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D4.4 EMERGING BUSINESS MODELS FOR VERTICALS

Work Package	WP4, Vertical Stakeholder Engagement and Coordination
Lead Author (Org)	Trust-IT Services
Contributing Author(s) (Org)	INNO, AALTO, IDC
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	RE: Restricted to a group specified by the consortium (including the Commission)
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Executive Summary

The 5G community has always exhibited a high level of interest in emerging business models for 5G, both for telecommunications providers and for vertical markets. An overview of the prevailing sentiment on the overall business case for 5G results in conclusions that vary according to the particular perspective taken.

For telecom operators, observers have noted that 5G market players are not far along at all in developing or pursuing new business models. Regions around the world are fighting for global 5G business leadership and European policymakers and regulators must continue to pursue and develop robust approaches to maintain an effective leadership position.

For vertical sector participants, there is little convergence to date in the community on which vertical sectors will profit the most from 5G. There is agreement that the public sector cannot be a bystander in the development of 5G in vertical markets, but must be an integral part of the equation. Most vertical markets will need to be analysed in considerable detail to identify the niches where 5G has a viable business case. In general, there is even less evidence of robust business model development so far in vertical sectors than in the telco operator domain.

In the Automotive vertical sector, a significant divide may be observed between the development of successful business models for non-critical applications such as infotainment versus safety-critical applications such as automated driving, where the requirement to conform to onerous certification standards remains a challenge. Moreover, public-private collaboration will be necessary to ensure the wide deployment of 5G and guarantee regulatory certainty for support of advanced Connected and Automated Mobility business models.

In the Manufacturing vertical sector, several new business models may arise out of the potential for new third-party service providers. One of the key issues in manufacturing will be the “build or buy decision”, whereby the attraction of private 5G networking is particularly strong and may create opportunities for new kinds of connectivity providers. Some regulatory bodies such as BEREC have come out strongly in favour of private networking in closed environments such as factories.

In the Energy sector, opportunities may arise in the area of massive Machine Type Communications, due to the dispersion of sensors over broad geographical areas. These opportunities will lead to pricing model issues in connectivity provision. Smart Grids are likely to be able to construct positive business cases. Telecom providers may have difficulty finding strong business cases given the severe constraints on connectivity provision for such mission-critical verticals as Energy.

Network slicing is emerging as one of the key enabling technologies for differentiating connectivity value propositions, and will be viable across multiple verticals. Regulatory and policymaking bodies will need to monitor competitivity conditions and appropriate allocation of spectrum in order to foster a vibrant and viable competitive vertical 5G ecosystem.

There are clear and significant opportunities for European SMEs to deploy successful business models for 5G, offering technologically advanced value propositions to narrow, sharply defined target customer segments as third-party providers.

1 Introduction

1.1 Purpose and Scope

> "The challenge for the industry is to identify **new services**, **new market segments** (especially enterprise) and the right business models to unlock the incremental 5G opportunity. The industry will need to address the underlying economic assumptions for cellular networks and embrace **new business models** that can achieve a healthy balance between network competition and sustainable investment in infrastructure."
>
> ***- Global5G.org Deliverable D2.1 "Identify Use Cases from Verticals", March 2018***

The purpose of this report is to build upon previous work in Global5G.org in order to provide new analyses of emerging business models in the 5G ecosystem, particularly in reference to vertical sectors (as opposed to the pure consumer / smartphone market).

The scope of the work is a **set of selected verticals** that have been chosen because the characteristics and requirements they exhibit are representative of the principal issues facing the new business models as they emerge. This selection does not imply that other verticals are less important – rather, it was preferable to circumscribe the scope in order to be able to make an adequate analysis within this first version of the report, in March 2019. Other verticals may be selected for further analysis (as well as other issues deemed pertinent) in the final version of this report, to be delivered in December 2019.

1.2 Relationship to other project outcomes

This report exploits the preceding deliverables of the Global5G.org project, building upon their outcomes to produce additional, complementary research. It also exploits the results of ongoing work in the consortium.

1.2.1 Previous relevant project outcomes

Previous deliverables from all Global5G.org partners have produced valuable inputs for the analyses contained in this report, as well as contextual information that need not be redundantly included in this report.

- **Trust-IT**. Deliverable D2.1 ("Identify Use Cases from Verticals"), analyses many elements of what goes into the development of business models, including
    - Stakeholder categories, as defined in WP4.
    - Use cases in several verticals, including energy, manufacturing, and automotive, as defined in relevant 5G PPP white papers and Global5G.org D2.1.
    - Use case categories according to the ITU classification, as applied in the Verticals Cartography blueprint and online tool.
    - Relevant standards, as defined in WP3 and 5G-IA Pre-standardization WG.
- **Aalto**. Deliverable D3.1 ("Small Cells Study") contains much specialized research relevant to this report.

  - Information on network slicing, a fundamental element further analysed in this report.
  - Information on spectrum related issues (Global5G.org is also active in the Spectrum WG).
  - Information on stakeholders for small cells, as defined in D31.
  - Information on infrastructure sharing, which is currently also being studied in the Automotive WG and its most recent white paper (March 2019).
  - Examination of the problem of interaction between the public and private sectors.
- **Trust-IT and Aalto**. D2.2 ("Verticals Cartography") contains up-to-date information on current activities in a number of vertical sectors, including targeted ITU functionalities.
- **inno-tsd**. Internally produced reports (published as publicly available reports on the Global5G.org website) on national 5G deployment programmes outside of Europe are producing information on analogous activities in other regions of the world, such as regulatory actions by the FCC.
- **IDC**. The series of webinars organized by IDC is producing valuable analytical inputs (e.g. for the energy and automotive sectors) and contextual information.

1.2.2 Ongoing complementary project work

The research and analysis in this report was carried out in the context of Global5G.org Task 4.4 (*Investigation into Emerging Business Models for 5G Vertical Applications and Services*). The main goal of this task is to support discussions and actions on emerging business models for 5G, and map rollout readiness levels with the coverage of Performance KPIs and 5G functionalities. This work leverages Global5G.org tracking documents and collaboration across the 5G PPP.

Ongoing work related to this task includes the following activities:

- Performance KPI tracking: the KPIs yield information about how well the 5G technology providers are doing in achieving the necessary performance (e.g. required latencies) for delivering on chosen business models.
- Verticals cartography – ongoing tracking and updating of verticals activities, including gap analysis of vertical use-case experiments.
- Standards tracking: certain business models (e.g. for autonomous driving) will not be implementable until the right standards are in place, including a mapping of 3GPP standards relevant to several verticals and gap analyses on vertical industry requirements.
- General working group participation and outreach programmes to keep abreast of the latest developments in the 5G PPP ecosystem.

In conclusion, the intention in this report is not to provide information that is redundant to previous or on-going work, but rather to concentrate on the real issues facing the emergence of 5G vertical business models:

- What are the actual new business models that are being contemplated?
- What are the uncertainties that must be resolved in order to implement these business models?
- Are there commonalities across verticals relevant to the emerging business models?

1.3 List of Acronyms & Abbreviations

Acronym/Abbreviation	Description
5G PPP	5G Infrastructure Public Private Partnership
5G AP	5G for Europe Action Plan
5G IA	5G Infrastructure Association representing the private side of the 5G PPP.
3GPP	3rd Generation Partnership Project, providing complete system specifications for cellular telecommunications network technologies, leading 5G standardisation, currently in Phase 1 of the 3GPP 5G effort for Release 15. Full compliance with the ITU's IMT-2020 requirements is anticipated with the completion of 3GPP Release 16 at the end of 2019 - In Phase 2 of the 3GPP 5G effort.
ASIL	Automotive Safety Integrity Level
BEREC	Body of European Regulators for Electronic Communications
BSS	Business Support Systems
CAM	Connected and Automated Mobility
CAN	Controller Area Network
Capex	Capital expenditure
CPS	Cyber Physical System
CSP	Communication Service Provider
CTO	Chief Technical Officer
DA	Distributed Automation
DER	Distributed/Decentralised Energy Resources
DMS	Distributed Management System
eMBB	Enhanced mobile broadband (use cases mostly associated with rollout phase 1 of 5G)
EMS	Energy Management System
FCC	Federal Communications Commission
FoF	Factories of the Future
GDPR	General Data Protection Regulation
IOT	Internet of Things
ITU	International Telecommunication Union, the standards setting body within the United Nations.
mIoT	Massive Internet of Things (use cases mostly associated with rollout phase 2 of 5G)
IS	International Standard
KPI	Key Performance Indicator
MCS	Mission critical services (use cases mostly associated with rollout phase 2 of 5G)
MEC	Mobile Edge Computing
MNO	Mobile Network Operator
MS	Member State
MTC	Machine Type Communications
MVNO	Mobile Virtual Network Operator

Acronym/Abbreviation	Description
NFV	Network Function Virtualisation
OpEx	Operating expenditure
OSS	Operational Support Systems (or sometimes Open Source Software)
PPDR	Public Protection and Disaster Recovery
SDA	Strategic Deployment Agenda
SDN	Software-Defined Networks
URLLC	ultra-reliable low-latency communications

Table 1: List of Acronyms

1.4 Structure of the document

Section 1 provides contextual information on this report, including the relationship and relevance of other outputs of Global5G.org – past, ongoing, and future. This section is intended to circumscribe the scope of the work, avoiding redundancies and fostering complementarity of outputs.

Section 2 provides a preliminary overview of the business of 5G, presenting the results of a recent survey of CTOs from a number of 5G community stakeholders. The results are organized from the perspective of vertical stakeholders and from the perspective of telecom operators.

Section 3 presents the methodology adopted in approaching the analysis of emerging business models, defining the distinct elements of a business model and identifying the upstream elements of strategy that represent the most critical questions to answer. These are briefly illustrated in a 5G context.

Section 4 is the heart of the report, whereby a set of selected vertical sectors is analysed with respect to emerging business models and the specific issues raised by each sector (which may be applicable also to other verticals).

Section 5 examines cross-vertical issues that are relevant to emerging business models, with particular focus on network slicing technology as a key enabler of differentiated value propositions.

Section 6 presents the government and regulatory perspective on vertical business models, concentrating on two specific aspects: the regulation of competition within the 5G ecosystem, and the regulation spectrum allocation to verticals, which is a highly debated topic at the time of writing.

Section 7 draws a set of conclusions from the analyses presented in the previous sections, and outlines further planned work culminating in the final version of this report in December 2019.

Section 8 contains a set of selected references from the discussions within the report.

2 The Business of 5G

The 5G community has always exhibited a high level of interest in "emerging business models for 5G", both for telecommunications providers and for vertical markets. On closer examination, much of what is written on this topic actually tends to focus on the broader question of the overall business case for 5G, that is: "Can 5G make money?"

So, it seems appropriate to begin with an overview of the prevailing sentiment on the overall business case for 5G before considering the issue of emerging business models in more detail. We will do this both from the perspective of the telecom operators and the vertical sectors.

2.1 A preliminary perspective on 5G and telecom operators

In February 2019, McKinsey published a survey of 46 Chief Technology Officers of large telecom operators engaged in various areas of 5G development and deployment. Although telco providers do not necessarily provide the same perspective on 5G as vertical operators, the two are inextricably intertwined (as we will see throughout this report) and it is worthwhile to see the provider perspective.

A first important question in the survey concerned how far along the operators are in a number of different 5G-related activities. Figure 1 shows the results.

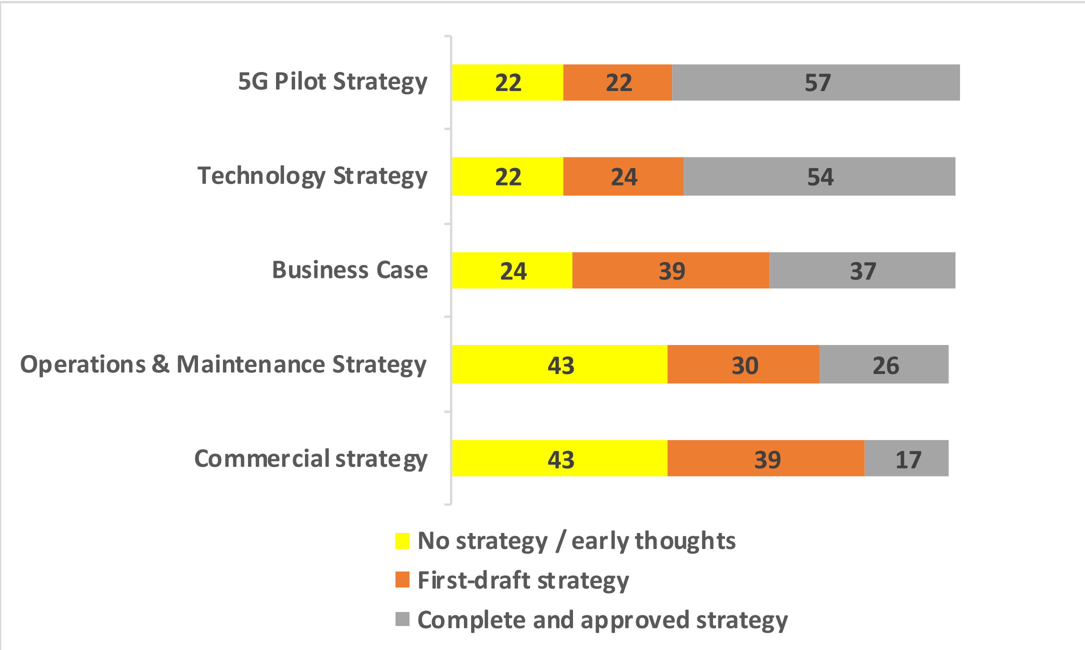

Figure 1: Current status of 5G related activities (*Source: McKinsey 2019*)

Some of these results are not surprising, because they are appearing in the news almost every day: most companies are either planning pilots or have already rolled them out. Technological strategies are being regularly reported on in the trade journals and congresses. Conversely, it is not surprising that operations and maintenance has yet to receive much attention at this early stage of 5G deployment.

