5G-VINNI BUSINESS LAYER: DESIGN, MATURITY LEVELS AND ROLLOUT

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EXECUTIVE SUMMARY

Given the high complexity of 5G value network and the conflicting interests between stakeholders, the collaboration and co-innovation of stakeholders is essential for 5G business success. Legacy Business Support Systems/Operation Support Systems (BSS/OSS) lack the necessary openness, scalability, flexibility and agility; therefore, the evolution of BSS/OSS plays a central role for 5G monetization. 5G-VINNI [1], introduces the notion of 5G-VINNI Business Layer (hereafter referred to as business layer), which is a collection of BSS and OSS functions required for the operation of pre-commercial 5G testbeds and commercial 5G networks. In this white paper, we present the capabilities and design of the business layer, and a plan for the phased rollout of these capabilities along four Maturity Levels (MLs) [2] of the 5G-VINNI facility. The MLs capture the evolution of 5G-VINNI facility: ML1 - operation for internal testing, ML2 - operation for a restricted set of customers, ML4 – outline of the long-term vision of commercial 5G-VINNI experimentation as a service.

In order to determine a rollout plan that fits the needs of the internal and external users, we have analysed how they rank their requirements to the business layer. Thereby, we can provide insights about how business layer functions should be prioritized in the rollout. In order to propose a plan for the release of the business layer capabilities, a mapping of requirements to capabilities is defined. The capabilities are grouped into three families of features:

- *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 E2E, 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.

Based on the prioritization of requirements and mapping of requirements to capabilities, we propose how the capabilities evolve through the MLs of 5G-VINNI facility considering multiple releases. Equally important is to capture the cost of delivering the features needed to meet each requirement and the relevance of the features for the operation of 5G-VINNI facility in each ML. Our study includes a Recommended Delivery Period (RDP) for the *main* release of features meeting each requirement, by assigning “Early”, “Medium” or “Late” release tags. A combined analysis of both requirement prioritization and recommended delivery period allows us to determine business layer design in each ML, i.e., the number and maturity of features that will be available in each release. In particular:

- *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 include 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.

The analytic methods used are described in the annex of this white paper.

CONTENTS

1 INTRODUCTION

5G is a mobile network generation, delivering among others, unprecedented performance with respect to data traffic throughput, End-to-End (E2E) latency, number of supported devices, reliability and automation. These new features render 5G one of the main pillars for the digitization of vertical industries. 5G will enable the emergence of new business ecosystems, creating opportunities for new business models and revenue streams for Mobile Network Operators (MNOs), Communications Service Providers (CSPs), and vertical enterprises by delivering innovative network services. According to a study [4], 5G will create over $13 trillion in global sales enablement by 2035.

To capitalize on this opportunity, MNOs and CSPs should take up a central role in the complex value network of 5G ecosystem, turning the network into an open multi-tenant, multi-provider, multi-vendor and multi-operator platform. Legacy 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 central role for 5G monetization [5]. The evolved 5G BSS should be able to support [6], [7]:

- 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 Service Level Agreement (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 3rd providers, suppliers and customers, through standardized Application Programming Interfaces (APIs)

5G-VINNI, introduces the notion of *business layer*, which enables a wide variety of BSS-oriented and OSS-oriented capabilities required for the operation of 5G testbeds. The business layer is meant to:

- facilitate the interaction of external users with the facility
    - vertical enterprises should be able to design, plan and perform experiments effortlessly
    - third-party service providers should be able to complement the 5G-VINNI platform by contributing their own services/products
- enable the business coordination of internal users i.e., facility site members
    - the appropriate business capabilities and enabler mechanisms should be in place to allow for provisioning of joint services in a highly automated manner.

In this report, we identify the business requirements for 5G-VINNI internal and external users and we define the capabilities that the business layer should have in order to support them. In addition, we perform a prioritization analysis on the user requirements and come up with a plan for the gradual roll-out of the different business layer capabilities. Considering the different 5G-VINNI facility Maturity Levels (MLs) [2] (see Figure 1-1 below), we recommend a business layer design per ML:

- **ML2** refers to a mature facility that will allow a restricted set of vertical 'customers', mainly ICT-19 projects[1] and 5G-VINNI External Stakeholder Board (ESB members, to integrate their 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

[1] Projects funded under H2020-ICT-2018-20 call: "Advanced 5G validation trials across multiple vertical industries".

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.

ML4 spans 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.

