
H2020 5Growth Project
Grant No. 856709

# D1.3: Business model validation with its complemented SLA

## Abstract

Report on the new business models developed and validated in the framework of the 5Growth project per vertical industries use cases as well as the validated SLA elicitation that will be used in 5G business layer (OSS/BSS) modelling to provide future advanced network services for vertical industries scenarios.

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# Disclaimer

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# List of Acronyms

AGV: Automated Guided Vehicle

AI/ML: Artificial Intelligence / machine Learning

AP: Amortization Time

BGP: Border Gate Protocol

BSS: Business Support Systems

CAPEX: Capital Expenditures

CKPI: Core KPI

CMM: Coordinate Measuring Machine

CU: Centralized Unit

DLT: Distributed Ledger Technology

DU: Distributed Unit

DA: Data Assembler

E2E: End 2 End

EMBB: enhanced mobile broadband

EMC: External Memory Controller

ENS: Energy Not Supplied

GSM: Global System for Mobile Communications

GPRS: General Packet Radio Service

HD: High Definition

I4.0: Industry 4.0

KPI: Key Performance Indicator

LC: Level Crossing

M2M: Machine to Machine

mMTC: massive Machine Type Communications

MTTR: Mean Time to Repair

MVP: Minimum Viable Product

NPN: Non-Public-Networks

O-CU: Open-CU

O-DU: Open-DU

O-RAN: Open-RAN

O-RU: Open Radio Unit

OPEX: Operational Expenditures

OVS: Open Virtual Switch

PLC: programmable logic controller

QoS: Quality of Service

QIF: Quality Information Framework

RAN: Radio Access Network

RL: Robot Link

RU: Radio Unit

AIDI: Average Interruption Duration Index

SCQ: Smart Connected Quality

SKPI: Service KPI

SLA: Service Level Agreement

SLE: Service Level Specification

SLI: Service Level Indicator

SLO: Service Level Objective

SO: Software Orchestrator

URLCC: Ultra-Reliable, Low Latency Communications

VNF: Virtual Network Function

VoMS: Vertical-oriented Monitoring System

VSMF: Vertical Service Management Function

VS: Vertical Slicer

YTV: Yearly Total Value

ZDM: Zero Defect Manufacturing

# Executive Summary and Key Contributions

5Growth D1.3 is the final deliverable of WP1 summarizing the work achieved on the Business Models, SLA elicitation and business layer modelling. It provides information, analysis, and main findings from pilot overviews and requirements and business models to techno-economic analysis and SLA elicitation.

The pilot overview provided in this document focuses on the most important business requirements that create value for all kinds of stakeholders: operators, service providers and verticals.

Following the line of work that was proposed in D1.1 [1] this deliverable identifies the main stakeholders, searching for the commonalities among the different vertical pilots, and their specific roles. Afterwards, the relationship among these stakeholders and the business value chain is established. Finally, the main business benefits of the pilots are identified, with the aim to setup the foundation for techno-economic analysis.

The techno-economic analysis gives a projection of the economic advantages that could be offered by 5Growth at a European scale. These economic advantages derive from savings on both CAPEX and OPEX as well as new models of revenue, obtainable thanks to a higher productivity or a better product quality.

For SLA elicitation, this deliverable defines a Business Layer with functional components based on (*i*) a discovery phase assisting on the establishment of relationship among different stakeholders participating in the 5Growth ecosystem, (*ii*) a negotiation phase determining the SLA that will be applied from the service perspective, (*iii*) a fulfilment phase provisioning the necessary resources and functions to serve the vertical request, and (*iv*) an adaptation phase to make any changes to the previously agreed SLAs.

# 1. Introduction

This deliverable provides a complete overview of the work done in WP1 - Business Modelling and Validation, based on the concepts and methodologies reported in previous deliverables.

Section 2 includes an overview of the pilots and a summary of the main requirements from a business point of view.

Section 3 contains the detailed design of the business models of each stakeholder for each pilot, using the Business Canvas methodology [2], in which the main actors, activities and strategies are identified.

Section 4 details the techno-economic analysis of the pilots, identifying and quantifying the main benefits of incorporating 5G technologies in each pilot, and distributing these benefits among the different stakeholders, thus validating the previously designed business models.

Finally, section 5 discusses the modelling of the business layer and the elicitation of service level agreements (SLAs) between verticals and operators.

# 2. Pilot Overview and Requirements

D1.2 [3] has reported the pilot overview, focusing on the most important business requirements. Furthermore, the deliverable also has identified main business benefits of the pilots, to setup the starting point for the techno-economic analysis.

The working methodology in WP1 is based on a continuous research and update, so requirements are constantly updated.

It is worth noting that the present document is a conclusive deliverable, and this section essentially updates D1.1 [1] and D1.2 [3]. In particular, towards the end of the project it would be important to consider what is really achieved in terms of the KPIs drafted at the beginning, which are the gaps, in terms of innovation, that the envisaged solution provides as a new feature.

An important consideration about the adoption of 5G has to be done. In fact, since the beginning, we considered 5G as an essential feature to provide the innovations required by the pilots. After more than two years of project, it is honest and indispensable to sum up and answer two disruptive but essential questions:

- Why is 5G useful in comparison to other existing technologies? In a more concrete way, which are the benefits of 5G for each pilot, with respect to other technologies, e.g., WiFi, LoRA, etc.
- Is 5G connectivity really needed for the verticals?

To answer these questions in a useful way, we consider assigning each Pilot to a particular category:

- CATEGORY A: There is at least one KPI requiring 5G, i.e., it is not possible to achieve needed performance/latency/connection density with 4G or 4.5G.
- CATEGORY B: There are no KPIs strictly requiring 5G performance, but they will benefit from 5G performance, or 5G will be essential for wide penetration of the service.
- CATEGORY C: There is no KPIs strictly requiring 5G performance. The use case can be performed using 4G/4.5G.; However, the trial will demonstrate effectiveness in a 5G environment as they may be a driver for other services or for a long term, strategic success in the specific vertical.

## 2.1. Industry 4.0 Pilot – INNOVALIA

This pilot is based on two main trial use cases:

- P1UC1: Connected Worker Remote Operation of Quality Equipment: This use case investigates 5G network broadband capacity and latency reduction to enable the implementation of a global virtual joystick for remote programming, configuration, and calibration of the CMM for quality control routines. It also deals with how 5G technologies can be used to support large 3D point cloud for computational geometry processing and visualization while keeping the time required to perform this analysis low.
- P1UC2: Connected Worker Augmented Zero Defect Manufacturing (ZDM) Decision Support System (DSS): The second UC works on top of the improvements performed under P1UC1.

Thus, apart from having a CMM system able to be remotely controlled and to perform the processing and analysis of metrological data using 5G network and 5G-core capabilities, a second aspect addressed in this use case is the development of a new M2M collaboration process. This will automate the process of loading the inspection program for the CMM, while an AGV is transferring the piece to be measured from the production line to the measuring station.

Table 1 summarizes the target business Key Performance Indicators (KPIs) for the INNOVALIA pilot.

**TABLE 1: TARGET BUSINESS KPIS FOR THE INDUSTRY 4.0 PILOT – INNOVALIA**

| | |
|---|---|
| 5G Service required | • Reduce cost of production by 10%<br>• Increase the production throughput by 15%<br>• Reduce customer visits by 40%<br>• Reduce scrap of at least 10% with an objective of 100%<br>• Predict up to 30% of form and/or welding errors<br>• Reduce service response time by 50% |
| These use cases will require both eMBB slice for the 4K video streaming and an URLLC slice for the communication between the CMM and the Cloud-Edge and the virtual joystick operation. | |
| Output | |
| The use case will prove that the network delay and resilience provided by either eMBB or URLLC slice that are needed to make this use case properly work for latching between the 4K video and virtual joystick service in the remote configuration of the Vulkan equipment, and especially for the proper processing of metrological data. | |
| Benefit | |
| Customers will not be forced to send large parts of their equipment to INNOVALIA Metrology laboratories (high cost and waste of time) while, at the same time, INNOVALIA will not need to send workforce abroad to program control strategies, for long periods of time. Also, the optimization of the usage of the CMM, as it will be possible to measure different references in a much faster way through the integration of M2M communication for ZDM DSS. | |

Even if business KPIs are hard to be measured in this phase of the project, be-weekly WP1 conference calls permitted to continuously check and update business KPIs. what is reported in Table 1 represents the latest version with realistic figures.

### 2.1.1. Innovation items

Several innovations are needed in order to reach the technical and operational capabilities required by the pilot. Furthermore, these need to reach a certain level of maturity for the use case to be able to transform ultimately into a commercial application, and thus bringing the business value. In connection with the tasks realized under WP2, the specific advances identified as key for a fruitful completion of the INNOVALIA pilot, and its use cases are innovations in the Vertical-oriented Monitoring System (I2), the Control-loop stability (I4) and the AI/ML support (I5), along with capabilities of Federation and Inter-domain (I6), Next-generation Radio Access Network (I7) and finally innovations in Smart Orchestration and Resource Control (I8). These innovations contribute overall to the general feasibility of the project and business modeling.

### 2.1.2. Gap analysis and innovative features

In terms of gap analysis, i.e., which problem(s) the use case has the ambition to cover, there is, for sure, the need for remote operation of the equipment, and M2M collaboration using 5G.

Nowadays (before the use case becomes operative) the staff must travel every time to a customer who needs to make a small change on the measurement process. Remote operation would allow to perform many of these tasks from one site, thus reducing costs both for the company and for its customer.

## 2.2. Industry 4.0 Pilot – COMAU

This pilot is based on three main trials use cases:

- P2UC1: Digital Twin Apps: The main idea is to replace the existing cable infrastructure by enabling wireless communication through 5G and, instead of owning and operating it, just paying for the service provided by telco companies.
- P2UC2: Telemetry/Monitoring Apps: Failure detection is a challenge throughout the manufacturing industry. Issues such as vibration patterns affecting the robots could be revealed by monitoring the process in real time.
- P2UC3: Digital Tutorials and Remote Support: This use case has the objective to reduce the Mean Time to Repair (MTTR), as well as the cost of maintenance and fixing activities. It is achieved by providing a digital tutorial library combined with remote support thanks to high-definition live streaming via 5G connection.

Table 2 summarizes the target business KPIs for the COMAU pilot. The objectives listed in the table should be interpreted as "objectives" obtainable with the concurrent implementation for all three use cases, rather than associating them with each one individually. For example, reducing repair time (MMTR) by 20% can be a goal that can be achieved both by having an eye on the digital twin of the plant (UC1), and by having monitoring information available for predictive maintenance (UC2), and finally having the remote support tools (UC3) for the technicians on site.

**TABLE 2: TARGET BUSINESS KPIS FOR THE INDUSTRY 4.0 PILOT – COMAU**

| | |
|---|---|
| 5G Service required | • Reduce infrastructure cost by 20%<br>• Reduce MTTR by 20%<br>• Reduce technicians' travels by 30% |
| This set of use cases require eMBB service to deliver the un-interrupted video streaming to multiple users with high-definition formats. | |
| Output | |
| Given the fact that 5G can support increased bandwidth demands, these use cases will deploy applications that will allow users to remotely access digital tutorials and support remote technicians though live connections at high resolution in real time. | |
| Benefit | |

| | |
|---|---|
| Main benefits will be an increase in productivity due to the possibility to access live tutorials/instructions and video tutorials, as well as a reduction of MTTR thanks to the real-time connection with technicians in remote locations supporting maintenance and repair operations. | • Reduce failure rate at least of 20% with objective 90%<br>• Service response time reduced by 30% |

Even if business KPIs are hard to be measured in this phase of the project, they have been continuously checked and updated (in the bi-weekly WP1 conference calls) and what reported in Table  is the latest version with realistic figures.

In particular, the reduction of MTTR by 20%, as the most important KPI, has been achieved and directly measured using the AR maintenance tool. However, reducing infrastructure cost is not directly measured because the cost of the equipment is not available since the degree of innovation does not consider the scale size of the production, but a forecasted evaluation can be provided, reported in section 4.

### 2.2.1. Innovation items

In this pilot several innovations are to be taken into account and to be developed in order to reach a level necessary to be commercially deployed. Considering what it has been envisaged in WP2, the innovations identified as fundamental for an accomplishment of the use cases considered in the COMAU pilot are related to in particular to the Support of Radio Access in Network Slices (I1), the Vertical-oriented Monitoring System (I2), the Control-loop stability (I4), the Next-generation Radio Access Network (I7) and, finally, all comprehensive under the Smart Orchestration and Resource Control (I8) innovations umbrella.

The innovations mentioned are fundamental to the general feasibility of the project, as well as to the development of an adequate business model, if considered as a whole. Details on the economic values of savings and new earnings are given in section 3.

### 2.2.2. Gap analysis and innovative features

In terms of gap analysis, i.e., which problem(s) the use case has the ambition to cover, there is for sure the remote monitoring of production lines and low-latency remote control, together with predictive maintenance and remote support and thus reducing the travel cost/time and MTTR as well as maintenance training.

Currently the most effective way to understand the actual behaviour of a production line is to physically go close to it. Low-latency robot remote control is a key enabler towards integrating advanced robot behaviours as well as for mobile robotics. Having a plethora of different sensors leads to a more effective physical representation and thus to a more effective predictive maintenance. Remote assistance cut the need of moving the right technical physically where the problem actually is.

## 2.3. Transportation Pilot – EFACEC Engenharia e Sistemas

In the pilot, it is desirable to replace cabled based networks by 5G technologies, assuring two types of communications: safety critical and non-safety critical.

Table 3 summarizes the target business KPIs for the transportation pilot, defined at the beginning of the project.

**TABLE 3: TARGET BUSINESS KPIS FOR THE TRANSPORTATION PILOT – EFACEC ENGENHARIA E SISTEMAS**

| | |
|---|---|
| 5G Service required<br>This pilot requires URLLC services/slices in order to transmit the safety critical communications between the Level Crossing (LX) controller and the level crossing train detector. And an eMBB slice is needed to transmit high-definition video to the train controllers and also a URLLC slice to transmit alarms and controller status to the maintenance agents.<br>Output<br>In this pilot a complete half barrier level crossing control system in a railroad crossing in the Aveiro harbor premises will be installed. The system will include a LX controller cabinet equipped with SIL48 safety PLC, an axle counter train detection system, EMC protections devices, an uninterruptible power supply and a 5G CPE. Each approaching train detectors will use a 5G CPE to communicate with the level crossing controller. Two half barrier drives, controlled by the LX controller, will protect the entry of cars at the rail crossing during the train approaching and passing. All the communications will be supported by safety-critical protocols (Safe Ethernet and RASTA), developed, and certified under the scope of the project.<br>Besides, a train engine will be equipped with an onboard 5G tablet, a level crossing with an HD video camera and a server that will connect the LX controller and the camera to the cloud using 5G communications. A mobile tablet will allow the monitoring and control of the level crossing systems. An app running in the maintenance agent tablet will allow the remote control of all LX system.<br>Benefit<br>The solution should reduce the level crossing CAPEX by 20%, the XSafe (EFACEC_S Level Crossing solution) level crossing system product will become more competitive with respect to the traditional wired level crossing signaling solutions. The level crossing time installation will be reduced by 50%.<br>Also, there is currently the development of a new market for the mobile video level crossings safety reinforcement with public standard communications. The remote asset monitoring from anywhere using 5G will allow much more competitive, mobile, flexible, and agile solutions compared to the actual wired solutions, allowing the reduction of costs and service response/reaction time, and creating new market. | • Reduce system CAPEX by 20%<br>• Reduce system installation cost by 50%<br>• Reduce installation time by 50%<br>• Reduce cable cost by 80%<br>• Reduce maintenance visits by 20%<br>• Reduce service response time by 20% |

In terms of performance KPI the latency for both the considered use cases are in line with the expectations. Concerning Bandwidth (needed for the Telemetry/Monitoring Apps) the measured values are bit lower than with the expectations, but improvements are being performed.

### 2.3.1. Innovation items

The transportation pilot will provide an unprecedented experimental stage to not only validation for the first time ever the contribution of 5G technologies and 5Growth service platform in such scenarios, but also to allow the validation of 5Growth innovations developed in WP2. In this scope, besides the main operation associated with the presented use cases, two innovations were validated in this experimental setting, i.e., the Inter-domain (I6) and Security (I11) innovations. These innovations will thus allow to take advantage of the unique characteristics of this scenario and will focus on the technical exploration and assessment of new mechanisms.

### 2.3.2. Gap analysis and innovative features

The main gap is related to the capability to use a 5G wireless network instead of a cable network assuring the same level of integrity (SIL) and compliance for supporting signaling Operations at Level Crossing environments. Also, the use of HD video transmission to reinforce the safety conditions of a Level Crossing represents an important innovation.

For the moment there are no train Level Crossings supported by 5G Technology. IP protocols, safety protocols, security issues are key goals to address since we are moving from close communications environments to open ones.

## 2.4. Energy Pilot – EFACEC Energia

EFACEC Energia's energy vertical pilot involves the deployment of two use cases:

- Advanced Monitoring and Maintenance Support for Secondary Substations MV/LV Distribution Substation.
- Advanced Critical Signal and Data Exchange across wide smart metering and measurement infrastructures

Their main purpose is to demonstrate the 5G capability to provide advanced monitoring and maintenance support for the Secondary Substations MV/LV Distribution Substation assisting the Control Centre operator and the teams dispatched to the field to better assess the severity and the impact of the outage they are facing.

Table 4 summarizes the target business KPIs for the energy pilot.

**TABLE 4: TARGET BUSINESS KPIS FOR THE ENERGY PILOT – EFACEC ENERGIA**

| 5G Service required | • Reduce SAIDI for LV (Low |
|---|---|
| This pilot requires eMBB services to support the video camera and augmented reality streaming, complemented with additional URLLC services | |

| | |
|---|---|
| for the time sensitive augmented reality application. It requires URLLC for the transmission of critical signals.<br>**Output**<br>An advanced monitoring and maintenance support should be available to assist the remote operator and then the crews dispatched to the field to better assess the severity and the impact of the outage they are facing. From the local surveillance systems available in the secondary substation, an HD video signal must be streamed in nearly real-time to the control center and to the mobile devices of the maintenance crew moving to the site. Aware of the infrastructure state, the maintenance crew and the operator managing the intervention, can be more efficient when implementing contingency and service restorations measures. Locally, the maintenance crews should also be capable of assessing an augmented reality<br>experience on the affected critical assets. The maintenance crews will thus gain an insight over the damage magnitude and the immediate consequences of the outage they are dealing with, leading to shorter response times.<br>**Benefit**<br>Enhanced performance from the advanced monitoring and maintenance support of secondary substation is crucial to improve the outage management and match the high reliability indexes required within a smart grid environment. Additionally, the improvement of the advanced critical signal and data exchange across wide smart metering and measurement infrastructures is crucial for the deployment of advanced control applications. | Voltage) in 15%: System<br>• Average Interruption Duration Index (SAIDI) measures the average of the total long duration of interruptions affecting the average delivery point for a given year<br>• Reduce ENS in 5%: Energy not supplied |

The text on Table 4 has been updated with respect to previous version reported in D1.2 [3]. In particular, despite being on-topic concerning the LV distribution smart grid and the type of automation systems involved, the mMTC is out of scope of both Energy Pilot use cases, but URLCC is becoming principal.

The reduction in maintenance costs (remote and local), and also the Average Interruption Duration Index (SAIDI) and the reduction in Energy Not Supplied (ENS) were not directly measured in this phase of the project. Nevertheless, the criteria that lead to the presented impact values in each have been accomplished.

### 2.4.1. Innovation items

The energy pilot will provide an unprecedented experimental stage to not only validate for the first time ever the contribution of 5G and 5Growth mechanisms in such scenarios, but also to allow the validation of innovative new mechanisms.

In this scope, besides the main operation associated with the presented use cases, two innovations will be validated in this experimental setting, i.e., the Inter-domain (I6) and Security (I11) innovations.

These innovations will thus take advantage of the unique characteristics of this scenario and will focus on the technical exploration and assessment of new mechanisms.

### 2.4.2. Gap analysis and innovative features

The main gap is related to remote supervision of the low voltage distribution electrical network, providing real-time telemetry and enhanced metering information (surveillance video streaming, blown-fuse detection, last-gasp detection) to the Low Voltage Dispatch Centre and to the field maintenance teams.

The current communication technologies used in the low voltage network (mainly PLC and Wi-Fi mesh supporting advanced metering infrastructures) and to connect the secondary distribution substations (GSM/GPRS-3G) can't support the use cases proposed by Energy pilot in 5Growth project.

In fact, in the present to determine the origin and nature of a fault in the low voltage network, the maintenance crew must be sent to the area reported as being with no power supply, most of the time with no better information than the one got from the received customers calls.

With the real-time and enhanced information on the power network and devices, upon the occurrence of a fault the maintenance team can be dispatched with no delays, directed to a much more narrowed area, and better prepared to the type of fault and related damages.

## 2.5. Role of 5G

As reported in the introduction to this chapter, it is not trivial checking how much the 5G technology is important for accomplishing the pilot use cases. Table 5 summarizes these considerations.

**TABLE 5: CATEGORIZATION OF PILOTS' USE CASES**

| | | | |
|---|---|---|---|
| Industry 4.0 (INNOVALIA) | P1UC1: Connected Worker Remote Operation of Quality Equipment. | A | Latency |
| | P1UC2: Connected Worker Augmented Zero Defect Manufacturing (ZDM) Decision Support System (DSS). | A | Latency |
| Industry 4.0 (COMAU) | P2UC1: Digital Twin Apps. | A | Latency, Position accuracy |
| | P2UC2: Telemetry/Monitoring Apps. | B | Latency |
| | P2UC3: Digital Tutorials and Remote Support. | C | --- |
| Transportation (EFACEC_S) | P3UC1: safety critical | A | When comparing it with 4G both Use cases belong to category A regarding latency, bandwidth, and |
| | P3UC2: non-safety critical | A | |

| | | | |
|---|---|---|---|
| | | | mobility (trains capable to receive video at speeds about 80Km/h) |
| Energy (EFACEC_E) | P4UC1: Advanced Monitoring | B | Latency |
| | P4UC2: Maintenance Support for Secondary Substations MV/LV Distribution Substation | A | Latency, mobility, slicing |

In addition, Table 6 summarizes which are the main benefits of 5G in comparison with other existing or research-phase technologies.

**TABLE 6: BENEFIT OF 5G WITH RESPECT TO OTHER TECHNOLOGIES**

| | |
|---|---|
| Industry 4.0 (INNOVALIA) | Very low latency is the main benefit of 5G, as metrology equipment and software require a very precise synchronism to be able to complete the measuring process (In the communication between the cloud-edge service and the CMM), and also because it implies the movement of a robot, and the sync between the video received and the movements of the operator (in the communication between the M3 software, the cloud-edge service and the CMM). |
| Industry 4.0 (COMAU) | With respect to Wi-Fi, 5G is giving huge improvement in latency, private spectrum and slicing (and so, security), mobility, device density and Gigabit bandwidth.<br>In comparison with wired (e.g., cable or fibre) 5G is improving the cost of ownership and the flexibility in case of re-arrangement |
| Transportation (EFACEC_S) | 5G achieves better in performance, slicing, bandwidth, security, public network with QoS., thus huge benefits when replacing cables by wireless. |
| Energy (EFACEC_E) | In terms of latency, slicing feature in 5G is really better with respect to PLC and Wi-Fi. When comparing with GSM/GPRS-3G, 5G gives an improvement in bandwidth and device density. Finally, the mobility guaranteed by 5G is really a plus with respect to wired solutions. |

# 3. Business Model Design per Pilot and Stakeholder

This section gathers the design of the business model for pilots, explored in D1.1 [1], that intends to be validated in 5Growth. First, the main stakeholders were identified, searching for the commonalities among the different vertical pilots, and with specific roles. Then, the relation between these stakeholders and the business flow is established.

Furthermore, the specific value proposition and Business Model for each stakeholder, is described in more depth in this section with the help of the Canvas model and will be validated within this deliverable.

## 3.1. Industry 4.0 Pilot – INNOVALIA

The INNOVALIA pilot is the most complex one, regarding the business flow, as it is the one with more stakeholders playing different roles. Figure 1 depicts the business relationship between the stakeholders involved in the INNOVALIA pilot.