The surprising revelation of the survey is that so little progress has still been made by companies in articulating their business case for 5G. Only a third have a fully developed business case, and nearly a quarter have none at all. Equally surprising is the observation that a mere 17 percent of these telco operators have complete commercialisation plans, while nearly half have none – or at best, some “early thoughts”. Considering that 5G deployment is on the verge of beginning in earnest, this is a sobering observation.

Even more intriguing is the geographical distribution of those respondents who were particularly worried about the business case for 5G, shown in Figure 2.

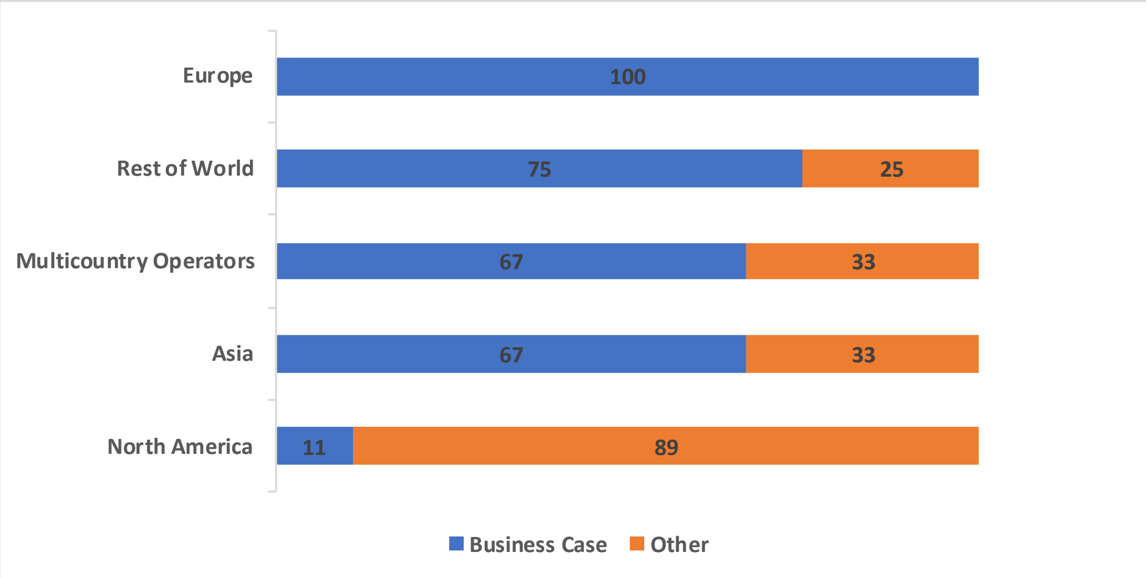

Figure 2: Largest challenge to 5G? (*Source: McKinsey 2019*)

The first standout result here is North America, where only about 10 percent of the respondents viewed the business case as the largest challenge – in other words, 5G optimism reigns in North America, at least among CTOs. In the rest of the world, including Asia and those operators present in multiple countries, the business case challenge was viewed as more significant.

But the other standout result is the view of European CTOs on the challenge of the 5G business case: without exception, *all* of them saw it as the biggest challenge they were facing. In other words, there is considerable preoccupation in Europe about making the business case for 5G.

The McKinsey survey appears to confirm the results of industry analyses by Global5G.org partner inno-tsd, which observed that North America (particularly the United States) and Asia (particularly China and South Korea) are aggressively investing in 5G deployment, along with the European Union, whereby each region is facing a set of particular challenges. For example, between the U.S. and China there is direct confrontation concerning 5G technology deployment (cf. the recent clamour around Huawei[1]). For the EU, the specific challenges to confront include:

- Smaller and more fragmented markets. As we will see in other sections of this report, the very fact of being a union of well over twenty sovereign Member States continually raises cross-border issues, both technically and economically, raising the complexity and cost of doing 5G business in Europe.

[1] https://www.reuters.com/article/us-usa-china-huawei-tech-canada/huawei-founder-says-huawei-cfo-arrest-was-politically-motivated-bbc-idUSKCN1Q71YZ

- Generally slower economic growth in Europe than in Asia and North America in the period since the Great Recession of 2008, which puts pressure on the relative market strength.
- 5G investments in the United States and China running at extraordinarily high, aggressive levels.
- Prices for fixed wireless access in the EU are already relatively low, so that there is not much headroom for improved economics in that market sector.

We conclude this section with some observations that the CTO respondents made about particular aspects of 5G deployment – observations to which we will return in subsequent sections of this report.

First of all, the respondents nearly unanimously believed that the early business cases for 5G will come from enhanced mobile broadband (eMBB) in some form, as well as the Internet of Things. The clear reason: the more limited size of investment necessary because of the ability to leverage 4G investments.

This leads naturally to the second observation made by the respondents: again, due to the large size of investments necessary, they were nearly unanimous in their belief that **network sharing** in various forms will need to happen. This will also include the new business models such as neutral hosting.

Yet another sobering conclusion concerned the attitude of the respondents toward the more advanced aspects of 5G deployment, such as millimetre waves, which are key to some of the more important potential 5G business models (e.g. those involving exploitation of uRLLC). Only around a third of the respondents expected deployment to occur in the short term, to a great extent due to the higher costs of densification (e.g. with small cells) to deal with millimetre waves. The most concerned were the European operators, perhaps due to the fact that there have been fewer millimetre wave auctions in Europe to date. This is related to the overall problem of regulatory issues influencing business models. For example, Global5G.org is studying the problem of small cell deployment having to deal with local regulations, a damper on developing robust business cases.

In spite of the concerns noted above, it would be wrong to conclude that operators are pessimistic in general about 5G and its future business cases. There is an overall optimism that 5G will fulfil its full promise over time. Nevertheless, several resulting observations will be taken up further in this report.

- **Business models are truly only *emerging*. 5G market players are not far along at all in developing or pursuing new business models**.
- **There is considerable conflation of terms such as "strategy", "business models", "monetisation", and the like.** Often these terms are used interchangeably and with little precision, further contributing to a sense of uncertainty among operators in how to approach the business of 5G.
- **Regions around the world are fighting for global 5G business leadership** and European policymakers and regulators must continue to pursue and develop robust approaches in order to maintain an effective leadership position.

2.2 A preliminary perspective on 5G and verticals

Since a special focus of this report is the vertical sectors, it is worthwhile to take a look at the prevailing sentiment among vertical sectors with regard to the business case for 5G. Here even more uncertainty reigns than among the telecom operators – which is perhaps not surprising, since it is the telecom operators who are expected to make a business *of* 5G, whereas the vertical sectors are generally expected to make their business *with* 5G. That is, vertical market players are pondering how 5G will affect their primary business, whether it be manufacturing cars or delivering electric power.

One of the main questions being asked today in the 5G community is “In *which* vertical sectors will 5G have the most effect on business?” There are many variations and refinements on this question (e.g. “In which vertical markets might entirely new businesses arise?”). There are also many different answers, depending on who is asked, but it is instructive to look at some of the answers, keeping in mind any possible bias on the part of the respondent.

Figure 3 illustrates one such projection of 5G-enabled digitalisation revenues for ICT players in 2026, in which the total revenue projection amounts to about 1.2 billion dollars.

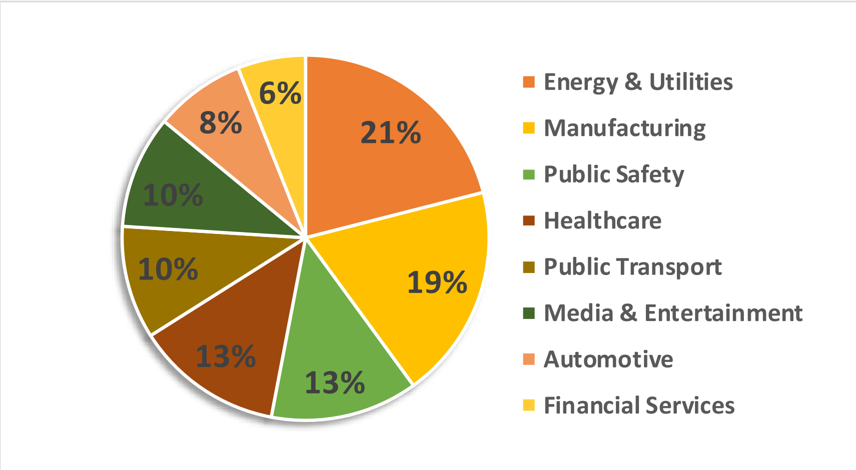

Figure 3: Projected 5G digitalisation revenues (*Source: Ericsson & A. D. Little 2017*)

The top spot is claimed by Energy and Utilities in this particular forecast, with Manufacturing close behind. In this report we will look more closely at the issues behind the 5G business case in these two sectors, which are not at all resolved.

Both Healthcare and Public Safety trail close behind in this forecast. Especially in the case of the Public Safety sector, this makes it abundantly clear that regulatory and policy agencies, and governments in general, cannot not avoid pro-active participation in the 5G ecosystem.

An interesting case is the Automotive sector, which has had an historically high profile in the race to 5G deployment. This particular forecast puts it only in the second-to-last category, however. In a presentation [Bosch2018] of this data to make the case for 5G in Manufacturing, Bosch offered the following analysis to support some of the conclusions also seen in the forecast:

- The **Consumer market** is already saturated, with omnipresent flat rates and a highly competitive business environment;

- **Smart cities** are plagued with many small niches (we will see in this report that this is a general problem in vertical sectors) with few, if any suitable business models yet;
- The **Automotive sector** will require enormous investments with limited value-added. As we will see in the section in this report on the Automotive sector, this view is by no means shared by all (to say the least). But it is an indication that there is not yet convergence on the future of 5G in vertical markets.

We will look more closely at all of this in subsequent sections, but a few takeaways can be synthesized even from this snapshot of one perspective on vertical markets:

- There is little convergence in the community on **which vertical sectors will profit the most from 5G.**
- The **public sector** cannot be a bystander in the development of 5G in vertical markets. Rather, it is an integral part of the equation.
- Most vertical markets will need to be analysed in considerable detail in order to identify the **niches where 5G has a viable business case**.
- There is even **less evidence of robust business model development** so far in vertical sectors than in the telco operators' domain.

3 The Elements of 5G Strategy and Business Models

As noted in the previous section, the term "business model" tends to be used in very broad terms in the discussion around the 5G business case, which is understandable given the still very broad nature of the discussion and early overall stage of deployment. But it is worth sorting out some of the terminology early in this report, in order to support subsequent presentation and analysis.

The term "business model" became especially popular during the Dotcom Boom of the 1990s. During this period, the primary preoccupation of the many Internet start-ups was to find a path to generating revenues. During this time, "business model" became to mean essentially the same thing as "revenue model". Even today, this remains one of the primary meanings attached to the term.

Over time, "business model" came to include nearly any aspect of how a company operates, obtains financing, and makes money. This phenomenon culminated in approaches such as the Business Model Canvas [Oster2010]. A typical list of elements of a business model from such methodologies is the following:

- target customer segments
- value propositions
- core capabilities
- distribution channels

- customer relationships
- commercial network
- partner network
- cost structure
- revenue model

But even such omnibus methodologies sometimes tend to conflate "business model" with other important concepts. In the above list, the first three elements are actually *strategy* [KFavaro2015]. Although business strategy and business modelling are closely related, they are not the same thing.

3.1 The elements of competitive strategy

Competitive strategy has evolved as a discipline since Porter's pioneering work in the 1980s [Porter1980]. The best current thinking about competitive strategy can be synthesized in a nutshell:

There is only one form of competitive advantage: differentiation.

