Deliverable D5.3

5G-VINNI Business Layer maturity levels

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Abstract

Building upon earlier work on business requirements and fundamentals of the 5G-VINNI Business Layer, in this report we present the final 5G-VINNI Business Layer design and discuss how the identified Business Layer capabilities will gradually rollout along the 5G-VINNI Maturity Levels (MLs), starting from 5G-VINNI operation for internal experimentation purposes, up to the long-term vision for commercial 5G-VINNI experimentation as a service. In order to determine this gradual and phased rollout, we apply a Multi-Criteria Decision Analysis (MCDA) approach, jointly taking into account: (i) the preferences of 5G-VINNI internal and external users, as well as (ii) the recommendation of project experts on the delivery period of the main release of Business Layer capability features that support each requirement. A set of Business and Economics (B&E) KPIs are promoted, aiming to evaluate the Business Layer capabilities performance, the overall business success and economic sustainability of the 5G-VINNI facility. The target values that should be achieved for each B&E KPI, over time-periods indicated by the 5G-VINNI Maturity Levels, are specified. Finally, we introduce a set of Business Layer enabler mechanisms that facilitate the cross-domain operation of Business Layer, including service catalogues interworking, multi-facility wide quote management and revenue sharing policies.

[End of abstract]

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Executive summary

5G promises to deliver the next generation mobile network of exceptional performance in terms of achievable data rate, end-to-end latency, reliability, automation and number of supported devices. It is expected that vertical sectors such as media, automotive, industry 4.0, health, utilities, etc., will take advantage of these advanced capabilities to develop innovative applications and services embracing the digitalization era. To this extent, Mobile Network Operators (MNOs) and Communication Service Providers (CSPs) will leverage upon their prominent role in the 5G ecosystem to reshape the telco business landscape and create new revenue streams. Given the high complexity of 5G value network and the potentially conflicting interests between stakeholders, the collaboration and co-innovation of different actors is a fundamental factor to 5G business success. In this sense, features that enable the emergence of novel, collaborative and flexible business models should be in place. Legacy Business Support Systems/Operation Support Systems (BSS/OSS) lack the openness, scalability, flexibility and agility required; thus, the evolution of BSS/OSS will play a significant role for 5G monetization.

In 5G-VINNI project, the notion of 5G-VINNI Business Layer is introduced, which is a collection of BSS and OSS functionalities mandated for the operation of pre-commercial 5G testbeds and for commercial 5G in general. The 5G-VINNI Business Layer facilitates and automates the interactions of 5G-VINNI external users (i.e., vertical customers, third-party providers) with the 5G-VINNI facility and enables the business coordination and collaboration of internal users (i.e., facility sites, vendors, etc.).

Building upon D5.2 [2] findings, in this report, we deliver the final capabilities and design of 5G-VINNI Business Layer, as well as a plan for the **gradual and phased rollout** of these capabilities along the four **Maturity Levels** (MLs) of 5G-VINNI facility operation, introduced in D5.1 [1]. The identified MLs capture the evolution of 5G-VINNI facility: starting from the operation for internal testing, going into the operation for serving a restricted set of customers, and finally capturing the long-term vision of commercial 5G-VINNI experimentation as a service.

In order to determine a rollout plan that best fits the needs of both 5G-VINNI internal and external users, we apply the **MoSCoW** method for **prioritizing business requirements** that were initially identified in D5.2. MoSCoW acronym stands for “must have”, “should have”, “could have” and “won’t have”, which are the potential responses to a question that asks how important a business requirement is for a 5G-VINNI facility user. Users’ preferences for all requirements were collected by means of questionnaires. The questionnaire results revealed that the vast majority of respondents considered all identified business requirements as relevant. The requirements that are classified with the highest overall priority for internal and external users, i.e., considered as critical for 5G-VINNI facility operation, are related to the:

- experimentation capabilities, experiment scheduling and setup, reporting of experimentation results, user login and assisted customer access when interacting with the 5G-VINNI facility,
- access to all available services across all facility sites’ (global service catalogue),
- real-time performance monitoring,
- platform documentation, handbook and tutorials.

The set of requirements that are identified as important but not critical for 5G-VINNI facility operation are associated to the:

- license management and openness to external suppliers,
- global coverage and end-to-end homogeneity of provisioned services,
- advanced customer control over network slices and user devices,
- automated replicability of services and ability to create complex services by combining existing ones offered by 5G-VINNI facility sites or third-parties.

- customer experience assessment through the establishment of a feedback mechanism.

Finally, the set of requirements that are assigned to the lowest priority are related to the:

- flexible SLA definition, billing, cost and revenue sharing
- knowledge sharing by means of communities and open documentation of experiment results.

The extracted requirements' prioritization provides insights with respect to the functionalities that should be prioritized in the Business Layer rollout. However, in order to propose a precise plan with respect to the release of the different Business Layer capabilities introduced in D5.1, a **mapping of requirements to capabilities** must be defined. The Business Layer capabilities are grouped into three families of features addressing User Login, Service Order Management and Knowledge Repository Management. The requirements that are directly or indirectly mapped to each family of Business Layer capabilities are presented below:

- **User Login** contributes to the fulfilment of requirements related to secure universal login, openness to external suppliers, device access control and assisted customer access.
- **Service Order Management** addresses requirements related to global service catalogue, assisted customer access, pick and choose for creating complex services, automated replicability, openness to external suppliers, advanced slice and user device control, global coverage and homogeneous service end-to-end, licence management, experiment scheduling and setup, flexible SLA and billing, flexible cost and revenue sharing.
- **Knowledge Repository Management** addresses requirements related to community and open documentation, real-time performance monitoring and reporting and to platform documentation/handbook/tutorials, while it indirectly addresses assisted customer access.

Having the mapping of requirements to capabilities and the prioritization of requirements based on user preferences (MoSCoW method), we propose how the capabilities will evolve through the MLs of 5G-VINNI Business Layer considering multiple enhanced releases. Equally important is to capture the difficulty of delivering the features needed to address each requirement and the relevance of the different features for the operation of 5G-VINNI facility in each ML. Taking one-by-one the requirements and considering the above aspects, this report includes a **Recommended Delivery Period** (RDP) for the *main* release of features addressing each requirement, by assigning "Early", "Medium-term" or "Late" release tags. Then, a **Multi-Criteria Decision Analysis** (MCDA) is applied to jointly capture both MoSCoW and RDP results to determine Business Layer design in each ML, i.e., the number and maturity of features that will be available in each release:

- **ML2** should include the main release of features that belong to the Knowledge Repository Management family. It should also include the main release of features corresponding to Experiment Setup & Scheduling, License Management and Notification Management.
- **ML3** should include the main release for User Login family and Service Order Management features such as Service Catalogue Management, Service Inventory Management and User Device Management.
- **ML4** should mostly focus on the release of Service Order Management features; these are mostly required for a commercial 5G-VINNI solution, i.e., on SLA, Quotes, Billing and Payment Management.

To assess the efficiency of Business Layer capabilities, as well as the business success and sustainability of 5G-VINNI facility, a set of **Business and Economic (B&E) KPIs** were promoted by revising the ones introduced in D5.1 and by including new ones. Business KPIs focus on the evaluation of aspects related to customers' engagement with 5G-VINNI facility, customers' experience, experimentation intensity, stakeholders' innovation, vertical customers' entry-barriers and actors' collaborations. Economic KPIs focus on evaluating the cost efficiency and value creation

of 5G-VINNI facility. A set of **target values** for B&E KPIs were defined considering the operation of 5G-VINNI facility in all MLs.

Finally, a set of **enabler mechanisms** for facilitating the cross-domain operation of Business Layer was introduced. The proposed mechanisms focus on Service Order Management family and support features related to service catalogue interworking, as well as quote management and revenue sharing policies when it comes to service offerings that involve multiple facilities.

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Abbreviations

5G	Fifth Generation (mobile/cellular networks)
5G-VINNI	5G Verticals Innovation Infrastructure
API	Application Programming Interface
B&E	Business and Economic
B2B	Business-to-Business
B2B2X	Business-to-Business-to-Any
BSS	Business Support System
CAPEX	Capital Expenditures
CSC	Communication Service Customer
CSP	Communication Service Provider
DevOps	Development and Operations
e2e	end-to-end
E2E	End-to-End
eMBB	enhanced Mobile BroadBand
ESB	External Stakeholder Board
GSMA	Global System for Mobile Communications Association
GST	General Slice Template
ICT	Information and Communications Technology
IoT	Internet of Things
IPR	Intellectual Property Rights
IRR	Internal Rate of Return
KPI	Key Performance Indicator
MCDA	Multi-Criteria Decision Analysis
MAVT	Multi Attribute Value Theory
mMTC	massive Machine Type Communications
ML	Maturity Level

MNO	Mobile Network Operator
MoSCoW	Must have, Should have, Could have and Won’t have
NSI	Network Slice Instance
NSD	Network Service Descriptor
OPEX	Operational Expenditure
OSS	Operation Support System
OTT	Over-The-Top
QAM	Quality Assurance Manager
QoE	Quality of Experience
PV	Present Value
QoS	Quality of Service
RDP	Recommended Delivery Period
SA	System Architect
SB	Service Blueprints
SD	System Designer
SLA	Service Level Agreement
SM	Service Manager
SW	SoftWare
TCO	Total Cost of Ownership
TMF	TeleManagement Forum
uRLLC	ultra-Reliable Low-Latency Communication
VAF	Virtual Application Function
VNF	Virtual Network Function
VNFD	Virtual Network Function Descriptor
WACC	Weighted Average Cost of Capital

1 Introduction and motivation

5G is a collection of revolutionary networking technologies that will deliver a highly virtualised next generation mobile network of unprecedented performance capabilities with respect to data traffic throughput, end-to-end latency, number of supported devices, reliability and automation. These new features render 5G one of the main pillars for the digitization of vertical industries such as media, automotive, industry 4.0, health, utilities etc. 5G will enable the emergence of new ecosystems, thus creating opportunities for new business models and revenue streams for Mobile Network Operators (MNOs)/Communications Service Providers (CSPs), as well as for vertical enterprises through the creation of innovative services. In particular, according to a recent study [3], it is expected that 5G will create over $13 trillion in global sales enablement by 2035.

In order to capitalize on this opportunity, MNOs/CSPs should establish a central role in the complex value network of 5G ecosystem, turning their network into an open multi-tenant, multi-provider, multi-vendor and multi-operator platform. However, legacy Business Support Systems/Operation Support Systems (BSS/OSS) lack the openness, scalability, flexibility and agility required to enable new 5G business models, thus the evolution of BSS/OSS will play a significant role for 5G monetization [4]. The evolved 5G BSS should be able to support [5],[6]:

- On-demand 5G service offerings with flexible product creation and close to real-time order fulfilment.
- Product/service customization by the vertical customer.
- Bundling of products/services offered by multiple providers and reselling capability.
- Time-to-market acceleration through user-friendly interfaces for non-technical users that will allow the quick creation, placements and management of orders.
- Flexible SLA and revenue management that will be able to support different pricing/charging schemes, complex revenues sharing policies and a variety of business models.
- Openness towards third-party providers, suppliers and customers, through standardized APIs.

In 5G-VINNI we introduce the notion of 5G-VINNI Business Layer, which enables a wide variety of BSS-oriented capabilities (as well as some OSS-oriented) required for the operation of pre-commercial 5G testbeds. 5G-VINNI Business Layer is meant to facilitate the interaction of external users with the facility and enable the business coordination of internal users. Regarding external users, vertical enterprises should be able to design, plan and perform experiments effortlessly, while third-party service providers should be able to complement the 5G-VINNI platform by contributing their own services/products. Regarding internal users, i.e., facility site members, the appropriate business capabilities and enabler mechanisms should be in place to allowing for provisioning of joint services in a highly automated manner. In D5.2 [2], we identified the business requirements for internal and external users. Based on these requirements and state-of-the-art literature, we defined the capabilities that 5G-VINNI Business Layer should have and we introduced its initial design.
In this report, we focus on the prioritization of business requirements for supporting internal and external users and the phased roll-out of Business Layer capabilities for satisfying these requirements. Considering the different 5G-VINNI facility Maturity Levels (MLs) introduced in D5.1 [1] (see Figure 1-1 below), we here recommend a Business Layer design per ML*[1]. Recall that:

- **ML2** refers to a mature facility that will allow a restricted set of vertical 'customers', mainly ICT-19 projects[2] and 5G-VINNI External Stakeholder Board (ESB members, to integrate their

1 Maturity Level 1 (ML1) of 5G-VINNI facility is omitted since it refers to the operation of the facility during the early stage of the project, which focussed on running certain internal experiments.

2 The projects funded under H2020-ICT-2018-20 call for proposals entitled "Advanced 5G validation trials across multiple vertical industries".

applications and run stress tests in order to assess the technical merits and feasibility of innovative use-cases.

- **ML3** refers to the same facility but for a 1-year period after the contracted duration of 5G-VINNI (December 2021-December 2022). In this period, we expect that the number of use cases for ICT-19 projects and ESB members will increase, and the customer base will also become wider with individual vertical organizations performing tests. In order to guarantee their sustainability, vertical organisations will have to compensate 5G-VINNI members for any additional capital or operational expenses incurred. Accordingly, we expect that some business-level experiments will be performed during this phase.
- **ML4** refers to the long-term vision for 5G-VINNI experimentation as a service toward vertical customers. This could involve individual and/or multiple 5G-VINNI facility sites or even interworking with other external facilities. Experimenters, such as vertical customers and vertical application providers are asked to pay competitive prices for using the infrastructure to get valuable feedback, considering various levels of public funding and support.

Note that ML4 goes beyond the lifetime of the project and considers the long-term vision of commercial 5G experimentation as a service. Thus, we argue that most of the identified capabilities as well as the proposed design, can be useful for commercial 5G systems.

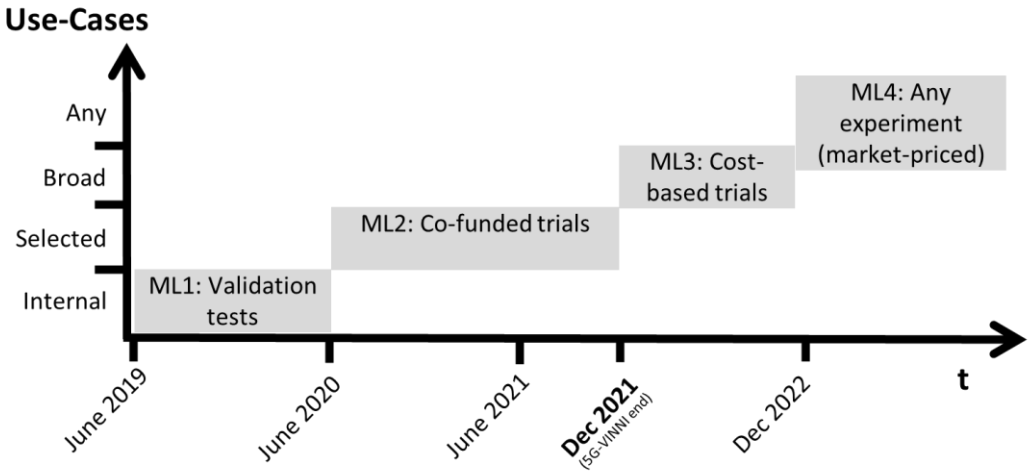


Figure 1-1: 5G-VINNI maturity levels [1].

As part of the Business Layer, in this document, we also introduce a set of enabler mechanisms for facilitating the automated business coordination of facility sites when it comes to the provisioning of services that involve multiple facility sites. Considering different potential structures for the 5G-VINNI ecosystem, we specify mechanisms that facilitate the interwork of Service Catalogues, multi-facility wide quote management and compensation/revenue sharing mechanisms.

Finally, this report also includes the definition of target values for a set of selected Business & Economics (B&E) KPIs, that will be used in the final report of WP5 (i.e., in D5.4 [7]), to evaluate the business success and sustainability of the 5G-VINNI facility. Some of the selected B&E KPIs came from the list of KPIs introduced in D5.1, while others are introduced in this document.

1.1 Objective of this document

The objectives of this document are summarised as follows:

- Prioritize the Business Layer requirements to be fulfilled in each ML, by jointly considering internal and external user preferences and facility site experts' recommendations.
- Specify the final set of Business Layer capabilities that are necessary for addressing the identified user requirements.

- Introduce algorithms and mechanisms for enabling cross-administrative domain Business Layer functionalities, that will enable the business coordination of facility sites when it comes to multi-facility site service offerings.
- Specify the final 5G-VINNI business layer design for each ML by proposing a phased rollout of the specific capabilities, and discuss how these capabilities will evolve along MLs.
- Specify the final set of B&E KPIs for evaluating the Business Layer capabilities performance, as well as the overall 5G-VINNI business success and sustainability, and define target values.

1.2 Relationships with other Deliverables

This report utilizes inputs from both D5.1 and D5.2 deliverables, while some of the aspects investigated in this document will be exploited or further studied in D5.4.

- 5G-VINNI MLs and the initial list of B&E KPIs were introduced in D5.1. The latter was the basis for the final set of selected B&E KPIs in this deliverable.
- User requirements were initially identified in D5.2, along with the Business Layer capabilities and a high-level design.
- The target values for B&E KPIs will be exploited by D5.4 to evaluate the business success of the 5G-VINNI facility.
- D5.4 will include further analysis and evaluation of the enabler mechanisms proposed in section 6 as part of governance and business model sustainability analysis.

The Business Layer design and the enabler mechanisms proposed in this document are related to the work conducted in deliverables D3.3 [8] and D3.4 [9]. In particular, D3.3 specifies the type of information the facility site catalogues exchange, while D3.4 also considers the ecosystem structures that we introduce in section 6.

1.3 Document structure

Section 2 presents the refined set of Business Layer requirements extracted by the users of the 5G-VINNI facility (initially introduced in D5.2) and suggests a prioritization for fulfilling these requirements based on the MoSCoW method. MoSCoW is a simple prioritization technique that is suitable for time-boxed projects with multiple releases, which in our case are the 5G-VINNI MLs. MoSCoW stands for “must have”, “should have”, “could have”, “won’t have”, which are the potential replies to a question that asks how important a requirement is for the 5G-VINNI facility user. Note that MoSCoW method was fed with internal and external users’ inputs gathered by means of questionnaires.

Section 3 presents the final set of Business Layer capabilities, including a mapping of user identified requirements to capability features. Note that there is not a one-to-one mapping between requirements and capability features, which means that multiple capabilities may directly or indirectly contribute to the fulfilment of a requirement.

Section 4 provides a recommendation with respect to the gradual rollout of the Business Layer capability features along 5G-VINNI MLs. In order to set priorities on the release of different features, we apply a Multi-Criteria Decision Analysis (MCDA) that takes into account: (i) the preferences of internal and external users (extracted by the MoSCoW method) (ii) the difficulty of delivering the features needed for addressing each requirement and the relevance of each features in each ML, based on the purpose that each ML serves. The assessment of the latter leads to a Recommended Delivery Period (RDP) for the *main* release of features addressing each requirement, assigning an Early, Medium-term or Late release tag to the features needed for fulfilling a requirement. Combining MoSCoW and RDP results, MCDA assigns each requirement in an ML, which indicates the period where the *main* release of related features should be available. Finally, driven

by the requirements assignment to MLs and the mapping to requirements to capabilities, the gradual rollout of capabilities features is discussed along with the Business Layer design for each ML.

Section 5 presents the set of refined B&E KPIs that were promoted for 5G-VINNI facility evaluation and specifies target values for all of them in time-periods specified by 5G-VINNI MLs.

Section 6 introduces a set enabler mechanism for enabling the cross-domain operation of Business Layer, which includes service catalogues interworking, multi-facility wide quote management and revenue sharing policies.

Section 7 concludes this report with our main findings and recommendations.

2 Final Business Layer requirements

In D5.2 [2], we identified the requirements of internal and external users with respect to the 5G-VINNI business layer. The user needs were extracted by defining multiple "persona" profiles, capturing the variety of 5G-VINNI internal and external users, and by investigating their "journeys". This section documents how requirements have been refined after a second phase of assessment and identifies the importance/priority of each requirement based on input gathered by both user groups through questionnaires.

2.1 Business Layer requirements refinement methodology

In this report, we refine the requirements by following the same design thinking approach applied in D5.2. According to this methodology, the 5G-VINNI users and their opinions are considered as the main driver for the identification and validation of the 5G-VINNI-Business Layer requirements. Thus, we reached out to potential users through questionnaires, in order to validate the already identified requirements (initially introduced in D5.2), extract the priority/importance of each requirement and identify potentially missing requirements that we didn't capture in the first phase.

Previews Methodology defined in D5.2 [2]

In the first phase, the 5G-VINNI Business Layer requirements were collected by carrying out an analysis of the state of art on BSS/OSS and by collecting inputs by the potential 5G-VINNI users, following design thinking and agile approaches as documented in D5.2.

The potential users of a 5G-VINNI facility, whose interaction will be facilitated by the 5G-VINNI Business Layer, are the:

- 5G-VINNI consortium members operating and supporting the facility sites;
- External Stakeholder Board (ESB) of 5G-VINNI;
- ICT19 projects;
- Other research projects focusing on specific vertical industries;
- Other vertical enterprises that develop 5G-enabled products and aim to experiment.

These users were split into two main groups, namely the internal and external users. The former group involves "all users that contribute to the operation of 5G-VINNI facility sites and have to interact for any reason with the Business Layer". The external user group involves "all external potential users that aim at using the business layer to perform 5G experiment or to provide thirty-party services". For each group, we identified a set of "job roles" described as "personae", in order to explore their needs and pains that the 5G-VINNI Business Layer should address. To achieve this, several relevant scenarios ("user stories") for the usage of 5G-VINNI Business Layer were considered, through which the main requirements were extracted.

The **external** user group includes the following personae: Digital Transformation Leader; Business Analyst & Digital Consultant; SW Developer; System Administrator/Network Specialist; Service Manager & Quality Assurance Manager; Solution Designer & System Architect.

The **internal** user group includes the following personae: DevOps Expert; Service Manager; Network Specialist; Solution Designer; Test Specialist; Account Manager.

Questionnaires for internal and external users

In order to refine the Business Layer requirements documented in D5.2, we again involved both internal and external users into two questionnaires, one for each user group. Each questionnaire was tailored considering our main user groups: internal users and external users (Those questionnaires are attached in Annex A).

The questionnaires were forwarded to 5G-VINNI users in the following order:

1) Inside 5G-VINNI partners (including in particular internal users from facility sites)
2) to ICT19 project and ESB (as external users).

Reaching out to ICT19 projects, we tried to specifically engage the projects that aim to use the 5G-VINNI facilities for the implementation of their pilots/testbeds, however, we also opened up the questionnaire for all ICT19 projects to obtain their feedback.

MoSCoW method [10],[11]

Even if all requirements are relevant for 5G-VINNI Business Layer, we need to prioritize requirements based on the preferences of both user groups and the needs in each ML of 5G-VINNI facility operation. Considering the high number of functionalities/features that need to be developed, we aim at understanding what we need to do first and what can be postponed, in order to deliver the best and most immediate business benefits early and within the budget/resource limits of the project. After a brief analysis of different methods, the MoSCoW method was promoted.

The MoSCoW method is a prioritization technique used in management, business analysis, project management, and software development to reach a common understanding with stakeholders on the importance they place on the delivery of each requirement. It is considered a prioritization technique for helping to understand and manage priorities. The MoSCoW letters stand for:

- “Must have”
- “Should have”
- “Could have”
- “Won’t have”

The MoSCoW method addresses some problems associated with other simpler prioritization approaches which are based on relative priorities. For instance:

- The use of a simple high, medium or low classification is weaker because definitions of these priorities are missing or need to be defined.
- The use of a simple sequential 1, 2, 3, 4… priority is weaker because it deals less effectively with items of similar importance. There may be prolonged and heated discussions over whether an item should be one place higher or lower.

A description of the meaning of each of the options “must have”, “should have”, “could have” or “won’t have”, provides a clearer indication with respect to the importance of each requirement. Following such an approach, it is made very clear to the project that during the development phase we must first deliver all the “must have”, and then the “should have” and “could have” requirements. In case of limited resources or other constrains (related to each ML) the priority of some requirement may change. For instance, a “should have” requirement may be postponed for later releases of the Business Layer due to resource constraints or low relevance to early MLs of 5G-VINNI. The joint consideration of all these aspects for the gradual and phased rollout of the 5G-VINNI Business Layer is discussed in section 4.

In order to validate and prioritize the collected 5G-VINNI Business Layer requirements, we asked the different users to give us their feedback following the MoSCoW method. The main description for MoSCoW parameters were somewhat different for internal and external users.

Internal users:

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)

- Could have (it is desirable because it could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have (it is considered as non-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't know

External Users:

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as non-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't know

We also gave the respondents the possibility to answer “I don’t know”.

2.2 Final 5G-VINNI Business Layer requirements

In the first phase of the project, we identified 20 business layer requirements (as reported in D5.2). Internal discussions before and after the questionnaire results motivated the addition of one more requirement, as well as to complete redefinition of the previously collected requirements in order to be more aligned with user expectations. These 21 refined requirements are described briefly in the following table.

Table 2-1 Consolidated list of final 5G-VINNI Business Layer requirements

Requirement title	Short description
Global Service Catalogue	The service catalogue should include all the 5G-VINNI facility offerings that are available and accessible to vertical customers (e.g., enterprises). These offerings can originate from any facility site in 5G-VINNI that may also involve services from 3rd-party providers that complement the 5G-VINNI platform.
Secure universal login	Unique customer access to the platform should be available to allow users’ account creation and log in. This access authorises each member to have a personalized view of past transactions and monitoring of pending items
Global coverage	A service should not be restricted to the subscribers and resources of a single communications service provider/network operator.
Flexible cost/revenue sharing agreements	Billing systems should support a wide range of revenue sharing and cost splitting agreements, addressing also the scenario where multiple facility sites contribute to a single service.
Homogeneous service E2E	Vertical organisations should obtain consistent experience, even in the case of federated/collaborative service provisioning. Thus, operators participating in service delivery should have a common view of the attributes to be met.

Automated replicability	A product/service/experiment should be automatically replicated in other regions or instantiated over time, in order to reduce complexity and time to market.
Open to external suppliers	A service catalogue should include capabilities and other services (e.g., VNFs - Virtual Network Functions) by other external suppliers, both facility sites and the so-called complementors (that is firms that want to use the 5G-VINNI platform for providing vertical services). Then, third-party developers and professionals can make their services available to 5G-VINNI platform customers rather than offer only a limited set of in-house solutions.
Pick and choose	Capabilities and services should be available so that vertical customers and aggregators/brokers can compose new chained services to cater to their needs and business models.
Experiment	Capabilities and services should be available so that customers can experiment and consider if it meets their requirements.
Community	Exchange of knowledge, such as results and best practices obtained from previous experiments, troubleshooting, etc. could be useful for new potential customers, who have limited experience with 5G onboarding processes.
Real-time performance monitoring	Resources and capabilities monitoring mechanism should be in place, allowing experimenters to track the status and performance of the experiment in real-time.
Reporting	At the end of the experimentation and for each experiment and single test inside it, a detailed report should be available of the results and used resources and capabilities. These reports can support vertical organisations to make better decisions for replication in the real world and to understand if they are meeting the required needs.
Open documentation	The experiment results and other reports can be made available and shared with registered and unregistered users. The experiment results should be open to all or at least to all registered users according to the experiment owners' preferences.
Feedback mechanism	Customer feedback on the experience perceived and trouble-shooting tickets can support facility owners to improve their offers and other users to have justifiable levels of trust to the system. Ability to communicate/interact with the customer, in the system.
Flexible way of SLA definition and billing	Customers should be able to define SLA terms (e.g., setting latency and/or bandwidth range according to their needs) and get a quote.
Slice Control	In some cases, the customer (vertical or complementor) could need to dynamically manage and control the parameters for the service instantiation (for instance the location to instantiate a specific VNF, modify the latency and bandwidth at run time, etc.). Slice Control could provide to the vertical customer the slice or service instantiation control.

Assisted customer access	Users should be assisted when interacting with a facility site during each phase of the experiment or service lifecycle by receiving notifications when certain events take place. Customers should easily monitor order status (including faults).
License management	Experimenters that want to onboard VNFs from 3rd parties should be able to supply license details or where these can be retrieved from.
Experiment scheduling and setup	Customers should be able to define when an experiment will take place and see an overview of other planned experiments. Customers should have the possibility to define and set the parameters for the service experimentation.
User device access control	Customers may want to restrict the set of participants in the experiments.
Platform documentation/ handbook/tutorial	Specific 5G-VINNI Platform documentations like videos, handbooks, tutorials on how to use it, can facilitate its utilization.

In the remainder of this section, we will present a brief statistical overview of the survey participants, and then the main results of the submitted answers.

The respondents that belong to the external users' group come from the sectors Energy, ICT, Media, Security, and Academia/Research, as illustrated in Figure 2-1. Note that one-third of internal users came from the ICT sector. As illustrated in Figure 2-2, we covered most external user roles, with Solution designers/System architects constituting 46% of our sample. Unfortunately, none System Administrator/Network Specialist replied to the questionnaire invitation.

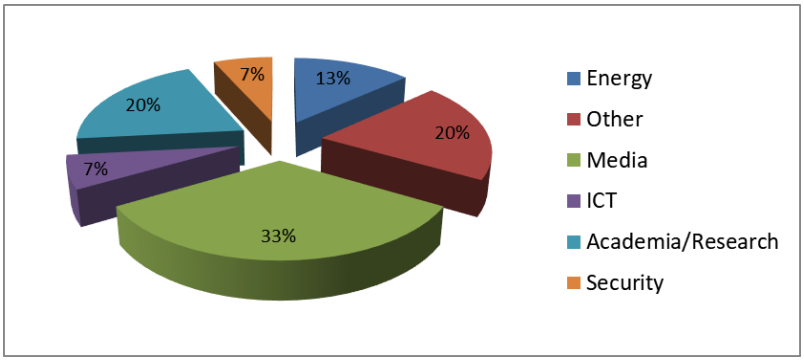


Figure 2-1: Sector of respondents in external users' group

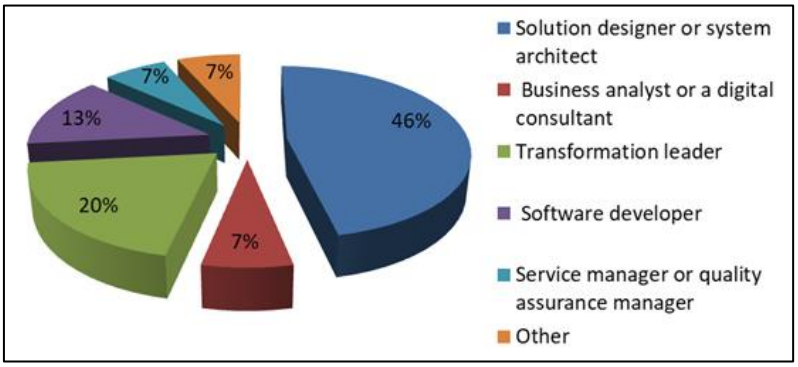


Figure 2-2: Roles/Personae of the respondents in external users' group

Of all the external users answering the questionnaire, 67% come from 5G-VINNI External Stakeholder Board (ESB) and ICT-19 projects that are using 5G-VINNI platform facilities for their 5G experimentations.

Focusing on respondents that belong to the internal users' group, 50% come from the academy/research sector (involved in the facility sites), and 37% from Telecom, as shown in Figure 2-3. Most of the answers from the internal user roles came from Network Specialist or also other roles, as shown in Figure 2-4. In total, we covered most other roles, except Account Manager.

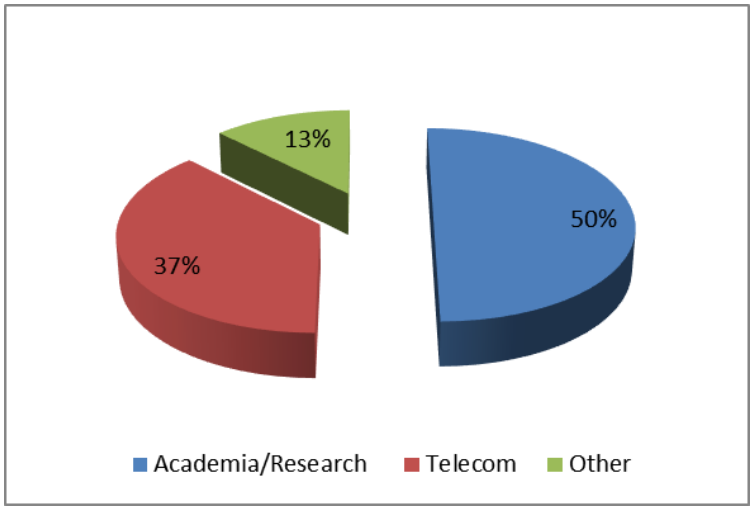


Figure 2-3: Sector of respondents in internal users' group

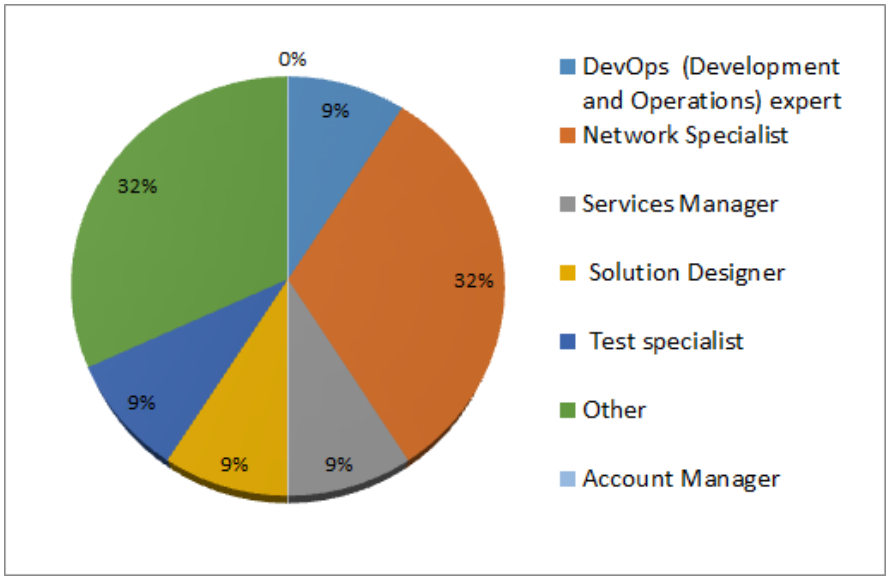


Figure 2-4: Roles/Personae of the respondents in internal users' group

The results of the questionnaire's responses validate the relevance of all our proposed requirements. However, in some cases, the degree of importance/priority of each requirement is different for internal and external users, as well as for the different roles within the same user group.

Global Service Catalogue: Considering internal users, 61% responded that "Global Service Catalogue" is a "must have", and 30% a "should have". Regarding, external users only 31% considered this a "must have", while 50% voted for this requirement as a "should have". Furthermore, 75% of the external users respond that the relevance for having a "Global service catalogue" can increase when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services.

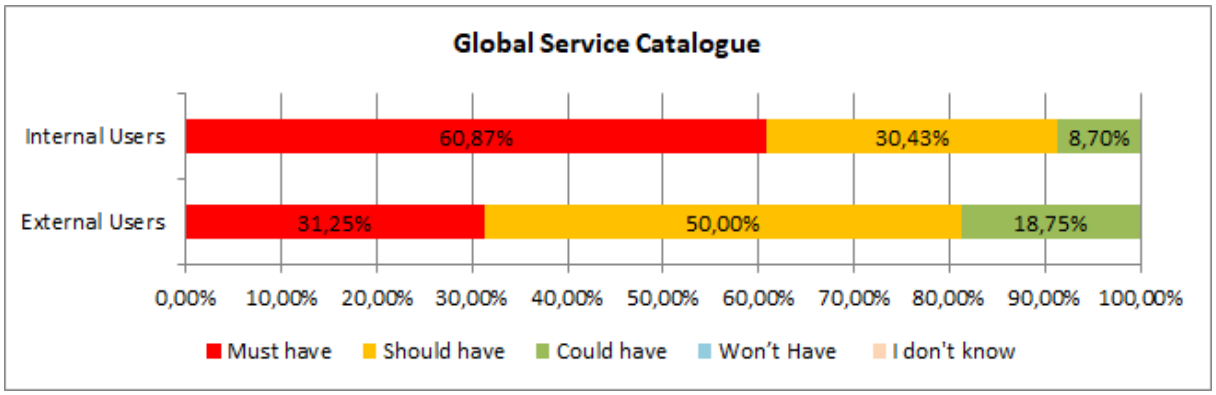


Figure 2-5: Global service catalogue according to internal and external users

Secure universal login: "Secure universal login" is considered very relevant for internal users. Specifically, 50% regard it as "must have" and 29% as "should have". External users find it less relevant considering that 50% consider it a "should have" and only 38% a "must have". Of external users, 69% respond that the relevance for having a "Secure universal login" could increase for a long-term commercial 5G-VINNI scenario.

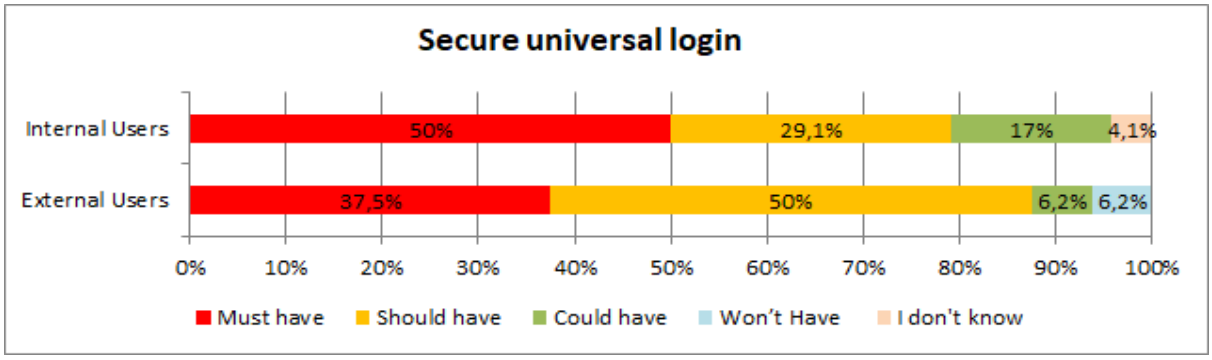


Figure 2-6: Secure universal login according to internal and external users

Global coverage: "Global coverage" as described in the table above, is considered not of primary relevance by both internal and external users. The former voted for "could have" with 35% and 44% of the latter voted "should have". Still, a minority part considers it as a "must have". In particular it seems more relevant for the internal user service manager role. According to 50% of the external users, the relevance of "Global coverage" could increase in a 5G-VINNI long-term commercial scenario.