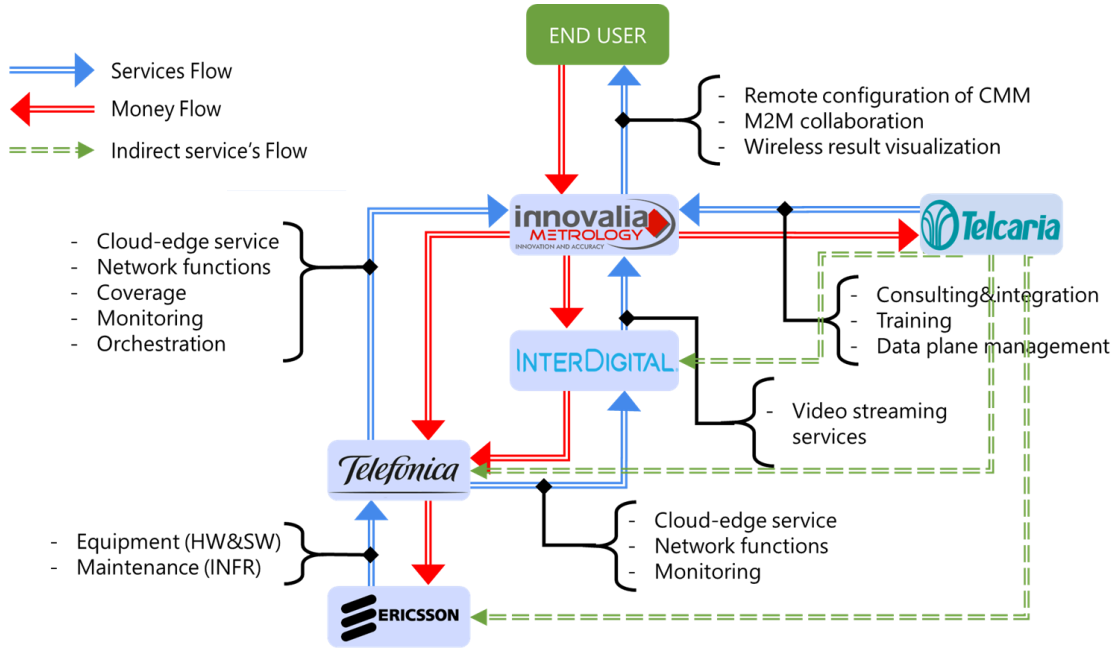


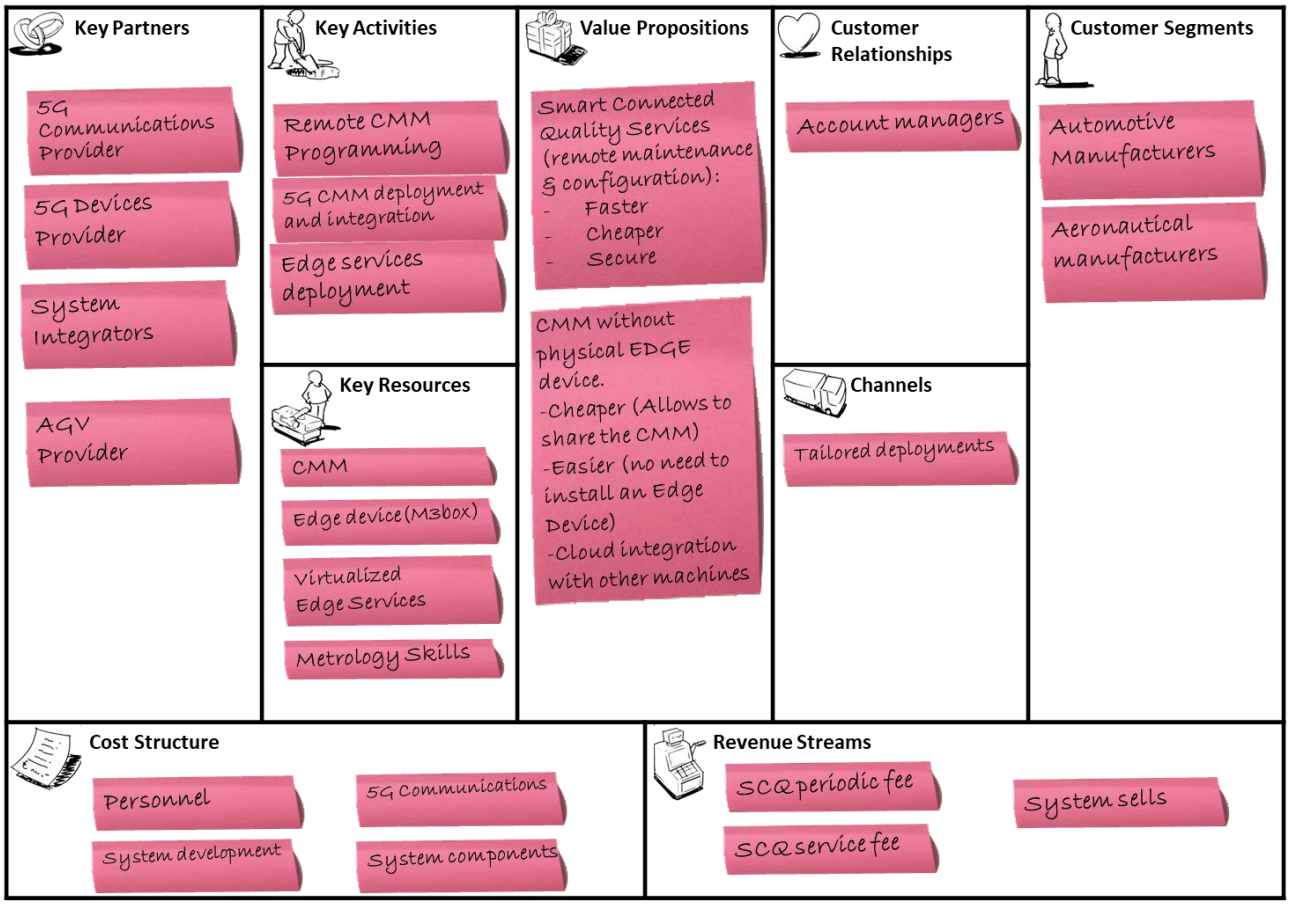

**FIGURE 1: INNOVALIA'S PILOT BUSINESS FLOW**

INNOVALIA is the Service Consumer of the 5G ecosystem but, to some extent, their customers are also Service Consumers, as part of the deployment is going to be at their premises, and they will also use the services. These services will be provided by two stakeholders: on one hand, Telefonica (TID), mainly providing communication services, edge-cloud services, network functions, indoor coverage, and also monitoring and orchestration services. On the other hand, there is an intermediate stakeholder, which is InterDigital (IDCC), providing video streaming services to INNOVALIA and, at the same time, consuming services (network functions, cloud-edge and monitoring services) provided by Telefonica (TID). Ericsson, on its side, will provide Telefonica with the equipment required to provide 5G services, both hardware and software. Also, will take care of the maintenance during

operation of this equipment. Finally, Telcaria will provide INNOVALIA with consulting and integration services, as well as data plane management and training services. As the services INNOVALIA wants to offer require that every customer deploys a 5G solution, Telcaria will design and integrate the new deployment to make it compatible with the customer's infrastructure.

The specific value proposition and Business Model of each stakeholder in the INNOVALIA Industry 4.0 Pilot is described in more depth in the following section.

### 3.1.1. Service Consumer – INNOVALIA




**KEY PARTNERS**

For the business model here presented, INNOVALIA intends to establish business relationships with:

- 5G communications providers (Telefonica…): that can provide a 5G slice on-demand to support the needs for plug-on, plug-off wireless data communication of high bandwidth, low latency and high reliability. This is the key component of the 5G solution to be commercialised, and an integral part of the broader Smart Connected Quality philosophy. INNOVALIA's main goal is to acquire 5G connection capabilities and processing power for the virtualised M3 execution engine in an IaaS modality.

- AGV provider (ASTI…): Related to the innovations within the second use case, the goal is to be able to establish a fair and transparent communication protocol between robots in the factory (AGVs) and the Quality Control device (CMM via M3 software). This will enable to establish human-machine-information communication schemes, then can leverage the low latency, high reliability of 5G technology.
- System integrator (Telcaria…): Since INNOVALIA's area of expertise is not within 5G nor telecommunications in a broader sense, the company could benefit to hire the services of a service integrator with broad knowledge in the field. This will enable to navigate these advanced innovations in a smoother manner, so INNOVALIA can focus on its core business (metrological HW, SW and services development).

**KEY ACTIVITIES**

The key activities to be developed by INNOVALIA within the business model are:

- 5G CMM programming: This is the key service offered by INNOVALIA within this business model. It can be offered directly to new clients looking to install a new quality control system from INNOVALIA Metrology, or to old clients that wish to improve their current quality control devices into smart, connected ones. The service offered is the remote programming of the quality control process via 5G communication. This is an on-demand service that will be provided over the lifetime of the CMM.
- CMM deployment and integration: new clients aiming to acquire quality control devices powered by 5G will also buy an INNOVALIA metrology CMM and software, which will imply its proper installation at the client's premises and the integration with the relevant components of the line of production.
- Edge service deployment: The virtualisation of part of the M3 metrological software entails several benefits that will be explored in other sections. However, it requires the development of this virtualised app, its deployment within the 5G core and the proper integration and connection between 5G core and the CMM.

**KEY RESOURCES**

INNOVALIA will have an integral quality control system prepared for remote control and programming via 5G. The key resources to be leveraged by INNOVALIA are:

- CMM and M3: The Coordinate Measuring Machine is the central component around which the quality control process is built. INNOVALIA Metrology is leader in integral hardware solutions for quality control. This includes the machine itself, in various and diverse formats (Vulkan, Gantry, Bridge-type, robot, etc.) adapted to different scenarios; the optical sensor OptiScan (built and designed in-house); and all the electronical integration. It also includes the proprietary metrological software M3, enabling data process, 3D-point cloud representation, simulation, digital twin generation, advanced analytics, and capacity to be leveraged within ZDM strategies.
- Edge Device (M3Box): this novel device performs proper pre-processing of data, enabling the remote communication via 5G under two circumstances, greatly simplifying the deployment:

1) When the deployment of fog services from the 5G core are not possible. It contains software (RL and DA) enabling the processing and control of the CMM in a smooth way, and sending pre-processed, clean, secure, synchronised metrological data to the experts controlling the CMM remotely. This metrological data will be standardised according to Quality of Information Framework (QIF), allowing for multi-platform, multi-device standardised communication required in ZDM implementation.
2) When the deployment of the virtualised RL and DA within the 5G core is possible, M3Box will enable the communication between software thanks to an integrated OVS.

- Virtualised Edge devices: INNOVALIA's virtualised apps of its data processing and control software (RL and DA), able to be deployed within the 5G core (2nd option explained for the Edge Device in the previous point), will allow the dynamic deployment of 5G metrological services, by taking advantage of the optimisation and increased computational power of a full 5G implementation.
- Metrology Skills: the metrological skills of the INNOVALIA experts are paramount for this remote-control business model, centred around the externalisation of the metrological drudgery so the client can focus on their core business. Furthermore, skills regarding the installation and configuration of new metrological services and devices, and of ZDM strategies, is key.

**VALUES PROPOSITIONS**

The key value propositions within INNOVALIA's business model are:

- Smart Connected Quality services: this includes remote assistance, remote maintenance, and remote configuration of the metrological equipment by experts from INNOVALIA. The main benefits will be to obtain faster, cheaper, more secure, and more environmentally friendly quality control of the manufacturing process. The time of response and time-to-deployment will be drastically reduced.
- CMM without physical edge device: if a company is suitable to benefit from a full 5G deployment, the data processing and command control apps within M3 architecture are virtualised into the 5G core. This allows on the one hand to reduce redundancies and computational power required on-site. Furthermore, it allows for fast and secure cloud integration with other CMMs and other machines, opening the gate to M2M and H2M collaboration and ZDM strategies.
- Simple, standardised metrological process: one of INNOVALIA's core advantages is to have an array of different metrological solutions, which allow to acquire devices optimised for the processes' requirements. Furthermore, all the devices run with a unique M3 software, which aside from having state-of-the-art capabilities, enables interoperability throughout the shopfloor, and thus industry 4.0 and ZDM strategies.

**CUSTOMER RELATIONSHIPS**

The customer relationship will be handled through account managements, allowing to establish personalised solutions. As Quality Control becomes one of the core components within I4.0 and ZDM

paradigms, trust and rapport will become increasingly valued by clients when considering handling this service outside of their premises.

**CHANNELS**

Metrological services are inherently dependent on the processes and products which quality they need to control. Thus, while some degree of automation and standardisation is possible and suitable (first to achieve interoperability, second, to reduce deployment and operation time, and third to reduce overall cost), the deployments ought to be tailored for each client's idiosyncrasy.

**CUSTOMER SEGMENTS**

Metrology is a key sector that is by definition transversal to the rest of the industrial sectors. However, INNOVALIA Metrology specialise in some key sectors such as automotive and aeronautical manufacturers. This is due to several characteristics shared between them, such as:

- High importance of the quality level of their final products.
- Top-notch technological materials, processes, and machines: these sectors are usually leaders in the implementation of new developments.
- Tight scheduling and organisational control.
- Mid to high financial capacity, which allows the purchase of expensive metrological equipment and tailored services.

**COST STRUCTURE**

The cost structure of INNOVALIA's business model is:

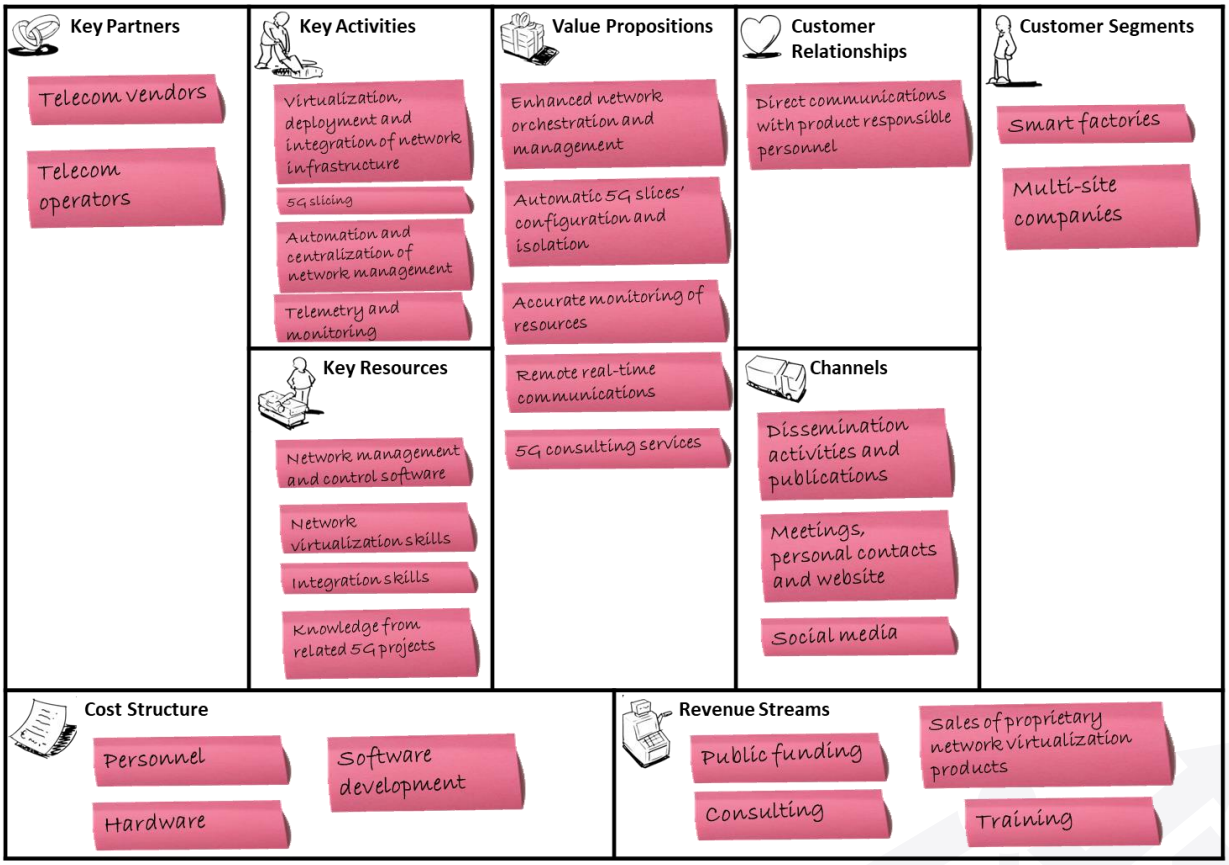
- System development: this is the cost related to the innovation required to achieve a state-of-the-art metrological system, which including but not limited to innovation within 5Growth, project. Furthermore, since it the target sector are technology leaders, a continuous improvement of the services and devices provided is required if the company wants to retain its competitive advantage.
- System component: this item is unique per client, and refers to the cost of the installation of a new metrological system: CMM, Optical Scanner, M3Box Device, routers, cables… Once installed, these components are not to be replaced for several years.
- 5G communications: INNOVALIA's business is not within telecommunications, so it will need to buy the services to an operator (i.e., Telefonica), that will offer the 5G service in return. This cost will include an entrance fee for the installation of the services, a periodic fee for the bandwidth and latencies required, and a service fee every time the 5G NW is used.
- Personnel: The cost of personnel will include the time and skills required for the installation (single cost per client) and subsequently the cost of the metrological expert in charge of providing the quality control services (variable cost). It also includes the cost for commercial and marketing personnel.
- Infrastructure: since the services are to be provided from INNOVALIA HQ, there need to be a reliable, secure infrastructure there. This, plus the cost of the offices (and electricity, water, etc.) are part of the fixed cost that need to be taken into account.

**REVENUE STREAMS**

The Business model explored in this use case relies on three specific revenue streams, that are related although distinct:

- System cells: this will be the price charged to the client for the installation of a new quality control cell and the equipment engaged (CMM, OptiScan…). It is an individual income per client (unless they want to increase the metrological capacity). It is important to note that it is impossible to provide a fixed price (even estimated). This is because each deployment is tailored to the client (see "Channels), and thus they may require different Optical Sensors, different Machines (Vulkan, Gantry, etc.), different processing capacity (from small pieces to big parts) and different interoperability modes.
- Smart Connected Quality periodic fee: Once the system installed, a small periodic (monthly or annual) fee will be charged to the client. This fee allows the client to access the SCQ service.
- Smart Connected Quality service fee: this is a fee for the service provided, and will depend solely on the amount of time, skill required, and data transmission requirements of the service provided. A general guideline on price estimation will be accessible to the client, but due to the highly personalised nature of the industry, a concrete price will be calculated on an individual basis.

## 3.1.2. Operation Support Provider – Telcaria



**KEY PARTNERS**

Telcaria's key partners are related to the telecommunications' sector, including telecom vendors and operators, establishing partnerships for providing enhanced services through their networks.

**KEY ACTIVITIES**

They key activities covered by Telcaria are related to the provision of enhanced network services, also focused on 5G networks. Examples of activities are the virtualization, deployment, and integration of network infrastructure, 5G slicing, automation and centralization of network management or telemetry and monitoring.

**KEY RESOURCES**

Telcaria has developed its own network management and control software to deal with the Key Activities exposed, also relying on network virtualization and integration skills derived from Telcaria's expertise in these fields, together with the knowledge obtained from related 5G European research projects.

**VALUES PROPOSITIONS**

Telcaria offers enhanced orchestration and management of smart factories' networks. Regarding 5G services, it also provides automatic 5G slices configuration and isolation, ensuring the necessary communication conditions for smart factories' operation. Moreover, it provides accurate monitoring of resources to guarantee 5G slices over time, and remote real-time communications between factories' equipment and teleworkers to reduce travel costs. Finally, Telcaria also provides 5G consulting services to customers.

**CUSTOMER RELATIONSHIPS**

Telcaria's relationships with customers are directly established with product responsible personnel, in order to directly satisfy customers' requirements.

**CHANNELS**

Telcaria, as company involved in research, relies on dissemination activities and scientific publications to report their work. For the communication with customers, it also makes use of meetings, personal contacts, its own website, and social media.

**CUSTOMER SEGMENTS**

Telcaria is focused on smart factories willing to automatize their operation and on multi-site companies willing to reduce their network costs.

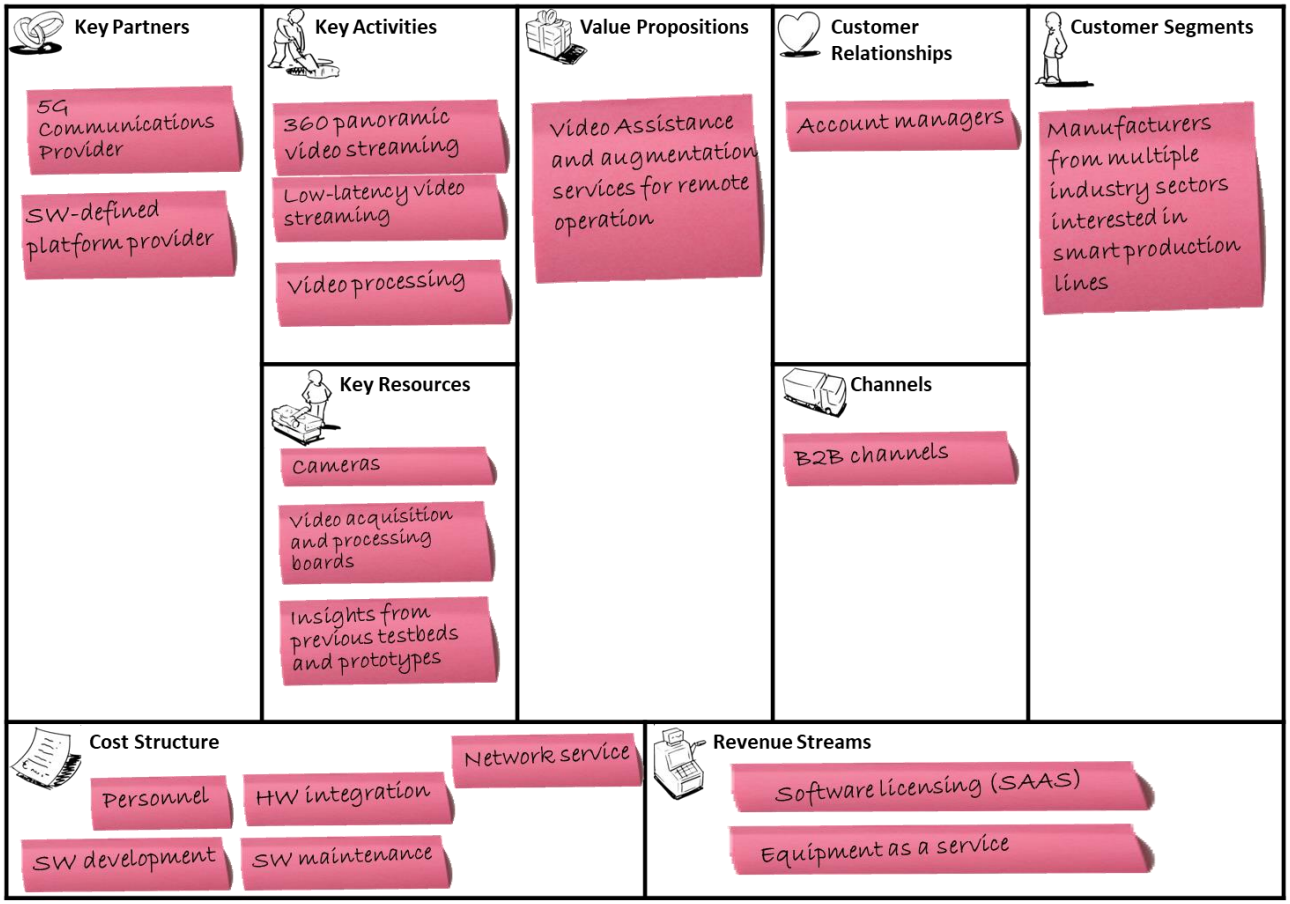
**COST STRUCTURE**

The main costs related to Telcaria's operation are the personnel, the hardware infrastructure used to provide services and the software development.

**REVENUE STREAMS**

With regards to the revenue streams, Telcaria relies on public funding, the consulting services offered, the sales of proprietary network virtualization products adapted to the software developed by Telcaria, and also training services for companies.

### 3.1.3. Service Provider – Interdigital




**KEY PARTNERS**

InterDigital's key partners mainly include 5G communications providers that operate 5G network and services and software-defined platform providers that enables platforms to run different functions including virtual functions as a software.

**KEY ACTIVITIES**

The key activities covered by InterDigital focus on video streaming and processing services. More specifically, 360-degree video streaming and video processing as well as low latency video transmission can be listed as the main activities.

**KEY RESOURCES**

The key resources to enable 360 video streaming and low latency video transmission are the 360-degree cameras, video acquisition and processing boards as well as experiences gained from previous activities on testbeds and prototyping.

**VALUES PROPOSITIONS**

InterDigital offers augmented telepresence for remote operation via its video assistance and augmentation services. These novel services would enable factory workers to remotely perform manufacturing tasks and/or augment the environment to perform dangerous tasks with robots.

**CUSTOMER RELATIONSHIPS**

InterDigital's relationships with customers are established with account managers that directly interact with the end customer.

**CHANNELS**

InterDigital relies on the B2B channels.

**CUSTOMER SEGMENTS**

Manufacturers from multiple industry sectors interested in smart manufacturing are considered as the customer segment.

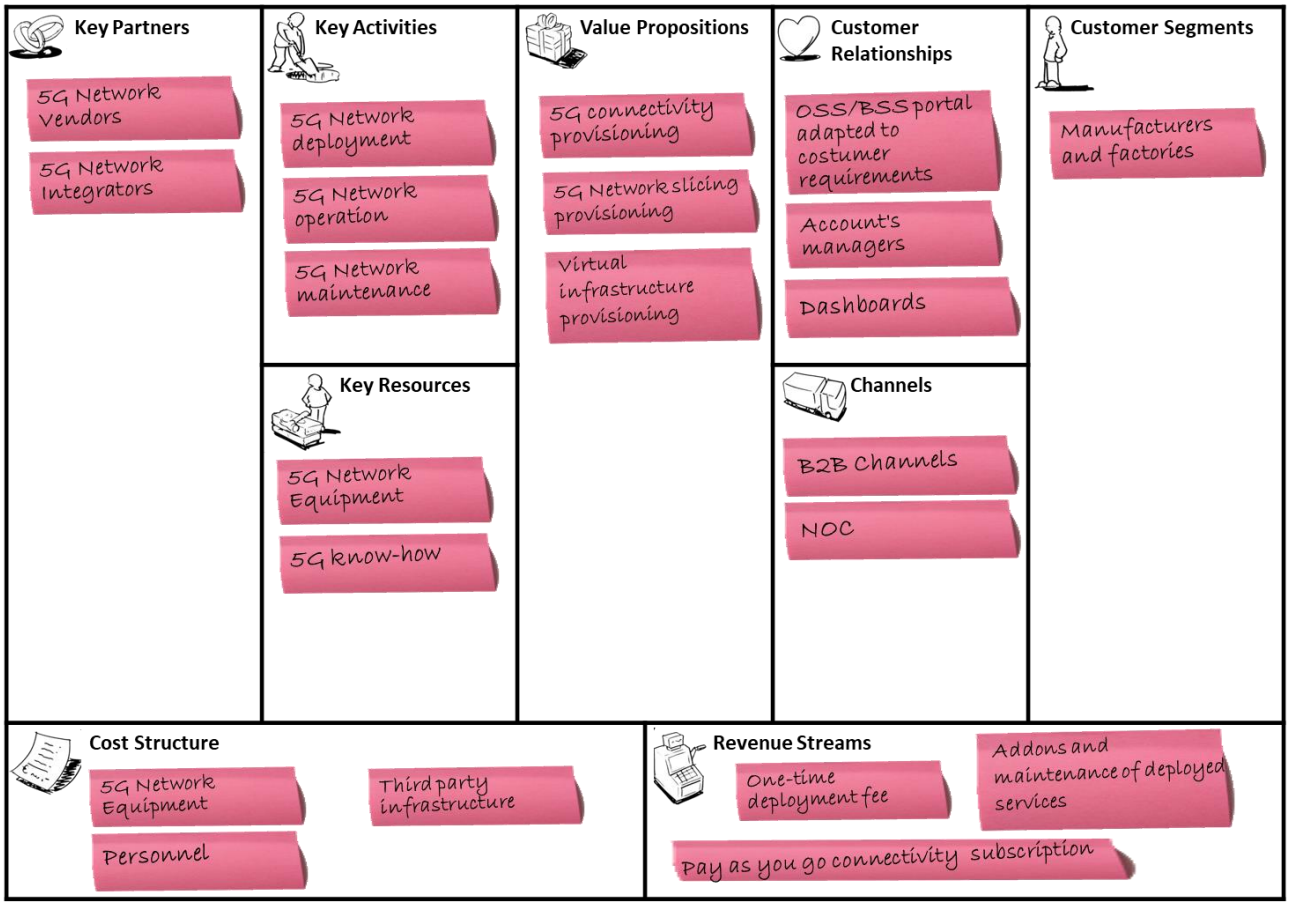
**COST STRUCTURE**

The main costs related to InterDigital are software development and maintenance, hardware integration, personnel, and network service.

**REVENUE STREAMS**

The revenue streams of this business model are video streaming and processing software licensing as well as equipment as a service. Regarding the equipment as a service revenue stream, cameras and/or servers that are capable of 360-degree video transmission/processing and low-latency video transmission can be considered.

## 3.1.4. Network Operator – Telefonica




**KEY PARTNERS**

TID's key partners include mainly 5G Network Vendors that provide all the required equipment for operating the 5G network and may include as well 5G network integrators that will help to put it all together.

**KEY ACTIVITIES**

As a telecommunication operator, TID key activities include the deployment of the equipment required to access the network, the operation of the different communication services based on the deployed network and if necessary, the maintenance and reparation of the network.