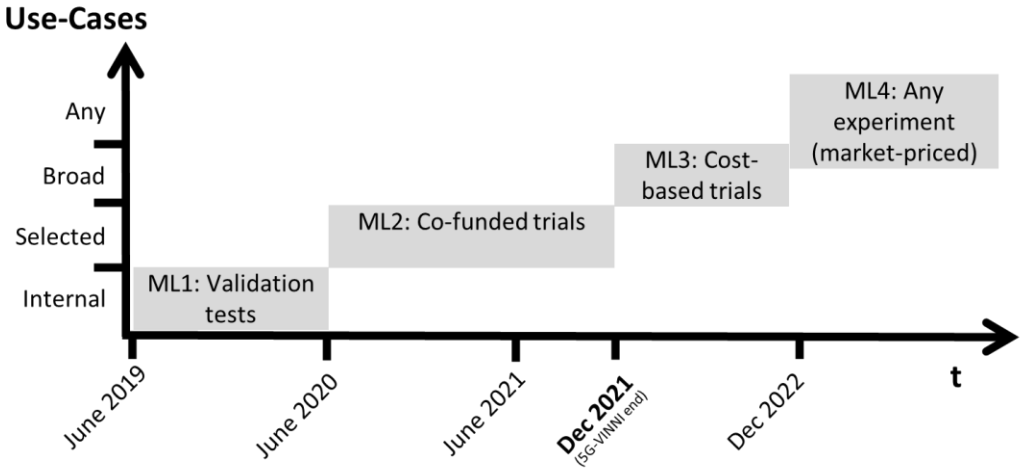


Figure 1-1: 5G-VINNI maturity levels [2]

In the remainder of this white paper, in section 2, we enumerate the business layer requirements taking into account the pain points and needs of internal and external potential users of the experimentation facility. The prioritization of these requirements considers how important these requirements are for the users, as well as how difficult and relevant is to deliver the required business layer capabilities in order to fulfil each of the requirements. The prioritisation is detailed in the Annex (section 5). In section 3, we provide a recommended plan for phased and gradual rollout of capability features along 5G-VINNI Maturity Levels. Finally, we conclude in section 4.

2 5G-VINNI BUSINESS LAYER CAPABILITIES AND DESIGN

2.1 DESIGN

The high-level design of the business layer is illustrated in Figure 2-1 and shows how the different capabilities interact with each other and provide services to customers. Vertical customers and other third parties in the 5G ecosystem 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 vertical customers as they seek to access the 5G-VINNI platform with a view to defining and running experiments. At each facility site, the business layer interacts with the Service Orchestration capabilities of the facility in order to fulfil and manage the requirements of the vertical customer.

The high-level design is derived from the prioritisation of mapped requirements that is illustrated in Table 2-1. A description of the identified requirements is provided in the annex (section 5.1.1). The requirements prioritization and the applied methodology are provided in the annex (sections 5.2 and 5.3).

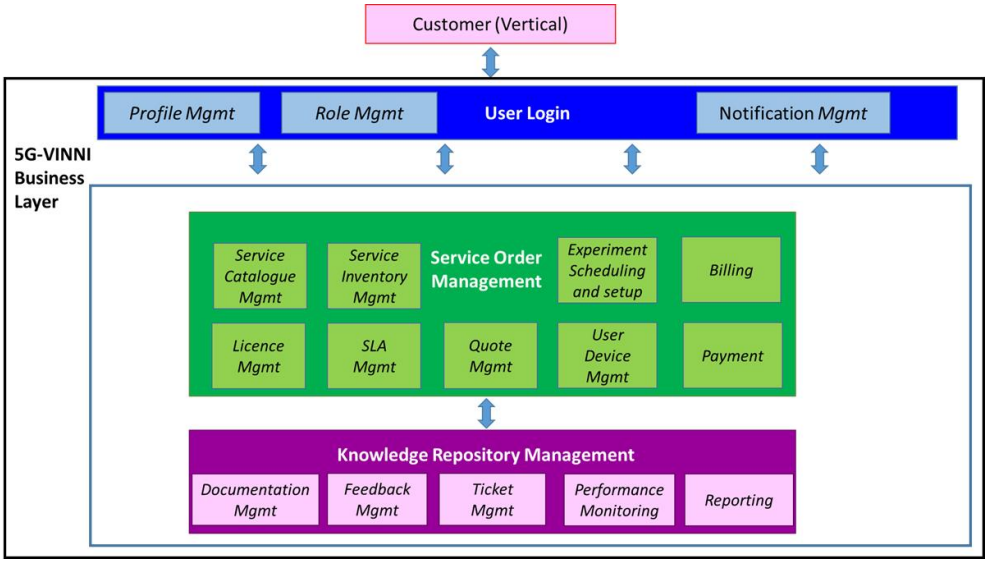


Figure 2-1: High-level design of the business layer

Table 2-1: Capability features rollout based on the prioritization of mapped requirements

	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	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				

2.2 CAPABILITIES

In this section, we provide the list of final 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. We identify three capability families, namely User Login, Service Order Management and Knowledge Repository Management, each of them consisting of multiple features.

2.2.1 USER LOGIN

User Login capability performs user authentication, authorization and accounting for user logins such as collecting timestamps, IP addresses, etc. enabling access control to the 5G-VINNI platform for external and internal users. 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, customer, third-party supplier, third-party consultant as well as the retrieval of their context. This feature can also 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.

