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WHITE PAPER

BEST PRACTICES FOR 5G TRANSFORMATION – KEY FINDINGS FROM THE NOKIA 5G MATURITY INDEX

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1. Executive summary

The deployment of 5G has the potential to facilitate and accelerate the digitalisation of society. By enhancing existing mobile and fixed communications services and enabling a range of new solutions (e.g. augmented/virtual reality, analytics supported by artificial intelligence), it promises to have significant impact on consumer experiences, business processes and operator revenue models.

However, these promises will only be fulfilled if 5G is deployed in a new way that is closely aligned to digital strategies and to emerging trends, such as the Internet of Things (IoT), that can drive new business models.

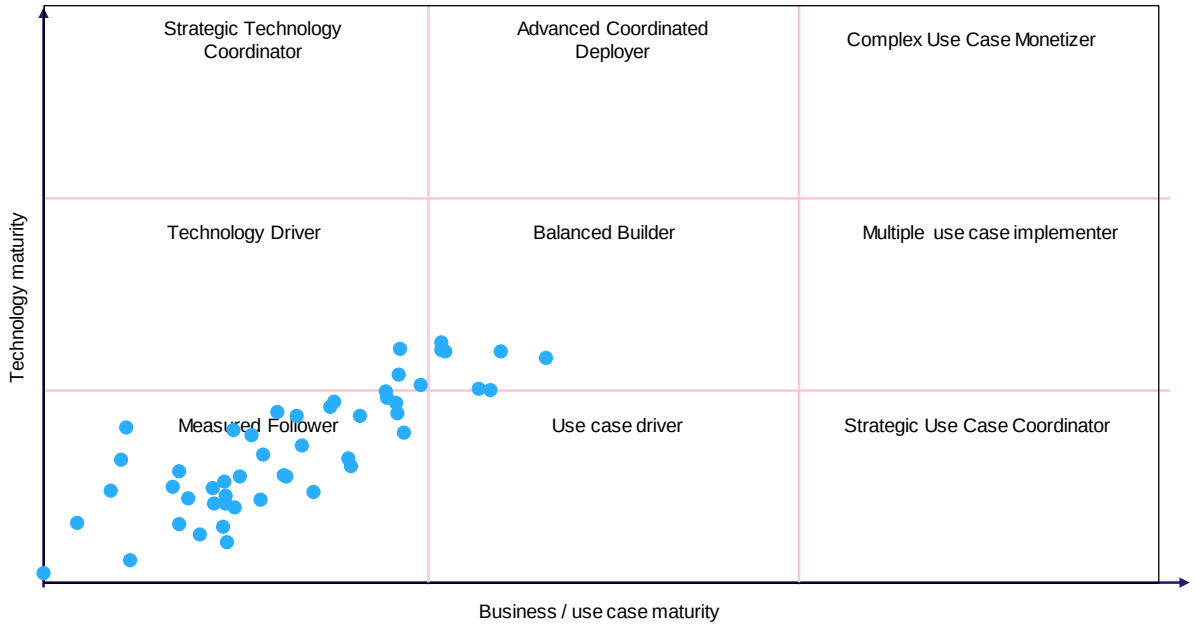
Most mobile operators only plan a commercial launch of 5G services from 2020 onwards. Given the limited number of 5G deployments to date, they often lack visibility about key success factors of 5G, and how to maximise the impact of their roll-outs. In creating the industry's first 5G maturity index, Nokia and Analysys Mason have identified six areas of best practice which, if adopted, will greatly increase operators' chances of being successful in the 5G era.

This white paper gives operators an overview of the key business and technology drivers of 5G maturity, which emerged from the study, and recommendations for how to adopt the best practices of the 5G leaders. This will be a valuable tool to help them to assess how far their plans are focused on the right drivers, and how to improve their current business and technology maturity to achieve the best results from 5G.

This assessment is based on a framework developed jointly by Nokia and Analysys Mason that evaluates the maturity of operators' 5G thinking across a series of business and technology factors identified from our research as being relevant to the overall success of 5G, and on data collected by Analysys Mason across a sample of 50 mobile operators worldwide during July–November 2018.

With a few exceptions, most operators are still in early stages of their 5G thinking ('measured follower' profile), suggesting a steep learning curve to improve maturity until the first 5G launches are expected in 2019–2020 (see Figure 1 below). The few most advanced operators have reached a "balanced builder" profile (seven operators) or a 'technology driver' profile (four operators).

Figure 1: Results of 5G maturity index



It is unsurprising that, in the first ever index, about 80% of operators are still in the least mature category. This is not because they have not thought about 5G. Indeed, it was notable that, among the 50 major mobile network operators interviewed, most had firm timelines to start deployment, and a clear 5G vision. As presented above, where most operators demonstrate low maturity, however, is in a limited alignment of those 5G plans with their digital strategies, and with a clear view of commercial use.

The study has identified six key drivers of 5G maturity and a set of best practices that operators should consider following to achieve 5G maturity and increase their chances of succeeding in the 5G era (see Figure 2 below).

Figure 2: Key drivers of, and best practices for, 5G maturity

Key driver	Best practice
Strategic ambition	5G must support ambitious strategic objectives, which directly generate new revenue streams
Use cases	Operators should deploy 5G as a platform to support many new use cases
Breadth of partner ecosystem	To maximise revenue opportunities, operators need to develop a web of cross-industry partner communities
Commercial deployment agility	Transformation of the whole platform, including the OSS/BSS, is essential to reduce time to profit for 5G
Automation	End-to-end automation, in networks and business processes, is indispensable to 5G economics
Digitalisation of operations	Digital innovations like artificial intelligence and DevOps will enhance the impact of 5G on customer experience and service agility

Figure 3 below provides an overview of how well/badly operators surveyed perform against these best practices.

Figure 3: Overview of best practices and key survey results

Best practice(s)	Achievement of best practice(s) by	Key survey results
5G must support ambitious strategic objectives, which directly generate new revenue streams	85% of responses	• Over 33% operators are planning to use 5G to increase their flexibility to support a wide variety of new revenue streams, and almost 30% regard 5G as a key enabler of new revenue sources in enterprise/IoT • High share (86%) of 'balanced builders' are planning to use 5G to generate new revenue streams, confirming the importance of an ambitious strategy as a key driver of 5G success
Operators should deploy 5G as a platform to support many new use cases	Eight or more use cases: 14% of operators	• Over 90% operators are planning to pursue more than four use cases to drive 5G plans, but only 14% are likely to pursue a large range of use cases (i.e. eight or more) • 57% of operators are planning to prioritise smart city solutions, 43% smart home services compared to only 30% for augmented/virtual reality-based solutions and 35% for healthcare solutions
To maximise revenue opportunities, operators need to develop a web of cross-industry partner communities	33% of operators	• A significant 33% have already assembled several partner communities across vertical sectors, but 44% continue to operate in siloes, and 12% have no leading role in partner communities • 100% 'balanced builders' have already built multiple partner communities, and two of them have achieved an advanced stage of leveraging cross-vertical partnerships
Transformation of the whole platform, including the OSS/BSS, is essential to reduce time to profit for 5G	45% of operators	• 45% of operators are in the process of transforming their OSS/BSS systems into fully flexible platforms, 15% have a basic platform to reduce service delivery time, and 10% are able to onboard new partners quickly, 30% are still deploying each service and use case individually • 60% 'balanced builders' are transforming their OSS/BSS into a flexible, digital platform for service delivery
End-to-end automation, in networks and business processes, is indispensable to 5G economics	41% are planning end-to-end SON 14% have a network zero-touch roadmap	• FOver 85% are applying basic network automation but only 41% are using/planning end-to-end SON in next 2 years (compared to 6% for end-to-end business automation) and 14% are planning zero-touch network automation (compared to 2% for zero-touch business automation) • 86% of 'balanced builders' are having/considering end-to-end SON but only 43% are considering zero-touch network automation. End-to-end business process automation is planned by only 29%, and zero touch by 14%
Digital innovations like artificial intelligence and DevOps will greatly enhance 5G's impact on customer experience and service agility	Artificial intelligence: 77% by 2020 DevOps: 32% by 2020	• Over 77% of operators are using or are planning to use artificial intelligence for customer experience by 2020, but only 32% are using or are planning to use DevOps by the same date, and a significant 35% have no plans / visibility to use DevOps at any point • 100% of 'balanced builders' are using or are planning to use artificial intelligence by 2020, and 86% DevOps

Operators can adopt several strategies to align their 5G plans to their commercial objectives and digital transformation, and so support the six critical success factors identified in this study.