There are three components of differentiation:

- **Value proposition** – better product, better service, better reputation, lower price, etc.
- **Capabilities** that enable you to deliver your value proposition better than anyone else
- **Target customer** - defining the customer differently from anyone else and designing your value proposition and capabilities accordingly.

Strategy is the choices made about how to differentiate with the value proposition, capabilities, and/or target customer, in the chosen market.

In summary, **strategy** consists in the answer to three fundamental questions:

- **Who is the target customer?** Out of the entire marketplace of potential customers, who is it that we want to reach?
- **What is the value proposition for this target customer?** Simply stated, the value proposition tells the customer "This is what you get for what you pay". Hopefully, that target customer will be convinced that it is worth paying for.
- **What are the essential capabilities that we must have** in order to be the best at marketing, selling, and delivering on our value proposition?

Whereas, the rest of the elements in the list are further components of a company's business model.

- **Distribution channels** – e.g. proprietary stores, partner channels such as major distributors, …
- **Customer relationships** – e.g. personal assistance, self-service, automated service, "communities", …

- **Commercial network** – who are the other members of the commercial system in which we are participating?
- **Partner network** – Will it be necessary to partner with somebody?
- **Cost structure** – e.g. no frills vs. luxury, fixed costs vs. variable costs, economies of scale
- **Revenue model** – e.g. per-use, subscription, licensing, etc. As noted earlier, many often think exclusively of this aspect when "business model" is mentioned.

3.2 Strategy influences the business model

As mentioned above, strategy is not a component of the business model; rather, it is separate and upstream from the business model. Strategy will influence the various elements of the business model of a company. Consider some concrete examples of this in a 5G context:

- The value proposition for a high-reliability 5G provider might include "we get paid only when we respect a certain SLA", injecting a contingency fee into the revenue model;
- A value proposition for a "seamless mobile infotainment experience" will influence the partnering structure;
- If you distinguish your target customer by where the components are made and by whom ("Made only in Europe!"), that will affect your supply chain setup;
- Your definition of your target customer (e.g. owners of luxury vehicles versus owners of utility vehicles) will influence your marketing and sales setup;
- Your value proposition (e.g. high SLA) will influence the core capabilities you need to have (e.g. excellence in network slicing).

We have observed that in the 5G community, much good work has now been carried out on certain components of business models, such as partnering models and revenue models, but significantly less has been published in those areas which we have characterised as strategy: identification of target customer, value proposition, and needed leading capabilities. In other words, business models are being developed in the absence of strategies.

Both a strategy and a business model are needed: without a business model, a strategy is only a set of choices that never becomes operational. But without a strategy, a business model only represents a vague hope that the way in which the company operates will somehow make money, without ever answering the fundamental question of why that is so. One objective of this report is to highlight the places where there are gaps and consider how they might be filled.

3.3 The relationship between strategy and 5G

Too many companies of any kind have never articulated a strategy that answers the three fundamental questions (target customer, value proposition, core capabilities). Does that mean that companies should start having a "5G strategy"? Not exactly – and *especially* in the case of vertical sectors.

It is easy to elevate some new development to the level of strategy by just adding the word. Many companies are expected to have an AI strategy, an IoT strategy, a China strategy, and so forth. But it is difficult enough to create even one strategy for a company's main business; it is impossible to have one for every new development.

The right question to ask is not "What is our 5G strategy?", but rather "How does 5G affect the strategy that we already have?" Or better, in the context of the discussion above, "How does 5G affect my answers to the three fundamental questions of strategy?"

- **Could 5G change or redefine our target customer?** For example, a manufacturing plant equipped with the power and flexibility brought in by 5G might switch its main target audience to customers for one-off, custom built parts.
- **Could 5G add to our value proposition?** A hospital whose value proposition is "the best doctors anywhere" might exploit 5G-enabled telesurgery to strengthen that value proposition even more. An automotive infotainment service provider could exploit 5G to offer film downloading in seconds to resolve the problem of streaming across different geographical locations, thus expanding its value proposition from "films locally" to "films anywhere".
- **How can 5G enhance our leading capabilities?** An energy sector provider that differentiates itself from others in its market-leading abilities to process Big Data coming from the field and customize billing data for its customers might improve those abilities further through massive 5G deployment of IoT sensor devices that provide even more timely and precise data.

Once again: these questions are particularly important for **vertical markets**. An automotive manufacturer is in the primary business of making cars, and its existing strategy concerns the making of cars. The questions above help the car manufacturer to stretch, modify, and sharpen its current strategy in the context of 5G.

3.4 Fundamental Stakeholder Considerations

As we enter the main discussion, a few words are in order about the stakeholders who exist in any context of vertical 5G deployment. In any deployment of 5G, there may be several stakeholders, but there are invariably at least the three shown in Figure 4.

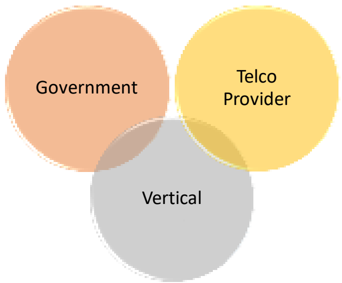

Figure 4: Fundamental stakeholders in vertical 5G context

- The Vertical Stakeholder may be the provider of a product (e.g. of a car) or service, or a customer (of 5G service).
- The Telco provider furnishes 5G services, whether as provider, or partner, or something else.
- The Government (including policy and regulatory agencies) is always relevant, at the very least because of spectrum-related issues.

It is extremely unlikely that any of these three fundamental stakeholders would ever be absent from strategic and business model related considerations in vertical sectors. But as we will see in the following, the roles that each plays, and the weight of these roles, can vary considerably according to the specific vertical sector and the target segments within those vertical sectors.

4 Vertical Sectors

In this section, a selection of vertical sectors is analysed, whereby the special characteristics of each sector are used to introduce and discuss broader topics that may involve all vertical sectors.

4.1 Automotive

The automotive sector is among those receiving the most attention in relation to 5G deployment. In Global5G.org's report on future vertical use cases [D2.12017], a Berkeley report on the economics of automotive 5G was cited as saying "… it is projected that that in 2035, 5G will enable more than $2.4 trillion in total economic output from across the automotive sector (including its supply chain and customers), which is equivalent to a fifth of the total global 5G economic impact."

In the analysis of business models emerging around Connected and Automated Mobility, it is important to avoid a phenomenon informally known as the *Jetsons Fallacy*, named after the 1960s cartoon show about a family living 100 years in the future [Bess2009]. One of the central features of the show was flying cars. But the show also featured a fallacy, which was to project an enormous technological advance into the future without also projecting any of the context around it into the future – for example, the very fact that the flying cars had a driver; or the legal context, where police would pull over a flying car for "speeding"; or the social context, where women were considered inadequate drivers. This fallacy tends to falsify the discussion, making it difficult to draw useful conclusions. For CAM, the entire technological, commercial, and regulatory context must be projected into the future, in order to be able to conduct a useful analysis. This future context is likely to be significantly different:

- Different kinds of vehicles with much more variety – big, small, fast, slow;
- Different business models – more service-oriented rather than product oriented; "Mobility on Demand"; customers buy trips, experiences – others own the vehicles;
- Different regulations, urban environments, liability / insurance, etc.

We will come back to each of these differences in more detail later in this and other sections.

4.1.1 The Connected Vehicle versus The Connected-And-Automated Vehicle

A key point of consideration when analysing the context surrounding emerging automotive business models is the chasm between mobility that is merely *connected* and mobility that is *connected and automated* – that is, automated driving. The business opportunities emerging around the "Connected Car" context (such as Infotainment) are likely to be realized in the near term and with much less regulatory complication, but possibly more commercial challenges (e.g. difficulties in achieving competitive differentiation). In contrast, safety-related applications, culminating in fully automated driving, are likely to arrive later, with significant regulatory complication.

- Since 2011, the ISO 26262 international standard for functional safety has brought with it stringent requirements on the electric and electronic elements of passenger automobiles, including onerous requirements on subsequent assessment by third parties. In December

2018, a second edition of this standard was issued which, among much else, extended the requirements to all road vehicles, including trucks, buses, and motorcycles (agricultural vehicles are covered by a separate standard for functional safety).

- In December 2017, the ISO 20077-1 International Standard "Road Vehicles – Extended vehicle (ExVe) methodology" was issued. This standard introduces the concept of a vehicle being extended beyond its physical boundaries by external communication means – in other words, V2X.
- In December 2018, an ISO Publicly Available Specification (PAS) "Safety of the Intended Functionality" was released that specifically covers safety-related considerations of Advanced Driver Assistance Systems (ADAS) and, in general, the elements that are expected to lead to fully automated driving (e.g. machine vision systems). This standard was jointly developed by national teams with representation from the major OEMs, Tier 1, and specialist suppliers throughout the world.

In order to convey a feeling for the impact that automated driving could have on the costs of development, we can look to the experience the automotive industry has gained in the eight years since the ISO26262 standard was first published. That standard contains a qualitative scale of so-called *Automotive Safety Integrity Levels* (ASILs) that characterise how "safety-critical" a particular application is. Some applications (like Infotainment) are not safety-critical at all. Others are moderately safety-critical (like headlights); and most applications directly affecting the operation of the vehicle (like braking) are highly critical. Figure 5 illustrates the common experience in industry to date.

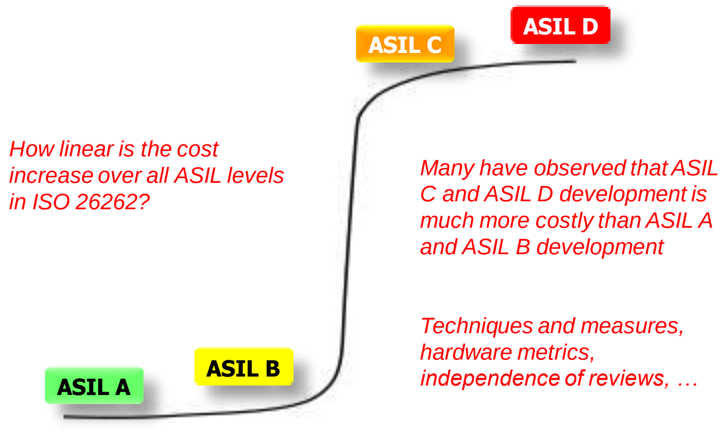

Figure 5: Difference in cost of development over Automotive Safety Integrity Levels

Low-to-moderately critical applications tend not to add much to the cost of development. But there is a sharp upturn in costs related to the highly-critical applications. It is expected that many of the features related to automated driving will fall into the ASIL C or ASIL D categories.

Furthermore, as BEREC [BEREC2018] has also observed, any wireless communication facility on which the safety of automated driving depends will necessarily have to be assessed / certified along with the rest of the system. This will clearly have implications on both CAPEX and OPEX, as well as an influence on deployment timelines.

Of course, the route to fully automated driving may not lead through V2X for the most critical functionalities, which may continue to be governed by onboard automotive systems as they are today, but any future applications intersecting with mission-critical use cases will need to take this regulatory complication into account.

4.1.2 The Connected Vehicle and Concepts of Proximity

In order to introduce innovative new approaches to automotive insurance made possible by the Connected Car, Smith [BWS2013] introduced a concept of proximity (of the manufacturer to the user) that also serves as a useful basis for projecting the future context that the Connected Car will create for most future business models related to 5G.

The context of vehicle purchase up to the advent of the Connected Car was analogous to that of most other articles sold: once it was transferred from the hands of the seller to the buyer, the relationship between buyer and seller ended – that is, there was no proximity. The Connected Car changes that fundamental context. The relationship between buyer and seller never really ends. Even after the car is sold, the buyer and seller remain in more or less close proximity to each other. Consider three typical levels of proximity:

- At a most **basic** level, the connected car permits many of the same things seen on the Web in today's context. Many sellers request the buyer to participate in their anonymous usage data programs, to help them improve their products. For example, Microsoft will send data back about how Office is being used; the printer will send back data about how the printer is being used, and so forth.
- At a **medium** level, of closer proximity, the seller could be able not only to track the customer, but also to contact them directly. Google uses information about a user's activities to target ads to the user. Amazon uses information about the user's buying habits to make recommendations that are personalized for that user. *It knows how to find the user*. The OEM, for example, would be able to contact the buyer to warn them about some kind of new safety risk that was discovered. That was not the case in the old context.
- Finally, a very **high** level of proximity is represented by control over the product itself, even in the field. Over the Air updates are an example of this. They can control the ways that the product is used, and even change the nature of the product itself.

4.1.3 The Connected Car and servitization

Each one of the different levels of proximity represents opportunities for new business models within the automotive context, and effectively changes the context. This new context offers a path to changing the entire business model to one in which the relationship to the customer is more explicitly manageable. This involves moving toward more service-oriented forms of business models – the word "servitization" is being used to express this idea.