2.2.2 SERVICE ORDER MANAGEMENT

The main objective of this capability is to allow vertical customers to simply manage the E2E lifecycle of service orders, e.g., instantiation of network slices with or without third-party Virtual Network Functions (VNFs) Virtual Application Functions (VAFs), real-time order status details, scaling of resources. Furthermore, 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 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). Interworking amongst service catalogues of different providers can be used to serve customers of vertical industries irrespective of their CSPs and to increase coverage.
- **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, service continuity assurance and compliance with the license terms as agreed with VNF vendors, etc.
- **Service Inventory Management** allows for the life-cycles management of instantiated 5G-VINNI service blueprints (e.g., hybrid enhanced mobile broadband and ultra-reliable low-latency communication) as they are created, updated, retrieved, and terminated. The customizable and reusable 5G-VINNI service blueprints are based on standardized Network Service Descriptors and Virtual Network Function Descriptor specifications in a machine-readable format, which allows for automation during deployment and operation of the Network Slice Instances.
- **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. When it comes to a network slice service, multiple levels of the service stack are involved and multiple interdependent SLAs need to be established. Therefore, SLA Management

features should support hierarchical SLAs. Mechanisms for closed-loop SLA adherence, healing, scaling or modification should be in place.

- **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. A vertical customer should be able to configure, negotiate or even decline a quote. The quotation process can be triggered either by the vertical customers in order to fulfil on-demand orders, or by Service Providers when it comes to "asynchronous" wholesale orders.
- **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).
- **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. 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.
- **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.

2.2.3 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. 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.
- **Reporting** provides users 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.

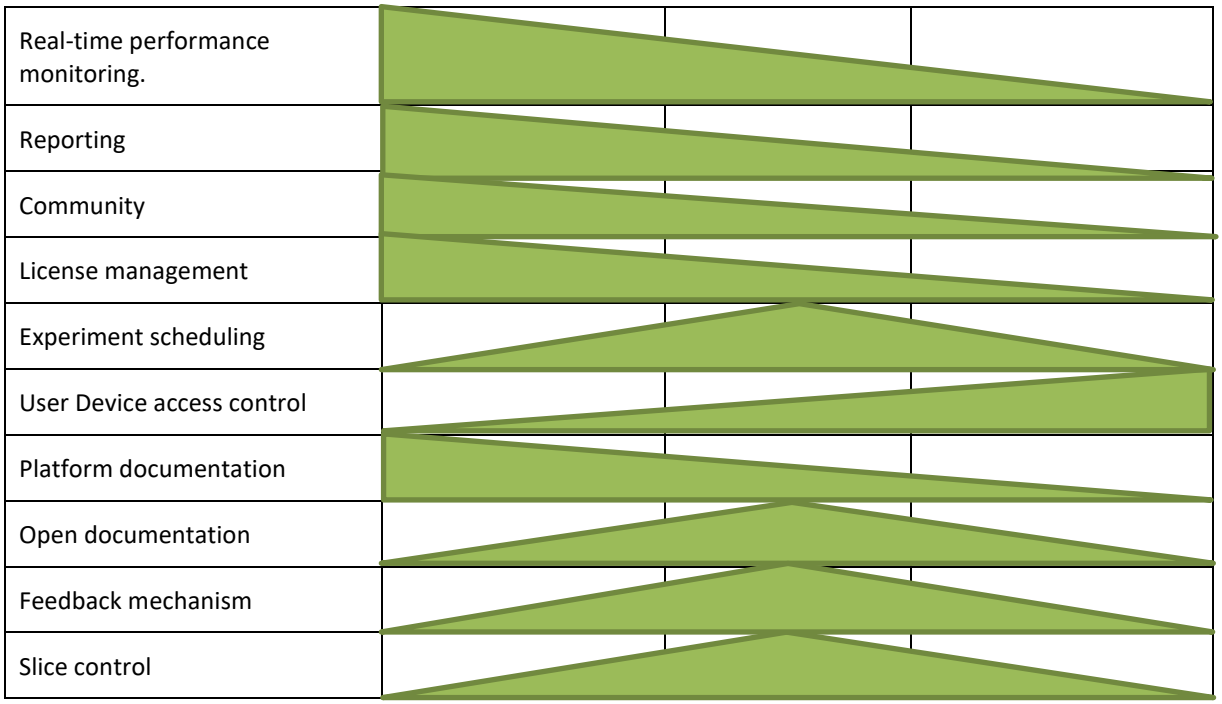
3 PHASED ROLLOUT

3.1 RECOMMENDED DELIVERY PERIOD FOR BUSINESS LAYER CAPABILITIES

Table 3-1 shows each business layer requirement and the recommended delivery period for the main release of the related business layer capability features that an MNO should consider while planning releases. 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. A detail assessment and justification for each requirement is reported in [3].

Table 3-1: 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.			



3.2 BUSINESS LAYER DESIGN PER MATURITY LEVEL

This section 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, the business layer capabilities will evolve accordingly.

In the remained of this section, we illustrate the business layer design for each maturity level by enhancing the one presented in Figure 2-1, 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 3-1, Figure 3-2, and Figure 3-3 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.