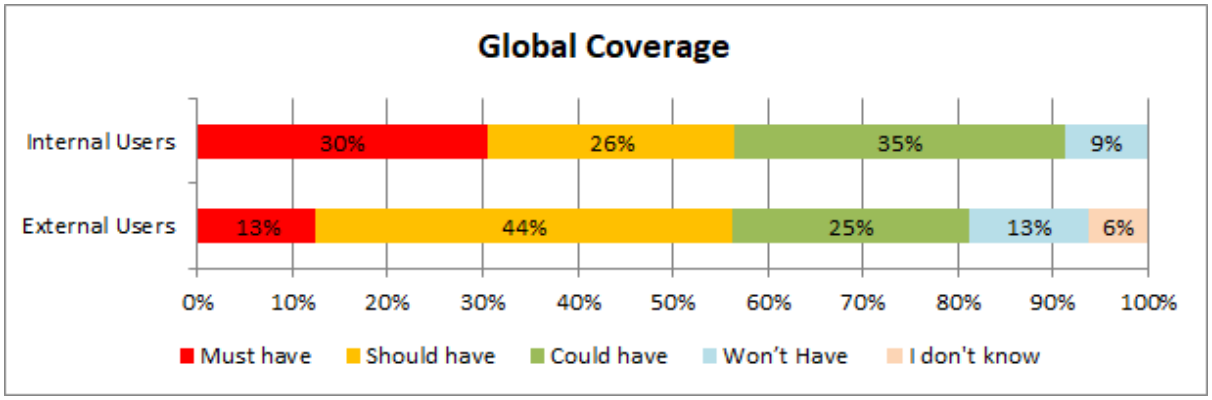


Figure 2-7: Global coverage according to internal and external users

Flexible cost/revenue sharing agreements: This requirement has similar importance for internal and external users, that is, they both place it as "could have". The mechanism for the cost/revenue sharing may be more relevant in the long-term sustainability of the 5G-VINNI platform. Considering

that, this requirement is considered not fundamental for the successful interaction with a 5G experiment platform at the time of the project life cycle. In fact, for 50% of external Users, the relevance for this requirement increases when considering a long-term commercial 5G-VINNI scenario.

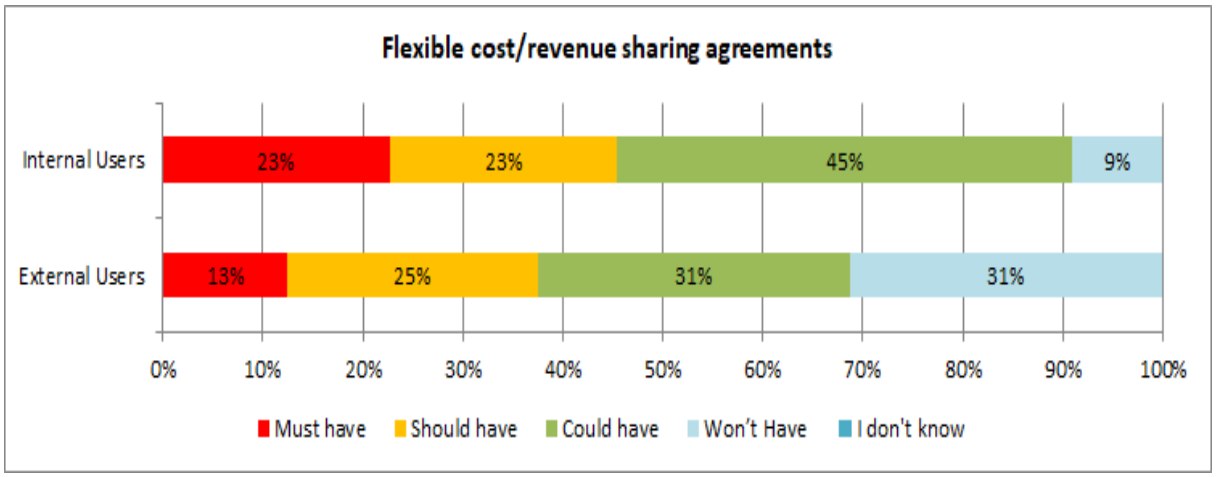


Figure 2-8: Flexible cost/revenue sharing agreements according to internal and external users

Homogeneous service E2E: According to the questionnaire results "homogeneous service E2E" seems very relevant. 44% of external users voted for "must have". Only 30% of internal users voted "must have" while a majority of 39% voted "should have". Considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services, 50% of external users said that the relevance for it can increase. 31% said that it could be the same.

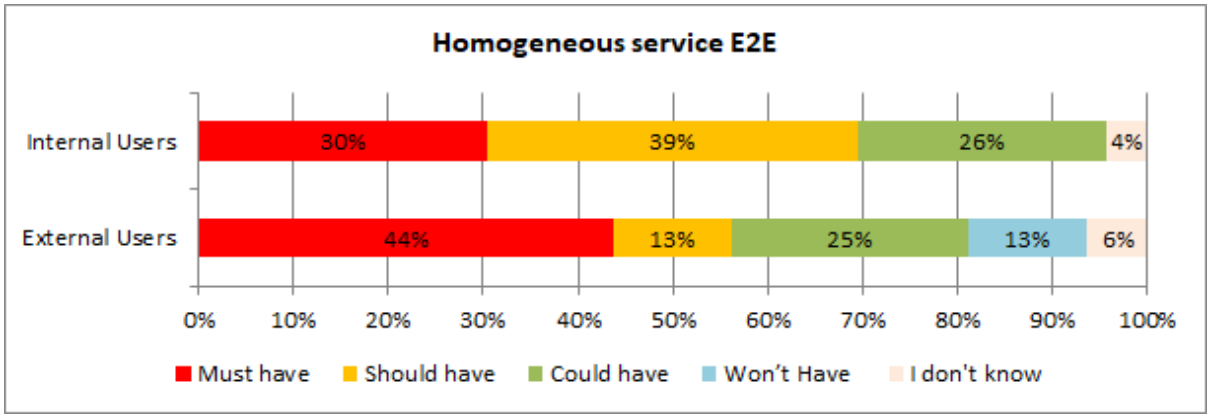


Figure 2-9: Homogeneous service E2E according to internal and external users

Automated replicability: For the requirement "automated replicability", both user groups agreed that it is important because it provides innovative features. However, it is not at all fundamental for interacting with the 5G-VINNI platform or for the platform's success - a low share regarded it as a "must have". Of external users, 44% voted "should have" and 50% of internal users did the same. Furthermore, 75% of external users responded that the relevance for having an "automated replicability" can increase when considering a long-term commercial scenario for 5G-VINNI.

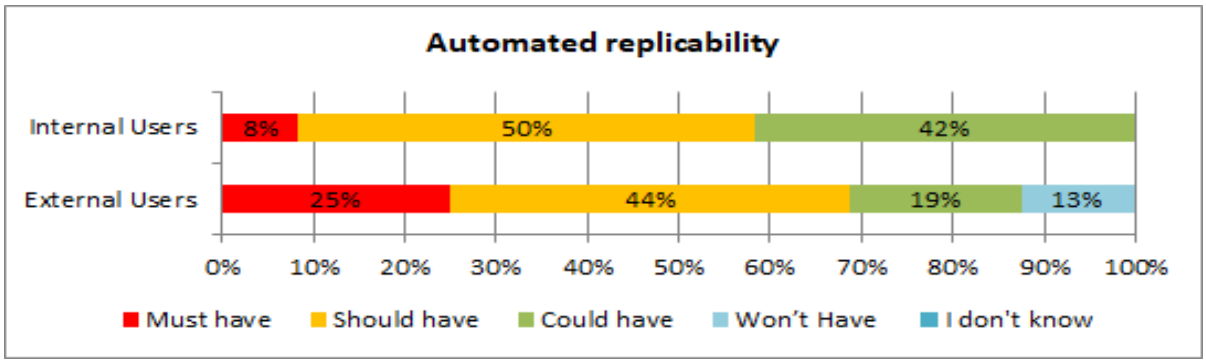


Figure 2-10: Automated replicability according to internal and external users

Open to external suppliers: Both user groups agreed that the "open to external suppliers" requirement is important because it provides innovative features. Again, only a few saw it as a "must have". 46% of internal and 44% of external users thought it is a "should have" requirement. In a long-term 5G-VINNI vision, 50% of the external users said that relevance can increase, and 38% said that it would be the same.

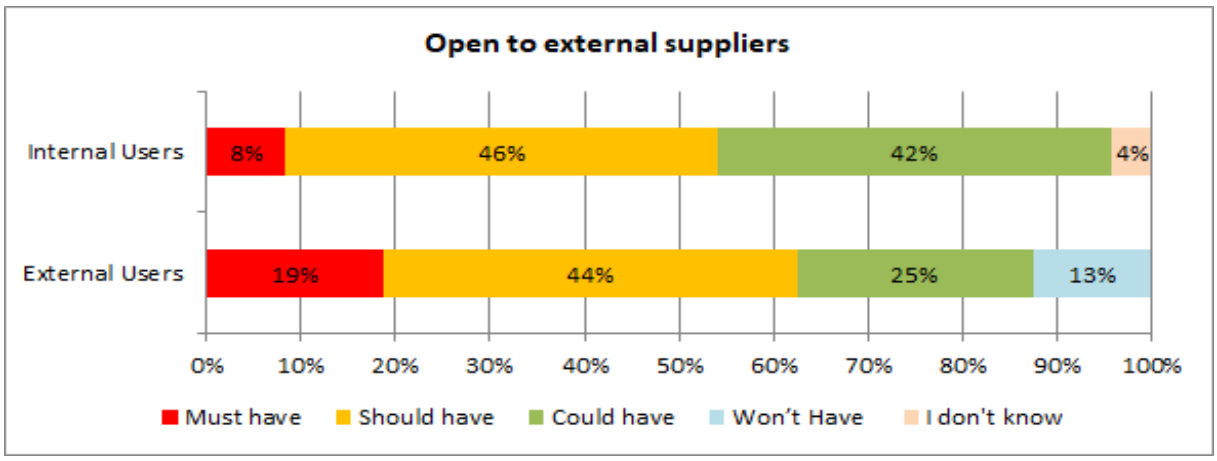


Figure 2-11: Open to external suppliers according to internal and external users

Pick and choose: On the "pick and choose" requirement, both user groups agreed on its importance because it provides innovative features. However, it is not currently regarded as fundamental for interacting with the 5G-VINNI platform or for the platform's success. 38% of internal and 50% of external Users voted "should have". Furthermore, in a long-term vision, 56% of the external users said its relevance can increase, against the 25% that said it would be the same.

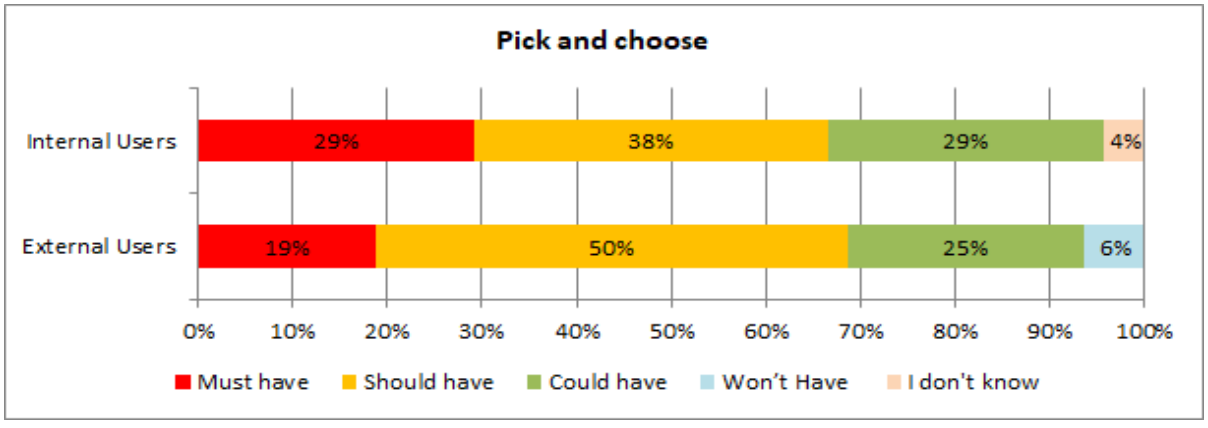


Figure 2-12: Pick and choose according to internal and external users

Experiment: The "experiment" requirement concerns "to have available capabilities and services for giving the possibility to customers to experiment and consider if it meets their requirements". Both user groups consider it a critical requirement for assuring the interaction with and the success of the 5G-VINNI platform. In this direction, 62% of external users voted for the "must have ". For internal users, 46% voted respectively for "should have" and "must have". In a long-term vision, 50% of the external users said that the relevance could increase even more, while the other 50% said that it would be the same.

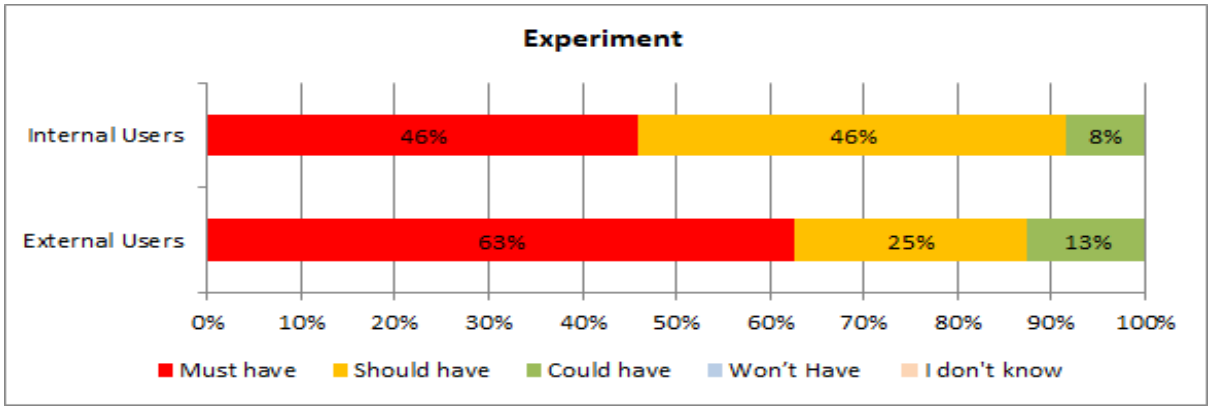


Figure 2-13: Experiment according to internal and external users

Community: The possibility to exchange knowledge, such as results and best practices obtained from previous experiments, troubleshooting, etc., seems a very debated requirement for both user groups. The majority of internal users tends to vote "could have" (46%), while the external users were split in three between "must have", "should have", and "could have". Consequently, we will consider this requirement as important for interaction in particular for the external users, though not at the same level as requirements with a higher evaluation. Also, in a long-term vision, only 50% of external users said that its importance could increase, while 44% thought it could be the same.

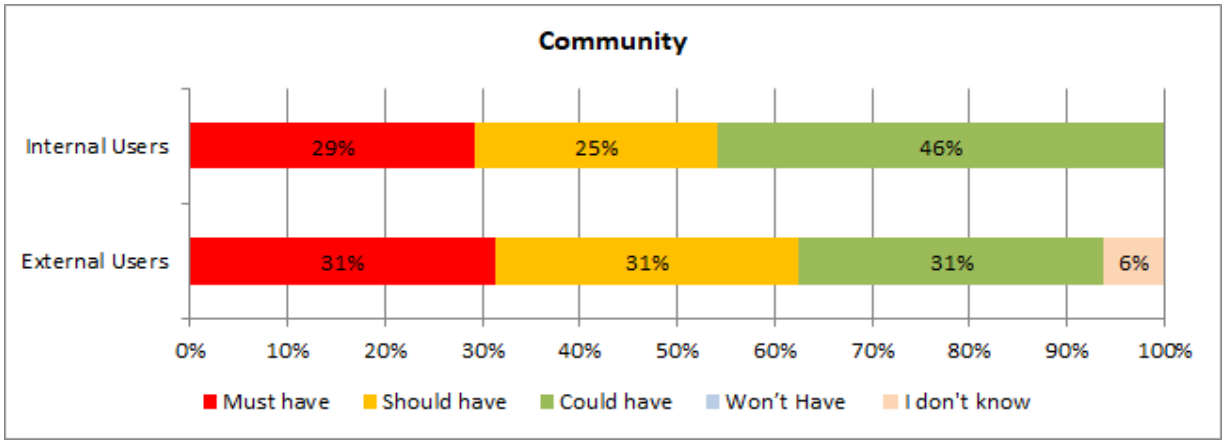


Figure 2-14: Community according to internal and external users

Real-time performance monitoring: The possibility to have in place mechanisms for real-time monitoring of resources and capabilities, in order to allow experimenters to track the status and performance of the experiment in real-time, is considered very critical. 75% of external users voted for "must have". Besides, 50% say its relevance could increase in a long-term vision, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services. 44% said it could be the same.

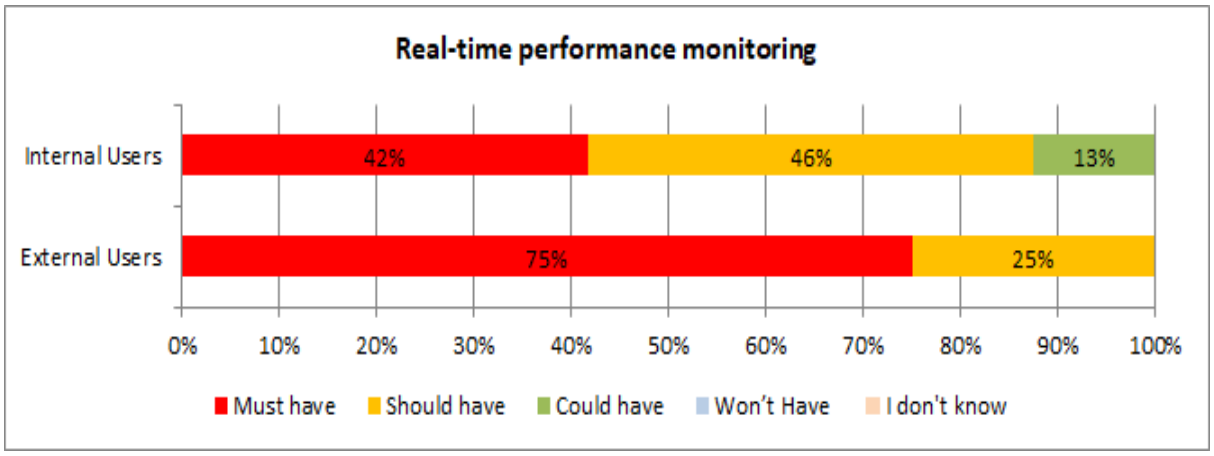


Figure 2-15: Real-time performance monitoring according to internal and external users

Reporting: The requirement "reporting" is one of the most critical requirements for the external users (56% of "must have"). A detailed report of the results and used resources and capabilities at the end of an experiment is a priority for vertical organisations. For internal users, this requirement is important because it provides innovative features, but is not fundamental for the 5G-VINNI platform's success. Of internal users, 54% said it was a "should have" requirement, and 42% said that it is a critical "must have" requirement. In sum, despite the difference in emphasis for interval versus external, we can consider "reporting" as a very relevant requirement, in particular for the external users. This relevance could increase said 50% of participants, in a long-term vision. For the rest of the participants, it could be the same.

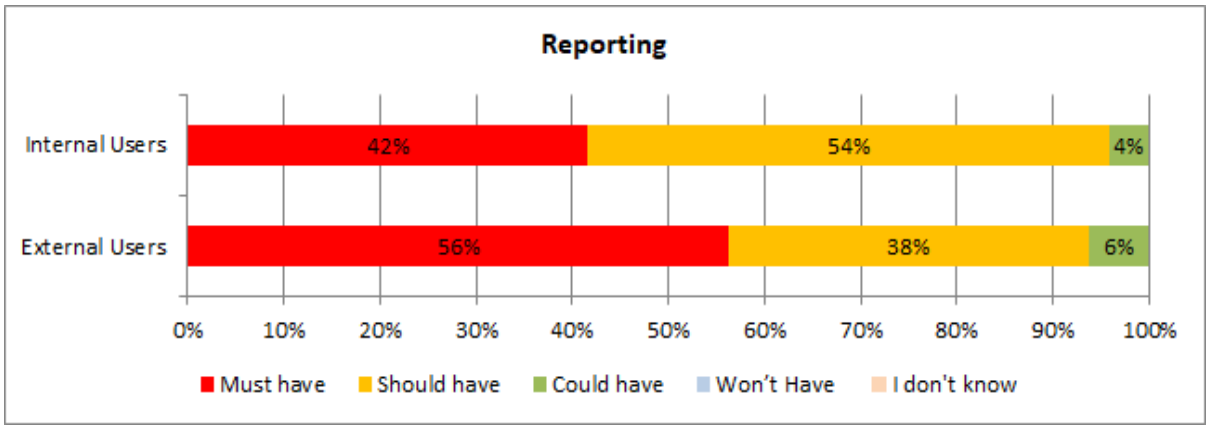


Figure 2-16: Reporting according to internal and external users

Open documentation: On the "open documentation" requirement, both user groups agree that it is desirable because it could improve the end-user experience or customer satisfaction at a low implementation cost. However, it is not necessary for the 5G-VINNI platform's success or for a successful interaction with the 5G-VINNI platform. A majority voted "could have", 29% of internal users and 44% of external users. In a long-term vision, 44% of external users said the relevance could increase, and 44% said that it could be the same.

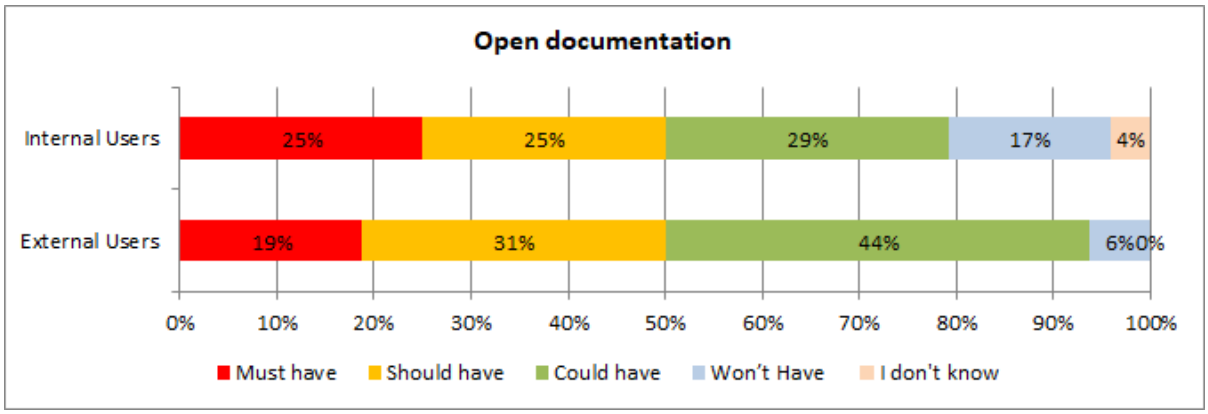


Figure 2-17: Open documentation according to internal and external users

Feedback mechanism: The "feedback mechanism" requirement is considered by both user groups as important because it provides innovative features, but it is not fundamental for interacting with the 5G-VINNI platform, for the platform success or the project implementation. We gathered mostly "should have" votes: 42% from internal users and 56% from external users. Even if 33% of internal users consider it as a critical requirement, in a long-term vision, 69% of the external users said that the relevance for it could increase, while the rest said that it could be the same.

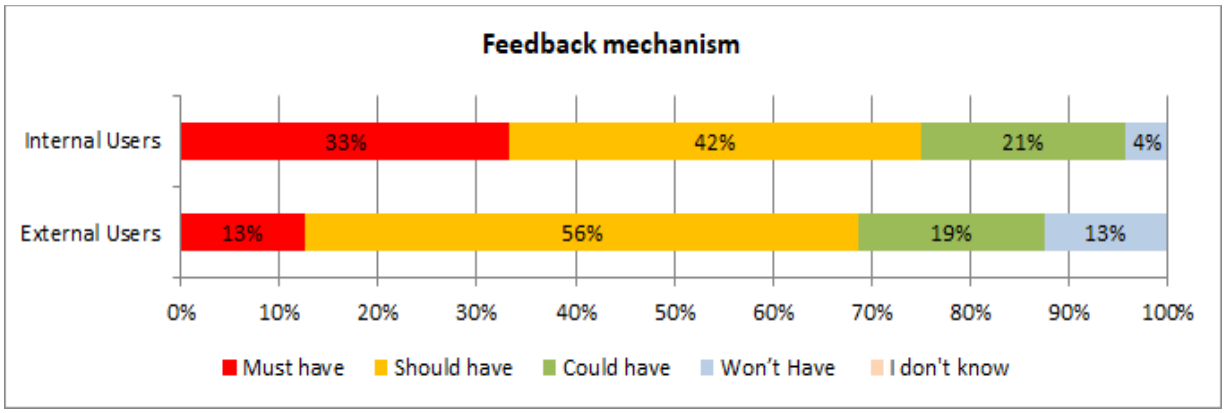


Figure 2-18: Feedback mechanism according to internal and external users

Flexible way of SLA definition and billing: For this requirement, both user groups agree that it is important because it provides innovative features but not fundamental for interacting with the 5G-VINNI platform or for the platform success (46% of internal and 38% of external users voted for "should have").

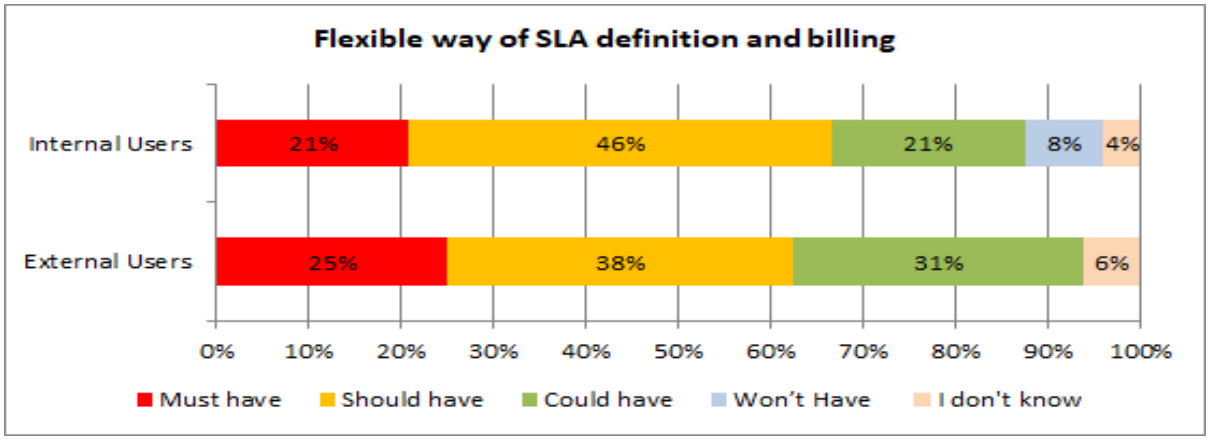


Figure 2-19: Flexible way of SLA definition and billing according to internal and external users

In a long-term vision, 69% of the external users, said that the relevance for it could increase, while 19% said that it could stay the same.

Slice Control: Both user groups have the same opinion for this requirement. It is considered important because it provides innovative features but not fundamental. 63% of internal users voted for "should have" as well as the 50% of the external users. In a long-term vision, 56% of the external users said that the relevance could increase, while 31% said that it could stay the same.

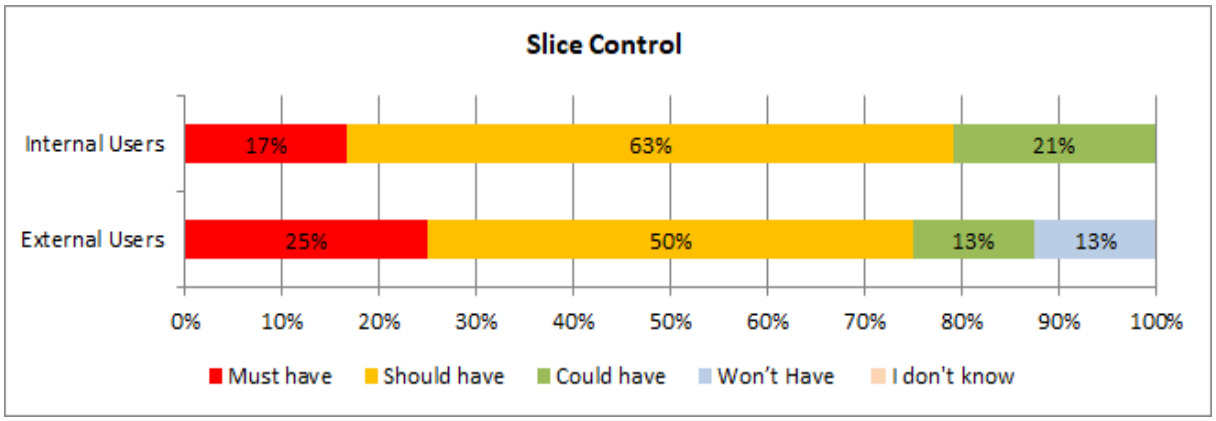


Figure 2-20: Slice Control according to internal and external users

Assisted customer access: This requirement "assisted customer access" is very critical for external users. 56% of them consider it a "must have" requirement. To be assisted when interacting with a facility site during each phase of experiment or service life-cycle is considered very critical for assuring a right interaction with the 5G-VINNI Platform, for instance by receiving notifications when certain events take place as well as the possibility to easily monitor order status. For the internal users, this requirement is important but it is not critical for the success of the platform. 38% responded "should have" and a total of 33% still consider it a critical requirement. In a long-term vision, 56% of the external users said that the relevance for it could increase further, while 31% said that it could be the same.

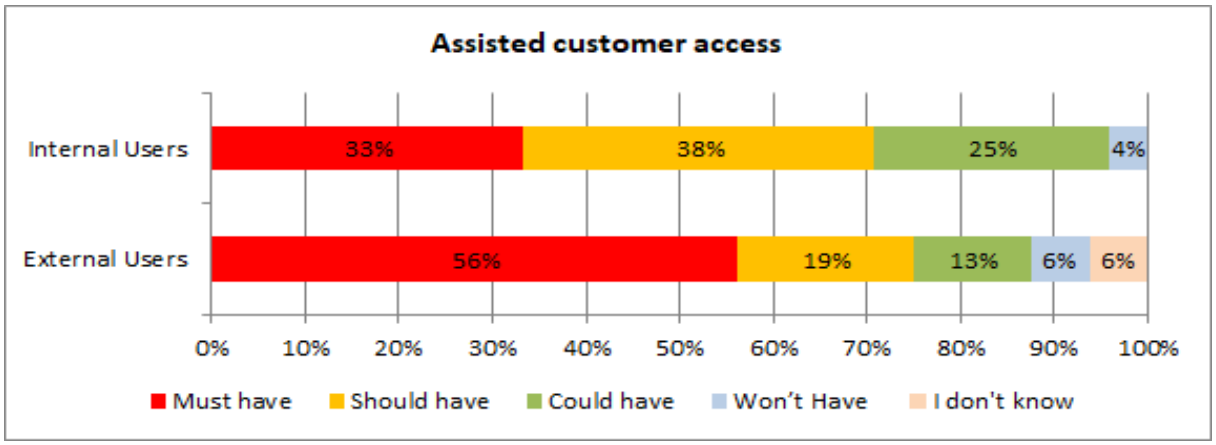


Figure 2-21: Assisted customer access according to internal and external users

License management: The "License management" requirement, is considered by both user groups as important because it provides innovative features but not fundamental for interacting with the 5G-VINNI platform. 50% of internal users voted "should have" and 56% of the external. In a long-term vision, about 69% of the external users said that the relevance for it could increase, while 19% said that it could stay the same.

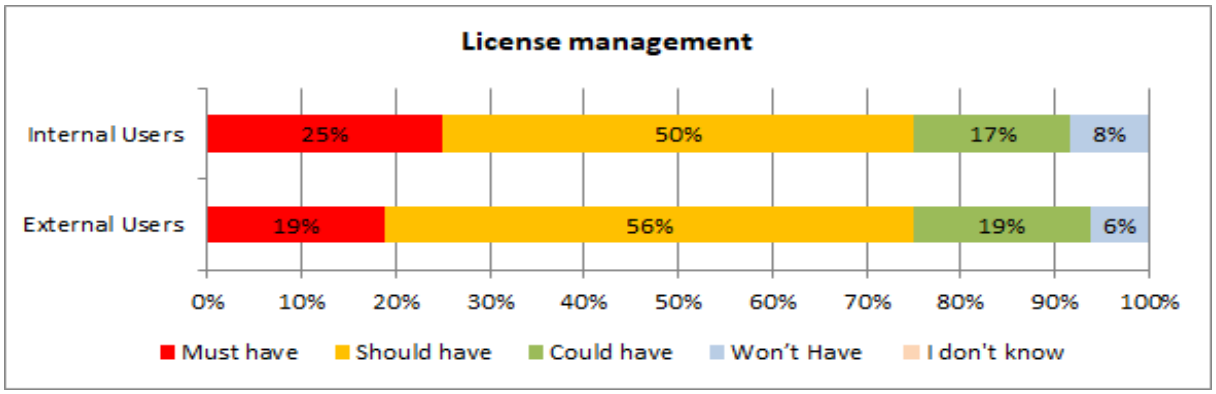


Figure 2-22: License management according to internal and external users

Experiment scheduling and set up: The "experiment scheduling and set up" is, according to the questionnaires' results, one of the fundamental requirements for both user groups. We gathered 50% of "must have" votes from internal users and 47% from external ones. Furthermore, a large share considered this requirement as a "should have", 33% and 29% of internal and external users as shown in the figure below. In a long-term vision, about 50% of the external users said that the relevance for it could increase even further, while 44% said that it could stay the same.

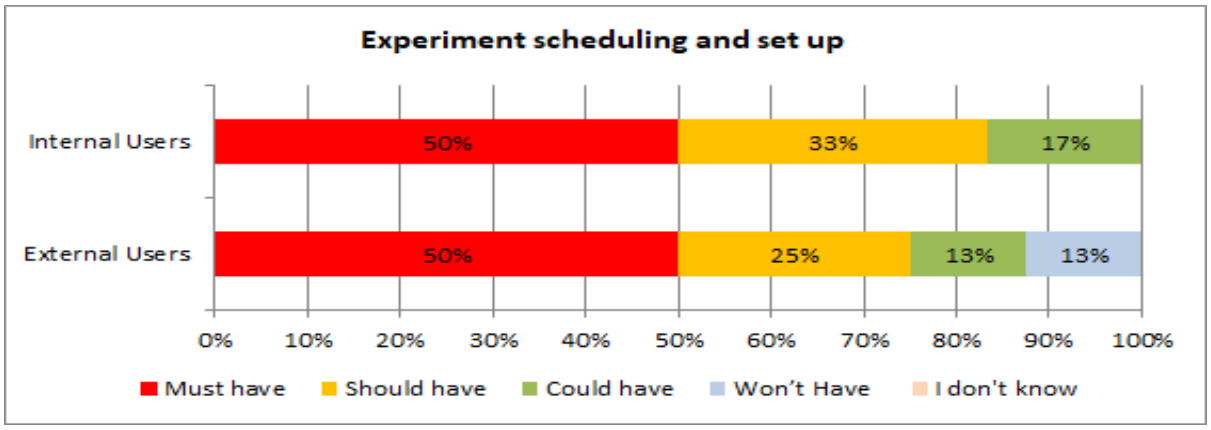


Figure 2-23: Experiment scheduling and set up according to internal and external users

User device access control: For the "user device access control" requirement, both user groups have a similar opinion. It is considered important because it provides innovative features but not fundamental. 67% of Internal users voted for "should have" and 44% of the external users.

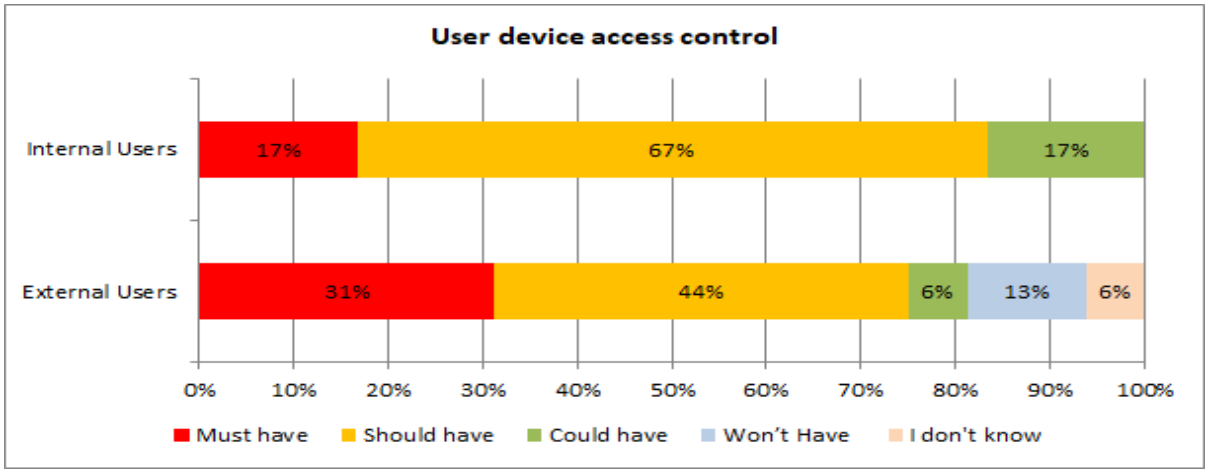


Figure 2-24: User device access control according to internal and external users

In a long-term vision, only 37% of the external users said that the relevance for it could increase, and another 37% said that it would stay the same.

