, it would meet the expectation on benefiting from the latest medical advancements and be up to date with your own health.

This UC addresses a number of critical KVs (and respective KVIs): *Societal sustainability,* from the considerable reduction in average cost in health care systems, per patient; *Personal health protection from harm,* via the intelligent and rapid identification of life-threatening situations, timely actuation, or proactive monitoring for healthy citizens; *Privacy and confidentiality,* via controlling the sensitive medical data of patients, their storage/transmission/processing policies, etc.; *Trust,* via ensuring reliable, explainable and verifiable AI-driven, automated event identification (via monitoring), as well as decision making/actuation. A summary of the related KVs and KVIs is included in Table 4 in Chapter 5.

4.3.2 KV enablers

On a technology level, the personal health service would consist of three parts: connected sensors communicating with the network, online data collection and analysis, and connected medicine or building control actuators and recommender systems. 6G should be able to enable reliable, secure, and privacy-preserving communication among all these parts.

In current state of the art solutions, wearable medicine devices typically communicate locally over e.g., Bluetooth to a smartphone, which then communicates to the network in the context of some healthcare mobile application. 6G devices should connect directly to network, not relying on a smartphone presence, and keeping within secure end-to-end protocols. Connecting many different smaller sensors in a body network and routing the data over a few more capable devices should be possible, and network access should be available, no matter the location.

Advanced positioning and localization services targeted by 6G networks, via the usage of sub-THz frequencies, intelligent reflective surfaces, advanced beam processing, as well as AI-powered techniques will enable real-time, high-precision potential obstacle detection, as well as tracking of elderly people, dementia patients, etc. This in turn will enable better control, while actuators, such as hospital door control systems may be applied.

Secure online analysis should be available while ensuring the data privacy, with full control over the whole data transmission, storage, and process chain. The collection and processing of data should be ensured in line with medical service agreements. The critical connection from the online analysis to taking action must further be ensured, both the access and functionality of connected actuators such as medicine dispensers, and actions such as alarms and alerts when a patient has been identified as being in danger or needs further examination. Going further, it should be possible to create a digital body double of a person’s body, following the so far primarily industry-driven Digital Twinning paradigm, where the function and status is represented in high detail and a simulation of the body performance is run continuously to predict future health.

Since health is of critical importance to both persons and society, a key challenge is to establish sufficient trust in 6G solutions, in order to move health systems from static physical meetings to connected mobile in the digital domain. The 6G platform needs to demonstrate end-to-end privacy and security, and guarantee that the service is resilient to disturbances and available where and when needed. Trust is of utmost importance in the operation of potential AI-driven components as well, which will be monitoring the patient’s data and generating alerts or issuing commands. The AI components’ decision-making and model outputs, as part of the native integration of intelligence into the 6G system, either centralized or decentralized (e.g., operating on a MEC or device level) should be also explainable for medical experts to be intervening and configuring the respective decision-making as required.

Connected health devices must be available at reasonable cost and fulfil medical requirements. At the same time energy-efficiency aspects must be properly addressed, besides the device energy management itself, from the 6G network side towards efficient communication protocols, though preserving reliability, high-performance, security and privacy at the same time. Convincing public and private health systems to invest in digital connected health monitoring involves showing cost savings as well as improved well-being for the end user. This involves online medical analysis systems that are automatised to a high degree, using AI-trained models, and importantly the ability of the 6G platform to smoothly interact with the existing medical systems. It is crucial that these models can be proved to be safe, explainable, verifiable, and thus trustworthy.

4.4 Use case area 4 - Living and working anywhere

4.4.1 KVs and related KVIs

The capability of humans to be present elsewhere than the location where they are physically and to interact with a remote environment has been a long-envisioned pursuit. To this end, tele-services are advancing over the years from simple teleconferencing to services tailored to specific aspects of humans living such as teleworking, distance learning, network-gaming, events remote attendance, etc. Such services have been broadly adopted regardless of their implementation efficiency especially during the Covid-19 pandemic, as a means to ensure safety, while providing continuity to economic activity. This trend is expected to continue and to even lead to a disruptive transformation even disruption to areas of established professional [35], educational (e.g., schooling, learning, interactive tutoring) [36] and personal activities, having thus have direct impact on personal and societal domains.

However, the global experience during the pandemic years has revealed that an omnipresence sense requires evolving remote human interaction beyond the nowadays simple exchange of conversational audio-video information [36]. "Living and working everywhere" use case area consists in *being present and interacting anytime, anywhere, using all senses if so desired*. It shall enable humans to interact with each other and with the other two worlds (physical and digital), and physical and digital things in these worlds, with all human senses used, exchanging sensory information, and even extending the capability of the senses [26]. "Towards 2030, future networks are expected to enable immersive communication combined with a fully digital representation of the physical world, which can allow very precise interaction and feedback loops that can remove distance as a barrier to interaction" [37].

