

Digital Transformation Tracker 7

**cutting
complexity**

**with automation
and AI**

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the big picture

Simplification of IT operations is a mantra communications service providers (CSPs) have been repeating for a decade. The drivers have not changed, though they sometimes shift in importance: improve customer experience, reduce costs, shorten time to new revenue. Now, operators are applying what they've learned to network transformation in an effort to monetize their massive investments in 5G. This is setting the stage for a big leap forward for intent-based automation and AI.

Cutting complexity across the business is key to helping operators address the myriad challenges they are facing. In addition to sustained capex spending on 5G, these include: a huge amount of technical debt; a punishing macroeconomic environment; regulation that hampers their ability to partner; cultural issues related to virtualization and disaggregation of the network; a lack of software skills; and an increasing need for standardization. But even in the face of these obstacles, operators remain optimistic because of their shared vision for accelerating automation.

For the past five years TM Forum's Digital Transformation Tracker reports have surveyed CSPs and their suppliers about transformation of IT operations and networks. This report delivers the results of our seventh tracker (DTT 7). Each year we ask the

same questions in the same way so that we can gauge progress and changes in sentiment about transformation over time. While some survey respondents are the same from year to year, many are different. We also ask a set of targeted questions in each survey to highlight an aspect of transformation such as culture or network modernization. This time our focus is on automation and AI.

The results of this survey come from our largest group of respondents ever: 325 CSP respondents from 174 unique operating companies and 144 supplier respondents from 79 unique companies (see graphic on p. 4). That's five times as many CSP respondents compared to last year's survey and nearly double the number of suppliers.

More than a third of CSP respondents work in IT roles and 20% in network roles, which is nearly the same as last year's breakdown. Roles in the "Other"



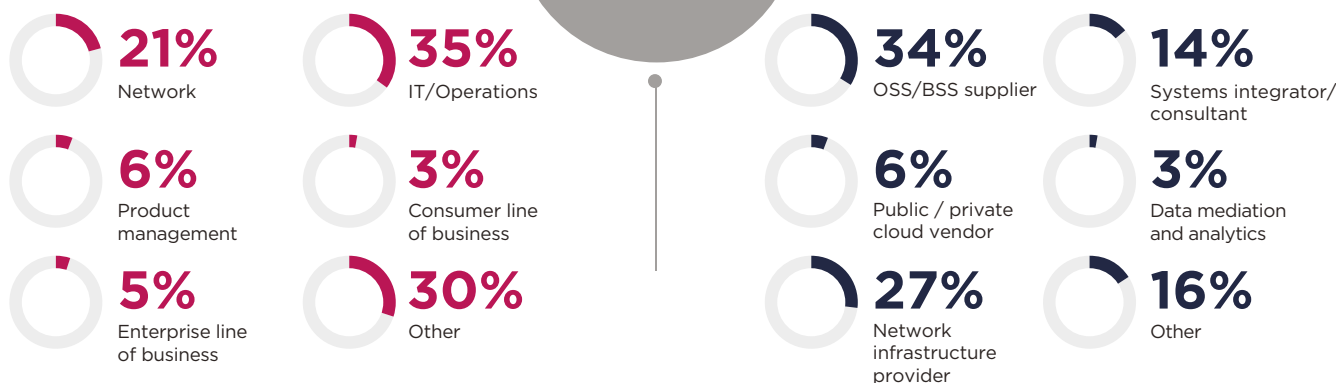
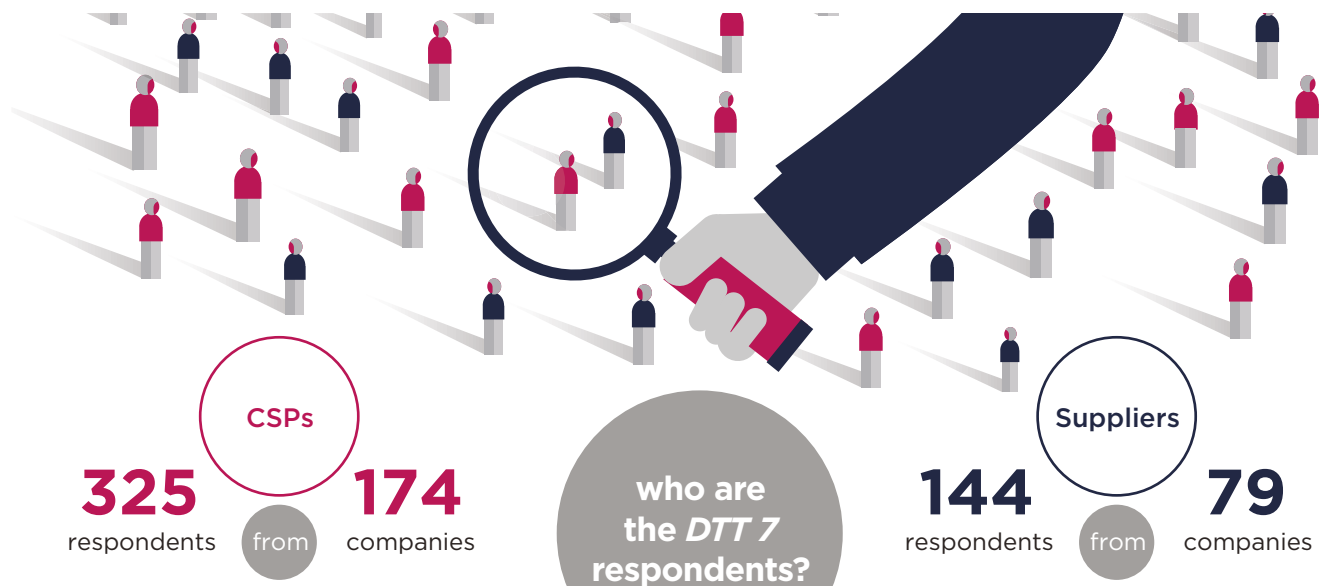
The drivers of transformation have not changed: improve customer experience, reduce costs, shorten time to new revenue.

category this time include C-level executives and people working in strategy, innovation, AI and marketing.

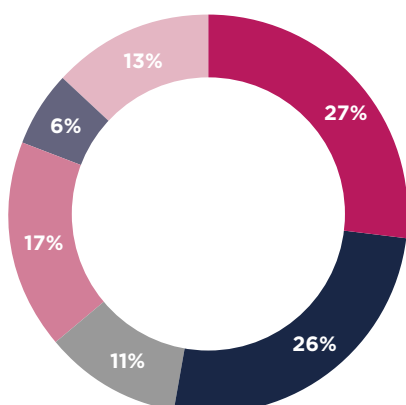
In addition to the survey, we conducted interviews with CSPs and suppliers, asking them about business models, intent-based automation and generative AI. We also listened to hours of panel discussions among C-level telco executives recorded during recent industry events.

Covid's impact

Our first DTT report five years ago found that CSPs had made little



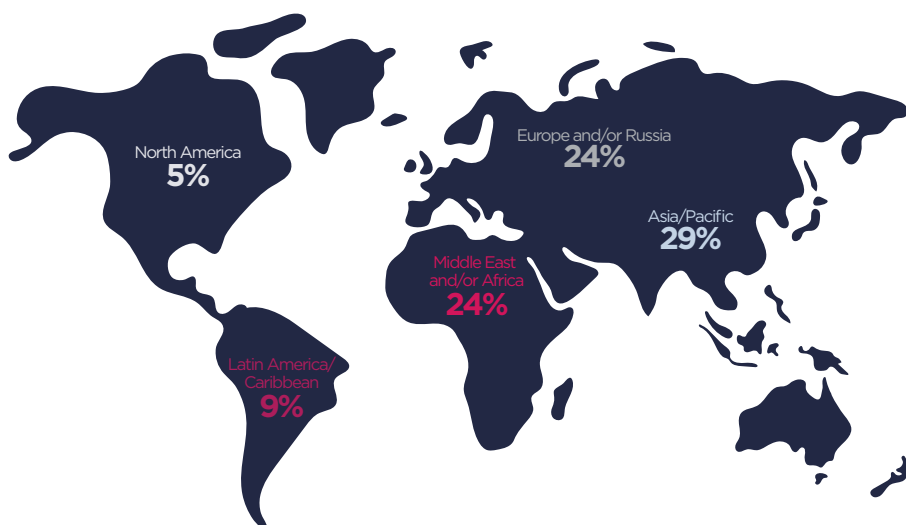
Size of CSP by subscribers



- Fewer than 5 million
- 5 million to 25 million
- 25 million to 50 million
- 50 million to 100 million
- 100 million to 150 million
- More than 150 million

TM Forum, 2023

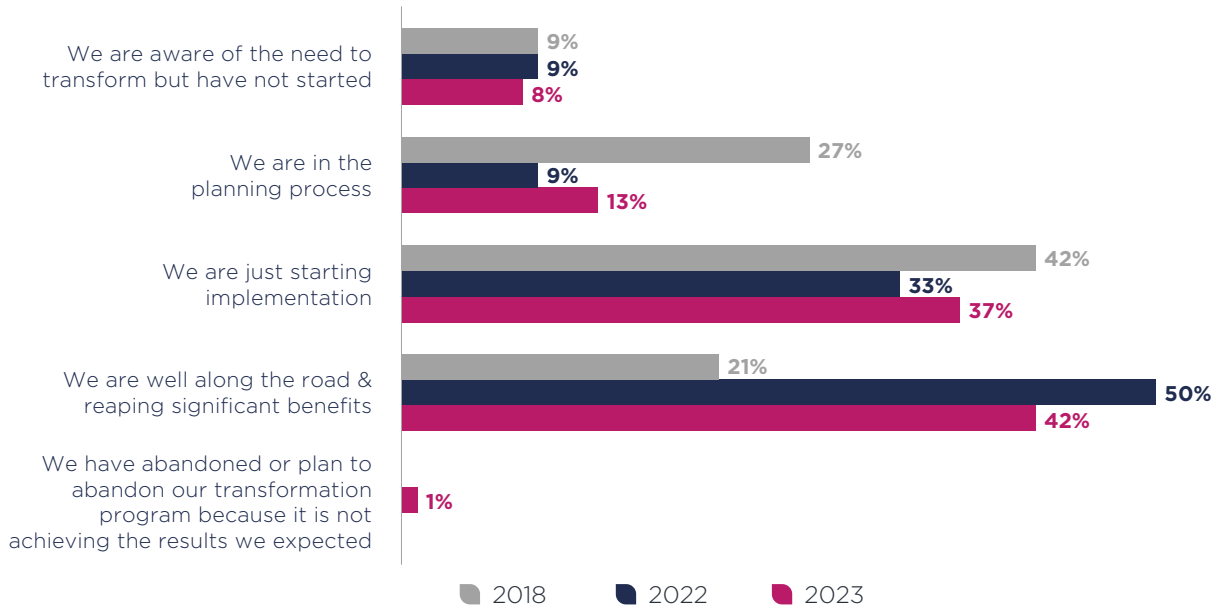
Where are CSP respondents from?