Platform documentation/handbook/tutorial: Both user groups agree that the requirement "platform documentation/handbook/tutorial" is a very critical requirement for successful interaction with the 5G-VINNI Platform. In fact, 62% from internal users and 56% from external ones voted for "must have". In a long-term vision, 50% of the external users said that the relevance for it could increase further, while about 44% said that it would stay the same.

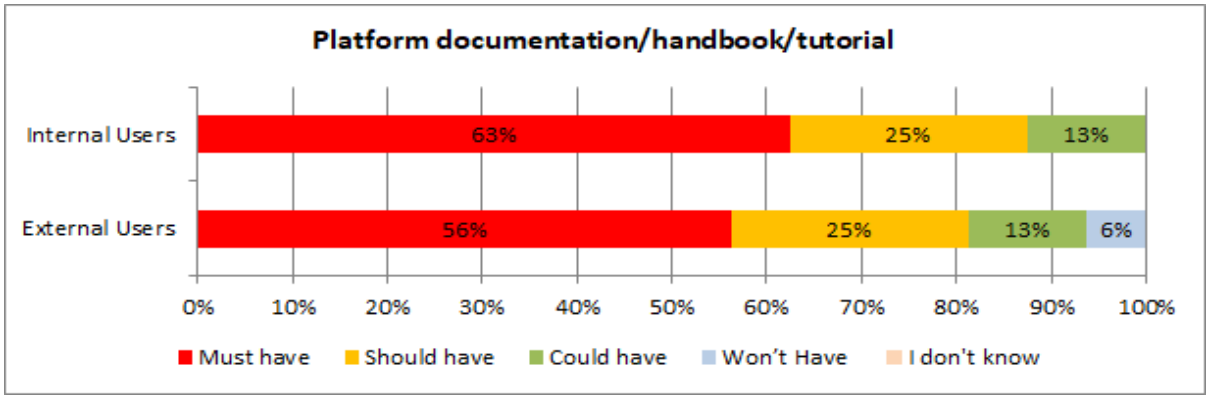


Figure 2-25: Platform documentation according to internal and external users

2.3 Business Layer requirements priority following the MoSCoW method

This section provides a summary of the users' priority, for the business layer requirements according to the results collected in the questionnaires. The overview presents the key outcomes of questionnaires, for each user group separately, as well as for users as a whole. An additional analysis of collected results per user persona is included in Annex B.

Considering the responses of internal users, Figure 2-26 shows the assignment of each requirement to a "must have", "should have", "could have" or "won't have" tag, based on the response with the highest percentage. The requirements that appear in the red area were identified as the most important ones for internal users, and considered as critical for the success of the 5G-VINNI platform. In particular, according to internal users, the requirements that must be addressed in the earliest 5G-VINNI Business Layer release are:

- Platform documentation/handbook/tutorial (62% "must have")
- Global service catalogue (61% "must have")
- Secure universal login (50% "must have")
- Experiment scheduling and setup (50% "must have")
- Experiment (46% "must have")

Accordingly, considering the responses of **external users**, Figure 2-27 shows the respective assignment of all requirements. Interestingly, the list of requirements considered very important for the successful interaction of external users with the 5G-VINNI platform, differs from the ones identified by the internal users:

- Real-time performance monitoring (75% "must have")
- Experiment (62% "must have")
- Reporting (56% "must have")
- Platform documentation/handbook/tutorial (56% "must have")
- Assisted customer access (56% "must have")
- Experiment scheduling and set up (47% "must have")
- Homogeneous service E2E (44% "must have")

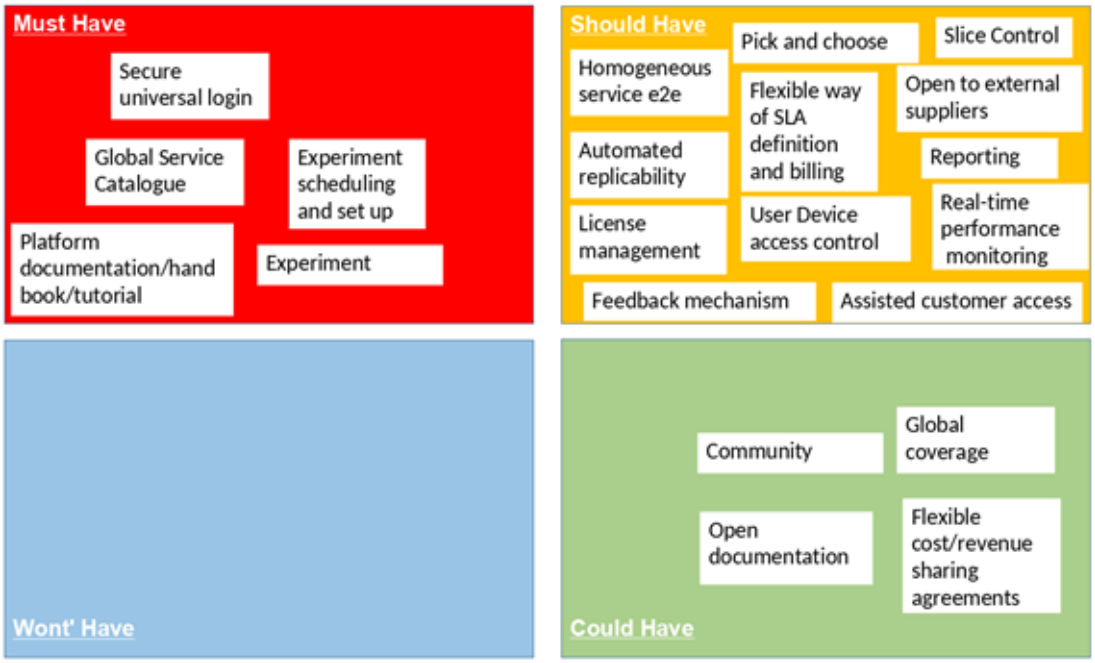


Figure 2-26: Requirements' prioritization for internal users

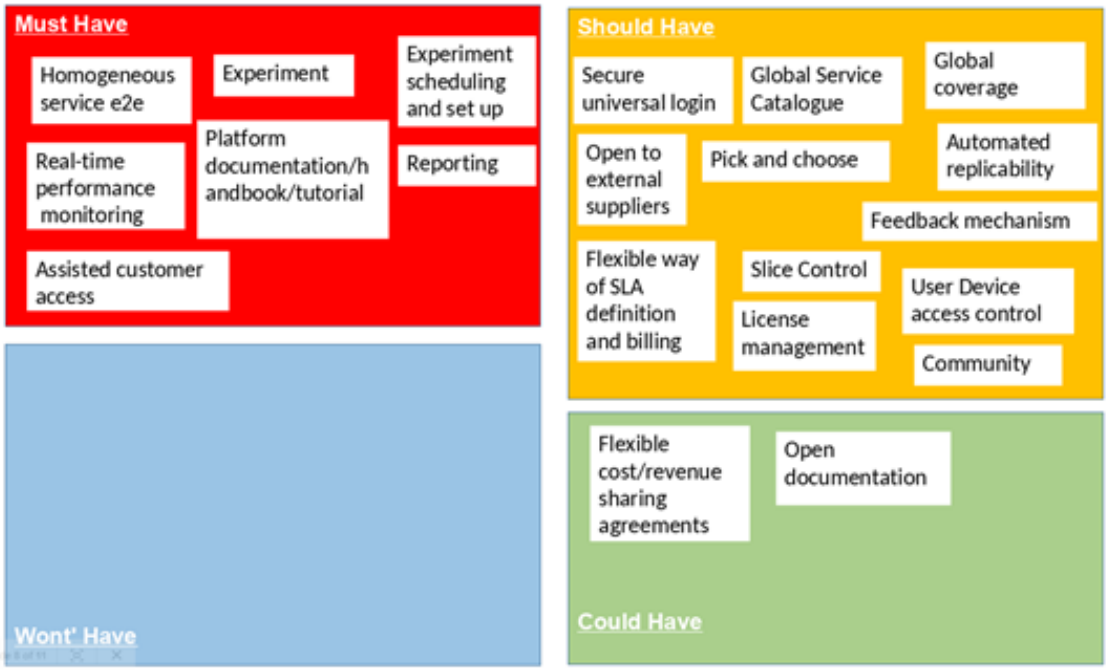


Figure 2-27: Requirements' prioritization for external users

The rest of the suggested and proposed requirements are allocated in the "should have" and "could have" areas. This means that even if they are considered important or desirable, they are not considered as critical for the success of or successful interaction with the 5G-VINNI platform. This means that they may be addressed in a later phase (i.e., future MLs). Specifically, for both internal and external users, the majority of the requirements (12 on 21) are considered as "should have". In some cases, the difference in votes between "should have" and "must have" is very low. This means that, even if those requirements are not critical, they are very important for providing innovative features by part of the 5G-VINNI platform. In Table 2-2 and Table 2-3 below, the "should have" requirements for the user groups are presented.

Table 2-2: "Should have" requirements for internal users

Requirements	"Should have" percentage
User device access control	67%
Slice Control	62%
Reporting	52% (42% "must have")
License Management	50%
Automated replicability	50%
Real-time performance monitoring	46% (42% "must have")
Open to external suppliers	46%
Flexible way of SLA definition and billing	46%
Feedback mechanism	46%
Homogeneous service E2E	39%
Assisted customer access	38% (32% "must have")
Pick and choose (38%)	38%
Community	32% (31% "should have")

Table 2-3: "Should have" requirements for external users

Requirements	"Should have" percentage
Feedback mechanism	56%
License Management	53%
Slice Control	50% (25% "must have")
Pick and choose	50%
Secure universal login	47% (35% "must have")
Global service catalogue	47%
User device access control	44% (31% "must have")
Automated replicability	44% (25% "must have")
Open to external suppliers	44%
Global Coverage	44%
Flexible way of SLA definition and billing	38%
Community	31%

The "could have" requirements are desirable because they can improve the user experience or customer satisfaction, but not necessary for the 5G-VINNI platform success. According to the questionnaire results, only 4 out of 21 requirements scored high on "could have" for internal users. These are the "Community", "Flexible cost/revenue sharing agreements", "Global coverage" and "Open documentation". While for the external users only two requirements are placed in the "could have" area, namely the "Flexible cost/revenue sharing agreements" and "Open documentation". Note that the response "won't have" was rarely used by the respondents. This means that all the included requirements can be considered valid and relevant for the majority of users.

In conclusion, the consolidated view of the Business Layer requirements priority is shown in Figure 2-28: Requirements' prioritization for users as a whole. The requirements that were identified as "must have" by 5G-VINNI users as a whole are:

- Real-time performance monitoring
- Experiment
- Platform documentation/handbook/tutorial
- Assisted customer access
- Experiment scheduling and set up
- Global Service Catalogue

- Secure universal login

This means, in a nutshell, that the minimal requirements needed for meeting the users' needs are linked to the possibility to access experiment resources, having the possibility to schedule, and set up their experiments. During this process, the users ask to be supported with different means (having a service catalogue, or with a specific tool for support the access, or also having available documentations, and tutorials). When the experiment process starts, the main request by users seems to be the possibility to monitor the performance in real-time. All the requirements that are placed in the "should have" and "could have" areas may be considered by us as requirements that could provide innovative features and to be taken into account in the future in order to orient services towards commercialisation.

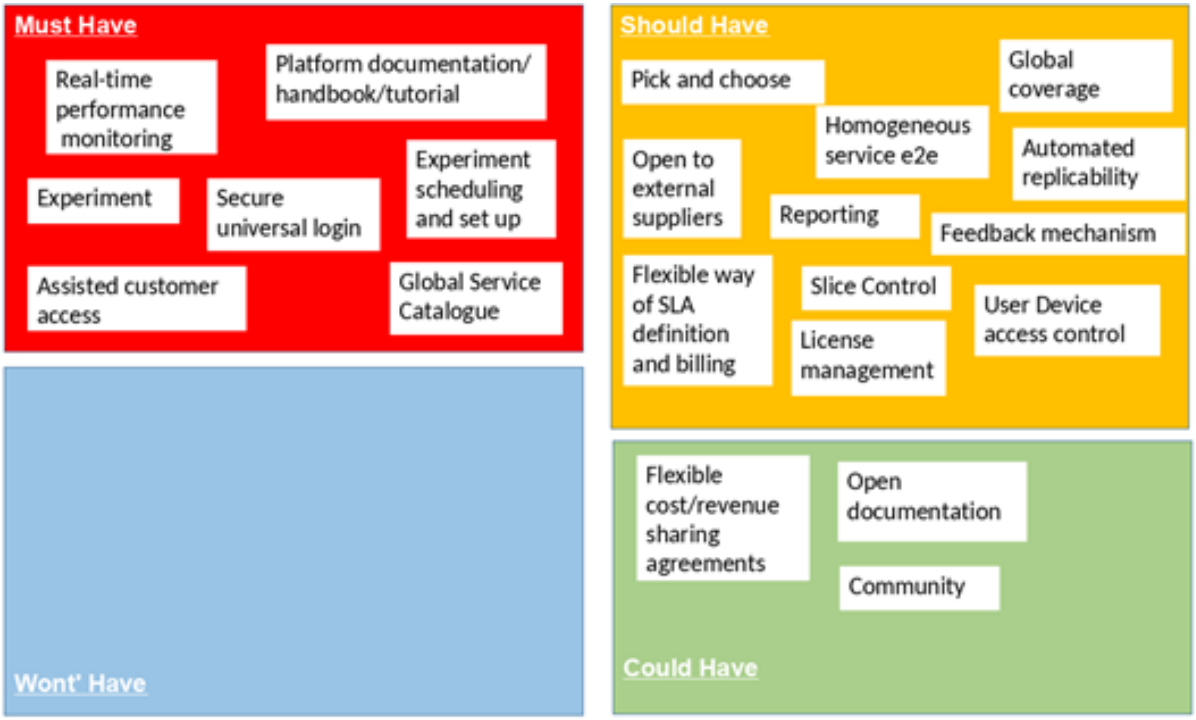


Figure 2-28: Requirements' prioritization for users as a whole

3 5G-VINNI Business Layer capabilities

3.1 Final Business layer capability features

In this section, we provide the list of final 5G-VINNI Business Layer capabilities along with a mapping between them and the identified Business Layer requirements. The mapping between requirements and capabilities aims to justify that the selected set of capabilities are enough to satisfy the identified requirements. Note that these capabilities were initially introduced and elaborated in D5.2 [2], thus avoiding repeating material we keep the current descriptions brief and we focus on certain capabilities' refinement. We have identified three main capabilities, namely User Login, Service Order Management and Knowledge Repository Management, each of them consisting of multiple features.

3.1.1 User Login

User Login capability performs user authentication, authorization and accounting for user logins such as collecting timestamps, IP addresses, etc. in order to enable access control to the 5G-VINNI platform for external and internal users. Examples of external users are other facility sites/ CSPs, third party suppliers, research community and end-users of the services offered. Additionally, User Login supports three features that enhance the main User login capability and will be further described below:

- **Role Management** feature allows the creation, update, deletion of roles such as (Business-to-Business) B2B customer, third- party supplier, third- party consultant as well as the retrieval of their context. This feature can further support a built-in role-based access control mechanism to order management capabilities on different accounts.
- **Profile Management** feature enables the creation, update, deletion of accounts as well as the retrieval of account details. Management of user roles assigned to a profile is also provided.
- **Notification Management** feature gives the user the ability to define its own rules/filters with respect to notifications, he/she would like to receive for different events related to order status, experiment status, potential SLA violations and availability of new services.

3.1.2 Service Order Management

The main objective of this capability is to allow vertical customers to simply manage the end-to-end lifecycle of service orders (e.g., instantiation of network slices with or without third-party VNFs/VAFs, real-time order status details, scaling of resources). To achieve this, a customizable user-friendly interface of the order workflow throughout the service fulfilment process should be in place. The order lifecycle includes service element selection, order temporary saving, retrieval, update, deletion and placement. Furthermore, this capability should allow vertical customers to place orders for network slices that involve both communication and digital services (i.e., set of VNFs/VAFs) contributed by multiple facility site operators, third-party VNF providers or Digital Service Providers. Therefore, this capability should facilitate the collaboration among different types of providers (e.g., CSPs and Digital Service Providers) or multiple providers of the same type, in order to create and provision "upstream" services. The joint offering is provided with an interoperable service catalogue, for which we introduce a mechanism in section 6.1. Finally, to ensure high level of order fulfilment for the vertical customers, this capability should allow the placement of both on-demand and asynchronous orders. The features included in the Service Order Management are the following:

- **Service Catalogue Management** allows service providers to manage the elements of their service catalogues, i.e., to create, update or remove service specification/network slice templates (blueprints) that are made available to a group of customers (i.e., vertical industries). This feature makes available the CSP service offerings to vertical customers, while

it allows the service configuration to feat each individual customer needs. Access restrictions can be applied in order to prevent specific users from accessing certain services. Interworking amongst service catalogues of different providers can be used to serve customers of vertical industries irrespective of their CSPs and to increase coverage. Furthermore, the feature enables third-party providers to define attributes, SW descriptors, VNFs, pricing and any other information for their Network Slice Instances (NSIs). The exposure of open APIs is also desirable since it enables entitled users to create, update, monitor and retire service request catalogue items in a fast and cost-efficient way.

- **License Management** performs operations like add, update, retrieve of the licensing information, which is associated with the VNFs and VAFs provided by third parties in Service Provider's domain. Prerequisites for the efficient management of the increasing VNF licenses are: tracking license events (e.g., expirations), selecting a cost-effective license scheme to enable the realization of cost savings and service continuity assurance, VNF license policy to limit the use of the VNF for several users/ specific facility sites/geographic region/ a given period. The feature should also ensure that the VNF utilisation complies with the license terms as agreed with VNF vendors.
- **Service Inventory Management** allows for the life-cycles management of instantiated 5G-VINNI service blueprints (e.g., hybrid eMBB and URLLC) as they are created, updated, retrieved, and terminated. The customizable and reusable 5G-VINNI service blueprints are based on standardized NSDs and VNFDs specifications in a machine-readable format, which allows for automation during deployment and operation of the NSIs.
- **SLA Management** provides the ability to dynamically create new SLAs, as well as to modify, retrieve and terminate the existing ones. SLA Management should support high automation and flexibility when establishing SLAs between facility sites, third parties and vertical customers. In particular, customers should be able to select one or more SLA instances among the ones being pre-defined by providers, or create the ones that fit their needs by selecting a subset of the available SLA attributes/metrics and the specific values (from an available set) that should be met for each of them. It is expected that vertical industries are going to adopt and support SLAs that are mostly “context-specific" rather than technology dependent. However, when it comes to a network slice service, multiple levels of the service stack are involved and multiple interdependent SLAs need to be established. For instance, SLAs defined at the product, communication services or software level, may depend on lower-level SLAs defined for access network, core network, physical/virtual infrastructure, etc. Therefore, SLA Management features should support hierarchical SLAs. Finally, in the case of SLA violations, it is a good practice to have a mechanism for closed-loop SLA adherence, healing, scaling or modification of the underlying network services supporting slice instances.
- **Quote management** enables the creation of quotes for vertical customers based on the order placed. Quote management should support the automated and flexible creation, retrieval, modification or withdrawal of quotes. Also, it should enable potential interactions between stakeholders when a service involves multiple facility sites and/or third-party service providers (studied in section 6.2). A vertical customer should be able to configure, negotiate or even decline a quote. Once accepted by the customer, a quote becomes an order. Quote management process should support a variety of pricing strategies that may be suitable for different network slice types (e.g., eMBB, URLLC, mMTC, custom) and capture different licensing models (i.e., pay-per-instance, pay-per-day, pay-per-transaction, etc.) when it comes to orders that involve third-party VNFs/VAFs. The quotation processing is triggered either by the vertical customers in order to fulfil on-demand orders, or by Service Providers when it comes to “asynchronous” wholesale orders. For instance, in the B2B2X case, the B2B service part can be created earlier than the B2X part and potentially at a different time scale. Quotations should also consider including incentives and discounts in

pricing information as well as creating proposals for the deployment of network slice instances (of the same type) on multi-domain infrastructures that comprise sharing, wholesale and roaming services and onboarding of diverse CSPs-partners.

- **Billing Management** enables the billing of provisioned services. Bills can be created, retrieved, updated and deleted, while they are issued only when an order is realized and after taking into account promotions, penalties and discounts due to SLA violations. The feature shall support real-time and offline charging (that is used in post-paid and prepaid plans). A single invoice can be issued per number of services obtained whilst bills receivable per upstream provider. For the latter a rating table will be required to carry out the pricing of billable events including real-time rating processes.
- **Payment Management** handles payments and helps initiate them from customers such as vertical industries and downstream providers to the upstream providers. The feature should support clearance of payable receivable bills related to a certain customer in order to minimize the payment events, while the capability of pre-paid contracts should be in place.
- **Experiment scheduling and Setup** conducts concurrent experiments on (multiple) slice instances by managing the time slots and locations to support vertical stakeholders in the evaluation of service development at the early and pre-launch phase. The feature supports isolated service experimentation, captured in three E2E slice patterns: dedicated part of network, single-tenant and multi-tenant. It involves testing on vertical service requirements (performance/feasibility, usability efficiency) (early phase) or on expected QoE through simulation of realistic conditions (pre-launch phase). Users should be able to gain access to the current schedule of planned experiments, and should be able to schedule and book time for their experiments directly into that schedule.
- **User Device Management** issues commands (create, update, delete) for the user device and performs retrieval of their details with the main purpose of controlling the access of users on the slices' provided services. In fact, the access of a device to the network slice is driven by the user subscription to the service, therefore this feature should be able to perform management of subscriptions attached to different devices. User Device Management is important to vertical industries as it enforces capabilities such as: negotiate access rights of users on the slices' resources based on a "pay-per-use" model and constrain authorization according to security requirements. Listing the user devices and keeping the users' list updated is a challenging task. On the other hand, forming groups of devices (e.g., IoT sensors) by using the concept of herding and linking the service instances to herds of devices provide the means to simplify operations and manage resource allocations (i.e., minimise up-to date device information repository).

3.1.3 Knowledge Repository Management

This capability allows users to build various expert network communities and a collaborative culture through the use of online (i.e., chats) and offline (i.e., forums) channels. By utilising these forms of interactions, users can connect more effectively, share knowledge, capture new ideas, troubleshoot problems in a peer-to-peer fashion, distribute learning and performance support content with respect to services, experiments, etc. This is important since it helps providers reduce their customer support costs. Users with authorised access should be responsible for the management and access control of the communities and their members' participation. Members of each community are eligible to take part in discussions. Repository Management includes the following features:

- **Documentation Management** allows users to create, modify and delete documentation articles, best practices, sample projects, tutorials, descriptor files, template configuration files etc. and query them (search and filtering capability).
- **Performance Monitoring** allows users to monitor the performance of the service obtained during runtime via performance metrics and event streams. Service compliance with the SLA

terms (if any) is also assessed. By using dashboards and/or APIs as an output of monitoring and metric-based analytics, users and closed-loop systems can easily take corrective actions empowered by operations such as scalability (scale-in/ scale-out) and healing when deviations from service performance occur.

- **Reporting** provides the user with the ability to set preferences with respect to reporting and retrieval or deletion of existing reports. The users should be able to define the reporting intervals and the exact contents, such as statistics and graphs to be included.
- **Ticket Management** enables the creation, deletion or cancellation of troubleshoot requests. It also supports ticket status checks, troubleshooting information, alerts notifications and queries that are based on various search criteria (i.e., user account, impacted service etc.).
- **Feedback Management** describes the perceived experience offered by CSPs in the 5G ecosystem. The feature offers feedback retrieval, update and deletion while it supports a scoring system to track CSPs' ranking. When a service involves multiple stakeholders, in case of service disruption, the scoring system should "punish" only the under-performing CSPs.

3.2 Mapping of Business Layer requirements to capability features

In this section, we identify which Business Layer capability features will contribute to the fulfillment of each requirement. Each requirement is directly addressed by the implementation of one or more features, while the implementation of some other features can also indirectly affect the fulfillment of a requirement. In the following paragraphs, we illustrate direct and indirect connections between requirements and capability features, as well as interaction between features that interwork to fulfill one or more requirements. Figure 3-1 shows the basic notation that is going to be used in the remainder of this section for illustrating the mapping of requirements.

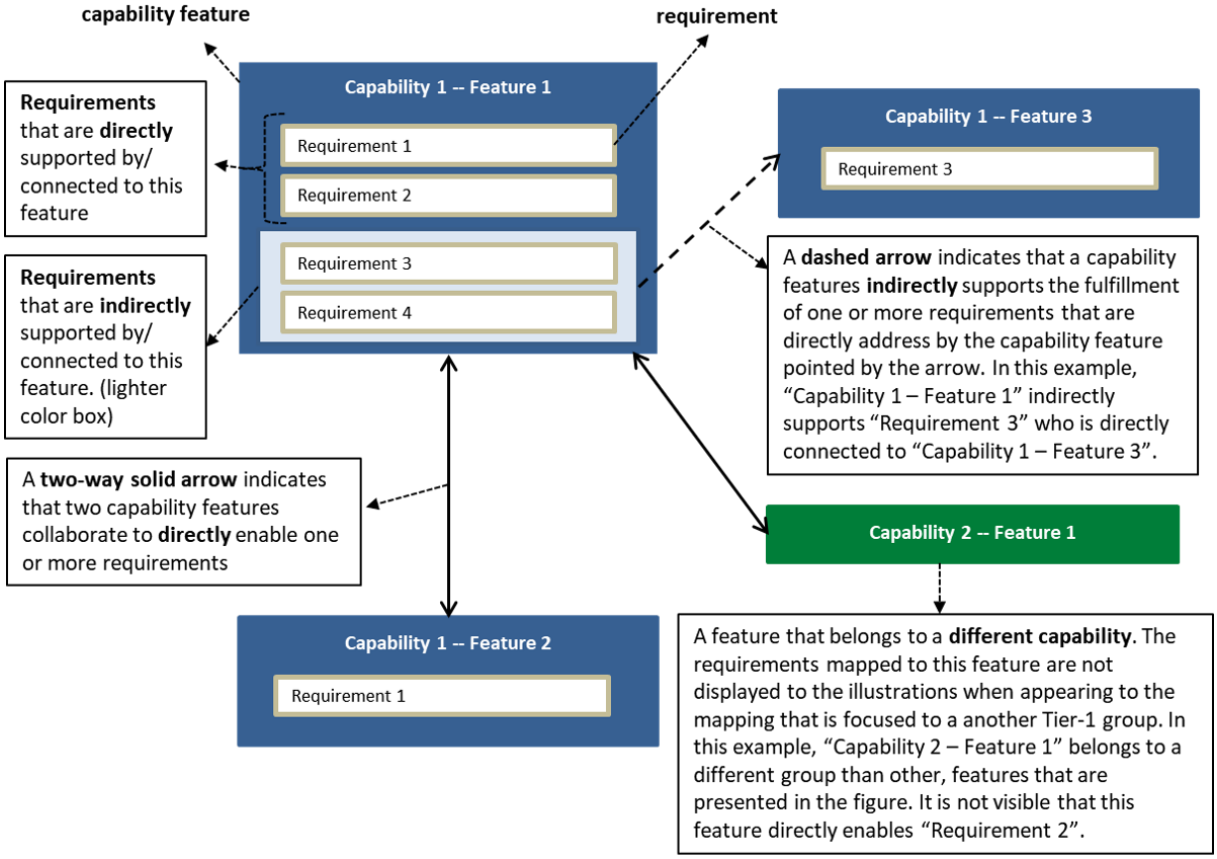


Figure 3-1: Basic notation for the mapping illustrations.

In particular, in the representations that will follow, each capability feature is represented by a colored rectangle that encloses a set of requirements that are directly or indirectly affected/ supported by the implementation of this feature. Each color denotes a capability, which includes a group of features. In particular, we use **blue for User Login**, **green for Service Order Management** and **purple for Knowledge Repository Management capability**. The requirements enclosed in a lighter color box are indirectly affected by the current feature, i.e., mainly addressed by another feature. We use two-way solid arrows to indicate that two capability features interwork to directly enable one or more requirements. A dashed arrow connects two capability features and denotes that the feature at the one end indirectly supports the fulfillment of one or more requirements that are directly supported by the feature pointed by the arrow. Each illustration focuses on one capability and its "family" of features, but when needed, connections between features of other capabilities are also included. Note that the illustration of interactions, represented by arrows, is not exhaustive and only focuses on the minimum set of interactions required for discussing the direct and indirect relationships between requirements and capabilities.

3.2.1 User Login

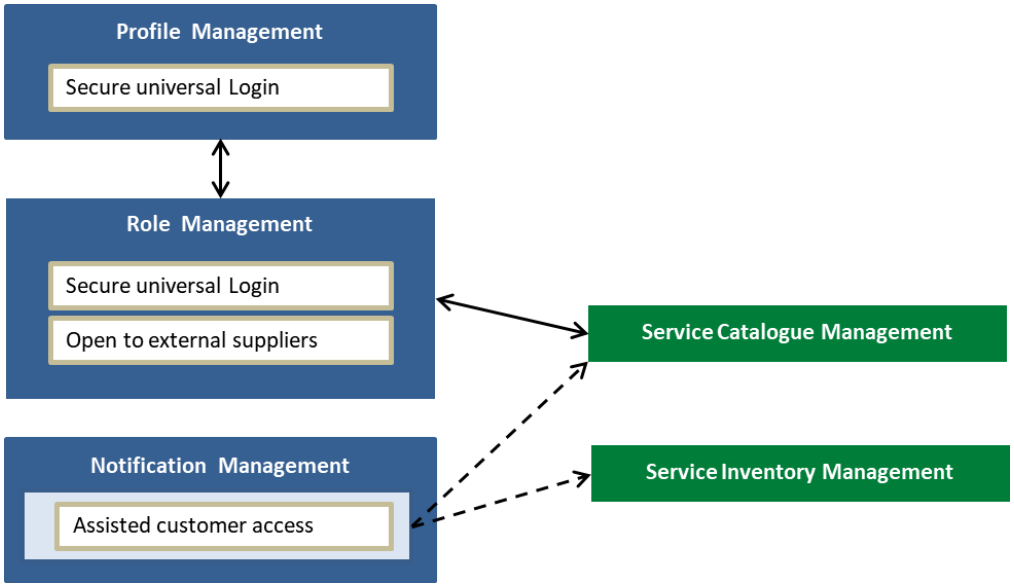


Figure 3-2: Mapping of requirements to User Login capability features.

Figure 3-2 illustrates all the mapping of requirements to User Login capability features, as well as how these capabilities interact with each other. The requirement for secure universal login is directly affected by the implementation of Profile Management and Role Management features since the former enables the creation of user accounts while the latter authorizes each user of the platform to have access to different services of the facility site. The requirement for openness towards external suppliers is directly connected to Role Management feature because it enables the creation of roles related to a variety of user types including third-party suppliers. The connection between Role Management and Profile management identifies the collaboration of these two features for enabling the universal login requirement. In fact, these two features interwork in order to assign roles to each user account.

The requirement for assisted customer access can be indirectly supported by the Notification Management feature, since this feature assists customer/experimenter with notifications during each phase of the experiment/service lifecycle, as well as with notification related to order status. Therefore, the Notification Management feature indirectly supports Service and Inventory Management features with respect to assisted customer access requirements. Note that for enabling real-time notifications, the performance monitoring feature should be in place, which is not visible in the illustrations.

3.2.2 Service Order Management

Figure 3-3 illustrates the mapping of requirements to Service Order Management capability features, as well as how features interact with each other.

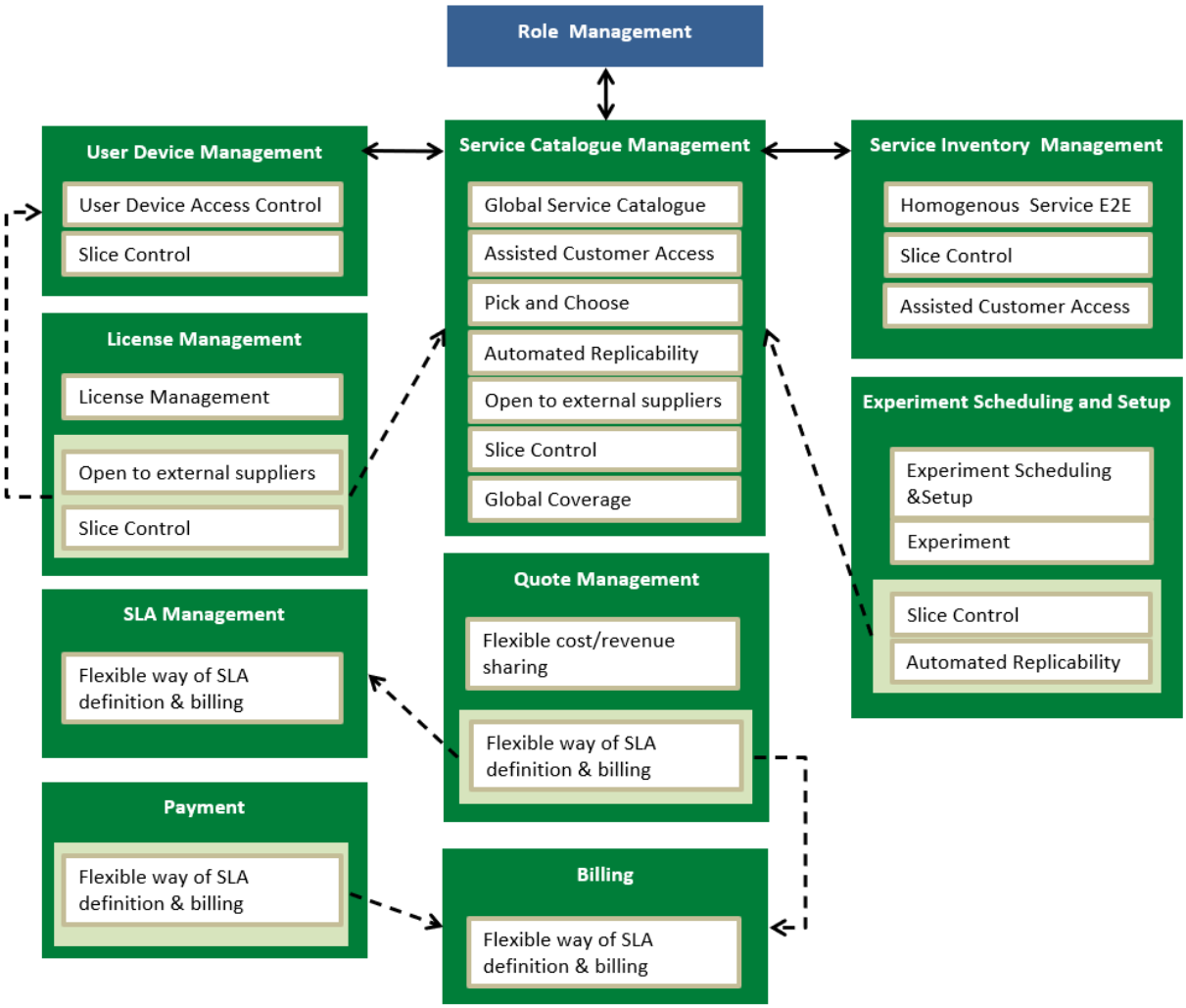


Figure 3-3: Mapping of requirements to Service Order Management capability features.

- Each **capability feature** is represented by a **colored rectangle** that encloses as set of requirements that are directly or indirectly affected/supported by the implementation of this feature.
- The requirements enclosed in a **lighter color** box are **indirectly** affected, i.e., mainly addressed by another feature.
- The **two-way solid** arrows to indicate that two capability features interwork to **directly** enable one or more requirements.
- A **dashed arrow** connects two capability features and denotes that the feature at the one end **indirectly** supports the fulfillment of one or more requirements that are directly supported by the feature pointed by the arrow.

Textbox 1: Guide to reading requirement mapping illustrations

Service Catalogue Management. It is straightforward that the requirement for a global service catalogue will be directly addressed by the Service Catalogue Management feature. This feature should also directly enable the Pick and Choose requirement, which means that the customer should be able to select different services from the Service Catalogue to create more complex ones. Also, the requirement for automated replicability of service orders as well for openness to external VNF

and VAF suppliers should be supported by this feature. Both of them can be achieved by the implementation of the appropriate APIs. Service Catalogue Management feature also assists in the fulfillment of slice control requirement because it allows the customers to modify attributes of service specification/network slice templates related to QoS parameters and/or service location. Global coverage requirement is supported through the interworking of different Service Catalogues (supported by the proposed mechanism of section 6.1). Finally, Service Catalogue Management is directly connected to the assisted customer access requirement, in the sense that it keeps track of retrievable (by the customer) information with respect to the status of each order.

Quote Management. Quote Management feature interacts with Service Catalogue Management feature for responding with quotes to customer orders. As will be elaborated in section 6.2 below, the Quote Management feature enables the creation of quotes based on an SLA defined by customers, as well as the establishment of mechanisms and policies that determine how this quote will be distributed among the participating parties when multiple facility sites are involved. Therefore, this feature is directly connected to the requirement for flexible cost/revenue sharing, while it indirectly supports the flexible SLA definition defined by the SLA Management feature. Finally, this feature interacts with the Billing feature for creating bills for the customers.