These services are considered as key enablers to achieve many of the SDGs (e.g. SDG#4, #8, #10, #11) [8], and other KVs. Use cases of this area can have a significant impact on *Societal sustainability* especially of less populated areas by enabling to perform remotely (without the need for people to re-locate or commute) various life activities (education, professional, human activities). These use cases can have an effect on *Economical Sustainability* by affecting the cost of performing these activities in other ways, by reducing unemployment at certain areas, etc. Among the affected KVs would be also the *Cultural Connection* and the access to *Knowledge,* as this use case area would enable broad access to cultural products, participation to cultural events and more education opportunities; which could be inevitable or at least burdensome if a person's physical presence is required. Last but not least, by mitigating isolation for remote persons this use case area will address in many ways the values of *Democracy* and *Digital Inclusion*. A summary of the related KVs and KVIs is included in Table 4 in Chapter 5.

4.4.2 KV enablers

In technical terms "Living and Working anywhere" implies broadening the scope of current communication services that focus on enhancing the capturing/ transmission and reproduction quality of audio-visual information elements, to capturing/ transmission and reproduction of Human Multimodality Information (i.e., audio, video, taste, odour, haptic and emotion). Key services to enable this family of use cases are (based on [26][3][38]) e.g. Holographic telepresence and Mixed Reality (MR) services making it possible to appear as though one is in a certain location while really being in a different location; and Extended Reality (XR) services and digital twinning enabling motion capturing of actual human activities (e.g. games, cultural events) in real time to create a Digital Twin of the activity, which can be experienced live from any angle, by millions of people worldwide. Merged reality and multimodal (i.e. audio, video, taste, odour, haptic and emotion) communication services will allow interaction with humans and objects that can be present in the physical world or digitally enhanced with visual, haptic, or olfactory sensation, or even fully digital but appear to be real. These services go even further to enabling one's full participation in an activity with hologram avatar of oneself, making him/her appear fully present, e.g. by delivering tactile and sensory feedback of him/her to others, and experiencing visual information immersively through a smart contact lens. Finally, cognition and intelligent interaction services in various forms are also important, allowing for capturing a person's intentions, desires, moods, and thoughts, going beyond one's senses.

To support such services (also according to [39][38]), deployments need to provide high bandwidth (for real time multi-modal data exchange), imperceptible latencies (to avoid dizziness) excellent synchronisation of multimodal communication and control, and high-accuracy, real-time positioning beyond 5G network capabilities – being the KV enablers.

These services could be enabled by 6G deployments at architecture level (1) by incorporating advanced extreme edge deployments for achieving low latency and allowing for real time rendering and network rendering, and at technologies level (2) through next generation cell structures (highly disaggregated networks, access network densification, cell-free networks, etc.) allowing coverage support for even higher data rates and devices density and (3) more precise synchronisation and localisation techniques as well as (4) by the integration of application with the networks which can enable AI/ML services for sensing, communication and feedback assisted by relevant network functions, ultimately supporting the "AI-as-a-Service (AIaaS)" concept to facilitate and enhance device context awareness [38][26].

Besides, the technical feasibility of these use cases at small scale, a common challenge in effectively contributing to the SDGs by scaling these use cases is the provisioning of service coverage to traditionally underserved areas and extending network deployments to "extreme edge". Such services will also necessitate advanced end user devices and applications being available at sufficiently low cost. Key challenges in this would be to create wearable devices such as earbuds and devices embedded in our clothing working seamlessly with each other, providing natural, intuitive interfaces [26].

4.5 Use case area 5 – Assistance from twinned cobots

4.5.1 KVs and related KVIs

Collaborative robots, or "cobots" are expected to bring human and robot interactions closer together. Cobots will reliably read and interpret human actions and interactions and react in a trustworthy, safe and efficient manner [38]. Cobots are predicted to enable a diverse range of tasks within different sectors: precise and challenging manufacturing tasks, care assistants for the elderly or disabled, manual labour, exoskeletons or and adaptive wheelchairs. The use case described in this paper has been taken from the Hexa-X project [40].

A key aim is that cobots are able to detect environmental factors and self-adjust accordingly. Human behaviour is included as an environmental variable, as cobots may be able to suggest recommendations after interacting with humans. Self-adjustment may include switching function or reconfiguring device settings to satisfy new performance requirements. For this adjustment to occur, cobots are likely to need to be managed by AI-driven resource allocation, positioning and interference management [39].