TM Forum, 2023

Note: Some graphics throughout the report do not add to 100% because of rounding.

Status of CSPs' digital transformation programs



TM Forum, 2023

progress with their digital transformation programs. Indeed, only one in five respondents reported that they were “well on the road and reaping significant benefits” (see graphic above). Then came Covid. Compared to 2018, last year’s survey recorded an astounding 138% increase in the percentage of CSP respondents who said they were seeing significant benefits from transformation.

This time the percentage of operators who said they are well on the way with transformation is slightly lower at 42%, which we believe is likely because of different and a significantly higher number of respondents to this survey. But even with the decrease, we believe the results and our interviews with operators provide evidence of continued acceleration of transformation post pandemic. Between 2018 and 2023 there has been a 100% increase in the percentage of CSP respondents who say they are reaping significant benefits from transformation programs. What

José María Álvarez-Pallete, Chair and CEO of Telefónica, [said back in April 2020](#) bears repeating:

“During the initial [Covid] confinement, digitalization advanced as much as it would have done in five years. Every month of confinement, we made a year’s progress in digitization.”

A year ago, we added another possible answer for this question: “We have abandoned or plan to abandon our transformation program because it is not achieving the results we expected.” No respondents chose that option last year, but this time three CSP respondents – two from large global operators in Europe and one from a mid-sized CSP in North America – said they have abandoned a project.

All three respondents declined to participate in a follow-up interview, but we expect this small percentage to rise in future surveys as operators advance their existing projects and start new ones – [many estimates suggest](#) that more than two-thirds of transformation projects fail.

Macroeconomic woes

The favorable reputation CSPs gained among customers with their strong performances during the pandemic is in danger of being tarnished as the macroeconomic environment worsens and operators fail to get returns on their investments in 5G. They have already spent billions. In the US alone, operators are shelling out [close to \\$50 billion a year](#) on 5G deployment, and McKinsey & Co. expects further global investment of [\\$650 billion between 2022 and 2025](#).

Inability to monetize 5G is part of the reason Vodafone Group and BT were forced to announce significant job cuts in May. Notably, BT CEO Philip Jansen, who said his company had made progress despite “an extraordinary macroeconomic backdrop”, attributed nearly 20% of planned job cuts to AI and automation. He is one of only a few telecoms executives to proclaim publicly that he is aiming for a significantly smaller workforce because of these technologies.

Our survey finds that adoption of automation and AI are accelerating across operators' businesses, driven by the same goals they have for digital transformation overall. In addition, they want self-healing networks, and they want to implement network-as-a-service (NaaS), network slicing and connectivity-as-a-service (CaaS). Improving sustainability is another important goal.

When it comes to challenges, changing culture continues to be high on the list. [During a recent panel discussion](#), Babak Fouladi, Chief Technology and Digital Officer at KPN, summed up the problem in relation to system modernization: "I have over 3,000 people reporting to me, and there are people that are managing systems that are 15 to 20 years old," he said. "Working with that engineering team to move towards openness is a very difficult thing because they come in day in and day out to build that application – that's their responsibility. How do you take that brownfield environment and bring the organization forward to the open, future architecture? There's not an easy answer."

Skills remain an issue as well. While they're cutting some jobs, telcos also are searching for people with skills in software, cloud, AI and data analytics. They also see the need for an industry-shared vision and architecture for autonomous networks, and for more standardization and collaboration among standards bodies and open-source groups to help them accelerate automation.

Finally, we take a brief look at the explosion of interest in generative AI and large language models (LLMs). These rapidly advancing technologies promise to accelerate automation and cost savings, but their potential to cause harm can't be ignored. Our research finds that CSPs are beginning to use generative AI in customer experience and network management. But access to data is an issue, and they are proceeding cautiously because of the technology's immaturity.

Read this report to understand:

- The status of digital transformation in telecoms and what the main drivers are
- Which business models operators are adopting and how they view their prospects for success in the future
- Why the gloomy macroeconomic environment is particularly challenging for CSPs
- Why culture and skills are still the biggest hurdles to clear
- Why intent-based automation is important and how CSPs plan to reach Level 4 autonomous networks by 2025
- What the business case is for intent
- Why CSPs are excited but uncertain about generative AI
- Why operators want more collaboration among standards bodies and open-source groups.



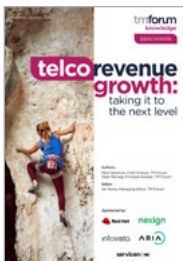
While telcos are cutting some jobs they are also searching for people with skills in software, cloud, AI and data analytics.

section 1:

accelerating automation in an uncertain economy

The big story from our [second telco revenue growth benchmark](#), published in October 2022, was a marked acceleration in revenue growth among the 33 operators we tracked. We attributed that partly to consumers regaining confidence and spending more post pandemic, with CSPs recording higher ARPU as consumers moved to faster networks and bigger data plans. This coincided with the Covid jump we saw in telcos' digital transformation progress. It's clear now, however, that the boost is over. That makes the march towards greater automation, and the economic benefits that it brings, imperative.

Read the revenue growth benchmark report



During a [recent panel discussion](#) featuring executives from BT, Telefónica and Vodafone, Greg McCall, BT's Chief Networks Officer, warned about a downside of CSPs' performance during the pandemic: "The thing that we should be concerned about is, we've done such a good job that people now just take it for granted that they'll have connectivity 24/7. We just need to think about, how do we make people realize the importance of that connectivity so that we can draw more value?"

It's the trillion-dollar question. By 2030, CSPs will have spent



well over that amount on 5G, but they have struggled to monetize their investments because the technology's most promising capabilities, like network slicing, will be available only after operators have widely deployed 5G standalone – [networks with a 5G Core](#). Today, 5G simply offers faster connectivity, and consumers take that for granted.

Dr. Ibrahim Gedeon, CTO at Canadian CSP Telus, [has gone so far as to call](#) deployment of 5G non-standalone a "travesty". "That's the worst thing we did as an industry, even though we voted for it, because we actually used 5G as 4G," he said. "Why did we do that? Because we had so much technical debt... Stuff has to work."



We've done such a good job that people now just take [connectivity] for granted... We just need to think about, how do we make people realize the importance of that connectivity so that we can draw more value?"

Greg McCall, BT Group

Operators also point to regulation as a reason they are struggling. Shortly before we published our Digital Transformation Tracker last year (DTT 6), the European Telecommunications Network Operators' Association (ETNO) [issued a report](#) detailing how tech behemoths Facebook, Amazon, Netflix and Google (FANG, sometimes written as FAANG to include Apple) generate a disproportionate amount of global network traffic (65% collectively). According to ETNO, this costs European operators between €15 billion (about \$16.1 billion) and €28 billion (\$30 billion) annually because the FANG companies do not contribute to the cost of transporting their traffic.

Since then, ETNO and GSMA have been leading an effort to get EU regulators to approve charges for FANG traffic. Recently, [the plan met with opposition](#) from the telecoms ministers of 18 countries who said there was no

evidence of an investment gap. But subsequently the majority of European Parliament [members voted for](#) "the establishment of a policy framework where large traffic generators contribute fairly to the adequate funding of telecom networks without prejudice to net neutrality".

Read the DTT 6 report:



Speaking on the same panel as McCall, Vodafone Group CTO Scott Petty said it's easy for telcos to blame regulators. But he acknowledged that only about half of Vodafone's EBITDA is impacted by regulation. Getting a return otherwise comes down to getting better unitary costs on

equipment, shutting off legacy technologies, and creating new products and services that customers actually want to buy.

Telcos are making progress toward these goals. Worldwide they are deploying fiber and retiring energy-intensive copper networks. They're also demanding that suppliers deliver lower-cost technology. In the radio access network (RAN), for example, operators are embracing Open RAN (see p.35), which increases agility and interoperability through open and standardized interfaces between components. In addition, CSPs are [using APIs across their businesses](#) to reduce complexity and costs.

Opex and jobs

Telco executives have also started talking openly about what "opex savings" and "simplification" really mean. Announcing in May that Vodafone Group will cut more than 10% of its workforce over the next three years, newly appointed CEO Margherita Della Valle said: "We will simplify our organisation, cutting out complexity to regain our competitiveness."

Two days later, BT CEO Philip Jansen said that by 2030 his company will cut potentially more than 40% of its workforce "by continuing to build and connect like fury, digitise the way we work and simplify our structure". He added: "By the end of the 2020s BT Group will rely on a much smaller workforce and a significantly reduced cost base."

Jansen is one of only a few telco executives to state publicly that his company is aiming for a significantly smaller workforce as a result of automation and AI. Telenor CEO Sigve Brekke is another. Back in 2018, Brekke [pointed to automation and](#)



[5G is] the worst thing we did as an industry, even though we voted for it, because we actually used 5G as 4G. Why did we do that? Because we had so much technical debt... Stuff has to work."

Ibrahim Gedeon, Telus

Many CSPs are shrinking the size of their workforce

The table below, compiled from CSPs' annual reports, shows the change in employee headcount during the past five years. While a handful of operators have increased the size of their workforce, most have shed a significant number of jobs, often quietly.

Some large reductions have been the result of divestment – [AT&T's spin-off of WarnerMedia](#), for example. Sometimes the cuts have been because of retirement, with CSPs opting not to fill the vacated posts: TIM [told Reuters in March](#) that it is seeking to cut 2,000 jobs through voluntary retirement.

In other cases, the eliminated jobs belong to contractors. BT's latest round of reductions, for example, includes contractor roles no longer needed to build fiber at scale. Similarly, Axiata XL in Indonesia reduced its workforce by 31% in 2019, primarily by cutting outsourced roles. Dialog Axiata in Sri Lanka cut its workforce by 28% in the same year.

And while most telco workforces are shrinking, some companies are growing jobs. Bharti Airtel and MTN Group operate mostly in developing countries where customers and new service

take-up are still growing. Others like NTT and Telus are growing through acquisition.

The huge increase at Telus is the result of acquisitions and growth in the company's "beyond connectivity" units. For example, in September 2022 the operator [completed its \\$2.3 billion acquisition](#) of LifeWorks, which has become part of Telus Health. Similarly, NTT has grown through acquisitions made by its NTT Data Systems IT services division, which [has bought](#) 13 companies in North America alone in the past four years.