One form of this servitization is selling automated driving products only to service organizations, such as taxi companies, where the relationship can be managed better. This is what is happening now in Pittsburgh with Uber, for example. (In strategy terms, this involves a new type of customer.) As another example, airplane manufacturers have been doing this kind of service-oriented business for a considerable amount of time: they sell only to airline companies, which provide only the service of transporting passengers, and have a traditionally close relationship to them.

As another example, the OEM could provide the services directly, in order to have more direct control not only over how the vehicle is used, but even over how it is maintained – how often it must go in for maintenance, etc. That is a better guarantee of keeping the vehicle in good shape, up to date, etc., and therefore managing risk better. In the route toward automated driving, that last part is not unimportant: managing the risk of using products for automated driving will certainly be a "leading capability" that an OEM will need to have in order to guarantee effective delivery of its value proposition to the customer.

This type of arrangement is not unprecedented by any means. *Leasing* is effectively this kind of servitization. GM used a leasing model when it made its first attempt to introduce electric cars back in the 1990s. When GM decided to stop the initiative, they didn't have to worry about leaving the cars behind in the hands of anonymous owners – they were able to get every one of them back and take the entire fleet off the road again. Note here that leasing corresponds to the *financing model* that would be a component of an overall business model for an OEM offering this specific kind of automated driving service.

4.1.4 Data ownership, security, and privacy in a context of proximity

The concept of close proximity between manufacturer and customer, and the flood of data made available in that way, can lead to much innovation in service management, as well as new service providers. But there is an elephant in the room that must be confronted in these new service models: the data.

As a representative of a premium car maker remarked once, "The big IT companies in particular make you sign an agreement to make all of your data available to them when you do a joint initiative. And everything is just sitting there, on the CAN bus – and there is a lot of it in a premium car. But just spend five minutes and you can think of a dozen applications of the car's data. That is why carmakers are reluctant to give it away."

There the matter of ownership of these volumes of data about what is happening in the car – whether it is the manufacturer's, or the insurers, or the driver's, or the owner's (who might be different) – is an important issue that is only now undergoing serious consideration.

Furthermore, given the new GDPR regulation and the ever-growing danger of hacking, issues of privacy and security are becoming important components of the data problem.

4.1.5 Usage-Based Services in a context of proximity

Let us take a closer look now at the opportunities presented by the various levels of proximity between buyer and seller in the future connected car context.

Global5G.org partner IDC hosted a webinar in October 2018 in which John Delaney, the head of IDC's European Mobility Team, suggested that usage-based services could become a new form of business opportunity for the connected car in a 5G context.

- At the **basic** level of proximity, predictive maintenance could be offered by the OEM to the owner. The value proposition would include the benefits of "lower maintenance costs through timely intervention and more precise location of faults in the car." Leading capabilities enabled by 5G in order to deliver the value proposition could include both the high capacity of 5G and the high connection density of mMTC.
- At the **medium** level of proximity, the White Paper [5Gppp2019] of the 5G PPP Automotive Working Group suggested that the car's data, in particular location-based data, could be used for advertising placement. Here, too, the high capacity and connection density offered by 5G could be a core capability enabling the value proposition. The White Paper suggests that the target customer could include the driver in the case of automated driving, since the driver would also be a passenger. 5G edge processing could form a leading capability for an AI-based service that is able to deliver high-quality recommendations based not only on location, but also on known preferences of the vehicle user. These examples yield several indications of questions about strategy; for example, which are the full set of customers? Potential advertisers? Who would the service provider be; what partnerships would be needed as part of that business model; what would the exact value proposition to each kind of customer look like? Most of these questions have yet to be asked by many in the 5G community.
- At the **highest** level of proximity, capabilities such as Over The Air updates of the connected car could have the potential to provide new, added-value services during the operational lifetime of the car. What would the value proposition be in this case, and who would be the service provider? The OEM? Other providers? Would 5G be an essential element in the formulation of the value proposition? This is not clear for the "merely" connected car.

In contrast, Over The Air updating could be a key leading capability for an OEM providing automated driving services, as a way of reducing or clarifying risk. When risks are discovered, then the system could be updated over the air; alternatively, when a suitable updated is not possible, the feature could be "bricked" – that is, rendered unusable – or even removed. This could enhance a value proposition of safety guarantees. However, the provider must still ask the question of whether 5G is an essential characteristic of this service – that is, whether it participates in competitive differentiation.

4.1.6 An example: proximity-based liability risk management

The issue of risk reduction is an important one in an automotive context. This is particularly important for liability in the case of the connected and automated car, which will affect OEMs, insurance providers, and car owners. 5G has the promise of enabling innovative new business models for automotive insurance provision, exploiting both the enhanced broadband and the connection density.

Note that the problem in insurance is not the *amount* of risk involved, but rather the *uncertainty* around the amount of risk involved. One the amount of risk is known, it can be priced. Close proximity opens a door to very sophisticated, dynamic risk management that permits us either to lower risk, or to circumscribe it – that is, to lower the amount of uncertainty around the question of how much risk is involved. Many vehicle owners already have those black boxes in their vehicles that collect data that allows for more reliable accident evaluation, and corresponding lower insurance rates. But with extreme proximity, the risks around automated vehicles can potentially be managed in much more innovative ways. For example, the insurance provider could stipulate that using automated features in certain areas known to be problematic (e.g. bad roads) raises insurance premiums during that time.

Or the provider could turn it around: use the enhanced control over the car's features to permit, for example, only using certain features at certain times of day, or in certain well-known environments, or on well-equipped highways with the right infrastructure, and so forth.

Consider now the fundamental questions of strategy involved in dynamic insurance management:

- *Who is the target customer?* Here it would be the owner of the car. Are there other target customers?
- *What is the value proposition?* Customized insurance policies that maximize safety and use of advanced automated driving functionality while minimizing cost?
- *What are the leading capabilities necessary to carry through on this value proposition?* Almost certainly, partnerships would be required among insurance providers, OEMs, Tier 1 providers (e.g. sensors), and telco providers able to provide 5G with the required characteristics at the required SLA. Road infrastructure providers would likely also be part of the partnership, in order to provide information about the geographic areas in which automated driving is or is not well supported by the infrastructure. What would be the strategy of a road infrastructure provider?

Many other usage-based services will have to answer a similar set of questions. To date, however, there have been very few answers to these three fundamental questions for usage-based and other types of vertical CAM service providers.

4.1.6.1 The 5G connectivity provider perspective on CAM

Recalling the three fundamental stakeholders of any 5G vertical business analysis – vertical, telco, government – the previous sections have mainly considered the perspective of the vertical service provider, such as an OEM or a seller of advertising or HD maps. In this section we consider the perspective of the provider of 5G connectivity for CAM.

As a matter of fact, much more has been written about the provision of 5G connectivity for CAM than for vertical CAM service business models, for the simple reason that a CAM business ecosystem will not exist at all without adequate 5G connectivity. Earlier in this report we saw an opinion that the required investment to achieve sufficient 5G connectivity might be so large that it could challenge the overall business case for CAM.

Therefore, much of the analysis to date has focused on various ways to demonstrate the general feasibility of providing 5G connectivity for CAM. The following sections present an overview of current work in demonstrating deployment feasibility.

4.1.7 5G deployment feasibility for CAM – possibilities under consideration

Two of the main challenges to the feasibility of 5G deployment for CAM are

- The overall investment costs, as mentioned above;
- Mobility-related issues such as cross-jurisdiction service in general and cross-border service in particular.

The two major paths under investigation to date to address these challenges forms of infrastructure sharing, and the possible entry of new types of service providers such as service aggregators.

4.1.7.1 Infrastructure sharing

An excellent, up-to-date example of a techno-economic analysis of the feasibility of 5G V2X deployment within an infrastructure sharing context is the recent White Paper [5GPPP2019] of the 5G-PPP Automotive Working Group on the subject. The Working Group identified a number of network-sharing options, including

- Passive infrastructure sharing;
- Active infrastructure sharing, excluding spectrum sharing;
- Active infrastructure sharing, including spectrum sharing;
- Core network sharing.

All of these forms of infrastructure sharing are well established now, and in fact were addressed back in 2017 (in a small cell context) in the Global5G.org deliverable D3.1 [D3.12017] study on small cells. The Automotive Working Group's White Paper took advantage of previous work that has studied and estimated the CAPEX and OPEX cost savings that may be obtained from each of the different forms of sharing [BEREC2018b]. The White Paper arrived at a cautiously optimistic conclusion for cost-effective deployment under the infrastructure-sharing option.

4.1.7.2 New types of 5G connectivity providers

The other major path under investigation, especially with respect to solving cross-border, cross-jurisdiction issues, is new forms of service provision such as intermediaries or aggregators, illustrated in Figure 6.

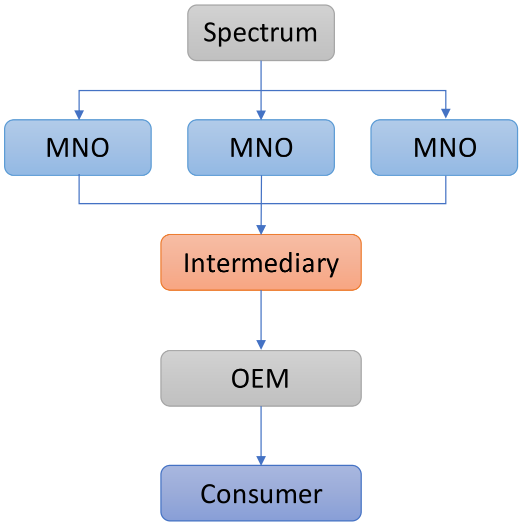

Figure 6: Intermediaries for mobile connectivity (*after [BEREC2018]*)

This form of service provision is already being used in various commercial contexts.

- *Service Provider*: Intermediary. What would the nature of that intermediary be? A third party?
- *Customer*: Who? OEM? End User? In fact, the target customer for such service can be defined in different possible ways, and there is still uncertainty about the set of potential target customers.
- *Value Proposition*: Seamless connectivity experience in going from one jurisdiction (including international) to another in the vehicle.
- *Leading capabilities*: superior ability to make contracts with MNOs in different jurisdictions.

Note that both the value proposition and the leading capability as defined above do not necessarily need 5G. It may have to be packaged with essential 5G features for a particular application in order to become a compelling value proposition. Note also that even the nature of the service provider and the target customer are not yet clear in the 5G community. In its comments on the recent 5G-PPP Automotive Working Group White Paper, the European Commission requested opinions from representative of the automotive industry on these questions – more evidence that business models are emerging and being elaborated without having first answered the three strategic questions.

4.1.7.3 Differentiating 5G service provision for CAM

The above considerations open the door to a discussion about the problem of differentiating 5G service connectivity in a CAM context. As a perfectly valid way to ensure both continuity and credibility, 5G has been carefully designed to evolve out of its predecessors (e.g. 4G LTE). But it brings with it the problem of differentiating service provision from its predecessors. This is where the chasm between services for the "merely" Connected Car and those for the Connected and Automated Car becomes most apparent.

There is a broad class of use cases around infotainment – and in general most non-safety related applications – where it will be challenging for a telco provider to create a compelling, differentiating value proposition. As noted earlier in this report, European consumers are already used to reliable, sufficiently fast broadband provision at low, flat fees. This may present an enormous challenge for a provider of advertisement, for example – the customer doesn't care about lag time in ad delivery.

It will be necessary for the service provider to narrowly and sharply define the customer in order to differentiate the service. For example, the promise of downloading video and audio content in seconds to ensure seamless delivery while driving might create differentiation (and may depend on leading capabilities such as superior expertise in network slicing).

A service provider may also have to combine with other types of leading capabilities to create a compelling value proposition. For example, a provider of predictive maintenance could combine superior Big Data capabilities and superior AI capabilities to offer the best predictive maintenance service available.

In contrast, the advanced applications in the CAM sector are tailor-made for differentiating 5G provision services. Fully automated driving will be essentially unthinkable without network slicing capability, which will give telco providers ample opportunities to provide differentiating levels of 5G connectivity, including flexible on-demand service creation.

4.1.8 The regulatory perspective on CAM

The perspective of governmental and regulatory authorities is to promote a "public value proposition" benefitting the citizenry in general, and support for Connected and Automated Mobility has been strong from the beginning (e.g. the "Europe on the Move" initiative). This public value proposition related to CAM involves societal benefits such as environmental improvement, enhanced public safety on the roads, and enhanced mobility for citizens.

As always, the role of governmental and regulatory authorities is firstly to ensure a healthy competitive market commensurate to its own objectives for creating public value, and secondly to identify areas of potential "market failure" within the competitive market where regulatory intervention could provide incentives to fill the gaps.