In this use case, an elderly woman, Ana, lives with diabetes and is recovering from a hip replacement operation. She lives on her own within a building complex designed for the elderly to live in. Apartments come equipped with a cobot (The Little Android Helper, or T-LAH), if the resident wants one. Ana has chosen to have T-LAH in her apartment, which allows her to do tasks that she would not be able to do unaided such as blood tests as and when she wants to do them; vacuuming the floor and gently dusting surfaces and the ceiling; carrying a food tray; collecting mail and picking up other items on the floor; giving physical support (e.g., entering and leaving the shower, or as a walking aid when moving within the building).

T-LAH also provides an interface to services that require data about Ana to be collected, used, and shared with other parties. This involves e.g. building management installed environment sensors in the building - T-LAH allows Ana to change the temperature in her apartment and report issues. It can also give Ana's doctor access to her blood test results from the surgery, and visiting healthcare assistants may also access this data. Ana is part of the resident community, so T-LAH adds events to her calendar and reminds her. She can also call other rooms via a secure channel.

The goal of T-LAH is to support Ana in independent living, with as little intervention as possible. E.g., Ana does not have to adjust her schedule to wait for home help or a cleaner. The societal value of T-LAH is to enable the elderly to live at home for as long as they can do so, encourage socialisation, and prevent injuries due to falls and accidents before they occur. Key values for Ana can be *Personal freedom*, which could be estimated from the degree of influence over her daily activities and her personal mobility and degree of independence. For the home care service personnel, their *Personal health and protection from harm* can be improved which can be estimated from a reduction in work-related injuries. Overall, an impact on *Societal sustainability* can be measured through an improved cost-efficiency in the care for elderly. These KVs and KVIs are summarized in Table 4 in Chapter 5.

4.5.2 KV enablers

Cobots likely need to interact with each other as well as with humans and other technology interfaces. A key opportunity is to develop enhanced machine type communications. 6G will deliver peer-to-peer communications with extensions enabling robots to generate their own collaboration service. This is different to 5G offerings in that this is enabled using volatile services, initiated and managed by robots through on-demand service [38]. A key challenge is to create interfaces for humans to interact with cobots in a safe an effective way, adapting to the human abilities. The AI models power the actions of cobots must be trustworthy and explainable, and the entire system must be reliable and resilient to ensure personal safety.

4.6 Use case area 6 - Sustainable food production

4.6.1 KVs and related KVIs

As worldwide population keeps growing, guaranteeing food security has been recognized as a main challenge and is in the scope of the SDG #2, "zero hunger". Food production should be maintained despite increasingly challenging environmental and climatic conditions. In recent years, changing climatic conditions with rise of temperatures, periods of drought or on the contrary heavy rainfall can ruin crops in some areas. They can also favour the appearance of diseases or parasites, also endangering the cultivation of local fruit and vegetables, or threatening species such as bees, whose role is crucial for biodiversity. For livestock a balance must be maintained between animal welfare, meeting regulatory requirements and satisfying food demand for the growing earth population.

Deployment of solutions enabled by 6G are envisioned [26], relying on captors and sensors to capture the status of environmental and climatic indicators in productions areas, and Digital Twins to monitor the evolution of these indicators, identify the threats and take actions to prevent the impact on production. In the case of livestock, farmers are supported by augmented reality equipment that guide them to individual animals that need attention [29].

Among impacted key values, *Environmental sustainability* is most prominent in this use case area, which could be estimated through the environmental footprint of agriculture activities, measuring CO2 emissions, use of fertilizers and pesticides, and impact on biodiversity. From the farmer's perspective, digitalization can mean a *Simplified life*, which can be measured in the form of time savings and reduction of manual work. Eventually, *Societal sustainability* is also addressed as guaranteeing food production will avoid shortage of food and inability to feed the planet. These KVs and KVIs are summarized in Table 4 in Chapter 5.

4.6.2 KV enablers

The solution will rely mainly on two parts: collection of data through a very wide set of sensors, deployed over wide areas, mainly rural, and sometimes with harsh environmental conditions (e.g., mountains) from one side, and the management of the data collected to visualize the instant status of the crops and conditions, to monitor and prevent potential threats harmful for the food production. 6G should be crucial to deliver these two parts. First, 6G should sustain the connection of very high number of sensors all over the world, setting challenging requirements on the number of connected devices and on wide area coverage. A main challenge are the deployment conditions. In these wide rural areas, power supply is a challenge, and the development of zero-energy devices, relying on energy harvesting for powering the sensors is needed. The use case will require development of sensors offering extreme robustness to climatic conditions, and extremely long lifetime to minimize the impact on the environment. Another challenge is related to the coverage, as the service should be offered everywhere there is agriculture including very remote areas. Finally, trustworthiness is necessary, to ensure that alerts are processed in due time.