[digitization](#) accounting for 6,000 job losses by the end of 2020. "Our efforts toward digital transformation, simplification and efficiency continue, with an increasing focus on structural improvements," Brekke stated in the company's 2018 annual report. Today its headcount is 55% lower than it was in 2017 (see table).

The AI effect

Until now, most C-level executives have characterized staff reductions as balancing out because they're hiring so many new skills (see sections 2 and 6). Vodafone, for example, is continuing its push to hire thousands of new software engineers, even though it intends to cut from its centralized technology division as part of the newly announced reductions.

"For a long time, our industry was very outsourcing dominated: We set strategy and then we worked with partners to build technology and run with it. In a software world, that just doesn't cut it," said Petty during the panel discussion. "You have to have your own

Number of employees at select CSPs

	2017	2022	% change
 AT&T	254,000	160,700	-36.7% ▼
 axiata	27,000	14,341	-46.9% ▼
 airtel	15,000	18,000	20.0% ▲
 BT	106,400	98,400	-7.5% ▼
 T	216,000	211,000	-2.3% ▼
 中国移动 China Mobile	464,656	450,698	-3.0% ▼
 中国电信 CHINA TELECOM	284,206	280,683	-1.2% ▼
 MTN	15,901	17,462	9.8% ▲
 NTT	274,844	333,850	21.5% ▲
 orange	152,000	136,000	-10.5% ▼
 telenor	31,000	14,000	-54.8% ▼
 Telefónica	122,718	101,227	-17.5% ▼
 Telstra	32,000	17,000	-46.9% ▼
 TIM	59,429	50,392	-15.2% ▼
 TELUS	53,630	108,500	102.3% ▲
 verizon	155,400	117,100	-24.6% ▼
 vodafone	108,271	102,275	-5.5% ▼

TM Forum, 2023 (source: companies' annual reports)

“

All the equipment's simpler and newer and more flexible, more nimble. And we've got AI and all the data that can help create self-healing networks. So, we're going to be a massive beneficiary on efficiency and costs, which is why we know we won't need all these roles in the future.”

**Philip Jansen,
BT Group**

software engineering capabilities, your own teams... If you don't have those skills and you're not driving those insourcing strategies, you're just not going to be able to move fast enough and build the

platforms that we're talking about, or even probably understand the technologies and methodologies for deploying those technologies in an effective way.”

But developments in technology like generative AI and large language models (LLMs) are likely to help telcos and other companies cut jobs much faster than they anticipated a year ago. Jansen said as much during BT's earnings call, explaining that the company will need 10,000 fewer network engineers to run its digital networks and that automation and AI are set to replace an additional 10,000 roles. He pointed to “huge opportunities” to use AI, noting that LLMs are a disruptor rivaling the smartphone.

“All the equipment's simpler and newer and more flexible, more nimble. And we've got AI and all the data that can help create self-healing networks,” Jansen said. “So, we're going to be a massive beneficiary on efficiency and costs, which is why we know we won't need all these roles in the future.”

Similarly, on an earnings call with financial analysts in May, AT&T CEO John Stankey said his company is using AI “to improve fleet dispatches so our field technicians can better serve customers”. The company is also using it in customer care. “We

“

You have to have your own software engineering capabilities, your own teams... If you don't have those skills and you're not driving those insourcing strategies, you're just not going to be able to move fast enough and build the platforms that we're talking about.”

**Scott Petty,
Vodafone Group**

think this is only the tip of the spear of what's possible,” he said.

We'll discuss the impact of new AI technology more in section 6. Next, we look at how CSPs view their prospects for the future, based on our survey responses.

section 2:

how do CSPs envision their future?

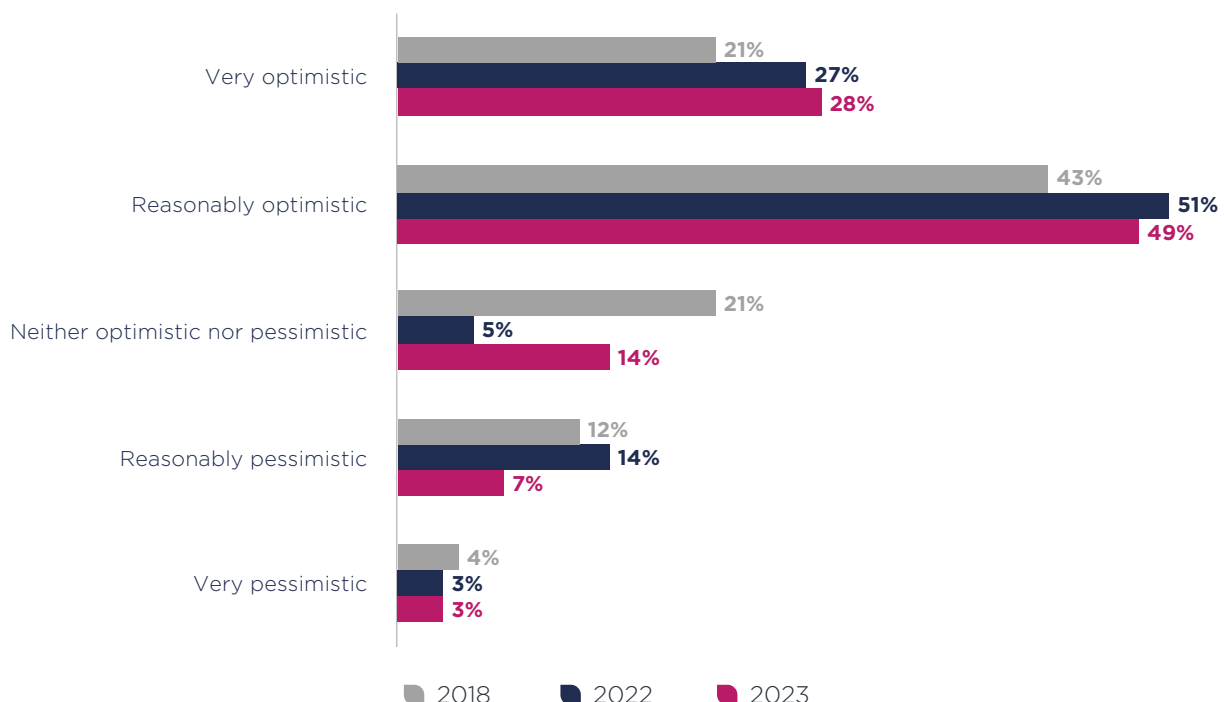
Most of us have experienced the optimism bias: human beings' [scientifically described](#) propensity to overestimate the likelihood of positive events while underestimating the probability of negative ones. Similarly, CSPs appear to remain steadfastly optimistic about their future despite the considerable headwinds they are facing.

For the past five years, our DTT surveys have asked operators how optimistic they are about the prospects for their businesses now and in

the future. A full 77% of CSP respondents to this survey are at least reasonably optimistic about their long-term prospects, with nearly 30% saying they are very

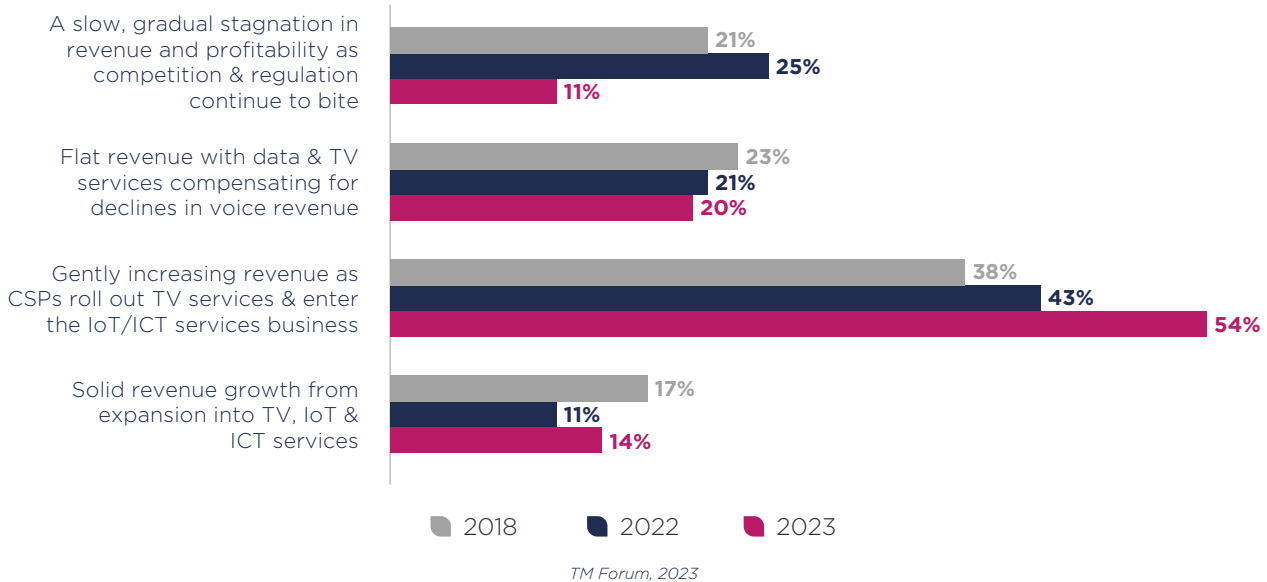
bullish about the future. Responses were about the same for the shorter-term opportunity in the next one to two years.

CSPs' optimism about their businesses (2-5 years)



TM Forum, 2023

CSPs' expectations for their businesses



Answers to another question about expectations for the global telecoms industry over the next two to three years provide further evidence of CSPs' optimism and suggest that it's growing. A lower percentage than ever expects revenue stagnation, with most respondents anticipating gently increasing revenue as they roll out new services.

We ask these questions of suppliers, too. A year ago, their level of optimism matched that of CSPs. But this year's results show a big change in vendors' attitudes. Whereas in 2022 43% said they were very optimistic, this year only 18% say the same (although 56% said they were "reasonably optimistic"). Vendors' answers to the expectations question are more in line with CSPs', with 56% predicting gently increasing revenue as operators roll out new services.

One possible explanation for supplier's decreasing optimism is that supplier respondents are thinking about the considerable challenges and competitive pressures CSPs are facing. But

another reason could be that they are considering their own prospects in increasingly competitive and fragmented markets.

Equipment manufacturers are also under pressure to improve their financial performance. Cisco Systems, Ericsson and Nokia [all have announced layoffs](#) this year to cut costs. Cisco and Ericsson are reducing their staffs by 7% and 8%, respectively, while Nokia is decreasing the size of its workforce by 5%. And as network functions become virtualized and cloud native, business models are changing. CSPs are no longer "locked in", and revenue from integration and training services is no longer guaranteed.