- Ensure that 5G is planned so that it directly relates to the organisation's most strategic objectives. The resulting 5G vision must be supported and communicated from the top levels of the company.

- Identify a wide variety of partners that will help to deliver new 5G-enabled services and create a rich community with the operator at the centre.
- Explore a wide range of 5G services and take a flexible approach that can be adapted quickly for an unexpected use case.
- Transform enabling platforms (e.g. OSS/BSS) in tandem with 5G planning, in order to create an agile, digital framework that can support all kinds of business models and industries, and greatly reduces time and cost to launch new services.
- Plan for the maximum level of automation, both of network operations and business processes, and set out a clear roadmap towards end-to-end automation, in order to maximise the efficiencies and responsiveness of 5G in future.
- Invest in a variety of digital technologies which can enhance the impact of 5G, including artificial intelligence/machine learning and telco cloud, as well as new processes such as DevOps. Align these carefully to an overall transformation strategy with clear objectives.

2. Introduction

Most operators plan a commercial launch of 5G services from 2020 onwards. By enhancing existing communications services (e.g. mobile broadband, fixed–wireless access) and enabling a range of new solutions (e.g. augmented/virtual reality, analytics supported by artificial intelligence), 5G holds the promise of facilitating and accelerating the digitalisation of society.

Given the limited number of commercial 5G deployments today, operators often lack visibility about key drivers of 5G success, therefore limiting their understanding of whether their current 5G developments are indeed focusing on improving the right drivers. The objectives of this white paper are therefore to give operators an overview of the key business and technology drivers of 5G maturity, offer unique insight about the best (and bad) practices adopted by operators to address these drivers, and provide recommendations to operators on how to improve their 5G maturity and their odds of being successful in the 5G era

This assessment is based on a framework developed jointly by Nokia and Analysys Mason to evaluate the maturity of operators' 5G thinking, and on data collected by Analysys Mason across a sample of 50 operators worldwide over July–November 2018.

- Analysys Mason established a series of business and technology maturity factors identified from our research as being relevant to the overall success of 5G, and forming the key criteria used to quantify the 5G maturity of operators interviewed.
- We developed a questionnaire of 25 questions to assess the maturity of operators against each of these criteria and built a scoring model to translate the answers provided by operators to each question into a business and technology maturity score.
- The output of this exercise is a 5G maturity index of operators surveyed, including an overall business score (calculated as the aggregated score associated to the answers to questions testing business maturity) and an

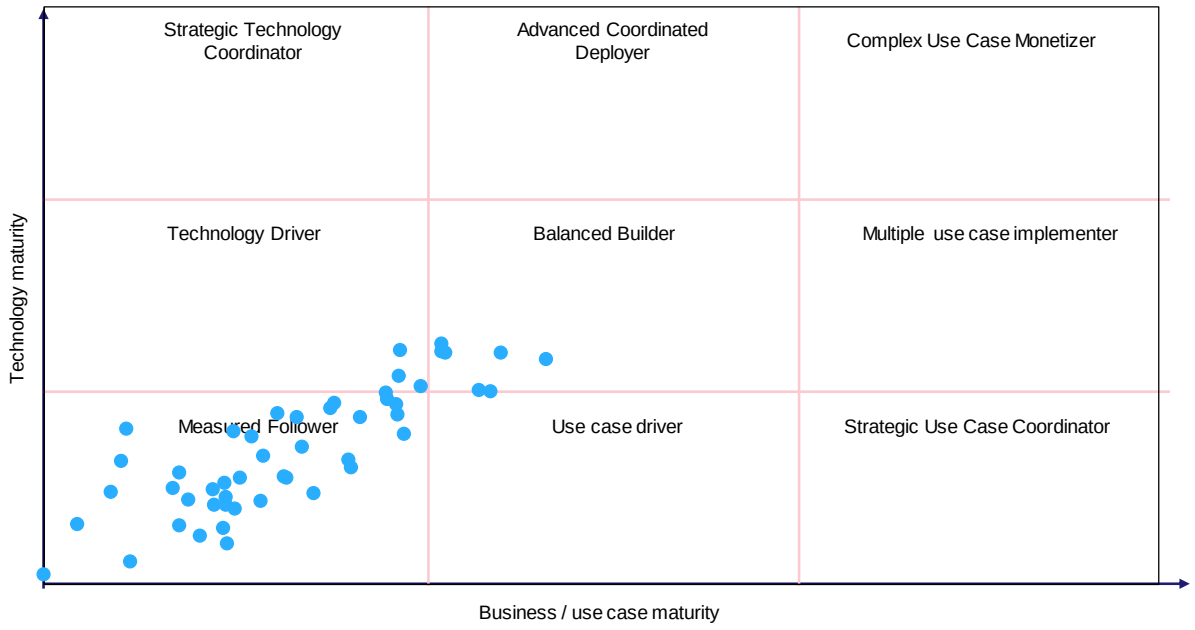
overall technology score (calculated as the aggregated score associated to the answers to questions testing technology maturity).

- We then assigned each operator to one of nine profiles, corresponding to one of the nine quadrants of a 3×3 matrix, based on the magnitude of its business and technology score. See Annex A for a more detailed description of our methodology and of each profile.

3. Key findings of the 5G maturity index

With a few exceptions, most operators are still in the early stages of their 5G thinking ('measured follower' profile), suggesting a steep learning curve ahead to improve maturity before the first 5G launches are expected in 2019–2020 (see Figure 4 below). The few most advanced operators have reached a 'balanced builder' profile (seven operators) or a 'technology driver' profile (four operators).

Figure 4: 5G maturity index



Most operators surveyed have firm deployment timelines for 5G services (over 95% of them are planning a limited commercial launch by 2019–2020) and ambitious strategic objectives for 5G. They also tend to place similar importance on the business and technology enablers of 5G. However, the survey results suggest a lack of a clarity about how they plan to commercialise 5G, as well as limited alignment with their digital strategies. This leads to a limited overall 5G maturity score and raises the risk that their strong 5G visions will not be easily translated into commercial success.

For example, while most operators plan to pursue a range of 5G use cases and understand the need to build an extensive partner ecosystem, few have already achieved the development of a full platform allowing them to deploy new services and onboard partners quickly. Similarly, although improving customer experience is a key driver of 5G deployment for a majority of operators surveyed, in practice very few have taken actual measures

or made plans to improve the experience of their customers with advanced features (for example, self-configuration of network resources, self-design of network services).