4.1.8.1 European Electronic Communications Code

We have already seen that the required CAPEX investments for CAM rollout are expected to be daunting, so a particular focus of governments is on that specific problem. One such initiative is the recently adopted European Electronic Communications Code (the Code) [EP2019], which was created exactly to promote advanced communications take-up, and 5G in particular.

We have already mentioned that risk management is especially relevant in the CAM environment, and not only with respect to safety and liability. Regulatory uncertainty can create downward pressure on investment readiness, and so the Code proposes new investment models that promise regulatory certainty to potential investors.

- The **first** investment model is yet another form of partnering: **co-investment** (that is, several operators investing in a single infrastructure, in a kind of joint venture). This provides a means of risk-sharing for the co-investing entities (which may well be competitors!). The co-investing must be open at any point in its lifetime to other service providers to join, and access seekers who do not participate must still be able to access the same set of services as were available to them before the investment, adapting over time to improving levels of service and quality (another example of regulations ensuring a healthy competitive environment).

- The **second** investment model involves a lighter regulatory regime for **wholesale-only** MNOs, which will reduce risk outright and hopefully encourage their increased investment in infrastructure.

The European Commission hopes that these regulatory backed investment models "could significantly decrease the cost of capital, and hence speed-up deployment and pay-back period, especially in less economically viable areas." This is another example of identifying potential "market failures" and using regulatory instruments to reduce investment risk.

Note that here we are "only" talking about the *financing and cost model* elements of the overall business model – the fundamental three questions of strategy remain to be answered for a service provider.

4.1.8.2 Strategic Deployment Agenda

The Strategic Deployment Agenda (SDA) is another important example of governmental / regulatory stakeholder engagement to identify and compensate for areas of market failure that form obstacles to the public value proposition – in this case, full European 5G coverage. The Commission input to the SDA says that

> *The overall aim is to ensure uninterrupted coverage of the full pan-EU network, using the Connecting Europe Facility mainly to drive investments in cross-border sections in complementarity with private investment projects in the commercially viable areas. National programmes could be mobilised to support investments in the remaining challenge areas.*

We can observe two points here:

- **First**, this is a form of public-private partnering: the governmental body invests in areas of market failure, and the private sector is expected to invest in other areas;
- **Second**, in Europe the situation is "hierarchical": one area of potential market failure is the cross-border zones, where the commercial and regulatory situation is ambiguous and therefore private investment may fail. It is appropriate here to have government expenditure at the EU level. But there are also areas within national territories that may create market failure (e.g. sparsely populated or extremely mountainous areas). Here an appeal is made to national governments for investment. This is another illustration of what was said in the beginning of this report: Europe faces special challenges with regard to 5G deployment, partly because of its nature as a union of sovereign Member States.

Once again, note that here the main goal (and rightly so) from the governmental and regulatory perspective, is to deliver the public value proposition of full 5G CAM coverage in Europe, whereby the "leading capabilities" to deliver this public value proposition include the range of co-investment models being proposed in the SDA. For service providers over this 5G CAM coverage, the three fundamental questions of strategy must still be answered, and the answers are not to be found in the governmental and regulatory perspective (again, rightly so).

4.2 Industry 4.0 and the Manufacturing Vertical

Europe has been a global leader in the movement toward Industry 4.0, and it has been a natural step to pursue the same leadership in the movement toward 5G in the factory.

4.2.1 The case for 5G in manufacturing

Earlier in this report, we saw an opinion [Bosch2018] that the only vertical to provider a true "killer app" for 5G is manufacturing. While this affirmation is destined to undergo intense scrutiny (especially by representatives of other verticals), it is worth considering the reasons that were put forth in making this affirmation.

- **Highly controlled environments**. This is one of the principal advantages usually cited. Factories are closed environments. They are not mobile. They tend to be under the administrative control of one authority (the owner of the factory). Not only that, but everything else can *also* generally be controlled. 5G base stations could be located in the ceiling of the factory. The distances are short, and often offer Line Of Sight (LOS) between devices, simplifying the implementation of advanced 5G capabilities like uRLLC. Equipment and production lines can be moved around to simplify 5G implementation, such as providing Line Of Sight. But even without LOS, the small spaces create strong reflections and keep signal strength strong.
- **Simpler traffic**. Arbitrary 5G traffic in a public mobile network is totally asynchronous and unpredictable. Within manufacturing facilities, the traffic is typical of real-time process control: cyclic, deterministic (and therefore predictable), with short bursts of small amounts of data. This fact also simplifies 5G implementation.
- **Simplified network operation**. Given the closed, limited environments, 5G implementations don't need the full complexity and scalability of a public mobile network. Even full cloud processing capability can be implemented locally within the environment, without resorting to an outside public provider.

All of these points – the simplified environment, both administratively and technically; simpler traffic; simpler network operation – naturally lead to an issue that is nowhere more pertinent than in the manufacturing context: the possibility of self-provision of 5G capabilities, also known as *private 5G networking* or the *buy versus build* decision, which we will examine more closely later.

More generally, they provide an argument for the lesser levels of investment required for 5G implementation in manufacturing facilities, with respect to other verticals such as automotive.

4.2.2 *5G related service providers and customers in manufacturing*

But lower required overall investment to acquire 5G capability for manufacturing does not, by itself, imply new and successful business models. Recent White Papers published by the major associations around the world such as 5G Americas [5GAmericas2018] and the 5G Alliance for Connected Industries and Automation [5GACIA2018] exhibit considerable convergence in their identification of the principal areas where business cases could exist. Table 2 shows a representative set of use cases that have been proposed, modelled after [BEREC2018].

Table 2: Manufacturing Use Cases and Service Providers (*After [BEREC2018]*)

Use cases	Impact on Industry	Service Provider?
Cell automation: devices in an assembly line and control units communicate wirelessly	Flexible and highly efficient production	Self? Third party? Telcos? SME?
Automated guided vehicle: autonomous vehicles to transfer goods in a factory	Increased safety, efficiency	Specialized vehicle manufacturers? Partnership?
Process automation: a high number of low maintenance sensors and actuators communicate wirelessly with control units	Increased efficiency, flexibility, lower inventory	Third-party? SME?
Logistics tracking: track flow of goods from raw material to delivery	Increased efficiency (cost and time)	Self? Third party?
Remote assistance and robot control: remote control of robot to fulfil operations such as measurements, digging	Increased product / process quality	Self? Third party? SME?
Augmented reality (AR): live direct or indirect view of a physical environment for training and maintenance	Increased efficiency, worker satisfaction, safety	Third party? Telco? SME?

4.2.3 *The manufacturer as service provider and customer*

Although each of these use cases has an acknowledged impact on the industry, as shown in Table 2, the impact alone does not answer the three major questions of strategy (customer, value proposition, and leading capabilities). In fact, perhaps more than in any other vertical domain, the question of *who* provides *which* service is equally important to answer. A car manufacturer is a special case of the general manufacturing vertical, where the product is cars. The answers to the three strategic questions for a general manufacturer will greatly depend on what the product or service is.

- **Could 5G change or redefine our target customer?** Will 5G capability create a new kind of customer for me? In the list of industry impacts in Table 2, most concern efficiency and safety, and do not imply a new type of customer. “Flexibility”, however, could lead to a different type of customer: for example, a customer for bespoke products. Or, it may not change the customer at all. This is a key question to answer in each individual manufacturing context.

- **Could 5G add to our value proposition?** We have already noted that car manufacturing is a special case of general manufacturing, and have introduced the concept of proximity: the ability to stay in contact with the product after sale. As a concrete example of proximity in the Manufacturing domain, a European producer of air compression machinery has enhanced its value proposition to its customers by using advanced predictive maintenance to increase the performance of its air compressors installed in the field. It has added a "pay per cubic meter of compressed air" payment option. In other words, it has added a contingency fee to its revenue model. Could this "proximity-based service" lead to a new, separate type of customer and separate value proposition? The industry impacts listed in Table 2 indicate that the main enhancement to a value proposition might be lower costs (only if the cost-related benefits are passed on to the customer!) and higher quality, which may or may not make the value proposition more compelling to the customer. The augmented reality use case may help the manufacturer to improve its own efficiency, but not have a perceptible effect on its value proposition. In contrast, if augmented reality is part of the value proposition for the manufacturer's *customer* – e.g. the augmented reality capability is actually delivered to the manufacturer's customer as part of a value proposition "the best possible support for your complex tasks" – then it could change the value proposition.
- **How can 5G enhance our leading capabilities?** Table 2 lists several use cases and impacts that will certainly enhance the capabilities of a manufacturer, but will they significantly enhance those capabilities identified *that are needed to be the best in consistently delivering the particular value proposition of the manufacturer*? Once again, many of the impacts generally cited concern improved operational efficiency, which may or may not be leading capabilities in the delivery of a value proposition.

4.2.4 Third party service providers

While manufacturers must ask themselves the soul-searching strategic questions to understand the implications of 5G capability on their customer base and value propositions, it seems clear that myriad opportunities will present themselves for third parties to become providers of 5G related products and services to manufacturers.

4.2.4.1 Automated vehicles

Consider the use case of the automated guided vehicle in Table 2. Recall also the Jetsons Fallacy of the automotive discussion. The future will bring a far larger variety of vehicles than simply cars, and this use case provides a good example: small, slow, light vehicles operating in a controlled environment with vastly simpler safety related issues (for example, they might not even need safety certification, a huge difference). A third party could provide such vehicles to the manufacturer customer, and that third party may even *be* an automotive OEM who identifies a new target customer (the manufacturer) and offers a value proposition (smart automated vehicles at a low price) using its leading capabilities (decades of experience in automotive manufacturing and expertise in connectivity, all at contained costs).

4.2.4.2 Other technologies

In fact, most of the use cases in Table 2 lend themselves to a third-party provider. Augmented reality could be provided by a third party to the manufacturing plant as customer; or to the manufacturer's customer in a partnership model. The manufacturing plant could be a customer for 5G enabled wireless sensors from a third-party seller. The value proposition of that seller might concern high-quality, powerful, and rugged sensors (for a particular kind of manufacturing customer), or cheap, low energy consuming sensors that offload computing capability to the local cloud (for a different type of manufacturing customer).

Many have said that the primary value capture from 5G could be in the third-party providers – that may well be true in the manufacturing vertical. In particular, SMEs specializing in specific niches may have strong opportunities with sharply, narrowly defined customers (e.g. for 5G-capable sensors) and value propositions enabled by advanced technological leading capabilities.

4.2.5 Telco service providers and the build or buy decision

The provision of 5G connectivity to manufacturing verticals is complicated by a number of factors.

- As mentioned earlier, the factory / warehouse context is favourable to self-provision of 5G connectivity. Over and above the factors already mentioned, self-provision also resolves a number of issues regarding privacy and security. Self-management of the network can mean that sensitive company information never has to leave the premises.
- The manufacturing context is also favourable to the provision of the advanced features of 5G that are needed to implement many of the most promising use cases (including most of those listed in Table 2, particularly uRLLC and (to a lesser extent) mMTC. The distances are short in a factory, making uRLLC easier and cheaper to deploy.
- Interesting new technologies can be deployed in the limited environment of the factory. For example, Li-Fi provides the wireless analogue to fibre optics – the use of light waves instead of radio waves – with all of the attendant advantages, including imperviousness to interference and excellent security characteristics (light waves don't pass through solid walls).

In view of all this, who are the potential 5G connectivity providers and who are the customers?

We can start with the Mobile Network Operators. They have a natural advantage of having spectrum available and expertise in implementing 5G. Factories are natural customers for the advanced, differentiating features that can be delivered through network slicing. This is likely to be necessary to make a convincing value proposition, because as BEREC has observed [BEREC2018], both 4G LTE and WiFi still have much to offer to a factory environment even without the advanced features of 5G. Even large wireless sensor networks will need to grow to sufficient sizes to need the mMTC capability – not a given in a factory environment.

Another potential provider of 5G connectivity services in factories could be third parties specialized in certain kinds of technologies, such as the Li-Fi mentioned above. Here, too, an opportunity may arise for SMEs who have mastered such technologies and could sell either to the MNOs serving factories or directly to the factories themselves. See the 5G-PPP IoRL project (https://iorl.5g-ppp.eu/) in this regard.

Suppose now that the factory decides to opt for the self-provision alternative. This still does not necessarily mean that the factory will build the 5G implementation on its own. It could contract the installation to a third party to install and service the deployment in the factory (another type of service provider with its own value proposition). This may be a private provider of small cell technology, creating another specialized type of seller with a compelling value proposition for close environments. That third party may also be an MNO who identifies the factory as a new kind of customer and offers custom connectivity packages to the factory, broadening its customer base. This third-party option will be explored further later in this report.

Finally, the factory could opt for full self-provision, building the installation with its own means. This will require expertise in 5G – although as mentioned earlier, 5G deployment in factories can be simpler than full public 5G.