Better together

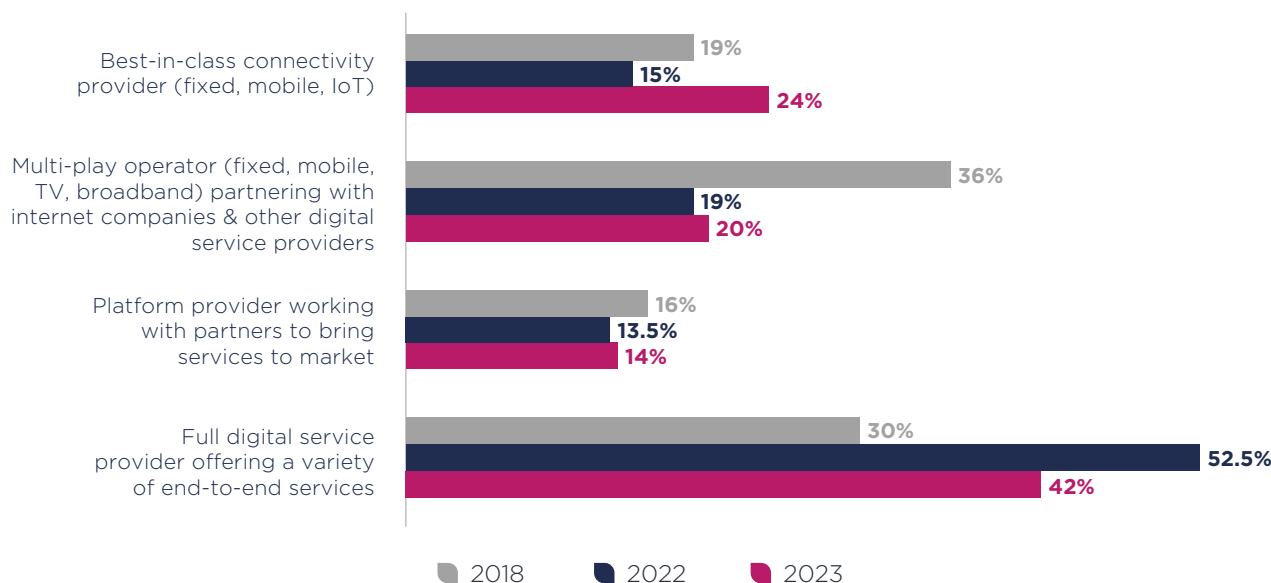
Some C-level telco executives speaking publicly about the future of the telecoms business have explained why they are, in the words of Telefónica Group CTIO Enrique Blanco, "extremely, extremely optimistic". One of the biggest reasons is their growing commitment to a common platform-based vision and a willingness to collaborate on it.

"I [have been] in this industry since the 1980s. This is the first time, to be honest, that I see that we have a common view; we have a common concern," said Blanco. He, Vodafone's Petty and BT's McCall all stressed that by

Comparison of CSPs' and suppliers' optimism (2-5 years)



What CSPs believe they should aspire to become



TM Forum, 2023

embracing platforms CSPs have an opportunity to work together in ways that have not been possible in the past.

“We need to think of platforms as an industry, not just platforms by telco,” said Petty. “If we want to be really successful, we need to create and scale platforms across our industry that make sharing interconnectivity between us much, much easier to do. I’m personally really excited about the work we’re doing with CAMARA and the work we’re doing with TM Forum to standardize architectures.”

Sami Luukkonen, Managing Partner with Singtel’s Telco+, which sits within the operator’s NCS technology services arm supporting Singtel and associates in the [Bridge Alliance](#), sees “a huge amount of commonality” among the service providers he is working with. Their focus on standardization and use of open APIs has increased substantially in the past year, he says.

“Standardization has become suddenly a huge topic, which is

caused by Open RAN, competition and the need for data,” Luukkonen explains. “In order for you to be able to manage that, you need standardization. It drives all levels of the stack.” (We discuss standards more in section 7.)

But even with standards, global collaboration among CSPs to deliver end-to-end services is easier said than done. Rules and regulations around spectrum allocation, data protection and privacy, and market competition are challenging because they vary so widely from country to country. Plus, CSPs are at different stages in their network-as-a-service (NaaS) transformations, which will enable them to abstract and expose network capabilities to developers (see sections 4 and 5).

Platforms and connectivity

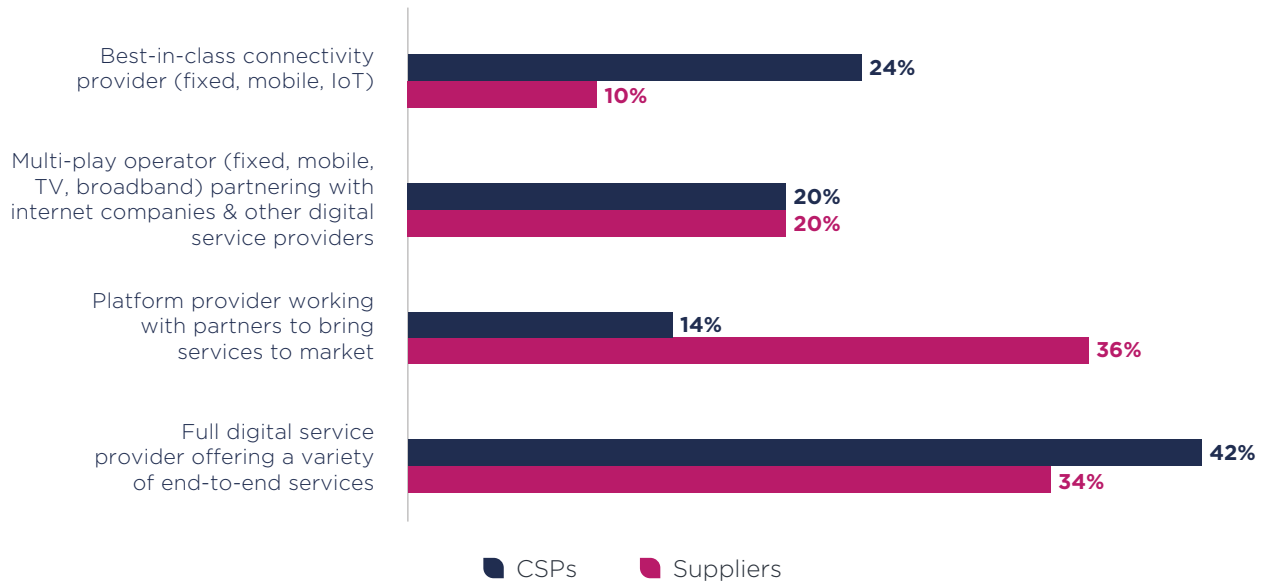
“CSPs believe that being a platform player will provide more value higher up the stack and will provide less vendor lock-in,” says Bill Lambertson, IBM’s VP of

Cloud, 5G and Edge, Global Telecommunications and Media Industries. “Many CSPs are struggling continuously on the back-end with actually delivering digital services, and transformations are moving slower than expected.”

Interestingly, when we ask CSPs in our surveys what they should aspire to become, and provide “platform provider working with partners” as an option, it typically receives the lowest percentage of votes from operators. That is the case again this time (see graphic above). But the most popular option – become a full digital service provider (DSP) – also implies a platform business model. The difference between the two is that in the full DSP approach the CSP owns the relationship with the customer.

We asked suppliers this question too, and they are bullish on the platform model for CSPs – with 36% choosing this option – which is not surprising given that so many of them sell platform-enablement tools.

Comparison of what CSPs and suppliers believe CSPs should become



TM Forum, 2023

We continue to believe that operators are missing an opportunity in how they view platforms. As we noted in our DTT 6 report, regardless of who owns the relationship with the customer, the owner of the platform is the biggest winner because they are involved in and earn revenue from every transaction.

A true IoT marketplace, for example, needs to go further than a simple platform that provides connectivity along with services like management of applications, data and devices to a single enterprise. It should enable all participants in the ecosystem to trade with each other so that the CSP can earn a share of revenue from all transactions.

One other change in the survey data worth noting is an increased focus this time among CSPs on becoming best-in-class connectivity providers. Nearly a quarter of CSP respondents chose this as the best way forward, up from just 15% last year.

Renewed focus on connectivity makes sense because it is still operators' biggest strength. The key to becoming a best-in-class connectivity provider lies in their ability to deliver it in a way that abstracts the complexity from customers. We'll discuss this more in sections 4 and 5.

Next we look at why culture and skills are still two of the biggest obstacles CSPs are facing.



The key to becoming a best-in-class connectivity provider lies in the ability to deliver it in a way that abstracts the complexity from customers.

section 3:

changing culture is more important (and harder) than ever

As CSPs increase their adoption of cloud, AI and automation, issues around culture are intensifying. Organizational divisions between network and IT and finding the necessary software skills continue to be significant obstacles.

The graphics on p.16 and p.17 show the barriers to digital transformation that CSPs and suppliers believe are “very serious”. By that measure, CSPs’ perceived challenges around culture, management support, governance, urgency, risk and budget all have increased in importance over the past year. And if we add respondents who called the issues “moderately serious”, more than 60% see culture, skills, budget and inflexible legacy IT as key challenges.