In the case of localisation of livestock needing attention, current solutions for extended reality equipment use short-range beacons to identify their location. 6G network coverage is needed to correctly position augmentation within the physical environment and provide access to high-definition video for monitoring.

6G should also enable digital twin monitoring in real time of conditions at the level of micro-locations, scattered over wide areas, but also to test and optimize potential solutions, such as plant treatment, and experiment specific strategies to remediate to the threat. AI algorithms can also be introduced to increase automation of the detection of threats and preventive actions.

For livestock monitoring, the motivation is for more efficient operation of farmers to look after the well-being of their animals, which can be reported to regulatory bodies to assess compliance with animal welfare regulations. The main innovation is for livestock such as cows, pigs and chickens to wear collars that monitor animals' well-being and health and if contraventions occur to animal welfare regulations, farmers and eventually regulatory bodies are notified. Parameters that are monitored are for example position, movement pensum and time spent indoors/outdoors, body temperature, audio from animals, or oestrous cycle. Related requirements include frequent estimation of accurate location and orientation allowing monitoring of mobility of the animals. Health data sensing is monitored every minute. The requirements on data volume and density of IoT devices are directly proportional to the monitored livestock population.

5 Expected impact on key values

Following the steps in Chapter 3, the use case areas described in Chapter 4 have been analysed with respect to KVs (listed in Chapter 2) and possible KVIs. An overview of the results is presented in Table 4. It should be noted that this is one initial set of KVs and KVIs that does not exclude other sets, with a more complete view.

Table 4. Key values mapped to use case areas, related KVIs, and enablers

Use case area	KV examples	KVI examples	KV enabler examples
1: Emergency response & warning systems	***Societal sustainability***	*Reduced emergency response times; Increased operational efficiency of interventions in remote areas*	*Flexible network fabric with dynamic network and service orchestration and automation; Mobile ad-hoc networking; TN/NTN convergence*
	Environmental sustainability	*Increased area of protected and surveyed natural habitats and climate preserves*	*Energy-efficient monitoring sensors; Flexible analytics services and network automation; Mobile ad-hoc networking; TN/NTN convergence*
	Personal health and protection from harm	*Increased operational efficiency for saving lives in emergencies; Reduced injuries in PPDR missions*	*Joint communication and sensing; Safe and easy to use XR devices; Network and service automation for low-latency analytics*
	Trust	*Reported confidence in advanced digital devices, systems, and services in critical missions*	*Rugged and robust devices; Secure and trustworthy AI; System E2E privacy and security*
2: Smart city with urban mobility	***Environmental sustainability***	*Environmental footprint of urban transport of persons and goods*	*Services for coordinating and planning routes; Precise positioning / localization*
	Simplified life	*Access and ease of use of public transport*	*Multimodal interconnectivity services*
	Personal health and protection from harm	*Injuries in urban traffic*	*Multi-agent supporting network architecture; 3D coverage; Resilient and reliable networks; Joint communication and sensing*
3: Personal health monitoring & actuation everywhere	***Personal health and protection from harm***	*Access to autonomous health monitoring service*	*Medically safe on-body devices with long autonomous operation time; Ubiquitous coverage; Precise positioning / localization; Secure and trustworthy AI; Digital twinning of patient's body*
	Privacy and confidentiality	*Reported user control of medical data for storage/transmission/processing*	*System E2E privacy and security; Decentralized processing / offloading to devices, edge, etc.; Secure and trustworthy AI*
	Societal sustainability	*Average cost saving in health care system per patient*	*System resilience; Ecosystem adaptation and integration; Zero-touch system (re)configuration for minimizing human intervention*