4.2.5.1 The government and regulatory perspective on 5G in manufacturing

As in the case of the automotive vertical, a principal concern of governments with respect to manufacturing is to promote 5G deployment. Therefore, a natural question is whether private networking as described above is considered to be incompatible with the objective of broad 5G deployment. After all, a 5G network that is built privately "steals" business from a public MNO.

Perhaps surprisingly, regulatory bodies like BEREC have come out in favour of private networking in closed environments like factories. They recognize that factories have special needs (such as privacy and security) that favour the Build decision, and in any case observe that even a private network contributes to the spread of 5G deployment. One thorny issue concerns the use of spectrum. This is an intensely debated issue at the moment, but a general outline of the problem can be stated briefly here:

- Factory 5G applications are likely to favour use of high bands like the mmWave bands (e.g. for uRLLC functionality), which are susceptible to interference.
- Private networks have a problem of getting access to licensed spectrum. MNOs traditionally have licensed spectrum.
- But sharing of unlicensed spectrum risks unacceptable levels of interference that can jeopardize the integrity and reliability of the needed uRLLC connectivity.

The problem of spectrum access with be treated in more depth in Section 6.2.

4.3 Energy and Utilities

There are great expectations for 5G enabled revenues in the Energy and Utilities sector. Recall that in the forecast presented in Figure 3, the first place was occupied by Energy and Utilities – ahead of all other vertical sectors including Manufacturing. During the webinar on Energy held on 12 March 2018 by Global5G.org partner IDC, Atos observed [ATOS2018] that global smart grid data analytics market is expected to triple by 2022; revenue from the home energy sector will more than double by 2023; and 27% of EU energy consumption should be coming from renewables by 2030.

After the webinar, Global5G.org partner IDC observed that "Energy technology is shaking traditional utility value creation at its core. Not only is it fuelling a shift in the way energy is produced, distributed, and consumed, but also in the ownership of the production capacity itself. In parallel, digital technologies are disrupting decade-old processes, creating opportunities and threats to the traditional utility business model."

Figure 7 shows a representative vision [ERIC2018] of the future smart grid that reflects the statements of Global5G.org partner IDC quoted above, whereby the ownership of the production capacity – the energy assets – is decoupled from "asset-free" business models that form a new value chain from supply to demand, with smart storage and aggregation in the middle.

Each of these components of the new value chain contains new potential providers and customers. This is the idea behind "unlocking value" through the new organization of the smart grid.

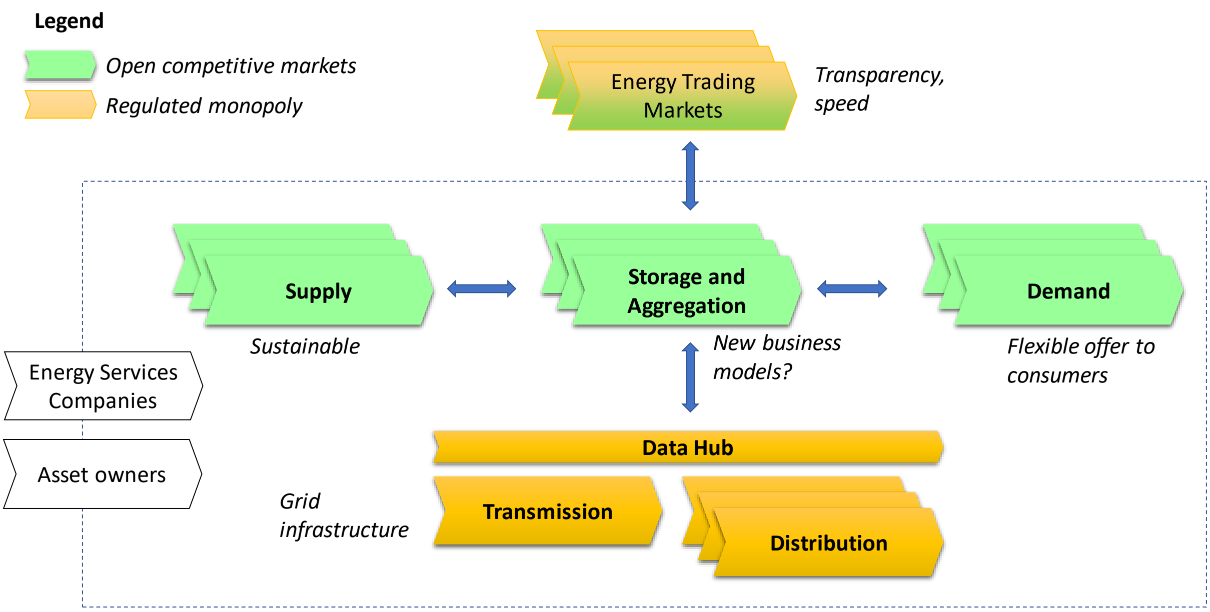

Figure 7: The 5G Connected, Distributed, Controlled, Monitored Smart Grid (*after [ERIC2018]*)

In the Global5G.org Energy seminar hosted by IDC, presenter Atos [ATOS2018] made an important remark to which we will return later: "Energy assets differ essentially in their communication needs. *While some need real time and ultra-reliable links, others are less critical and IoT oriented*."

The White Paper produced by the 5G Industry Association [5GIA2015] provides some clues as to what the Energy and Utilities industry is expecting in terms of business model disruption due to 5G.

- **Improved differentiation for consumer energy delivery**. A smarter Smart Grid could permit the creation of more differentiated value propositions for consumers. That could include differentiated quality levels of electricity supply (traditional, low-cost, back-up only, etc.), or differentiated pricing schemes (pay-as-you-go, bartering, real-time peak pricing, etc.);

- **New services exploiting improved data collection**. This may include services for optimization of consumption, predictive maintenance, home surveillance, etc.

These considerations are confirmed by the BEREC [BEREC2018] study that consolidates the major use cases expected for 5G in the energy area into two principal categories:

- **Smart metering**. This use case involves improved monitoring of energy flows and consumption, enabling the differentiated pricing schemes, optimization, etc. mentioned above.
- **Smart grids**. This involves a complete overhaul of the entire energy grid, decentralizing it, and connecting everything with full monitoring and control.

4.3.1 Smart metering – the 5G value proposition problem

Smart metering is basically an IoT application, and there are many instances of such applications already in the field today. Furthermore, the data volumes are not large, and the latencies are not critical. In fact, smart metering is not mission-critical and does not need 5G features like uRLLC (at least today).

The fact is that today, when a smart metering provider asks the second strategic question, “How does 5G enhance my value proposition?” the answer may well be that it does not.

4.3.2 Smart Grids – a complex, critical infrastructure

In contrast to smart metering, the Smart Grid is a use case with significantly more opportunities (and challenges) directly related to 5G. Much of what it must do exhibits the characteristics that 5G provides: high capacity, massive machine type communications, ultra-reliable, low latency links.

One important task of the new Smart Grid is to cope with the challenges brought by the drive toward renewable energy assets (e.g. wind farms). Here, too, 5G has much to offer.

- Renewable energy assets are often located in remote areas, far away from the other elements of the grid (think wind farms and geothermal energy assets). Wireless 5G represents an attractive opportunity for overcoming the problem of remote locations.
- Renewable energy assets are generally unpredictable, unlike traditional assets like coal (geothermal energy is an interesting exception – it has the potential to replace traditional demand deployment assets like coal with a predictable, yet renewable source). This also leads to the need for reliable, low-latency communication and increased data analytics.

Therefore, the question “What will 5G do for my business?” could well be answered in a positive manner by the Smart Grid as customer. An equally important question, however, is once again one of the central questions of this report: who are the providers of 5G-related services in the Energy sector?

4.3.3 The telecom provider perspective on 5G and Energy

As always, the first candidate for 5G connectivity provision in the Energy sector is the MNO. What service would the MNO provide, with what value propositions?

[ALEX2016] presents an interesting insight on where the most successful services are likely to lie: "No longer will voice communications become the primary revenue source for operators, nor will they account for the bulk of communications. Instead, machines communicating with machines … provide the momentum for the business case in the sector." In other words, IoT is likely to provide the most opportunities.

Although smart metering will provide traditional IoT opportunities that could be potentially handled with existing wireless connectivity, as discussed above, the Smart Grid could provide opportunities for the massive Machine Type Communication services that only 5G can provide.

4.3.4 Massive IoT – the pricing problem

This is where Mobile Network Operators will have to grapple with one of the specific components of business models discussed in Section 3: the cost structure [BEREC2018]. A value proposition offering "a full data analytics solution for a renewable energy asset provider" could be compelling, but it is likely to involve the installation of a dense sensor network with thousands of communicating sensors, and a prohibitive cost structure for the client could weaken the value proposition considerably.

We have already noted that much IoT could be provided with existing technologies, like master-slave networks. But they become complex and unwieldy as the number of connected devices grows exponentially. 5G offers an elegant solution with mMTC, where large number of devices can be connected individually (and with low power consumption!).

But this flexibility brings a question with it: what is the pricing structure for these independently connected devices? Known pricing structures in use cases like tracking devices often offer monthly mobile subscriptions at relatively low costs (e.g. less than 5 Euros per month) for individual devices. But customers area likely to balk at per-device subscriptions when there are possibly thousands of devices involved. MNOs will have to consider how they can bring the marginal cost of new devices down to the level where either a flat rate can be offered, or at least the cost growth rate does not discourage the customer from buying into the value proposition.

[BEREC2018] notes that this dilemma could ultimately lead to the entrance of new service providers. Analogous to today's Mobile Virtual Network Operators who buy "consumer connectivity" wholesale and then resell it in the consumer market, a similar kind of intermediary could buy "machine-to-machine connectivity" wholesale from MNOs and repackage it for mMTC customers in verticals like Energy or Agriculture, exactly in order to smooth out the problem of pricing structures. Such intermediaries could have the possibility to sharpen and customize their value propositions (strategic question #2) for specific, narrowly-defined customers (strategic question #1), based on their own leading capabilities (strategic question #3) which could include 5G mMTC expertise, data analytics expertise, and superior capabilities for making arrangements with different MNOs.

4.3.5 Mobile network operators and the critical infrastructure problem

The Smart Grid is typically a regulated monopoly, as shown in Figure 7. More specifically, the power grid falls into the category of Critical Infrastructures, which bring a number of special issues with them.

Several organisations, such as BEREC [BEREC2018] and in particular the 5GIA [5GIA2015] have indicated some characteristics that pose potential problems for the business case for 5G provision.

4.3.5.1 High reliability and high availability

Critical infrastructure has high reliability requirements by definition. Depending on the type of infrastructure, it may also have high availability requirements, and that certainly applies to the power grid, which is expected to be operational 24/7.

4.3.5.2 Safety related issues

A communications system like the telephone network or a financial transactions system may well be classified as critical infrastructure with high reliability / availability requirements, but they generally are not considered safety critical. In contrast, several categories of critical infrastructure like Intelligent Transport Systems, Air Traffic Control, and in general any infrastructure responsible for cyber-physical systems are generally considered safety related. At least some areas of the power grid are likely to be classified as safety related and thus be subject to safety certification issues (as we have seen in the section on the automotive vertical).

4.3.5.3 Security related issues

While not all critical infrastructure is safety related, it is most certainly security-related. Whether it is a financial communication backbone or a power grid, hostile penetration is a hazard that must be confronted. There are a number of onerous security related standards, such as the ISO27000 family, that may be called into force, as well as certification frameworks like the Common Criteria, which could increase the costs of deploying 5G communication infrastructure. (The European Commission has been particularly pro-active, and created the Critical Infrastructure Directive in 2008.)

Mobile network operators are already sensitized to the need to secure consumer smartphones, but securing a power grid communication infrastructure is a step up in effort. It should be noted, however, that 5G security has been an integral concern from the beginning, and working groups such as the 5G-PPP Security WG have been active for several years now.

4.3.5.4 Longevity issues

Smart grid applications live for long periods, up to 15 years, and must have stability both technically and economically. Commercial operators have an obvious problem there – it is normally not in their interests to maintain long-lived applications (on the contrary, they welcome periodic commercial turnover). In this respect, the Energy sector shares such problems with other sectors like Space (cf. the European Space Agency) and the military (which sometimes buys an entire company in order to ensure availability of long-term support for a particular application).

4.3.5.5 Resilience

Resilience concerns the provision of service in the face of blackouts, where there may well be local or national regulations concerning the allowed amount of time to remain in blackout before sanctions are incurred. Commercial MNOs may find it difficult or unattractive to offer such service levels. On the other hand, 5G is designed to have the potential to deliver high SLAs, and the advanced features such as network slicing may prove to be able to overcome reluctance to confront this level of service for smart grids. For example, “true” mMTC profiles could be defined, where a network slicing function could deliver mMTC and uRLLC features, but not eMBB, making the delivery of the needed service levels sufficiently cost-effective. See the section on Network Slicing for more discussion of this.