Transforming networks

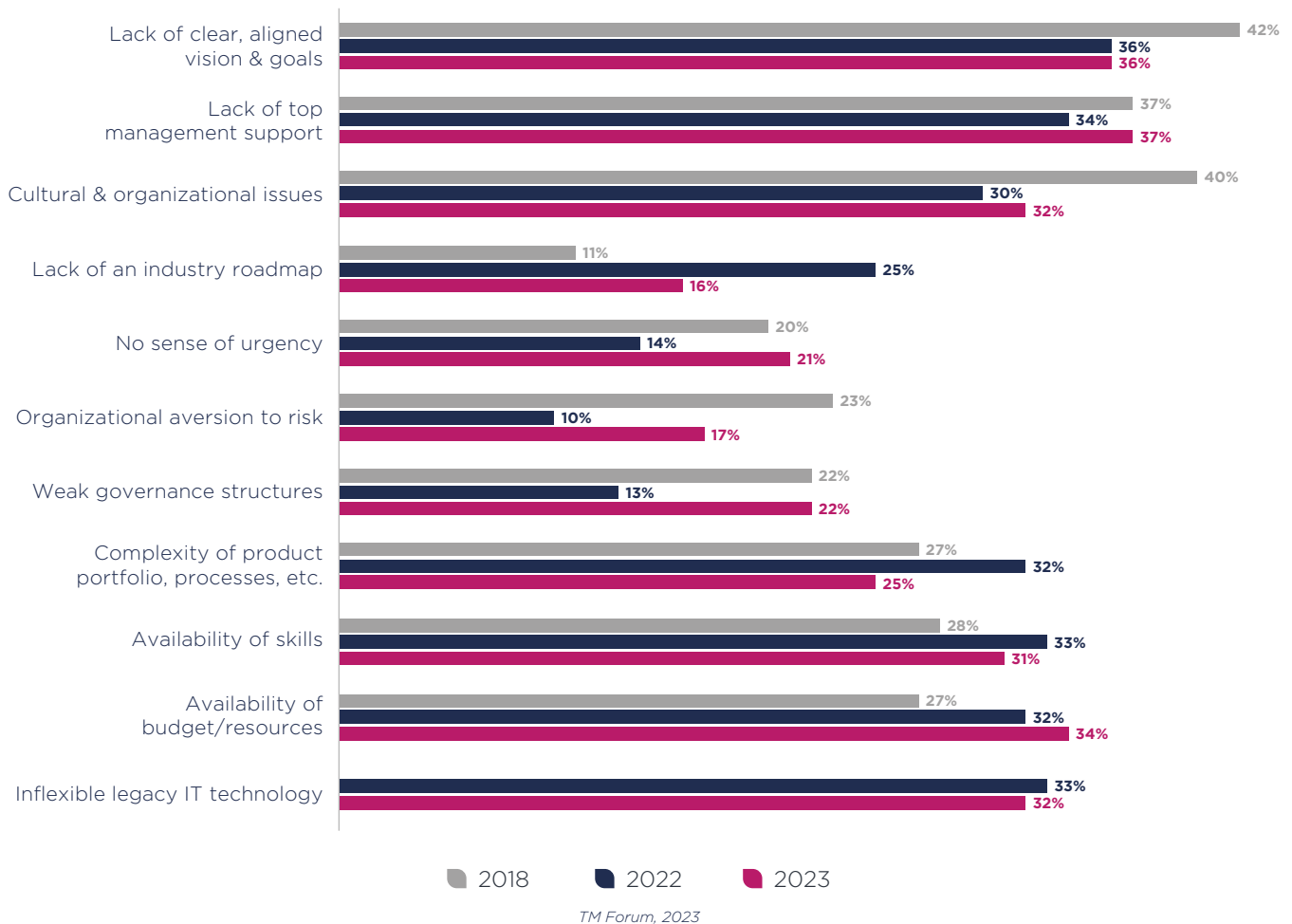
As we noted in [our recent report on Open RANs](#), CSPs have spent considerable time and money developing open, multi-vendor OSS/BSS ecosystems capable of full business process automation. Now they want to apply this approach to networks.

Our additional research has identified persistent challenges around culture and skills as CSPs transform their networks. One of the biggest issues is that the use of plug-and-play software and

APIs in the network is relatively new for teams who are used to managing hardware that has been built for purpose and does not change often.

Laurent Leboucher, Group CTO and Senior Vice President of Orange Innovation Networks, sees this as one of the industry’s biggest challenges, namely “how to change the way people in network engineering and operations work”. He explains: “When you’ve worked using certain processes and practices

Very serious barriers to CSPs' digital transformation programs



for a long time, it's always difficult to consider moving to a different way of working. And this, by the way, is not only for us as the telco, but also for our ecosystem, especially the network vendors."

Indeed, CSPs have tight relationships with their network equipment vendors, which have been cultivated over many years. Not only do operators buy products from them, but also integration and training services. Typically, within CSPs' network organizations, Ericsson-trained engineers only work on Ericsson products, while Cisco-certified engineers work only on Cisco gear, and so on.

Virtualizing the network and moving parts of it to the cloud changes the business model. When network functions can be accessed through standard APIs, there is no need for specialized engineers, for example. That means less training and integration revenue for the equipment makers. It also eliminates vendor lock-in.

"That's something, of course, that is sometimes not an easy discussion with the vendors," says Sami Luukkonen at Singtel's Telco+. "It doesn't matter whether you talk to BSS/OSS vendors or network vendors, it's the same thing

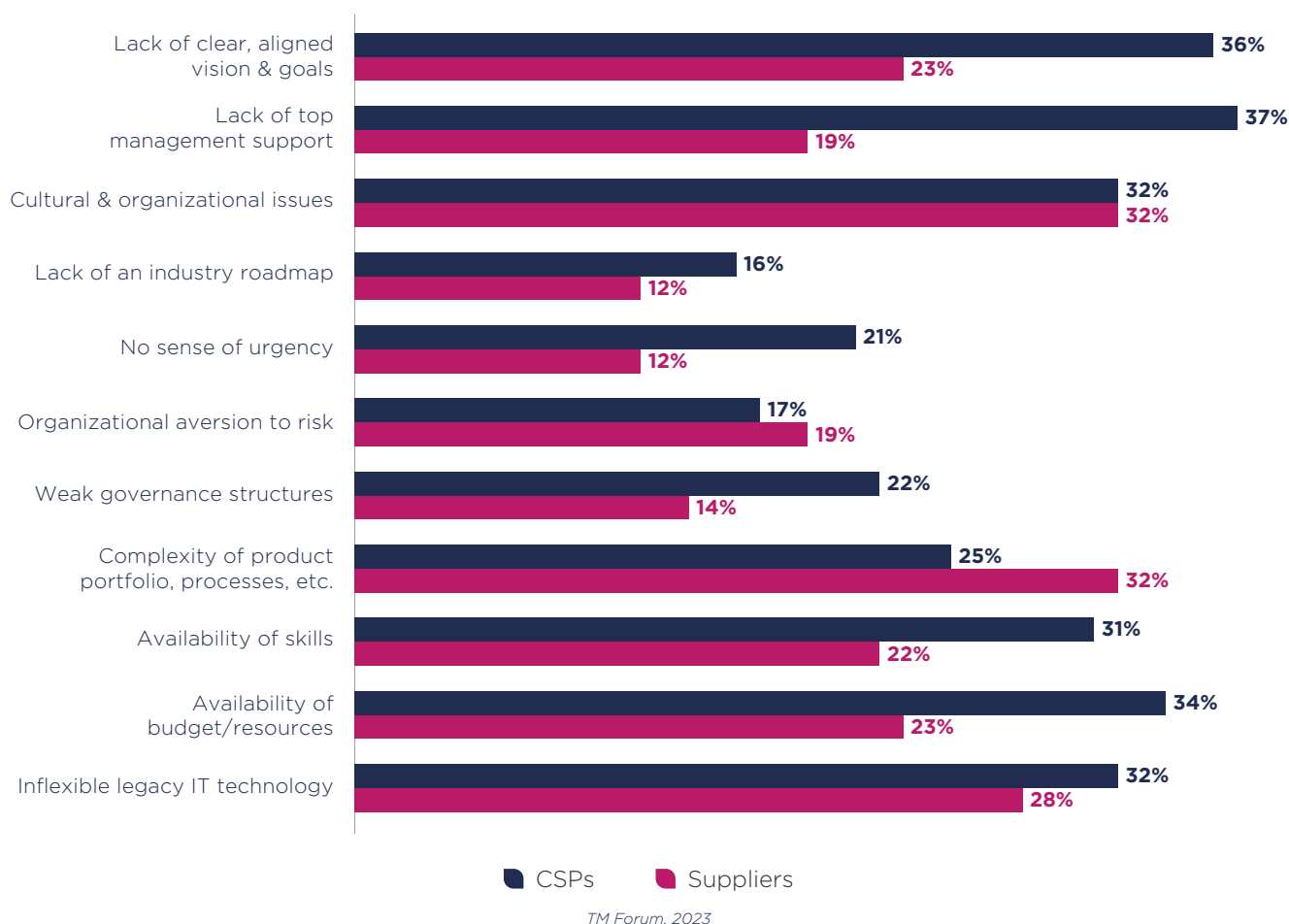
because they realize that once the telco takes control of their own data, then it means that there's less lock-in with those systems."

Risk aversion

Another challenge is that network engineers tend to be more conservative than their counterparts working in IT, and for good reason. The Covid-19 pandemic highlighted the importance of high reliability in telecoms networks.

"Traditionally, we are quite risk averse, and this is normal because we need to manage very critical

Comparison of how CSPs and suppliers view barriers to transformation



infrastructure,” Leboucher says. “At the same time, if we want to learn new practices fast, we need to be able to take some controlled risks and fail over fast if needed.”

Intent-based automation increases the perception of risk because it requires turning over decision-making to AI and machine learning. The worry, among network engineers, is that automation will make it more difficult to figure out the root cause of problems, leading to a potential degradation of service or even outages.

This is an issue in IT operations too. “People need to be comfortable with a level of

abstraction and a lack of direct control. And in many cases, I think people’s skill sets move from doing things to designing processes, systems and software that do things in, frankly, a more repeatable, higher volume and cheaper way,” said Grant Lenahan, Partner and Principal Analyst at Appledore Research, during [a recent interview with Telecom TV](#).

CSPs have organized their IT operations around linear software processes managed by separate teams (fulfillment, service activation and assurance, for example). These silos exist in every domain, but as automation is introduced, the same software

that sets up a service or a network element also monitors and heals it and handles scaling. This necessitates breaking down the operational silos operators have built over decades.

“But you’ve got to remember, these silos often represent people’s careers, and people are invested in them and very, very proud of what they’ve accomplished,” Lenahan said. “So, it does become disruptive. And if you try and bring in the automation without changing the structure of an organization and how people believe they are rewarded, it’s probably not going to be that smooth.”

Network vs. IT

A common complaint among CSPs (and their suppliers) is that IT and network teams don't always communicate as well as they should. Johanne Mayer, founder of consulting and training company NaaS Compass and the leader of TM Forum's NaaS transformation project, works with both teams within CSP organizations. She has found that the groups often don't have clarity around who is responsible for what, which can lead to an "us versus them" mentality. This is something TM Forum's work on NaaS transformation addresses in one of its key principles: clarification of the roles and responsibilities supporting a separation of concerns between the Production domain in the Open Digital Architecture, which refers to the abstracted infrastructure, and the Core Commerce Management domain, which is where functions like the product catalog and order management sit.

Mayer recalls conducting a survey for a research firm several years ago asking CSPs about merging their network and IT functions. Some companies that had consolidated teams under a CTIO were taking steps to separate them again because the IT departments felt they had "lost their voice" to the network departments. Within CSP organizations, network teams are often ten times the size of the IT teams, with a similarly outsized budget.

The pendulum is swinging the other way again, however, because softwarization of the network is accelerating. Orange moved Leboucher, a software expert, [into the Group CTO role](#) at the end of 2021, for example. Other operators have C-level executives in roles that combine network and IT. Telefónica CTIO Enrique Blanco and KPN Chief Technology and Digital Officer Babak Fouladi are examples.