Service Inventory Management. Service Inventory Management feature is responsible for the lifecycle of orders/network slices instantiated based on standardized specification, therefore it directly enables the requirement for Homogenous Service E2E. Additionally, assisted customer access requirement is also directly supported by notifying the customer of events related to the service/experiment lifecycle events. Slice control requirement is also directly supported by this feature in the sense that a customer should be able to request on-the-fly modification of the service instance, e.g., scale up or down.

Experiment Scheduling and Setup. It is straightforward that the Experiment Scheduling Management feature directly supports the fulfillment of requirements such as the experiment scheduling, setup and experiment. Slice control requirement is also supported by this feature since it allows the experimenter to determine certain parameters of the experiments such as the number of devices, location or other QoS-related parameters. However, we assume that this relation is indirect because these interactions will be enabled by the Service Catalogue Management feature. The same applies to the automated replicability requirement.

User Device Management. The implementation of the User Device Management feature directly affects the user device access control, which as we have mentioned above is also indirectly connected to the Role Management feature. Slice Control is another requirement that is directly supported by the implementation of such a feature since it controls the devices to be served by each slice.

License Management. This feature directly supports the fulfillment of license management requirement, but it also indirectly supports the openness to an external supplier by allowing adding licenses of VNFs and VAFs by external/third-party stakeholders. Furthermore, slice control is also indirectly affected because licensing may add restrictions to the number of users using a VNF or to the location that a VNF can be placed.

SLA Management, Billing and Payment. SLA Management feature directly addresses the requirement for giving the customer the flexibility to define and negotiate SLA terms. The billing requirement is directly connected to the Billing feature, which is indirectly supported by the Payment feature.

3.2.3 Knowledge Repository Management

Figure 3-4 illustrates all the mapping of requirements to Knowledge Repository Management capability features, as well as how these features interact with each other.

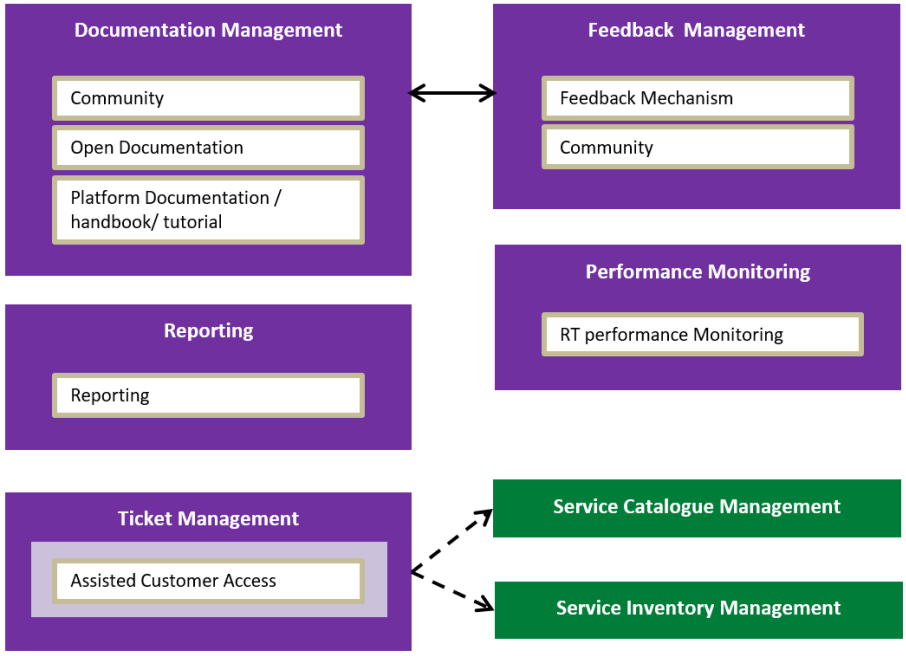


Figure 3-4: Mapping of requirements to Knowledge Repository Management capability features.

Documentation Management feature will directly address the open documentation, platform documentation/handbook/tutorial and community requirements. Also, it is straightforward that the Reporting feature will enable the reporting requirement, i.e., the documentation of results after each experiment. Note that these reports are utilized by the Documentation Management feature, which does not appear in the illustration above. The Feedback Management feature enables users to give feedback on their experience when using the services of the facility. Making each user's feedback available to other users we also support the community requirement by enriching the information that can be shared. The Performance Monitoring feature will directly address the requirement for real-time monitoring. Real-time events could generate notifications (through the Notification Management feature) for customers based on the filters/policies defined by them. Finally, the Ticket management feature indirectly supports the assisted customer access requirement in the sense that it handles user requests for information or troubleshooting.

As a summary, Table 3-1 illustrates a matrix composed of both direct-indirect connections between requirements and business layer capability features. The rows of the matrix correspond to requirements and the columns correspond to Business Layer capability features. A mark in a cell of the matrix means that the requirement and the business Layer capability feature associated with the cell have a direct (black mark) or an indirect link (light grey mark). The mapping of requirements to business layer capability features is vital for determining the gradual roll-out of features aiming to satisfy the requirements that have been prioritized by the users.

Table 3-1: Global view of requirements' mapping to Business Layer capability features

	User Login			Service Order Management									Knowledge Repository Management				
Requirements \ Business Layer Capabilities	Profile Mgmt	Role Mgmt	Notification Mgmt.	Service Catalogue Mgmt	License Mgmt	Service inventory Mgmt	SLA Mgmt	Quote Mgmt	Billing Mgmt	Payment Mgmt	Experiment Scheduling & Setup	User Device Mgmt	Documentation Mgmt	Feedback Mgmt	Ticket Mgmt	Performance monitoring	Reporting
Global Service Catalogue				X													
Secure universal login	X	X															
Reporting																	X
RT performance monitoring																X	
Assisted customer access			x	X		X									x		
Homogeneous service E2E						X											
Experiment scheduling and set up											X						
Experiment											X						
Platform documentation/ handbook/ tutorial													X				
Automated replicability				X							x						
Global Coverage				X													
Flexible way of SLA definition & billing							X	x	X	x							
Slice Control				X	x	X					x	X					
User device access control												X					
License Management					X												
Pick and choose				X													
Feedback mechanism														X			
Open to external suppliers		X		X	x												
Flexible cost/ revenue sharing agreements								X									
Open documentation													X				
Community													X	X			

X Direct connection
x Indirect connection

4 5G-VINNI Business Layer design: Maturity Levels and capability features rollout

The high-level overview of 5G-VINNI Business Layer design, i.e., how capability features are organised into modules and how they interact with each other, was initially introduced in D5.2. Given that 5G-VINNI Business Layer capability features should be rolled-out gradually aiming to satisfy internal and external user requirements, this section aims to discuss the Business Layer design in each of the Maturity Levels (ML2, ML3 and ML4*[3]) of the 5G-VINNI facility. In order to achieve this, we introduce a method that jointly considers: a) the preferences of users as extracted by the MoSCoW analysis (in section 2) and; b) the Recommended Delivery Period (RDP), as suggested by WP5 experts, for the *main* release of the Business Layer capability features supporting each requirement. The latter is discussed in the following section 4.1.

4.1 Business Layer requirements and recommended delivery period

To this point, all business layer requirements for supporting verticals have been identified. However, to deliver the related Business Layer capability features to time, budget and consortium expectations, we should consider two sets of criteria for each requirement:

- **Difficulty of delivery.** In general Business layer features that cross multiple facilities, involve external users, or enable the platform's commercialization are characterized by increased difficulty. In contrast, features related to the implementation of Open interfaces / APIs are characterized by lessened difficulty. The difficulty of delivery assessment is performed based on 5G-VINNI WP5 teams' technical understanding and delivery experience. Our assessment criteria include the operational administration of 5G services and other telco platforms, as well as the general programme delivery within consortia. The difficulty of delivery can be de-risked by some work performed at the earlier ML(s).
- **Requirements and MLs relevance.** As described above, each Maturity level serves a different purpose. Hence, to recommend a delivery time-plan for the main release of features supporting each requirement, we should account for the perceived interest and demand from users and stakeholders (verticals/5G VINNI consortium/partners) implied by each ML. We must also be mindful that at each ML, differing project resources and funding levels will be available.

Note that the development of features for supporting all requirements should have started early (i.e., in ML1 or ML2), but we here *recommend the time-period where the **main** release of features satisfying each requirement should be delivered,* based on the two above aspects.

In the following, we pick requirements one-by-one and discuss the difficulty to fulfil each of them and what is their relevance in each ML. We recommend the time-period where the main release of the related Business Layer features should be available. The Recommended Delivery Periods are Early, Medium-term and Late to reflect the three considered MLs, i.e., ML2, ML3 and ML4, respectively.

4.1.1 Secure universal login

Unique customer access to the platform should be available to allow users' account creation and log in. This access authorises each member to have a personalised view of past transactions and monitoring of pending items**.**

[3] Maturity Level 1 refers to the operation of the facility during the early stage of the project, which focussed on running certain experiments for ensuring that 5G-VINNI Release 0 and 1 validate the 5GPP defined KPIs. This was done prior to D5.3 authoring and does not feature in this section.

Recommended Delivery: **Medium-term**

Justification: It should be relatively easy to design and implement role-based access (e.g., 2FA) and a policy outlining who can see what. However, some facility sites may not support this in ML2. Considering that, the implementation of a set of capability features satisfying this requirement would be more likely to be available in ML3. The focus could begin on internal users and a subset of external users in ML2. A more advanced implementation can be provided in ML4 as the 5G-VINNI platform grows and its customer-base increases (Verticals, partners, operators). Hence, the recommended period of delivery is medium-term.

4.1.2 Assisted customer access

Users should be assisted when interacting with a facility site during each phase of the experiment or service lifecycle by receiving notifications when certain events take place. Customers should easily be able to monitor order status, including faults.

Recommended Delivery: **Early**

Justification: It should be relatively easy to design and implement Assisted customer access so that customers can at least monitor orders and faults but should also have access to service lifecycle events. Considering that, the implementation of a set of capability features satisfying this requirement could be front-loaded and released early, i.e., during ML2, initially focussing on monitoring the status of non-billable services. Note that assisted-customer access, related to customer notification for events, can be available even without having a fully blown Service Portal with user login capabilities. This can be achieved by exploiting other communication means such as e-mail, etc. A more advanced implementation can be provided in ML3 and ML4 as the 5G-VINNI platform grows and chargeable monitoring of services, linked with SLA are delivered. This will require some effort, but the recommended delivery is early.

4.1.3 Global service catalogue

A service catalogue should include all the 5G-VINNI facility offerings that are available and accessible to vertical customers (e.g., enterprises). These offerings can originate from any facility site in 5G-VINNI that may also involve services from 3rd-party providers that complement the 5G-VINNI platform.

Recommended Delivery: **Medium-term**

Justification: The design and implementation of a Global service catalogue should be relatively easy. By ML2, an onboarding process should provide access to a 5G-VINNI portal through which customers will access the service catalogue. This is extended in ML3 to also provide service cost and SLA details. For other business layer requirements, commercial aspects are predominantly delivered during ML4 (costs, billing, SLAs and other fulfilment details). In this case, the global service catalogue needs to be almost fully formed during ML3, thus work must be relatively front-loaded. In balance, the recommended delivery period is medium-term.

4.1.4 Open to external suppliers

A service catalogue should include capabilities and other services (e.g., VNFs) by other external suppliers, both facility sites and the so-called complementors (that is, firms that want to use the 5G-VINNI platform for providing vertical services). Then, 3rd-party developers and professionals can make their services available to 5G-VINNI platform customers rather than offer only a limited set of in-house solutions.

Recommended Delivery: **Medium-term**

Justification: If each facility provides its own service catalogue in an agreed format, these will be relatively easy to link up and offer up through the 5G-VINNI portal (for ML2). However, at ML3, SLAs associated with external integration and site interworking should be added, with no change during ML4. Any business requirement that relies on integrating and interworking between facilities does raise the level of difficulty and so early planning (somewhat front-loaded effort) would be required to resolve any issues for ML3. Also, facilities must be up and running before they can integrate and interwork with each other and this may not be the case by ML3. Taking all of this into account, it is recommended that this is delivered medium-term.

4.1.5 Pick and choose

Capabilities and services should be available so that vertical customers and aggregators/brokers can compose new chained services to cater to their needs and business models.

Recommended Delivery: **Medium-term**

Justification: Some services and capabilities must be available at the earliest maturity level (ML2) and these can be added to during ML3. For ML4, SLAs should be defined to reflect these aggregated services. Given that SLAs are part of a more commercial ecosystem of service offerings, the difficulty arrives during ML4. The implementation of a business layer requirement where customers combine services also increases the level of difficulty. Much depends on the complexity of the design and how/which services can be combined and this could require much testing to ensure compounding issues do not arise from combining services. Also, is the complexity of creating associated SLAs, as these may be unique to the combination of services. Such bespoke and complex SLAs might be considered relatively difficult to deliver. So, customers must be able to create complex services from those available in the catalogue which is arguably later than ML2. Taking this into account, along with preparatory plans and designs for the ML4's commercial ecosystem, it is proposed that a medium-term delivery is recommended.

4.1.6 Experiment

Capabilities and services should be available so that customers can experiment and consider if the system meets their requirements.

Recommended Delivery: **Early**

Justification: This is a fundamental function of the platform and the prime focus and priority for the consortium. Mechanisms supporting the interaction with verticals are established by ML2. Formalising for ML4 should not be difficult other than the ramping difficulty associated with SLAs and combination SLAs that reflect the commercial services. As this function is fundamental and required at an early stage, effort must at least be front-loaded. It should be noted that as SLAs are introduced in ML4, there must be some back-loaded effort. On balance, the recommended period is early.

4.1.7 Global coverage

A service should not be restricted to the subscribers and resources of a single communications service provider/network operator.

Recommended Delivery: **Late**

Justification: For ML2 and ML3, services are restricted to a single operator. Incorporating offerings from other operators would require those operators to conform to the same templates and structures as existing operators, i.e., use of the portal, SLA formats, agreed APIs, etc. The emphasis should be on those operators to conform rather than change the game to suit the new player. This might be easy to enforce but difficult to get right. Note: WP3 covers the exchange of service blueprints between facilities to allow services over multiple facilities. Whilst this does not include SLAs, at ML4 the number of operators may have increased to a handful but may not be global.

However, these other operators will be allowed the opportunity to provide and charge for service operations. Perhaps the focus here should be on UEs that are served by another (e.g., competing) provider for traditional services (e.g., voice), but still would like to have access to 5G-enabled Over-The-Top (OTT) services. In other words, the OTT provider should be able to supply a list of UEs that can access a certain slice. This business requirement is closely related to "User Device access control" (see User device access control) Given the difficulty of getting this right for ML4 and the corresponding effort involved, the recommended period is late.

4.1.8 Homogeneous service end-to-end

Vertical organisations should obtain consistent experience, even in the case of federated/collaborative service provisioning. Thus, operators participating in service delivery should have a common view of the attributes to be met.

Recommended Delivery: **Late**

Justification: During ML2 and ML3, this business requirement is not applicable due to a single operator. All effort is directed to the delivery of a homogeneous service, end to end in ML4 where a common attribute view should be provided across all participating operators. Hence, the recommendation is to back-load work. Hence, late.

(Note: Participating operators may be required to specify the common attribute.)

4.1.9 Automated replicability

A product/service/experiment should be automatically replicated in other regions or instantiated over time, in order to reduce complexity and time to market.

Recommended Delivery: **Late**

Justification: For ML2 and ML3, some experimentation should be replicable but not automated. During ML4, experiments should be replicable and automated. Ensuring experiments are automated will be difficult as each step of the experiment must also be automated and an assumed orchestration of all steps for a fully automated experiment. Only at ML4 should this be possible. The difficulty means that the work should start earlier than ML4, though the delivery for full automated replicability would be delivered during ML4. Thus, work is to begin in earnest in ML3 in readiness for ML4. On balance, the recommended period where the majority of effort is required is late.

4.1.10 Flexible cost/revenue sharing agreements

Billing systems should support a wide range of revenue sharing and cost splitting agreements.

Recommended Delivery: **Late**

Justification: This will be complex and will comprise a fully tested commercial BSS. The use of stubbed billing model/components and zero-cost transactions in ML2 and ML3 will de-risk ML4. For ML2 and ML3, billing may not be applicable but network and service parameters that would enable billing data to be compiled should be available. This should be accompanied by a stubbed billing model (cost of the transaction would be zero) to help de-risk ML4. For ML4, a full range of accounting, data collection (e.g., usage), tariffs, and actual transactions should be provided, that is, a fully tested, commercial BSS ecosystem needs to be in place. Some have commented that ML4 only partially meets this business layer requirement as the current description seems to be rather static, i.e., support a limited set of revenue sharing agreements. There will be pressure towards standardised pricing models, i.e., the internal pressure is a hurdle towards more comprehensive pricing models. Overall, this is one of the requirements that is more difficult to reach but also one of the more relevant for assuring the future sustainability of the platform. Due to the relative complexity and difficulty of delivering what is required in ML4 to only partially satisfy the business

requirement, the majority of effort should be in ML4. Hence, the recommended period for delivery is late.

4.1.11 Flexible way of defining SLAs and billing

Customer to define SLA terms and get a quote.

Recommended Delivery: **Late**

Justification: For ML2, SLAs can be expressed as simple, high-level intent, potentially with latency and/or bandwidth levels cited. Access to the facility is free. The difficulty for implementing SLA increases for ML3 onwards, where SLA definitions can be hierarchical. The requirement covers high-level intent down through to partner provided components, billing for business-level experiments and usage logged and available for billing and audit. For ML4, further complexity and effort are required to provide a full, hierarchical SLA system in place with usage logs, billing accounts, cross-partner (service provider) agreements and contracts in place, agreed, automated SLA penalty compensation. Full OSS/BSS system is in place. The complexity and difficulty arise from the requirement for a fully tested commercial BSS + hierarchical SLA. Also, the more versatile (enabling customers to plug and play), the more difficult to build and offer. Some complexity can be reduced if we do not offer management of all the platform parts. This would reduce the complexity for verticals as well. Perhaps, it may be more feasible and useful to consider only a few parameters to be flexible (e.g., latency and bandwidth) in a defined range or a discrete set of options. Based on them, the potential billing could be defined (if appropriate). In summary, the majority of effort is required during ML4. Hence, the recommended period for delivery is late.

4.1.12 Real-time performance monitoring

Resources and capabilities monitoring mechanisms should be in place, allowing experimenters to track the status and performance of the experiment in real-time.

Recommended Delivery: **Early**

Justification: This business requirement is almost fully formed at early maturity levels. For ML2 and ML3, a wide range of real-time performance parameters are available from the 5G system to the operator, many of which will be available to the customer. This business layer requirement should be fully mature by ML4 in that a 'full' range of real-time resource parameters are available instead of a wide range. The delivery of this business layer requirement across all maturity levels is considered easy and as it is almost fully formed early on, the recommended delivery period is early.

4.1.13 Reporting

After experimentation and for each experiment and single test inside it, a detailed report should be available which contains the results, along with resources and capabilities employed. These reports enable vertical organisations to make better decisions for real-world replication and to understand if they are meeting the required needs.

Recommended Delivery: **Early**

Justification: This business requirement is almost fully formed at early maturity levels. For ML2 and ML3, a formalised template is defined and used for reporting to ensure a common structure across all experimentation. For ML4, this is extended to include the use of some of the data to compile these reports which may also be used for billing purposes. On balance, the recommended period of delivery is early.

4.1.14 Community

Stakeholders can enhance their 5G knowledge by exchanging results and best practices obtained from previous experiments, troubleshooting, etc. This will be useful for candidate customers, who have limited experience with 5G onboarding processes.

Recommended Delivery: **Early**

Justification: The business requirement is almost fully formed at early maturity levels. For ML2 and ML3, a results repository should be in place which also takes into account any relevant Intellectual Property Rights (IPR). For ML4, the value of IPR may be part of the commercial transactions between partners. To enable the above, there may be a dependency on the business layer requirements which deliver secure login and for ML4, perhaps a commercial model should be available. Other than that, the recommended period of delivery is early.

4.1.15 License management

Experimenters that want to onboard VNFs from third parties should be able to supply license details including where these can be retrieved from.

Recommended Delivery: **Early**

Justification: This business requirement is almost fully formed at early maturity levels. For ML2 and ML3, license details should be stored in an appropriate repository. For ML4, access to this license repository could be part of an agreed SLA. The requirement seems to call for a secure login and license whereabouts knowledge. This may therefore not be straightforward. Designing this is front-loaded work – hence the recommended delivery is early.

4.1.16 Experiment scheduling and setup

Customers should be able to define when an experiment will take place and see an overview of other planned experiments. Customers should also be able to define and set the parameters for the service experimentation.

Recommended Delivery: **Medium-term**

Justification: This business requirement does not change much across early maturity levels. For ML2 and ML3, a formalised experimentation schedule should be offered to customers. However, for ML4, a more complex, more sophisticated and difficult to deliver scheduling arrangement is planned. By this time, an increase in supporting technology should be in place to manage the increased complexity of multiple customers, partner operators and facilities. Experiment scheduling is required early but some effort will be required ahead of (i.e., ML3) and during ML4 to create a more fully-formed business requirement, the recommended delivery period is medium-term.

4.1.17 User device access control

Customers may want to restrict the set of participants in the experiments.

Recommended Delivery: **Late**

Justification: At ML2, customers should have a level of access control and this ramps up through ML3 and ML4. For ML3, customers should have an improved level of access control in which they can provide more sophisticated access administration and governance. For ML4, access control should be part of the SLA. To deliver this business layer requirement at the early maturity levels is deemed relatively easy. However, the introduction of access control into service levels becomes a more difficult proposition and requires late effort. Hence, the recommended delivery period is late.

4.1.18 Platform documentation

Users should have access to information, handbooks, tutorials, etc. on how they can use the 5G-VINNI platform, thus facilitating better platform utilisation.

Recommended Delivery: **Early**

Justification: Documentation should be provided as early as possible. Ideally, as functionalities and services come online, incrementally, descriptions, access details, parameters of use and tutorials would be made available either at the same time or earlier. So, for ML2, for all available functions and services on the 5G-VINNI platform, corresponding documentation and tutorials must be available. This is the same for ML2 and ML4. On balance, the initial creation of the documentation server, templates and initial services and function documentation would be for ML2. Therefore, it is recommended that the delivery period for this is early. Towards this directly 5G-VINNI project has already made available a set of public deliverables and series of webinars[4].

4.1.19 Open documentation

The experiment results and other reports can be made available and shared with registered and unregistered users. The experiment results should be open to all (or at least to all registered) users according to the experiment owners' preferences.

Recommended Delivery: **Medium-term**

Justification: At ML2 and ML3, experimentation results should be made available in the appropriate repository. For ML4, experimentation results may be charged for and be a party to an SLA. This requirement is easily reached but it covers something more than purely a document repository. The difficult part is to make open (to external users to the specific experiment) all the documents/reports because this depends on experiment owners. It is feasible at a technological level but difficult in reality. In order to make it more feasible, it is important to manage through the system the IPR, licenses and any right linked to those reports/documents by part the owners (defining who is the owner/s). The difficulty of what must be delivered at ML4 calls for the most effort, therefore the recommended delivery period is medium-term.

4.1.20 Feedback mechanism

Customer feedback on the experience perceived and trouble-shooting tickets can support facility owners to improve their offers and other users to have justifiable levels of trust in the system. Ability to communicate/interact with the customer, in the system.

Recommended Delivery: **Medium-term**

Justification: At ML2, a template should be designed and used for customer feedback. A customer feedback template could be as simple as a questionnaire word document, excel spreadsheet or even templated e-mail. However, this does not imply the implementation of this component. From ML3 and through ML4, trouble management and other aspects of service support may be part of the SLA. As for other business layer requirements the introduction of SLAs and assumed commercial ecosystem will be difficult. Besides, each facilities' trouble ticketing systems may have to operate together to form an overall trouble ticketing system. All of which needs to be agreed upon and managed even-handedly across the programme. In summary, whilst ML2 requirements should be easy to provide and could be performed early, work in earnest will begin in ML3 and continue into ML4. Therefore, the recommended delivery period is medium-term.

[4] https://www.5g-vinni.eu/dissemination/

4.1.21 Slice control

In some cases, the Customer (vertical or complementor) could need to manage and control dynamically parameters for the service instantiation (for instance the location to instantiate a specific VNF, modify the latency and bandwidth at run time, etc.).

Recommended Delivery: **Medium-term**

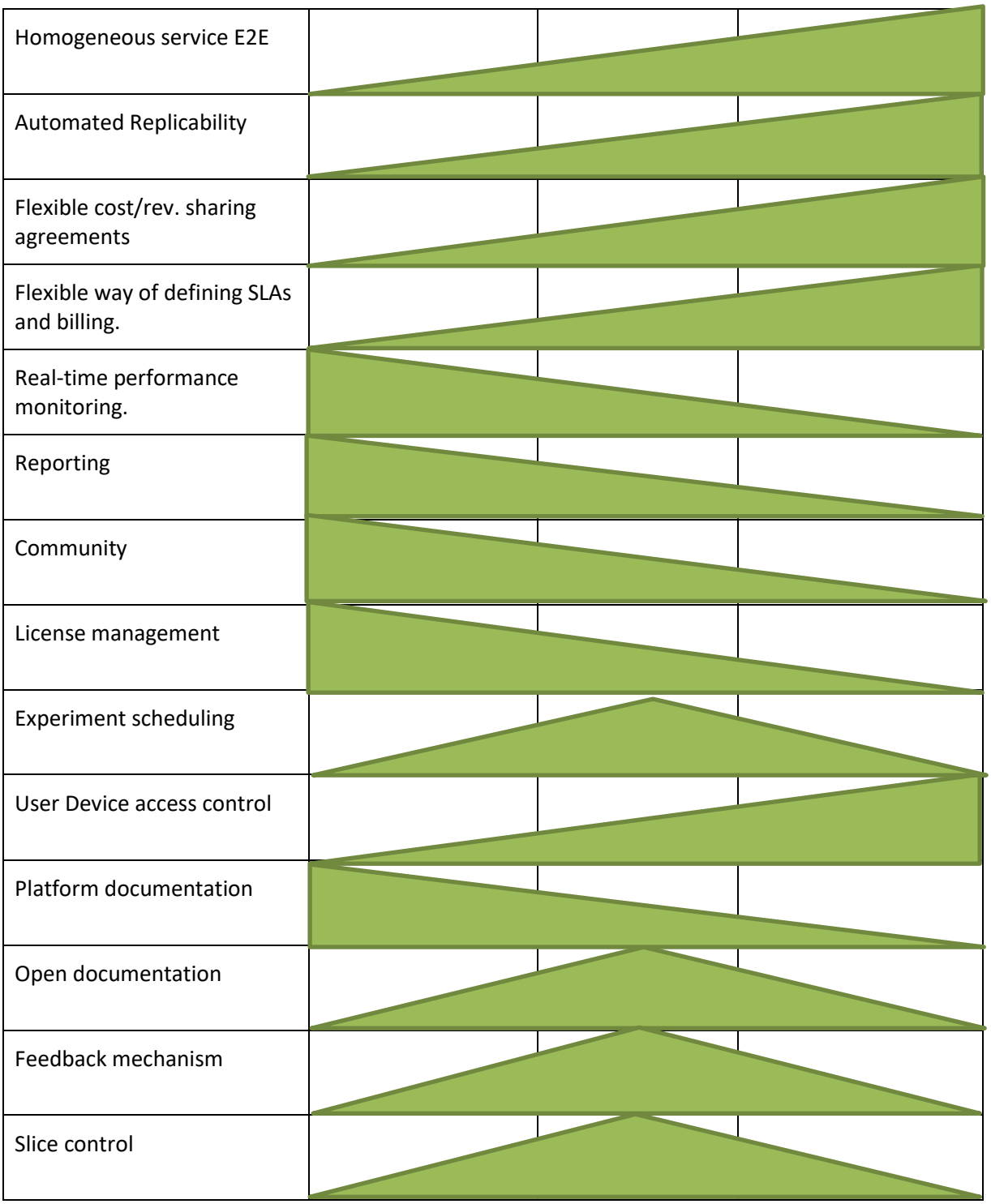
Justification: For ML2, once slice services are available, a capability should evolve to control slice service parameters. For ML3, slice control is a major part of the service offering to verticals. For ML4, this may be part of the SLA. A gradual delivery across all maturity levels is expected, finalising in a requirement that is linked to SLAs. Slice services, control and their management within agreed SLAs would be deemed difficult to deliver from ML2 through to ML4. However, effort concentrated on ML3 requirements will help de-risk ML4. Hence, the recommended delivery periods are medium-term. It should be noted that much depends on the slice. Some complex slice instances might not be able to offer full control.

4.1.22 Summary

Table 4-1 shows each business layer requirement and the recommended delivery period for the main release of the related Business Layer capability features. The thickness of the shape at each delivery period indicates how "rich" the new/updated features of the respective release are. For instance, marking a requirement as Early (front-loaded) means that most of the related features should be released early, however some additional or updated features will be added in later period. Accordingly, marking a requirement as Medium-term means that most of the related features should be released at the second time period, however some features (fewer) will be available earlier or later. In any case, each release builds upon the previous one, thus the complete full-blown Business Layer will be available in the last release.

Table 4-1: Business Layer requirements and recommended delivery period for the main release or related Business Layer capability features

	Early (front-loaded)	Medium-term	Late (back-loaded)
Secure universal login			
Assisted Customer access			
Global service catalogue			
Open to external suppliers			
Pick and Choose			
Experiment			
Global coverage			


Homogeneous service E2E
Automated Replicability
Flexible cost/rev. sharing agreements
Flexible way of defining SLAs and billing.
Real-time performance monitoring.
Reporting
Community
License management
Experiment scheduling
User Device access control
Platform documentation
Open documentation
Feedback mechanism
Slice control

4.2 Requirements' prioritization considering MoSCoW and RDP

In this section, the application of multi-criteria decision analysis (MCDA) is proposed as a means of prioritizing the Business Layer requirements in a transparent manner. In this approach, the preferences of users captured by MoSCoW in section 2 and the RDP analysis output presented in section 4.1 are jointly considered for determining the relative priority of each requirement.

4.2.1 Methodology

We consider MCDA as a holistic approach that incorporates the problem definition, a procedure to support the identification of Decision Maker's[5] objectives (namely criteria), and the classification of the possible alternatives to be evaluated in a way that leads to the resolution of the problem [15], [16]. Considering that the MoSCoW method and RDP analysis serve different objectives, their results may lead to conflicting recommendations with respect to the Business Layer capabilities roll-out. In that case, MCDA can be a useful tool for helping Decision-Makers to resolve conflicts and draw up recommendations that will respect (to a high degree) both the preferences of internal/external users (MoSCoW) and recommendations of WP5 experts (RDP).

In particular, the assessment of each Business Layer requirement's prioritization in section 4.1 has taken into consideration the difficulty of delivery and relevance of features for each requirement at each ML, and recommended a delivery period for each. These need to be brought together and considered the primary results of the MoSCoW method. MCDA is a systematic approach that can incorporate the aforementioned aspects using multiple criteria.

Based on the evaluation of different and sometimes conflicting alternatives for specific criteria, it helps the Decision- Maker to identify compromises or dominant preferences that could eventually support the main goal; to have the relevant requirements delivered for each Maturity Level. With the purpose of capturing both of the above aspects, the Decision-Maker chooses a collaborative application of MCDA, combining two value-based methods, namely the Direct Weighting and the Rank Sum methods, that use as a basis the "*linear additive model*", a special form of the Multi-Attribute Value Theory (MAVT) [17] to reasonably achieve preferences such as evaluation, prioritization and selection, over alternatives within the multi-criteria decision analysis framework.

These methods have been selected for two reasons. Firstly, they are considered able to generate a consistent, easy to use, effective, transparent, straightforward MCDA model, whilst allowing for the integration of quantitative and qualitative information simultaneously without the need of using an advanced software tool; Secondly, they are weighting methods whose weights are a combination of direct ones obtained by the Decision-Maker and indirect ones generated by a formula to minimize the risk of decision-making error. More specifically, providing scores and weights as inputs, these two linear-based methods apply weighting to decision criteria to alternatives (or options) with respect to each criterion, to suggest an overall ranking amongst alternatives/options (aggregation process). Next, the procedure for computing the criteria priority weights is briefly presented in the context of the above methods:

- Direct Weighting or Direct Rating method [18]: it is a value-based and "purely subjective" method, where the Decision-Maker has the preference for selecting ("*judge*") to rate each criterion on a 0-100 scale. In this approach, the highest rate is assigned to the most important criterion and lower rates are determined for the other criteria relative to it. Then, the criteria are weighted; that is each criterion's' score was divided by the sum of scores that Decision-Maker had provided in total to all criteria. Note, that priority weights are "range-insensitive" and are summed to 100.

[5] This section assumes a single Decision-Maker throughout application of MCDA representing multiple D5.3 contributors. Note that the DM(s) are in control of decision and final implementation.

- Rank Sum method: to convert criteria ranks into numerical weights, the Rank Sum weight method will additionally be used [19]. Weights, in this case, are a function of criteria ranks, which are decreasing linearly with a fixed slope of -1. The Rank Sum weights are given by the formula below:

$$w_j(RS) = \frac{n - r_j + 1}{\sum_{k=1}^{n} n - r_k + 1} = \frac{2(n + 1 - r_j)}{n(n+1)}$$

where n the number of criteria, w_j and r_j are the weight and the rank of the j-th criterion respectively, j=1, 2, ..., n.

4.2.2 Prioritization process

The next part of this section is a concise description of a step-by-step process to carry out the multi-criteria decision analysis (MCDA) [20] as a combination of the two value-based methods. It involves:

(i) defining the key goal(s) of the decision problem,

(ii) structuring the decision problem with the use of a value tree; a tool intended for determining and representing the hierarchy of decision alternatives with respect to combined criteria and sub-criteria against which alternatives have to be evaluated,

(iii) setting up an evaluation matrix to be used for "scoring" each alternative on each criterion and sub-criterion,

(iv) computing weights for the criteria and sub-criteria according to their relative importance to the decision problem by combining the MAVT-based methods, Direct Weighting and Rank Sum, and

(v) applying weights, scores and aggregation to yield a ranking for each of the alternatives. The exercise of "*subjective judgment*" is also required by the Decision-Maker, in order to explore how well the different alternatives achieve the decision goal.

What follows, is the case-study details linked to the specified steps with the focus placed on setting the key goal(s) and describing the evaluation process of alternatives for the prioritization of the Business Layer requirements per Maturity Level.

As the key goal, a prioritization is needed for each requirements' deployment during the roll-out phase that spans ML2, ML3 and ML4. For this purpose, the Decision-Maker sets the order of 9 alternatives with respect to combinations amongst two parent criteria and their underlying six (6) sub-criteria (children-criteria). Criteria and sub-criteria are associated with the MoSCoW method (section 2) and "Recommended Delivery Period" (RDP) (section 4.1). Two criteria were selected relevant to the key goal of the decision problem: the MoSCoW and the RDP.

The MoSCoW criterion has three sub-criteria: MUST HAVE, SHOULD HAVE, COULD HAVE that describe the responses of the user groups for each requirement by means of importance. The “WON’T HAVE" response is not to be used in the formulation of the alternatives since it is rarely selected as a response by the stakeholders of the user groups. Therefore, we use the acronym **MoSCo** (instead of MoSCoW) in our analysis below.

The RDP sub-criteria were selected for the evaluation of the requirements in terms of difficulty of features’ delivery for each requirement, impact and relevance to the Business Layer launch within each ML or effort required prior to each ML to de-risk delivery. Note that the resultant recommended delivery periods are annotated as: EARLY, MEDIUM-TERM, LATE.

Figure 4-1, illustrates the ***value tree*** showing the key goal, criteria, sub-criteria, alternatives list and their inter-relations within the MCDA framework.

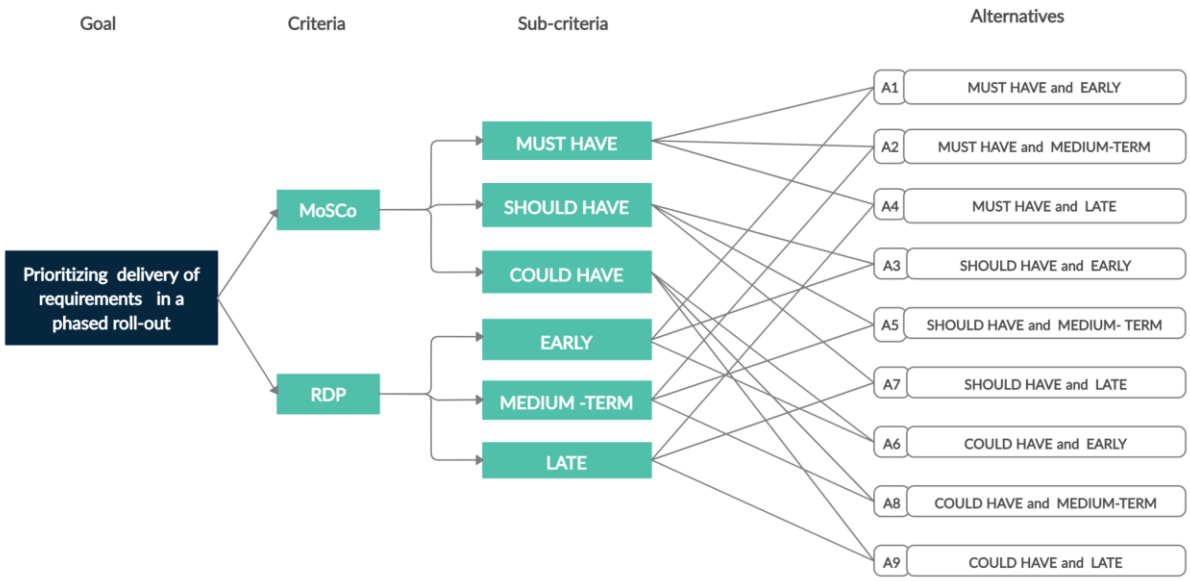


Figure 4-1: Our scenario value tree including the MCDA goal, criteria, sub-criteria and resulting alternatives.