Unsurprisingly, all 'balanced builder' and 'technology driver' operators come from the most advanced mobile regions – Developed Asia–Pacific, North America and Western Europe. Operators in the 'measured followers' group come from a mix of regions. Similarly, Tier 1 and Tier 2 operator groups generally achieved better scores on both business and technology dimensions than smaller Tier 3 and Tier 4 operators. Larger operators tend to have access to more resources and skills and therefore tend to be more ambitious with their 5G plans (early launch, coverage, digital transformation) than smaller operators, which tend to adopt a more cautious approach towards 5G.

However, nearly all operators, large and small, need clearer roadmaps to achieve their ambitious strategic objectives for 5G. In the course of the study, six key areas of best practice emerged as critical to 5G success. The following sections will provide detail on how these practices can maximise the return on 5G investment by aligning it with new revenue streams and agile digital platforms.

4. Best practices for operator 5G success

The study has identified six key drivers for operator 5G success. Against each of these drivers, we have generated a set of best practices that operators should follow to positively influence these drivers and have measured how well and/or how badly operators surveyed were following these best practices. The following sub-sections discuss each of these six drivers, associated best practices and survey results.

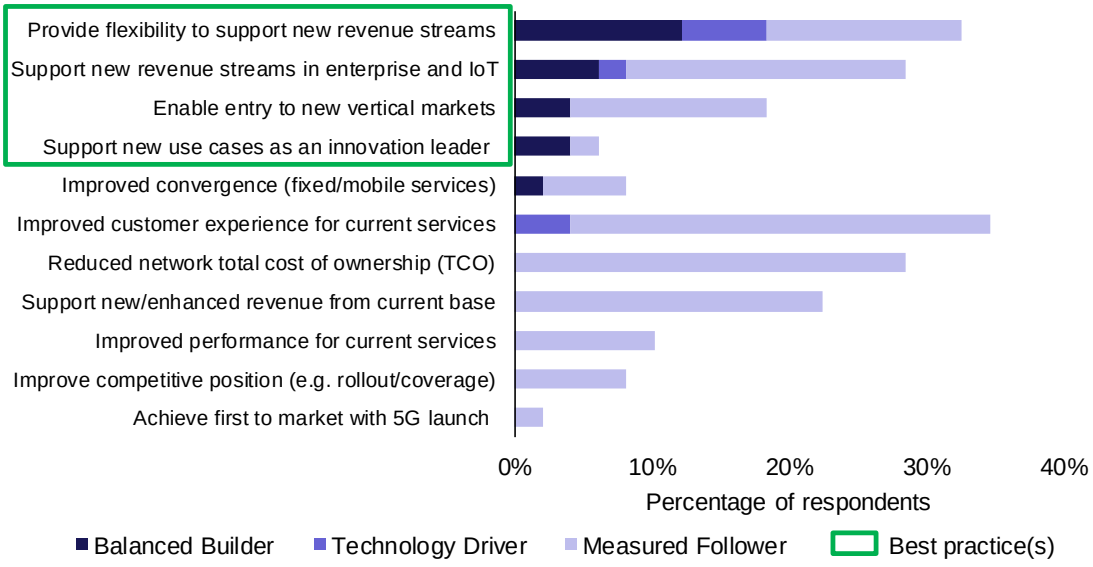
Figure 5: Key drivers and best practices to 5G maturity

Key driver	Best practice
Strategic ambition	5G must support ambitious strategic objectives, which directly generate new revenue streams
Use cases	Operators should deploy 5G as a platform to support many new use cases
Breadth of partner ecosystem	To maximise revenue opportunities, operators need to develop a web of cross-industry partner communities
Commercial deployment agility	Transforming the whole platform, including the OSS/BSS, is essential to reduce time to profit for 5G
Automation	End-to-end automation, in networks and business processes, is indispensable to 5G economics
Digitalisation of operations	Digital innovations like AI and DevOps will greatly enhance 5G's impact on customer experience and service agility

4.1 5G must support ambitious strategic objectives, which directly generate new revenue streams

The high deployment costs of 5G networks suggest that the success of operators in the 5G era will be closely related to their ability to leverage the unique capabilities of 5G to generate new streams of revenue, for example by supporting enterprises in their digital transformation efforts across a variety of use cases. Operators that have more-limited ambitions or expect to derive significant revenue by delivering a 5G-enhanced version of their existing connectivity services are unlikely to achieve a significant return on investment.

Figure 6: Top 2 primary objectives of operators' 5G strategy[1]



Source: Analysys Mason

This aspect is well understood by most operators surveyed in the study, with over a third planning to use 5G to increase their flexibility to support a wide variety of new revenue streams, and almost 30% seeing 5G as a key enabler of new sources of revenue in enterprise and IoT. While a large number of operators (35%) plan to use 5G to improve customer experience and/or to reduce TCO (30%), these have also selected a more 'strategic' objective as a second driver, suggesting widespread awareness of the imperative to consider new business opportunities. Worth noting is the high share (86%) of 'balanced builders' planning to use 5G to generate new revenue streams, confirming the importance of an ambitious strategy as key driver to 5G success.

4.2 Operators should deploy 5G as a platform to support a range of new use cases

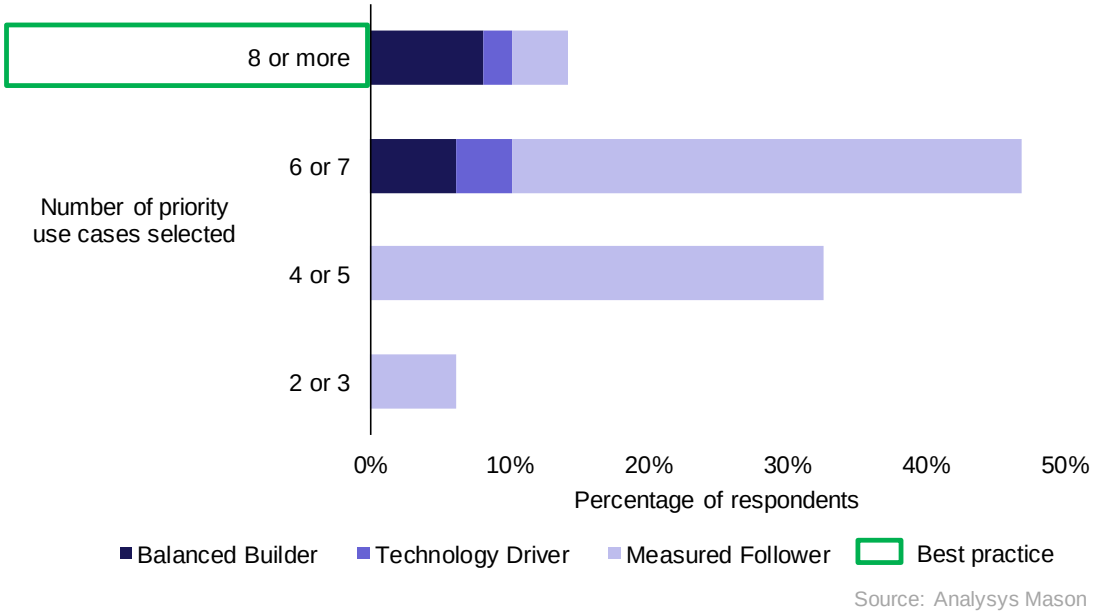
A generally widely accepted view to 5G use cases is that taken individually, each will only deliver limited incremental revenue for operators and account for a negligible share of their existing connectivity revenue. The number of 5G use cases, however, is likely to be significant: several studies conducted by industry associations have identified early use cases[2], across a variety vertical sectors (e.g. automotive, healthcare, manufacturing, retail), and it is expected that new, innovative services will continue to emerge in the coming years. As a result, achieving significant revenue from 5G, whether as a 'smart' network services provider or a full digital services platform monetiser, will depend on the ability of operators to pursue business opportunities across multiple 5G use cases.