4.3.5.6 Cost stability

Grid applications traditionally need cost stability, which is obviously a problem for commercial operators who generally need to see revenue growth over time.

All of these factors could conspire to discourage traditional commercial MNOs from entering into the 5G connectivity market for Energy. However, before descending too much into pessimism, a couple of observations are in order:

- As discussed above, 5G was designed with critical applications in mind, at least with its advanced features. Security is built in carefully, and reliability and resilience have also been taken into careful consideration during its design. 5G deployment may well turn out to be an excellent coupling with Critical Infrastructures.
- The discussion earlier about potential intermediaries buying wholesale connectivity packages from MNOs could lead to a thriving market of “virtual mission-critical network operators” who specialize in delivering not only connectivity, but also in solving the other issues associated with critical infrastructure, such as certification, network slicing to reach guaranteed service levels, customization, and so forth. The spectrum would continue to be owned / licensed by the MNO.
- Finally, analogous to the case of Manufacturing, another approach to dealing with the special problems associated with Critical Infrastructure is simply to acquire a private dedicated network. [5GIA2015] cites the example of Dutch Distribution System Operators doing exactly that, including obtaining their own frequency license for the 450 Mhz band.

A concrete example of a third party seeing an opportunity to expand beyond its traditional customer base to propose private networking solutions giving mission-critical connectivity to customers like smart grids and factories is Nokia, who presented their plans in January 2019 [Nokia2019] in this regard. Table 3 shows the projections they have made for the number of potential installations of such mission-critical private networks. The largest number of installations by far is in the Manufacturing sector (and related sector Warehousing). But other well-known critical infrastructure categories like power generation, utilities, oil and gas, and the military are well represented.

Table 3: Potential private networking site installations (*Source: [Nokia2019]*)

Industry	Number of Sites
Transport venues and Ports	50K
Military bases	10K
Warehouses	3300K
Industrial and manufacturing	10.7M

Industry	Number of Sites
Oil and gas	8K
Power generation	47.6K
Water utility players	140K
Mining	54K
Hospitals and laboratories	263K
Total number of installations	**14.5 Million**

4.3.5.7 Other 5G Energy related service providers

Many of the same considerations apply to the Energy vertical that we have seen in both the automotive and the manufacturing verticals regarding other prospective suppliers of 5G related services and products.

4.3.5.7.1 Drones and maintenance

A use case that is frequently put forward is maintenance of the energy grid, in particular through the use of drones. For example, 5G-connected drones could be used for performing tasks that are normally dangerous, like climbing towers for inspection; or in general for performing tasks in areas that are difficult to reach. These drones are likely to be supplied by third parties who package the product together with service based on leading capabilities of real-time 5G operation and advanced data analytics (e.g. for predictive maintenance).

4.3.5.7.2 Augmented reality

Analogous to the case of factories, augmented reality could be used to render complex 3D models of underground networks and to assist technicians with the operation of complex and potentially dangerous grid management equipment if improperly used. The service provider of the augmented reality capability is also likely to be third party providing also a complete package of equipment and customized software, often for the specific apparatus under control.

As in the case of other verticals, there is a significant opportunity for the third-party suppliers of products and services in this vertical to be **Small to Medium Enterprises**, with sharply, narrowly defined customers and leading capabilities incorporating excellence in 5G related technologies.

5 Cross-Vertical Issues related to 5G Business Models

It is evident from the discussions within the sections on verticals that many issues arising in 5G related business models are common across many vertical sectors. Examples of this include private networking, spectrum related topics, and specialized 5G functionality like network slicing.

It is important, therefore, to raise the level of discussion above the single vertical sectors to examine some issues in a cross-vertical context. This is also important from the point of view of business models: several authoritative sources (e.g. [BEREC2018]) have come to the conclusion that, especially in the near to medium term, 5G may not present sufficient opportunities within a single vertical sector to justify business cases. Rather, the opportunities for potential service providers may lie in a well-defined, cross-vertical characterization of the customer (strategic question #1) with a value proposition (strategic question #2) based upon leading capabilities (strategic question #3) related to crucial 5G capabilities. An example is provided in the next section.

5.1 The Key Role of Network Slicing

"Network slicing will truly be the bedrock of 5G monetization …" [MATR2018]

Network slicing is at the very heart of emerging business model creation in 5G. The concept of network "slicing" has become central in the architecture of 5G [5GPPP2018], as illustrated in Figure 8.

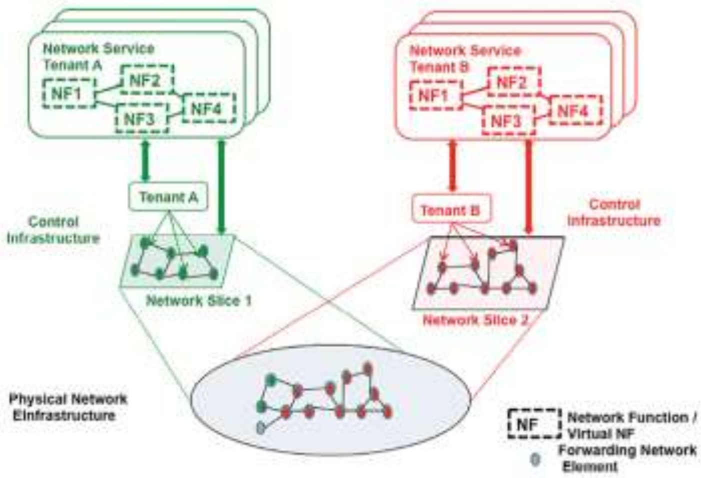

Figure 8: Network Slicing Basic Concept (*Source: [5GPPP2018]*)

Network slicing is related to more traditional concepts like Quality of Service (e.g. DiffServ, the Differentiated Services Architecture), Network Function Virtualisation (NFV), and Virtual Private Networks (VPNs), whereby network users ("tenants") share the physical network infrastructure but receive different services over that same infrastructure. But there are key differences that make network slicing unique to 5G.

In a nutshell: none of the other traditional techniques "go all the way" in providing a service that is *complete*. Rather, the others are all *incomplete* in some way. For example, DiffServ can indeed differentiate high definition video traffic from voice-grade traffic – but cannot differentiate between different users of the same kind of traffic. Nor can DiffServ provide key characteristics like traffic isolation (e.g. for privacy concerns) that may be needed by certain classes of users.

The key to the approach of Network Slicing is that it includes not only networking, but also compute and storage functions, thus making it possible to complete the service offering both across quality and characteristics and across individual tenants / users.

It has been estimated that there will be a 40% reduction in the cost of the 5G core through network slicing, and at the same time, about 35% potential revenue uptake.

5.1.1 Network slicing for differentiation across ITU dimensions

Table 4 presents a feature of network slicing that forms an important basis for differentiation. Applications placing strong requirements in one of the three major ITU dimensions typically place only medium or only weak requirements in the other dimensions.

Table 4: ITU Applications and Requirements

ITU functionality	Typical requirements on bandwidth	Typical requirements on connection density	Typical requirements on low latency
Enhanced Mobile Broadband	**STRONG**	Medium	Weak
Massive Machine Type Communications	Medium/Weak	**STRONG**	Medium/Weak
Ultra-Reliable Low Latency	Medium/Weak	Weak	**STRONG**

This differing mix of networking requirements means that service providers can provide differentiated services to clients, making them pay less (or more) for exactly what they need. This is the embryonic motivation behind the possibility of supporting new, differentiable value propositions with network slicing.

As an example, differentiated services based on different mixes of eMBB and uRLL are illustrated in Table 5.

Table 5: Differentiated communication services and applications (*After CStreet2019]*)

Communication requirements	Applications
Ultra Capacity Sensitive	• Broadcasting • Surveillance • UHD Video • Virtual Reality

Communication requirements	Applications
Capacity Sensitive	• IPTV • OTT Video • Social Video • Gaming • Audio
Best effort	• Email • Social Apps • Syncing • Web Apps • Calendar Sync
Delay sensitive	• Voice • Web Conferencing • Telemedicine • Internet of Things • Critical Communications
Ultra delay sensitive	• Vehicle-to-Everything • Smart Factory Automation

Although the ITU requirements are the baseline point of departure for differentiation, they are not the only factors. Others include:

- **Appropriate levels of privacy and security**. This may be necessary in environments such as mission-critical and financial, as discussed earlier; but it may be less critical in environments such as consumer media streaming.
- **Rapid service setup**. Some 5G applications will need very quick service setup, especially in very dynamic environments (e.g. Industry 4.0 or Energy). Setup time may be required in terms of days, hours, or even minutes (recall the example of energy trading markets illustrated in Figure 7).
- **Energy efficiency**. Some applications involving remote, battery-powered sensing devices that must be long-lived, and network slices optimizing energy consumption will be needed (consider the discussion of massive IoT in Section 4.3.3).

Rapid service setup requires virtualized resources that can be rapidly orchestrated into new services. It also, therefore, implies a high degree of automation – especially because the numbers of network slices could grow into the hundreds for an operator and it must be possible to build services quickly. But note that network slicing may well imply not just the involvement of virtualized resources, but also the marshalling and provisioning of physical network resources, such as edge computing resources to implement ultra-reliable-low latency.

It is also worth mentioning that the techniques and technologies being put into place for network slicing are not necessarily always specific only to 5G – once they are in place, some of them will be applicable, for example, also to fixed line, 3G, and 4G services. This means that the potential service provider will always have to answer the three strategic questions: "Who exactly is the customer?" "How will 5G network slicing enhance the value proposition over mere 4G network slicing capability?" "Is 5G relevant to the leading capabilities in network slicing needed to deliver the value proposition?"

Fortunately, in this strategic context, network slicing will also support "agile business model development". It will be possible to try out new services quickly on the market, and see whether they catch on. If they don't catch on, it won't be necessary to build an entirely new infrastructure to support the next service.

5.1.2 A concrete example: the 5G-PPP MATILDA project

MATILDA (www.matilda-5g.eu) is a 5G-PPP project to develop services based upon network slicing. It has conducted analyses to answer the three strategic questions

- **Who is the customer?** "The ultimate direct potential customer of MATILDA's overall solution will be the Telecommunication Service Providers (TSPs), including small telcos, VNO, NaaS, etc., spanning from the radio and/or fixed access to the edge, transport and core network"
- **What is the value proposition?** "Bridging the existing gap in end-to-end orchestration solutions and delivering an easy and flexible environment for integration of vertical applications into a 5G ecosystem."
- **What are the leading capabilities for delivering this value proposition better than anyone else?** "Capability of setting up and managing 5G-ready application deployments and operation over an application-aware network slice for the fast expansion of their service portfolio in various vertical markets."

Vertical markets in which MATILDA expects to find customers include Industry 4.0, Automotive, Smart Cities (which includes aspects of Energy and Utilities) and Emergency Communications. Most or all of these include mission-critical applications / infrastructures.

Currently (Spring 2019) components of the envisioned business model are being drafted, including channels, cost structure, and revenue model.

6 Government and Regulatory Aspects

As noted in the beginning of this report, there are always at least three stakeholders in any vertical analysis: the verticals themselves, the telecom operators, and the government. As with the telecom operators, some governmental and regulatory issues span across all vertical segments. In this section, certain aspects are treated that have a direct impact on the successful development of the emerging business models discussed in earlier sections of this report.

6.1 Competition Aspects of Verticals

One of the most important tasks of governments and regulatory bodies is to ensure a healthy competitive environment, and this issue is especially pertinent in the context of verticals.

6.1.1 Regulation of infrastructure sharing

A key concept for ensuring 5G rollout for verticals is infrastructure sharing, as discussed at length for the Automotive vertical. While this is certainly a method for avoiding duplication of costs, there have been cases in which potential was seen for anti-competitive behaviour among the sharing providers, especially when usage-based wholesale charging is used. This form of charging has been viewed as a possible way for the sharing providers to coordinate retail pricing. Regulators have, in the past, imposed capacity-based wholesale pricing (whereby the provider is charged on his allocated capacity rather than the amount of traffic). There is no single, obvious answer to this problem, and it will not go away (small cell networks, in particular, can make it very difficult to avoid network sharing simply because there is not enough room for more than one physical network). Therefore, regulators will be monitoring the network sharing activities of providers as 5G rollout proceeds, looking out for potential anti-competitive situations and possible solutions.

The “opposite” problem also exists: given that in the case of small sites there is not enough room for more than one network, the site owner may decide to allocate everything to a single provider, creating a possible anti-competitive situation. In fact, if the government itself is the owner of a particular site, then it may be tempted to increase revenues by such arrangements [BEREC2018]. This must also be guarded against. This is where neutral hosts and their associated business models could be part of a robust solution.