'Netware' engineers

[Speaking on a recent panel](#), BT's Chief Networks Officer, Greg McCall, said he believes CSPs need to develop a new role that blends IT and network skills. "I think we've got to create a new model – we call them 'netware' people," he said. "They've got to have brilliant network skills and brilliant software skills."

The netware engineer needs the Agile and DevOps skills of a software engineer, plus an understanding of what it takes to operate a network 24/7 at five-nine's reliability. "We need people who really understand the nuances of networks – how networks work and how they're configured – but they must also have a software brain," says TM Forum CTO George Glass. "They have to think about pattern matching and abstraction and they have to build a standardized interface that enables the management, operations and control of multiple vendors' equipment."

“

I think we've got to create a new [skills] model – we call them 'netware' people. They've got to have brilliant network skills and brilliant software skills.

Greg McCall, BT

Because the netware role doesn't exist outside telecoms, it will need to be developed through training, either upskilling existing employees or training new software engineers in network operations. But that is another huge pain point for CSPs because they simply cannot compete with hyperscalers and other tech companies to acquire – or in many cases keep – the skills they need.

Our research finds that most CSPs offer compensation packages that are 30% to 50% lower than those offered by hyperscalers, for example. This challenge is particularly difficult for US telcos, which must compete with Silicon Valley techco salaries.

The next section looks at progress toward autonomous networks and the role of intent.

section 4:

aiming for Level 4 autonomy by 2025

CSPs have a common vision for the future: They want to be able to deliver connectivity and other services via autonomous networks (ANs) that require almost no human intervention. Machines using predictive analytics and AI will eventually decide which network resources are used to fulfill a customer's business goals, with all complexity hidden from the customer. The telecoms industry hasn't agreed on the path to get there yet, but that's not stopping some operators from implementing ambitious programs to achieve a high level of autonomy in their networks and operations in the next two years.

CSPs need to be able to orchestrate zero-touch, zero-wait and zero-trouble services end to end across network domains, including their partners', at scale. This requires automation of the entire service lifecycle, from ordering to fulfillment, activation, orchestration, management, assurance, optimization and billing. Operators have been working on this kind of automation for years and have made progress. In fact, TM Forum's [Open API program](#) was born out of this need. But end-to-end automation has remained

elusive because of interoperability issues, architectural fragmentation and customization.

Based on TM Forum's definition, Level 4 autonomous networks (see graphic on p.23) mark the transition between traditional automation of human-defined process behavior and autonomous behavior, where systems make decisions independent of humans.

The need to monetize 5G network slicing is intensifying the push to scale end-to-end automation, with a goal of reaching autonomy. Ultimately, operators want to be able to turn

their customers' business goals, or intents, into instructions for the network that can be fulfilled without customers needing to know any details about the underlying infrastructure (see panel on the next page). The idea is to abstract the complexity and communicate with customers using a common language or ontology that can also be made machine readable.

The graphics on p.21 show the most important drivers for automation and transformation overall, based on our survey for this report.

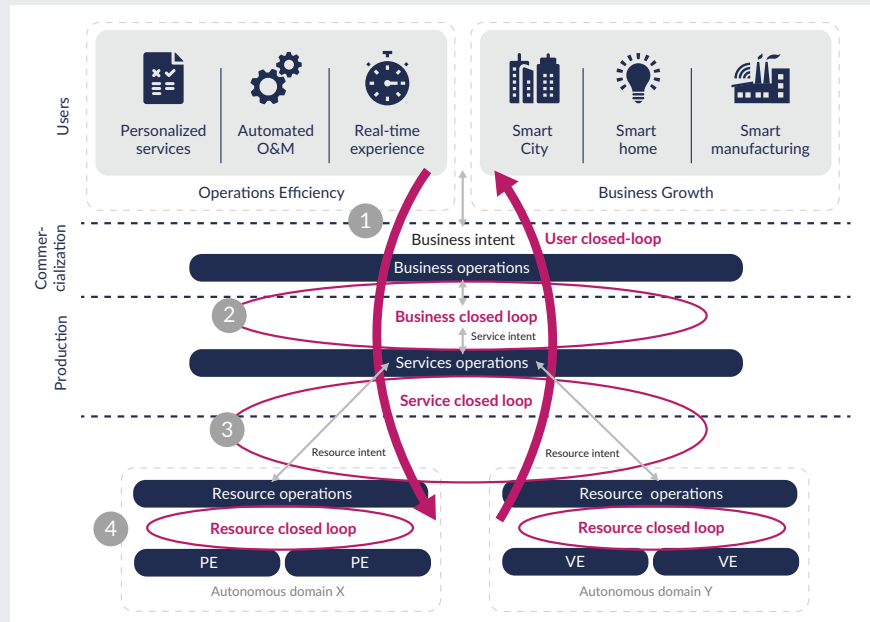
What is intent-based automation?

In TM Forum's [Autonomous Networks Project](#), CSPs and their suppliers are working on how to implement intent-based automation and integration between autonomous domains. They are building on and extending previous standards work on intent wherever possible. For example, the team's definition of intent-based networking is compatible with the IETF's.

The systems in ANs are governed by intent, which sets expectations as requirements, goals and constraints. These are abstracted from the technical inner workings of the network. Put more simply, intents are the "what" not the "how" – meaning, you tell the system what goal or outcome is required without having to tell it how to achieve it. This decoupling increases agility, allowing autonomous systems to fulfill the intent using data, machine learning and AI, while enabling supplier innovation that can be easily integrated and adopted.

Intent can be expressed at various levels (business intent, service intent and resource intent, for example). In the [TM Forum AN Reference Architecture](#) intents are used with closed-loop management to automate the full lifecycle of services. Closing the loop means collecting and analyzing data to figure out how networks can be optimized, and then implementing those changes in an automated way. The graphic shows the interaction of intents across a CSP's operational layers.

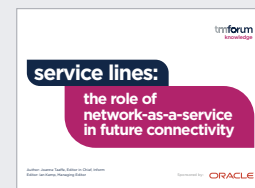
Orange's Leboucher uses a robot metaphor to explain intent. The traditional way of automating how



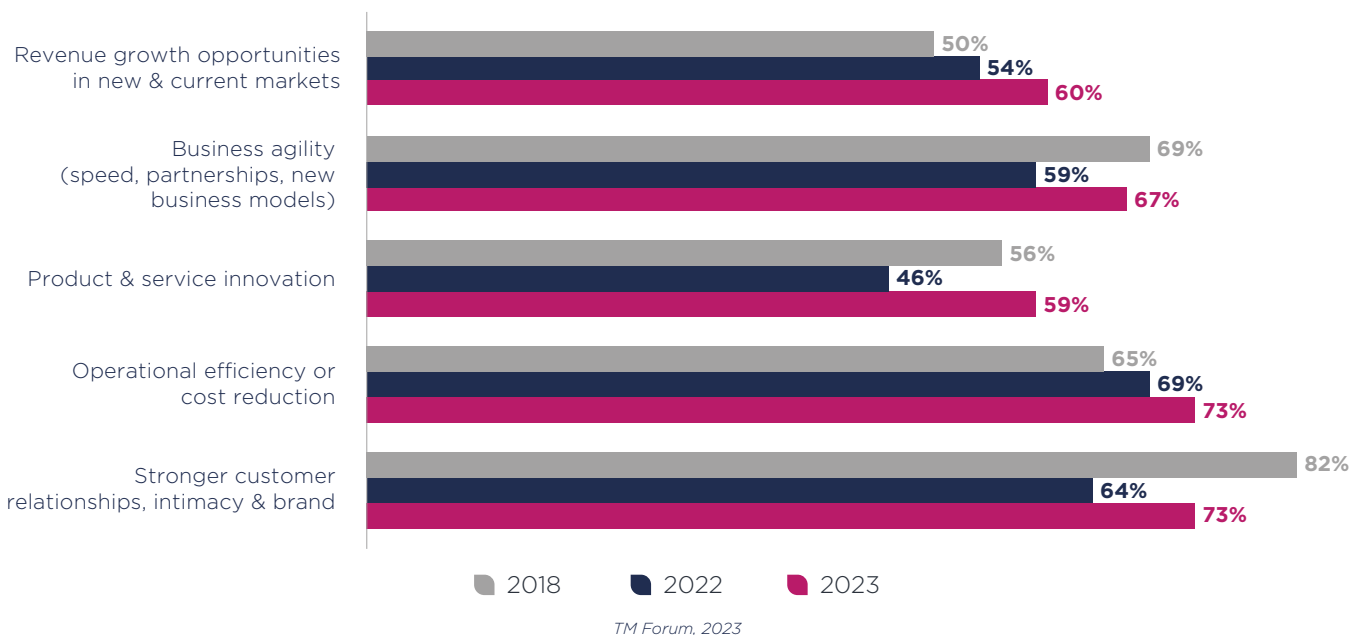
a robot might travel from room A to room B in an apartment is to use basic scripting. "I would measure the distances between room A and room B and then program the robot to navigate the apartment, and it would work," Leboucher explains. "The problem is, if I try to move the robots to another place – to the neighbor's apartment, for example – I will need to redo the scripting."

By using intent, the robot can adapt to different situations and configurations that may happen. "Intent is this mechanism to abstract and to be able to keep what is essential: the intent of going from room A to room B," says Leboucher. "Being able to do that in network operation is absolutely essential. If we stay at the edge of basic scripting, we will never be able to scale and never be able to reach the level of repeatability – industrial repeatability."