Over 90% of operators surveyed plan to leverage more than four use cases to drive their 5G plans, but only a small share (14%) would likely pursue a large range of use cases (i.e. eight or more). While the limited size and resources of Tier 3 and Tier 4 operators can justify why most would focus on a reduced number of use cases, the relatively low proportion (27%) of Tier 1 and Tier 2 operators that have selected more than eight use cases, out of 12 proposed by the survey questionnaire, suggests an overall cautious approach to 5G use cases.

1 Question: What are the primary objectives of your 5G strategy? [multiple choice] (*n*=49).

2 See for example www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf

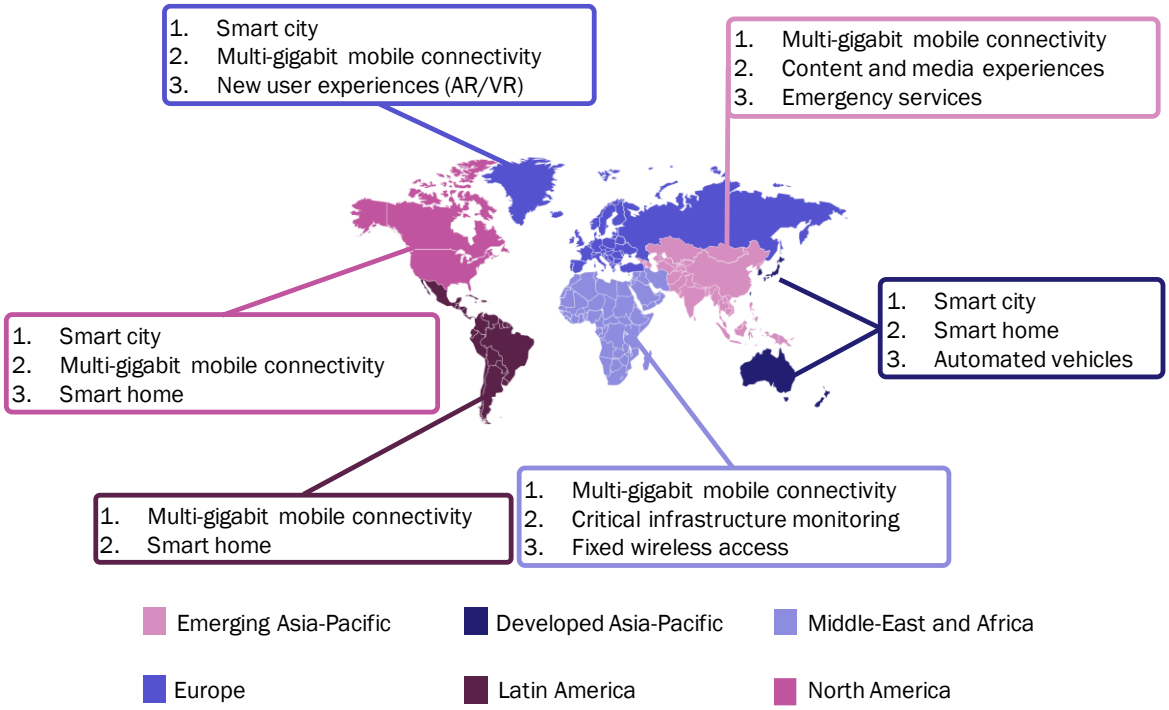
Figure 7: Number of use cases selected by operators to drive their 5G strategy[3]



Survey results show also that operators tend to prioritise 5G services building on existing solutions, which, while already familiar to operators, are unlikely to provide significant upselling opportunities, as being limited by the premium customers will be willing to pay for an enhanced version of a service delivered via 3G/4G today. As an illustration, 57% of operators plan to prioritise smart city solutions and 43% smart home services, while by contrast, more advanced solutions such as those based on augmented/virtual reality or use cases for the healthcare industry have been selected by respectively 30% and 35% of operators. Future-looking use cases based on ultra-low latency communications such as drone-based emergency services and intelligent transportation solutions are being considered by less than 20% respondents at the moment.

3 Question: If you plan to support eMBB/LLLB/CC/URLLC use cases, which are the top 2 eMBB/LLLB/CC/URLLC use cases which will drive your 5G strategy? (*n*=49).

Figure 8: Top 3 5G use cases most commonly selected by operators to drive their 5G strategy, by region[4]



Source: Analysys Mason

4.3 To maximise revenue opportunities, operators need to develop a web of cross-industry partner communities

As discussed previously, operators' 5G success will be driven by their ability to pursue a wide variety of use cases. In addition to the revenue generated by the provision of connectivity services, new revenue pools can be captured by offering new services across other layers of the value chain (e.g. service platforms, end-to-end solutions). While operators may already have the capabilities to offer some services (e.g. cloud/hosting, storage, application enablement platforms) to individual value chain players, extending reach further into vertical-specific or end-to-end solutions will be dependent on their ability to engage with a large ecosystem of partners, either to develop specific capabilities (e.g. technology, skills), or as channels to market to engage with new types of customers. This necessity for operators to collaborate with partners was recently highlighted by the GSMA[5], as is the need to standardise APIs and develop suitable partnership models with this ecosystem.

In addition, the ability develop cross-vertical partner relationships will be important for operators to apply the learning acquired from one industry to another and achieve synergies, therefore reducing the effort to enter new verticals and time to market to launch new solutions. Another benefit will be that by leading the development of multiple communities, operators will be well placed to attract new partners, thereby achieving a greater pool of capabilities to choose from.

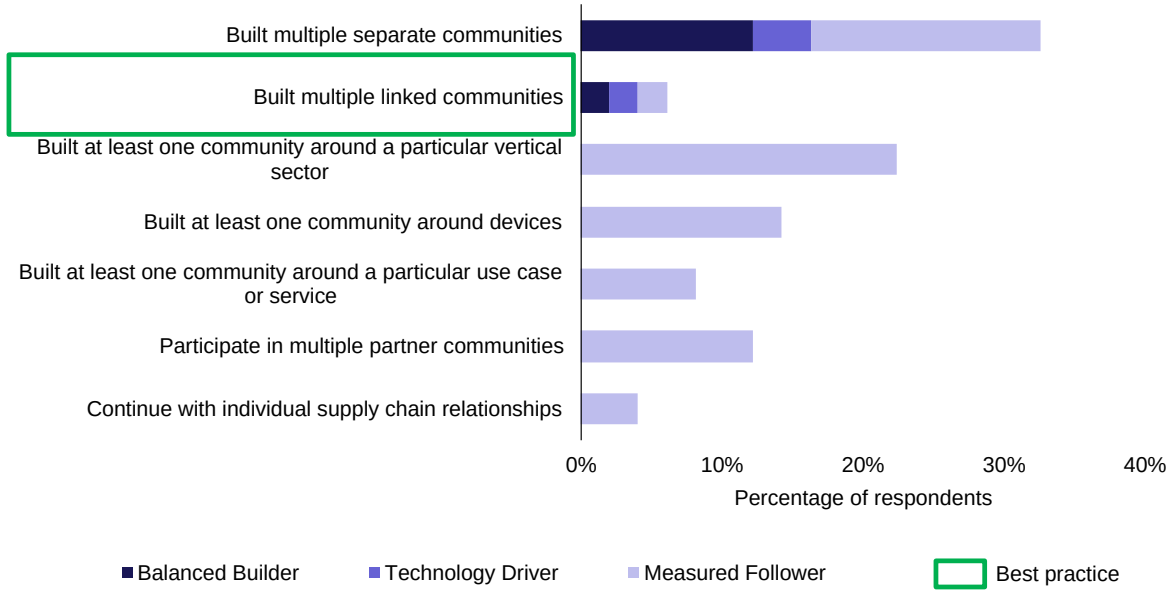
Operators surveyed understand that leading the development of partner communities is a key 5G success factor, but their level of achievement to date varies significantly. While a significant proportion (33%) has already assembled several partner communities across separate vertical sectors, a fair number of operators (44%) remain