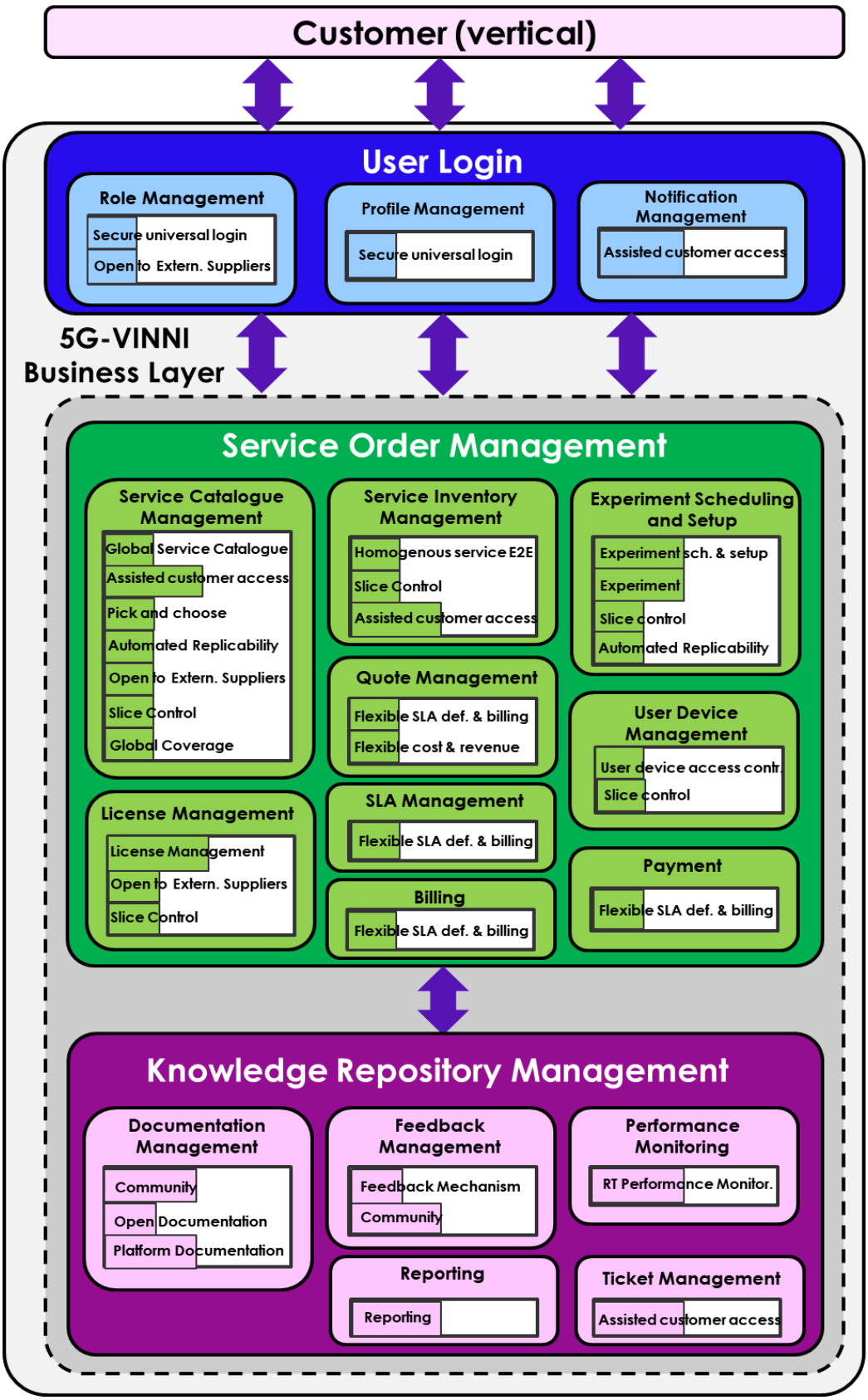


Figure 3-1: business layer design for ML2

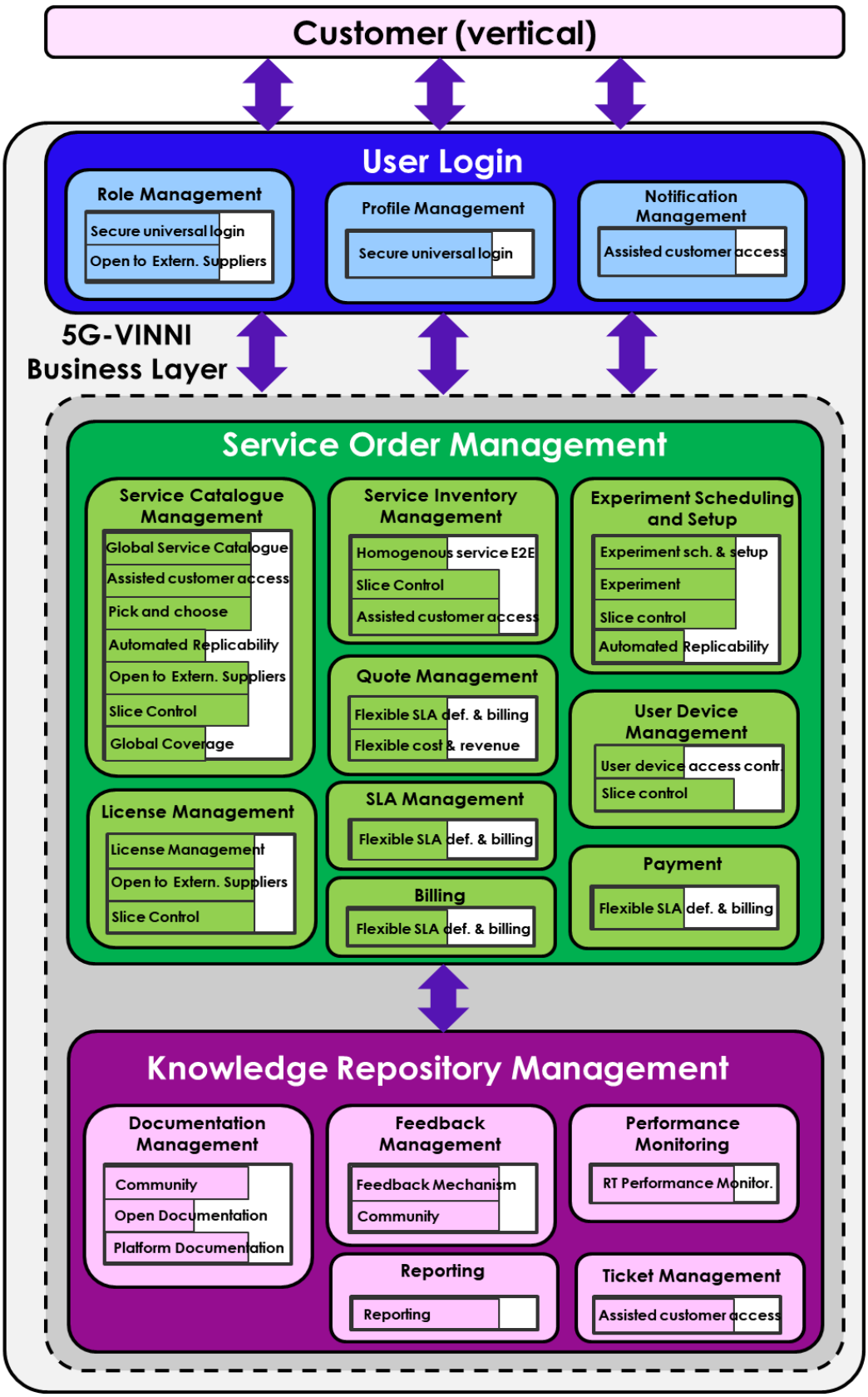


Figure 3-2: business layer design for ML3

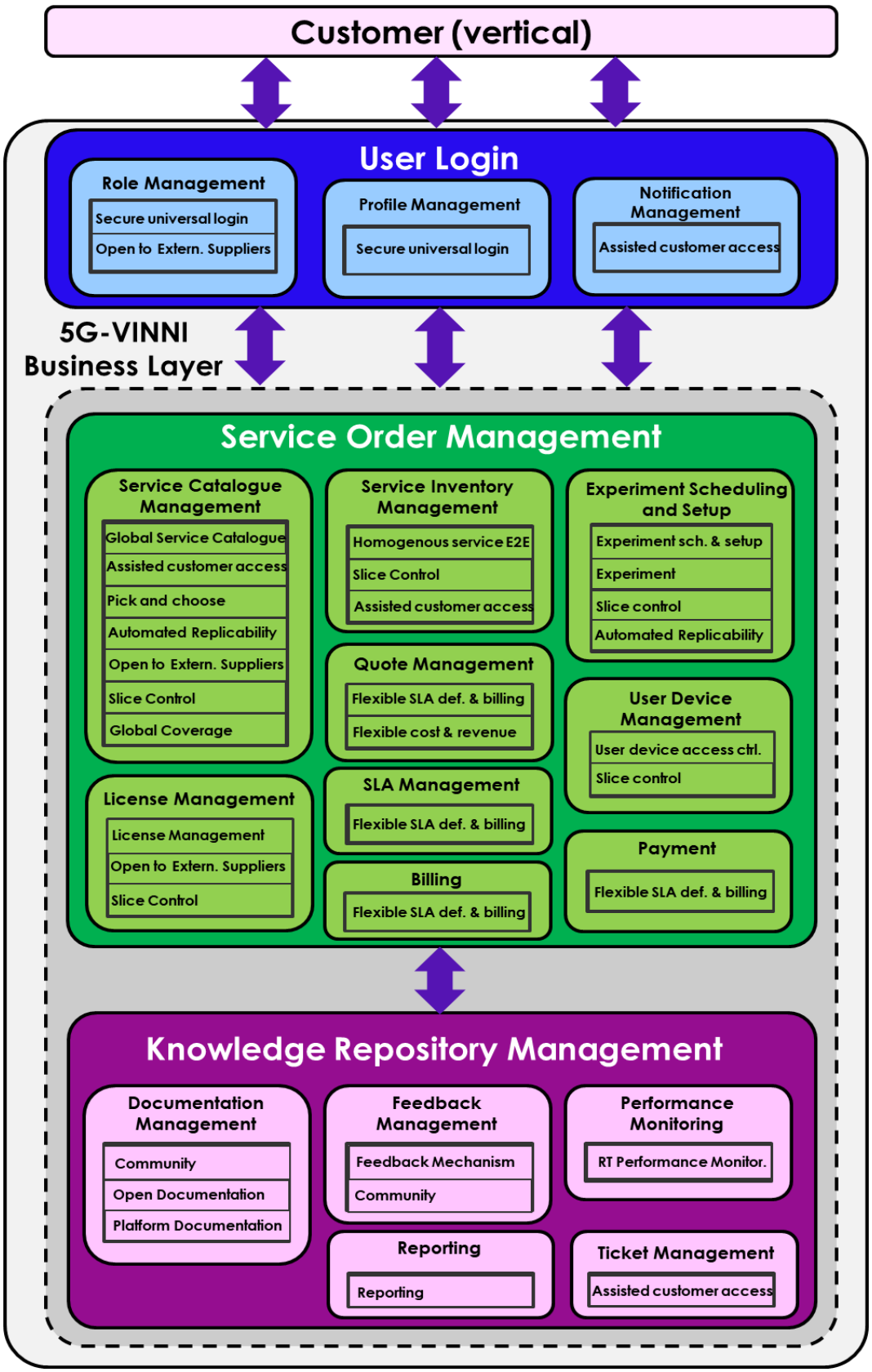


Figure 3-3: business layer design for ML4

4 CONCLUSIONS AND RECOMMENDATIONS

5G is transforming the relationship among different industry stakeholders 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 responding 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. We 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. The main conclusions of our study are the following:

- Even if all the 21 identified requirements are relevant, the opinions of both external and internal users of the 5G-VINNI platform allowed 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 most immediate business benefits early.
- Requirements and capabilities have been analysed in terms of technical, operational and economic constraints (Recommended Delivery Period) for understanding the difficulty of delivering them.
- 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, and considering internal technical constraints. Following a Multi-Criteria Decision Analysis, the design of the business layer for each ML considers users' preferences captured through the MoSCoW method and the results of the Recommended Delivery Period analysis.

The recommendations derived from the performed activities and reported in this document, are:

Drive 5G-business layer design by user needs and requirements engaging all potential stakeholders in the 5G ecosystem – 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.

Address 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 the needs of the vertical customers 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.

5 ANNEX – METHODOLOGY