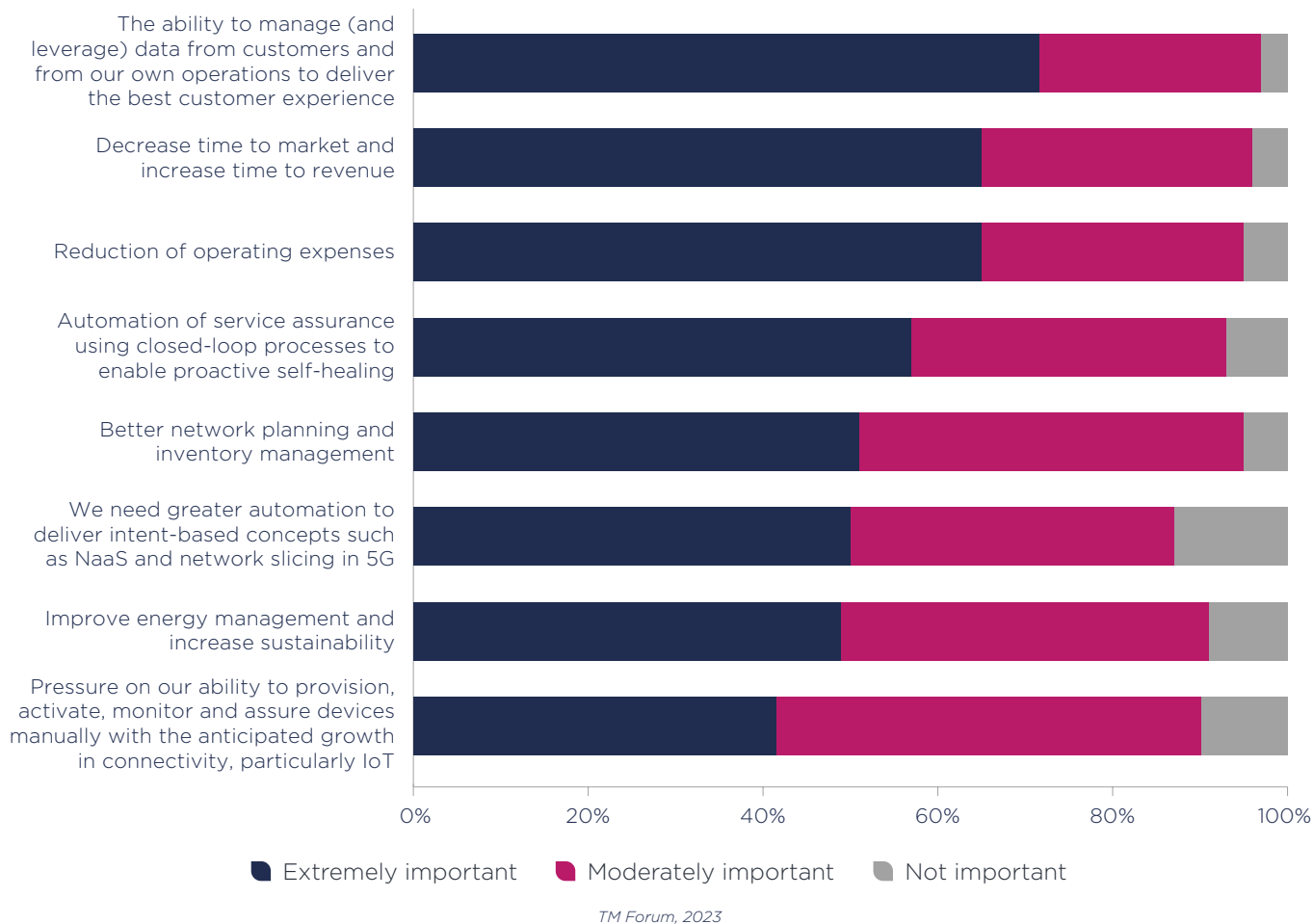
To learn more about intent-based management, read these publications:



Very important drivers of CSPs' digital transformation programs



CSPs' drivers for automation



Drivers of automation

The top drivers for both digital transformation programs and automation, as shown in the charts on p.21, are the same, with improving customer experience ranking highest for both. CSP respondents rated reducing the time it takes to get to new revenue as the second most important driver for automation, which is not surprising given their increasing need to get a return on 5G investments.

Indeed, one of the first use cases for intent-based automation is 5G network slicing in standalone 5G networks. At first operators will set up static slices manually, but the goal is to move to dynamic slices. For example, if a CSP wants to set up a fixed wireless access (FWA) slice to meet a customer's request, the fulfillment and orchestration systems first need to know whether there is congestion in the RAN.

"To address that and to cope with different situations, you need intent," says Leboucher at Orange. "This is why we want to introduce an orchestration solution when we move to dynamic slicing. For the

very first deployments of slices in the network, we can do it without full automation. But if we want to be repeatable – if we want to do it at scale and we have to deal with different requirements from customers for their own mobile private networks or IoT deployments – then it has to be intent-driven."

One way to do this is to introduce multi-domain service orchestration, which relies on dynamic inventory to provide a real-time view of the resources that are available. Operators also need to be able to introduce a rules mechanism to allow for the next level of automation, says Leboucher. "And it's not just for provisioning," he adds. "Very often we think of provisioning as the most important use case, but ... the most important is in production, when you have to keep the service level agreement [SLA] under control. Intent-driven orchestration is needed for that."

CSPs will take a step-by-step approach to introducing intent-based automation, and Leboucher thinks that multi-domain orchestration for slices could be one of the first areas where it's

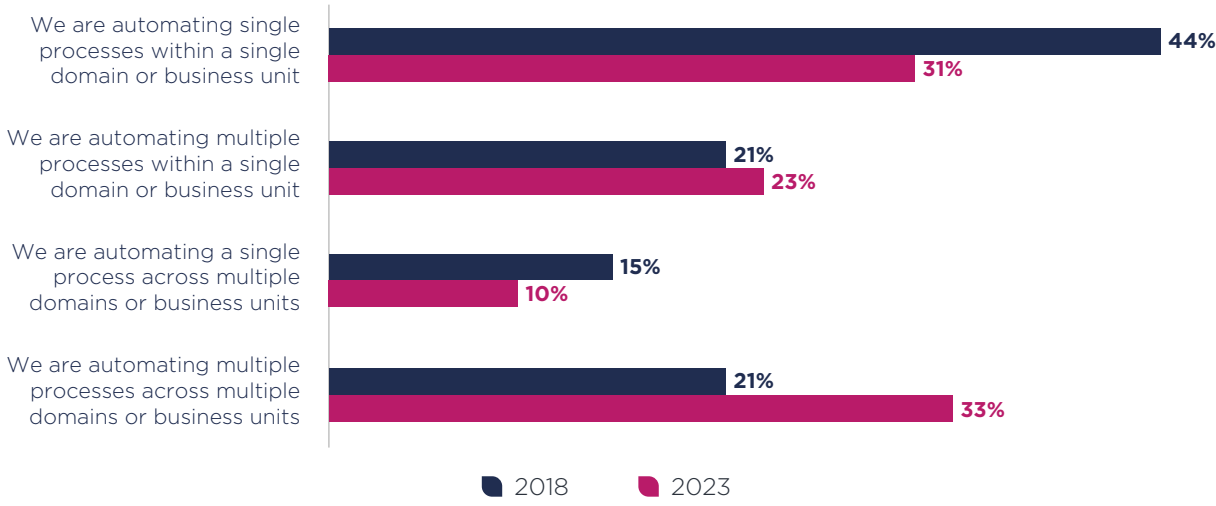
used. In our survey we asked operators a question about how they are automating processes and compared the results to a survey we conducted in 2018. The data shows that multi-domain orchestration is increasing (see graphic below).

No consensus

A challenge for CSPs, however, is that several layers of network management are evolving in parallel with no consensus about whether to use a traditional network-centered approach to managing the transition to ANs or a "cross-layer approach", as China Mobile's Dr. Lingli Deng, Director and Researcher, describes it. In addition, there is no consensus around the core reference architecture and APIs. For example, some industry efforts are focusing on introducing new APIs, while others promote enhancement of existing interfaces.

"Agreeing a foundational data model between all the standards organizations has to come before intent," says Dr. Lester Thomas, Head of New Technologies and Innovation, Vodafone. "I'm 100%

How CSPs are automating processes



TM Forum, 2023

behind the intent model, but we're trying to do something advanced when we've still got basic issues to resolve." See section 7 for more on the need for collaboration among standards efforts.

China Mobile, Orange, Vodafone and other large operators participating in TM Forum's AN Project are embracing a cross-layer approach that relies on the Open Digital Architecture (ODA) and Open APIs. Part of the Open Digital Framework (see p.45), the ODA is a component-based approach that defines standardized, interoperable software components organized into loosely coupled domains. These components expose business services through Open APIs, which are built on a common data model.

Measuring progress

The AN Project team has developed the six-step maturity model shown opposite for CSPs to measure their progress in implementing ANs. Today, most operators are between Levels 2 and 3, but some including China Mobile, China Telecom, China Unicom, MTN, Orange and Telecom Argentina are aiming to achieve Level 4 autonomy for at least some processes by 2025. Orange, for example, wants to achieve autonomy for two processes: deployment and fault monitoring/maintenance within the next two years.

The Chinese telcos are the most ambitious. China Mobile is aiming for Level 4 autonomy for nearly all the services the company is providing, across multiple domains including the mobile RAN and core, IP, optical and telco cloud networks.

China Mobile's network and operations are massive, with 31 local operators serving 975 million mobile customers and 272 million

cable broadband customers. Its total investment in 5G networks in 2022 alone was RMB 96 billion (about \$13.5 billion). The company has deployed 1.28 million 5G base stations and serves 330 million 5G network customers.

China Mobile's technology function is centralized, and it is using its end-to-end service operation layer as the catalyst to drive the overall development of its technical AN capabilities. "We have an end-to-end service



5

Fully autonomous network

The system has closed-loop automation capabilities across multiple services, multiple domains – including partners' domains – and the entire lifecycle.

4

Highly autonomous network

In a more complicated, cross-domain environment, the system enables decision-making based on predictive analysis or active closed-loop management of service-driven and customer experience-driven networks.

3

Conditional autonomous network

The system senses real-time environmental changes and in certain network domains will optimize and adjust itself to the external environment to enable intent-based, closed-loop management.

2

Partial autonomous network

The system enables closed-loop operations and maintenance for specific units based on AI modelling under certain external environments.

1

Assisted operations and maintenance

The system executes a specific, repetitive subtask based on pre-configuration in order to increase execution efficiency.

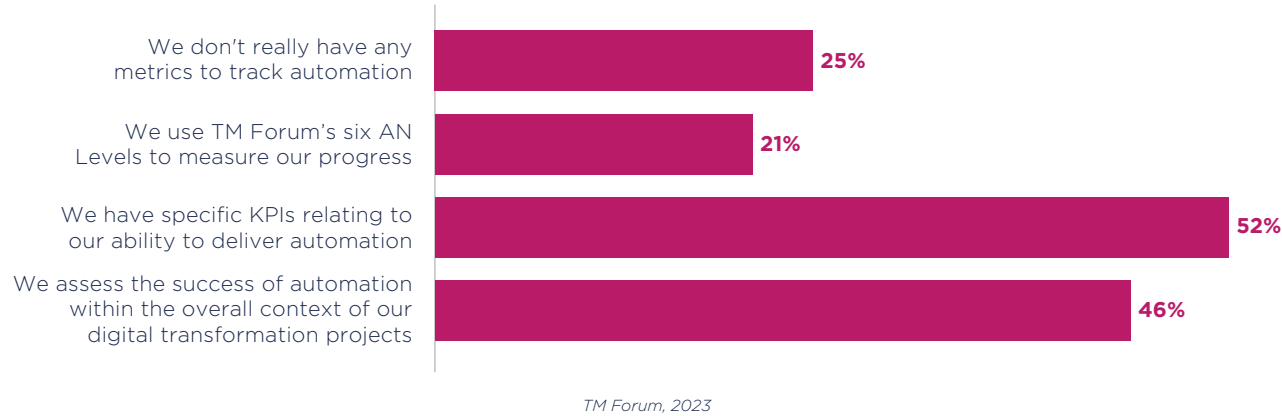
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Manual operations and maintenance

The system delivers assisted monitoring capabilities, but all dynamic tasks must be executed manually.