4 Question: If you plan to support eMBB/LLLB/CC/URLLC use cases, which are the top 2 eMBB/LLLB/CC/URLLC use cases which will drive your 5G strategy? (N=49)

5 See: https://www.gsmaintelligence.com/research/?file=0efdd9e7b6eb1c4ad9aa5d4c0c971e62&download

at the stage of having built a sector-specific, device-centric use case-specific community, while a few (12%) still do not play yet a leading role in partner communities. All 'balanced builders' have all already built multiple partner communities, and two have achieved an advanced stage of leveraging cross-vertical partnerships.

Figure 9: Operator approach to build an ecosystem to support 5G business models[6]



Source: Analysys Mason

4.4 Transformation of the whole platform, including the OSS/BSS, is essential to reduce time to profit for 5G

As discussed in sub-section 4.2, 5G success will require the flexibility to create new services quickly, in response to demand from a wide variety of user groups. Some applications are currently unforeseen, but as new requirements emerge, operators need to have a platform in place which enables them to address a new opportunity rapidly, with modern development processes and a robust framework for integrating new ecosystem partners (see section 4.3). In that way, they can behave more like digital providers. A fundamental step in achieving this will be to transform current OSS/BSS platforms to support an entirely new operating model, dramatically reducing the time and cost to launch a new service and to create new partnerships.

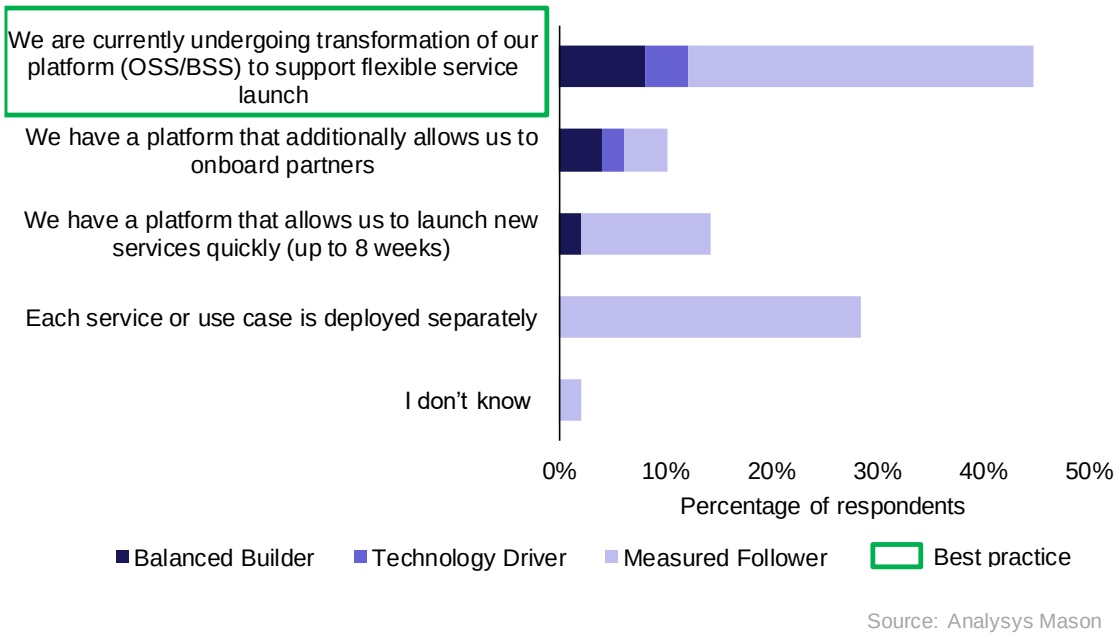
Operators with high scores in this area have already made some progress in transforming their processes to support fully flexible service launches, ahead of 5G roll-out (~45% of operator respondents). About 15% of operators have implemented processes to reduce new service delivery time to less than eight weeks, while 10% are also able onboard new partners rapidly. All 'balanced builders' and 'technology drivers' have more advanced platform thinking and about 60% of them transforming their OSS/BSS systems into a flexible, digital platform for service delivery.

With 30% operators still deploying each service and use case individually, a number of companies have still a long way to go to adopt best practice in this area, while the timescales considered among those undergoing transformation may be too long to deliver maximum impact for 5G launch. Some operators may feel cautious about platform transformation and may have legitimate reasons for doing so. The cost and risk of a 'big bang'

6 Question: What is your approach to building an ecosystem to support your 5G business models? (*n*=49).

approach may lead them to adopt a phased approach, or even to wait until 5G is commercial before addressing the OSS/BSS. But if the phases of transformation are not clearly linked to those of 5G deployment, operators risk falling behind in their ability to leverage the 5G networks in the most agile profitable way.

Figure 10: Operator approach to deploying 5G services[7]



Source: Analysys Mason

4.5 End-to-end automation, in networks and business processes, is indispensable to 5G economics

Automation, both at network level as well as through all business processes including operations and customer services, will be a crucial element of operators' success in 5G. As discussed in the previous sections, successful 5G operators will use network slicing to offer *many* services across a wide variety of use cases. Manual management and coordination of network slices will be practically impossible, so extreme automation will be essential. This importance of automation is recognised by the TM Forum, which emphasises zero-touch automation as a key requirement for operators to work with and onboard cost effectively a wide range of ecosystem partners in the 5G era.[8] Furthermore, the 5G world will be characterised by the co-existence of physical and virtual infrastructure for a foreseeable future – without automation, the cost of managing functions across the two worlds will be crippling for operators. Finally, 5G will also be need intense cooperation with a great variety of new partners – partner onboarding, partner management and the deployment of new functionalities and technologies will all need to be automated too. Therefore, we assessed operators' current and planned levels of automation of network and business processes to measure their 5G maturity.

Most operators surveyed already apply some basic network/process automation, but more advanced implementation still appears far away. All operators have deployed SON in the RAN or plan to deploy it within the next 2 years, but, in many cases, SON is not feeding into any other parts of the network/business process. The most advanced operators, 'balanced builders', tend to already have or are considering end-to-end SON deployment (~86% of them), but only about 40% of them have planned to implement close to zero-touch

7 Question: What is your approach to deploying new 5G-enabled services? (*n*=49)

8 https://www.tmforum.org/5g/

automation for all their network processes in the next 2 years (see Figure 11). Even when there is a vision for end-to-end network automation, business process automation is not clearly tied to network automation and is often in its infancy. In fact, only 14% of 'balanced builders' plan to implement close to zero-touch automation for business processes in the next 2 years (see Figure 12).

The cost-saving potential, the promise of high agility and quick scaling of services will not be realised in the 5G world without operators' strong focus on automation. In other words, 5G will not make much sense for operators without end-to-end automation of network management linked to business process automation.