The potential users of a 5G-VINNI facility, whose interaction will be facilitated by the business layer, are the: 5G-VINNI consortium members operating and supporting the facility sites; 5G-VINNI ESB members; ICT19 projects; other research projects focusing on specific vertical industries; and 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 business layer should address. To achieve this, several relevant scenarios ("user stories") for the usage of business layer were considered, through which the main requirements were extracted. A detailed analysis of this study can be found in [8].

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

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

5.1.1 IDENTIFIED REQUIREMENTS

1. **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.
2. **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.
3. **Global coverage –** A service should not be restricted to the subscribers and resources of a single communications service provider/network operator.
4. **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.
5. **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.
6. **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.
7. **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, 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.
8. **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.
9. **Experiment –** Capabilities and services should be available so that customers can experiment and consider if it meets their requirements.

10. **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.
11. **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.
12. **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.
13. **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.
14. **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.
15. **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.
16. **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.
17. **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).
18. **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.
19. **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.
20. **User device access control –** Customers may want to restrict the set of participants in the experiments.
21. **Platform documentation/ handbook/ tutorial –** Specific 5G-VINNI Platform documentations like videos, handbooks, tutorials on how to use it, can facilitate its utilization.

5.2 REQUIREMENTS PRIORITIZATION

In order to prioritize the user requirements and come up with a plan for the gradual rollout of business layer features addressing these requirements, we apply a Multi-Criteria Decision Analysis (MCDA) taking into account users' priorities through a MoSCoW analysis and experts' feedback through a Recommended Delivery Period (RDP) analysis that take into account the difficulty of delivering the necessary features for each requirement as well as the relevance of each requirement to each Maturity Level.

5.2.1 MOSCOW ANALYSIS

In order to capture the user priorities with respect to the different requirements, we engaged both internal and external users in two questionnaires (available in [3]) that that apply the MoSCoW method. 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 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.

5.2.2 MOSCOW RESULTS

The questionnaire respondents that belong to the external users' group come from the sectors Energy, Information and Communication Technologies (ICT), Media, Security, and Academia/Research, as illustrated in Figure 5-1. Note that one-third of internal users came from the ICT sector. 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. Of all the external users answering the questionnaire, 67% come from the 5G-VINNI ESB and ICT-19 projects that are using 5G-VINNI platform facilities for their 5G experimentations.

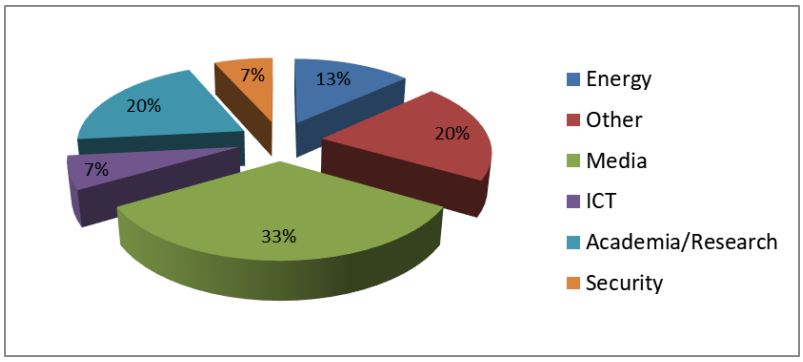


Figure 5-1: Sector of respondents in external users' group

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 5-2. Most of the answers from the internal user roles came from Network Specialist or also other roles. In total, we covered most other roles, except Account Manager.