Since the alternatives are rank-ordered relative to the criteria, the rank ordering of the criteria and sub-criteria are required only. It is then assumed that the MoSCo criterion that captures the user preferences is more accountable than RDP, thus we assign weighting coefficients 0,60 and 0,40 to MoSCo and RDP, respectively.

The sub-criteria priority judgment refers to the relative importance of the sub-criteria with respect to their parent criterion. Sub-criteria values follow a 3-point quantitative linear scale, where 1 means the least important sub-criterion and 3 means the most important one. Regarding MoSCoW sub-criteria, the Decision- Maker judges that “MUST HAVE" responses with respect to requirements are the highest priority (value 3), followed by the "SHOULD HAVE" (value 2), and finally “COULD HAVE" (value 1). Regarding RDP sub-criteria, it is considered as the most high-scoring the "EARLY" (value 3) deployment of the corresponding requirements, while the "MEDIUM-TERM" (value 2) one comes second in priority and the “LATE" sub-criterion is the least important and is given a value of 1.

The sub-criteria priority weights are computed by the Rank Sum formula and are referring to the local priorities. Multiplying each priority weight of the individual sub-criterion times the priority weight of the parent determines the "global priorities[6]": MUST HAVE 0.50, SHOULD HAVE 0.333, COULD HAVE 0.167, EARLY 0.50, MEDIUM-TERM 0.333, LATE 0.167.

Assuming that $M = \{1,2,3\}$ and $R = \{1,2,3\}$ are the sets that include all potential values for the main criteria, and m_A, r_A denote the values of alternative A over MoSCoW and RDP respectively, then the global priority score for alternative$S(A)$ is calculated by the composite weighted formula below:

$$S(A) = 0.6\frac{m_A}{\sum_{i\in M} i} + 0.4\frac{r_A}{\sum_{j\in R} j}$$

The end result of this process is a column vector of normalized importance weights for the alternatives. The overall rank ordering for each alternative and the contributions of each sub-criterion towards the final scores is shown in Table 4-2.

[6]Global priority of an attribute is determined by multiplying local priority of an attribute (the relative priority of the attribute within a group or a parent criterion) with the respective relative group or a parent criterion priority.

Table 4-2: Application of MCDA and resulted ranking of alternatives

	Criteria	Acronym	Rank Importance	
	MUST HAVE, SHOULD HAVE, COULD HAVE	MoSCo	MoSCo >RDP	
	Recommended Delivery Period	RDP		

Calculation of criteria and sub-criteria weights						
Criteria	**MoSCo**			**RDP**		
Criteria Weights (Direct Weighting)	0,60			0,40		
Sub-Criteria Priority	MUST HAVE (Priority #1)	SHOULD HAVE (Priority #2)	COULD HAVE (Priority #3)	EARLY (Priority #1)	MEDIUM-TERM (Priority #2)	LATE (Priority #3)
Sub-Criteria Priority judgment	3	2	1	3	2	1
Sub-Criteria Priority Weights (RANK SUM)	**0,500**	**0,333**	**0,167**	**0,500**	**0,333**	**0,167**
Global Priorities	0,300	0,200	0,100	0,200	0,133	0,067

Alternatives ranks and scores			Normalized Scores	Rank
A1	"MUST HAVE" AND "EARLY"	0,50	1,00	1
A2	"MUST HAVE" AND “MEDIUM-TERM"	0,43	0,80	2
A3	"SHOULD HAVE" AND "EARLY"	0,40	0,70	3
A4	"MUST HAVE" AND “LATE"	0,37	0,60	4
A5	"SHOULD HAVE" AND “MEDIUM-TERM”	0,33	0,50	5
A6	"COULD HAVE" AND "EARLY"	0,30	0,40	6
A7	"SHOULD HAVE" AND “LATE"	0,27	0,30	7
A8	"COULD HAVE" AND “MEDIUM-TERM”	0,23	0,20	8
A9	"COULD HAVE" AND “LATE"	0,17	0,00	9

The order of rating ("rank") among the alternatives is reduced from the most important to the least and is the following: A1>A2>A3>A4>A5>A6>A7>A8>A9. The top preferred alternative identifies requirements which are considered as "MUST HAVE" and "EARLY” to design and implement, followed by "MUST HAVE" AND "MEDIUM-TERM", "SHOULD HAVE "AND"EARLY", etc. Taking into consideration both the questionnaire's results by the application of the MoSCoW method and the output of the RDP, each Business Layer requirement is assigned to one of the identified alternatives (A1-A9). The fulfillment of requirements that are assigned to high priority alternatives (e.g., A1) should come in the early stage of 5G-VINNI operation, while low priority requirements (e.g., the ones assigned to A8 or A9) should mostly be satisfied in later stages. In order to determine the gradual/phased rollout of Business Layer capabilities, as Decision Makers we should map alternatives A1-A9 to 5G-VINNI MLs. We follow a simplistic approach, where the top three scoring alternatives A1, A2, A3 are mapped to ML2, the following three A4, A5, A6 are mapped to ML3 and finally the bottom three A7, A8, A9 are mapped to ML4.

4.2.3 Resulting prioritization of requirements along MLs

The following tables (Table 4-3, Table 4-4, Table 4-5) present how the requirements linked to each alternative are distributed in MLs, considering separately the results for internal and external 5G-VINNI users. The requirements enclosed in light green colored rectangles are assigned to the exact same alternative for internal and external users. The requirements highlighted with blue font are assigned to different alternatives for internal and external users, but based on the mapping of alternatives to MLs they end-up to the same ML. Thus, there are no conflicting interests. Finally, there are four non-common requirements highlighted in red that are linked to different MLs for internal and external users. In order to resolve this conflict, the Decision-Maker should evaluate each non-common requirement separately and evaluate whether each of them is more relevant for

internal or external users. A discussion for each of the identified conflicting requirements is presented below:

- *Secure Universal Login*. This requirement should be partially addressed in ML2 for supporting internal users, while an enhanced release of features that support this requirement should be made available in ML3 for supporting external users as well, such as vertical users, suppliers and 3rd-party service providers. In this regard, most of the effort should be put in ML3 to have the majority of features for the secure universal login.
- *Global Service Catalogue*. This requirement focuses mostly on facilitating the external users, by providing access to the services available in all 5G-VINNI facility sites. Thus, we follow the suggestion of external users and we link the main release of features related to this requirement in ML3.
- *Community.* This requirement enables knowledge sharing between both internal and external users. However, we expect that most of the internal users of a facility have a greater experience and knowledge of 5G technology, contrary to external users that may have limited knowledge and attempt to make the transition to 5G. Thus, we follow the suggestion of external users and we link the main release of this requirement to ML2.
- *Homogeneous service E2E.* This requirement is for achieving a consistent experience for external users (i.e., vertical customers). However, this can only be achieved if the proper capabilities for enabling the internal users' (i.e., facility sites) coordination are in place. Therefore, we here follow the suggestion of internal users for having the main release of this requirement linked to ML4.

Table 4-3: Business Layer requirements linked to ML2-mapped alternative for internal and external users.

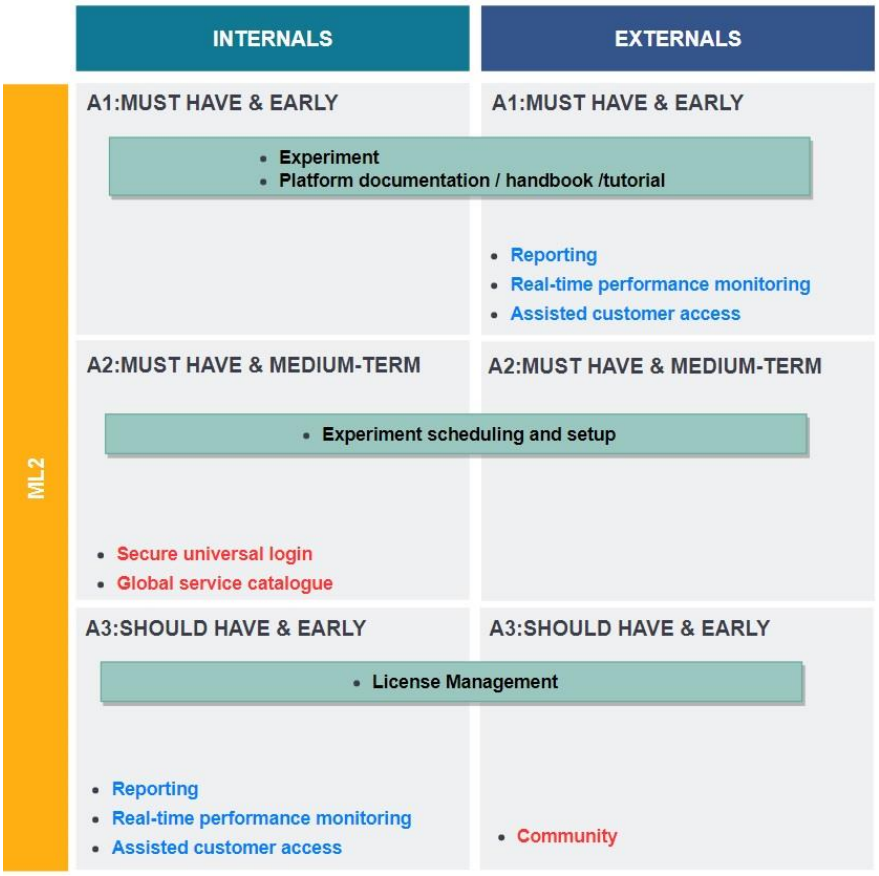


Table 4-4: Business Layer requirements linked to ML3-mapped alternative for internal and external users.

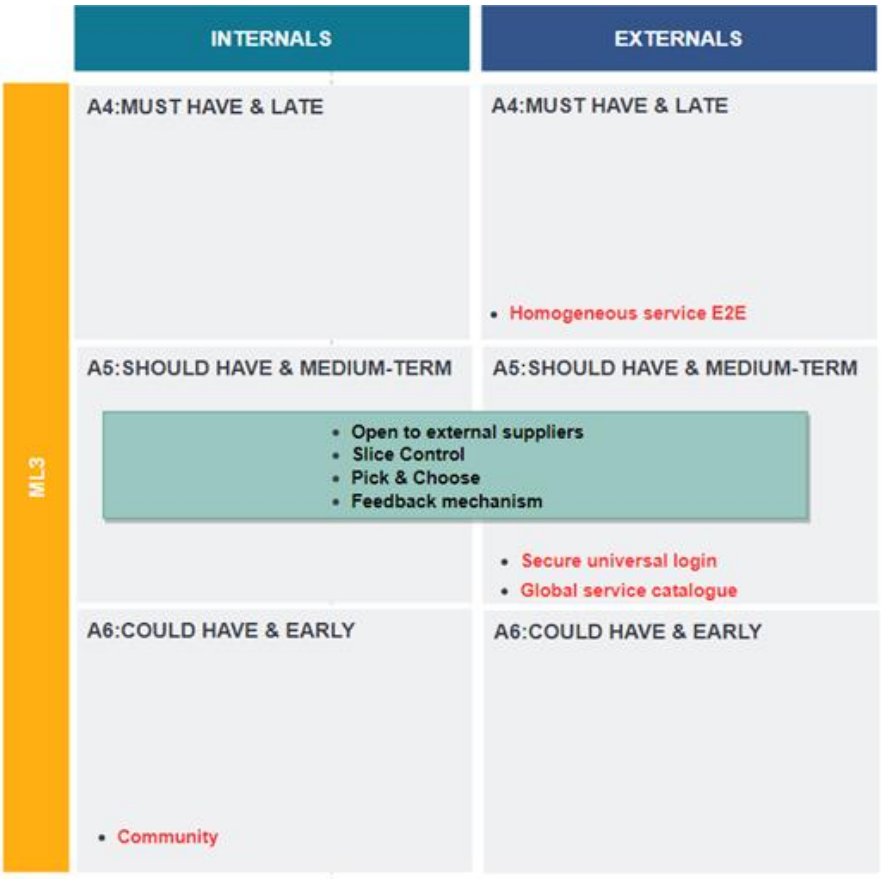
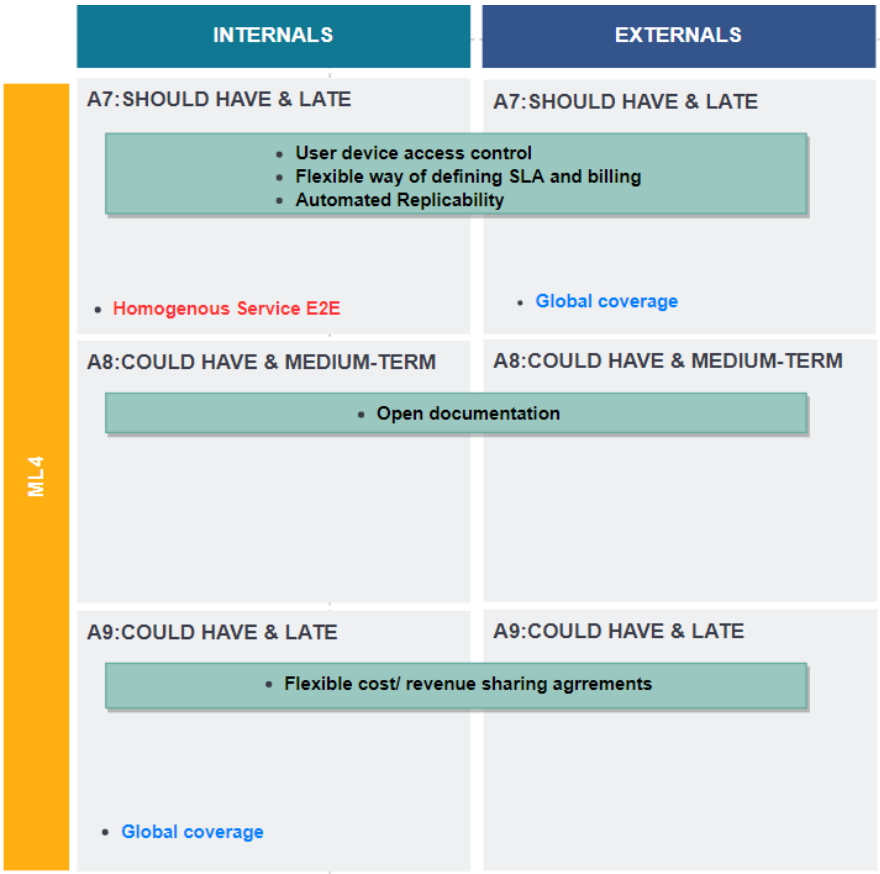


Table 4-5: Business Layer requirements linked to ML4-mapped alternative for internal and external users.



Having resolved the mapping of conflicting requirements, the final step is to summarize the distribution of requirements in response to the suggestions made by both user groups, internal and external. The final distribution of requirements is presented in Table 4-6 below. In particular, the requirements assigned in the first column of the table denotes that the main release of the relevant Business Layer capability features is going to be available in ML2. Accordingly, the requirements assigned in the second and third column demand the main release of relevant features in ML3 and ML4, respectively.

Table 4-6: Final distribution of requirements in MLs, identifying when the main release of related Business Layer features should be available.

ML2	ML3	ML4
• Reporting • Real-time performance monitoring • Assisted customer access • Experiment scheduling and set up • Experiment • Platform documentation/ handbook / tutorial • License Management • Community	• Global service catalogue • Secure universal login • Slice Control • Pick and choose • Feedback mechanism • Open to external suppliers	• User device access control • Homogeneous service E2E • Automated replicability • Global Coverage • Flexible way of defining SLA and billing • Flexible cost/ revenue sharing agreements • Open documentation

4.3 Business Layer design per Maturity Level

This subsection presents the Business Layer design per Maturity Level, by capturing the evolution of the proposed Business Layer capability features, based on the mapping of requirements to capabilities presented in section 3 and the final prioritization of requirements presented in Table 4-6. 5G-VINNI capability features should be rolled-out gradually, with some of them becoming mature before others.

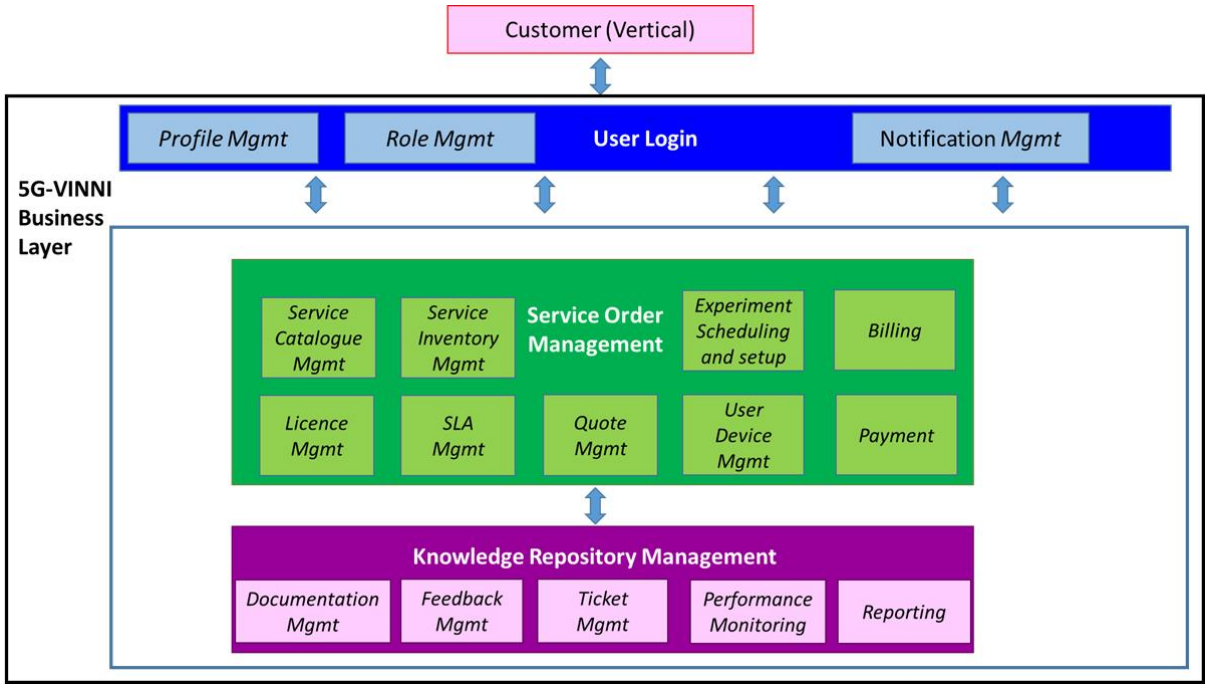


Figure 4-2: High-level design of 5G-VINNI Business Layer [2]

In D5.2 [2] the high-level design of the 5G-VINNI Business Layer was introduced, showing how the different components/capability features interact and provide services to customers. This business layer design is shown in Figure 4-2 and provides a pictorial representation of the main capabilities, how these are arranged, and how they interact. Verticals (customers) interact via the User Login layer and access Service Order Management and Knowledge Repository Management capabilities as required. The Business Layer provides the first point of interaction for verticals as they seek to access the 5G-VINNI platform with a view to defining and running experiments. At each facility, the Business Layer will interact with the Service Orchestration capabilities of the facility in order to fulfil and manage the requirements of the vertical. Based on the outcome of the previous subsection with respect to requirements prioritization, we now provide a viewpoint on how Business Layer capability features evolve. Table 4-7 identifies at which ML the main release of features supporting a requirement should be available and which capabilities are affected.

Table 4-7: Capability features rollout based on the prioritization (Table 4-6) of mapped requirements (Table 3-1)

	User Login			Service Order Management									Knowledge Repository Management				
Business Layer Capabilities / Requirements	Profile Mgmt	Role Mgmt	Notification Mgmt.	Service Catalogue Mgmt	License Mgmt	Service inventory Mgmt	SLA Mgmt	Quote Mgmt	Billing	Payment	Experiment Scheduling & Setup	User Device Mgmt	Documentation Mgmt	Feedback Mgmt	Ticket Mgmt	Performance monitoring	Reporting
Experiment scheduling and set up											ML2						
Experiment											ML2						
Reporting																	ML2
RT performance monitoring																ML2	
Assisted customer access			ML2	ML2		ML2									ML2		
Platform documentation													ML2				
License Management					ML2												
Community													ML2	ML2			
Global Service Catalogue				ML3													
Secure universal login	ML3	ML3															
Slice Control				ML3	ML3	ML3					ML3	ML3					
Pick and choose				ML3													
Open to external suppliers		ML3		ML3	ML3												
Feedback mechanism														ML3			
User device access control												ML4					
Homogeneous service E2E						ML4											
Automated replicability				ML4							ML4						
Global Coverage				ML4													
Flexible way of SLA definition & billing							ML4	ML4	ML4	ML4							
Flexible cost/ revenue sharing agreements								ML4									
Open documentation													ML4				

The remainder of this subsection provides a view of how all Business Layer capabilities evolve as we move from ML2 to ML3 and then to ML4. We assume that the first release for all capabilities should be available in ML2, but additional/enhanced features should be included in ML3 and ML4. The capability features that should be released in each ML are determined by the mapped requirements. Considering that each requirement calls for the **main** release of features at different Maturity Levels (as identified in Table 4-7), the Business Layer capabilities will evolve accordingly.

In the rest of this section, we illustrate the Business Layer design for each Maturity Level by enhancing the one presented in Figure 4-2, with information related to the evolution of features in relation to the mapped requirements. In the illustrations, the Business Layer capabilities that belong to different Tier-1 Business Layer capability families are highlighted with a different colour, i.e., we use blue for User Login, green for Service Order Management and purple for Knowledge Repository Management. Each Tier-2 Business Layer capability is represented by a lighter colour box that encloses the list of mapped requirements, while the gradual rollout of capabilities is illustrated by

means of histograms that capture the percentage of features that should to be available in each ML for satisfying the mapped requirements. In order to graphically capture the gradual rollout of capabilities, we assume that the progress with respect to each of the mapped requirements is captured by a single bar that increases by ~50% in the ML when the **main** release becomes available and ~25% in the other two ML releases. Note that these percentages are not accurate and we only use them to visualize the amount of effort that will be needed in each ML for releasing the necessary features.

Figure 4-3, Figure 4-4, Figure 4-5 show the Business Layer design in ML2, ML3 and ML4, respectively, capturing also the percentage of features that should be available per capability in each ML. The main ***observations*** are summarized as follows:

- **ML2.** It is shown that most of the capability features that belong to the Knowledge Repository Management family, such as Reporting, Real-Time Performance Monitoring and Community, should be prioritized in ML2. While it is also important to prioritize the features that enable Experiment Scheduling & Setup, License Management and assists the Vertical customers to place orders and receive notification about their status. The implementation of the relevant capabilities should be prioritized either because they are early winners (i.e., "must have" and easy to implement) or mandated for the operation of the 5G-VINNI facility in ML2. Based on the analysis performed, the capabilities considered as **early winners** are the Experiment Scheduling & Setup (focusing mostly on the latter), Reporting, Documentation Management, Feedback Management, Notification Management and a light-weight implementation of Service Catalogue Management feature.
- **ML3**. We can observe that features that enable the management of roles and profiles both for internal and external users should be prioritized in ML3, along with the development of standardized APIs that should allow 3rd-party suppliers to contribute services or infrastructure. It is also shown that the focus should be on delivering a significant number of Service Order Management features. These will enable access to services available to all facility sites, giving customers the ability to create complex services combining multiple existing ones. Finally, enhanced network slice control capabilities to the vertical customers should be provided.
- **ML4.** The efforts in ML4 should mainly focus on preparing 5G-VINNI facilities for the long-term plan for 5G-VINNI as a commercial solution for Experimentation as a Service. Therefore, the focus should be mostly on developing features related to the flexible management of SLAs, quotes and bills, as well as to the development of sophisticated mechanisms for advanced cost and revenue sharing, when complex services that involve multiple stakeholders are offered. Finally, additional features that boost the automation of each facility, such as the Automated Replicability of orders/experiments, are not considered of high priority and it is expected that should be released in ML4.

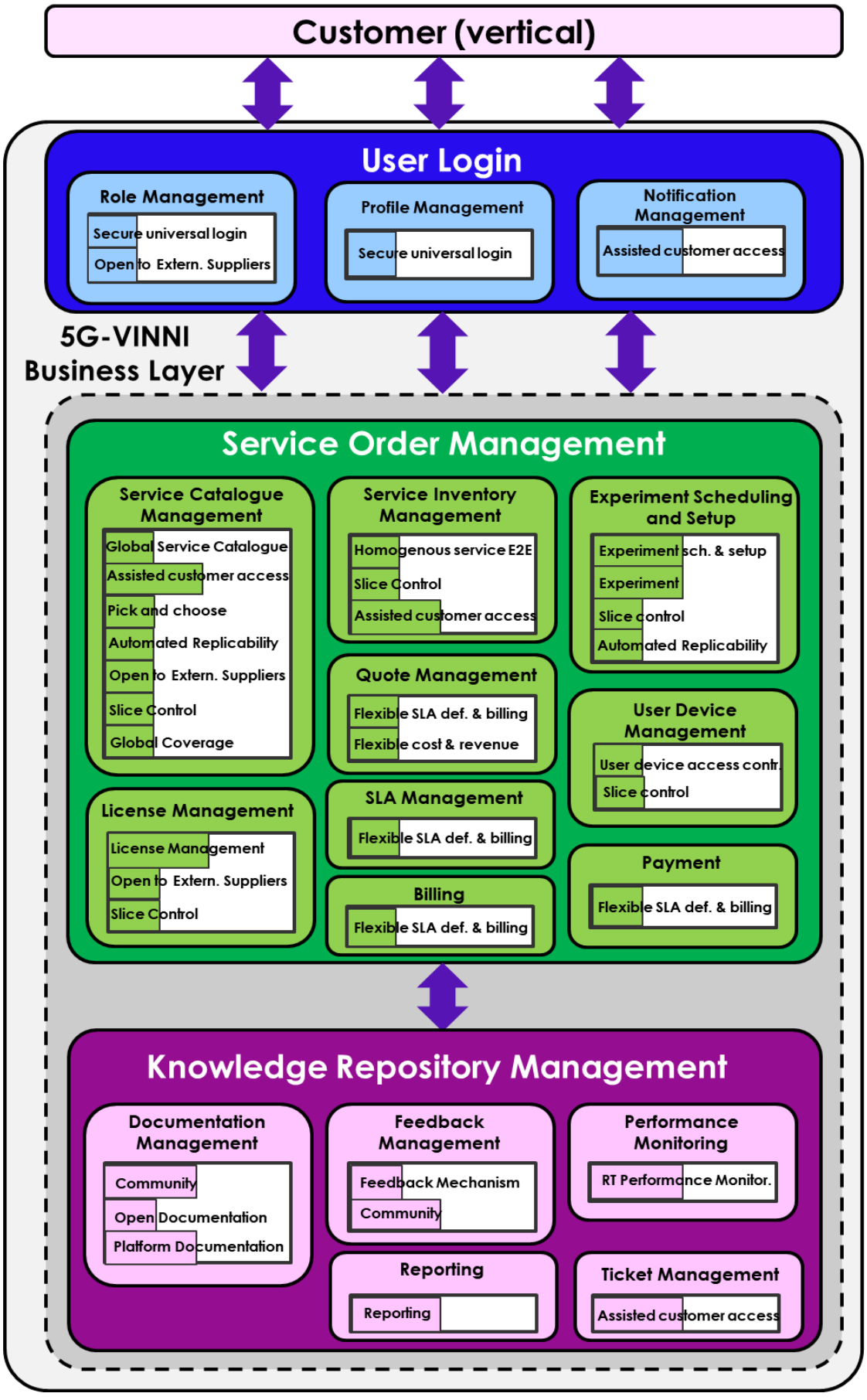


Figure 4-3: 5G-VINNI Business Layer design for ML2

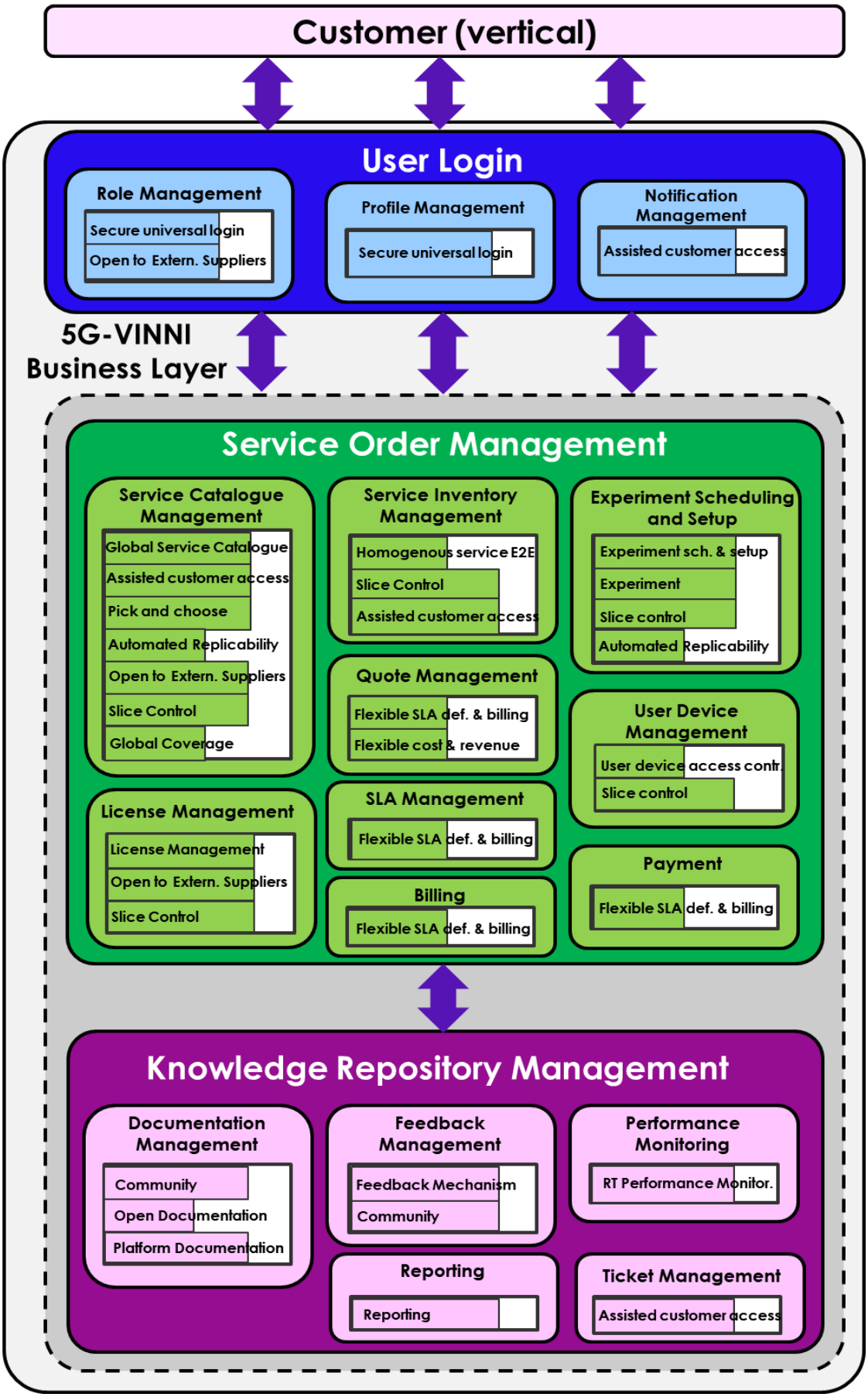


Figure 4-4: 5G-VINNI Business Layer design for ML3

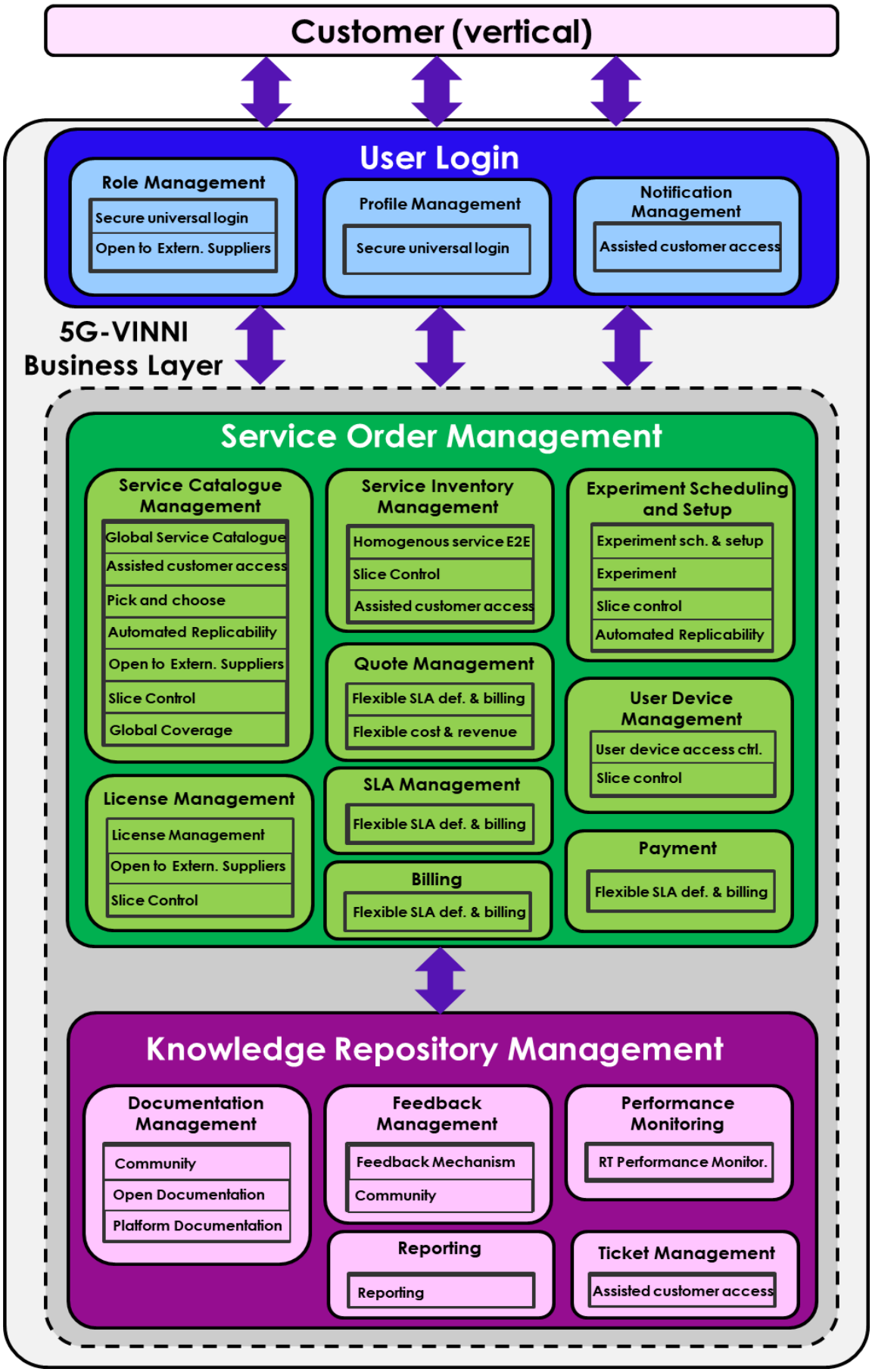


Figure 4-5: 5G-VINNI Business Layer design for ML4

5 Target values for Business and Economic KPIs

The evaluation of the success of 5G-VINNI is based, as expected, on several KPIs (Key Performance Indicators) that reflect the nature of the system and express its objectives. In this section, we list the KPIs that are going to be used for the evaluation and introduce the target values that these KPIs should achieve at each ML, capturing also a period beyond the project's lifetime (i.e., ML3 and ML4). The evaluation for ML2 (up to the end of the project) is going to take place in D5.4 [7], where we will find out whether the KPIs achieved their target values.

The provisioning of services in the 5G-VINNI platform necessitates the interaction of internal and external users, and involves business and economic aspects. Therefore, for the evaluation of the 5G-VINNI platform two types of relevant KPIs are needed, namely the Business KPIs and Economic KPIs. The Business KPIs evaluate the business success of 5G-VINNI as well as the efficiency of the Business Layer capabilities, while the Economic KPIs evaluate the sustainability of the 5G-VINNI facility.

A set of KPIs that could be used for our system was provided in D5.1 [1]. However, as 5G-VINNI proceeds, some of those KPIs appeared to be poor indicators of the 5G-VINNI platform performance, while others needed updates in order to express it better. In this chapter we present the set of KPIs we finally selected, and determine target values for them.

5.1 Selected Business and Economic KPIs

5.1.1 Business KPIs

The Business KPIs focus on evaluating the Business Layer capabilities efficiency through indicators that capture the vertical customers' experience, as well as the business success of the 5G-VINNI platform, through the quantification of the impact that the 5G-VINNI platform has on the vertical customers and complementors. In this paragraph, we are going to present the Business KPIs that we are actually going to employ.

In order to highlight their importance, we have grouped them into six categories, based on the features of the system they aim at evaluating. Most of the KPIs are defined as the percentage change of some measure. This is due to the fact that we are not interested in achieving specific values of these measures; we are rather interested in achieving the desirable growth (or decrease) rates for them. Therefore, an increase in such a KPI should be interpreted as an increase on the growth rate of the corresponding number/magnitude.

5.1.1.1 Vertical Customers' Engagement

An important factor for the success of 5G-VINNI is the degree to which it keeps its customers engaged with the system. In particular, we aim at creating a system that will have a lot of customers and will be accepting a lot of order requests.