Figure 11: Operator use or planned deployment (within 2 years) of network process automation

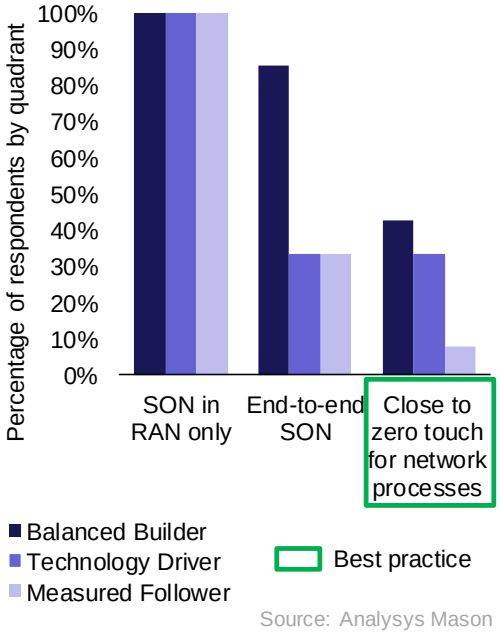
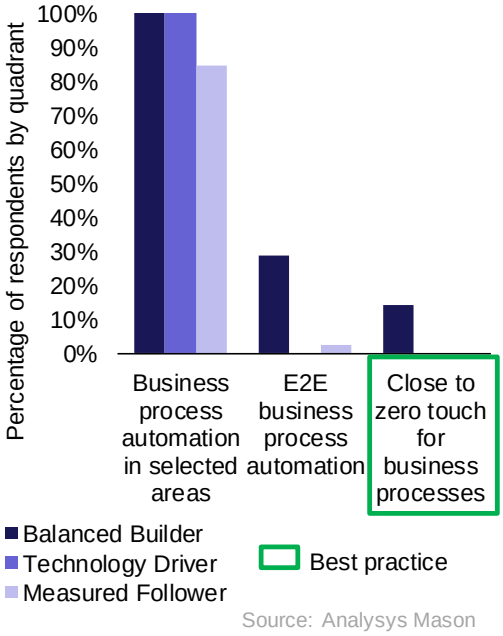


Figure 12: Operator use or planned deployment (within 2 years) of business process automation



4.6 Digital innovations like artificial intelligence and DevOps will greatly enhance the impact of 5G on customer experience and service agility

The study shows that operators recognise how 5G must be more than a network performance upgrade. They have a complex set of success factors for commercial 5G, many of these linked to the imperative to generate new revenue via greater agility to deliver new services competitively, as well as the need to improve customer experience to differentiate against traditional and digital competitors to attract and retain users. These can only be achieved if 5G deployment is linked to progress in fully digital operations.

The study identified key indicators of advanced thinking in this area, including the level of adoption or planning for: artificial intelligence/machine learning for network management, customer experience, or data analytics; modern development processes applied to network services (DevOps and continuous delivery); telco cloud; and mobile edge computing.

Operators leading best practice in this area had either already embarked on projects in all these areas, or had clear timelines to do so, linked to 5G timings and use cases. For instance, operators scored highly if they had placed a high priority on strong customer experience and were also using artificial intelligence/machine learning

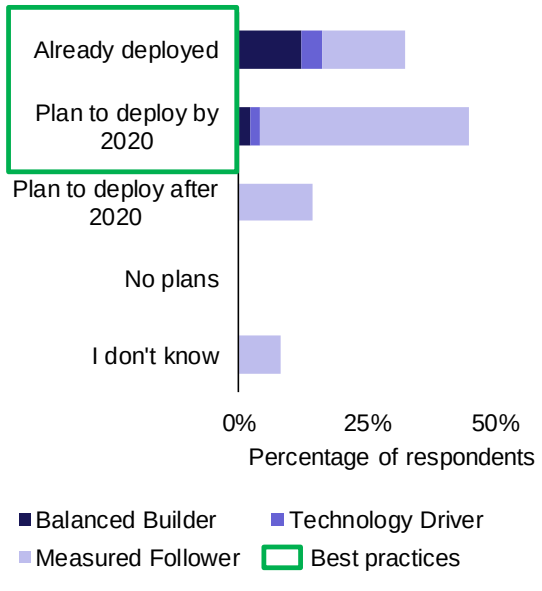
for this purpose; or if they were targeting a highly flexible 5G service platform and had already invested in DevOps and continuous delivery.

While the need to digitalise operations to achieve 5G success was understood by a large number of respondents, the steps to achieve digital operations maturity were often less clear to operators. In these examples, the adoption of artificial intelligence/machine learning for customer experience was more advanced than uptake of DevOps. Over 77% of operators have already deployed the former, or plan to do so by 2020. All 'balanced builder' and 'technology driver' operators intend to deploy by 2020; while no operators had no plans at all. This shows how operators understand clearly how increased responsiveness and interactivity of customer support systems enabled by artificial intelligence (e.g. a chatbot or digital assistant) will impact customer satisfaction with 5G services.

By contrast, the level of confidence in DevOps is lower. Techniques like DevOps and continuous delivery are becoming the norm in cloud and data centre environments, but the survey shows they are only slowly extending into network services, even among some operators which have ambitious cloud strategies. Only 10% had already deployed DevOps, and 22% planned to do so by 2020, and a significant 35% had no plans or did not know. Even some of the 'balanced builders' (14%) do not expect to deploy DevOps until after 2020.

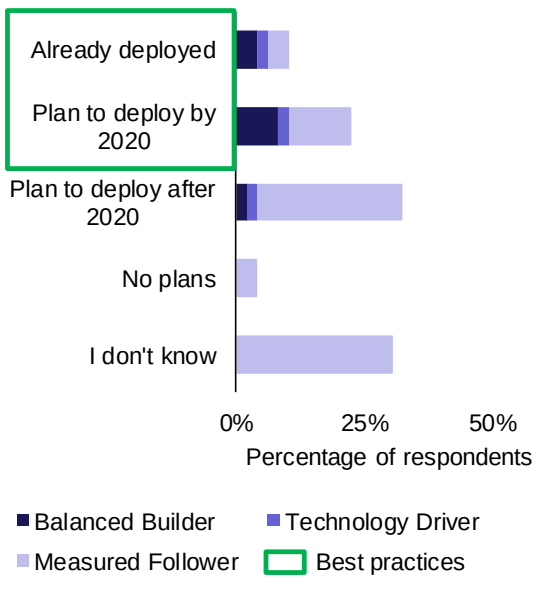
There are complex reasons for this caution, including the barrier which exists in a range of operators between IT and network operations, and the cost and time to overhaul long-established development processes. However, processes like DevOps have been proven, in the cloud environment, to support rapid and flexible service creation – which emerged as an important goal for most 5G deployers. There needs to be a far stronger link made between those high-level commercial goals and the actual tools which operators need to adopt to achieve them.

Figure 13: Use of artificial intelligence/machine learning for customer experience



Source: Analysys Mason

Figure 14: Use of artificial intelligence/machine learning for DevOps[9]



Source: Analysys Mason

9 Question: What systems and technologies do you plan to deploy for your digital operations? [multiple choice] (*n*=49)

5. Conclusion and recommendations for operators

5.1 Conclusion

The 5G Maturity Index provides the industry's first opportunity to understand, in detail, how mobile operators are positioned for 5G. Operators are able to see how their progress relates to that of other providers, and to learn from the best practice of the 5G leaders.

It is unsurprising that, in the first ever index, about 80% of operators are still in the least mature category. This is not because they have not thought about 5G. Indeed, it was notable that, among the 50 major mobile network operators interviewed, most had firm timelines to start deployment, and a clear 5G vision. For instance, the most-cited objectives of the 5G strategy, in this response base, were to improve customer experience; to provide the flexibility to support new revenue streams; and to increase revenues from enterprise and IoT. All of these are forward looking and commercially minded.