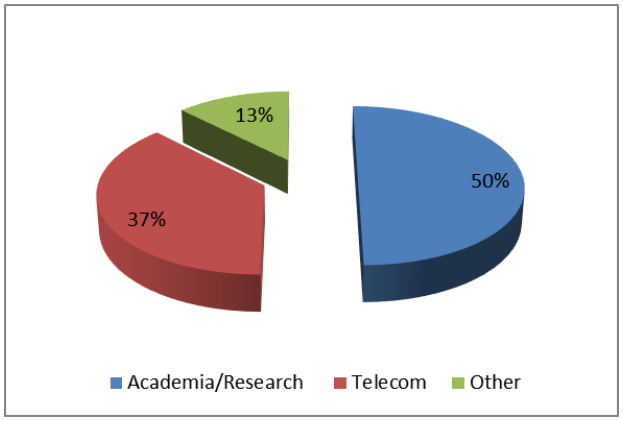


Figure 5-2: Sector of respondents in internal users' group

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.

Considering the responses of **internal users**, Figure 5-3 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 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 5-4 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")

5.3 USER PRIORITIZATION

The next figures illustrate the relative prioritisation of requirements in the four quadrants according to the MoSCoW method (must have, should have, could have and won't have) by the internal users (Figure 5-3) and by the external users of the business layer (Figure 5-4).