**KEY RESOURCES**

The key resources that allow TID to offer their value proposition are both the 5G network equipment and the 5G network know-how necessary for managing such a network.

**VALUES PROPOSITIONS**

The value proposition consists of three points. First, the 5G network connectivity provision that possibilities the existence of novel services. Second the network slicing provision that makes available

a particular virtual network for each of the novel services. Finally, the virtual infrastructure provisioning, for those novel services that require it.

**CUSTOMER RELATIONSHIPS**

TID's relationships with customers are established through an OSS/BSS portal adapted to the particular customer requirements, through account managers that directly interact with the end costumer or through a set of different Dashboards.

**CHANNELS**

As a telecommunication operator, TID will rely on the company channels, being the B2B Channels and NOC the most relevant for the project.

**CUSTOMER SEGMENTS**

The customer segments of this business model are the Manufacturers and factories that have the objective of modernizing and updating their operation by introducing 5G connectivity.

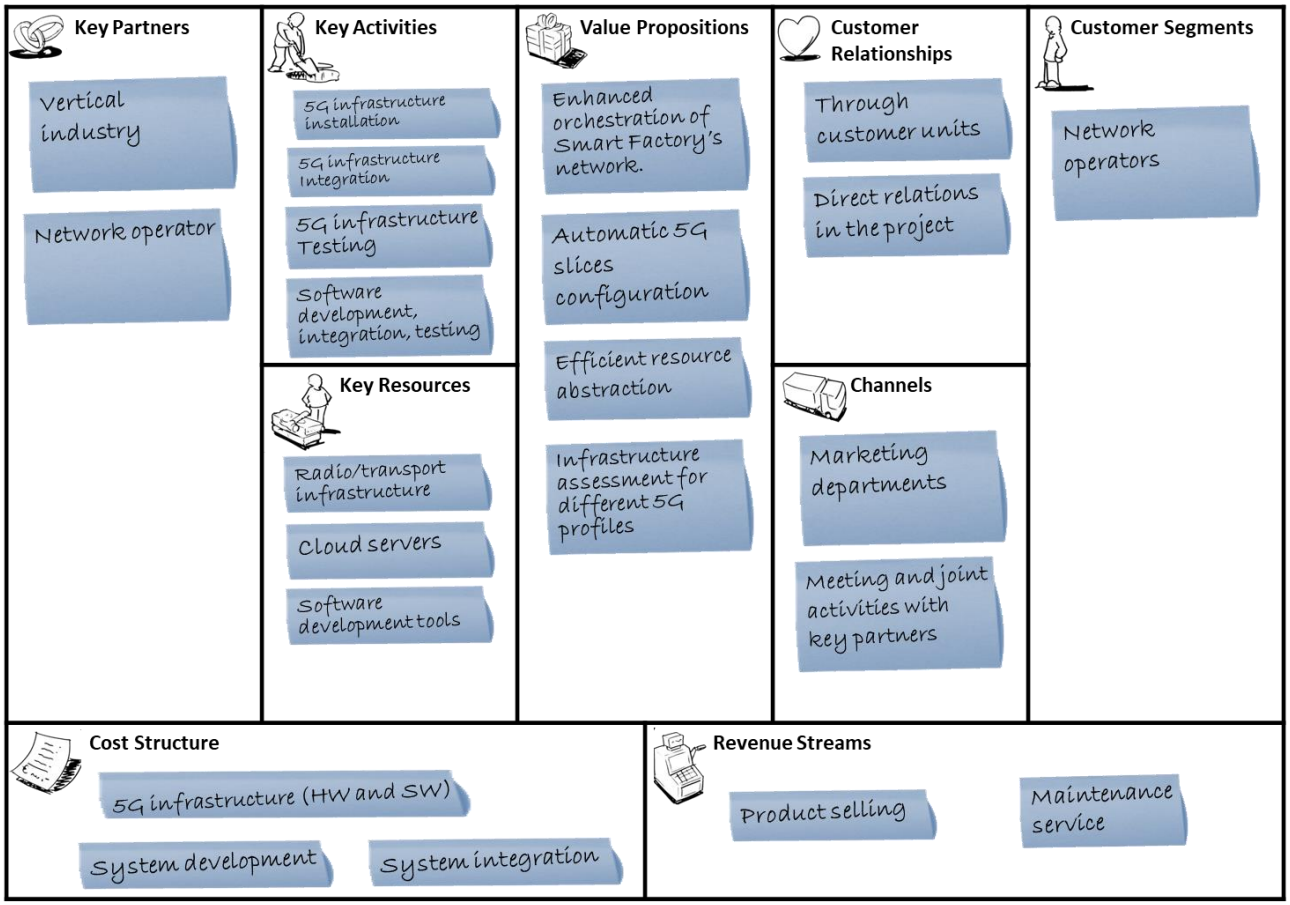
**COST STRUCTURE**

The cost structure of TID consist of the 5G network equipment that has to be acquired through vendors, the personnel that work for TID and that will perform the key activities and finally the third-party infrastructure that TID has to rent or buy.

**REVENUE STREAMS**

TID will perceive revenue through the one-time deployment of the 5G solution as well as a monthly pay-as-you-go subscription that will be charged to the costumer. In the case that the customer asks for addons or maintenance of the deployed solution, TID will also perceive a revenue.

## 3.1.5. HW/SW Provider – Ericsson




**KEYS PARTNERS**

Vendors of telecommunication infrastructures, like Ericsson, supply all the components of the industrial network to the Network Operator and, through them, bring the 5G equipment to the manufacturing plants. Transport elements, like optical networking systems, can be also part of the deployment. Software modules for orchestration and real-time network automation can be part of the overall offer.

**KEY ACTIVITIES**

The first activity in charge of a network manufacturer is to support the network operator in installing the various equipment constituting the telecommunication infrastructure. Specifically, it is related to the installation, integration, and testing of the hardware systems (e.g., antennas, base stations, optical fibres…). The telecommunication infrastructure is then integrated with the production infrastructure, e.g., the manufacturing line. This process of installing, integrating, and testing is also applied to the software components like the control and orchestration platforms.

**KEY RESOURCES**

The resources that are provided by the manufacturer are systems for radio and transport infrastructure, servers to support virtualized radio functions and, possibly, software at the application level, software tools for control and management of the network.

**VALUES PROPOSITIONS**

Ericsson offers in its portfolio an orchestration platform (namely Ericsson Orchestrator) which enables automation of hybrid infrastructures (radio, transport, cloud) including PNFs and VNFs. It supports Resource Orchestration, VNF Life Cycle Management and End-to-end Service Orchestration for both operators and enterprise environments. This orchestration platform includes a multi-layer, multi-domain, and multi-vendor hierarchical SDN controller for the orchestration of the various transport domains to build end to end connectivity with guaranteed constraints. The various domains can be managed via domain controllers from different vendors or belonging to different layer (e.g., IP/MPLS, Optical, Microwave).

The 5G network support network slicing which enables new business opportunities for communications service providers (Ericsson's customers) across a wide range of use cases and sectors, by making it possible to create fit-for-purpose virtual networks with varying degrees of independence. Ericsson has a complete portfolio of business support systems (BSS), operations support systems (OSS), RAN, transport, core network functions, cloud infrastructure and related services to realize the full potential of network slicing. Network slicing allows Ericsson's customers to serve different vertical needs with the same 5G network with significant savings in terms of TCO.

In addition, the resource abstraction technique can further facilitate operations and commercial deployment. Abstraction is a "compact" description of a resource (radio, transport, and cloud), exposing with the corresponding service parameters. Abstraction allows to hide resource details (such as quantity, vendors, location of the resource, physical details, real topology, etc.) and to consider the transport since the placement process starts.

In conjunction with different performance needs and vertical requirements, Ericsson can provide consultancy on the best infrastructure deployment in support to an optimal 5G coverage for the considered deployment area. This activity attains the network planning and assessment of the different 5G profiles that better matches the final user needs (for example low latency profile for remote robot control or massive machine type communication for a very dense sensor deployment).

**CUSTOMER RELATIONSHIPS**

Ericsson is one of the leading providers of Information and Communication Technology (ICT) to service providers and, particularly, to telecom operators. The whole world is "partitioned" in market areas like, for example, the Market Area Europe and Latin America (MELA) where are located all the pilots deployed in the 5Growth project. Inside each market area, specific customer units (CU) oversee the relations with the main customers, acting as organizational "contact points" between the company and specific customers.

In the project, the relationship with customers is also related to project experimentations and trials so, often, the relation is mainly at the "technical level". For example, in 5Growth the Ericsson Research laboratories directly interacts with the research centre of Telecom Italia TILab. As a possible follow-up of cooperation at technical level, the related commercial units can interact to leverage on the results obtained in the project to frame a business model or a commercial engagement.

**CHANNELS**

Communication channels are active through marketing and communication departments at both corporate and country level. Periodical meetings, workshops, seminars are means of sharing insights and learnings with key partners and customers.

**CUSTOMER SEGMENTS**

Ericsson's customers are mainly telecom operators and service providers at global level.

**COST STRUCTURE**

The main costs for Ericsson are for the supply of sub-systems and components that constitute the basis for the deployment of products. Software development and licensing are also integral part of costs. Integration of hardware and software elements is also a relevant part of the cost structure.

**REVENUE STREAMS**

Ericsson has two main revenue streams: product selling towards customers and maintenance services. As for maintenance, it includes the support for the overall lifecycle of current and legacy products. It also includes the provisioning of software upgrades.

## 3.2. Industry 4.0 Pilot – COMAU

In the COMAU Pilot, COMAU itself is the end service consumer. Searching for greater security and flexibility, COMAU is the only pilot within 5Growth not relying on public 5G networks, using instead a private network (NPN).

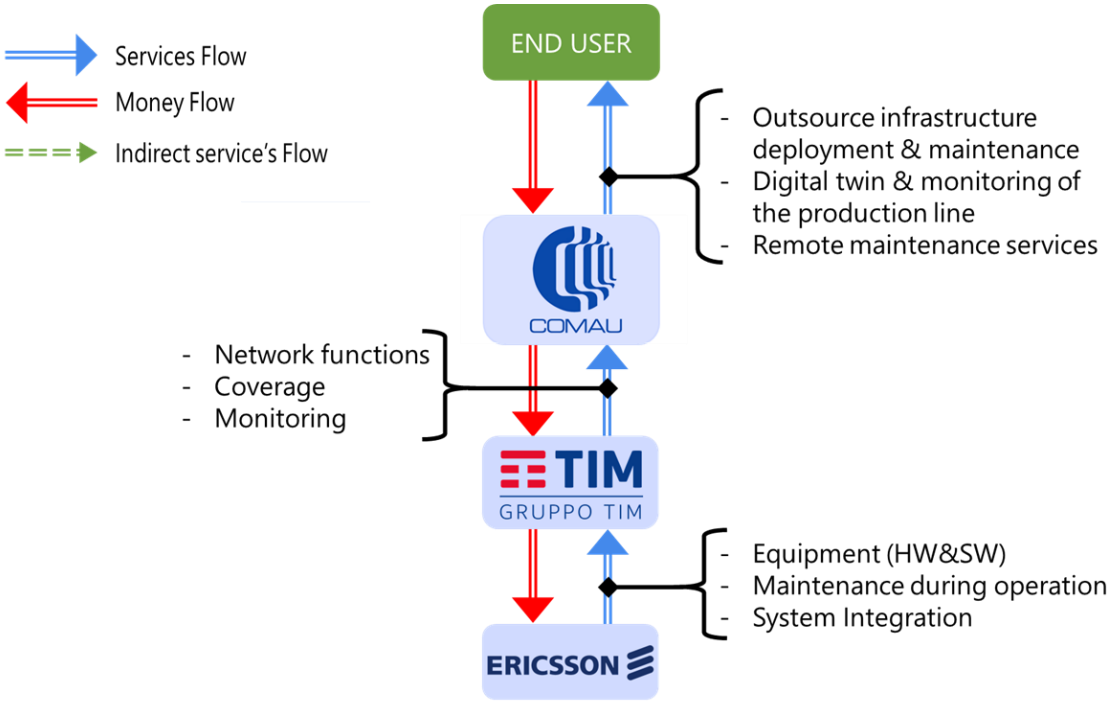
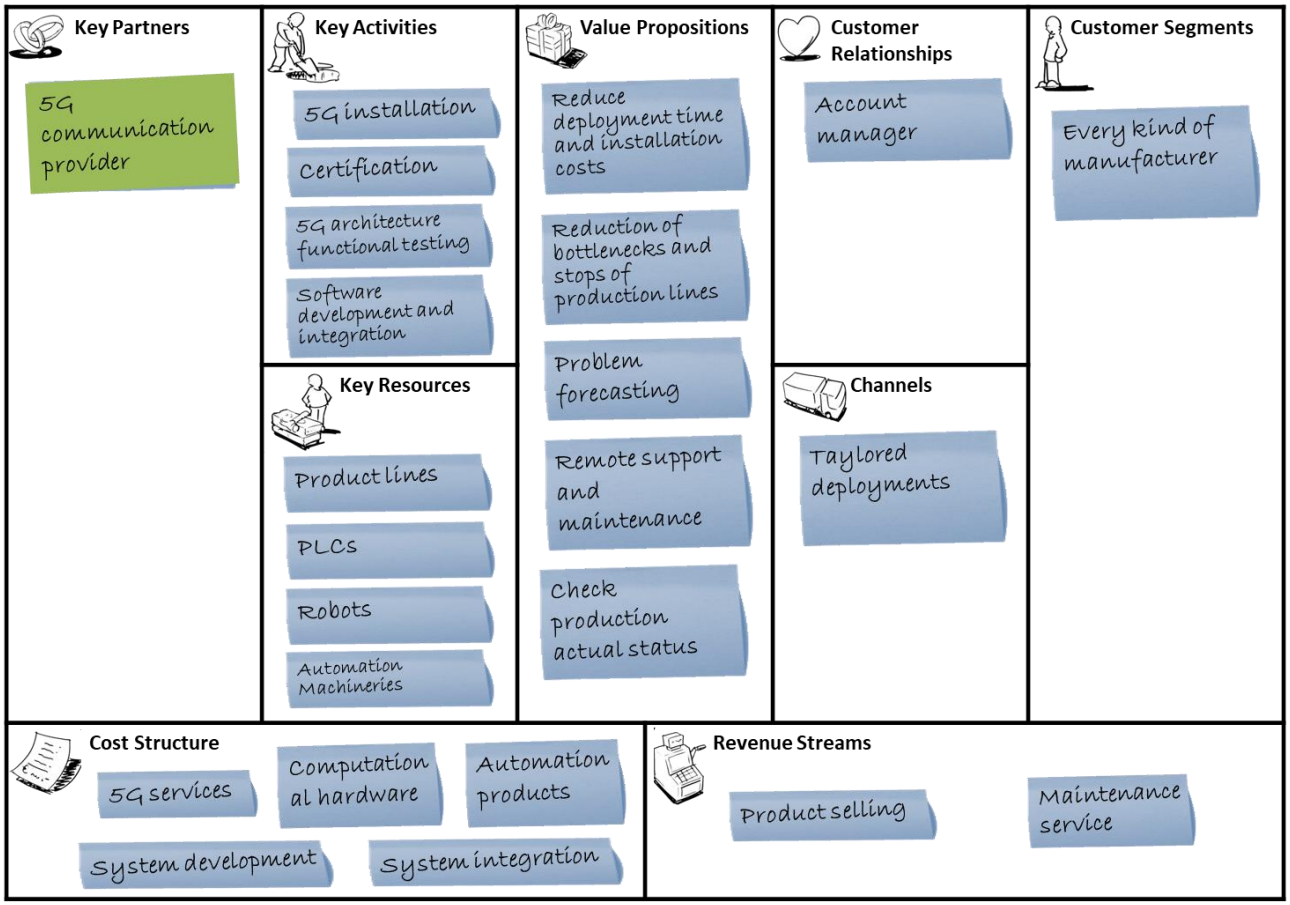



**FIGURE 2: COMAU'S PILOT BUSINESS FLOW**

COMAU is provided by Telecom Italia (TIM) of indoor coverage, communication services, network functions and monitoring. At the same time, Ericsson Italy (TEI), provides Telecom Italia with the necessary equipment to run the services, the maintenance services during operation and also the system integration.

The specific value proposition and Business Model of each stakeholder in the COMAU Industry 4.0 Pilot is described in more depth in the following section.

### 3.2.1. Service Consumer – COMAU




**KEY PARTNERS**

COMAU regarding the 5G could be both the integrator as well as the end user. Nevertheless, in the broader scenario COMAU's customer is the actual end user which needs cutting-edge automation solutions and process design, optimising costs and production cycle time.

For the sake of business relationship simplicity and to effectively receive support in case of sudden 5G network malfunctions, it is worth having one single service provider which is in charge of guaranteeing the correct system functionality based on a specific SLA, instead of coordinating effort between service and technological providers. That single point of contact in this case is TIM.

**KEY ACTIVITIES**

The first preparatory activity is the physical installation of all the equipment required for a private 5G deployment. Contrary to what would be expected, the 5G installation is not as straightforward as it may seem, since it requires a specific integration between the 5G system and the legacy LAN, which is often tricky in terms of defining boundaries, interconnections, and all cyber security aspects.

Once the 5G system has been installed, the first activity to address before being able to activate the system is related to safety, indeed, it is strictly necessary to perform a test campaign to certificate

that the electromagnetic emissions are in line with the local rules and policies, to guarantee a safe working environment for all the people.

Before being able to actually use the private 5G network deployed for industrial applications (typically characterized by high availability and reliability requirements) a deep functional testing is required in order to guarantee the network capabilities and their correct functionalities accordingly with the SLA and technical requirements (which will depend on the end user needs and on the automation process and technical solution chosen).

Then it is possible to deploy over the 5G network all the automation solutions and software components, each of which will rely on the network slices offered by the 5G solutions depending on the type of application.

**KEY RESOURCES**

Based on the use cases under developing and testing in the scope of the 5Growth project, it is possible to integrate over the 5G network a wide range of different industrial equipment as well as devices such as entire product lines (the studies have been performed on automotive), in addition to more specific ones as PLCs, robots and automation machineries (e.g., powertrain machines).

**VALUES PROPOSITIONS**

5G is the first mobile network which has the capabilities and the performance to enter in typical industrial environments and use cases. The first benefit which this new network brings is thus connected to its mobile nature, which means not having to connect everything wired anymore, which leads to a reduced deployment time and installation costs.

Moving away from the common benefits of mobile network, the three main 5G characteristics (URLLC, eMBB, mMTC) are the key enabling technologies to be able to both send a huge amount of data with low latency which leads to have an always updated and comprehensive equipment status, to understand what is currently happening as well as have enough historical information to perform problem forecasting.

Another positive side-effect due to the combination of 5G performance and its mobile nature is the possibility to enable an effective remote support and maintenance, since it is possible to nullify geographical distances without losing the possibility to actually see what is happening in the actual shop floor (thanks to augmented reality, remote calls, the possibility to share complex files like CAD)

**CUSTOMER RELATIONSHIPS**

The customer relationship will be handled through account managements, allowing to establish personalised solutions.

**CHANNELS**

One of the key elements in COMAU's business positioning strategy is to offer tailored automation solutions, starting from the design, through the development and the actual deployment.

**CUSTOMER SEGMENTS**

The customer segments of this 5G business model are the big manufacturers and factories that have the objective of optimising production costs and cycle time, in addition to the need of always having functionalities at the current state-of-the-art in terms of technology.

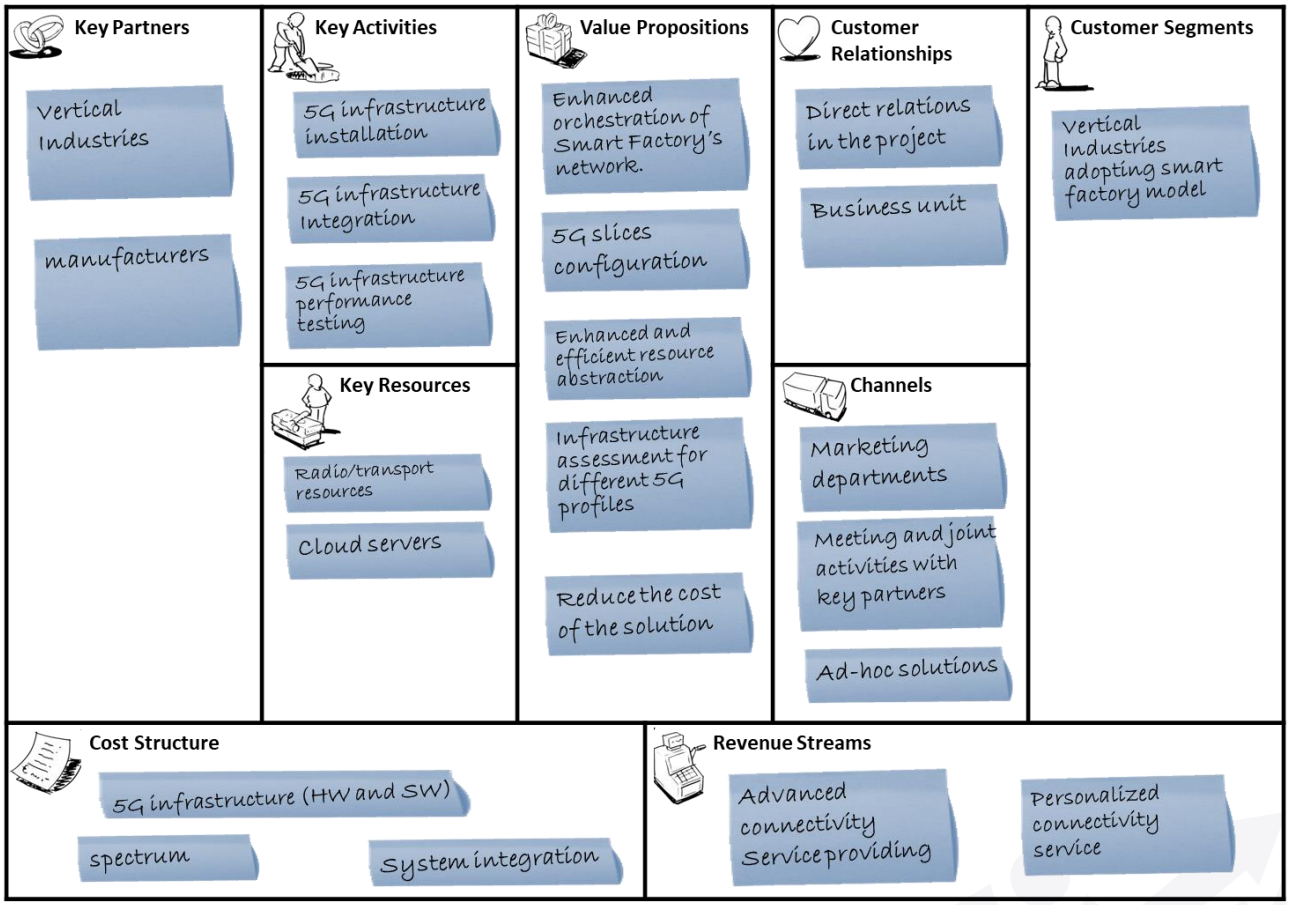
**COST STRUCTURE**

In addition to the typical costs related to the automation solution design, development, and deployment there are now all the costs (as a service) due to the 5G network in terms of computational power, hardware, spectrum and all the services provided by the new network infrastructure.

**REVENUE STREAMS**

All the revenue streams go around product selling (and to their extend, consultancy and process design) and the maintenance service. The impact on this direction due to the 5G is dual, on the one hand it allows to have a more efficient offer (in terms of cost and effectiveness) and on the other hand to be more exposed in different market sectors, with different environments and use cases but similar automation needs of automotive.

## 3.2.2. Network Operator – Telecom Italia



**KEY PARTNERS**

The network operators play the role of the "main-in-the middle" since it buys telecommunications devices from manufacturers (e.g., antennas, routers, ...) and sells a full connectivity to verticals, where connectivity is not only a "bare-metal" bit stream, but a complex environment where 5G enables a set of services.

**KEY ACTIVITIES**

They key activities covered by TIM are related to the provision of enhanced network services.

The first of these activities is the installation of devices that to be efficiently provided need of a complex design before. Then the telecommunication infrastructure should be integrated with the production infrastructure, e.g. The production industrial chain.

Finally, it is necessary to test the performance of communications systems and verify if design technical KPIs are satisfied. In order to perform this important step network management or telemetry and monitoring.

**KEY RESOURCES**

TIM owns its licensed spectrum, configured as radio resources. The network is much more complex than a pure connection system. It also includes virtualization and cloud systems, as well as sophisticated monitoring systems.

All the infrastructure to connect, where necessary the factory network to the public network is provided by TIM, as well as segregated or private networks to connect different vertical premises.

**VALUES PROPOSITIONS**

TIM offers enhanced orchestration and management of smart factories' networks. Regarding 5G services, it also provides automatic 5G slices configuration and isolation, ensuring the necessary communication conditions for smart factories' operation. Moreover, it provides accurate monitoring of resources to guarantee 5G slices, devoted in particular to predictive maintenance, reducing the production chain stops. Finally, TIM also provides 5G consulting services to customers in order to verify the CAPEX and OPEX savings.

**CUSTOMER RELATIONSHIPS**

TIM's relationships with customers are directly established with product responsible personnel, in order to directly satisfy customer requirements. In particular for big customers, like automobile producers, TIM dedicated a small unit integrating marketing, technical and engineering skills dedicated to satisfying the customer's needs

**CHANNELS**

TIM, as company involved in research, relies on dissemination activities and scientific publications to report their work. For the communication with customers, it also makes use of meetings, personal contacts, its own website, and social media. Since a dedicated unit is appointed, some TIM employees are perfectly updated with the customer needs.

**CUSTOMER SEGMENTS**

TIM is a huge telecom operator, and it is involved in different areas. About 5G it has the ambition to cover a huge share of Italian population within 2025. It is deeply involved in ad-hoc project with verticals is different areas (smart energy, smart factory, logistics, ...) In 5Growth TIM focuses on smart factories and in particular to automatize automobile industry operation in to reduce their network costs and increment the final product quality.

**COST STRUCTURE**

The main costs related to TIM are the spectrum (bought to the Government), the personnel for operation and the hardware infrastructure used to provide services and the software development (bought from the manufacturers).