Where most operators demonstrate low maturity, however, is in a limited alignment of those 5G plans with their digital strategies, and with a clear view of commercial use case priorities. Despite the emphasis on a flexible services platform, for instance, only 13% of operators selected eight or more use cases to prioritise for 5G; and only 6% had experience of building multiple linked communities of partners – the kind of ecosystem which an agile 5G service strategy will require.

The operators which achieved the highest rating in this study – reaching the 'balanced builder' index profile – are those which are investing in strategies which will maximise the benefits of 5G and support new revenue models. Examples include artificial intelligence, network automation and end-to-end virtualisation. Others are investing in some aspects of the new platform – almost all of them will deploy some aspects of business process automation by 2020, and about 80% will deploy artificial intelligence technologies for customer experience in the same timeframe. But only the 5G leaders are planning to take the next steps – to end-to-end automation, or to apply artificial intelligence/machine learning across all network operations.

These bolder steps will be essential to generate optimal return on investment in 5G and generate brand new revenues. 5G vision is in place – in future rounds of the 5G maturity index process, it will be important to see joined-up thinking to achieve concrete roadmaps to make that vision a reality.

5.2 Recommendations for operators

Operators can adopt several strategies to align their 5G plans to their commercial objectives and digital transformation, and so support the six critical success factors identified in this study.

- Ensure that 5G is planned so that it directly relates to the organization's most strategic objectives. The resulting 5G vision must be supported and communicated from the top levels of the company.
- Identify a wide variety of partners who will help deliver new 5G-enabled services and create a rich community with the operator at the centre.
- Explore a wide range of 5G services and take a flexible approach which can be adapted quickly for an unexpected use case.

- Transform enabling platforms (e.g. OSS/BSS) in tandem with 5G planning, in order to create an agile, digital framework that can support all kinds of business models and industries, and greatly reduces the cost of launching new services and the time taken to do so.
- Plan for the maximum level of automation, both of network operations and business processes, and set out a clear roadmap towards end-to-end automation, in order to maximise the efficiencies and responsiveness of 5G in future.
- Invest in a variety of digital technologies that can enhance the impact of 5G, including artificial intelligence/machine learning and telco cloud, as well as new processes such as DevOps. Align these carefully to an overall transformation strategy with clear objectives.

Annex A Methodology

The process of developing the 5G maturity index consisted of five steps:

- Step 1: definition of 5G maturity key criteria
- Step 2: development of questionnaire for operators to evaluate operator maturity against each of the criteria
- Step 3: operator survey
- Step 4: development of a scoring model to calculate operators' maturity score based on their responses to questionnaire
- Step 5: allocation of operators to one of the nine quadrants of 5G maturity based on their score.

A.1 Step 1: definition of 5G maturity key criteria

In collaboration with Nokia, Analysys Mason has established a series of business and technology maturity factors identified from our research as being relevant to the overall success of 5G, and forming the key criteria used to quantify the 5G maturity (step 4) of operators interviewed (step 3) through the questionnaire developed in step 2. Figure A.1 below provide the list of these business and technology maturity factors / criteria and a description of a (theoretical) high scorer against each criterion.

Figure A.1: List of 5G business maturity criteria

#	Criteria	A high scorer against this criterion is...
1	Commitment to a clear 5G roadmap	An operator with plans to launch 5G, ideally within a short timeframe
2	Strategic ambition	An operator with plans to leverage 5G to achieve 'strategic' objectives, i.e. objectives related to the generation of new revenue streams or implying a significant transformation of the organisation
3	Use case and investment priorities	An operator exploring multiple distinct use cases, with realistic expectations of the magnitude of the investment required for each use case selected
4	Commercial deployment agility	An operator undergoing a transformation of its OSS/BSS systems towards a flexible platform able to support a variety of business models and the onboarding of various partners across multiple new use cases
5	Breadth of partner ecosystem	An operator with multiple communities of partners already established, ideally linked together
6	Focus on customer experience	An operator offering or planning to offer (ideally within a short timeframe) customer self-management of services (e.g. service design, network resources configuration, self-care applications, management of network slices) for both business and consumer segments

Figure A.2: List of 5G technology maturity criteria

#	Criteria	A high scorer against this criterion is...
1	Network and business process automation	An operator using or planning to implement (ideally within a short timeframe) close to zero-touch network and business process automation
2	NFV/SDN deployment roadmap	An operator tying its network virtualisation efforts with its 5G strategy closely, pursuing ambitious objectives (e.g. full network automation, service-based architecture) and a short implementation timeline for the various components of its NFV/SDN deployment
3	Digitalisation of operations	An operator using or planning to implement (ideally within a short timeframe) agile systems (e.g. artificial intelligence/machine learning, telco cloud, mobile edge) and

#	Criteria	A high scorer against this criterion is...
		processes (e.g. DevOps, continuous delivery) across key component of digital operations (e.g. network management, customer experience, big data analytics)
4	Approach to 5G spectrum	An operator capable of executing 5G friendly spectrum approaches (e.g. full duplex, dynamic spectrum with radio co-existence in similar bands)
5	Multi-access convergence and integration	An operator planning to integrate (ideally shortly after launch) its 5G network with own other access networks (e.g. 3G/4G, fixed) and with third-parties (e.g. RAN sharing, deep roaming)

A.2 Step 2: development of questionnaire for operators

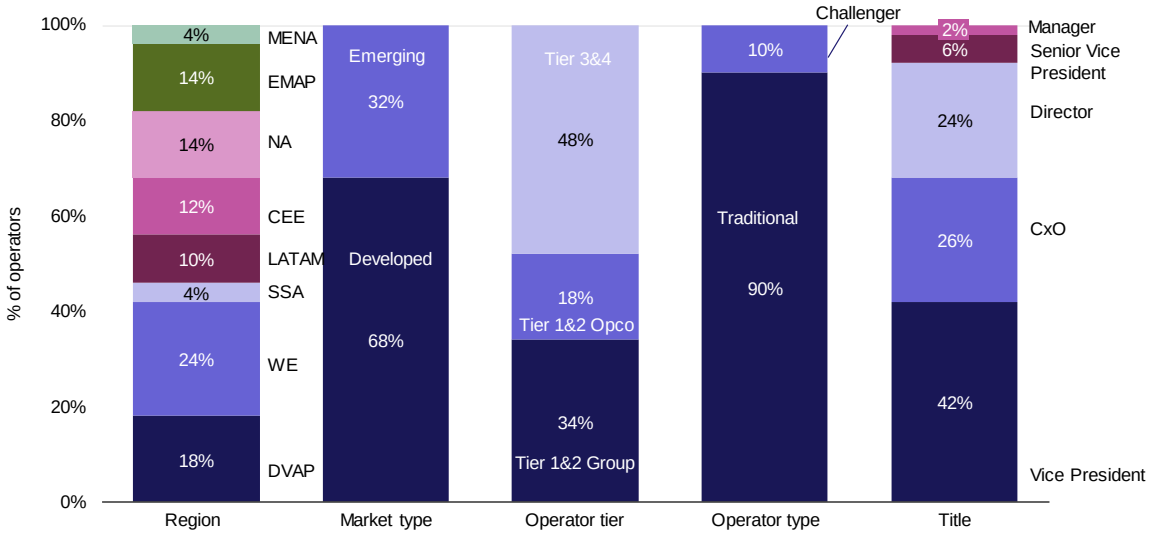
We developed a questionnaire of 25 questions to assess the maturity of operators against each of the 5G maturity criteria listed above. The questionnaire contained single-choice, multiple choice and a select number of open-ended questions. Each question had a number of options to choose from.