	Trust	*Reported trust level for autonomous e-health components; Accuracy rate in e-health AI-related events' identification and/or decision making*	*Secure and trustworthy AI; System resilience*
4: Living and working everywhere	***Societal sustainability***	*Travelling / commuting time reduction; Access to job market; Life opportunities in rural areas*	*Ubiquitous coverage for basic MBB; Low-cost connectivity*
	Economical sustainability and innovation	*Cost-efficiency of living and working in rural areas; Number of activities that can be performed anywhere*	*Operational cost efficiency; Low-cost scalability and expandability*
	Cultural connection	*Access to cultural products (#products / product types); Access to cultural events (#events / product types); Number of cultural domains impacted*	*Extended service coverage with sufficient QoS – especially for XR applications; XR reality services*
	Digital inclusion	*Access to internet in communities and areas*	*Ubiquitous coverage for basic MBB*
	Knowledge	*Access to quality education (at all levels, esp. higher); Access to digital libraries; Access to and interaction with knowledge groups*	*Merged reality and multimodal communication services*
	Democracy	*Access to / active participation in administrative and political functions*	*Ubiquitous coverage for basic MBB; Merged reality and multimodal communication services*
5: Assistance from twinned cobots	***Personal health and protection from harm***	*Injuries in labour-intense activities*	*Autonomous cobots using trustworthy AI; Human-adaptive interfaces with intent interpretation; System resilience*
	Societal sustainability	*Cost-efficiency in labour-intense operations*	*Autonomous cobots using trustworthy AI*
	Personal freedom	*Degree of influence over your daily activities; Degree of personal mobility*	*Human-adaptive interfaces with intent interpretation; System resilience*
6: Sustainable food production	***Environmental sustainability***	*Environmental footprint of agriculture activities; Energy use in agricultural activities*	*Energy-efficient monitoring sensors / zero-energy devices; Ubiquitous coverage; Digital Twin for monitoring and intervention*
	Simplified life	*Time savings in agricultural activities*	*Joint communication and sensing; Federated learning; AI for detection of threats and action*
	Societal sustainability	*Increase in agriculture productivity; Reliability of food production*	*Ubiquitous coverage; Digital Twin for monitoring and intervention*

6 Terminology

6G: the 6th generation of wireless network technology planned for 2030

AI/ML: Artificial Intelligence / Machine Learning, learning-based virtual intelligence

AR/VR/MR/XR: Augmented / Virtual / Merged / Extended Reality

eMBB/URLLC/mMTC: Enhanced Mobile Broadband / Ultra Reliable Low Latency Communication / massive Machine Type Communication

E2E: End-To-End, i.e. between communication endpoints

GNSS: Global Navigation Satellite System, e.g. Galileo, GPS

ICT: Information and Communication Technology

KV (Key Value): values important to people and society that may be directly addressed or indirectly impacted by future network technology

KVI (Key Value Indicator): a measurable quantity or requirement on future networks that in some form provides an estimate of an enabled KV

Key Value enabler: an aspect of future network technology that enables a usage related to a KV

KPI (Key Performance Indicator): a measurable quantity or requirement technically on future networks that in some form provides an estimate of performance

NTN: Non-Terrestrial Networks, e.g. UAV/HAP/LEO

PPDR: Public Protection and Disaster Relief

SDG: Sustainable Development Goal, defined by UN [4]

SNS: Smart Network & Services, a joint undertaking program between EC and 6G-IA [2]

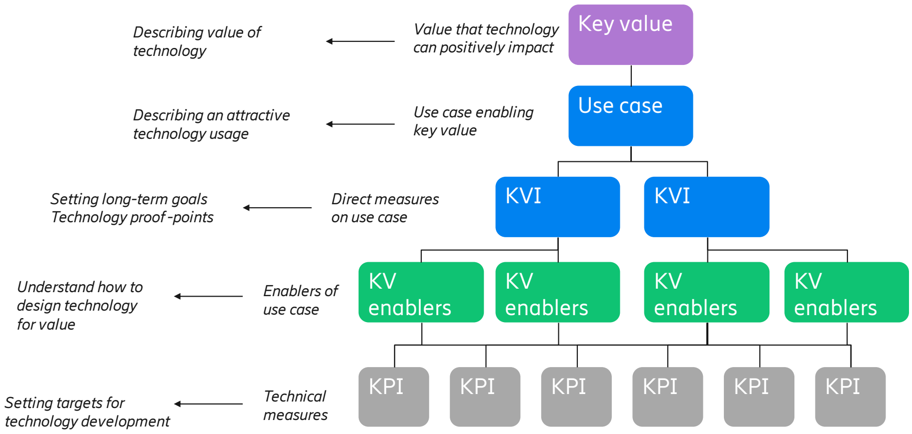
T-LAH: The Little Android Helper – a home care cobot example

TRL: Technology Readiness Level [22]

UAM: Urban Air Mobility, e.g. with drones or air taxis

UAV/HAP/LEO: Unmanned Aerial Vehicle / High Altitude Platform / Low Earth Orbit satellite

Use case: a usage of future network technology involving a delivered service or functionality



Overview of KVI-related concepts and purposes

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