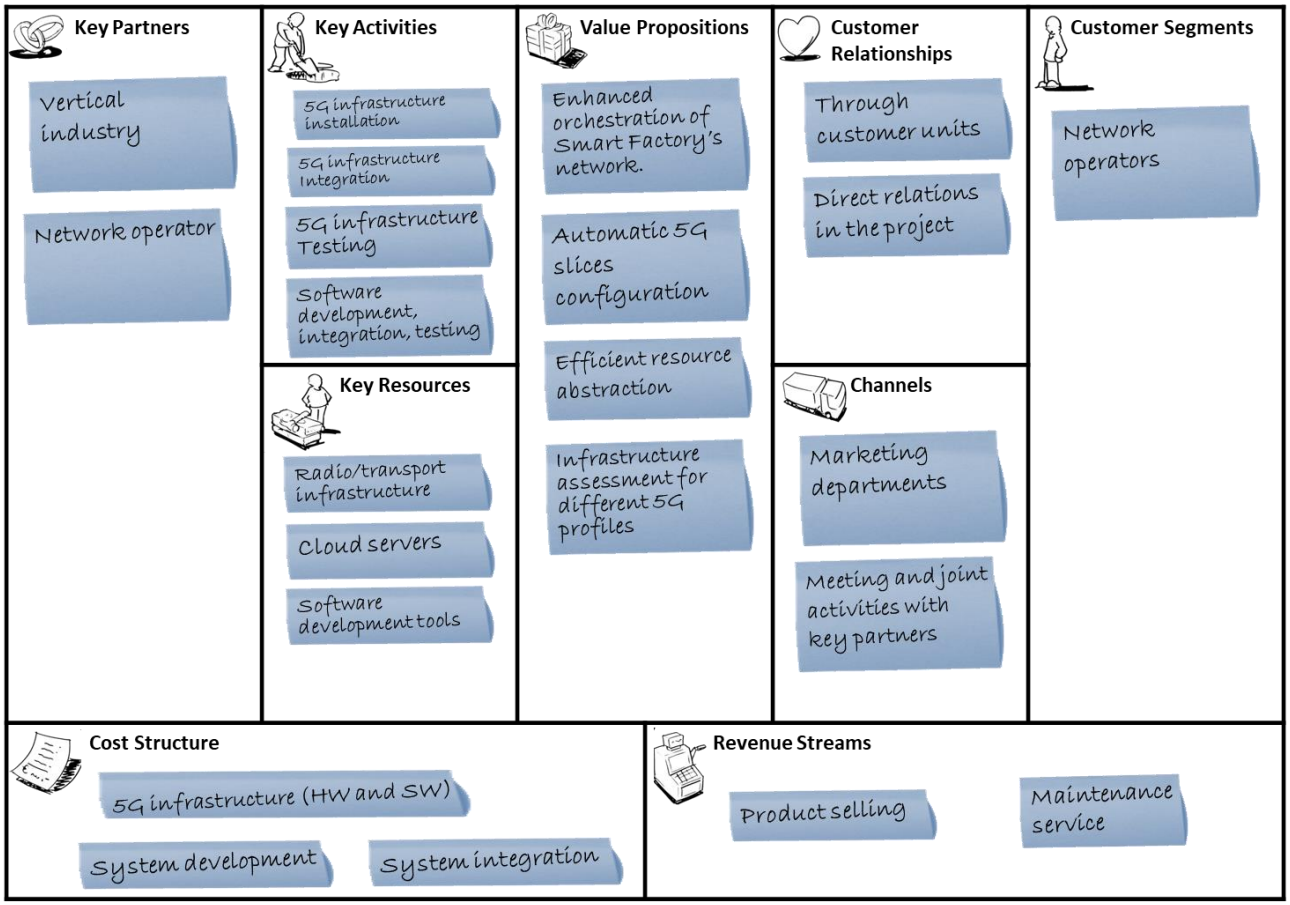
**REVENUE STREAMS**

TIM has two main revenues streams:

- Standard 5G services
- Customized 5G services

For big customers, a customized service is preferred, where TIM follows the entire process: design, infrastructure building, pricing, maintenance.

## 3.2.3. HW/SW provider – Ericsson Italy




**KEYS PARTNERS**

Vendors of telecommunication infrastructures, like Ericsson, supply all the components of the industrial network to the Network Operator and, through them, bring the 5G equipment to the manufacturing plants. Transport elements, like optical networking systems, can be also part of the deployment. Software modules for orchestration and real-time network automation can be part of the overall offer.

**KEY ACTIVITIES**

The first activity in charge of a network manufacturer is to support the network operator in installing the various equipment constituting the telecommunication infrastructure. Specifically, it is related to the installation, integration, and testing of the hardware systems (e.g., antennas, base stations, optical fibres…). The telecommunication infrastructure is then integrated with the production infrastructure, e.g., the manufacturing line. This process of installing, integrating, and testing is also applied to the software components like the control and orchestration platforms.

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**VALUE PROPOSITIONS**

Ericsson offers in its portfolio an orchestration platform (namely Ericsson Orchestrator) which enables automation of hybrid infrastructures (radio, transport, cloud) including PNFs and VNFs. It supports Resource Orchestration, VNF Life Cycle Management and End-to-end Service Orchestration for both operators and enterprise environments. This orchestration platform includes a multi-layer, multi-domain, and multi-vendor hierarchical SDN controller for the orchestration of the various transport domains to build end to end connectivity with guaranteed constraints. The various domains can be managed via domain controllers from different vendors or belonging to different layer (e.g., IP/MPLS, Optical, Microwave).

The 5G network support network slicing which enables new business opportunities for communications service providers (Ericsson's customers) across a wide range of use cases and sectors, by making it possible to create fit-for-purpose virtual networks with varying degrees of independence. Ericsson has a complete portfolio of business support systems (BSS), operations support systems (OSS), RAN, transport, core network functions, cloud infrastructure and related services to realize the full potential of network slicing. Network slicing allows Ericsson's customers to serve different vertical needs with the same 5G network with significant savings in terms of TCO.

In addition, the resource abstraction technique can further facilitate operations and commercial deployment. Abstraction is a "compact" description of a resource (radio, transport, and cloud), exposing with the corresponding service parameters. Abstraction allows to hide resource details (such as quantity, vendors, location of the resource, physical details, real topology, etc.) and to consider the transport since the placement process starts.

In conjunction with different performance needs and vertical requirements, Ericsson can provide consultancy on the best infrastructure deployment in support to an optimal 5G coverage for the considered deployment area. This activity attains the network planning and assessment of the different 5G profiles that better matches the final user needs (for example low latency profile for remote robot control or massive machine type communication for a very dense sensor deployment).

**CUSTOMER RELATIONSHIPS**

Ericsson is one of the leading providers of Information and Communication Technology (ICT) to service providers and, particularly, to telecom operators. The whole world is "partitioned" in market areas like, for example, the Market Area Europe and Latin America (MELA) where are located all the pilots deployed in the 5Growth project. Inside each market area, specific customer units (CU) oversee the relations with the main customers, acting as organizational "contact points" between the company and specific customers.

In the project, the relationship with customers is also related to project experimentations and trials so, often, the relation is mainly at the "technical level". For example, in 5Growth the Ericsson Research laboratories directly interacts with the research centre of Telecom Italia TILab. As a possible follow-up of cooperation at technical level, the related commercial units can interact to leverage on the results obtained in the project to frame a business model or a commercial engagement.

**CHANNELS**

Communication channels are active through marketing and communication departments at both corporate and country level. Periodical meetings, workshops, seminars are means of sharing insights and learnings with key partners and customers.

**CUSTOMER SEGMENTS**

Ericsson's customers are mainly telecom operators and service providers at global level.

**COST STRUCTURE**

The main costs for Ericsson are for the supply of sub-systems and components that constitute the basis for the deployment of products. Software development and licensing are also integral part of costs. Integration of hardware and software elements is also a relevant part of the cost structure.

**REVENUE STREAMS**

Ericsson has two main revenue streams: product selling towards customers and maintenance services. As for maintenance, it includes the support for the overall lifecycle of current and legacy products. It also includes the provisioning of software upgrades.

## 3.3. Energy Pilot – EFACEC Energy

EFACEC Energia focuses on the energy vertical and offers the deployment and operation of energy monitoring systems for the secondary distribution substations and the Low Voltage distribution network. EFACEC_E will be the Service Consumer, as depicted in Figure 3.

The provider of the 5G network is Altice Labs which is the R&D company of MEO, the main telecommunication operator in Portugal. They provide EFACEC with network functions, monitoring and the usage of the public 5G network.

Also, there is IT Aveiro, which provides consulting and integration services to EFACEC, and oversee the design of new implementations, and also when dealing with foreign operators (in case they sell the new developed services to customers abroad).

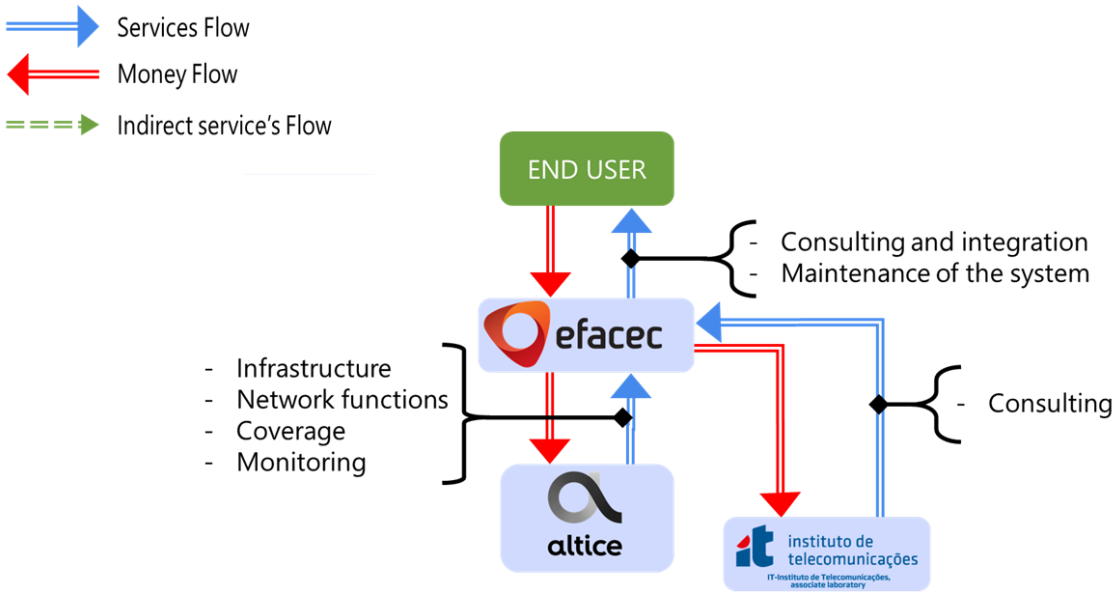
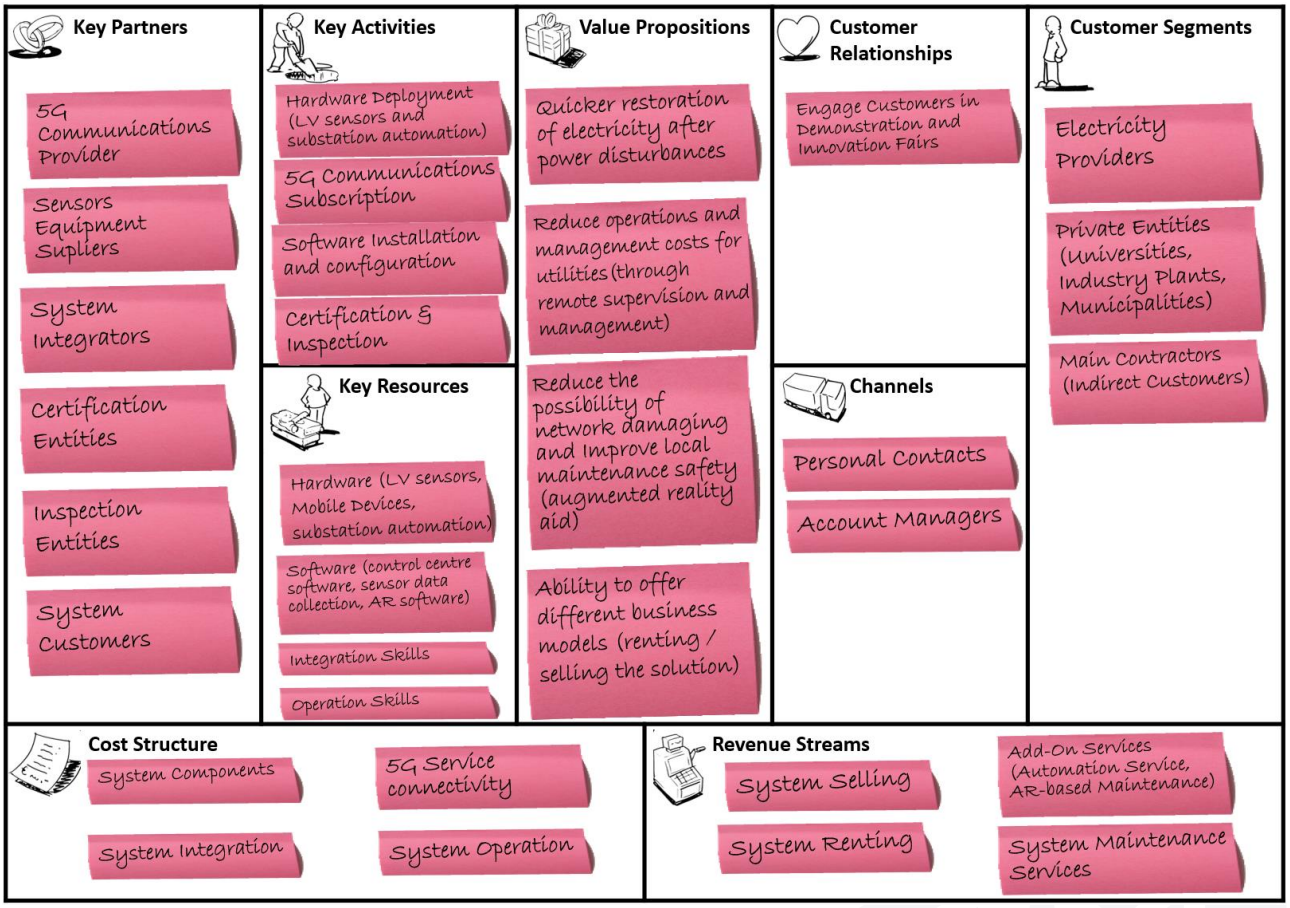



FIGURE 3: EFACEC ENERGIA PILOTS BUSINESS FLOW

The specific value proposition and Business Model of each stakeholder in the ENERGY Pilot is described in more depth in the following section.

## 3.3.1. Service Consumer – EFACEC Energy



**KEY PARTNERS**

EFACEC_E has a wide ecosystem of partners due to the complex nature of the business. Most of them are related to the energy sector, including equipment suppliers (electronic vendors, hardware vendors), engineering subcontractors, system integrators and certification entities.

Technical consulting and communication providers are also involved in the delivery of turn-key systems.

**KEY ACTIVITIES**

EFACEC_E Energy has a vast portfolio of products and systems for the energy market, including automation products such as the Low Voltage Sensors and the Substation Controllers, and the centralized SCADA/ADMS network management system.

EFACEC_E is also involved in the certification process of its automation products, dependent on the market geographies.

Has a provider of turn-key solutions, EFACEC_E is also involved in engineering works such as the configuration and deployment of its products and solutions. In this sense, EFACEC_E act has a system integrator, and can provide the telecom solution with the participation of its technical consulting partners and communication providers).

**KEY RESOURCES**

EFACEC_E owns a comprehensive portfolio of automation products and develop its own SCADA/ADMS software highly modular and configurable to match the specific needs of different costumers in the energy market (TSOs, DSOs, Renewable production, etc).

EFACEC_E has and trains highly specialized engineering teams owning operational and integration skills, to provide integration, deployment, and maintenance services to the costumers.

**VALUE PROPOSITIONS**

EFACEC_E offers enhanced electrical network management for the secondary substations and the low voltage electrical network, providing a complete top-to-bottom solution, from the field low voltage sensors, through the secondary distribution substations controllers, up to the central SCADA/ADMS network management system, relying on 5G network connecting the low voltage network sensors, automation, and installations.

With such a smart-grid solution, it is possible to improve the efficiency and safety of electrical network operation and to optimize the maintenance costs. The time needed to the restore electrical supply upon an outage is significantly reduced, improving the quality of service to the end consumers (households, commerce, services, etc).

**CUSTOMER RELATIONSHIPS**

EFACEC_E 's relationship with its customers is ensured by key account managers. They are responsible for the commercial management and ensure the top coordination with second contact lines.

In a second contact line, the client project managers ensure a continuous coordination with the client throughout the whole lifecycle of each active project.

EFACEC_E 's Product Managers, in turn, are responsible for fostering the relationship with current customers promoting the demonstration of new products and features, and for engaging potential customers in innovation industrial fairs.

**CHANNELS**

The contact with the end customer is made either directly, or via main contractor when it exists.

**CUSTOMER SEGMENTS**

EFACEC_E's larger customer segment consists of electricity providers (DSOs, TSOs and Renewable Energy Producers).

Main contractors (indirect customers) are also a customer segment for EFACEC_E Energia, in large scale projects involving different areas (civil works, infrastructures, etc) and/or multiple suppliers.

On a lower scale, EFACEC_E provides also private entities (universities, industry plants, municipalities).

**COST STRUCTURE**

The major costs concerning EFACEC_E 's operation can be summarised as follows:

- System development – This is the cost with R&D team, responsible for the execution of the product roadmap, implementing new products and contributing to the continuous improvement of each HW and SW component belonging to EFACEC_E portfolio.
- System components - Purchase of electronic components from suppliers, to be integrated in EFACEC_E's products and solutions.
- Engineering - the costs with delivery team concerning the system integration, configuration and deployment, and the costs with after-sales team concerning the system maintenance.
- 5G Service Connectivity – EFACEC_E will have to acquire the 5G telecom service from an Operator according to the requirements of the client project. This will result in an initial cost component, and a periodic cost component that may vary with the expansion and/or usage of the installed 5G capacity.

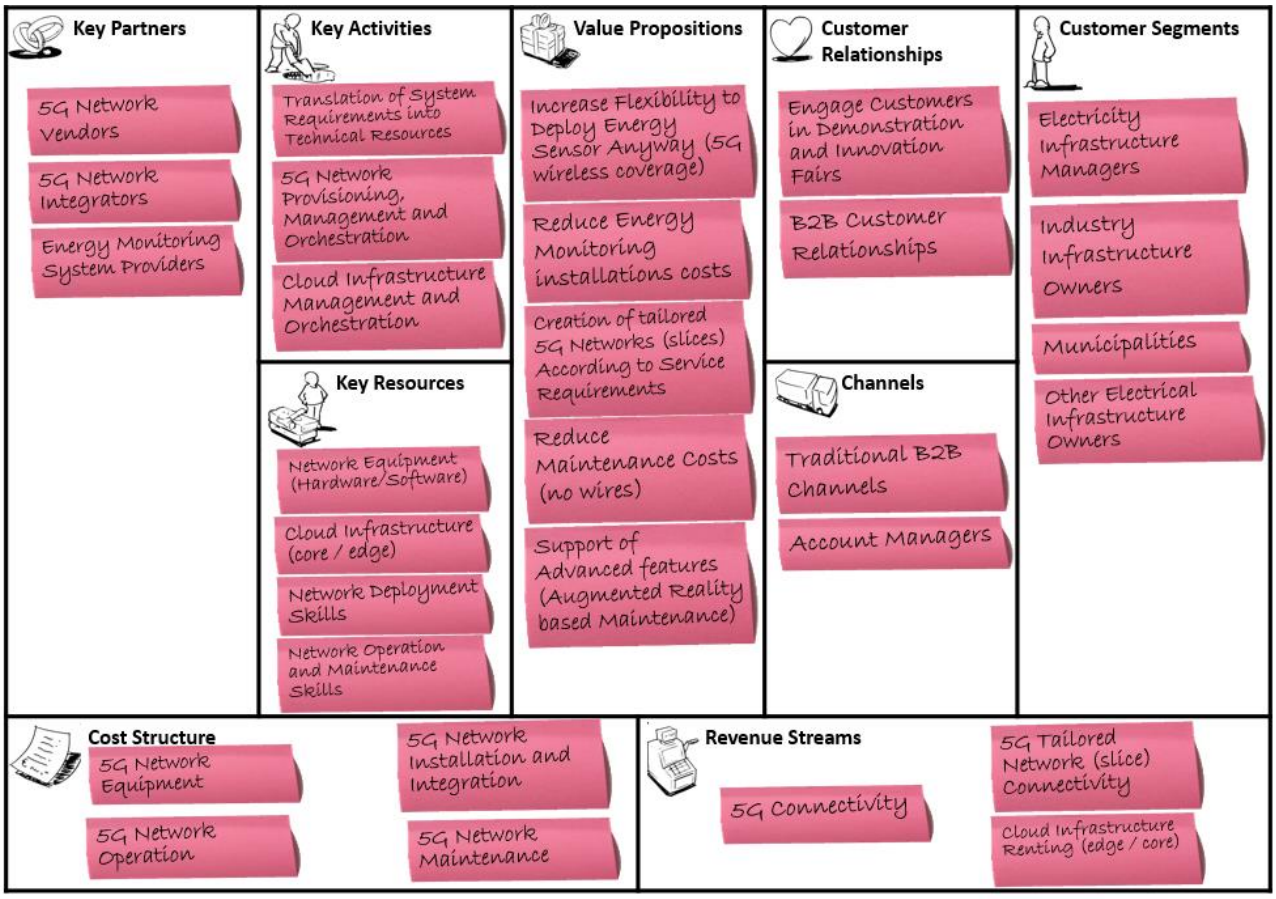
**REVENUE STREAMS**

The Business model may involve complementary revenue streams including:

- System selling – This will apply mainly to the components deployed on premises, like the secondary substation automation and the low voltage sensors, or the control centre in those cases where it is deployed on customer datacentre.
- System Renting – This is an alternative revenue stream to system selling, serving similar purposes.
- Add-On as a Service – Some added value optional features, including web and mobile applications to enhance system maintenance (ex: AR-based maintenance).

- System Maintenance Services – This will include pluri-annual maintenance contracts that may include periodical SCADA/ADMS system upgrades, cyber-security periodical assessment, periodical firmware upgrades to low voltage automation and sensors, etc.

## 3.3.2. Network Operator – Altice Labs




**KEY PARTNERS**

The key partner in the context of Energy pilot is the energy monitoring system provider (EFACEC_E) but Altice relies also on 5G network equipment manufactures and integrators to deploy and manage the 5G network.

**KEY ACTIVITIES**

Altice as mobile and network operator should understand the vertical systems requirements and guarantees the necessary network resources to provide it. The network provisioning, management and orchestration activities are carried out in order to guarantee the contracted SLA with the minimum network resources usage, investment and OPEX. Apart from fulfilling the user needs in terms of requirements these activities are necessary to achieve the business success of the company that operate in the Telecom very competitive environment.

**KEY RESOURCES**

Altice as mobile and network operator should understand the vertical systems requirements and guarantees the necessary network resources to provide it. The network provisioning, management and orchestration activities are carried out in order to guarantee the contracted SLA with the minimum network resources usage, investment and OPEX. Apart from fulfilling the user needs in terms of requirements these activities are necessary to achieve the business success of the company that operate in the Telecom very competitive environment the mobile operator should own good network operation and maintenance skills. Customer satisfaction is a leading indicator of consumer repurchase intentions and loyalty.

**VALUE PROPOSITIONS**

The creation of tailored 5G Networks (slices) offers to the verticals the capability to ensure that its requirements are meet. Particularly the use of a 5G services brings to the energy vertical increased flexibility to deploy energy sensors anyway (5G wireless coverage), reduced energy monitoring installations costs and reduced the maintenance costs (no wires).

**CUSTOMER RELATIONSHIPS**

Altice as network operator has a commercial structure orientated to serve and respond to demands of different segments of market, this vertical is addressed internally as a B2B relationship. But, for this vertical the engagement of the customers in demonstration and innovation activities it is also very suitable.

Altice has a special focus on customer satisfaction as a strategy to keep its customer loyalty, repurchase intentions and to attract new customers.

**CHANNELS**

Altice communicates with use the traditional B2B channels and account managers to reaches its customer segments to deliver a value Proposition. The account managers have the responsibility of:

- Calling prospects and fixing an appointment,
- Visiting customer's place,
- Understanding the requirements of the customers,
- Suggesting a product or service and
- Keeping updates in the telecommunications industry.

**CUSTOMER SEGMENTS**

Altice Labs is the innovation branch of Altice Portugal and the Altice Group companies worldwide, as well as a provider of network systems and services. In this dual research and industrial role, Altice Labs intends to exploit 5Growth results to strengthen Altice Portugal technological leadership and prepare the transition to new service paradigms enabled by network virtualization, programmability and 5G. Altice intends to address energy vertical customer segments as: industry infrastructure owners, municipalities and other electrical infrastructure owners are also subjects of Altice commercial demarches.

**COST STRUCTURE**

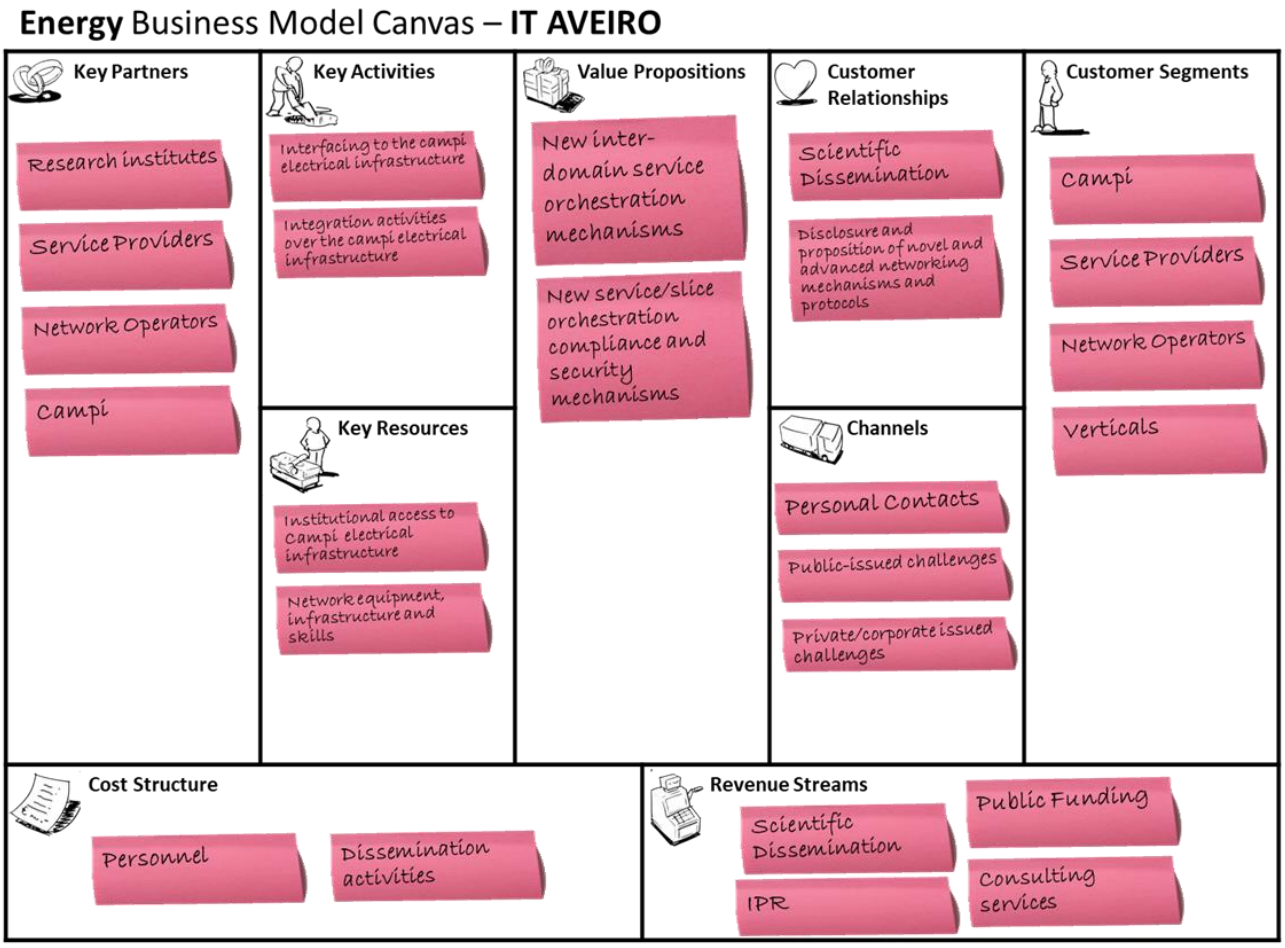
The main Altice costs are acquisition of telecom equipment's, network installation, integration, operation and maintenance. Basically, the traditional CAPEX and OPEX of any network operator. Despite the elevated cost of the 5G spectrum license it is not very significant when compared with the overall network deployment and operation costs during the 15-20 years of the spectrum license.