When the government / public sector owns a site and wants to sell access to competing MNOs, it might allow full competition, or might even restrict access to an exclusive provider. The point is that even the public administration will have to think about its own emerging “public business models”. For example, if it owns a site and is not sure how much to charge for it, then it could open it up to a competition among MNOs and see what the bidding results are.

6.1.2 Sectoral regulation and government support for competitivity

Finally, there has been much discussion about the problem of sectoral regulation, especially in mission-critical environments. As noted earlier, each vertical sector has its set of relevant regulations (especially safety and security related), but national and supranational governments also have a role to play in issuing regulatory directives and recommendations in order to ensure both the integrity and the competitiveness of the vertical markets.

As a specific example, the United States has issued national guidelines [NHTSA2016] covering 15 points including state laws, cybersecurity, ethical considerations, and validation. It helps companies active in the automated driving sector by providing some legal protection. If a car crashes, courts may look to these guidelines to help us determine what was reasonable and not.

As another specific example, the European Parliament commissioned a study on "A common EU approach to liability rules and insurance for connected and autonomous vehicles," [EP2018] intended also to help accelerate the adoption of driverless and connected vehicles in Europe.

These two examples underscore the importance of governments in giving verticals a certain degree of regulatory certainty when pursuing their chosen business models.

6.2 Spectrum and Verticals

Vertical sectors have a special set of problems concerning access to spectrum. The discussions of the various verticals in this report have already highlighted a number of these problems.

Much of consumer related connectivity is "best effort" in terms of service level quality, and often "best effort" in terms of coverage (that is, a consumer is usually willing to put up with inadequate coverage in most circumstances). But verticals generally have more stringent requirements on connectivity, both in terms of service levels (reliability, resilience, latency) and coverage. If these requirements are not met, many of the innovative business models we have seen, from network slicing to mission-critical intermediary suppliers, will be unable to deploy (in order words, missing "leading capabilities" – strategic question #3).

As we have seen earlier, these issues have led many vertical sectors to consider introducing private networks, which still do not entirely solve the problem of spectrum access:

- Regulatory bodies must still decide which bands are available for verticals;
- The spectrum may be in the hands of the MNOs, which may or may not be adequate for the implementation of the chosen business models of the verticals (including cost considerations).

In addition, [BEREC2018] points out yet another problem arising from the "hierarchical" nature of the European Union, already mentioned several times in this report: spectrum may be allocated in different ways in different Member States, making it difficult or impossible for a vertical enterprise to implement its business model across borders. Different Member States may have come to different conclusions about which bands to use for private networks, for example. One Member State may decide upon 2.5 GHz; another country may settle on 3.6 GHz. Yet another country may have not yet made any decision at all, and the vertical service provider will have to resort to support from an MNO.

6.2.1 Radio Spectrum Policy Group Third Opinion

The regulatory bodies are in full alert on this topic, and there is much current activity. The Radio Spectrum Policy Group "RSPG Opinion on 5G implementation challenges (RSPG 3rd opinion on 5G)" was published on 30 January 2019, and contains an extensive discussion of the problem of spectrum provision for 5G verticals. Above all, it attempts to bring clarity into the situation.

The Third Opinion first identifies two main categories of verticals, in order to focus the discussion:

- **Network infrastructure dependent verticals**. These are verticals who, in order to implement their business models, need the characteristics of the full infrastructure. The most obvious reason is *wide area coverage*. We have two examples in this report: automotive, where broad, cross-border corridor coverage is needed; and Energy / Utilities, where the energy assets and the grid in general may be spread out over a large geographical area.
- **Verticals requiring only local, "on-site" coverage**. The obvious example in this report is Manufacturing, but in reality, as the Third Opinion notes, this type of vertical is fragmented and very "niche" – for example, some elements in the Energy value chain might also fall into this category, depending on local conditions. Indoor sites are also typical candidates. These verticals often are interested in operating private networks, for reasons of security, privacy, and so forth, as mentioned earlier.

The RSPG Third Opinion also addressed the question of harmonising bands among the Member States. It came to the conclusion that indeed it could be important and useful to harmonise bands for certain industries, for "pan European vertical applications" such as automated vehicles and other types of automated transportation like trains. This essentially corresponds to the first category above ("Network infrastructure dependent verticals").

But the Third Opinion also came to the conclusion that European-wide band harmonisation was not necessary for the second category of "local" verticals. Harmonisation within each Member State should be adequate to meet the needs of these verticals, according to the Opinion.

6.2.2 Public Consultation on the Draft Third Opinion

An extremely useful insight into the positions of various stakeholders (both verticals and public connectivity providers) on the issue of spectrum provision for verticals may be obtained by examining their responses during the Public Consultation leading up to the final presentation of the Third Opinion. A number of stakeholders weighed in, giving insight into how verticals and their prospective providers are confronting 5G connectivity today.

6.2.3 Responses from verticals

In its reply to the draft Third Opinion, **AIRBUS** expressed its conviction concerning the close relationship between 5G connectivity and emerging business models:

> *Many AIRBUS products are increasingly relying on connectivity to deliver new and secure services through innovative business models. The evolution from 4G to 5G is accelerating this trend, as 5G is designed to support a wide range of applications beyond mobile broadband. The Factory*

> *of the Future can potentially increase the productivity of all industrial sites of AIRBUS, regardless of the type of business. AIRBUS looks forward having the opportunity to introduce innovative concepts, as deemed relevant/timely, in order to stay at the forefront of the aerospace industry, hence ensuring the sustainability of its sites across Europe.*

AIRBUS came down firmly in favour of dedicated spectrum for verticals.

BASF is a large chemical manufacturer, and described its approach to operating its own private network and the reasons associated with the choices they have made. For example, as discussed earlier in the section on the Energy vertical, the needs of certain mission-critical verticals may simply be too much for a mobile operator to be interested:

> *Industrial mobile radio applications in the chemical industry have* ***technical and legal requirements*** *which are* ***not met by the business models of the mobile phone providers*** *and which are not covered by them. The core requirements in terms of legally required operator responsibility and operational reliability are as follows: adherence to maximum latency times; the provision of minimum upload speed; compliance with the many legal and normative requirements.*

BASF also mentioned the problem of confronting massive Machine Type Communications in a cost-effective way, as discussed earlier in the section on IoT pricing structures.

> *Chemical production plants are currently typically equipped with approx. 3000 - 5000 sensors and actuators. Digitization is expected to result in the cost-effective installation of a large number of additional sensors for monitoring and diagnostic tasks. As in automotive engineering, the number of installed sensors is expected to increase tenfold. At a large site like BASF's in Ludwigshafen with about 200 production plants, one can assume a potential of >500,000 additional sensors, which can only be used economically* ***if the necessary communication infrastructure can be operated economically and reliably****.*

BASF left no doubt that it is particularly interested in private network operations.

6.2.4 Responses from telco providers

A number of connectivity providers also weighed in on the question of spectrum allocation. Deutsche Telekom pointed out the problems of reserving spectrum in the ECS bands exclusively for industrial usage, noting that in Germany, 25% of the overall resources have already been made unavailable for national 5G services, and due to the rather local industrial usage, to an inefficient usage of spectrum.

Another type of connectivity provider also weighed in: **EchoStar Mobile**, a satellite-based connectivity provider. EchoStar was especially concerned about fragmentation of the spectrum by reserving exclusively for verticals, because of a global operator like EchoStar needing to rely on European Union harmonised allocation for its pan European services.

Taken together, these responses not only give us an additional snapshot of the current business models being pursued by verticals and their connectivity providers, but also the effect of regulatory actions on these business models. Collectively, these responses also provide the rationale for the final form of the RSPG Third Opinion presented earlier.

6.2.4.1 Recommendations for Secondary Licensing

The RSPG Third Opinion – and for that matter, the opinions of the verticals in the Public Consultation – effectively only described a set of alternatives. What are the concrete recommendations for proceeding with regard to spectrum for verticals? One recommendation currently gaining traction in several quarters involves **secondary licensing**.

As noted above, most stakeholders are against the idea of reserving parts of the spectrum exclusively for verticals, because of the inefficient resulting use and the fragmentation of the spectrum. An obvious alternative is shared use of unlicensed spectrum, where there are no such restrictions. The 5G-PPP Spectrum Working Group (of which Global5G.org is a member) has studied a number of promising technological innovations in spectrum sharing, from beamforming to massive MIMO, that can reduce the possibility of interference. And certain techniques like using mmWave bands (or light) can reduce interference even further, with their characteristics of limited propagation. But today, at least, mission-critical verticals simply do not trust unlicensed spectrum sharing – they cannot count on achieving the needed service levels – and rightfully so, given the heavy regulatory requirements they must face.

The Body of European Regulators for Electronic Communications has spoken out favourably on secondary licensing to resolve this problem [BEREC2018]. In this case, spectrum is licensed by the **primary provider**, and then sub-licenses parts of it to a **secondary licensee**, the vertical. This has several advantages: the spectrum would not be fragmented, because it is not reserved only for verticals; the primary user would be protected from interference by the secondary user; and the primary licensee would have a potential new business model to pursue with a new type of customer.

In fact, the Global System for Mobile Communications (GSMA), in its Europe Policy Position Paper in January 2019 [GSMA2019], highlighted the possibility of encouraging the secondary licensing business model by providing incentives. The GSMA report recommends the inclusion of license obligations within specific bands that would oblige primary licensees to provide service to local verticals. They also noted that it could be complemented by a leasing obligation where there is "market failure" – that is, not sufficient commercial impetus for one reason or another. In that case, verticals could directly lease the spectrum from the primary provider and use the spectrum to construct its own private network – in this way, at least the vertical would not be blocked.

In summary, there is much convergence now in clarifying the situation on spectrum access for verticals, providing hope that the spectrum problem will not impede the emergence and success of the new vertical business models.

7 Conclusions

The following set of major conclusions may be drawn from the discussion in the body of this report:

- Some verticals have requirements that are so onerous that traditional telecom providers may not be interested in providing connectivity.

- Mission-critical vertical applications bring both the most challenges and the most opportunities, including opportunities for MNOs in creating added value services and strengthen their procurement power.
- Although much has been written about "business models" to date, far less has been done with respect to answering the three key strategic questions. Even when this *has* been done to some extent, the identified customers, value propositions, and leading capabilities are not yet sharply defined.
- There are significant opportunities for **Small to Medium Enterprises** with sharply defined target customers and unique value propositions to be successful in 5G business, exploiting highly specialized leading capabilities. This is also a potential exploitation opportunity for 5G PPP projects with relevant results, leaving it up to individual SMEs to define their own business models.
- Private networking not only will help verticals to realize their own business models with 5G, but will open up new opportunities for providers of those private networking solutions.
- In general, a whole new set of emerging business models may by observed for "intermediaries", from neutral hosts to mission-critical functionality providers.
- Governments have a large role to play in the deployment of 5G, especially in Europe, where its nature as a union of sovereign Member States brings special challenges. Spectrum for verticals and competitive policy are particularly relevant, as is defining standards-based, guaranteed SLAs in the procurement process.
- Many of the emerging business opportunities will not be within specific verticals, but across many verticals – such as network slicing capability for mission-critical applications.

7.1 Further Work

As noted in the beginning of this report, this is the first version (March 2019), which will be followed by a final version nine months afterward (December 2019). In this section, we outline the further work that is currently being planned for the final version.

Global5G.org personnel are participating in a number of 5G PPP Working Groups that are actively pursuing several of the topics that were discussed in this report, and will provide valuable inputs for updates and extensions to the relevant sections of the document.

- The Spectrum WG is currently discussing the topic of spectrum for verticals and preparing an opinion to be communicated to the RSPG.
- The Automotive WG is discussing the Strategic Deployment Agenda, for which a specific working group has been created, with Global5G.org participation.

In 2019, the 5G PPP projects initiated many activities around topics relevant to this report, including techno-economic analyses; sustainability assessment; analysis of business drivers; stakeholder analysis; innovation management; and business/economic KPIs. The projects involved include 5GCity, ONE5G,

5GCAR, NRG5, 5G-MEDIA, MATILDA, 5G EVE, 5GENESIS, and 5G VINNI. These activities are being tracked by Globabl5G.org and a summary / discussion of the results obtained may be included in the final version of this report. The Steering Board reports on business model tracking within 5G PPP, with Global5G.org participation.

Hence, more verticals may be added for analysis, especially those which bring in new issues. One under consideration is Emergency Communications for Public Safety.

Finally, the confirmed workshop on 19 June 2019 at EuCNC 2019, *Emerging Business Models: Opportunities for SMEs and large companies – lessons from 5G PPP*, is co-hosted with the SME WG and experts that have already contributed to related discussions. It therefore offers an opportunity to build consensus on the findings presented here and identify gaps for future investigation.

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