5.1.1.1.1 Number of Customer Accounts

As the size of the customer base is critical for our system, we need to be able to evaluate its progress. This KPI measures the percentage change in the number of accounts registered to the Service Catalog of a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{CustomerAccounts\_\%Change} = \left(\frac{\text{CustomerAccounts}_L}{\text{CustomerAccounts}_K} - 1\right) 100\%$$

For better understanding of the computation of this KPI, we provide an indicative example. Assume that there are 15 accounts that have been registered to the Service Catalogue at the end of period K,

which could correspond to ML2. Assume further that at the end of period L, which could correspond to ML3, there are 28 registered accounts. The percentage change on the number of accounts is:

$$CustomerAccounts\_\%Change = \left(\frac{28}{15} - 1\right)100\% = (1.87 - 1)100\% = 0.87 * 100\% = 87\%.$$

The computation of the rest KPIs, defined below, is performed in the same way.

We note here that negative values of the KPI do not imply reduced interest in using the 5G-VINNI facility. They may just reflect specific patterns in the usage of 5G-VINNI, for instance periods of time when a relatively small number of customers have access to the facility or when not all functionality is being offered yet.

5.1.1.1.2 Number of Requested Orders

This KPI measures the percentage change in the number of orders that have been requested on the Service Catalog of a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{OrdersRequested\_\%Change} = \left(\frac{\text{OrdersRequested}_L}{\text{OrdersRequested}_K} - 1\right)100\%$$

As previously mentioned, negative values could be attributed to usage patterns and are not necessarily associated with reduced interest in using 5G-VINNI.

5.1.1.2 Vertical Customers' Experience

Attracting customers is the first step towards a successful system. However, the customers have to be satisfied with the system in order to continue using it. We employ the KPIs of this section in order to evaluate the customers' experience with 5G-VINNI.

5.1.1.2.1 Number of Fulfilled Orders

This KPI measures the percentage change in the number of orders prepared on the Service Catalog of a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{OrdersFulfilled\_\%Change} = \left(\frac{\text{OrdersFulfilled}_L}{\text{OrdersFulfilled}_K} - 1\right)100\%$$

As in the previous case, negative values could be attributed to usage patterns and not associated with reduced interest in using 5G-VINNI.

5.1.1.2.2 Duration of Orders' Processing

This KPI measures the percentage change on the average time for a 5G-VINNI facility site to process the orders placed between period K>=1 and period L>K. Here, by the duration of an order's processing, or service creation time, we denote the time needed from the moment a request is received until we respond about whether we are going to fulfil the request or not. We should note that this KPI is primarily affected by constraints on the resources of different 5G-VINNI facility sites. The formula to be used is the following:

$$\text{OrderProcessingDuration\_\%Change} = \left(\frac{\text{OrderProcessingDuration}_L}{\text{OrderProcessingDuration}_K} - 1\right)100\%$$

Negative values on this KPI may imply that the maturity of the related Business Layer capabilities increases and thus the order processing is performed faster and in an automated way. On the other hand, positive values do not necessarily mean inferior performance because this can also be attributed to higher complexity of orders placed; if for example VNFsActivated_%Change (see below)

is positive. Therefore, the interpretation of this KPI value should be performed by also taking into account other relevant KPIs.

5.1.1.2.3 Number of Information Requests

This KPI measures the percentage change in the number of information requests (e.g., financial information) on a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{InformationRequests\_\%Change} = \left(\frac{\text{InformationRequests}_L}{\text{InformationRequests}_K} - 1\right) 100\%$$

5.1.1.2.4 Number of Troubleshooting Requests

This KPI measures the percentage change in the number of troubleshooting requests (i.e., requests for technical support) on a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{TroubleshootingRequests\_\%Change} = \left(\frac{\text{TroubleshootingRequests}_L}{\text{TroubleshootingRequests}_K} - 1\right) 100\%$$

5.1.1.3 Experimentation Intensity

Another important aspect of 5G-VINNI is the load of experiments it can support. An efficient system should have many VNFs activated, accomplish many orders and do it as soon as possible. The KPIs in this section aim at evaluating these aspects. We remind here that an order consists of a set of one or more experiments.

5.1.1.3.1 Number of Activated VNFs

This KPI measures the percentage change in the total number of VNFs (including VAFs) activated on a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{VNFsActivated\_\%Change} = \left(\frac{\text{VNFsActivated}_L}{\text{VNFsActivated}_K} - 1\right) 100\%$$

5.1.1.3.2 Number of Experiments Started

This KPI measures the percentage change on the average number of experiments started on a 5G-VINNI facility site between period K>=1 and period L>K. Note that each experiment is mapped to a specific customer order and may include multiple sub-experiments. The formula to be used is the following:

$$\text{ExperimentsStarted\_\%Change} = \left(\frac{\text{ExperimentsStarted}_L}{\text{ExperimentsStarted}_K} - 1\right) 100\%$$

5.1.1.3.3 Number of Experiments Abandoned

This KPI measures the percentage of the experiments abandoned on a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{ExperimentsAbandoned\_\%Change} = \left(\frac{\text{ExperimentsAbandoned}_L}{\text{ExperimentsAbandoned}_K} - 1\right) 100\%$$

The number of abandoned orders should be essentially equal to the difference between started and fulfilled orders.

5.1.1.3.4 Duration of Experiments

This KPI measures the percentage change on the (average) duration of the experiments started on a 5G-VINNI facility site between period K>=1 and period L>K. Note that if an experiment consists of multiple sub-experiments, we account for the duration of all sub-experiments. Thus, if a vertical customer needs to test the feasibility, effectiveness, efficiency, etc., of a certain service configuration, then several sub-experiments should be performed. The formula to be used is the following:

$$\text{ExperimentDuration\_\%Change} = \left(\frac{\text{ExperimentDuration}_L}{\text{ExperimentDuration}_K} - 1\right) 100\%$$

5.1.1.4 Innovation

The innovation 5G-VINNI introduces to the market can be evaluated based on the new VNFs created, and new services and products developed. We employ KPIs that aim at evaluating these aspects.

5.1.1.4.1 Number of Facility-Site-Created VNFs Onboarded

This KPI measures the percentage change on the number of facility-site-created VNFs being onboarded on a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{FacilitySiteCreatedVNFsOnboarded\_\%Change} = \left(\frac{\text{FacilitySiteCreatedVNFsOnboarded}_L}{\text{FacilitySiteCreatedVNFsOnboarded}_K} - 1\right) 100\%$$

5.1.1.4.2 Number of Customer-Created VNFs Onboarded

This KPI measures the percentage change on the number of custom VNFs (i.e., those created by customers themselves) being onboarded on a 5G-VINNI facility site between period K>=1 and period L>K. The formula to be used is the following:

$$\text{CustomerCreatedVNFsOnboarded}_{\%}\text{Change} = \left(\frac{\text{CustomerCreatedVNFsOnboarded}_L}{\text{CustomerCreatedVNFsOnboarded}_K} - 1\right) 100\%$$

5.1.1.4.3 Service portfolio enrichment

This KPI evaluates the service portfolio enrichment. It calculates the percentage change of the number of new services developed, deployed and tested using the 5G-VINNI facilities between period K>=1 and period L>K. We define as *new*, those services that stop using testing slices and start using production slices. The formula to be used is the following:

$$\text{ServicePortfolioEnrichment\_\%Change} = \left(\frac{\text{Number\_of\_Services\_created}_L}{\text{Number\_of\_Services\_created}_K} - 1\right) 100\%$$

5.1.1.4.4 Innovation by Verticals

This KPI calculates the % change of the number of new products introduced by a vertical in 5G-VINNI between periods K>=1 and L>K. These numbers can be derived from the questionnaire, and we may consider as period 1 the current situation. The formula to be used is the following:

$$\text{VerticalsInnovation\_\%Change} = \left(\frac{\text{New\_products\_introduced}_L}{\text{New\_products\_introduced}_K} - 1\right) 100\%$$

5.1.1.5 Entry barriers and Collaboration

Two criteria that are decisive for the usefulness of 5G-VINNI are the difficulty of testing products in realistic settings, as well as whether it eases the collaboration of different stakeholders in order to provide VNFs to a service. We introduce KPIs that evaluate these aspects.

5.1.1.5.1 Entry Barriers — Difficulty of testing products in realistic settings

This KPI calculates the minimum number (on average over all facility sites) of VNFs required by the customer in order to test a product in a large-scale, end-to-end setup in 5G-VINNI. Part of the VNFs required to test a use case are provided by the 5G-VINNI facility. As 5G-VINNI matures, the facility sites will have implemented more VNFs and therefore the customers will have to contribute less VNFs in order to test their use cases. In this way the entry barriers of the system lower: The more mature the facility site, the easier for the customer to test use cases there. The formula to be used is the following:

$$\text{ExperimenationDifficulty\_Entry\_Barrier} = \left(\frac{\text{MandatoryVNFs}_L}{\text{MandatoryVNFs}_K} - 1\right) 100\%$$

5.1.1.5.2 Collaboration among stakeholders

We define the collaboration among stakeholders as a set of stakeholders providing VNFs to a single service. The corresponding KPI calculates the percentage change of the average number of stakeholders providing VNFs to a single service between period K>=1 and period L>K. The formula to be used is the following:

$$\text{CollaborationDegree\_\%Change} = \left(\frac{\text{Collaboration\_degree}_L}{\text{Collaboration\_degree}_K} - 1\right) 100\%$$

5.1.1.6 Additional Customer Experience KPIs

In this section, we include some additional Business KPIs that are related to customer experience. Considering that these KPIs are not of high importance and given that their computation may be challenging for some facility sites, at least at the early maturity levels of the 5G-VINNI facility, we keep them separately and we will use them for the evaluation in D5.4 only in case such information is available.

5.1.1.6.1 Duration of Handled Information Requests

This KPI measures the percentage change on the (average) handling duration of information requests on a 5G-VINNI facility site between period K>=1 and period L>K. We should note that this KPI is primarily affected by constraints on the resources of different 5G-VINNI facility sites. The formula to be used is the following:

$$\text{InfoRequestsHandledDuration\_\%Change} = \left(\frac{\text{InfoRequestsHandledDuration}_L}{\text{InfoRequestsHandledDuration}_K} - 1\right) 100\%$$

5.1.1.6.2 Duration of Handled Troubleshooting Requests

This KPI measures the percentage change on the (average) handling duration of troubleshooting requests on a 5G-VINNI facility site between period K>=1 and period L>K. We should note that this KPI is primarily affected by constraints on the resources of different 5G-VINNI facility sites. The formula to be used is the following:

$$\text{TroubleshootRequestsHandledDuration\_\%Change} = \left(\frac{\text{TroubleshootRequestsHandledDuration}_L}{\text{TroubleshootRequestsHandledDuration}_K} - 1\right) 100\%$$

5.1.1.6.3 Number of Pending Information Requests

This KPI measures the percentage change on the number of information requests that are pending 24 hours upon receipt on a 5G-VINNI facility site between period K>=1 and period L>K. We should note that this KPI is primarily affected by constraints on the resources of different 5G-VINNI facility sites. The formula to be used is the following:

$$\text{PendingInfoRequests\_\%Change} = \left(\frac{\text{PendingInfoRequests}_L}{\text{PendingInfoRequests}_K} - 1\right) 100\%$$

5.1.1.6.4 Number of Pending Troubleshooting Requests

This KPI measures the percentage change on the number of troubleshooting requests that are pending 48 hours upon receipt on a 5G-VINNI facility site between period K>=1 and period L>K. We should note that this KPI is primarily affected by constraints on the resources of different 5G-VINNI facility sites. The formula to be used is the following:

$$\text{PendingTroubleshootRequests\_\%Change} = \left(\frac{\text{PendingTroubleshootRequests}_L}{\text{PendingTroubleshootRequests}_K} - 1\right) 100\%$$

5.1.2 Economic KPIs

We continue by presenting the selected Economic KPIs. Again, in order to highlight their essence, we have grouped them in two categories, based on the features of the system they aim at evaluating: We distinguish between KPIs that evaluate the cost efficiency of the system and KPIs that evaluate the system's ability for value creation. Economic KPIs are more difficult to estimate since we need information from each facility on the network deployment model/setup, the supported services, the cost items and the relevant member/entity that faces each cost. Furthermore, we need to make predictions on the revenue flows for each service.

In order to make the definitions of the economic KPIs clear, we remind here that the 5G-VINNI facility is provided by a set of facility sites, and each facility site has one or more participating members.

5.1.2.1 Cost efficiency

5.1.2.1.1 Total CAPEX for 5G-VINNI facility member

This KPI calculates the total cost of the infrastructure deployed by a certain member i of the 5G-VINNI facility. In particular, it covers the CAPEX for a certain setup j of the facility site where this member belongs to and it is sensitive to the dimensioning needed, the business models adopted, etc. It is calculated as the present value (PV) of all cost items $c = 1, \dots, C$ that are used over a specific period of time, e.g., 10 years, with a certain discount rate (e.g., WACC). The formula to be used is the following:

$$\text{MemberCAPEX}_{i,j} = \sum_{c=1,\dots,C} PV(\text{CapEx}_{i,j}^{c}, \text{DiscountRate})$$

where:

- $\text{CapEx}_{i,j}^{c}$ is the capital cost of item c (e.g., for masts) of site member i under setup/value network j
- **DiscountRate** is the interest rate used to determine the present value of future cash flows (in this case outflows/expenses). This is usually needed as investments in telecommunications industry a) enable multi-year service provisioning and b) are capital intensive and thus cannot be amortised at the end of the accounting period. A popular discount rate is the **Weighted Average Cost of Capital** (WACC), which represents the average risk faced by an organization. When the discount rate equals zero (0) the future

value of those expenses is calculated, which is useful when an investment is assessed using metrics such as Internal Rate of Return (see below). For simplicity, we assume that the same discount rate is used for all members that belong to the same facility site.

5.1.2.1.2 Total CAPEX for 5G-VINNI facility site

This KPI calculates the total cost of the infrastructure deployed by all members $1, \dots, N$ of a 5G-VINNI facility site. In particular, it covers the CAPEX for a certain setup j of the facility site in terms of the dimensioning needed, the business models adopted, etc. It is calculated as the present value of these costs over a specific period of time, e.g., 10 years, with a certain interest rate (e.g., WACC). The following formula is to be used:

$$\mathrm{SiteCAPEX}_j = \sum_{i=1,\dots,N} \mathrm{MemberCAPEX}_{i,j}$$

where $\mathrm{MemberCAPEX}_{i,j}$ is defined in Section 5.1.2.1.1.

5.1.2.1.3 Total OPEX for 5G-VINNI facility member

This KPI calculates the total variable costs for the services offered by a certain member i of the 5G-VINNI facility. In particular, it covers the Operational Expenditures (OPEX) for a certain setup j of the facility site in which this member belongs, and it is calculated as the present value (PV) of all these cost items $o = 1, \dots, O$ over a specific period of time, e.g., 10 years, with a certain interest rate (e.g., WACC). The formula to be used is the following:

$$\mathrm{MemberOPEX}_{i,j} = \sum_{o=1,\dots,O} PV(\mathrm{OpEx}_{i,j}^{o}, \mathrm{DiscountRate})$$

where:

- $\mathrm{OpEx}_{i,j}^{o}$ is the operational cost item o of site member i under setup/value network j
- $\mathrm{DiscountRate}$ is the interest rate used to determine the present value of future cash outflows.

5.1.2.1.4 Total OPEX for 5G-VINNI facility site

This KPI calculates the total variable costs for the services offered by the members $1, \dots, N$ of a 5G-VINNI facility site. In particular, it covers the Operational Expenditures (OPEX) for a certain setup j of the facility site in terms of the dimensioning needed, the business models adopted, etc. It is calculated as the present value of these costs over a specific period of time, e.g., 10 years, with a certain interest rate (e.g., WACC). The formula to be used is the following:

$$\mathrm{SiteOPEX}_j = \sum_{i=1,\dots,N} \mathrm{MemberOPEX}_{i,j}$$

where $\mathrm{MemberOPEX}_{i,j}$ is defined in section **Error! Reference source not found.**.

5.1.2.1.5 Total Cost of Ownership for a 5G-VINNI facility site

This KPI expresses the total cost of ownership (TCO) for all members of a 5G-VINNI facility site. It is calculated as the sum of the respective KPIs for the CAPEX and OPEX for a particular site configuration j. It is computed by the formula:

$$\mathrm{SiteTCO}_j = \mathrm{SiteCAPEX}_j + \mathrm{SiteOPEX}_j$$

where $\mathrm{SiteCAPEX}_j$ is defined in Section **Error! Reference source not found.**, while $\mathrm{SiteOPEX}_j$ is efined in **Error! Reference source not found.**.

5.1.2.2 Value creation

5G-VINNI creates value for the vertical industries and the other involved stakeholders since it facilitates the innovation. Value is created for every stakeholder that either joins 5G-VINNI as a facility provider or uses 5G-VINNI for testing.

5.1.2.2.1 Total Revenues for 5G-VINNI facility member

This KPI calculates the total revenues for the services $r = 1, \dots, R$ offered by member i of the 5G-VINNI facility. It includes the incomes for a certain setup j of the facility site (e.g., the business models adopted) from the services offered to its customers, like those in the targeted vertical industries. It is calculated as the present value (PV) of these revenues over a specific period of time, e.g., 10 years, with a certain interest rate (e.g., WACC). The formula to be used is the following:

$$\text{MemberRevenues}_{i,j} = \sum_{r=1,\dots,R} PV(\text{Revenues}_{i,j}^{r}, \text{DiscountRate})$$

where:

- $\text{Revenues}_{i,j}^{r}$ is the revenue stream r of site member i under setup/value network j
- DiscountRate is the interest rate used to determine the present value of future cash inflows, which equals the discount rate of outflows.

5.1.2.2.2 Total Revenues for 5G-VINNI facility site

This KPI calculates the total revenues for the services offered by all the members $1, \dots, N$ of a 5G-VINNI facility site. It includes the incomes for a certain setup j of the facility site (e.g., the business models adopted) from the services offered to its customers, like those in the targeted vertical industries. It is calculated as the present value (PV) of these revenues over a specific period of time, e.g., 10 years, with a certain interest rate (e.g., WACC). The formula to be used is the following:

$$\text{SiteTotalRevenues}_{j} = \sum_{i=1,\dots,N} \text{MemberRevenues}_{i,j}$$

where $\text{MemberRevenues}_{i,j}$ are defined in section 5.1.2.2.1.

5.1.2.2.3 Total Earnings/Losses for 5G-VINNI facility member

This KPI calculates the total net benefit for the services offered by member i of the 5G-VINNI facility. It is calculated by subtracting the present value of the total expenditures (both capital and operating ones) for that particular facility site member from the present value of the relevant revenues. The formula to be used is the following:

$$\text{MemberTotalEarnings}_{i,j} = \text{MemberCAPEX}_{i,j} + \text{MemberOPEX}_{i,j} - \text{MemberRevenues}_{i,j}$$

where $\text{MemberCAPEX}_{i,j}$ is defined in section 5.1.2.1.1, $\text{MemberOPEX}_{i,j}$ is defined in section 5.1.2.1.3, and $\text{MemberRevenues}_{i,j}$ is defined in section 5.1.2.2.1.

5.1.2.2.4 Internal Rate of Return for 5G-VINNI facility member

This KPI calculates the interest rate at which the net present value of all the future cash flows (i.e., negative during the first year(s) and hopefully positive in most of the following years) of a certain 5G-VINNI facility site member equals zero. The Internal Rate of Return (IRR) is calculated by choosing a discount rate such that the following equation holds: $\text{MemberTotalEarnings}_{i,j} = 0$.

5.1.2.2.5 Total Earnings/Losses

This KPI calculates the total net benefit of all members participating in a 5G-VINNI facility site for a certain setup j. It is calculated by subtracting the total cost of ownership for that particular facility site from its revenues. The formula to be used is the following:

$$\text{SiteTotalEarnings}_j = \text{SiteTotalRevenues}_j - \text{SiteTCO}_j$$

where SiteTCO_j is defined in section 5.1.2.1.5, and $\text{SiteTotalRevenues}_j$ is defined in section 5.1.2.2.2.

5.2 Target values

In this section, we identify target values for the aforementioned KPIs, discussing also how these values may change across the different maturity levels. We consider values in the time intervals determined by the defined maturity levels:

- ML2: Last year of the 5G-VINNI project
- ML3: One-year time-window after project ends
- ML4: A longer time period, after ML3's end, that captures the 5G-VINNI commercialization vision that will also go beyond 5G. We set target values for a period of 2 years after ML3's end.

First, we will present the target values for the Business KPIs. We begin by presenting in section 5.2.1 the methodology we followed, and continue in 5.2.2 with the outcomes of this process.

5.2.1 Methodology

In order to compute the target values of the Business and Economic KPIs, we took into account the objectives of the whole 5G-VINNI project, as well as the objectives in each of the above maturity levels. After a high-level communication with each of the facility sites we got insight on the details of the system and were able to determine target values that if achieved by the facility, they would imply the success of 5G-VINNI.

In the rest of this section, we present the KPI target values we determined for the 5G-VINNI facilities. For each KPI we determine three target values. Each such value corresponds to the end of a specific maturity level, so we provide target values for the ends of maturity levels ML2, ML3 and ML4.

5.2.2 Target values for Business KPIs

At this point we should make a note regarding the customer base of 5G-VINNI that will be useful in understanding all of our following choices. In maturity levels ML1 and ML2 our customers are the ICT-19 projects and ESB members. In ML3, our customers will be the ICT-19 project members, expected to be performing more experiments than in ML2, the ESB members and some external collaborators. This means that the customer base will not change significantly. On the other hand, as the development of the 5G-VINNI facility will have been finalized, it will be able to fulfil more demanding requests. In ML4, however, 5G-VINNI will be open to the general public so the number of customers is expected to increase, implying rise to the experimentation intensity.

Another thing we would like to mention is that the various maturity levels have different duration. While ML2 and ML3 last for one year each, we consider the duration of ML4 to be two years.

The above two remarks played an important role in determining the KPI target values that follow and thus they are part of the justification for all of them.

5.2.2.1 Vertical Customers' Engagement

5.2.2.1.1 CustomerAccounts_%Change

The number of customer accounts in the 5G-VINNI facility are currently 40. As we expect that their number will increase from now on, we have set target values for the % increase of this number that are presented in the Table 5-1 below. Not the percentage of ML2 (75%) is based on the current number of customer accounts (i.e., 40), while the percentages of ML3 and ML4 are related to the number of accounts at the end of ML2 and ML3 respectively.

Table 5-1: Target values for CustomerAccounts_%Change in each ML

Maturity level	CustomerAccounts_%Change target value
ML2	75%
ML3	43%
ML4	100%

As explained in the introduction of this section, in ML3 we expect to have roughly the same customer base as in ML2, so we expect a moderate increase in the number of customer accounts. In ML4, however, we expect to attract new customers and so we have decided on a much higher target value.

5.2.2.1.2 OrdersRequested_%Change

Currently about 101 orders have been requested from the 5G VINNI facility. The number of requested orders increases with the customers, so we have determined for the OrdersRequested_%Change KPI the target values that are presented in the Table 5-2 below.

Table 5-2: Target values for OrdersRequested_%Change in each ML

Maturity level	OrdersRequested_%Change target value
ML2	75%
ML3	57%
ML4	82%

The number of requested orders is expected to depend on the number of customer accounts. In some cases, we expect that we are going to have only one order per customer account.

5.2.2.2 Vertical Customers' Experience

5.2.2.2.1 OrdersFulfilled_%Change

We expect that the orders that are being fulfilled will increase as the maturity of the 5G-VINNI facility increases. This will happen for two reasons: first, we expect that the number of requests will increase; second, we expect that the ratio of fulfilled orders over requested orders will also increase. Currently there are 70 orders that have been fulfilled in the 5G-VINNI facility. The target values we have set for the %Change of this number are presented in the Table 5-3 below.

Table 5-3: Target values for OrdersFulfilled _%Change in each ML

Maturity level	OrdersFulfilled_%Change target value
ML2	139%
ML3	59%
ML4	87%

We expect a high increase in ML2 due to the fact that the facility will be offering all of its functionality by then, so it will be able to fulfil much more of the requested orders that it is currently fulfilling. Moreover, we expect a moderate increase in ML3 and a higher (compare to ML3) increase

in ML4 when the customer base is expected to change significantly. Finally, we expect the ratio of fulfilled orders over requested orders, which is currently equal to 70%, to increase to 95%, 96.4% and 99% for ML2, ML3 and ML4, respectively.

5.2.2.2.2 OrderProcessingDuration_%Change

The processing duration of orders is expected to decrease as 5G-VINNI evolves. Currently it is 48 minutes on average, and we have set for the OrderProcessingDuration_%Change KPI the target values that are presented in the Table 5-4 below.

Table 5-4: Target values for OrderProcessingDuration _%Change in each ML

Maturity level	OrderProcessingDuration _%Change target value
ML2	-46%
ML3	0%
ML4	-23%

The decrease in processing time is attributed to the fact that the system matures and the orders are processed faster and in an automated way.

5.2.2.2.3 InformationRequests_%Change

Until now 251 information requests have been placed to 5G-VINNI platform. This number is expected to increase with time, with a growth rate that depends on the maturity level. The target values we have set for the InformationRequests_%Change KPI are presented in the Table 5-5 below.

Table 5-5: Target values for InformationRequests_%Change in each ML

Maturity level	InformationRequests_%Change target value
ML2	86%
ML3	61%
ML4	53%

We expect a rapid growth in ML2 and smaller growth rates as 5G-VINNI gets more mature and there are documentation and related guides available online. so that part of the customers will be able to get informed about the 5G-VINNI facility without needing to perform information requests. The expected increase is due only to the fact that the number of customers is expected to increase.

5.2.2.2.4 TroubleshootingRequests_%Change

Until now 155 troubleshooting requests have been placed to 5G-VINNI. This number is expected to increase with time, with a decreasing growth rate that depends on the maturity level. The target values we have determined for the TroubleshootingRequests_%Change KPI are presented in the Table 5-6 below.

Table 5-6: Target values for TroubleshootingRequests _%Change in each ML

Maturity level	TroubleshootingRequests_%Change target value
ML2	174%
ML3	72%
ML4	68%

We expect a rapid growth in ML2 and smaller growth rates as 5G-VINNI gets more mature and there are documentation and related guides available online. In this case, customers will be able to access troubleshooting information (help) without necessarily performing troubleshooting requests. The expected increase in the troubleshooting requests is solely due to the increase of the number of customers.

5.2.2.3 Experimentation Intensity

5.2.2.3.1 VNFsActivated_%Change

There are on average 17.6 VNFs that are currently activated in 5G-VINNI platform. We expect them to increase with time, demonstrating larger growth rates in ML2 as the functionality becomes richer, and in ML4 as the customer base will get wider. The target values we have determined for the VNFsActivated_%Change KPI are presented in the Table 5-7 below.

Table 5-7: Target values for VNFsActivated _%Change in each ML

Maturity level	VNFsActivated_%Change target value
ML2	57%
ML3	15%
ML4	77%

Many of the ICT-19 projects or ESB experiments are expected to have been completed by the end of ML2, so in ML3 we expect fewer and more targeted experiments. On the other hand, in ML4 we expect a significant increase, because the 5G-VINNI facility will be opened to new customers.

5.2.2.3.2 ExperimentsStarted_%Change

Currently there are 87 experiments that have been started in 5G-VINNI. Note here that, till now, each order consists of exactly one experiment; however, in the future each order may consist of more than one experiment, i.e., multiple sub-experiments. We expect them to increase with time as the system's full functionality gets implemented and the customer base gets wider. The target values we have determined for the ExperimentsStarted_%Change KPI are presented in the Table 5-8 below.

Table 5-8: Target values for ExperimentsStarted_%Change in each ML

Maturity level	ExperimentsStarted_%Change target value
ML2	170%
ML3	59%
ML4	78%

We expect a large increase at ML2 as the implementation of the system's functionality is completed, and increase with smaller, however increasing, growth rates in ML3 and ML4, dependent on the size of the customer base.

5.2.2.3.3 ExperimentsAbandonded_%Change

Currently there are 17 Experiments that have been abandoned in 5G-VINNI. We expect them to increase with time as the number of orders increases. The growth rate, however, should be decreasing. We expect the average percentage ratio of the number of abandoned orders to the number of started orders to decrease from its current value of 12.7% to 11.5% and 10.7% in ML2 and ML3 respectively, and increase to 12% in ML4. In ML4 the 5G-VINNI is opened to a new set of customers, so we expect that the ratio of abandoned/started experiments will increase because some of the new customers will be immature with 5G technology. The target values we have determined for the ExperimentsAbandoned_%Change KPI are presented in the Table 5-9 below.

Table 5-9: Target values for ExperimentsAbandonded_%Change in each ML

Maturity level	ExperimentsAbandonded_%Change target value
ML2	233%
ML3	70%
ML4	29%

We expect a large increase at ML2 as by then the system will be offering its full functionality and it will have started receiving massive order requests, and a much smaller increase in ML3 as the customer base gets a bit wider.

5.2.2.3.4 ExperimentDuration_%Change

The average duration of experiment execution is currently 10.6 hours. As we expect them to exhibit some little increase as 5G-VINNI matures and the orders become more demanding, but on the other hand it does not depend on the size of the customer base, we have determined for the ExperimentDuration_%Change KPI the target values that are presented in the Table 5-10 below.

Table 5-10: Target values for ExperimentDuration _%Change in each ML

Maturity level	ExperimentDuration_%Change target value
ML2	20%
ML3	0%
ML4	0%

5.2.2.4 Innovation

5.2.2.4.1 FacilitySiteCreatedVNFsOnboarded_%Change

In each facility site there is a set of onboarded VNFs that are created by the facility. At present there are on average 14 such VNFs on each facility site. We expect a large increase on this number as the implementation gets closer to completion. Then we expect only slight modifications. The target values we have determined for the FacilitySiteCreatedVNFsOnboarded_%Change KPI are presented in the Table 5-11 below.

Table 5-11: Target values for FacilitySiteCreatedVNFsOnboarded _%Change in each ML

Maturity level	FacilitySiteCreatedVNFsOnboarded_%Change target value
ML2	50%
ML3	5%
ML4	3%

We have determined small target values for ML3 and ML4, as the vast majority of facility site VNFs should have already been onboarded.

5.2.2.4.2 CustomerCreatedVNFsOnboarded_%Change

In each facility site there is a set of onboarded VNFs that are created by customers or third parties. At present there are on average 2.5 such VNFs on each facility site. We expect a large increase on this number in ML2 as the vertical experimentation gets closer to. At ML3 we still expect increase, however we expect the growth rate to be smaller because the customer base will remain the same. On the other hand, we expect a significant increase in ML4 due to the potential new customers. We have determined for the CustomerCreatedVNFsOnboarded_%Change KPI the target values that are presented in the Table 5-12 below.

Table 5-12: Target values for CustomerCreatedVNFsOnboarded _%Change in each ML

Maturity level	CustomerCreatedVNFsOnboarded_%Change target value
ML2	160%
ML3	31%
ML4	61%

5.2.2.4.3 ServicePortfolioEnrichment_%Change

Currently there are on average 2.5 new service specifications developed by each facility site. We expect that their number will increase as 5G-VINNI matures, with growth ratio decreasing with time since the main 5G-VINNI network slice templates will have been implemented by the end of ML2 and the new ones will be developed to capture specific scenarios that require customization. The target values we have determined for the ServicePortfolioEnrichment_%Change KPI are presented in the Table 5-13 below.

Table 5-13: Target values for ServicePortfolioEnrichment _%Change in each ML

Maturity level	ServicePortfolioEnrichment _%Change target value
ML2	180%
ML3	21%
ML4	6%

5.2.2.4.4 VerticalsInnovation _%Change

We evaluate the innovation introduced by 5G-VINNI in terms of the number of new services/products created by its customers. Currently there are on average 3.5 new services introduced in each facility site. We expect that their number will largely increase in ML2 as most of the vertical use cases will have been completed and new vertical products will be released. In ML3 we expect a smaller increase since the customer base remains the same, but some new products will be released. On the other hand, in ML4 we expect that new products will be released because of the new customers. The target values we have determined for the VerticalsInnovation_%Change KPI are presented in the Table 5-14 below.

Table 5-14: Target values for VerticalsInnovation _%Change in each ML

Maturity level	VerticalsInnovation _%Change target value
ML2	143%
ML3	35%
ML4	57%

5.2.2.5 Entry barriers and Collaboration

5.2.2.5.1 ExperimentationDifficulty_Entry_Barrier_%Change

We express the entry barriers to the 5G-VINNI technology as the number of mandatory VNFs needed per use case. Currently they are 3 on average, and we expect them to decrease as the system matures. This is because as 5G-VINNI matures, the facility sites and the third parties offer wider functionality in terms of VNFs and therefore the customers have to create less VNFs themselves in order to test their use cases in 5G-VINNI. The target values we have determined for the ExperimenationDifficulty_Entry_Barrier_%Change KPI are presented in the Table 5-15 below.

Table 5-15: Target values for ExperimenationDifficulty_Entry_Barrier_%Change in each ML

Maturity level	ExperimenationDifficulty_Entry_Barrier_%Change target value
ML2	-33%
ML3	0%
ML4	-50%

5.2.2.5.2 CollaborationDegree_%Change

We express the degree of collaboration among the various stakeholders as the average number of stakeholders providing VNFs to a single service. Currently there are on average 2 stakeholders

providing VNFs to each service. We expect collaboration to strengthen with time, so we have determined the following (Table 5-16) target values for the CollaborationDegree_%Change KPI.

Table 5-16: Target values for CollaborationDegree_%Change in each ML

Maturity level	CollaborationDegree_%Change target value
ML2	100%
ML3	50%
ML4	33%

The collaboration degree should increase drastically as the functionality of 5G-VINNI is enriched during ML2 due to cross-facility site experiments, and then it should increase further but with a smaller growth ratio.

5.2.2.6 Additional Customer Experience KPIs

5.2.2.6.1 InfoRequestsHandledDuration _%Change

We expect the time needed to handle information requests to decrease as 5G-VINNI matures, as the 5G-VINNI facility becomes more mature and the related processes are automated. The target values for the InfoRequestsHandledDuration _%Change KPI are presented in the Table 5-17 below.

Table 5-17: Target values for InfoRequestsHandledDuration _%Change in each ML

Maturity level	InfoRequestsHandledDuration_%Change target value
ML2	-48%
ML3	-33%
ML4	-50%

5.2.2.6.2 TroubleshootRequestsHandledDuration_%Change

We expect the time needed to handle troubleshooting requests to decrease as 5G-VINNI matures, since the 5G-VINNI facility becomes more mature and troubleshooting is automated through a ticketing system. The target values for the TroubleshootRequestsHandledDuration_%Change KPI are presented in the Table 5-18 below.

Table 5-18: Target values for TroubleshootRequestsHandledDuration_%Change in each ML

Maturity level	TroubleshootRequestsHandledDuration_%Change target value
ML2	-40%
ML3	-50%
ML4	-33%

5.2.2.6.3 PendingInfoRequests_%Change

We expect the percentage of information requests that are being handled in time to increase as 5G-VINNI matures. The target values for the PendingInfoRequests_%Change KPI are presented in the Table 5-19 below.

Table 5-19: Target values for PendingInfoRequests_%Change in each ML

Maturity level	PendingInfoRequests_%Change target value
ML2	15%
ML3	10%
ML4	5%

The number of pending information requests are expected to increase with the number of customers in 5G-VINNI, but the growth rate should be significantly decreasing with time as the system matures.

5.2.2.6.4 PendingTroubleshootRequests_%Change

We expect the percentage of troubleshooting requests that are being handled in time to increase as 5G-VINNI matures. The number of pending troubleshooting requests are expected to increase with the number of customers in 5G-VINNI, but the growth rate should be significantly decreasing with time as the system matures. The target values for the PendingTroubleshootRequests_%Change KPI are presented in the Table 5-20 below.

Table 5-20: Target values for PendingTroubleshootRequests_%Change in each ML

Maturity level	PendingTroubleshootRequests_%Change target value
ML2	20%
ML3	10%
ML4	3%

5.2.3 Target values for Economic KPIs

In this section we will present the target values for the most important Economic KPI, which measures the profitability for each 5G-VINNI facility member.

5.2.3.1 Internal Rate of Return for 5G-VINNI facility member

Table 5-21: Target values for IRR in each ML

Maturity level	$IRR_{i,j}$ target value
ML2	-
ML3	-
ML4	WACC (i.e., 7%)

Given that each ML2 and ML3 last up to one year, IRR cannot be computed. However, the target value for ML4 is the Weighted Average Cost of Capital (WACC), which is the minimum return a commercial entity must earn on its projects. It is calculated by weighing the cost of equity and the cost of debt (i.e., loans) by their relative weights in the capital structure. At the time of writing this report and according to Finbox, a provider of financial data and metrics on publicly traded companies, a reasonable value for the WACC indicator in the telecommunications sector is 7% (see Table 5-22 below).

Table 5-22: Estimated WACC values for selected European telecommunications operators in low and high-risk scenarios (source Finbox[7], accessed on December 8, 2020)

	Telenor ASA (SWX:TEL)		BT Group plc (DB:BTQ)		Telefónica, S.A. (NYSE:TEF)		Telecom Italia S.p.A. (OTCPK: TIAO.F)	
	Risk Scenario		Risk Scenario		Risk Scenario		Risk Scenario	
	Low	High	Low	High	Low	High	Low	High
Cost Estimates								
Cost of Equity	6.30%	10.40%	9.00%	21.10%	8.30%	17.80%	9.00%	17.80%
After-tax Cost of Debt	3.00%	3.70%	3.20%	4.00%	3.00%	3.70%	3.00%	3.70%
Weights								
Equity % of Capital	65.00%	45.00%	45.00%	20.00%	40.00%	20.00%	35.00%	20.00%
Debt % of Capital	35.00%	55.00%	55.00%	80.00%	60.00%	80.00%	65.00%	80.00%

[7] https://finbox.com/

WACC Range	5.20%	6.70%	5.80%	7.40%	5.10%	6.50%	5.10%	6.50%
Selected WACC	**7.00%**		**7.00%**		**7.00%**		**7.00%**	

However, not all projects face the same risk so it would require an upward adjustment if the project in question is riskier than the company's average projects and a downward adjustment in the opposite case. Thus, a slightly adjusted WACC value eventually may be used. Furthermore, it is very likely that the WACC value for other members of those facility sites will differ according to their role and risk profile.