**REVENUE STREAMS**

Altice foresee at least two main revenue streams:

- 5G connectivity to address different usage scenarios as eMBB, URLLC and mMTC.
- 5G tailored network (slice) connectivity to address to specific needs of the verticals.

## 3.3.3. Operation Support Provider – IT Aveiro




**KEY PARTNERS**

IT Aveiro (ITAV), as an academic research center and having experience in several telecommunications, services and cloud segments, has naturally build up important interactions with different partners belonging to network operators, service providers and other research institutes.

This allows it, along with a more neutral positioning in regard to business, to acquire important generic and holistic insight that support it in its consulting activities. This comes naturally as an addition to all the relevant scientific (both academic and jointly with the industry) work, ranging from deep blue-sky research, up to standardization work. ITAV, besides being a research center, is a research unit associated with the Informatics, Electronics and Telecommunications Engineering Department, which also brings the educational/Training academic component into view, having access to infrastructure and human resources.

**KEY ACTIVITIES**

IT has been supporting connectivity interaction with two electrical facility points on campus (i.e., the IT Building 1 and the Central Technical Zone), truly acting under the scope of what can be considered consulting services, particularly for the Operator and Vertical component. Building up from the key partners capabilities showcased in the previous point, ITAV exploits such relationships in order to position itself as a decisive asset for these key activities.

**KEY RESOURCES**

ITAV houses assets that are part of the pilot and provides access to such assets belonging to the University of Aveiro. These assets are not only related with the actual electrical components that are to be controlled and provide information, but also with the necessary supportive communications infrastructure. Moreover, ITAV was decisive in the first phase of the project, by housing the laboratory experiments of the pilot which were not yet placed in the original pilot targets, due to the COVID19 delays, and in the second phase of the project by providing infrastructural and deployment support to the 5G network, and to the integration of the vertical's assets.

**VALUE PROPOSITIONS**

ITAV has been pursuing technological innovations that explore novel concepts, taking as a base the possibilities allowed not only by 5G and 5Growth mechanisms, but also by exploring having for the first time such verticals as customers. However, such innovations are not considered critical, as they are not fundamental for the base scenarios of the pilots to operate. Additionally, in this panorama where vertical players are still increasing their knowledge on the capabilities of 5G, independent consulting entities (such as ITAV) can act as advisors in terms of mobile network technology uptake, unbiased from specific operators or vendors (thus ensuring that the vertical is able to benefit from the best possible offers).

**CUSTOMER RELATIONSHIPS**

ITAV maintains the traditional dissemination media associated with academic research labs. Of course, if 5G expertise allows ITAV to acquire more consulting contracts, it should also increase the diversity and amount of consultancy actions.

**CHANNELS**

ITAV maintains its three-way possibilities for offering its consulting contracts, namely personal contracts, public-issued contracts and private/corporate issued challenges.

**CUSTOMER SEGMENTS**

The customer segments basically share the key partners constituent's, along with the unique critical mass provided by the campus' CAMPI, which can operate as beta testers, try-outs, etc.

**COST STRUCTURE**

The cost structure is associated to the Values Proposition, as consultancy services are charged on a per-project basis, or resources basis.

**REVENUE STREAMS**

ITAV maintains this list of possible revenue streams to offer consultancy services, both directly and indirectly. Indirectly means leveraging interactions to better position itself in accessing public funding, and patents.

## 3.4. Transportation Pilot – EFACEC Engenharia e Sistemas

Both EFACEC Pilots have similar business model, the same stakeholders and the same business flows, as can be seen in Figure 4 depicting the TRANSPORT Pilot business flow. However, as they target different verticals and have some peculiarities, this business model will be explored like the previous ones.

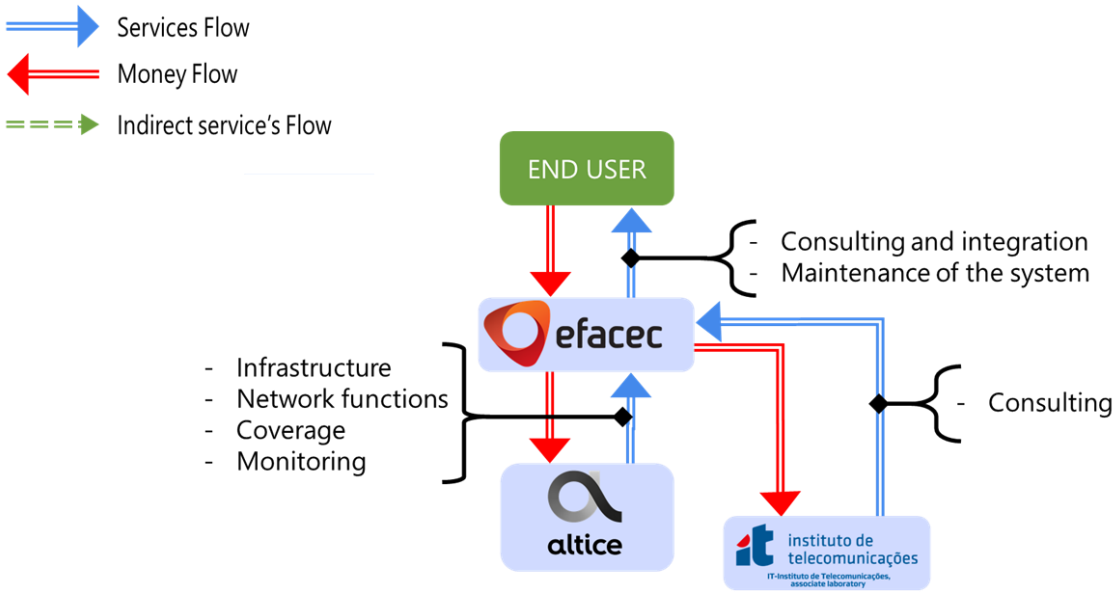



FIGURE 4: EFACEC ENGENHARIA E SISTEMAS PILOTS BUSINESS FLOW

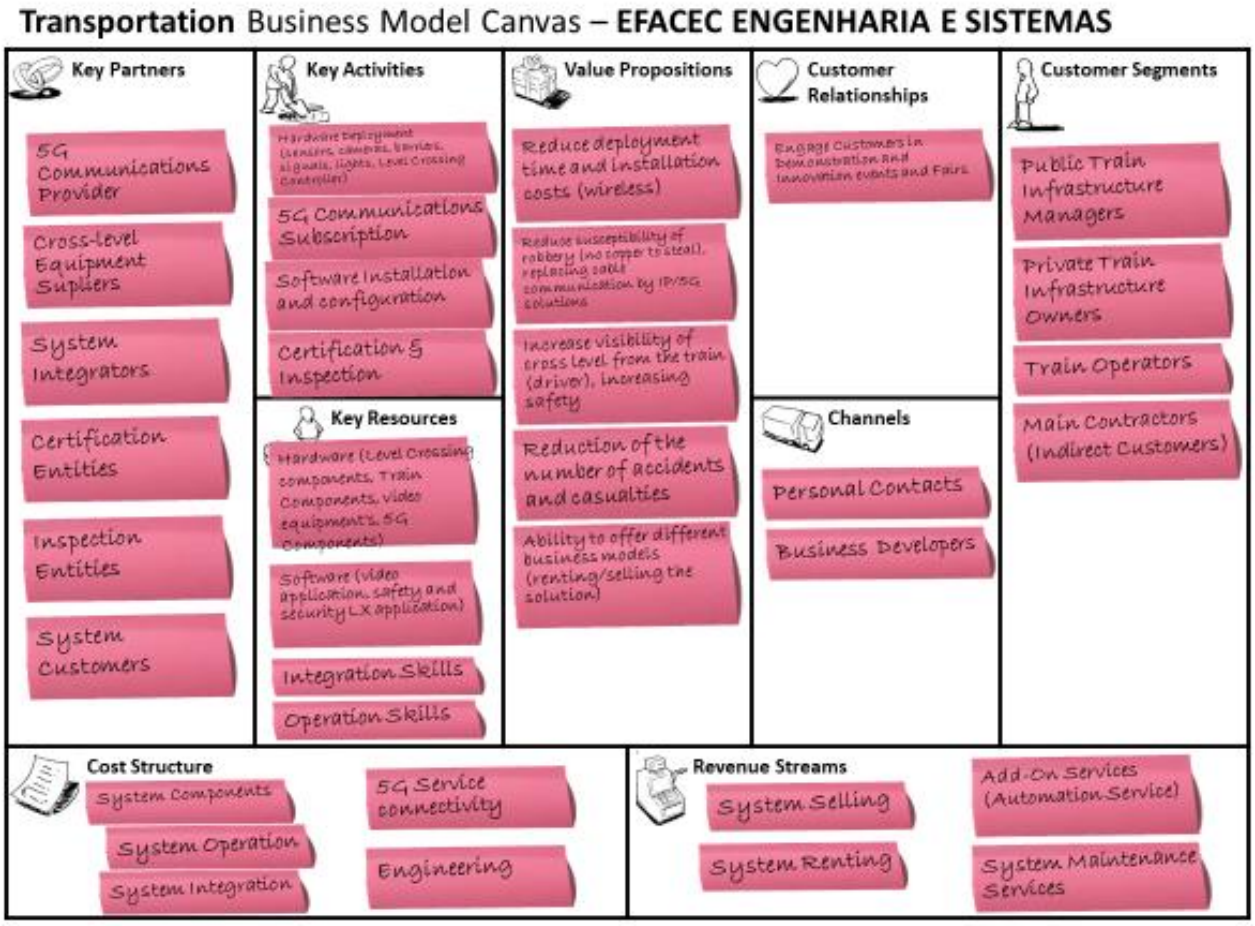
EFACEC Engenharia e Sistemas addresses to the transportation vertical, specifically, to the railway market. It offers to their customers (which could be the owner of the infrastructure or others, like town halls) the deployment and operation of signalling systems for railway crossing.

Like in the Energy Pilot, the provider of the 5G network is Altice Labs which is the R&D company of MEO, the main telecommunication operator in Portugal. They provide both EFACEC companies with network functions, monitoring and the usage of the public 5G network.

Also like in the Energy Pilot, there is IT Aveiro, which provides consulting and integration services to EFACEC, and are in charge of the design of new implementations, and also when dealing with foreign operators (in case they sell the new developed services to customers abroad).

The specific value proposition and Business Model of each stakeholder in the Transportation Pilot is described in more depth in the following section.

### 3.4.1. Service Consumer – EFACEC Engenharia e Sistemas




**KEY PARTNERS**

The business of signalling and specifically Level Crossing systems involves several partners with specific competencies such as communications, safety, security, integration and certification in order to EFACEC_S be able to supply turn-key solutions.

**KEY ACTIVITIES**

Several activities are necessary to provide systems with such level of complexity and safety. There are activities related to design, hardware deployment, configuration, software and certification according to the railway's standards. With the new 5G technology available, new challenges rise, in order to

address communication skills to design and supply the proper infrastructure and the appropriate level of quality of service according to the application and operations required.

**KEY RESOURCES**

The key resources are the one related to engineering teams that typically design, configure, and deploy the solution, the production team that are in charge of manufacturing the systems, the Development team that provide the hardware or the software for these critical systems and the safety team which assure the functional and technical certification of the complete solution. Resources for integration, operation, configuration, and maintenance are also necessary to address in order to supply the turn-key 5G Level Crossing solution to the costumer.

**VALUE PROPOSITIONS**

Replacing the traditional cable communication solution by a wireless solution in order to assure the communication between the sensor's that detects approaching train, and the level crossing controller allows to reduce the cable cost as well the time and installation cost. Additionally, the capability to transmit video imagens (from the level crossing area) to the train increases the safety conditions and prevents accidents.

**CUSTOMER RELATIONSHIPS**

EFACEC_S's relationship with its customers are ensured by the Business Developers. They are responsible for the commercial management and ensure the top coordination with second contact lines.

In a second contact line, the client project managers ensure a continuous coordination with the client throughout the whole lifecycle of each active project.

EFACEC_S's Product Managers, in turn, are responsible for fostering the relationship with current customers promoting the demonstration of new products and features, and for engaging potential customers in innovation industrial fairs.

**CHANNELS**

The contact with the end customer is made either directly by EFACEC Business Developers or via main contractor when it exists.

**CUSTOMER SEGMENTS**

EFACEC_S's larger customer segment consists of Transportation, specifically related to light Metro and Railways. For these new business model, Train/Metro operators, Train/Metro infrastructure owners and main contractors (indirect costumers) will be the key costumers.

**COST STRUCTURE**

The major costs concerning EFACEC_S's operation can be summarised as follows:

- System development – This is the cost with R&D team, responsible for the execution of the product roadmap, implementing new products and contributing to the continuous improvement of each HW and SW component belonging to EFACEC_S portfolio.

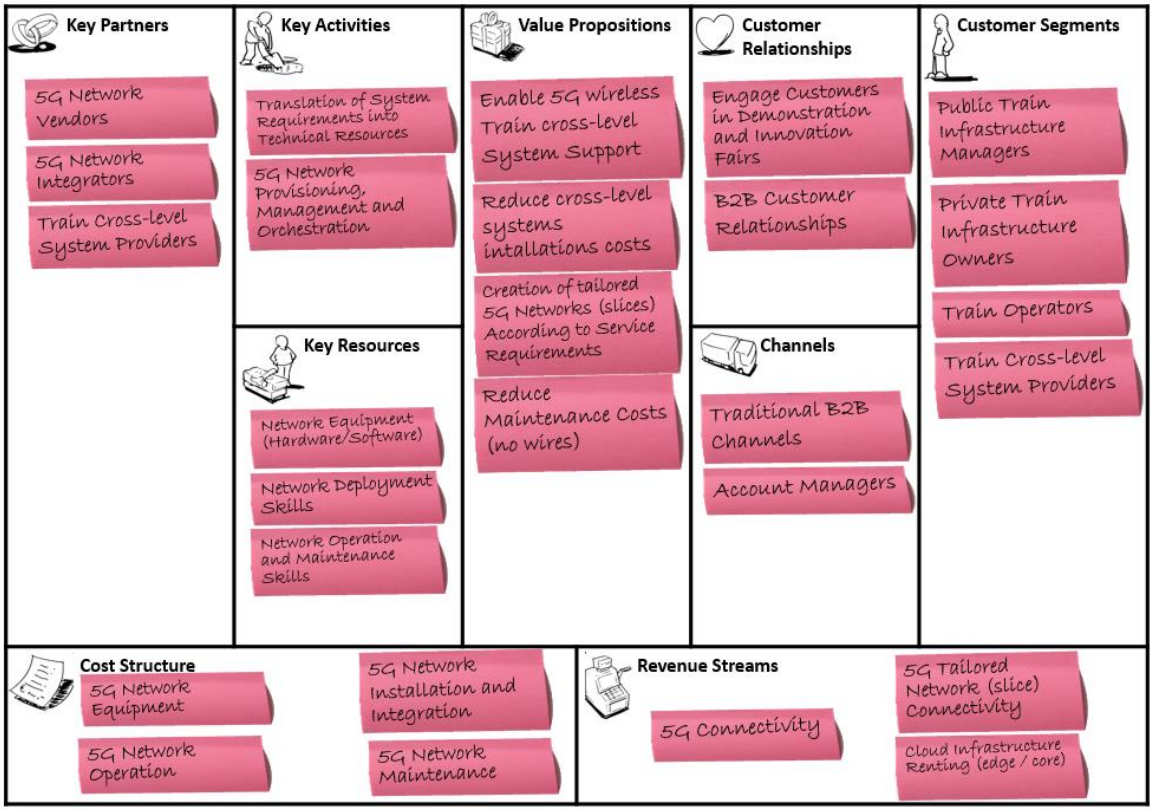
- System components - Purchase of electronic components from suppliers, to be integrated in EFACEC_S's products and solutions.
- Engineering - the costs with delivery team concerning the Design, system integration, configuration and deployment, and the costs with after-sales team concerning the system maintenance.
- 5G Service Connectivity – EFACEC_S will have to acquire the 5G telecom service from an Operator according to the requirements of the client project. This will result in an initial cost component, and a periodic cost component that may vary with the expansion and/or usage of the installed 5G capacity.

**REVENUE STREAMS**

The Business model may involve complementary revenue streams including:

- System selling – This will apply mainly to the 5G communications solution,
- System Renting – This is an alternative revenue stream to system selling, serving similar purposes.
- Add-On as a Service – Some added value optional features, including web and mobile applications to enhance system remote maintenance
- System Maintenance Services – This will include pluri-annual maintenance contracts that may include periodical system upgrades, cyber-security periodical assessment, periodical firmware upgrades as well as preventive or corrective procedures.

## 3.4.2. Network Operator – Altice Labs



**KEY PARTNERS**

The key partner in the context of Transportation pilot is the train cross-level system provider (EFACEC_S Transportation) but Altice relies also on 5G network equipment manufactures and integrators to deploy and manage the 5G network.

**KEY ACTIVITIES**

Altice as mobile and network operator should understand the vertical systems requirements and guarantees the necessary network resources to provide it. The network provisioning, management and orchestration activities are carried out in order to guarantee the contracted SLA with the minimum network resources usage, investment and OPEX. Apart from fulfilling the user needs in terms of requirements these activities are necessary to achieve the business success of the company that operate in the Telecom very competitive environment

**KEY RESOURCES**

The network infrastructure HW and SW are the mobile operator main assets. The mobile operator should own the knowledge and the capability of deployment a fully functional and optimized network for the user and services that will intend to serve with the minimum CAPEX and OPEX costs possible. The 5G radio mobile network planning and optimization is a particularly complex process with a significant impact on CAPEX and OPEX that the mobile operator must control. In order to achieve an optimum usage of the network resources and user satisfaction.

**VALUE PROPOSITIONS**

The creation of tailored 5G Networks (slices) offers to the verticals the capability to ensure that its requirements are meet. Particularly the use of a 5G services brings to the transportation vertical increased flexibility to the cross-level system installation. The 5G wireless solution, comparing with the wired, reduce the installation and maintenance costs as well the deployment time.

**CUSTOMER RELATIONSHIPS**

Altice as network operator has a commercial structure orientated to serve and respond to demands of different segments of market, this vertical is addressed internally as a B2B relationship. But, for this vertical the engagement of the customers in demonstration and innovation activities it is also very suitable.

Altice has a special focus on customer satisfaction as a strategy to keep its customer loyalty, repurchase intentions and to attract new customers.

**CHANNELS**

Altice communicates with use the traditional B2B channels and account managers to reaches its customer segments to deliver a value Proposition. The account managers have the responsibility of:

- calling prospects and fixing an appointment,
- visiting customer's place,
- understanding the requirements of the customers

- suggesting a product or service and
- Keeping updates in the telecommunications industry.

**CUSTOMER SEGMENTS**

Altice Labs is the innovation branch of Altice Portugal, and the Altice Group companies worldwide, as well as a provider of network systems and services. In this dual research and industrial role, Altice Labs intends to exploit 5Growth results to strengthen Altice Portugal technological leadership and prepare the transition to new service paradigms enabled by network virtualization, programmability and 5G. Altice intends to address transportation vertical customer segments as: public train infrastructure managers, private train infrastructure owners, train operators and train cross-level system providers.

**COST STRUCTURE**

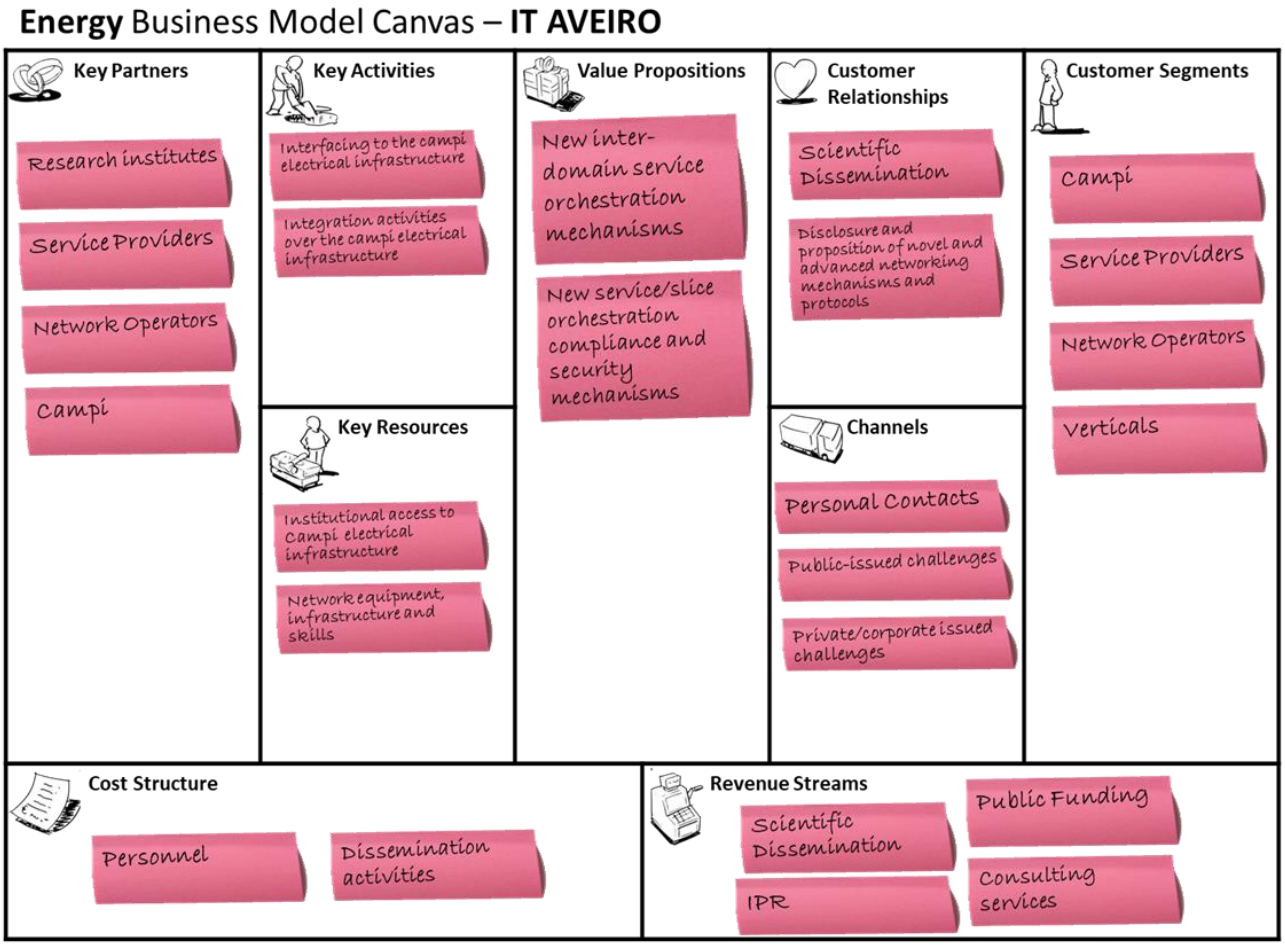
The main Altice costs are acquisition of telecom equipment's, network installation, integration, operation, and maintenance. Basically, the traditional CAPEX and OPEX of any network operator. Despite the elevated cost of the 5G spectrum license it is not very significant when compared with the overall network deployment and operation costs during the 15-20 years of the spectrum license.

**REVENUE STREAMS**

Altice foresee at least two main revenue streams:

- 5G connectivity to address different usage scenarios as eMBB, URLLC and mMTC.
- 5G tailored network (slice) connectivity to address to specific needs of the verticals.

### 3.4.3. Operation Support Provider – IT Aveiro




**KEY PARTNERS**

IT Aveiro (ITAV), as an academic research center and having experience in several telecommunications, services, and cloud segments, has naturally build up important interactions with different partners belonging to network operators, service providers and other research institutes. This allows it, along with a more neutral positioning regarding business, to acquire important generic and holistic insight that support it in its consulting activities. This comes naturally as an addition to all the relevant scientific (both academic and jointly with the industry) work, ranging from deep blue-sky research, up to standardization work. ITAV, besides being a research center, is a research unit associated with the Informatics, Electronics and Telecommunications Engineering Department, which also brings the educational/Training academic component into view, having access to infrastructure and human resources.

**KEY ACTIVITIES**

IT has been supporting connectivity interaction with two electrical facility points on campus (i.e., the IT Building 1 and the Central Technical Zone), truly acting under the scope of what can be considered consulting services, particularly for the Operator and Vertical component. Building up from the key

partners capabilities showcased in the previous point, ITAV exploits such relationships in order to position itself as a decisive asset for these key activities.

**KEY RESOURCES**

ITAV houses assets that are part of the pilot and provides access to such assets belonging to the University of Aveiro. These assets are not only related with the actual electrical components that are to be controlled and provide information, but also with the necessary supportive communications infrastructure. Moreover, ITAV was decisive in the first phase of the project, by housing the laboratory experiments of the pilot, which were not yet placed in the original pilot targets, due to the COVID19 delays, and in the second phase of the project by providing infrastructural and deployment support to the 5G network, and to the integration of the vertical's assets...

**VALUE PROPOSITIONS**

ITAV has been pursuing technological innovations that explore novel concepts, taking as a base the possibilities allowed not only by 5G and 5Growthmechanisms, but also by exploring having for the first time such verticals as customers. However, such innovations are not considered critical, as they are not fundamental for the base scenarios of the pilots to operate. Additionally, in this panorama where vertical players are still increasing their knowledge on the capabilities of 5G, independent consulting entities (such as ITAV) can act as advisors in terms of mobile network technology uptake, unbiased from specific operators or vendors (thus ensuring that the vertical is able to benefit from the best possible offers).

**CUSTOMER RELATIONSHIPS**

ITAV maintains the traditional dissemination media associated with academic research labs. Of course, if 5G expertise allows ITAV to acquire more consulting contracts, it should also increase the diversity and amount of consultancy actions.