A.3 Step 3: operator survey

Senior members of Analysys Mason conducted a survey of operator staff in senior positions (Director, VP, SVP, C-level) in departments relevant to 5G (e.g. business strategy, network planning and strategy). 50 operators completed the survey, of which 26 by phone or in person, and 24 by email. For some operators, Analysys Mason interviewed more than one staff member to gather details from departments focused on the business aspect and the technology aspect. As well as noting down and discussing the answer to each question, the interviewer also captured the underlying rationale.

The vast majority (>98%) of interviewees were senior executives of operators (VP, SVP and C-level) and 52% operators were Tier 1 and Tier 2 operators. The full segmentation of operator respondents is provided in Figure A.3.

Figure A.3: Segmentation of operator respondents



A.4 Step 4: development of scoring model

Analysys Mason developed a scoring model translating the answers of the questionnaire into a business and technology score.

Each question was given a maximum score – the magnitude of which based on our view of the importance of the question to the driver evaluated and / or the estimated importance of the driver evaluated to the overall 5G maturity. For example, the 'commitment to 5G launch' driver was estimated as relatively more important than all other drivers to 5G business maturity; questions related to this driver were therefore assigned with a higher maximum score than say questions related to the 'number of 5G use cases' driver (for example) – which while being an important driver to the overall success of operator 5G strategy is likely be less critical than the timely achievement of network deployment milestones.

Each possible answer to each question was assigned a share of the maximum score depending on how well the answer addresses the key driver of 5G maturity associated to the question. For example, question 1 ('When do you expect your 5G deployment to reach the following milestone – lab test') is one of the questions designed to measure how well an operator addresses the 'commitment to 5G launch' driver. It has a maximum score of 2 and the following possible answers and scores are assigned:

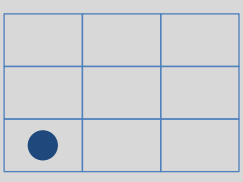
Possible answers	Share of maximum score assigned to each possible answer	Implied score for each possible answer
Completed	100%	100% x 2 =2
By the end of 2018	80%	80% x 2 = 1.6
By the end of 2019	60%	60% x 2 = 1.2
By the end of 2020	40%	40% x 2 = 0.8
By the end of 2022	20%	20% x 2 = 0.4
By the end of 2024	15%	15% x 2 = 0.3
Later	5%	5% x 2 = 0.1
I do not know	0%	0% x 2 = 0

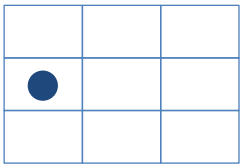
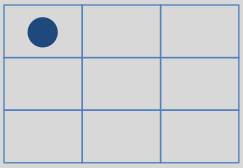
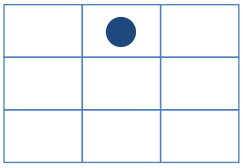
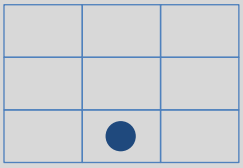
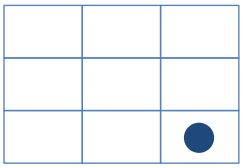
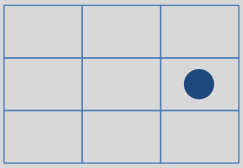
Some questions measured both business and technology maturity, some business maturity only, some technology maturity only.

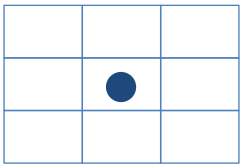
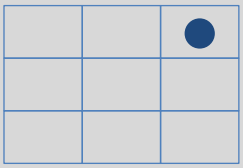
A.5 Step 5: allocation of operators to one of the nine maturity profiles

We assigned each operator to one of nine profiles, corresponding to one of the nine quadrants of a 3x3 matrix, with business maturity on the x-axis and technology maturity on the y-axis, based on the magnitude of its business and technology score. Figure A.4 below provides a definition of the nine 5G maturity levels.

Figure A.4: 5G maturity profiles [Source: Nokia, 2019]

Profile	Definition	Position in 5G maturity index
Measured follower	Wait to see what leaders and markets do. Cautious, risk-averse CSP that is not early adopter of technology or new business strategies because of tactical business needs (e.g. cost reduction, low ARPU, high churn, hyper-competitive market) Will wait and see what 5G leading operators and vendors / markets define as the optimum use cases for 5G before deciding investment requirements	

Profile	Definition	Position in 5G maturity index
Technology driver	Simply adopts the next level of technology evolution, i.e. considers that 5G is used to replace out of date network. 5G is primarily being deployed with current use cases in mind (new technology for same use cases) May develop a stronger use case focus when 5G leading operators and vendors start defining strong new revenue streams from new use cases but will still drive from technology perspective	
Strategic technology coordinator	Strategically coordinates technology evolution components in its Tech deployment (e.g. cloud core, cloud RAN, LTE, 5G, etc). Has a strong understanding of how technology – if deployed effectively – can support current and possible future market requirements. Trains and develops competencies to support but does not yet tie into business drivers and organisational / business models shift	
Advanced coordinated deployer	Coordinates and orchestrates an advanced technical backbone through the CTO organisation as a springboard to supporting major changes in market / business opportunities. Has developed understanding / capability around network slicing as a way of supporting key use cases	
Use case driver	Is focused on what 5G brings in terms of new use case / business model opportunities. Has started investigating how consortiums and partnerships may be developed to identify and prioritise some early use cases. Is already considering all activities (over and above technology) to successfully take the lead and monetise use cases	
Strategic use case coordinator	Has implemented fully optimised business processes, organisation and systems consolidation such that they are fit for purpose when implementing new use cases. Looking to understand how use cases may overlap and benefit from a coordinated deployment Understands that there are segments of use cases and starts to build or join the right ecosystems to serve those use cases. Not necessarily focused on whether a full 5G deployment is required to support a use case, so may be pushing for technology to provide full 5G when LTE or less are sufficient (e.g. IoT)	
Advanced / multiple use case implementer	Similar to a strategic use case coordinator, but also invests heavily in (or outsources) the required and proven technology to ensure the rapid delivery of multiple new innovative use cases and services while also optimising operational costs. May largely outsourced technology operations, except in key use case innovation areas (as a differentiator). Will uses a DevOps organisational structure and culture. Had developed strong partnerships (likely to demonstrate strong digital operator behaviours) Understands their value in each of the use case segments and the value to themselves in terms of monetization / new revenue stream. Focuses efforts on enabling the related platforms and ecosystems. Identifies vendors who can support them in their platform development / management.	
Balanced builder	Takes a balanced approach to investment strategy, weighing up the interlock between technology and use case requirements / new	

Profile	Definition	Position in 5G maturity index
	business models. Carefully looks at how the technology is supporting use cases and rolls out as and when required in a cost-efficient manner. Considers process, organisational and business shifts required to support new use cases and implements 5G efficiently May initially choose use cases that do not require 5G for effective deployment / adoption	
Complex use case monetiser	Effective monetisation of simple and complex use cases using a state-of-the-art network that applies optimum network application to appropriate use case deployment. Fully understands the value of each use case segment and their own value in the identified ecosystem for that segment. Fully realising benefits from the implementation of use cases in terms of new revenue models, cost reduction, new markets and customer experience	

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