5.2.3.2 Total Revenues for 5G-VINNI facility member

Given the nature of 5G-VINNI project, we expect that the cost of the experiments run during ML2 and ML3 should be subsidized (i.e., assuming that no additional network infrastructure will be required, vertical enterprises that belong to projects under the ICT-19 call or the External Advisory Board should pay only for their share of the 5G-VINNI operational costs).

On the other hand, the revenues of 5G-VINNI members during ML4 should be based on retail prices that will be announced. Table 5-23 summarizes the target values for the revenues of each 5G-VINNI member for ML2, ML3 and ML4.

Table 5-23: Target values for 5G-VINNI member revenues in each ML

Maturity level	$MemberRevenues_{i,j}$ target value
ML2	$\sum_{o=1,\dots,O} OpEx_{i,j}^{o}$
ML3	$\sum_{o=1,\dots,O} OpEx_{i,j}^{o}$
ML4	$(MemberCAPEX_{i,j}$ $+MemberOPEX_{i,j})$*(1+WACC)

6 Enabler mechanisms for the cross-domain operation of Business Layer

5G-VINNI Business Layer aims to facilitate the interaction of 5G-VINNI facility with Vertical Customers by realizing the concept of 'Service Portal' introduced in D3.3 [8], as well as the collaboration among the different facility sites when it comes to the provisioning of services that involves more than one site. Focusing on the latter, as reported in D5.2 [2], how the different facility sites will interact with each other greatly depends on the ecosystem structure and the business agreements between the facility site operators. We consider two main ecosystem structures, namely the *distributed* and the *centralized* one, however, multiple *hybrid* regimes between these two extremes can be also considered.

In the distributed structure, each facility site implements the 5G-VINNI Business Layer providing access to services that are available through its own Service Portal. These services offered by the Service Portal of a facility site may be restricted within this site's domain or can be also extended to other sites as well, depending on each site's policy. Consequently, a vertical customer (CSC-Communication Service Customer) may be able to access different sets of services through the Service Portals of different facility sites. Figure 1-1Figure 6-1, which was initially introduced in D5.2, illustrates how the Business Layer implemented in both facility sites, A and B, should interact with each other (East/West interfaces) in order to provision extended coverage services, i.e., services using resources of both A and B. In other words, vertical customers should be able to access services that involve both facility sites through the Service Portal of one of them, e.g., site A. The implementation of these APIs is out of the scope of this document, however material to their potential implementation can be found in D3.4 [9].

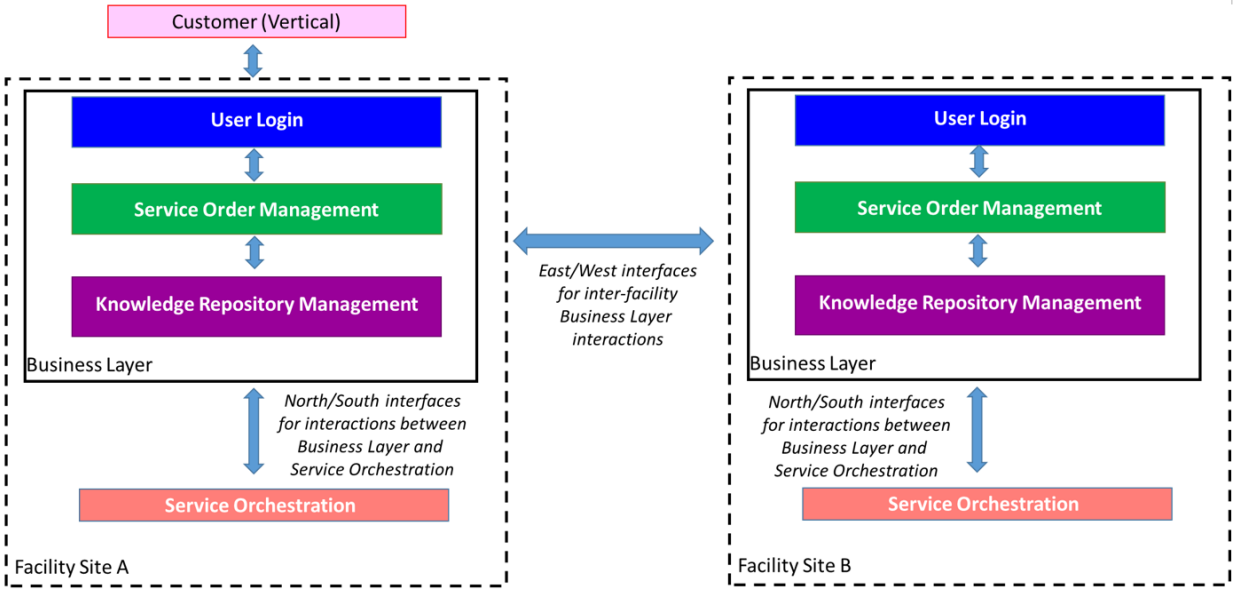


Figure 6-1: Business Layer implementation under a distributed ecosystem structure [2].

On the other hand, in the centralized ecosystem structure, we consider the existence of a central 5G-VINNI Broker entity that hosts a 'Global Service Portal', through which the vertical customers can access services offered by the different sites of the 5G-VINNI facility. The Broker can also aggregate or combine services offered by different facility sites in order to provide extended coverage services. Figure 6-2, shows the Business Layer implementation under a centralized ecosystem structure. Note that there is no need for facility sites to implement the user login set of features, since all customers will go through the VINNI Broker for requesting services. Accordingly, a facility site may implement a subset of knowledge repository management features that are only related to a single facility site,

e.g., performance monitoring, while the global one will be implemented by the Broker. The Broker entity does not own resources; thus, it is not involved in service orchestration. The Broker role can be either adopted by one (or more, jointly) of the facility site operators or a neutral third-party entity.

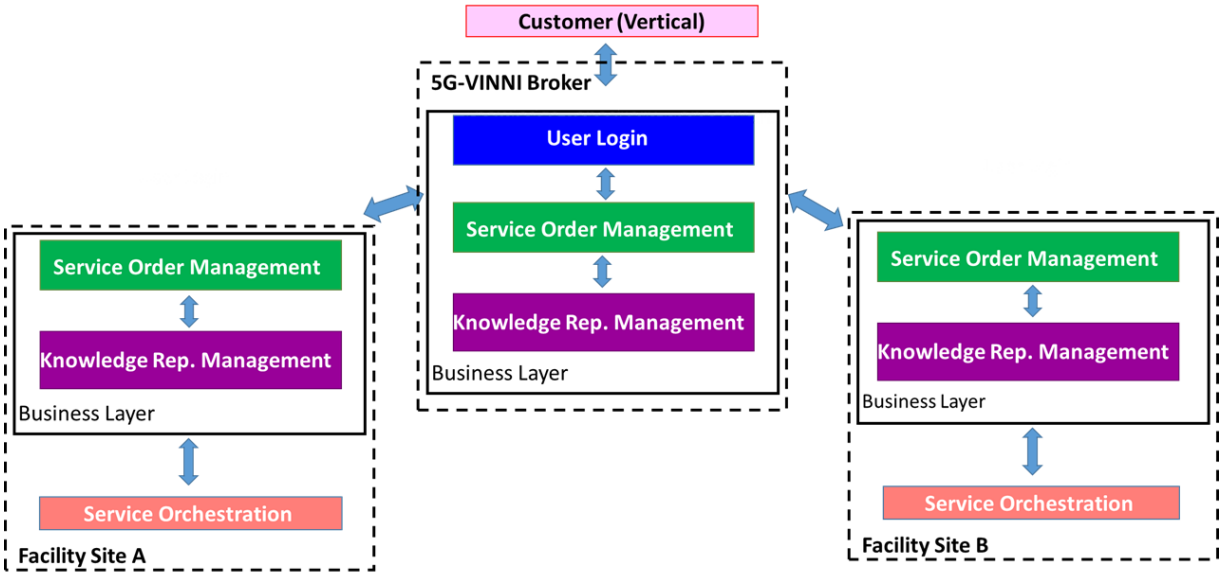


Figure 6-2: Business Layer implementation under centralized ecosystem structure.

Our Focus: In the rest of this section, we introduce a set of enabler mechanisms for the 5G-VINNI Business Layer that extend the identified Business Layer capabilities beyond one facility site. Note that we focus on a subset of capability features, which we consider as the most challenging ones (business-wise) when we need to apply them to a cross-facility site service offering scenario. In particular, we focus on mechanisms that enable two Service Order Management features, namely the Service Catalogue Management and Quote Management. Regarding the former, we propose the establishment of an information-sharing mechanism for enabling the creation of services that can simultaneously involve resources from multiple facility sites. This mechanism is valuable for the distributed ecosystem structure where the knowledge is not aggregated by a single entity such as the central Broker in the centralized structure. Regarding the Quote Management feature, we introduce a set of policies for the composition of quotes towards the vertical customer (CSCs -Communication Service Customers), capturing the different ecosystem structures and their specificities. Note that in this document we present the set of enabler mechanisms and their potential alternatives for achieving the cross-domain operation of 5G-VINNI Business Layer. The evaluation of these mechanisms will be delivered in D5.4 [7] as part of the 5G-VINNI Governance models evaluation.

6.1 Service Catalogue Management - Extended service coverage

To automate the interaction of the VINNI facility with vertical customers, 5G-VINNI has introduced the VINNI Service Blueprints (VINNI-SBs), which builds upon the GSMA Generic Slice Template (GST) [21], as defined in D3.1 [12]. These form service specification/network slice templates for the different network slice types that become available through a Service Catalogue. Each template consists of a set of strict unmodifiable attributes, but it also includes a wide set of attributes whose values can be determined by the CSC by selecting one of the available options for each attribute. The templates are modelled as TMF633 Service Specifications (included in D3.3). In the case of SBs that involve a single facility site, setting values to unmodifiable attributes or determining the set of potential values for the modifiable attributes can be easily determined by the facility site operator who has full knowledge of the service capabilities of its site and fully controls the infrastructure. Interworking of Service Catalogues is vital when it comes to SB bundles/network slice templates that require the involvement of two (or more) facility sites or access to the SBs of a remote facility site.

Such interworking should be achievable under all of the 5G-VINNI ecosystem structures, i.e., centralized and distributed structures. To extend the coverage of existing SBs beyond a single facility or build new SBs that involve multiple facility sites, information from multiple facility operators should be combined.

In the centralized structure, the services offered by the different sites of the 5G-VINNI facility are all made available to the vertical customers through the Global Service Portal that combines/aggregates service offerings/SBs from the Service Catalogues of all facility sites, serving as an One-Stop-Shop. In the distributed structure, each facility site provides access to the services available in its own Service Portal. These services will definitely include SBs coming from this facility's Service Catalogue, but it can also have services that combine SBs from other remote sites/partners depending on agreements. While in a centralized structure the Global Service Portal can gather information from the Service Catalogues of all sites and compose bundle services, this is not straightforward when it comes to distributed structure. In particular, an information-sharing mechanism should be established among the facility sites, in order to enable the establishment of extended (or global) coverage services that will be accessible through every single Service Portal, realizing the One-Stop-Shop concept in a distributed manner. The need for sophisticated information sharing mechanisms becomes clearer if we consider a more mature status of 5G-VINNI facility (i.e., ML4 and beyond), where more facility sites (potentially from new stakeholders) may join the VINNI facility, providing services to the same or new geographic regions.

Next, we define a scalable information-sharing mechanism for the distributed ecosystem structure that: (i) enables the interworking of service catalogues for achieving extended coverage and (ii) gives facility site operators the "freedom" to set their own policies regarding which service capabilities (i.e., VINNI-SBs) are making available to each of the other facility sites.

6.1.1 Information sharing mechanism for distributed structure

Each facility site adopts a mechanism for exchanging information related to its service capabilities and costs. This information is exchanged in the form of paths that involve multiple facilities, on top of which network slice services can be provisioned for reaching remote geographic regions. As an *augmentation* of the Service Catalogue, each facility site maintains an additional private (i.e., not exposed to CSC) table of facility site paths, i.e., ***table of preferable paths***, whose entries determine which path of interconnected facility sites is preferable for reaching a remote geographic region from the current site. The length of paths, in terms of the number of facility sites involved, depends on the topology of interconnected facility sites and the criteria based on which a path is selected as "preferable". For instance, in the case of a full mesh topology, if the path criterion selection is the shortest path in terms of number of hops, then each facility site will be able to reach a remote destination at a single hop. However, if the criterion for path selection is not the number of hops, but for instance the lowest cost or Quality of Service (QoS), then alternative (possibly longer) paths may be selected.

Geographic region. In this document, we define "geographic region" at a national level, e.g., Spain, Greece, Norway, UK, etc. However, the model can also capture larger or smaller regions than a country region. Each facility site appears in one geographic region, while each geographic region may host multiple facility sites. We expect that the latter will be the case when considering the 5G-VINNI long-term vision, i.e., ML4 and beyond.

Network slice type. Given that a single path may not be the most suitable option for hosting different types of network slices (i.e., eMBB, uRLLC, etc.), each facility site should maintain multiple paths that lead to a certain geographic region, each of them satisfying different QoS requirements, i.e., different values for attributes including but not limited to the following:

- network slice service type
- end-to-end latency

- throughput
- number of supported devices

The basic SBs/ network slice types considered by 5G-VINNI facility sites are the eMBB, uRLLC and mMTC. Also, 5G-VINNI gives CSC the option to request and customize network slice combining characteristics from more than one of the above categories. In this study we do not consider the standard mMTC network slice type since the formation of end-to-end paths is not critical.

Quality classes. In order to reduce the amount of information (i.e., number of paths) that needs to be exchanged among the different facility sites for defining a SB/network slice templates that involve multiple sites, we consider several *quality classes* per network slice type that sets different values on the attributes of the VINNI-SBs. Each quality class provides different guarantees (actual target values) with respect to throughput, latency, etc., having also a different *cost*. Thus, the **number of entries** maintained in each facility site's table of preferable paths for a given destination geographic region, is also affected by the number of quality classes considered. For instance, considering an example with two quality classes (Standard and Premium) per each basic network slice type, the following path table entries could be considered for a given destination geographic region:

- Standard uRLLC: E2E latency <= 10ms, Throughput >= 1Gbps
- Premium uRLLC: E2E latency <= 5ms, Throughput >= 3Gbps
- Standard eMBB: E2E latency <=15ms, Throughput >= 10Gbps
- Premium eMBB: E2E latency <=10ms, Throughput >= 20Gbps

Note: Depending on the facility operators' policy, the number of paths an operator maintains for each destination geographic region, may be more than one for the same service type and quality class (e.g., for redundancy). The same applies to the number of paths per destination that an operator is sharing with its neighbours. However, this can be also limited by the information-sharing mechanism implementation or agreements among the facility site operators.

Update and Publish procedures. The proposed mechanism consists of two procedures, i.e., the *update* and *publish* procedures. The update procedure is initiated after receiving path information from neighbours that indicates a "better" path that reaches a certain remote geographic region, for deploying a network slice of a certain type and quality class. In this case, the respective entry on the facility site's table is updated. The update and publish procedures are dynamic in order to capture the network utilization changes, caused by the market demand. The criterion for selecting which path to maintain as "better" for a given destination region can be the *lowest cost* or another strategic selection that depends on each facility site's policy. The publish procedure can take place either periodically or after an update event, in an asynchronous manner. During the publish procedure, the facility that modified one or more entries pushes the updated information maintained in the table of preferable paths to its neighbours. Each entry of the table includes values for the following parameters:

- *Source geographic region.*
- *Destination geographic region.*
- *End-to-end path*. This is a vector that denotes the sequence of interconnected facility sites from source to destination geographic region.
- *Latency.* This is the value of the guaranteed end-to-end latency for source to destination facility sites.
- *Throughput.* This is the value of the guaranteed throughput for all the elements of the network slice.
- *Cost.* This is the expected total cost for establishing a certain type of network slice at a desired quality class along the path. (*Note that using price instead of cost makes also sense in case of a low level of trust among the facility sites.*)

A snapshot of a facility site's table of preferable paths for a given destination region is presented in Table 6-1 below, where different paths are selected for each combination of network slice type and quality class. Recall that the table of preferable paths is not exposed to the CSCs, but it resides with the Service Catalogue and provides guidance to facility sites when deploying an SB that involve multiple/remote facility sites. In other words, each facility site operator can take advantage of the entries table of preferable paths, in order to create new SBs (of extended coverage) and place them into his own Service Catalogue. Note that unlike all other attributes in the table, the "devices/km^2" attribute is not an end-to-end one, but it is related to a certain destination location.

Table 6-1: Facility site's table of preferable paths for destination Region L2

Attributes	Standard uRLLC	Premium uRLLC	Standard eMBB	Premium eMBB
Source region	L1	L1	L1	L1
Destination region	L2	L2	L2	L2
End-to-end path	{i, …, j}	{i, …, k}	{i, …, m}	{i, …, j}
E2E latency	9ms	4ms	14ms	9ms
Throughput	2Gbps	1Gbps	10Gbps	20Gbps
Cost	20€ /h	30€/h	15€/h	25€/h

The efficiency of the proposed mechanism, in terms of satisfied network slice service requests, against the (full information) centralized ecosystem structure will be evaluated in D5.4 [7].

6.1.2 Illustrative Example of the proposed information-sharing mechanism

We consider the topology scenario presented in Figure 6-3, which involves eight interconnected facility sites dispersed in four geographic regions $\{UK, NO, SP, GR\}$. Each facility site is represented by a single graph node, since we assume each facility share abstract information about its service capabilities, without disclosing its actual internal topology. In this scenario, we assume that each facility site maintains a single preferable path per destination region for a certain network slice type and quality class. Note that these paths are abstract ones and differ from the network level paths. In fact, such an abstract path may involve multiple physical network routes. Focusing on this scenario, we are going to illustrate the different steps of the proposed mechanism focusing on facility site i which aims to create a SB for an eMBB network slice of Premium quality that will reach remote destination GR.

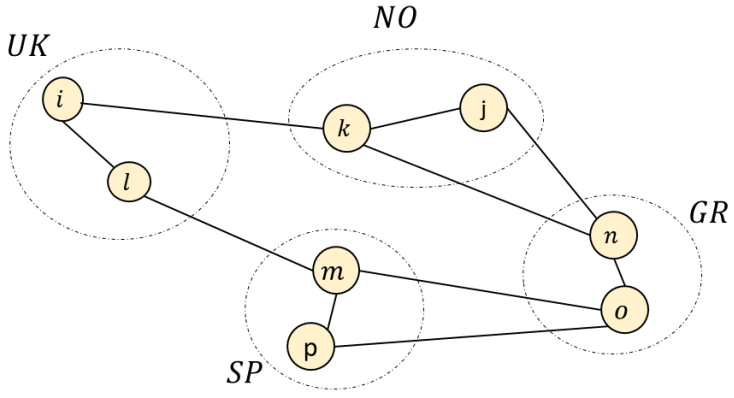


Figure 6-3: Topology of interconnected facility sites as an undirected graph. Each node (e.g., i) represent a facility site while edges represent direct interconnection between pairs of facility sites. Geographic locations are identified by dashed shapes, e.g., facility sites i and l are located to geographic region UK

We assume that at a given time t, depicted in Figure 6-4, facility site i maintains path $\{i, k, n\}$ as the preferable path for establishing a Premium quality eMBB network slice since it satisfies the lowest-cost path that can support the required QoS, i.e., Throughput >= 20Gbps and E2E latency <=10ms.

Note that while path $\{i, l, m, o\}$ has a lower cost is not feasible since the throughput that can be achieved is limited by the interconnection link $\{m, o\}$, where the guaranteed throughput is 5Gbps which is lower than the one required for a Premium quality eMBB network slice, i.e., 20Gbps.

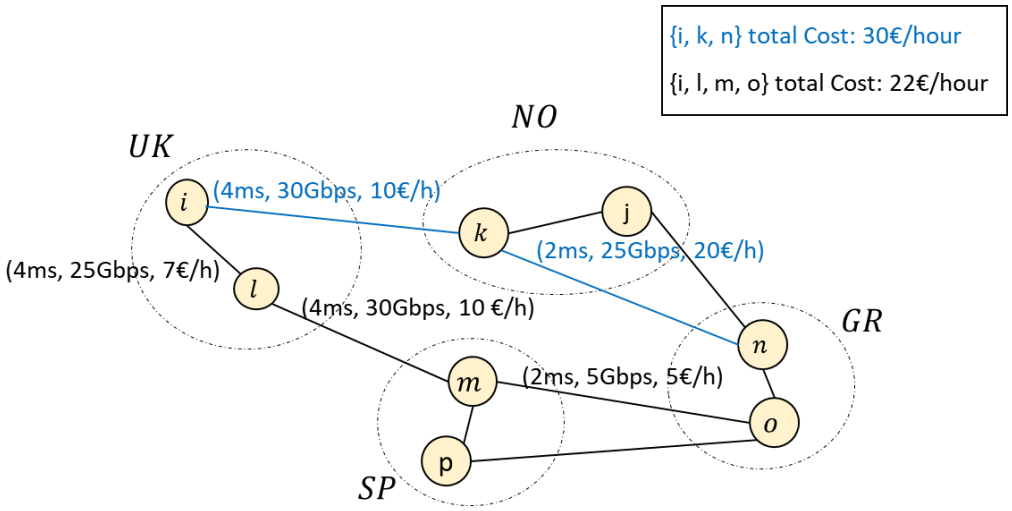


Figure 6-4: Paths from facility site i that can reach geographic region GR in a Premium eMBB quality. Snapshot of the system at time $t1$. While path $\{i, l, m, o\}$ is more cost-effective, it is not a feasible path since the required throughput cannot be achieved.

We assume that at moment $t2 > t1$ (Figure 6-5), more resources become available on link $\{m, o\}$ and thus the achievable throughput over it increases to 25Gbps, i.e., becomes higher than the required threshold, thus path $\{i, l, m, o\}$ becomes feasible. Note that the cost of the path increases as well, but remains most cost-effective than path $\{i, k, n\}$ and therefore will be selected as the new preferable path for reaching geographic region GR at premium eMBB quality.

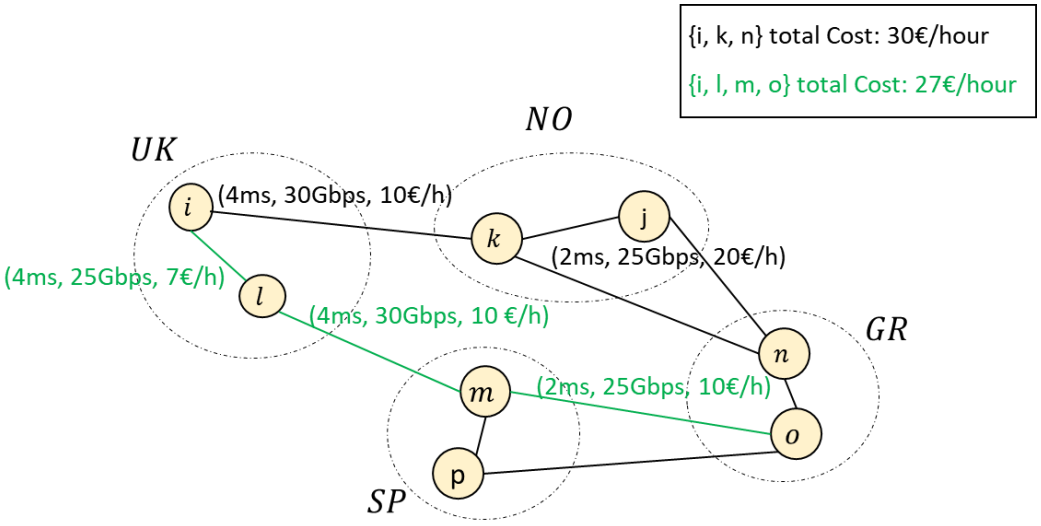


Figure 6-5: Snapshot of the system at time t2 > t1.

Note that it will take several *update* and *publish* procedures, along the path $\{i, l, m, o\}$, in order to eventually reach a state where the facility site is informed about the changes on the path. In particular, the following events occur, one after the other, when the achievable throughput on link $\{m, o\}$ changes:

1. First, facility site o will publish to facility site m, that can reach region GR through o at Premium eMBB quality and with a cost of 10€/h.
2. Then, gathering the information from facility site o, facility site m will evaluate that path $\{m, o\}$ has become feasible for establishing Premium eMBB network slices that reach region

GR. Considering that this is the most cost-effective option, it will update his table of paths and will then publish path $\{m, o\}$ to his neighbours, including l.

3. Accordingly, facility site l will update his table of paths with $\{l, m, o\}$ as the preferable one for reaching region GR at Premium eMBB quality through l, and will publish this update to its neighbours, including i.
4. Finally, facility site i will now evaluate that path $\{i, l, m, o\}$ is a new feasible option for Premium eMBB towards region GR, which is more cost-effective than the existing entry $\{i, k, n\}$. Thus, the table of i's preferable paths will be updated accordingly.

Strategic behaviour considerations (Coopetition). Note that the proposed mechanism can allow the strategic behaviour of facility site operators, i.e., allow them to act strategically in path selection. For instance, assuming that i and l are competitors, they may need to collaborate with each other in some cases, because of lack of alternative paths. However, i may avoid using paths or placing service offerings/ SBs that include facility site l when possible. Considering the above example, it is quite possible that facility site i would choose a higher-cost path such as $\{i, k, n\}$ over $\{i, l, m, o\}$.

6.2 Quote Management in multi-facility service offerings

In this section, we study the management of quotes towards the vertical customers (CSCs), when multiple facility sites are involved. There are several alternatives on how to compute a quote or how to share quoted prices among the facility sites participating in the service offering. Which alternative is appropriate for applying it to a specific case, depends on the ecosystem structure and agreements among the facility sites that participate in service provisioning. Next, we discuss quote management under centralized and distributed ecosystem structures, by considering again the topology of Figure 6-3.

In particular, we are going to illustrate all alternatives in the scenario where facility sites i, l, m, o are contributing to an end-to-end network slice that interconnects geographic regions UK and GR (passing through SP). Figure 6-6 shows how the different components of the service graph, i.e., VNFs, PNFs, etc. of the network slice, are deployed along the facility sites' path $\{i, l, m, o\}$. Each facility site contributes to a different subset of service components in the form of sub-slices that eventually constitutes the end-to-end network slice. Note that a facility site may host a different number of service components or more/less resource-demanding components than others. For instance, facility site i should contribute both cloud and network resources in order to enable service components 1 and 2 as well as their interconnection, while l only provides interconnection between 2 and 3. Consequently, quote management should take into account the contribution level of each facility site when computing a quote, since some facility sites may exhibit higher cost than others and should be compensated accordingly.

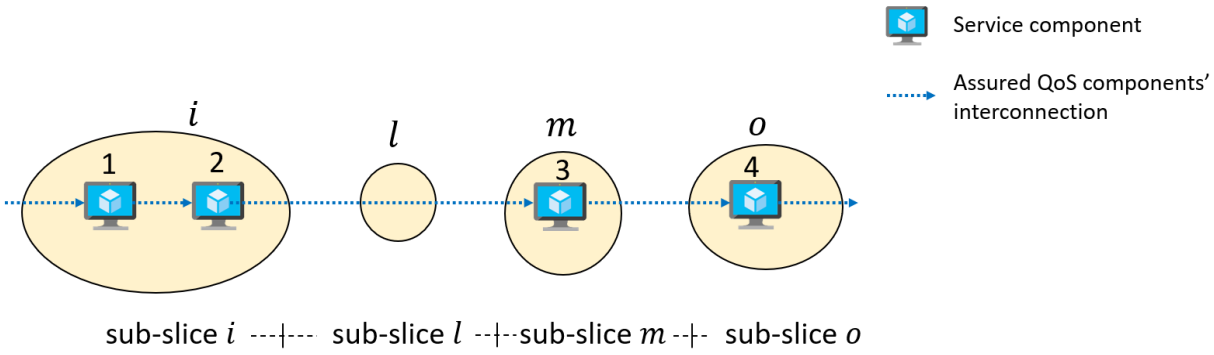


Figure 6-6: Sub-slices offered by facility sites i, l, m, o, each of them enabling a different subset of service components or interconnection between pairs of them.

6.2.1 Distributed structure

In the distributed structure, vertical customers access services through the Service Portal of each facility site. For the service request of our scenario, i is the "customer-facing" facility site. This means that the vertical customer interacts with i's Service Portal and facility site i is responsible to return a quote after coordination with other facility sites along the path$\{i, l, m, o\}$. In particular, each site should calculate a price for the sub-slice it contributes to the end-to-end slice and shares it with facility site i. This price can be computed based on the cost generated by the service components each facility site hosts or it can even be strategic. There are several cost-based pricing schemes in literature [13] that could be applied by a facility site in order to compute a price for each sub-slice it contributes. For instance, facility sites could potentially adopt a pricing policy that charges twice the cost of offering the respective sub-slice. Cost-based pricing schemes as well as the impact of strategic pricing is out of the scope of this document and will be investigated in D5.4. In this document, we only investigate how the computed prices are utilized by the customer-facing facility site, in order to return a quote to the vertical customer.

Figure 6-7 and Figure 6-8 show two alternative flows of quote information for a distributed ecosystem structure. In particular, Figure 6-7 illustrates the alternative where the customer-facing facility site i gathers a sub-quote for each facility site in the path and uses this information in order to produce the final quote, towards the vertical customer. The final quote p_{tot} is produced by a bundling of all sub-quotes including that of i, and it is computed by $p_{tot} = p_i + p_l + p_m + p_o$. In this case, facility sites l, m, o generate a sub-quote for the part of the service each of them is going to fulfil, however none of them is aware of the sub-quotes of others. Lack of such information will lead to more "truthful" sub-quotes, avoiding competitive behaviour that would possibly lead to high quoted prices - not acceptable by the customer.

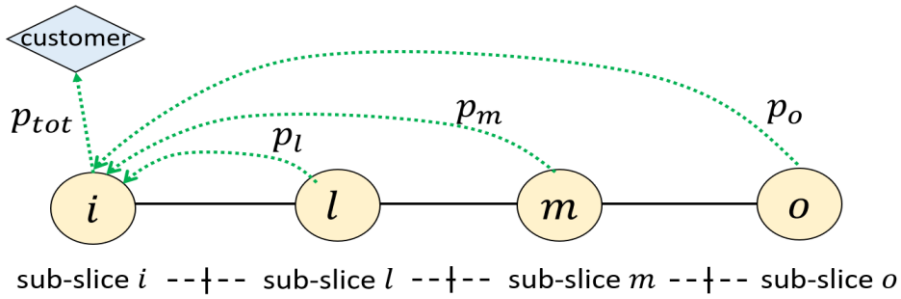


Figure 6-7: Flow of sub-quotes in the alternative where the customer-facing facility i interacts with each facility site in the path, including those that are not directly connected to i.

On the other hand, in the alternative presented in Figure 6-8, we assume that each facility site exchanges sub-quote information only with its *direct* neighbours. Hence, the final quote is computed in a cascading manner. Specifically, after receiving a sub-quote p_o from site o, site m produces a bundle sub-quote $p'_m = p_o + p_m$, where p_m is the price set for its own sub-slice. Then, when the bundled sub-quoted is p'_m is forwarded to site l, l does not have the information how p'_m will be shared among sites m and o. Consequently, when customer facing facility site i receives the bundled sub-quote p'_l, is not aware of how this is shared among the rest of the path. Contrary to the previous scenario, where the source facility i has the competitive advantage of full knowledge, in this scenario the information is hidden at each hop of the path.

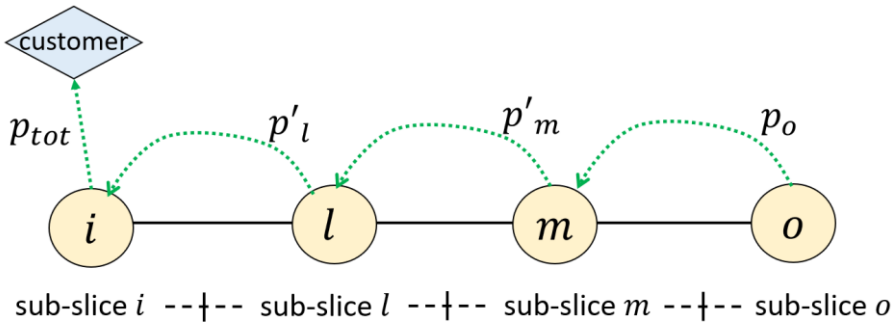


Figure 6-8: Flow of sub-quotes in the cascading alternative. Customer-facing facility site i is not aware of the in between bundling steps.

Discussion: When the facility sites fully cooperate and all follow a commonly agreed pricing strategy (e.g., common cost-based formula), both alternatives will lead to the same final quoted price as well as to the same distribution of it along the path. On the other hand, in a case where all facility sites act in a coopetitive (cooperative + competitive) manner, the customer-facing site has a competitive advantage against other sites. In particular, in the alternative presented in Figure 6-7, facility site i is the one that has full knowledge, i.e., it is aware of both the customer's willingness to pay and the other facility site's sub-slices along the path. Assuming that facility site i has the ability to negotiate with others for the sub-quotes, i is able to push sub-quotes to lower possible values and obtain a higher revenue share than other sites. In the cascading alternative of Figure 6-8, the competitive advantage of site i diminishes a bit since the knowledge for the sub-quotes' bundling is not available to the customer-facing sites. However, in this alternative, facility sites l and m do not have knowledge for the customers willingness to pay, thus if all sites along the path adopt an aggressive strategy trying to increase their revenues, the final quote can be quite high and eventually rejected by the customer.

6.2.2 Centralized structure

Contrary to the distributed structure which can be applicable from the early MLs of 5G-VINNI, the centralized structure is more forward looking and require the establishment of a central entity that will operate under commonly agreed policies. Therefore, the centralized structure is more forward-looking, i.e., ML4 and beyond.

In the centralized structure, the vertical customers access services through the Global Service Portal maintained by the central Broker entity. Therefore, the Broker determines which facility sites will contribute certain service components (sub-slices) for fulfilling the request and is also responsible for coordinating with all facility sites and generating the final quote for the customer. Again, we foresee that two alternatives are applicable in the centralized ecosystem structure.

In the alternative presented in Figure 6-9, after the Broker decides to utilize path $\{i, l, m, o\}$ for serving a certain request, all the involved facility sites respond with their sub-quotes towards the Broker. The Broker bundles all these sub-quotes and produces a final quote that is pushed to the vertical customer. Note that this quote can also include a remuneration for Broker p_{br}, i.e., $p_{tot} = p_i + p_l + p_m + p_o + p_{br}$. We assume that the interconnection/transit cost is quoted by the site that receives the traffic, i.e., considering that o is the destination site of traffic p_l, p_m and p_o will quote for the interconnection costs along the path.

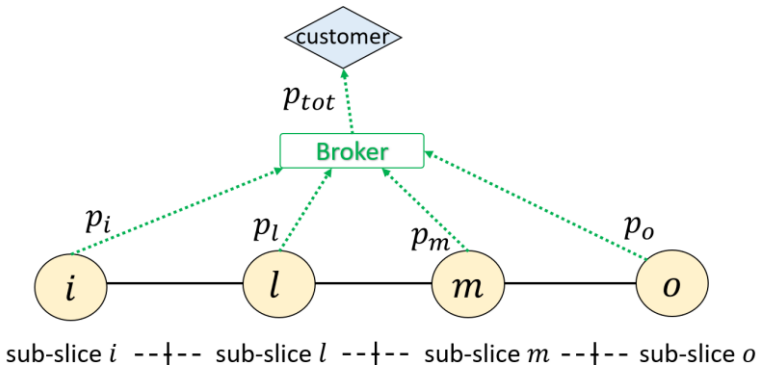


Figure 6-9: Flow of sub-quote information in a centralized ecosystem in the bottom-up alternative.

Contrary to the bottom-up approach presented above, in the top-down alternative presented in Figure 6-10, the facility sites do not push sub-quotes. Instead, we assume that the Broker is aware of the cost that each sub-slice may have, and after computing a final quote p_{tot} based on certain policies, the Broker determines how this quote will be shared among the facility sites along the path. Revenue sharing policies that could be potentially adopted by the Broker entity are described in section 6.2.2.1 below.

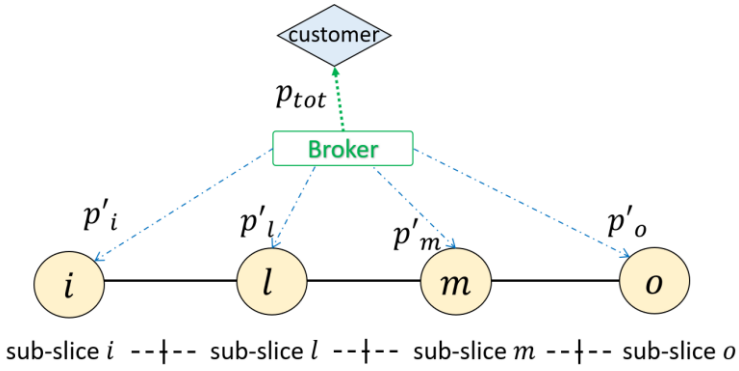


Figure 6-10: Flow of sub-quote information in a centralized ecosystem in the top-down alternative.

The top-down alternative is mostly suitable for highly collaborative and high trust centralised ecosystems, where the facility sites reveal cost figures and infrastructure utilization information to the central Broker entity. On the other hand, the bottom-up approach can also support centralized ecosystems where the information that facility sites share with the Broker can be limited to available service components or sub-slices and a price for using them.

6.2.2.1 Revenue sharing policies

In this section, we consider how revenues are shared between facility sites in the top-down centralized approach outlined in the previous section. Given a payment p_{tot}agreed between the Broker and the customer how should it be distributed among the facility sites contributing resources? From the point of view of economic theory, this is a problem of fair division of a fixed value and may lead to multiple answers depending on which definition of fairness is adopted. We describe two approaches which both arise naturally.