**CHANNELS**

ITAV maintains its three-way possibilities for offering its consulting contracts, namely personal contracts, public-issued contracts, and private/corporate issued challenges.

**CUSTOMER SEGMENTS**

The customer segments basically share the key partners constituent's, along with the unique critical mass provided by the campus' CAMPI, which can operate as beta testers, try-outs, etc.

**COST STRUCTURE**

The cost structure is associated to the Values Proposition, as consultancy services are charged on a per-project basis, or resources basis.

**REVENUE STREAMS**

ITAV maintains this list of possible revenue streams to offer consultancy services, both directly and indirectly. Indirectly means leveraging interactions to better position itself in accessing public funding, and patents.

# 4. Techno-economic analysis and business model validation methodology

## 4.1. Methodology

The deliverables already issued by WP1 (D1.1 [1] and, in particular, D1.2 [3]) have shown that the adoption of 5G in the use cases that the project has devised are widely advantageous from an economic point of view.

Moreover, a projection of the economic advantages at a European scale shows that these advantages become much higher if adopted by everyone.

Even if it is very difficult to establish what the flow of money may be (it depends very much on regulations, type of contracts and boundaries of competence that can only be diluted case by case when switching from Pilot to commercial solutions) it is clear that any carrying out the experiments enables a treasure given by savings (both in terms of investments and in terms of operating costs) and an increase in revenues. In any case we made the effort to provide a possible share of economic gains among the main stakeholders (verticals, manufacturers, telecom operators).

In D1.2 [3] has been demonstrated how the innovations proposed by the 5Growth Pilots are sustainable from an economic point of view.

More in detail, the quantity of money "produced" by the pilots thanks to the introduction of 5G was assessed numerically (and continuously updated).

These economic advantages derive from savings on investments (CAPEX), on annual operating costs (OPEX) and on an increase in revenues, obtainable thanks to higher production or better product quality.

The adopted formula (see below) calculates the Yearly Total Value (YTV), which is the parameter that will allow us to compare between legacy and new solution networks:

$$\mathrm{YTV}=\sum_{i=1}^{N}\frac{\mathrm{CAPEX_i}}{\mathrm{AP_i}}+\sum_{j=1}^{M}\mathrm{OPEX_j}+\sum_{k=1}^{R}\mathrm{RE_k}$$

where:

- $CAPEX_i$ is the i-th component of the N identified items of Capital Expenditures, i.e. the amount of cash flow that a company uses to purchase, maintain or implement its operating assets, such as buildings, land, plants or equipment.
- $OPEX_j$ is the the j-th components of the M identified items of the Operational Expenditures, i.e. operating, maintenance and management costs.
- $RE_k$ is the component of new revenues.

In order to harmonize the sum, each CAPEX has to be annualized, splitting the investment by the appropriate Amortization Period (AP).

The continuation of the study is collected in this document. It consists in highlighting some collateral elements of earnings, often not exploitable, first of all, the savings in human lives that were lost in railway accidents and at work in factories. by automating these sectors and remote control, people can be further away from dangerous places, reducing injuries and deaths.

Furthermore, a more in-depth analysis of the savings and increase in revenues made it possible to identify the "champions" for each category of Pilot and to understand if there could be economic advantages common to more than one Pilot, clustering the results.

Besides the mere methodology for a metric calculation (Yearly Total Value) already presented in D1.2 [3] and here refined, the methodology has been enriched by a business and technological validation scheme, produced in tight collaboration with the H2020 ICT-19 5G-SOLUTIONS project [4], as reported in Figure 5.

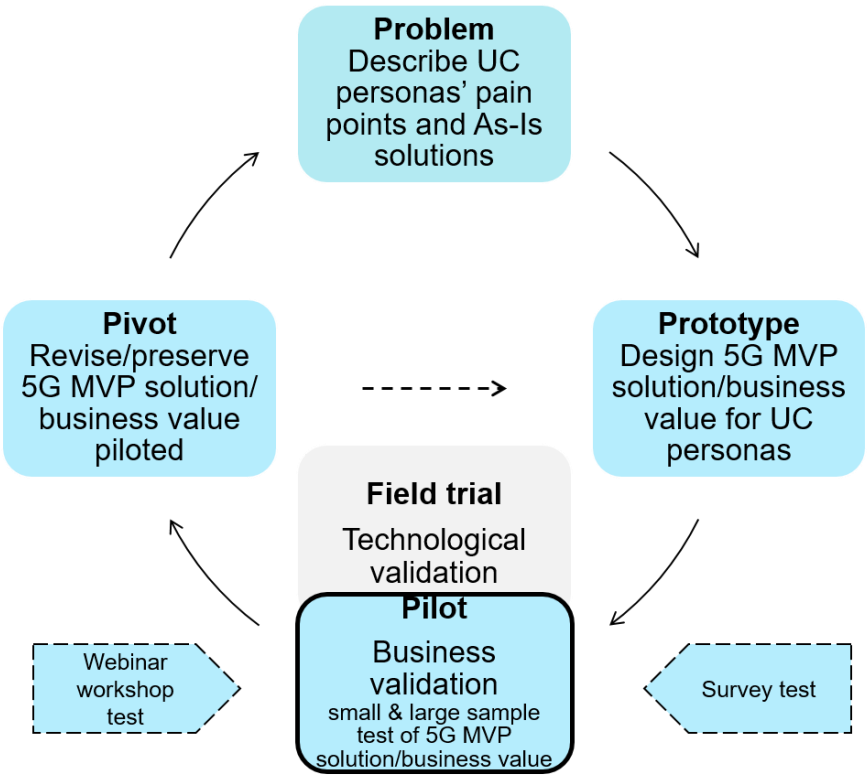



FIGURE 5: BUSINESS AND TECHNOLOGICAL VALIDATION

Pilot solution means the development of an MVP (minimum viable product) representing the technical validation. The method consists of understanding if the envisaged solution solves the customers' problem (identified in the 5G-SOLUTIONS as "personas' pain") and, eventually, the market analysis transfers the customers' needs to the technical side, elaborating a new MVP.

On the business side it is important to understand which are the benefits of the customers and how much they are able to pay for the new solution.

5G-SOLUTIONS organized a workshop describing this technique and providing a full example for the media & entertainment industry. In next sections 5Growth uses these concepts for its Pilots (industry 4.0, energy and transportation).

## 4.2. General Considerations

The economic benefits can be classified into several categories:

- Directly linked to the adoption of 5G
- Enabled by the adoption of 5G
- Collateral savings, not necessarily monetizable

The first category is linked to the possibility offered by 5G of providing connectivity performance (latency, reliability, bitrate) very close to those of optical fiber. This makes it possible to replace cable systems with wireless systems, obtaining enormous economic advantages in the installation phase (e.g., of new production lines in Industry 4.0) or in the continuous optimization of data resources, often the true value of companies. Furthermore, having less expensive systems (wireless to be precise) offers the possibility of connecting a greater number of sensors, previously impossible for cost reasons. Finally, 5G enables the edge computing that is a fundamental technology to guarantee QoS with URLLC for sensors but also to offload network traffic, providing an optimized use of the network transport resources.

This kind of advantages mainly allows CAPEX savings, which, if projected to EU scale brings to impressive benefits, as reported in Table 7.

Verticals are probably the main beneficiaries (immediately) of this kind of the adoption of 5G because network operators have to take investments for R&D and spectrum. In any case, the proportion is approximatively 50% (vertical), 25% (operators and manufacturers, each), as shown in Table 8.

**TABLE 7: ECONOMIC BENEFITS DIRECTLY RELATED TO 5G ADOPTION (ITEMS)**

| Economic item | Type | Total EU (yearly) [k€] |
|---|---|---|
| Edge Device Maintenance | SO | 0.0 |
| Spectrum | GR | -515.899 |
| Network Slices | GR | 0 |
| Cloudification | SO | 9087.5 |
| Cable cost | SC | 19200 |
| Network Operational cost | SO | 18270 |
| Edge Computing | SC | 24000 |
| QoS – SAIDI LV | SO | 0 |
| QoS - ENS | SO | 16575 |

**TABLE 8: ECONOMIC BENEFITS DIRECTLY RELATED TO 5G ADOPTION (PER STAKEHOLDER CALSS)**

| Category | K€ |
|---|---|
| Network operator | 25817.5 |
| Manufacturer | 2726.25 |
| Customer | 0 |
| Citizen | 0 |
| Vertical | 58072.85 |

The second category includes everything that is not directly linked to the adoption of 5G, but that 5G, thanks to its performance characteristics, allows enabling. In the industrial or transport sector, the remote control of factories or level crossings offers the possibility to drastically reduce the number and duration of business trips, to have greater availability of experts who, remotely, are able to solve problems. Furthermore, one of the most important advantages is the predictive maintenance which allows drastically reducing the number of interruptions in the production chain. The control of products and semi-finished products at each stage of the manufacturing process (comparing it, for example, with high-quality images present in the databases) allows increasing the quality of the products. Specifically, in the electric supply market, there is the reduction of electric supply outrage due to a better control.

Main economic benefits are taken to innovations not directly related to 5G. They worth million Euro if consider EU scale (see Table 9).

Having a look to Table 10 appears evident that the beneficiaries of the savings are telecommunications operators, manufacturers and, to a lesser extent, verticals. Instead, it turns out that a large part of the savings will be directed to customers (of the vertical).

This division of savings is indicative, as it strongly depends on the business model that will be adopted, as will be better explained in the next chapter.

**TABLE 9: ECONOMIC BENEFITS NOT DIRECTLY RELATED TO 5G ADOPTION (ITEMS)**

| Economic item | Type | Total EU (yearly) [k€] |
|---|---|---|
| Travel Reduction | SO | 360 |
| Experts Availability | SO | 345.6 |
| CMM Maintenance response time | SO | 90.72 |
| CMM Usage Optimization | SO | 157.224 |
| Lot Size Reduction | GR | 65.25 |
| Edge computing | GR, SC, SO | 90 |
| Video platform network | GR | 93.6 |
| OPEX energy | O | -2500 |
| Infrastructure initial deployment | SC | 860 |
| Civil Works | SC | 50.0 |
| Operational and provisioning | O | 500 |
| Change of production line | SC | 2500 |

| | | |
|---|---|---|
| Predictive maintenance | O | 279661 |
| Installation Cost | SC | 120000 |
| Installation time | SC | 30000 |
| Maintenance cost | SO | 12000 |
| Network resources optimization | SC | 10801 |
| Consultancy | GR | 16 |
| Local Maintenance cost | SO | 1 |
| Remote Maintenance cost | SO | 1 |

**TABLE 10: ECONOMIC BENEFITS NOT DIRECTLY RELATED TO 5G ADOPTION (PER STAKEHOLDER CLASS)**

| Category | K€ |
|---|---|
| Network operator | 18712.8 |
| Manufacturer | 4578.2 |
| Customer | 452250.9 |
| Citizen | 0 |
| Vertical | 2441.52 |

The third category is probably the most important, even if it is more difficult to exploit economically. In fact, it concerns the advantages that the solutions enabled by 5G and envisaged and tested by the innovative pilots of 5Growth bring in a collateral way. We have previously talked about the reduction of business trips or the movement of experts. This leads to environmental benefits. The remote control of factories limits the presence of people in the most dangerous areas of the company perimeter, reducing accidents at work. In addition, better control of level crossings reduces rail accidents, saving lives.

Although in D1.2 [3] an attempt was made to numerically enhance this class of benefits from an economic point of view, in order to add these benefits to purely monetary ones, it is more correct not to translate human or environmental benefits with euros, dollars or other currency.

### 4.2.1. Human lives

The use of 5G in level crossing (LC) scenarios will reinforce the safety conditions and may reduce the number of train accidents. These benefits can have a significant impact in the costs associated with damages (material) and human lives (persons who can die or be injured) [5].

According to [6], there are currently about 120000 level crossings (LC) in the EU. Therefore, there are, on average, 50 LC per 100 line-Km. Half of these LC are active and have some level of automation and the other ones have no type of active equipment meaning that are only equipped with a St. Andrew's cross traffic sign (passive). There is a relationship between the kind of LC (active, passive/unprotected) and the number of accidents meaning that the number of train accidents is higher at unprotected LCs. The statistics show that LC accidents occur at passive LCs (39,8 %) while at active LCs this percentage ranges from 4,1% to 30,6% depending on the level of automation.

According to these considerations, we believe that the European market can accommodate 60000 new generation level crossings (automated and supporting advanced communication technologies).

Our estimations consider 5% of Safety benefits in terms of human lives, using automation and video images to reinforce the safety conditions (use case 1 and use case 2 of the Transportation Pilot).

Indeed, the general public will benefit of safer road crossings that will lead to fewer accidents and deaths. The customer (generally the public administration in charge of road security) is equally benefited, since it is its *raison d'être* to watch out for the public's well-being, by reducing accidents in this case.

### 4.2.2. Work accidents

Across Europe, 3,497 people died in working accidents in 2015. From a statistical point of view, this is 2.4 fatal workplace accidents per 100 thousand workers.

Many other workers suffer non-fatal injuries, even severe ones. One of the advantages enabled by 5G is to automate factories, being able to control them remotely. This will prevent workers from accessing particularly dangerous areas of the company, thereby reducing accidents.

In addition to accidents, workers' health is often damaged by other factors such as particularly strenuous work due to physical fatigue or chemicals or electromagnetic radiation present in the workplace. Removing workers from situations or environments that can cause damage to health is certainly a social good.

### 4.2.3. Environmental benefits

In the current age, economical aspects are not the only ones that need to be taken into account and explored. Indeed, other considerations, such as societal and environmental, become increasingly drivers of progress and transformation within companies. And none of these considerations has become more important than the fight against climate change, and thus against $CO_{2eq}$ emissions that cause it. Sadly, in the hyper-competitive international market of manufacturing, it is many times hard to find actions tackling climate change that don't hinder the bottom-line and thus brings a competitive disadvantage. This makes even more relevant to rally behind the few instances where improvements in competitivity go hand in hand with climate change mitigation actions, especially if -like in this case- it also implies a better quality of service. In the use cases explored, this relates to two main items, namely the reduction in the number of travels performed, and the reduction of scrap.

The first one is a self-evident benefit, as it derives directly from the business model change addressed in this pilot. Indeed, business travel can amount to 50% or more of the non-manufacturing $CO_{2eq}$ emissions of a company [7] if all European companies cut their business travel by 20%, it would save 22 million tonnes of $CO_2$, equivalent to taking one third of UK cars off the road [7].

For example, for the European Commission and European Investment Bank, both institutions with high number of business travels (like INNOVALIA metrology), these amount to 37,5 and 69,9% of the total emissions, respectively (see figure below). As comparison, these trips contribute over three

times and almost seven times more (respectively) than the commuting emissions of all the workers of each institution.

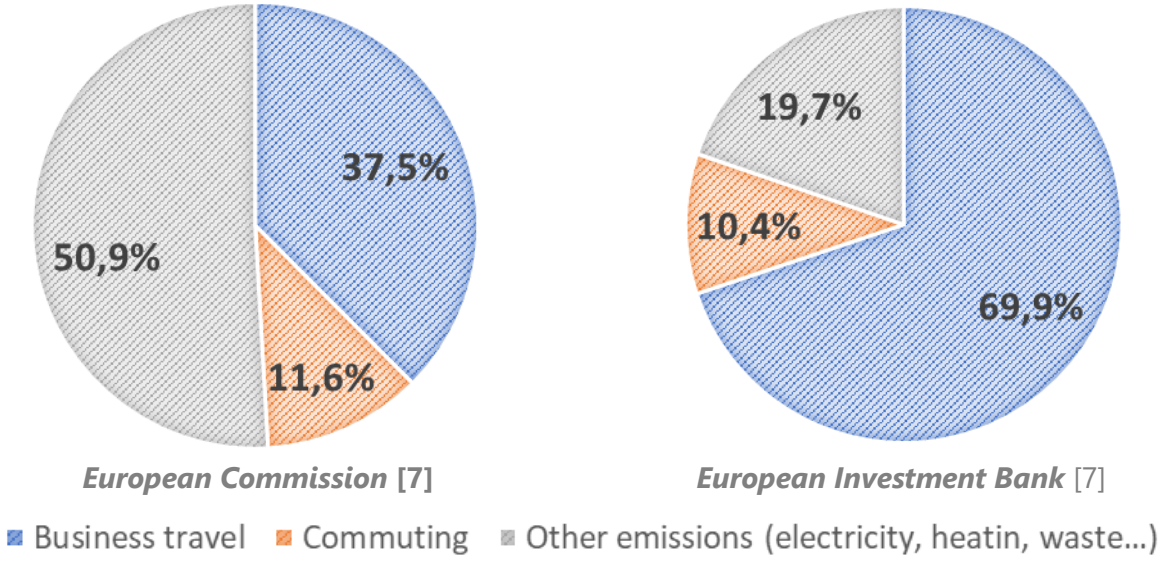



**FIGURE 6: CARBON EMISSIONS BY CATEGORY EMISSIONS BY CATEGORY AND IMPACT OF BUSINESS TRAVEL FOR THE EC AND THE EIB (MODIFIED)**

These emissions could be reduced by travelling by bus or train instead of car or plane, but only few of the travel connections are susceptible of being able to change because of too far of a distance covered, not good enough connections or too much time lost. Thus, eliminating all together the travel (the use case studied in the INNOVALIA Pilot) is most times the only viable way of curbing the huge emissions from business travel.

According to [6], the average emission factor of business travel (by air) ranges from 0,155 to 0,621 [kg $CO_{2eq}$ / passenger km], while car emissions range are of 0,132 to 0,227 [kg $CO_{2eq}$ / km]. This means that for many cases, car travel (alone) or flight travel (if in economy or premium economy) are equivalent in their carbon footprint. This is consistent with data from the UK Department of Business, Energy and Industrial Strategy (figure below), which estimates an average of 0,255 [kg $CO_{2eq}$ / passenger km] for domestic flights.

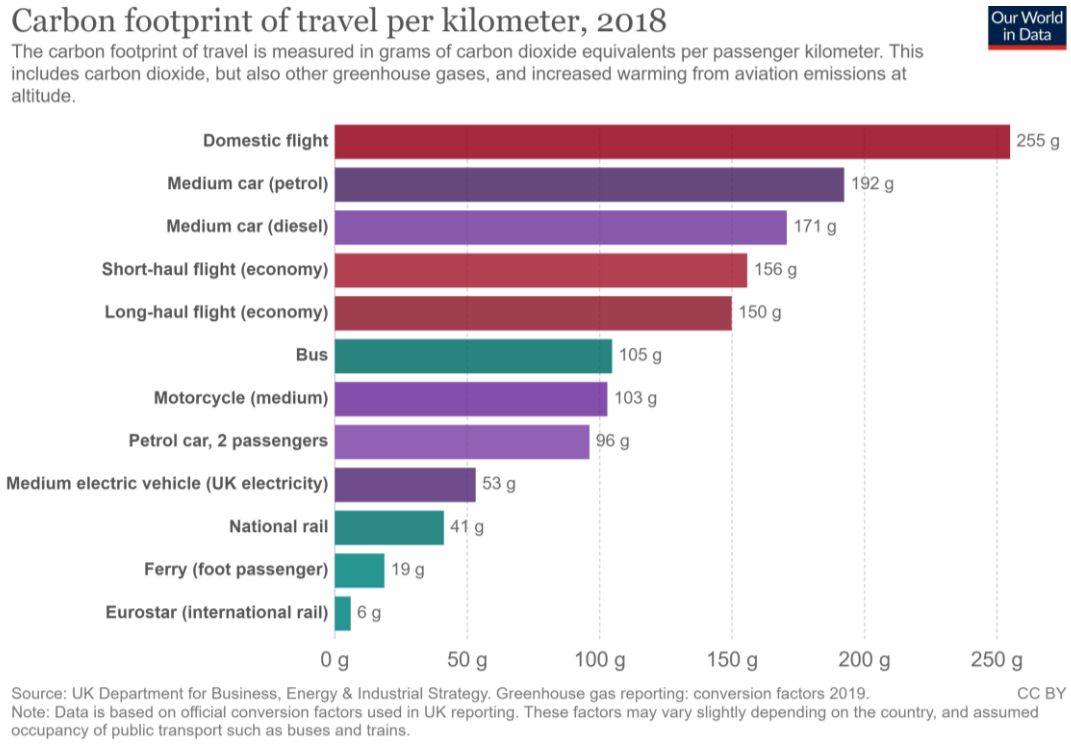



**FIGURE 7: CARBON FOOTPRINT OF TRAVEL PER KM AND PASSENGER, 2018 [6]**

Average flight distance in Europe is of 1714 km, but for the case of INNOVALIA, we are going to consider a flight to be Bilbao-Barcelona (around 600 km, or 1200 round-trip), to account for the fact that most travels would have been within Spain. This means emissions ranging from 446 to 1.788 kg of $CO_{2eq}$ avoided for every client, or from 26.784 to 107.309 kg of $CO_{2eq}$ saved total by INNOVALIA in flight reduction, or an average of 29 people compatible annual emissions [8]. This is simply from a medium company of around 60 employees, but the impact on a European scale could be huge.

The other item that could lead to major environmental impact is the reduction of scrap. Indeed, scrap is a huge contributor to excess emissions in industrial process, as not only it costs money, but generates wastes, consumes valuable goods, and takes energy to be produced. This item is likely to be bigger in terms of emissions reduction than the travel counterpart but is 100% dependent on the specificity of the clients manufacturing system, and therefore out of the reach of this project.

The beneficiaries of this item are mainly the citizens since climate change is poised to affect every person. However, the vertical and customer could also benefit from an improved image as a green business. This may lead to marketing and business advantages for climate-conscious clients that view the reduction of the carbon footprint as an asset when selecting what service to choose.

## 4.3. Final considerations

The results reported in D1.2 [3] and the further elaboration drawn in previous section of the current chapter demonstrates essentially three important statements:

- All the use cases we considered (pilots) are economically advantageous

- All the main stakeholders (network operators, telecommunications manufacturers, verticals and verticals' customers) can obtain economic benefits
- The economic benefits are not at the expense of the environment or safety. On the contrary, most use cases promise a reduction in pollution (mainly due to the drastic reduction in travel) and better safety at work and in society.

These three points support the evidence of 5G technology evolution being on the right path, and that what is envisaged by 5Growth pilots can be successfully implemented.

### 4.3.1. Business cases

Many private and public initiatives and projects have addressed the application of cellular technologies to smart manufacturing. In this direction, the H2020 5Growth is addressing the technical and business validation of 5G, from the verticals' points of view, following a field-trial-based approach on four vertical-owned [8] sites located in Italy, Portugal, and Spain.

From the business schemes previously reported, it is clear that, whatever the Pilot, the main stakeholders are the industrial Vertical, the network operator and the manufacturing of telecommunications equipment.

In this context, business and technical aspects are strictly related as the new 5G paradigm has the merit not only to allow a simple "cable replacement" but also to unlock important use cases which that were not possible with legacy technologies. These significant advances are achievable possible if the 5G radio layer is complemented with an appropriate underlying transport infrastructure and if these two elements interwork together under the direction of an orchestration platform. Similarly, cloud platforms become part of these such integrated synergy as radio functionalities and vertical applications migrates from the current dedicated hardware platforms towards virtual machines on commercial-off-the-shelf (COTS) general purpose serves, often located on the vertical premises to preserve data confidentiality and reduce data transfer delay.

#### 4.3.1.1. Verticals

In a first step, 5Growth considers a vertical-centric business. this means that the advantages are evaluated from a vertical point of view. After having amply demonstrated that the adoption of the solutions proposed by the project (whose backbone is 5G) are advantageous for the vertical, we think about how it is possible to distribute these advantages to all stakeholders.

In the study we did it was noted that for each Pilot there are some "champions" of savings that often catalyse more than 50% of the total economic advantages and are easily experienced and adaptable in similar situations.

In particular:

- The INNOVALIA Pilot on Industry 4.0 has its "champion" on remoting the control, i.e. the possibility of manage the factory from outside and, in particular, if some particular problems

occur experts can solve the problem remotely, avoiding long trips for few hours work. Just to give an idea, in a medium size factory this would imply a saving of 700 k€ per year.

- In the COMAU Pilot the "champion" is the possibility of having predictive maintenance, i.e. a wide network of sensors connected to the mechanical parts of robots that, together with IA system, allows the possibility to react before a failure occurs. Taking into account that COMAU robots are largely used in car manufactory, one minute stop for failure of the production chain can bring 10 k€ loss. In a large factory composed by 8 production chains it is estimated that the 5G and IA based predictive maintenance admits savings for more than 11 M€.
- The EFACEC_T considers taking advantage from the installation costs, avoiding cable, in remote rural area. This advantage can be quantified on about 40 k€ per crossing level, but, due to their high number, in Europe the saving can be more than 2 M€ per year.
- EFACEC_E sees the main saving item on household. If we consider the European size, this saving can be quantified for 19 M€ per year.

Further business advantages can be reached moving most of the UCs to a shared infrastructure. In this case the IA vendor can take advantage of reduced TCO cost and fully delegate the infrastructure management to the MNO. Moreover, this extends the wireless smart manufacturing also to SME that cannot deal with private network deployment. These advantages can be considered as a common business value that should be partitioned among the actors taking part on the business itself.

Among the technical challenges, the deployment of an orchestration platform is very relevant. It will also impact the MNO and vendors operations reducing the activities in field. In addition, the realization of a transport network tailored for the specific vertical needs (among which the low and controlled latency is the most challenging) requires further investment from vendor and operators.

#### 4.3.1.2. Network operators

The 5Growth case studies concern particularly innovative vertical applications. In Section 2 of this document, the hypothesis has been made that some applications do not need the performance of 5G but could serve as an economic flywheel since a greater penetration of 5G connectivity will certainly decrease the individual costs of connectivity and allow for the expansion3 audience of services that use 5G for which it will become a sort of dominant connectivity technology.

From a technical point of view, one of the major innovations of 5G, already begun with Rel. 15 and perfected with Rel. 16 and 17, is the possibility of providing slices.

Network slicing is the operators' best answer on how to build and manage a network, that meets and exceeds the emerging requirements from a wide range of users. The way to achieve a sliced network is to transform it into a set of logical networks on top of a shared infrastructure. Each logical network is designed to serve a defined business purpose and comprises of all the required network resources, configured, and connected end-to-end.

The network slice is a logically separated, self-contained, independent, and secured part of the network, targeting different services with different requirements on speed, latency and reliability.

Network slice characteristics are for example low latency, high bandwidth and ultra-reliability for a critical IoT use case or higher latency and lower bandwidth for a massive IoT use case.

A network slice can be dedicated to one enterprise customer or shared by multiple tenants. For example, a slice may consist of dedicated radio, transport and core resources including a dedicated user plane function at the edge. Another slice shares radio and transport resources between tenants but provides dedicated core network functions per tenant.

Beside to technical benefits, it is important to note that end-to-end network slicing enables new business model innovation and use cases across all verticals and creates new revenue opportunities for communication service providers. It provides service flexibility and ability to deliver services faster with high security, isolation, and applicable characteristics to meet the contracted SLA. Network slicing enables operators to maximize the return on investment via efficient usage and management of the network resources and provide differentiated services at scale. As 5G brings new technologies and creates new business opportunities across all industries, enterprises are looking for innovative solutions to meet their needs and to address new opportunities. Enterprise users want automated business and operational processes starting from ordering the service, activation, delivery, and de-commissioning of the service. They are expecting services to be delivered faster with high security.