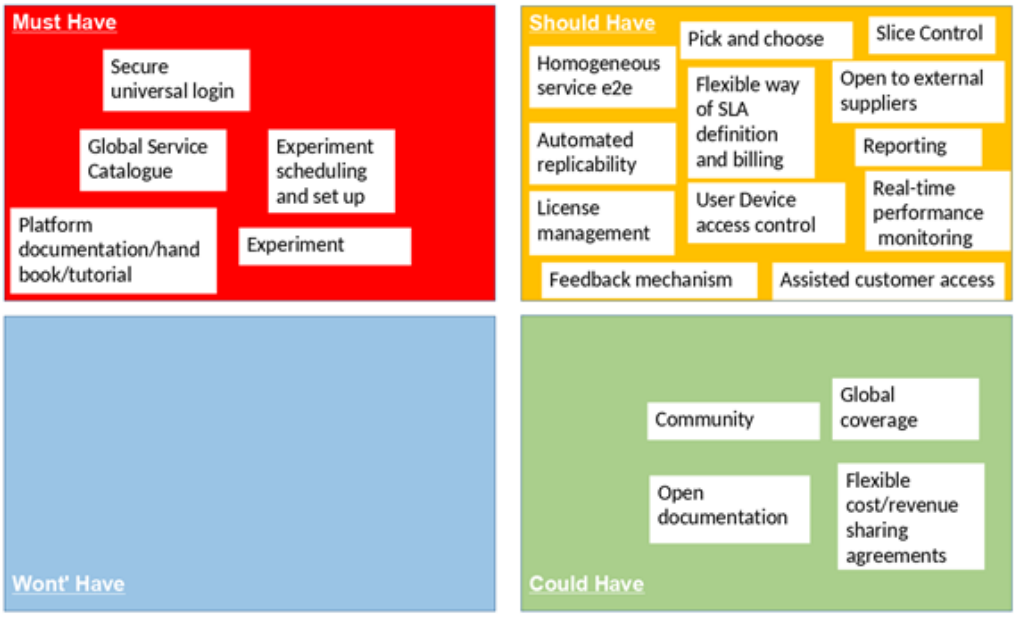


Figure 5-3: Requirements' prioritization for internal users

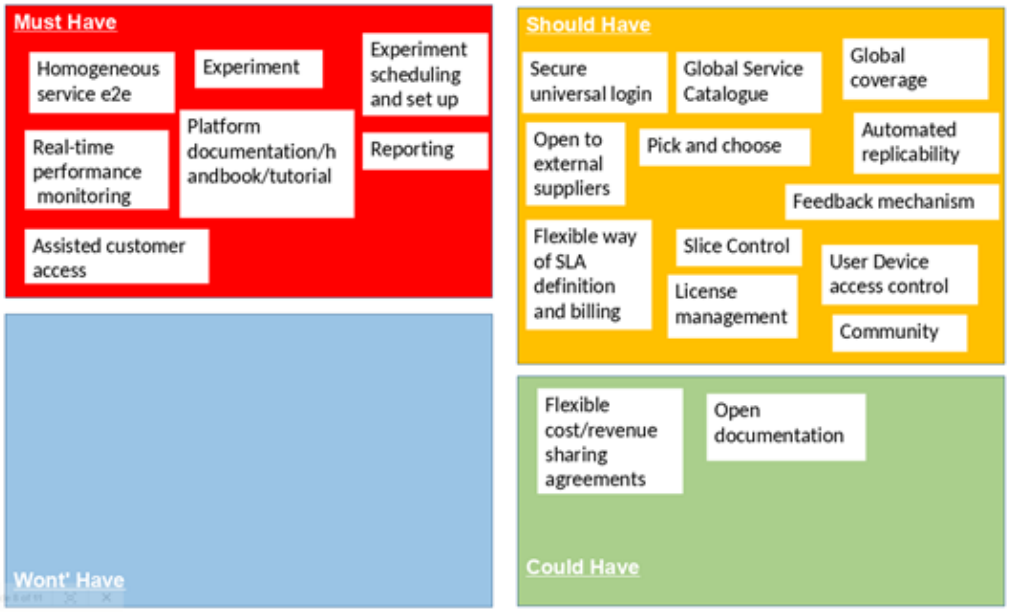


Figure 5-4: Requirements' prioritization for external users

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 5-1 and Table 5-2 below, the "should have" requirements for the user groups are presented.

Table 5-1: "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 5-2: "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". 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.

5.3.1 RECOMMENDED DELIVERY PERIOD ANALYSIS

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.

After considering the above aspects for each requirement, 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.

5.3.2 MULTI-CRITERIA DECISION ANALYSIS RESULTS

We consider Multi-Criteria Decision Analysis (MCDA) as a holistic approach that incorporates the problem definition, a procedure to support the identification of Decision Maker's[2] objectives (namely criteria), and the classification of the possible alternatives to be evaluated in a way that leads to the resolution of the problem [9]. 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 5G-VINNI experts (RDP). The step-by-step process to carry out an MCDA involves:

- Defining the key goal(s) of the decision problem
- 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
- Setting up an evaluation matrix to be used for "scoring" each alternative on each criterion and sub-criterion
- Computing weights for the criteria and sub-criteria according to their relative importance to the decision problem by combining Multi Attribute Value Theory-based [10] methods, Direct Weighting and Rank Sum
- 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

As the key goal, a prioritization is needed for each requirement's 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) as presented in the value tree of Figure 5-5.

[2]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.

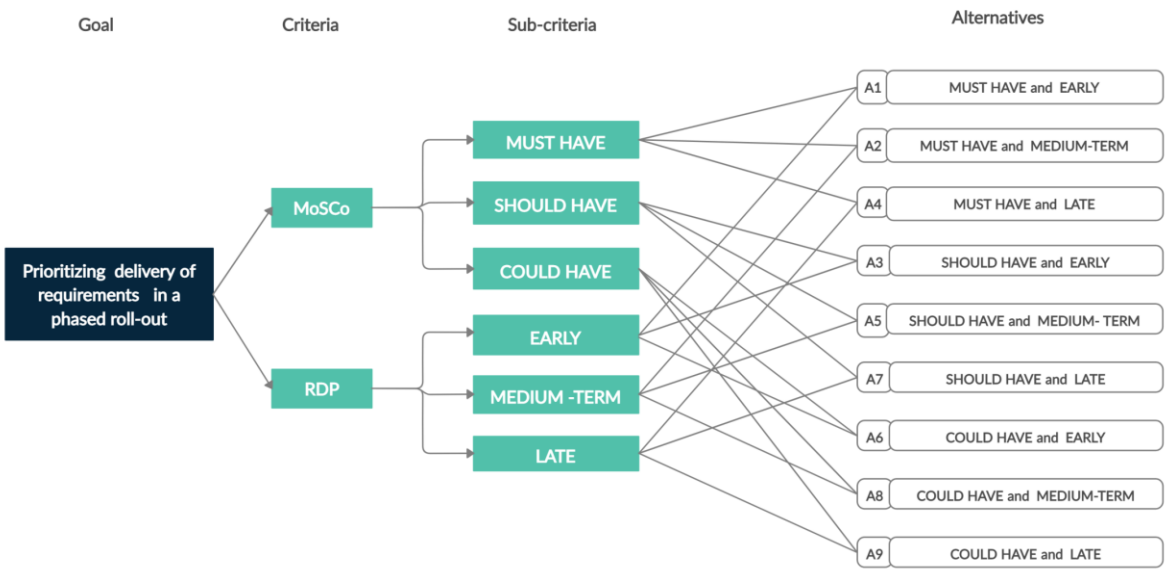


Figure 5-5: Our scenario value tree including the MCDA goal, criteria, sub-criteria and resulting alternatives.

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[3]": MUST HAVE 0.50, SHOULD HAVE 0.333, COULD HAVE 0.167, EARLY 0.50, MEDIUM-TERM 0.333, LATE 0.167.

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 5-3.

[3]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 5-3: 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

5.3.2.1 MCDA RESULTS

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. The requirements linked to each alternative are distributed in MLs, considering separately the results for internal and external 5G-VINNI users. The vast majority of requirement ended up at the same ML both for internal and external users. However, there were four non-common requirements that are linked to different MLs for internal and external users and this conflict needed to be resolved. In order to resolve this conflict, we considered each non-common requirement separately and evaluated 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.

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 5-4 below. In particular, the requirements assigned in the first column of the table denote 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 5-4: Final distribution of requirements in Maturity Levels, identifying when the main release of related Business Layer features should be available.

Maturity Level 2	Maturity Level 3	Maturity Level 4
• 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

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