In the first approach, the payment p_{tot} is apportioned in such a manner that the profit (i.e., revenue share minus operating cost for resource provision) of each facility site is equal. If the end-to-end service is offered by n facility sites and c_i is the cost of the resources provided by the i-th facility site, for $i = 1, \dots, n$, then $p_i - c_i = p_j - c_j$, where p_i is the (gross) revenue of the i-th site (so $\sum_i p_i = p_{tot}$). This is an egalitarian way of sharing revenues between facility sites and coincides with the Nash bargaining solution [14]. That is the outcome, a set of n parties, is predicted to reach under a natural set of axioms.

- To illustrate this, consider the four facility sites depicted in Figure 6-10 with $c_i = 4, c_l = 1, c_m = 3, c_o = 2$. If the customer agrees a payment of$p_{tot} = 20$ with the Broker entity then this is apportioned according to$p_i = 6.5, p_l = 3.5, p_m = 5.5, p_o = 4.5$, so the profit of each facility is the same and equal to 2.5.

On the other hand, one might expect that a facility site that provides more resources (and hence has higherc_i) than others should make a higher profit. Note that the Nash bargaining solution $p_1, \dots, p_n$can be also characterized as the solution which maximizes $\sum_i \log(p_i - c_i)$ over all possible divisions of p_{tot}. One way to increase the revenue share of facilities facing higher operating costs is to divide revenues according to the solution which maximizes $\sum_i c_i \log(p_i - c_i)$. Here, the cost weights produce a bias favoring the facility sites which face higher costs. In fact, it can be easily shown that the maximizing solution satisfies $\frac{p_i - c_i}{c_i} = \frac{p_j - c_j}{c_j}$for all i, j, i.e., the profit *to cost ratio* is the same for all facility sites. It is interesting to note that this approach can be again seen as a Nash bargaining solution but now among $\sum_i c_i$ parties, with the i-th facility site represented by c_i such parties.

- In terms of the numerical example given above, the same payment of $p_{tot} = 20$ is divided now as $p_i = 8,\ p_l = 2,\ p_m = 6, p_o = 4$ so the profit to cost ratio is equal to 1 for all sites. The corresponding profits are $p_i - c_i = 4, p_l - c_l = 1, p_m - c_m = 3, p_o - c_o = 2,$ where facility sites with higher costs make a higher profit.

To sum up, in the top-down centralized approach, the facility sites need to inform the Broker of the operating costs for each type of resource they offer in order for the latter to divide the revenues accordingly. In the second approach above, the profit received by a facility site increases with c_i if everything else is held fixed. The strategic behaviour of both facility sites under both revenue sharing solutions will be further investigated in D5.4 [7]. Also, note that the revenue sharing policies presented above tackles the problem of revenue sharing options when considering a single network slice, however in a more realistic setup multiple network slices will be offered by the facility sites, possibly sharing some of the incurred costs. In that case, more advanced policies should be considered, that take into account the total demand as well as the possible alternatives for serving a request. Such policies will be proposed and evaluated in D5.4 [7].

7 Conclusions and recommendations

5G is transforming the relationship among different industrial actors and especially between MNOs/CSPs and vertical sectors. New opportunities are expected for all of them but it is crucial to re-think network services from a different perspective where the vertical sectors and their needs/expectations became the focal points. BSS/OSS needs to be evolved for replying to these new needs in terms of openness, scalability, flexibility and agility for supporting the diffusion of new 5G business models. Vertical industry's needs, pains and expectations are the main starting points for the identification of their requirements and re-designing the current BSS/OSS. This document has presented a systematic design thinking approach embracing customer stakeholders, for redefining and prioritizing business layer requirements and the associated capabilities leading to the design of a conceptual system for supporting business relationships and interaction in a 5G services experimentation context.

In particular, we reached out to potential 5G-VINNI Business Layer users (the vertical companies that will access the 5G-VINNI infrastructure to perform experiments and test their vertical services and applications in a 5G environment and the users who have to manage 5G-VINNI facility sites) through a questionnaire, where they validated the proposed identified requirements, and provided their priority and further suggestions for missing requirements. The MoSCoW method was used for setting up a questionnaire and consolidating the business layer users' requirements. On the other hand, the Business Layer capabilities have been reviewed and mapped with the user's requirements; the set of characteristics for each requirement, such as the difficulty for delivering the related features and how relevant is to release them early or late, has been analysed for better addressing the Business Layer capabilities delivery in the different maturity levels. Our main conclusions are:

1. Even if all the 21 identified requirements are relevant, the involvement of the potential users both external and internal to the 5G-VINNI platform through the questionnaire has driven us to prioritise in a user-centric way the requirements, understanding that the crucial requirements for users are a short list of them, with small differences between external and internal users and helping us in delivering the best and most immediate business benefits early.
2. The Business Layer has been designed taking into account the user business requirements. Specific capabilities, for the Business Layer, have been considered in order to satisfy one or more user requirements. Anyhow, requirements and capabilities have been also analysed in terms of technical, operational and economic constraints (Recommended Delivery Period (RDP)) for understanding the difficulty of delivering them.
3. 5G-VINNI Business Layer capability features will be rolled-out gradually according to the defined maturity levels (ML2, ML3 and ML4) of the 5G-VINNI facility, aiming to satisfy internal and external user requirements but also internal technical constraints. The design of the 5G-VINNI Business Layer for each maturity level takes into account the prioritization results of the Multi-Criteria Decision Analysis (MCDA) which enable us to prioritize Business Layer requirements putting together the preferences of users captured through the MoSCoW method and the results of the Recommended Delivery Period (RDP) analysis.
4. Considering that 5G systems involve business interactions as well as economic transactions, their evaluation should be based on business and economic KPIs. In this document, a list of Business and Economic KPIs have been analysed and consolidated for the 5G-VINNI platform. Business KPIs focus on evaluating the business success of the 5G-VINNI platform, through the quantification of the impact that the 5G-VINNI platform has on the vertical customers and complementors, as well as the efficiency of developed Business Layer capabilities, though the assessment of users' experience. On the other hand, economic KPIs focus on evaluating the cost efficiency of the 5G-VINNI platform and its potential for value creation.

Some recommendations based on the performed activities and reported in this document, are listed in the following:

1. *Driving 5G-business layer design by user needs and requirements engaging all the 5G ecosystem potential stakeholders as a first point.*

The 5G ecosystem involves multiple stakeholders that all come together and form a platform ecosystem by complementing CSP offerings towards Vertical Customers. Therefore, the potential users of a 5G Business Layer can be members of different types of organizations that hold different user roles with very varied requirements. This document provides a list of reviewed requirements by part of potential 5G Business Layer users, that even if it may not be considered as complete, it is a solid starting point for all communication and service providers for designing and deploying a business layer supporting system for their customers.

2. *Addressing 5G-Business Layer capabilities delivering, prioritizing needs and requirements and analysing internal constraints.*

5G Business Layer implementation can require a large effort and commitment in order to satisfy potential user needs. Prioritizing user needs and understanding internal constraints is a reasonable approach for facing this challenge following a phased roll-out of needed capability features taking into account vertical's needs and operational/economic constraints. This document provides a set of methodologies for prioritizing the implementation of Business Layer features using a multi-criteria decision analysis. Based on the outcome of the analysis, a phased rollout of Business Layer features was proposed, aiming to address the user requirements at each ML. This analysis, can be a solid tool for CSPs that aim to design and deploy a 5G business supporting system for their customers.

3. *Identifying the more appropriate business and economic KPIs for assuring the 5G platform business and economic success*

KPIs are becoming more and more relevant for measuring inside companies. Organizations use KPIs to evaluate their success at reaching targets. This document provides a set of business and economic KPIs to assess the success of the 5G-VINNI Business Layer as well as its cost efficiency and ability to create value. This is a solid starting point for all communication and service providers that need to evaluate success and efficiency of a business layer supporting system.

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Annex A Business Layer requirements questionnaires

A.1 Questionnaire for internal users

The main interest of this survey is to refine the 5G-VINNI business layers requirements identified in the first phase of the project in the WP5 activities. It aims to understand the relevance of the identified requirements for the different potential users of the 5G-VINNI platform business layer. The Business Layer is meant as the higher layer of the system for assuring potential users' interaction with the 5G-VINNI "operational" platform.

For validating those requirements, you will find (after the first section on collecting a few personal information), a section for each identified requirement and one or more question/s related to it. On the top of each section, you will find the "name of the requirement" and "its brief description" then the question/s to answer.

The time needed is about 20 minutes considering that most of the questions are at multiple choices. Please consider that the answers are saved only at the end of the process after to SEND it, and if you will miss the connection, it is needed to start the questionnaire again.

For more details, please contact Giusi Caruso - giuseppa.caruso@eng.it.

Few Information about YOU

Few information about you can support us to identify possible correlations between job/organisation needs and answers to the next sections related to 5G-Business Layer requirements

1. **Your email (not mandatory but useful)**

2. **Company/organisation name (not mandatory)**

3. **Sector of your Company/organisation**
   - Telecom
   - IT (software production/supply)
   - IT (Hardware production/supply)
   - Academia/Research
   - IT (service provider)
   - Other

4. **What is your role in your company/organisation?**
   - My role can be considered as a DevOps (Development and Operations) expert (or something similar)
   - My role can be considered as a Services Manager (or something similar)
   - My role can be considered as a Network Specialist (or something similar)
   - My role can be considered as a Solution Designer (or something similar)
   - My role can be considered as a Test specialist (or something similar)
   - My role can be considered as an Account Manager (or something similar)
   - Other

Requirement 1 - Global Service Catalogue

Description: A service catalogue should include all the 5G-VINNI facility offerings that are available and accessible to vertical customers (e.g., enterprises). These offerings can originate from many facility sites in 5G-VINNI that may also involve services from 3rd-party providers that complement the 5G-VINNI platform.

5. **According to your view on the above-described requirement 1, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 2 -Secure universal login

Description: A unique customer access to the platform should be available to allow users' account creation and login. This access authorises each member to have a personalized view of past transactions and monitoring of pending items.

6. **According to your view on the above-described requirement 2, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 3 - Global coverage

Description: A service should not be restricted to the subscribers and resources of a single communications service provider/network operator.

7. **According to your view on the above-described requirement 3, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)

- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 4 - Flexible cost/revenue sharing agreements

Description: Billing systems should support a wide range of revenue sharing and cost splitting agreements.

8. **According to your view on the above-described requirement 4, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 5 - Homogeneous service E2E

Description: Vertical organisations should obtain consistent experience, even in the case of federated/collaborative service provisioning. Thus, operators participating in service delivery should have a common view of the attributes to be met.

9. **According to your view on the above-described requirement 5, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 6 - Automated replicability

Description: A product/service/experiment should be automatically replicated in other regions or instantiated over time, in order to reduce complexity and time to market.

10. **According your view on the above-described requirement 6, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 7 - Open to external suppliers

Description: A service catalogue should include capabilities and other services (e.g., VNFs) by other external suppliers both facility sites and the so called complementors (that is firms that want to use the 5G-VINNI platform for providing vertical services). “Then, third-party developers and professionals can make their services available to 5G-VINNI Platform customers rather than offer only a limited set of in- house solutions”.

11. **According to your view on the above-described requirement 7, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 8 - Pick and choose

Description: Capabilities and services should be available so that vertical customers and aggregators/brokers can compose new chained services to cater to their needs and business models.

12. **According to your view on the above-described requirement 7, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).

- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 9 - Experiment

Description: Capabilities and services should be available so that customers can experiment and consider if it meets their requirements.

13. **According to your view on the above-described requirement 9, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 10 - Community

Description: Exchange of knowledge, such as results and best practices obtained from previous experiments, troubleshooting, etc. could be useful for new potential customers, who have limited experience with 5G on boarding processes.

14. **According to your view on the above-described requirement 10, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 11-Real-time performance monitoring

Description: A resources and capabilities monitoring mechanism should be in place, allowing experimenters to track the status and performance of the experiment in real time.

15. **According to your view on the above-described requirement 11, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 12 - Reporting

Description: At the end of the experimentation and for each experiment and single test inside it, a detailed report should be available of the results and used resources and capabilities. These reports can support vertical organisations to make better decisions for the replication in the real world and to understand if they are meeting the required needs.

16. **According to your view on the above-described requirement 12, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 13 - Open documentation

Description: The experiment results and other reports can be made available and shared with registered and unregistered users. The experiment results should be open to all or at least to all registered users according to the experiment owners' preferences.

17. **According to your view on the above-described requirement 13, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 14 - Feedback mechanism

Description: Customer feedback on the experience perceived and trouble-shooting tickets can support facility owners to improve their offers and other users to have justifiable levels of trust to the system. Ability to communicate/interact with the customer, in the system.

18. **According to your view on the above-described requirement 14, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 15-Flexible way of SLA definition and billing

Description: Customers should be able to define SLA terms (e.g.: setting latency and/or bandwidth range according their needs) and get a quote.

19. **According to your view on the above-described requirement 15, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 16 - Slice Control

Description: In some cases the customer (vertical or complementor) could need to manage and control dynamically parameters for the service instantiation (for instance the location to instantiate a specific VNF, modify the latency and bandwidth at run time, etc.). Slice Control could provide to vertical customer the slice or service instantiation control.

20. **According to your view on the above-described requirement 16, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)

- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 17 - Assisted customer access

Description: Users should be assisted when interacting with a facility site during each phase of experiment or service life cycle by receiving notifications when certain events take place. Customers should easily monitor order status (including faults).

21. **According to your view on the above-described requirement 17, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 18 - License management

Description: Experimenters that want to on-board VNFs from third parties should be able to supply license details or where these can be retrieved from.

22. **According to your view on the above-described requirement 18, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 19-Experiment scheduling and setup

Description: Customers should be able to define when an experiment will take place and see an overview of other planned experiments - Customers should have the possibility to define and set the parameters for the service experimentation.

23. **According to your view on the above-described requirement 19, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 20 - User device access control

Description: Customers may want to restrict the set of participants in the experiments.

24. **According to your view on the above-described requirement 20, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).
- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Requirement 21- Platform documentation/handbook/ tutorial

Description: Specific 5G-VINNI Platform documentations like video, handbooks, tutorial on how to use it, can facilitate its utilization.

25. **According to your view on the above-described requirement 21, as facility manager/owners or other involved stakeholder in the 5GVINNI platform supply, what is the priority for this requirement?**

- Must have (it is critical for the 5G-VINNI platform success and implementation)
- Should have (it is important because it provides innovative features but not fundamental for the 5G-VINNI platform success)
- Could have (it is desirable because could improve the user experience or customer satisfaction for a little implementation cost, but not necessary for the 5G-VINNI platform success).

- Won't have, (it is considered as no-critical or not appropriate at that time for the 5G-VINNI platform success)
- I don't Know

Conclusion

26. Do you think there are any 5G-VINNI business layer requirements not considered yet?
- **Yes**
- **No**
- **Maybe**

27. Please list here the requirements still missing in your opinion

A.2 Questionnaire for external users

The 5G-VINNI Business Layer is meant to be a kind of 5G-era business support system that lays on top of 5G-VINNI architecture, assuring the high-level interaction of the potential users with the 5G-VINNI "operational" platform.

In particular, the purpose of this layer is to facilitate the interactions between the vertical organizations willing to experiment with 5G-VINNI facility, the third-parties willing to advertise and offer services through the facility, and the facility site operators.

The main interest of this questionnaire is to refine the 5G-VINNI Business Layer requirements identified in the first phase of the 5G-VINNI project. It aims to understand the relevance of the identified requirements for the different potential users of the 5G-VINNI platform. Towards this direction you will need to fill in some information related to your company and your role in it, along with some of your high-level responsibilities. Then, you will need to answer a set of questions related to the Business Layer requirements, which however follow the same format.

On the top of each questionnaire page, you will find the "title" of each requirement followed by a “brief description”. The question that needs to be answered is presented below and the available options (Must have, Should have, Cloud have, Won’t have) highlight how relevant this requirement is for your company and your role in it.

The importance of each Business Layer requirement will be evaluated for two different Maturity Levels (MLs) of the business Layer. In particular, you should consider how important is a requirement both in the current situation where 5G-VINNI serves ICT-19 projects and ESB members, and in a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services.

The time needed is between 15 to 20 minutes considering that most of the questions are of multiple-choice form. Please, consider that the answers are saved only at the end of the process and after pressing the button "SEND". If you miss the connection you will need to start over again the questionnaire.

For more details contact Giuseppa Caruso - giuseppa.caruso@eng.it

Few Information about YOU

Few information about you can support us to identify possible correlations between job/organisation needs and answers to the next sections related to 5G- VINNI Business Layer requirements.

1. **Sector of your Company/organisation**

- Energy
- Automotive
- Security
- Media
- ICT
- Academia/Research
- Other

2. **What is your role in your company/organisation?**

- My role can be considered as a digital transformation leader (or something similar)
- My role can be considered as a business analyst or a digital consultant (or something similar)
- My role can be considered as a software developer (or something similar)
- My role can be considered as a system administrator/network specialist (or something similar)
- My role can be considered as a service manager or quality assurance manager (or something similar)
- My role can be considered as a solution designer or system architect (or something similar)
- Other

3. **Company/organisation name (not mandatory)**

4. **Your email (not mandatory but useful)**

5. **Are you involved in a project/Pilot using 5G-VINNI Facility sites?**

- Yes
- No

<u>Requirement 1 - Global Service Catalogue</u>

Description: A service catalogue should include all the 5G-VINNI facility offerings that are available and accessible to vertical customers (e.g., enterprises). These offerings can originate from any facility site in 5G-VINNI that may also involve services from 3rd-party providers that complement the 5G-VINNI platform.

6. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 1 "Global Service Catalogue" described above? ***

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).

- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

7. **How the importance/relevance of the requirement above "Global Service Catalogue" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 2 – Secure universal login

Description: A unique customer access to the platform should be available to allow users' account creation and log in. This access authorises each member to have a personalized view of past transactions and monitoring of pending items

8. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 2 "Secure universal login" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

9. **How the importance/relevance of the requirement above "Secure universal login" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 3 - Global coverage

Description: A service should not be restricted to the subscribers and resources of a single communications service provider/network operator.

10. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 3 "Global coverage" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

11. **How the importance/relevance of the requirement above "Global coverage" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 4 - Flexible cost/revenue sharing agreements

Description: Billing systems should support a wide range of revenue sharing and cost splitting agreements.

12. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 4 "Flexible cost/revenue sharing agreements" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

13. **How the importance/relevance of the requirement above "Flexible cost/revenue sharing agreements" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 5 - Homogeneous service E2E

Description: Vertical organisations should obtain consistent experience, even in the case of federated/collaborative service provisioning. Thus, operators participating in service delivery should have a common view of the attributes to be met.

14. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 5 "Homogeneous service E2E" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

15. **How the importance/relevance of the requirement above "Homogeneous service E2E" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 6 - Automated replicability

Description: A product/service/experiment should be automatically replicated in other regions or instantiated over time, in order to reduce complexity and time to market.

16. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 6 "Automated replicability" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

17. **How the importance/relevance of the requirement above "Automated replicability" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 7 - Open to external suppliers

Description: A service catalogue should include capabilities and other services (e.g., VNFs) by other external suppliers both facility sites and the so called complementors (that is firms that want to use the 5G-VINNI platform for providing vertical services). Then, third-party developers and professionals can make their services available to 5G-VINNI Platform customers rather than offer only a limited set of in- house solutions.

18. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 7 "Open to external suppliers" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

19. **How the importance/relevance of the requirement above "Open to external suppliers" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 8 - Pick and choose

Description: Capabilities and services should be available so that vertical customers and aggregators/brokers can compose new chained services to cater to their needs and business models.

20. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 8 "Pick and choose" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

21. **How the importance/relevance of the requirement above "Pick and choose" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 9 – Experiment

Description: Capabilities and services should be available so that customers can experiment and consider if it meets their requirements.

22. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 9 "Experiment" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

23. **How the importance/relevance of the requirement above "Experiment" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 10 – Community

Description: Exchange of knowledge, such as results and best practices obtained from previous experiments, troubleshooting, etc. could be useful for new potential customers, who have limited experience with 5G onboarding processes.

24. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 10 "Community" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

25. **How the importance/relevance of the requirement above "Community" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 11 - Real-time performance monitoring

Description: A resources and capabilities monitoring mechanism should be in place, allowing experimenters to track the status and performance of the experiment in real time.

26. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 11 "Real-time resource monitoring" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

27. **How the importance/relevance of the requirement above "Real-time resource monitoring" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase

- It could decrease
- I don't Know

Requirement 12 – Reporting

Description: At the end of the experimentation and for each experiment and single test inside it, a detailed report should be available of the results and used resources and capabilities. These reports can support vertical organisations to make better decisions for the replication in the real world and to understand if they are meeting the required needs.

28. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 12 "Reporting" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

29. **How the importance/relevance of the requirement above "Reporting" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 13 - Open documentation

Description: The experiment results and other reports can be made available and shared with registered and unregistered users. The experiments results should be open to all or at least to all registered users according to the experiment owners' preferences.

30. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 13 "Open documentation" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

31. **How is the importance/relevance of the requirement above "Open documentation" affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase

- It could decrease
- I don't Know

Requirement 14 - Feedback mechanism

Description: Customer feedback on the experience perceived and trouble-shooting tickets can support facility owners to improve their offers and other users to have justifiable levels of trust to the system. Ability to communicate/interact with the customer, in the system.

32. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 14 "Feedback mechanism" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

33. **How the importance/relevance of the requirement above "Feedback mechanism" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 15 - Flexible way of SLA definition and billing

Description: Customers should be able to define SLA terms (e.g.: setting latency and/or bandwidth range according their needs) and get a quote.

34. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 15 "Flexible way of SLA definition and billing" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

35. **How is the importance/relevance of the requirement above "Flexible way of SLA definition and billing" affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 16 - Slice Control

Description: In some case the customer (vertical or complementor) could need to manage and control dynamically parameters for the service instantiation (for instance the location to instantiate a specific VNF, modify the latency and bandwidth at run time, etc.). Slice Control could provide to vertical customer the slice or service instantiation control.

36. Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 16 "Slice Control" described above?

- o Must have (it is critical for my interaction with the 5G-VINNI platform)
- o Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- o Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- o Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- o I don't Know

37. How the importance/relevance of the requirement above "Slice control" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?

- o It could be the same
- o It could increase
- o It could decrease
- o I don't Know

Requirement 17 - Assisted customer access

Description: Users should be assisted when interacting with a facility site during each phase of experiment or service life-cycle by receiving notifications when certain events take place. Customer should easily monitor order status (including faults).

38. Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 17 "Assisted customer access" described above?

- o Must have (it is critical for my interaction with the 5G-VINNI platform)
- o Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- o Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- o Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- o I don't Know

39. How the importance/relevance of the requirement above "Assisted customer access" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services? *

- o It could be the same
- o It could increase
- o It could decrease
- o I don't Know

Requirement 18 - License management

Description: Experimenters that want to on-board VNFs from third parties should be able to supply license details or where these can be retrieved from.

40. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 18 "License management" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

41. **How the importance/relevance of the requirement above "License management" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services? ***

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 19 - Experiment scheduling and set up

Description: Customers should be able to define when an experiment will take place and see an overview of other planned experiments - Customers should have the possibility to define and set the parameters for the service experimentation.

42. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 19 "Experiment scheduling and set up" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

43. **How the importance/relevance of the requirement above "Experiment scheduling and set up" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 20 - User device access control

Description: Customers may want to restrict the set of participants in the experiments.

44. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 20 "User device access control" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

45. **How the importance/relevance of the requirement above "User device access control" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Requirement 21 - Platform documentation/handbook/tutorial

Description: Specific 5G-VINNI Platform documentations like video, handbooks, tutorial on how to use it, can facilitate its utilization.

46. **Considering your role and the tasks you have to accomplish when interacting with 5G-VINNI platform, what is the importance/priority level of the requirement 21 "Platform documentation/handbook/tutorial" described above?**

- Must have (it is critical for my interaction with the 5G-VINNI platform)
- Should have (it is important because it provides innovative features but not fundamental for my interaction with the 5G-VINNI platform)
- Could have (it is desirable because it could improve my user experience and satisfaction, but not necessary for my interaction with the 5G-VINNI platform).
- Won't have, (it is considered as no-critical or no relevant for my role at that time for my interaction with the 5G-VINNI platform)
- I don't Know

47. **How the importance/relevance of the requirement above "Platform documentation/handbook/tutorial" is affected, when considering a long-term commercial scenario where 5G-VINNI enables the concept of Experimentation as a Service along with other services?**

- It could be the same
- It could increase
- It could decrease
- I don't Know

Conclusion

48. **Do you think there are any 5G-VINNI business layer requirements not considered yet?**

- Yes
- Maybe
- No

49. If "yes" please list here the requirements still missing in your opinion

Annex B Requirements priority according the identified personae

If we consider the specific users potentially involved in the 5G-VINNI Business Layer, the priorities can change according their point of view and maybe needs and pains in their job roles. In D5.2 [2], we have also identified user stories linked to requirements. In this way we can better understand personae' motivations and in turn more precisely specify and act on solutions addressing the requirements. In this document, though, the main focus is to validate and to give a priority for each of the identified requirement by using the user responses to the questionnaires.

B.1 External users

In this section we go through each of the requirements and analyse the point of view of the specific potential external users. Unfortunately, no System Administrator/ Network specialist from external users replied to our questionnaire, so we are not able to validate the requirements from their job point of view.

Global Service Catalogue

The Global Service Catalogue is considered a "should have" requirement for the majority of external users, and for SW developers, Service Managers & Quality Assurance Managers and Solution Designers & System Architects. Digital transformation leaders and Business Analysts consider it as a "must have".

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Global Service Catalogue	S	M	M	S	S	S

Secure universal login

It is important to note that the "secure universal login" is a "must have" requirement for SW developers and Service Managers & Quality Assurance Managers. The majority of users, though, considers it as a "should have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Secure universal login	S	S	S	M	M	S

Global coverage

The majority consider "global coverage" as a "should have" requirement. However, it is less relevant for SW developers that consider it as a "could have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Global coverage	S	S	S	C	S	S

Flexible cost/revenue sharing agreements

The majority of potential users consider this requirement as a "could have". It should be noted that Solution Designers & System Architects consider this is a "won't have" requirement. This is an expected result from external users, considering that the 5G facilities must be freely available for all the 5G VINNI project life cycle.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Flexible cost/revenue sharing agreements	C	C	C	M	C	W

Homogeneous service E2E

The "homogeneous service E2E" is considered from most of external users as a "must have", however, Solution Designers & System Architects consider it as a less relevant requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Homogeneous service E2E	M	M	M	M	M	C

Automated replicability

"Automated replicability "is considered a "should have" by most of potential external users, apart for Digital transformation leaders who consider it less relevant.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Automated replicability	S	C	S	S	S	S

Open to external suppliers

We here say that a majority consider the "open external suppliers" requirement as a "should have". However, the users are split and indicate this requirement as either a must or could have. Digital transformation leaders and Solution Designers & System Architects are part of this majority for "should have". For SW developers and Service Managers & Quality Assurance Managers, this requirement is a "must have", and for Business Analysts only a "could have".

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Open to external suppliers	S	S	C	M	M	S

Pick and choose

In sum, we say that the majority consider "Pick and choose" as a "should have" requirement. However, for Digital transformation leaders and Business Analysts it is only a "could have", while for SW developers and Service Managers & Quality Assurance Managers, it is a "must have" requirement. Finally, only Solution Designers &System Architects actually note this as a "should have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Pick and choose	S	C	C	M	M	S

Experiment

The "experiment" requirement put all external users on the same page, considering it as a "must have" requirements.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Experiment	M	M	M	M	M	M

Community

Even if it is considered from the majority of external users a "must have" requirement, for some users it is less relevant. In fact, Service Managers & Quality Assurance Managers consider it as a "should have" requirement while for Digital transformation leaders and Solution Design & System Architects it is only a "could have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Community	M	C	M	M	S	C

Real-time performance monitoring

Also, this requirement puts all external users on the same page, considering it as a "must have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Real-time performance monitoring	M	M	M	M	M	M

Reporting

All external users considering "Reporting" to be a "must have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Reporting	M	M	M	M	M	M

Open documentation

The "open documentation" is considered from the majority as a "could have" requirement. Still, it is more relevant for SW developers who consider it as a "must have" requirement and for Solution Designers & System Architects who considers it as a "should have" requirement.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Open documentation	C	C	C	M	C	S

Feedback mechanism

The majority consider the "feedback mechanism" a "should have" requirement and on the same page are both Solution Designers & System Architect and Service Managers & Quality Assurance Managers. Anyway, it is a "must have" requirement for Digital transformation leaders and SW developers, while it is less relevant for the Business analysts.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Feedback mechanism	S	M	C	M	S	S

Flexible way of SLA definition and billing

Also, for the "Flexible way of SLA definition and billing", the majority consider it a "should have" requirement and on the same page are both Digital transformation leaders and Service managers & Quality assurance managers. On the contrary, it is a "must have" requirement for SW developers and Business analysts, while it is less relevant for the Solution Designers & System Architects (could have).

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Flexible way of SLA definition and billing	S	S	M	M	S	C

Slice Control

Even if the majority of the external users consider the "slice control" as a "should have" including Business analysts and Solution Designers & System Architects for the other users (Digital transformation leaders, Service managers & Quality assurance managers and SW developers) it is more relevant and considered as a "must have" requirements.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Slice Control	S	M	S	M	M	S

Assisted customer access

The "Assisted customer access" requirement put all external users on the same page, considering it as a "must have" requirements. The need to have appropriate processes for assist customers during the access to the different platform services seems something very relevant for all the potential users.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Assisted customer access	M	M	M	M	M	M

License management

The "license management" considered from the majority as a "could have" requirements (including Digital transformation leaders and Solution Designers & System Architects), It is less relevant for Service managers & Quality assurance managers and Business analysts (considering it a "could have" requirement) but it is more relevant for the SW developers (must have).

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
License management	S	S	C	M	C	S

Experiment scheduling and set up

Also, the "Experiment scheduling and set up" requirement put all external users on the same page, considering it as a "must have" requirements.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Experiment scheduling and set up	M	M	M	M	M	M

User device access control

The "user device access control" even if is considered from the majority as a "should have" requirements as well as by Service managers & Quality assurance managers and the Solution Designers & System Architects. For the rest user personae, it is more relevant (it is a "must have" requirement).

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
User device access control	S	M	M	M	S	S

Platform documentation/handbook/tutorial

Finally, also the "Platform documentation/handbook/tutorial" requirement put all external users on the same page, considering it as a "must have" requirement. We can consider it as a specification of the previous requirement on "Assisted customer access" and consequently each form of support to the platform services access is something very important for all the external users and the different job roles.

	External Users	Digital transformation leader	Business Analyst	SW developer	Service Manager (SM) & Quality Assurance Manager (QAM)	Solution Designer (SD) & System Architect (SA)
Platform documentation/handbook/tutorial	M	M	M	M	M	M

B.2 Internal users

In this section we go through each of the requirements and analyse the point of view of the specific potential internal users. The so-called internal users identified in the D5.2 are the following: DevOps Expert, Service manager, Network Specialist, Solution designer and Test specialist. Unfortunately, no "Account managers" from internal users replayed to our questionnaire, so we are not able to validate the requirements from this job point of view.

Global Service Catalogue

The "global service catalogue" is considered from the majority of the internal users as a "must have" requirement, as well as for DevOps Experts, Service managers and Network Specialists. Anyway, it is less relevant for the Solution designers and Test specialists that consider it as a "should have" and "could have" requirement respectively.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Global Service Catalogue	M	M	M	M	S	C

Secure universal login

Also, the "secure universal login" is considered a very relevant requirement from the majority. DevOps Experts, Service managers and Solution designers consider it as a "must have" requirement while for the Network Specialists and Test specialists seem less relevant.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Secure universal login	M	M	M	S	M	C

Global coverage

For the "global coverage" we have very different point of view by part of the different involved internal users. The majority, including Network specialists consider it as important but not necessary for the success of the 5G-VINNI platform (could have). Only Service managers consider it as a critical

requirement (must have). DevOps Experts and Solution designers state it as important for the platform success (should have), while Test specialists claim that it is not needed at the moment.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Global coverage	C	S	M	C	S	W

Flexible cost/revenue sharing agreements

The majority of the internal users consider the "Flexible cost/revenue sharing agreements" as a desirable but not necessary ("could have"), as well as most of the roles considered. Only Test specialists consider it as a "won't have" requirement while for DevOps Experts consider it as a critical requirement.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Flexible cost/revenue sharing agreements	C	M	C	C	C	W

Homogeneous service E2E

The majority of the internal users consider the "Homogeneous service E2E" as a very important but not critical at this time requirement ("should have"), as well as most of the roles considered. Only Service managers consider it as a "could have" requirement, while for DevOps Expert it is a critical requirement (must have).

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Homogeneous service E2E	S	M	C	S	S	S

Automated replicability

Quite all the internal users consider the "automated replicability" an important requirement. DevOps Experts, Network Specialists, Solution designers and Test specialists in fact consider it as a "should have" requirement. Only for Service managers it is a little less relevant consider it as a "could have" requirement.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Automated replicability	S	S	C	S	S	S

Open to external suppliers

For the "open to external suppliers" we have met different positions by part the internal users. The majority of them including the Network specialists and the Solution designers, consider it as an important but not critical requirements (should have). Service managers as well as Test specialists consider it as just a desirable requirement but not necessary for the 5G-VINNI platform success (could have). Finally, only DevOps Experts consider it as critical (must have).

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Open to external suppliers	S	M	C	S	S	C

Pick and choose

Also, for the "pick and choose" requirement, we have different point of view by part of the different potential users. The majority of internal users together Solution designers consider it as an important requirement (should have). While for DevOps Experts and Service Managers it is a very critical requirement for the success of the platform. Finally, the Network and Test specialists consider it only as desirable but not necessary at this time.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Pick and choose	S	M	M	C	S	C

Experiment

The "experiment" requirement is considered as a very critical aspect for the platform success. DevOps Experts, Service Managers and Solution designers agree that it is a "must have" requirement, but for Network and Test specialists it seems less relevant even if desirable.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Experiment	M	M	M	S	M	C

Community

The majority of internal users as well as DevOps Experts consider it as something desirable but not necessary for the success of the platform (could have). For Network specialist it is a critical requirement (must have). While for all other roles (Service manager, Solution designer and Test specialist) it is a "should have" requirements for the platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Community	C	C	S	M	S	S

Real-time performance monitoring

Even if the majority of the internal user including Network Specialists and Solution designers consider this requirement as a "should have" that is important but not critical. On the other hand, DevOps Experts, Service managers and Test specialists consider it as a critical aspect for the platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Real-time performance monitoring	S	M	M	S	S	M

Reporting

Also, the "reporting" sees two main position: the majority of the internal users including Service managers and Solution designers consider it as important but not critical, the rest of users including DevOps Expert, Network Specialist, and Test specialist consider it as critical for the future platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Reporting	S	M	S	M	S	M

Open documentation

For the "open documentation" we have met different positions by part the internal users. The majority of them, including the Service managers and the Test specialists, consider it as a desirable but not currently necessary requirement. On the other hand, it is considered critical for DevOps Experts while for Network Specialist it is an important requirement (should have). Finally, it is not relevant for Solution designers.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Open documentation	C	M	C	S	W	C

Feedback mechanism

The "Feedback mechanism" results highlight two main position: the majority of the internal users including Network Specialists and Solution designers consider it as important but not critical (should have), while the rest of users including DevOps Experts, Service managers and Test specialists consider it as critical for the future platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Feedback mechanism	S	M	M	S	S	M

Flexible way of SLA definition and billing

For "Flexible way of SLA definition and billing" requirement, we have different point of view by part of the different potential users. The majority of internal users, together Solution designers and Test specialists, consider it as an important requirement (should have). While for the majority of the DevOps Experts and Network Specialists it is a very critical requirement for the success of the platform. Finally, the Service manager consider it only as desirable but not necessary at this time.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Flexible way of SLA definition and billing	S	M	C	M	S	S

Slice Control

The "slice control" is considered by the majority of internal users as an important requirement. On the same page are also the Service managers, Network Specialists and Solution designers. Instead,

for DevOps Experts it is a critical aspect (must have) for the platform success. Finally, it is less relevant for Test specialists that consider it as a could have requirement.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Slice Control	S	M	S	S	S	C

Assisted customer access

This requirement sees quite all the internal users as well as DevOps Experts, Network Specialists, Solution designers and Test specialist agree on the priority for the "assisted customer access". They consider it as important but not critical (should have), while for the Service manager it is very critical for the platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Assisted customer access	S	S	M	S	S	S

License management

Even if DevOps Experts, Service managers and Network Specialists consider the "license management" as a critical point, the majority of the internal users as well as the test specialists agree on the importance of it but not its criticality (should have position). Finally, for Solution designers, it is desirable but not necessary at this time for the platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
License management	S	M	M	M	C	S

Experiment scheduling and set up

Even if the majority of internal users consider the "Experiment scheduling and set up" as a critical aspect for the platform success, analysing the specific job roles we can see different position about it.

In fact, Solution designers and Test specialists consider it a "must have" requirements, while DevOps Experts and Network Specialists see it as an important but not critical requirement (should have position). Finally, the Service managers consider it only as a "could have" requirement.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Experiment scheduling and set up	M	S	C	S	M	M

User device access control

The "User device access control" is considered by the majority of internal users as an important requirement. On the same page are also the Network Specialists, test specialists and the Solution designers. Instead, for DevOps Experts it is a critical aspect (must have) for the platform success. Finally, it is less relevant for the Service managers that consider it as a could have requirement.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
User device access control	S	M	C	S	S	S

Platform documentation/handbook/tutorial

The “Platform documentation/handbook/tutorial” requirement is considered as a very critical aspect for the platform success. The DevOps Experts, Service Managers and Network Specialists agree that it is a “must have” requirement, while for Solution designers and Test specialists it seems less relevant even if important but not critical for the platform success.

	Internal Users	DevOps Expert	Service manager	Network Specialist	Solution designer	Test specialist
Platform documentation/handbook/tutorial	M	M	M	M	S	S