Stating this, the main business model, and the real novelty is providing business models for emerging 5G technology, from a network operator point of view is a network slicing cost allocation model. Many studies in literature have been done. In our opinion the most promising and, where 5Growth leverages for its business evaluations is based on Figure 8.

The main pillars are the cost allocations of core network and the throughput. This splitting into the main components permits to the network operator to have a clearer idea about the cost of a single use case, even if take part of a complex network. In fact, the output of use cases (comprised the ones envisaged by 5Growth) includes the requested throughput and the necessary core network resources. Using the formulas provided in [9], it is possible for a network operator to calculate the cost of each slice, and, as consequence the price of the customized connectivity offer.

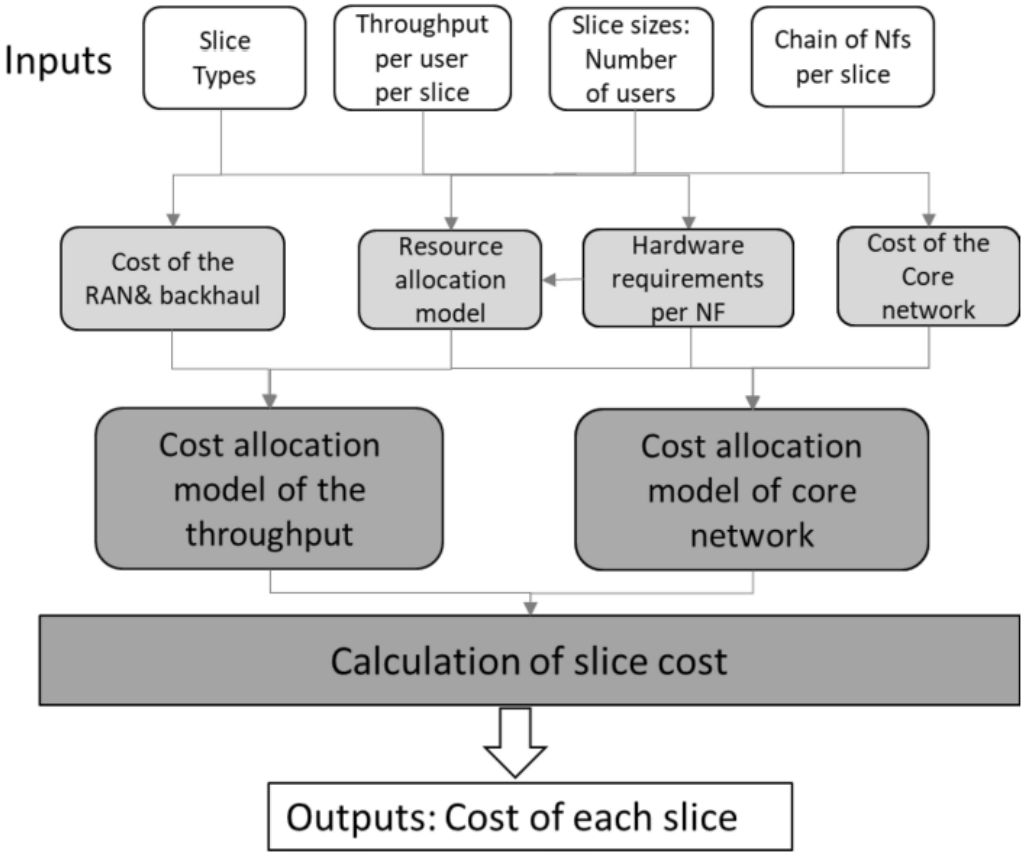



FIGURE 8: COST ALLOCATION MODEL DIAGRAM (FROM [9])

The study reported in [9] outlines a calculation for video and voice providers and reported in Figure 9.

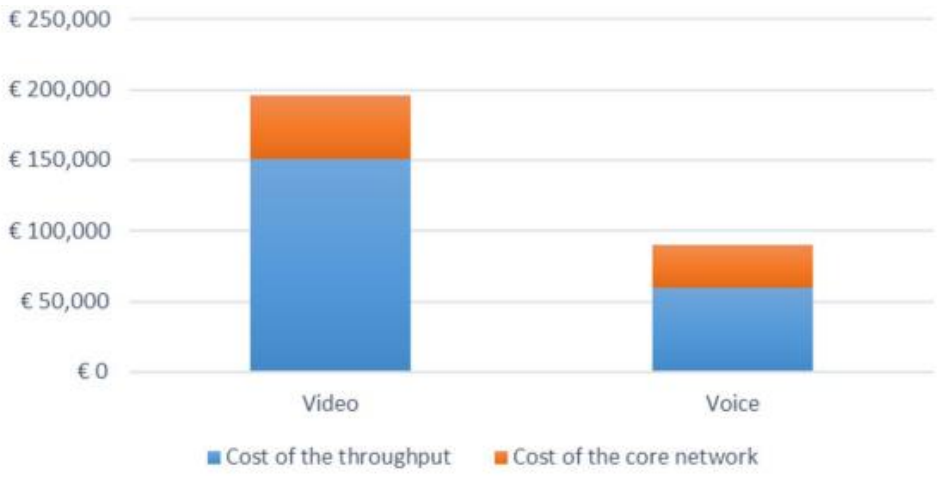



FIGURE 9: ALLOCATION OF THE NETWORK COST TO EMBB VIDEO AND VOICE SLICES (FROM [9])

Using the formulas in [9] and pilot evaluations we evaluated the yearly cost of slice from an operator point of view for solutions very similar to the use cases provided in the project.

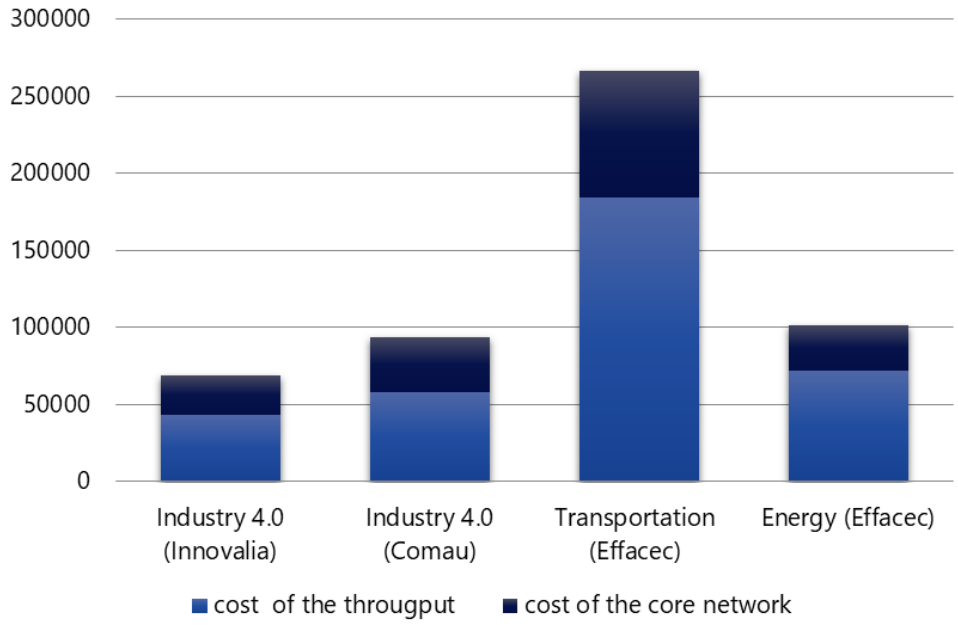



**FIGURE 10: COST OF SLICES**

Of course, figures are considering current data and validated by the project. In any case it is not the absolute value the interesting result.

The slice is related to the Figure 10 reports the cost (in Euros) for a slice of a European Operator accomplishing the needs of a use case described in section 2 and in the other WPs of the project).

What it is important, indeed, is that slice bears the significant amount of the network costs (from 68% to 70%). This is reasonable, because these use cases require more throughput on the RAN and backhaul and more computing resources on the core network part as well. For more retail and consumer services we expected different slice costs distribution where the network components is lower, due to the necessity of lower network performances, like latency and data rate.

The results obtained in these studies consider the methodology provided in [9] and [10] with the specific use cases in 5Growth. For each of the use case, the needs in terms of bandwidth and number of users and the cost has been estimated, using the set of parameters (costs of single elements) provided in [9] and [10] and updated with the experience with the Network Operators, partners of 5Growth . This part of the study is complementary with respect to what is provided in section 4.2. In fact, in Section 4.2 we estimated the economic benefits in terms of CAPEX / OPEX savings and increasing revenues. In this part of the study, it is calculated the cost of the slices and considering the cost of the throughput and the cost of the core network.

There is an additional cost saving due to the use of virtualization on the core network. It is about 45% (cost per Mbit/s) compared to the cost used in [9] and “only” 12% if the cost is calculated per user compared to the cost found in [10].

In any case the savings can be identified as significant and prove that the use of NFV and network slicing reduces the cost of the core network deployment. Just for giving figures, the cost of 5G network core per user is 53 €/year, compared with about 60 € /year in a traditional network. The cost per Mbit/s decreases from 38€ / year to 21 €/ year.

### 4.3.2. Social acceptance

The last point of the bulleted list outlined above is very important. In fact, if on the one hand, in an industrial context, such as those analyzed by 5Growth, large savings or considerable increases in revenues, due to an increase in production efficiency are sufficient arguments to convince top managers to adopt innovative solutions involving 5G.

Ordinary citizens often see new technologies as enemies, and 5G is not exempt from this problem. In order to overcome this obstacle, social acceptance studies have been carried out, for example in 5G-SOLUTIONS. As for 5Growth, social acceptance is helped by real and tangible benefits immediately.

Two of the four pilots of the project concern solutions in Industry 4.0. 5Growth use cases impact citizens and immediately on industrial workers. In fact, the best working conditions enabled, for example, a remote control of a company, allows for example to stay at home against an office to control a company, while before we would have had to go inside a factory. This improves the quality of life and also reduces the number of accidents at work, which is currently a very big problem, often sensitized also by the President of the Italian Republic, Mr. Mattarella. In addition, the large savings and new revenues that the manufacturing companies that will adopt Industry 4.0 enabled by 5G will have will allow end customers, and therefore citizens, to have products at lower prices, without sacrificing quality.

Added to this is the fact that we have been able to demonstrate a reduction in CO2 production and also advantages on safety at work and in the specific use case of level passes, where the number of accidents that unfortunately frequently occur in such situations should be drastically reduced. All this makes the work of social acceptance of 5G easier for all segments of the population.

# 5. SLA elicitation and business layer modelling

Any technical and commercial relationship between a customer and a provider is subject to a Service Level Agreement (SLA) among parties. This kind of agreements state the conditions of the service execution as well as potential penalties associates to the infringement of the agreement conditions. That conditions are established in terms of the accomplishment of a certain number of technical parameters, including typically a percentage of time in which such negotiated parameter should be committed. The set of technical parameters is known as Service Level Objectives (SLOs), and there is possibility of measuring them in order to validate the commitment of the negotiated values. The measured values of those parameters are referred as Service Level Indicators (SLIs), and the assessment of the SLA is basically the comparison along the time of the negotiated SLOs with the observed SLIs. Finally, it could be the case that the customer requires of some additional characteristics associated to a given service, which relates to parameters or conditions that cannot be directly measured (e.g., restrictions of the service to exclude a certain geographical area, or isolation of resources), but in which the provider can as much provide some evidence. This can be referred as Service Level Expectations (SLE). This differentiation of concepts is leveraged from [11] which addresses the Network Slicing for transport networks.

For instance, in the context of 5Growth, the SLA could contain SLOs defined by vertical customers as those in [12]. The SLOs, as expressed by the Verticals to the provider, while be presented from the perspective of the vertical service. Thus, the provider will run through a process of adaptation or mapping of that service-related SLOs to equivalent network-related SLOs, in a manner that vertical expectations are satisfied. Once that mapping is defined, the provider will be in the condition of honouring the vertical slice request, triggering any necessary provisioning action in the network including function instantiations, compute resource allocation, network connectivity setup, etc.

However, it should be noted that the SLAs should be met along all the lifetime of the slice service, thus requiring of a continuous assessment of compliance. This will help to avoid, in the provider side, any penalty associated to the agreed commercial contract with the vertical. Whatever issues occurring during the slice service lifetime should be fixed with the aim of satisfy the agreement terms. Such actions could be either internal to the provider, i.e., by automatically triggering corrective actions transparently to the customer; or such action could require some additional interaction with the customer to adjust the previous SLA to the new circumstances of the provider network, even implying reconfiguration of the slice.

All this functionality, i.e., SLA negotiation, fulfilment, and adaptation, should be supported by the business layer of the provider as front-end of vertical customer service. Furthermore, as a primary step, such business layer should permit a dynamic interaction with vertical customers for enabling an overall automation process.

According to [13], the SLA management can be divided into four blocks: *Start Up*, *Negotiation*, *Implementation* and *Review*. In the Start Up block, the signatory parties (provider and customer) establish by technical means the commercial relationship. In the Negotiation block, the service offer definition, understood like the supplier ability to fulfil the contract, QoS monitoring, cost, and

payments, takes place. Consequence of this negotiation, the service SLOs as expressed by the vertical customer are mapped to network SLOs actionable in the network. In the Implementation block, the creation and assignment of resources capable of satisfying the negotiated SLA is performed. Finally in the Review block, based on measurements and observations of performance metrics, some adjustments are done if necessary (both internal to the provider respecting the negotiated SLA, and external requiring new interaction with the customer to re-negotiate or re-define the SLA).

Based on the previous blocks and a preliminary relationship with 5Growth components existing on the project's architecture, the 5Growth business layer (above 5Growth stack) with support to SLA management blocks is defined, as shown in Figure 11.

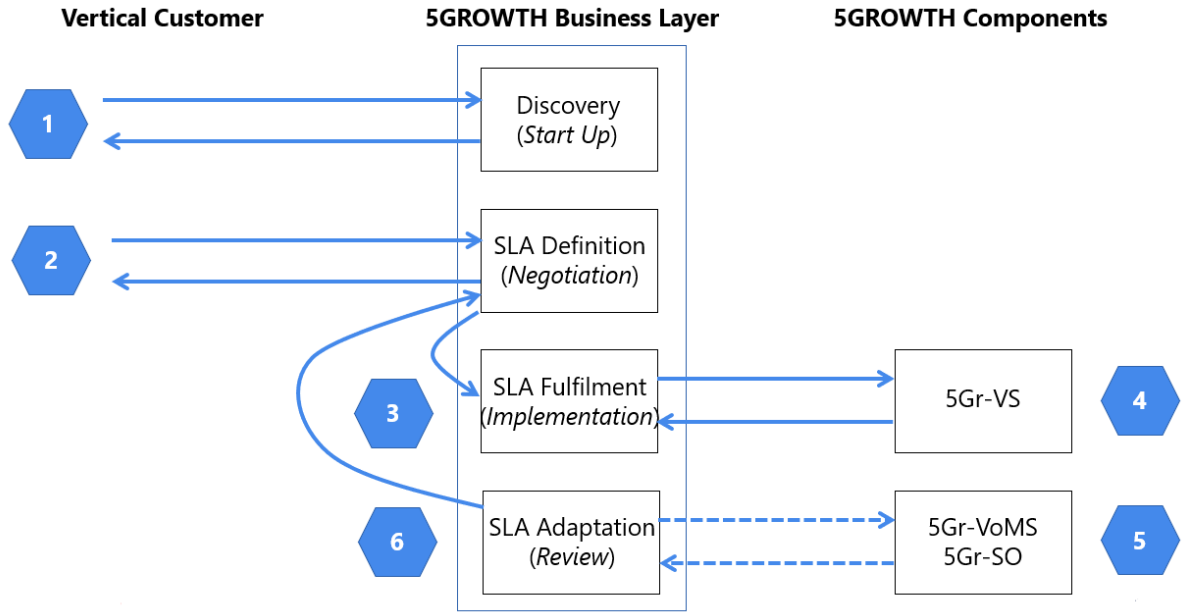



FIGURE 11: SLA MANAGEMENT

Three existing components from the 5Growth architecture are proposed in the previous figure to interact with the SLA management blocks. First, the Vertical Slicer (5Gr-VS) which is the entry point on 5Growth architecture for verticals to demand the provisioning and management of vertical services. This is achieved with a simplified northbound interface with the vertical OSS/BSS. Second, the Vertical-oriented Monitoring System (5Gr-VoMs) which is the monitoring platform in 5Growth architecture to monitor heterogeneous set of services and technological domains. It offers functionalities such as log aggregation, a scalable data distribution system and dynamic probe reconfiguration. Third, the Service Orchestrator (5Gr-SO) that interacts with the SLA management blocks when it is necessary to renegotiate or adapt the original SLA request.

Hereafter, each of the SLA management blocks are described in detail. In 5.1, 5.2, 5.3 and 5.4 Discovery, Definition, Fulfilment and Adaptation blocks can be found respectively.

## 5.1. SLA discovery

The SLA Discovery phase concentrates on the potential mechanisms in place for verticals in order to be associated with public providers offers with the purpose of accomplishing end-to-end service delivery. The more obvious case is the one in which such association is pre-determined after a commercial discussion between parties, in a traditional manner. This is obviously not disruptive nor innovative in the sense that conventional customer-provider relationship is maintained as in the past. It can be also assumed that in such traditional mode of operation the establishment of technical configurations and settings can be naturally performed in a manual or semi-automated manner, because the lack of incentives to improve the process. There is however in 5G the trend to move toward open scenarios in a broad sense. It is here where there is an innovation space that could be explored to foster much more advance scenarios for interaction between verticals and public providers, with a more flexible and fluid interaction among parties.

This subsection discusses on that potential evolution as argument for a dynamic discovery process for interconnection of Vertical and Public provider settlement, including SLAs.

### 5.1.1. Dynamic interconnection scenarios for verticals

Several different scenarios of interconnection between vertical or Non-Public Networks (NPN) networks and public providers have been proposed in the literature, including industrial organizations [14] and research papers [15]. Figure 12 summarizes the approach described in [14].

In Figure 12-1, the NPN is deployed as an independent, standalone network. This implies that all the functions are located inside the industrial premises. The only communication between the NPN and the operator is done via a firewall for accessing external data networks (i.e., the Internet).

In Figure 12-2, the deployment consists of a combination of an operator network and an NPN. The RAN is shared, with the NPN making use of some part of spectrum, with the NPN retaining all the control capabilities. Though not shown explicitly in the figure, in some cases the traffic will flow completely on the operator side and in others will flow on both the operator network and the NPN.

In Figure 12-3, the NPN and the operator network share the radio access network and core control plane capabilities, being performed on the operator side. From that point, all the external traffic will flow on the NPN.

Finally, in Figure 12-4, the NPN relays entirely on the public network but it is treated as if they were part of completely different networks. This is achieved by the use of network function virtualization.

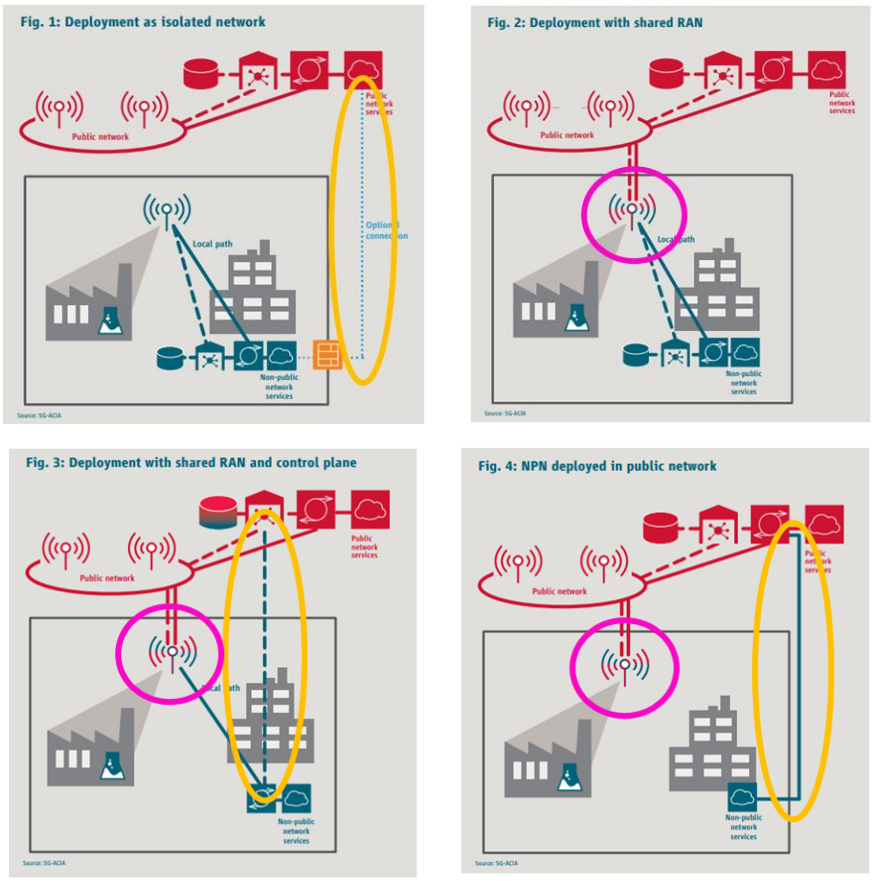



**FIGURE 12: NETWORK DEPLOYMENT SCENARIOS FOR NPN**

Some of the scenarios present capabilities for developing "logical" interconnection schemes (represented by orange lines in the corresponding figures) as the ones present in traditional interconnection schemes for peering or transit, where logical interconnection (i.e., BGP sessions) are established among parties basically for the interchange of IP traffic. Interesting to consider, the advent and deployment of neutral points, as in the case researched by projects like 5G-City, or the existing flourishing market of carrier houses (i.e., Interxion, Equinix, etc) can motivate the connection of vertical industries to such kind of open, neutral environments where multiple public providers could offer their services to multiple customers. Thus, such kind of ecosystems can act as a "meet-me" environment where verticals could interact with multiple providers in a dynamic manner. Is in situations like this where flexible, dynamic mechanisms for discovery, including SLA, can be fully exploited, since interconnecting with one public provider or another can be a matter of process automation. Another potential scenario of dynamic connectivity, convenient for Discovery processes, could be the following. Thinking on shared Radio Access Network (RAN) cases and considering a disaggregated approach as the one promoted by O-RAN, apart from the straightforward spectrum sharing case, it can be possible to dynamically interconnect private O-RUs in the vertical premises to public O-DUs (or similarly private O-DUs to public O-CUs, which could be more technically feasible since the connectivity requirements become much more relaxed in midhaul vs fronthaul). Figure 13 [16] presents a variety of possible sharing scenarios between private (or local) and public 5G infrastructures.

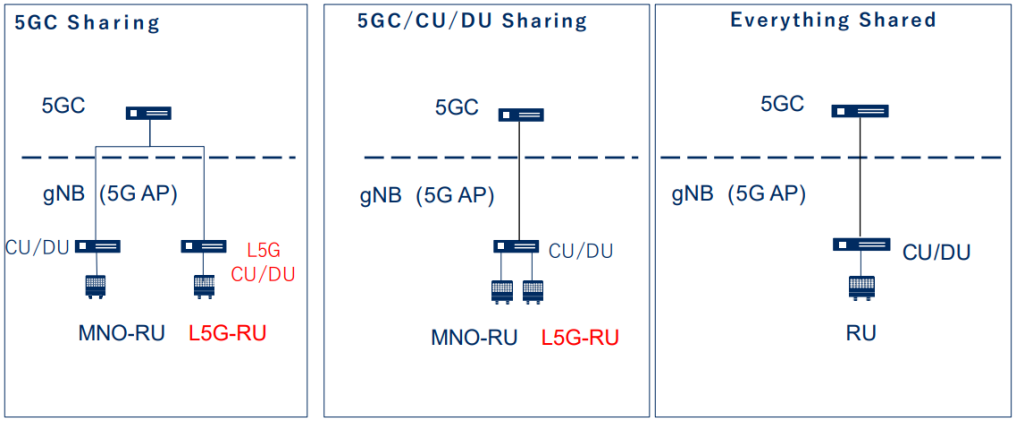



FIGURE 13: ALTERNATIVE SHARING SCENARIOS OF DISAGGREGATED 5G INFRASTRUCTURE [16]

## 5.1.2. Dynamic discovery

Figure 14 presents an example assuming the presence of multiple public providers in a given neutral host.

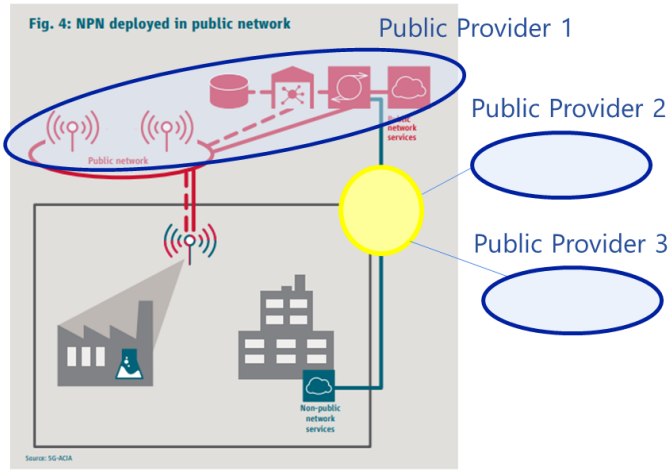



FIGURE 14: MULTIPLE PUBLIC PROVIDERS GIVEN A NEUTRAL HOST NETWORK DEPLOYMENT SCENARIO

In this example, it is assumed that all public providers participating from a given neutral host have similar radio coverage (alternatively, it could be the case that the vertical manages its own spectrum and radio access, then only requiring to complement its communication infrastructure partnering with some public operator). From a physical perspective, in a classical approach, the vertical-provider interconnection is a dedicated interconnection usually managed by a manual back-to-back configuration and operation. Leveraging on these neutral host facilities, the connection between vertical and whatever public provider can be either back-to-back or by means of shared infrastructure at the neutral host. On top of that physical interconnection, the logical connection between a vertical and a provider could leverage on manual configuration for session establishment or in some auto-discovery mechanism. Similar situation can be present, for instance, in other multi-domain environments such as in [17] Advanced mechanisms could be also explored, as it is the case of distributed procedures, automatically making use of negotiation or transactions with mechanisms like DLT (left for further study). Finally, it is worthy to state that this vertical-provider discovery

interaction can be also extended to provider-provider interconnection, all of them supporting the 5Growth architecture.

## 5.2. SLA definition

Novel services and applications are no longer based on a single isolated provider. They are composed by different service providers that combined can provide a service. In 5Growth these stakeholders are different for each use case. However, they can be generalised in three main stakeholders:

- Vertical: The customer that requires the service.
- Telco service provider: The one in charge of providing the communication infrastructure as well as the connectivity.
- Other service providers: Depending in the pilot, other service provider might be relevant for the SLA elicitation, such as video providers or public authorities.

The interaction between the telco service provider and the other service providers will determine the SLAs that can be guaranteed to the vertical. It is important to at this point to handle the concepts of SLAs, SLIs and SLOs:

- Service Level Objective or SLO: SLO is a goal that the vertical wants to reach.
- Service Level Agreement or SLA: SLA is a contract that the service provider promises verticals on service availability, performance, etc.
- Service Level Indicator or SLI: SLI is a measurement that the service provider uses for the predefined goal.

Depending on how the SLOs, SLAs and SLIs are processed, a two-dimension analysis should be performed, as indicated in Figure 15:

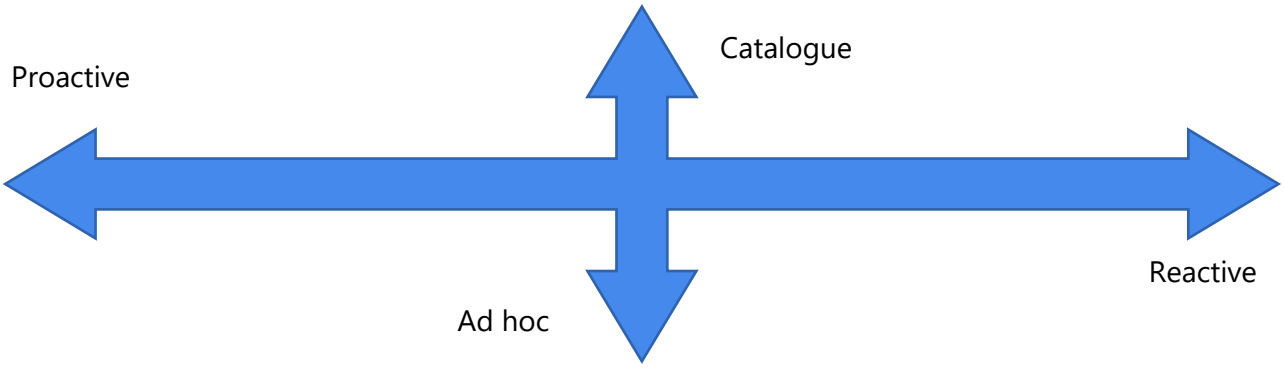



**FIGURE 15: TWO DIMENSION ANALYSIS**

Depending on the dimension selected to vary in this two-dimensional analysis SLAs will be defined in a different way. To reflect such an idea, this section is structured in three subsections. Depending on the way SLOs are negotiated we will have two possible approaches, as explained in section 5.2.1. Once negotiated, the offering can be provided in the form of a catalogue or ad hoc, as described in section 5.2.2.

### 5.2.1. SLAs negotiation

The negotiation of an SLA between a customer and a provider can be a long process between the two parties. In addition, novel services, and applications as those of 5Growth are no longer based on a single service provider. Instead, they are composed of several providers that cooperate to serve the vertical.

Two possible approaches are foreseen to implement the SLA negotiation based on the previous idea: the reactive approach and the proactive approach.

- Reactive: In this approach the vertical sets an SLO and asks the telco service provider about its possibilities to fulfil it. In the same way, the telco service provider asks other stakeholders about their capabilities at the time of receiving the request and provides this information to the vertical in the form of an SLA. If the vertical accepts, the SLA will be monitored, checking the negotiated SLOs against measured SLIs.
- Proactive: In this approach, the vertical interrogates the telco service provider (which has done the same beforehand with the rest of stakeholders to know the potential services that can be honoured) with the aim of collecting their capabilities to being able to determine on the go whether a request from a particular vertical can be satisfied.

The previous ideas can be summarized in a flowchart as in Figure 16:

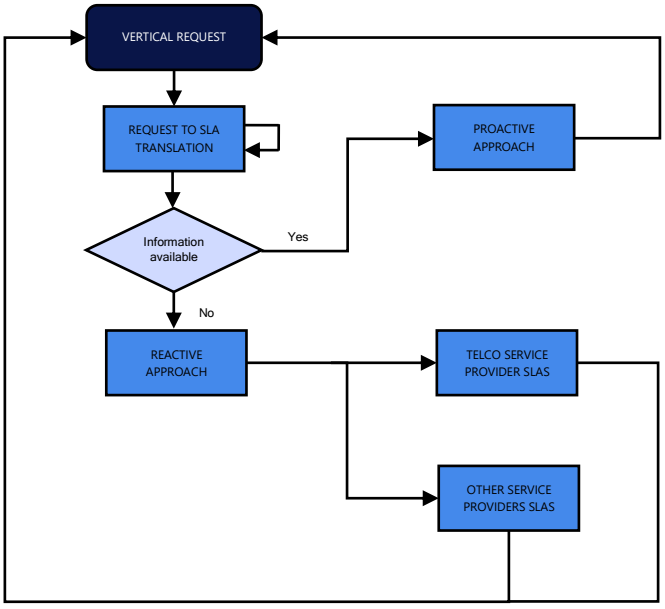



**FIGURE 16: SLA NEGOTIATION**

Depending on the pilot and the use case that is considered one approach or the other could be used. It would be also possible to combine both approaches by gathering the information that all the service providers communicate when using the reactive approach.

If the request cannot be fulfilled with any of the approaches, a further negotiation must be done to guarantee an SLA (maybe re-scoping the initial SLA).

### 5.2.2. SLAs offering

When the SLA has been agreed between parties, the formal SLA offering takes place. It can be done by following two approaches:

- Catalogue approach: From a catalogue, verticals consume previously prepared SLAs. The main advantage of this approach is that when the vertical proposes a SLO and can be satisfied with an SLA present in the catalogue, it is automatically provided without incurring in unnecessary delays. However, this approach implies that no other SLAs outside the catalogue can be provided.
- Ad hoc: The SLAs are negotiated when the vertical defines its SLOs. This approach supposes the creation of a contract in an ad-hoc manner. It can be more flexible than the catalogue approach but will need more time to be completed.

### 5.2.3. E2E Example

In order to make things more understandable, we propose an example based in the E2E service composition described in [13]. The example supposes a user that wants to be served a service composed by three components: communication server, processing server and a data server.

This user requires that the processing time of the service is less than 2 s in 90 % of the cases, given that the processed request in one second is less than 1000. The SLO linked to the user needs would be:

SLO1: E2E processing time < 2 s if the number of requests < 1 000 in 90 % of the cases

In terms of SLAs, the E2E objectives at the vertical level must be linked to measurable QoS parameters. In [13] such parameters are referred as round-trip time, availability, bandwidth, MTBF and MTTR as the parameters to be checked for this example. From the realization perspective, the 5Growth provider could have originally collected from other stakeholders the information to ensure that such kind of service can be honoured (proactive case), stating that capabilities on a specific offering of the service catalogue or simply reacting in an ad-hoc manner to a vertical request.

## 5.3. SLA fulfilment

After the definition the SLA must be translated from a business layer language to a technical language. Indeed, the 5Growth platform can only understand a technical specification in order to create appropriate slices, network services, VNFs, that satisfy the requirements expressed by the vertical in the negotiated SLA. The SLA fulfilment phase takes care of translating the requirements in the SLA into configurations for the 5Growth platform and also to communicate the output to all the relevant components in the platform. In this section, we will describe this process both with a generic approach and in detail following the example introduced section 5.2.3.

### 5.3.1. SLA Fulfilment phases

As shown in Figure 17, the SLA Fulfilment phase is divided into three internal phases. The information received as input is the result of the SLA definition phase, consisting of a list of SLI and associated SLO. The output of the SLA Fulfilment phase is then forwarded to the SLA Adaptation phase. In the following, the terminology of Service KPI and Core KPI as defined in [12] is used as equivalent to service SLOs, as understood by the vertical customer, and network SLOs, as actionable by the provider.

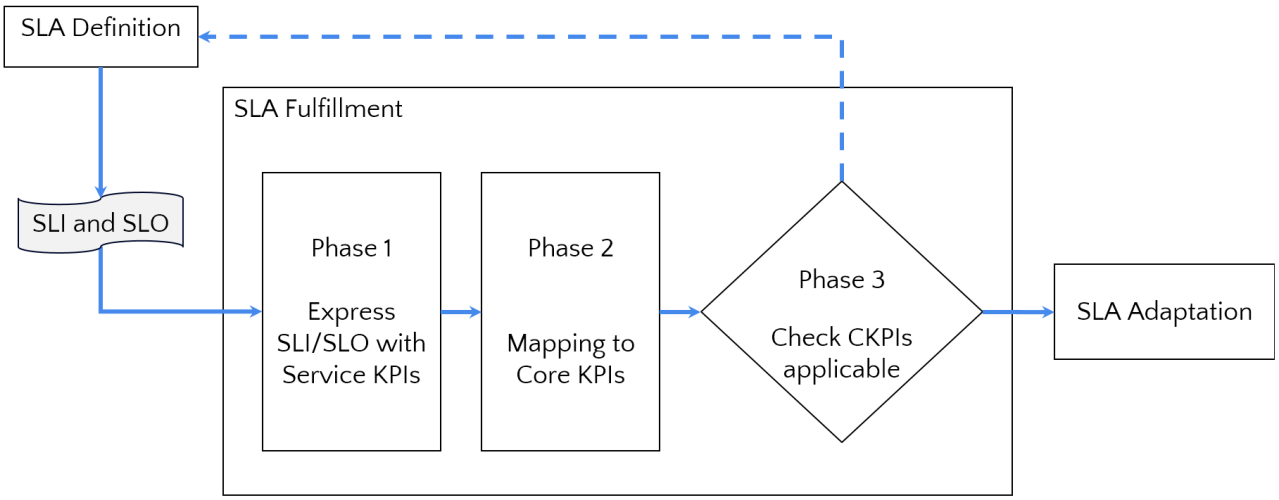



**FIGURE 17: SLA FULFILMENT INTERNAL PHASES**

A high-level overview of the three internal phases is reported below.

- Phase 1: Express SLI/SLO with Service KPIs: The SLI and associated SLO are associated to Service KPIs (SKPI). The latter are KPIs supported by the platform and express a performance requirement at the service level.
- Phase 2: Mapping to Core KPIs: The Service KPIs from Phase 1 are mapped to Core KPIs (CKPI). The latter are KPIs expressed at the infrastructure level and so directly applicable by the platform.
- Phase 3: Check CKPIs applicable**:** Since the platform is multi-tenant and conflicting requirements can happen, a check is performed in order to establish if the desired Core KPIs are applicable. In case of a negative answer by the platform, the control is returned to the SLA Definition phase, as shown by the dashed line in Figure 17.

In the next sections we are going to present each internal phase in more details. Additionally, we are also going to perform the translations regarding SLO1 example.

### 5.3.2. Express SLI/SLO with Service KPIs

Service KPIs have been identified and defined in D4.1 [18]. They express the service needs and at the same time, they are used to measure whether a 5G service deployment is satisfying the expected behaviour or not. The 5Growth project has defined a list of 11 Service KPIs, according to the

experience acquired by interacting with the pilots and to partner's experience in other 5GPPP projects.

Service KPIs allow validating an industrial 5G scenario from the vertical point of view, hence they can be easily associated to SLIs and SLOs. Each SLA available in the catalogue is mapped to a subset of Service KPIs and their target values, reflecting the requirements necessary to satisfy the agreement. The set of 11 independent Service KPIs available in the 5Growth project and the possibility to combine them into several combinations, provides the platform owner with a wide range of possibilities in the creation of their catalogue. The definition of the SLA templates is very flexible and granular enough to customize an SLA for a specific customer. This ensures that SLA templates are not too rigid, so that the provider can heavily customize its commercial offer. Regarding our SLO example in section 5.2.3, the service availability expressed in terms of overall service uptime, needs to be translated into Service KPIs as defined by the 5Growth project. As for the availability SLO, the uptime of each service component must be accounted.

For the convenience of the reader, we report the SLO example here:

E2E processing time < 2 s if the number of requests < 1 000 in 90 % of the cases.

The SLO is expressed in a semi-structured English form. We can express it through the following Service KPIs:

- 5GR-SKPI-8: Service Operation Time. The service operation time is the minimum time needed to perform one iteration of the complete service workflow. E.g., in an industry 4.0 context, the time that it takes to scan an industrial piece, process the information and display the results to a QA operator.
- 5GR-SKPI-9: Service Operation Capacity. Number of iterations of the service workflow that are being performed simultaneously at a specific instant of time.

These Service KPIs have been selected by reading the SLO expression in terms of service parameters (processing time and number of requests per seconds or processing capacity) and picking up related platform implemented ones from the 5Growth platform specification.

The translation can be done manually by the platform provider, if starting from a pre-defined and limited catalogue of SLOs. Otherwise, if more flexibility in the SLO definition is required, Natural Language Processing techniques can be used similarly to what is done in [19] [20] for SQL Statements.

### 5.3.3. Mapping to Core KPIs

While Service KPIs are useful to validate an industrial 5G scenario from the vertical point of view, they are in most cases not directly measurable. Hence, Service KPIs must be mapped to Core KPIs in order to be correctly implemented on the 5Growth platform. The mapping is defined in D4.1 [18] and it has subsequently been updated in D4.2 [21], according to new requirements and experience collected in the interactions with the pilots.

The Service to Core KPI mappings are unambiguous relationships made by the 5Growth platform for assessing the defined CKPIs for each specific SKPI. Table 11 reports the detailed mapping of SKPI to CKPI. The set of SKPIs for each service deployed is a set parameter being exclusively relevant and/or meaningful for that specific service. Thereby, the set of SKPIs for a given service may be orthogonal (not relevant) to other vertical services even if both coexist and are rolled out over a common (compute and network) infrastructure. Thanks to the defined mapping, the set of SKPIs is converted into a pool of CKPIs bound to the specific compute and networking resources to be allocated for accommodating the vertical service. Indeed, the CKPIs provide measurable performance parameters associated with the network and compute infrastructure supporting the functions, applications, connectivity, etc. required by the vertical service.

**TABLE 11: SERVICE TO CORE KPI MAPPING**

| 5GR-SKPIs | Core 5G KPIs | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CKPI-1 | CKPI-2 | CKPI-3 | CKPI-4 | CKPI-5 | CKPI-6 | CKPI-7 | CKPI-8 | CKPI-9 | CKPI-10 | CKPI-11 |
| 5GR-SKPI-1 | | | | | X | X | | | | | |
| 5GR-SKPI-2 | X | X | | | | | | | | | |
| 5GR-SKPI-3 | | X | X | X | X | | | | | X | X |
| 5GR-SKPI-4 | | X | X | | | | | X | X | | |
| 5GR-SKPI-5 | X | | | | X | | | | | | |
| 5GR-SKPI-6 | | X | X | | X | | | | | | |
| 5GR-SKPI-7 | X | X | X | X | X | | X | | | | |
| 5GR-SKPI-8 | X | X | X | | | | | | | | |
| 5GR-SKPI-9 | | | X | | X | | | | | | |
| 5GR-SKPI-10 | | | | | X | | | | | | |
| 5GR-SKPI-11 | X | | X | | | | | | | | |

For a more complete description of each SKPI and an explanation of the rationale behind its mapping to Core KPIs, please refer to D4.2 [21].

Considering the SLO example, we can map 5GR-SKPI-8 and 5GR-SKPI-9 to the following 5GR core KPIs:

- 5GR-CKPI-1: End-to-end Latency (ms). Aggregation of one-way time delays measured between specific components of the logical architecture of the use case.
- 5GR-CKPI-2: Packet Loss (%). The number of packets that fail to reach their destination, measured in specific interfaces of the use case logical architecture.
- 5GR-CKPI-3: Guaranteed Data Rate (Mbits/s). The data rate Number of bits per unit of time sent over a specific interface of the use case logical architecture. The guaranteed data rate is the minimum expected data rate for the overall use case to function correctly.
- 5GR-CKPI-5: Availability (%). Percentage of time during which a specific component of the use case (application, server, network function, etc.) is responding to the requests received with the expected QoS requirements. That is, it is the ratios between the up time of a specific component over the total time the component has been deployed.

### 5.3.4. Check applicable CKPIs

The Core KPIs involved in the service implementation are checked to be compliant with respect to the actual status of the platform, i.e., actual level of resource utilization across all the tenants and margin to deploy new services. The process is shown in the form of a workflow in Figure 18.

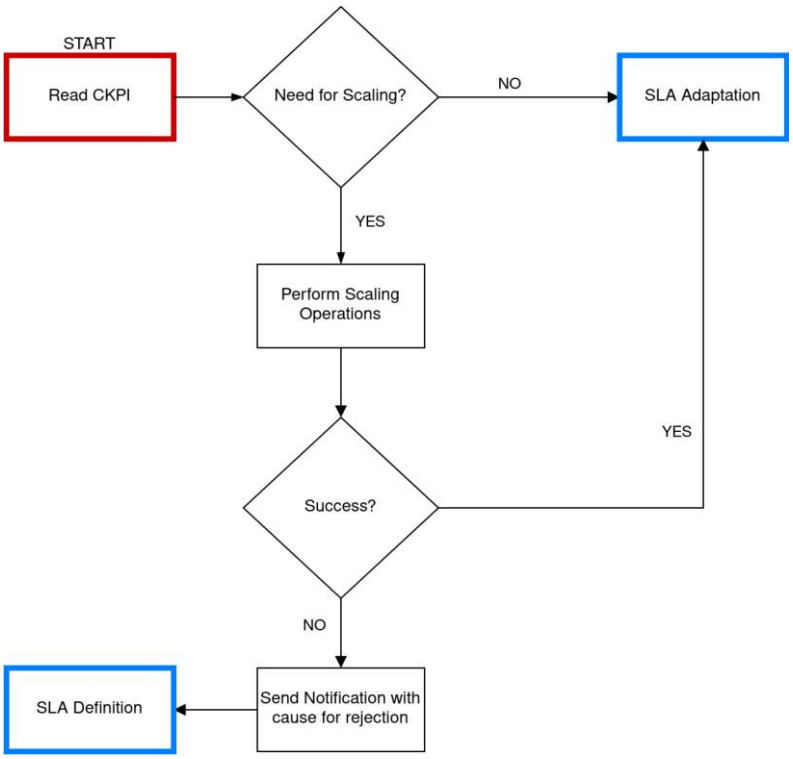



**FIGURE 18: WORKFLOW FOR CHECKING CORE KPIS APPLICATION**

After reading the requirements of the Core KPIs and getting the platform status, the need for scaling operations is evaluated. In fact, the platform can perform some horizontal and/or vertical scaling operations on the network services already deployed on the platform to free some resources and guarantee the newly requested CKPIs. If no scaling operations are needed in order to fulfil the new CKPI set, the request is considered accepted by the platform and the control is forwarded to the SLA adaptation phase.

In case the platform does not have enough free resources to fulfil the request, it will attempt to perform some scaling operations on existing network services, taking into account their requirements and their priorities. If the new request for Core KPIs can be satisfied by the platform without disrupting the performance of any other network service already present, scaling operations are applied successfully, and the workflow can move on to the SLA adaptation phase.

In case conflicts appear, we consider the platform not able to fulfil the new request at the moment, (i.e., condition of no feasibility) and no operation is executed on the platform. The control is returned back to the SLA definition phase for an SLA re-negotiation. Additionally, a warning notification is delivered to describe the causes of the rejection. This notification should include (i) information about conflict type (i.e., resource utilization limit exceeded or impossibility of applying scaling operations)

and (ii) IDs of the Service KPIs which are determined to be not feasible to be implemented. If at least one of the CKPIs composing a SKPI is not feasible, the whole SKPI is flagged unfeasible.

## 5.4. SLA adaptation

SLA adaptation is considered with a twofold meaning. In the first one the 5Gr-SO adapts the services and the resources which a tenant is provided with to fulfil the SLA agreed upon based on the monitored KPIs to which the SLA is mapped to. In this case SLA adaptation is considered as service/resource adaptation. In the second meaning SLA adaptation is considered as SLA re-negotiation. In this case the 5Gr-SO is not capable of guaranteeing the required KPI target bound to specific SLA, therefore it starts an escalation procedure to trigger SLA re-negotiation. This concept is depicted in Figure 19.

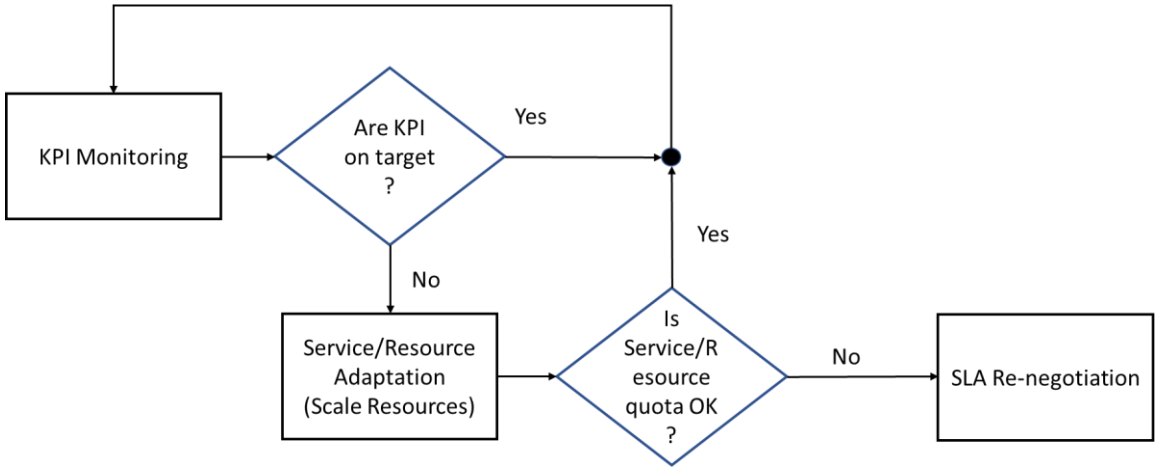



**FIGURE 19: SLA ADAPTATION**

For what concerns service/resource adaptation, as depicted in Figure 11, the interaction between the SLA adaptation blocks interacts with 5Gr-VoMS and the SLA definition (negotiation). It is assumed that, based on the agreed SLA, a tenant is initially assigned a specific quota of resources. To implement the SLA service/resource adaptation the SLA adaptation block interacts with the 5G-VoMS to monitor KPIs related to the agreed SLA. If any KPI is not achieving the target value required to the fulfil the agreed SLAs, the SLA adaptation block interacts with the 5Gr-SO to scale the service related to that tenant. However, the service/resource scaling is limited by the initial quota agreed upon the SLA definition. If the quota must be overcome to guarantee the required KPIs service/resource scaling is not internally performed and SLA re-negotiation process is triggered.

In SLA re-negotiation, the 5Gr-SO verifies that the target KPIs cannot be achieved without overcoming the agreed service/resource quotas. In this case the SLA adaptation module interacts with the SLA negotiation module to renegotiate the SLA and the corresponding service pricing. Such procedure, as depicted in Figure 20 reported from D2.3, involves the 5Gr-SO that notifies the 5Gr-VS that, in turn, notifies the vertical.

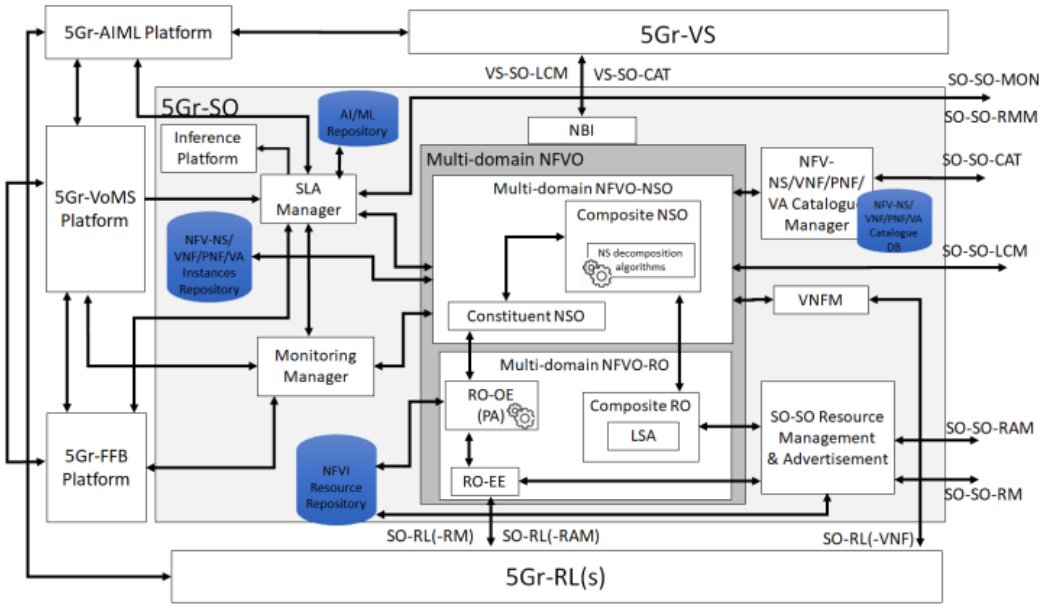



**FIGURE 20: 5GROWTH MODULE INTERACTIONS**

Considering the aforementioned example, if the 5Gr-VoMS observes that the 5GR-CKPI-1: End-to-end Latency (ms) is overcoming the value of 2s it triggers Service/Resource Adaptation by interacting with the 5Gr-VS. For example, the 5Gr-VS can trigger service scale up. However, if, through the measurements performed by the 5Gr-VoMS the target latency cannot be achieved and further service scale up cannot be performed, SLA re-negotiation is triggered.

# 6. Conclusions

The main goal of WP1 is to validate the business models that emerge from the pilot deployments and evaluate their benefits and advantageous for all the stakeholders, including operators, service providers and, of course, vertical industries.

The first step to achieve this goal is to refine and clarify the technical and functional requirements of the pilots from the business point of view. These requirements set the ground to design the business models for each stakeholder involved in each pilot, which identifies the main actors, activities and strategies that compose it. To picture these business models the Osterwalder methodology [2] has been chosen, as it provides a highly visual understanding of the most important variables that show the values of the business.

With a clear vision of the business models for each stakeholder it is possible to validate if the overall business is profitable for each of the actors, from the network providers to the vertical industries. This has been done through a techno-economic analysis that collected the main benefits that the deployment of each pilot generates, splitting it among the different stakeholders. The results of this exercise, as described in section 4, show that, without any doubt, the adoption of 5G technologies by the four vertical industries involved in the project is highly profitable for all the stakeholders.

However, it is key for the verticals to clearly ensure the required service levels in the process for the pilot implementation to be successful. This is what is addressed in the last section, when discussing SLA elicitation.

For the handling of SLAs, this deliverable specifies a Business Layer with functional components supporting the following features:

1. Discovery, for assisting on the establishment of technical and commercial relationship among parties.
2. Negotiation, for determining the SLA to be of application to the vertical slice, including measurable SLOs, from the service perspective.
3. Fulfilment, for setting up and configuring the necessary resources and functions in the network to honour the vertical slice request.
4. Adaptation, to assist on the adjustment of the previously negotiated SLA in case such SLA cannot be satisfied because of eventual circumstances in the provider side.

The proposed Business Layer is related to existing components in 5Growth architecture.

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