Source: TM Forum, 2021

How CSPs measure automation progress



operation management layer on the top of the five different technical domains, and we are specifying for each year the technical maturity level requirements,” says Deng. At Levels 4 and 5, network systems leverage AIOps to acquire knowledge rather than needing to be programmed by humans through northbound interfaces. The systems learn to build knowledge from what they have observed and experienced in production.

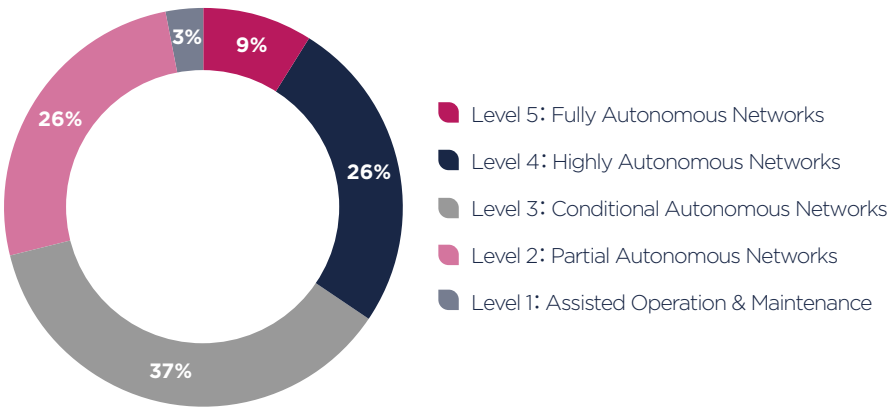
Deng sees Level 5 as “very far reaching” and likely to incorporate technology such as generative AI. However, getting to that level may never happen in operators’ production networks because they will not be willing to exclude humans from the overall service delivery and assurance processes. “Perhaps Level 5 autonomy is only achievable from the technical perspective and not from the production network perspective – it will always be dependent on the service providers and their own policies,” she says.

In our survey, only a fifth of CSP respondents said their companies are using TM Forum’s AN levels to measure their progress in automating networks and

operations. But an earlier survey of CSPs active in the AN Project showed that more than a third are aiming for highly or fully autonomous networks by 2025. Most people interviewed for this report agreed that TM Forum’s work on ANs has been forward looking and in some respects ahead of its time, but progress with digital transformation and the

need to monetize 5G at scale are helping operators build a business case for ANs. Network-as-a-service (NaaS), orchestration and policy-based management are precursors to full AN transformation. In the next section, we look at some key TM Forum Catalyst projects that are beginning to develop a convincing business case for autonomous networks.

CSPs’ predicted level of automation in next 3 years



TM Forum, 2023

section 5:

building the business case for autonomous networks

CSPs are increasing automation in their networks and operations by moving OSS/BSS and network functions to the cloud, creating network-as-a-service (NaaS) platforms, and implementing policy-based orchestration and management that rely on machine learning and AI. But getting to the highest levels of autonomy means accelerating all these efforts. That requires investment and establishing the business case to support it.

The most important reason to move to ANs and intent-based management is ability to scale. CSPs cannot manage thousands of dynamic 5G network slices or millions of IoT devices using manual processes. The complexity of networks and operations demands cloud-based networks that rely on intent-based management enabled by AI. The problem is, most CSPs are not yet ready to scale AI. It's often still not trusted, and access to data and

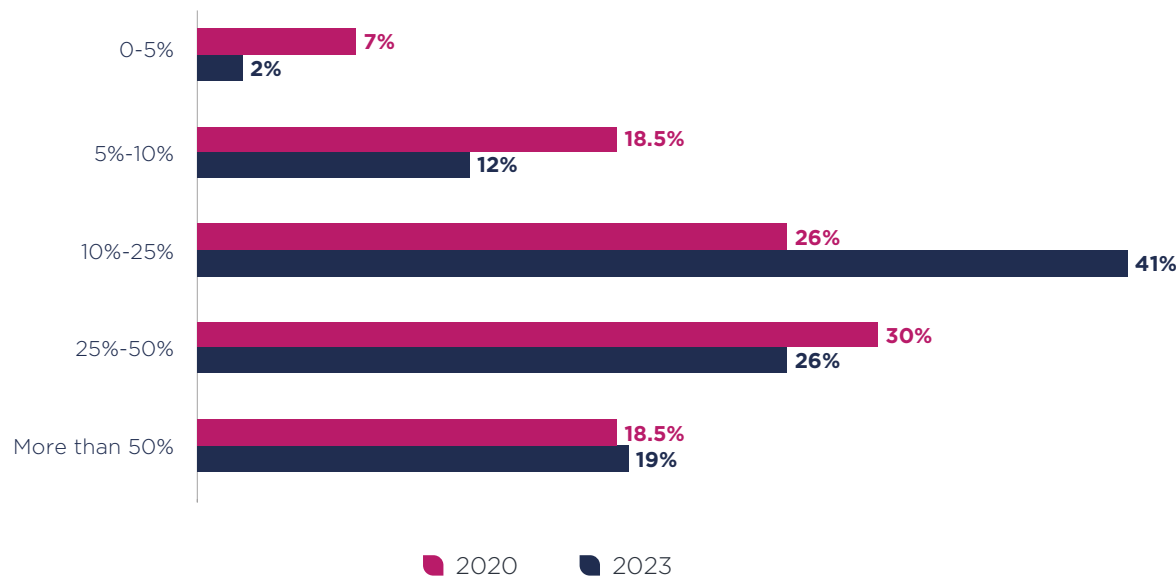
quality of data remain significant challenges (see section 6).

Cost savings is another reason to deploy autonomous networks, but the investment can be more difficult to justify if a CSP's systems and processes are already highly automated and 5G slicing isn't a driver. In the AN Project, one area where operators are focusing is on cost savings related to energy consumption. At DTW 2023 in September, a group of ["Moonshot" Catalysts](#) will

demonstrate projects aiming to introduce automation in order to reduce energy consumption and increase sustainability.

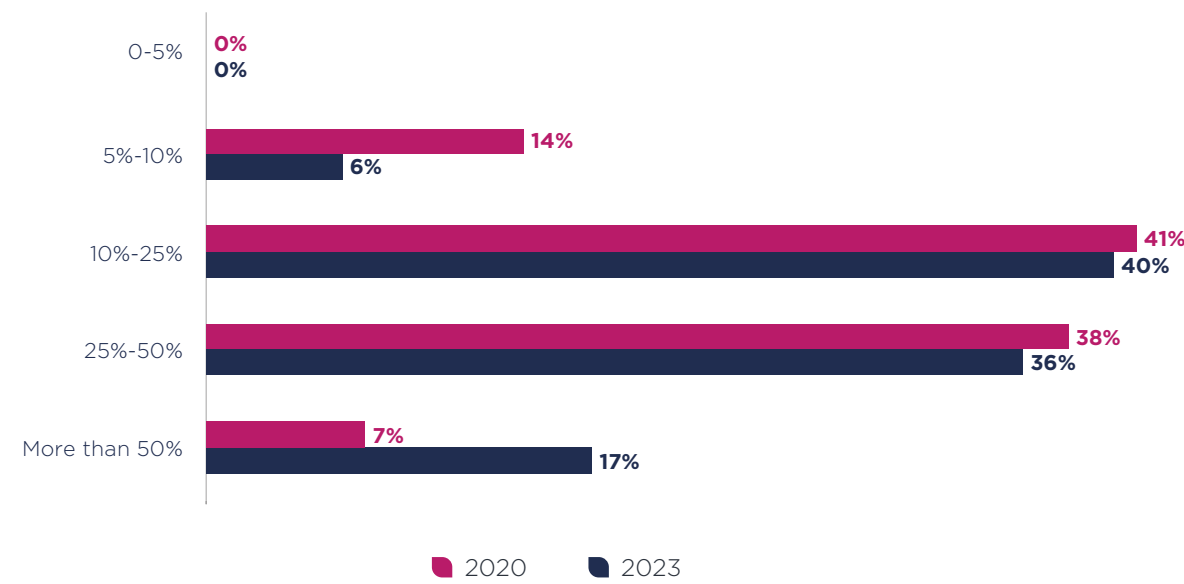
Our survey found that the efficiency gains CSPs and their suppliers expect from automation are increasing, particularly among vendors. In fact the percentage of suppliers that believe they can realize a gain of more than 50% has more than doubled since 2020 (see chart at bottom of next page).

CSPs' anticipated efficiency gains from automation



TM Forum, 2023

Suppliers' anticipated efficiency gains from automation



TM Forum, 2023

In a pilot, China Mobile reduced carbon emissions by 30% by training AI data in the western part of the country, where energy costs and computing demand are much lower than in the east. Now China Mobile is championing [a Moonshot Catalyst project](#) that

will demonstrate several approaches to reducing energy consumption in 5G cell sites and equipment rooms including use of solar and wind power to supply 5G base station equipment and provide backup power. The team will also focus on simplification of

networks, intelligent adjustment of 5G equipment room air conditioning, and development of an AI intelligent power-saving model, with an aim to achieve a 10% reduction in energy consumption in 5G base stations.

Read this report to learn more about how CSPs are reducing energy consumption and increasing sustainability:



Following are select TM Forum Catalyst projects that are demonstrating how to prove the business case for automation and ANs using NaaS and intent-based management. You can learn about all the TM Forum Catalysts that are working on these concepts by searching key words [on this webpage](#).

Converged access

A Catalyst called [Converged access with ODA](#) is showing how CSPs can improve customer experience and potentially save millions of dollars, perhaps even billions, on element management systems (EMSs) by implementing technology-agnostic, abstracted access services (NaaS) to deliver converged access. The project is in its second phase, with Claro Brazil, e&, GCI Communication, NTT, Verizon and VNPT as champions. NBN Co and Telstra were additional sponsors in the first phase of the project.

The team aims to help CSPs move away from selling specific access technologies (for example, cable, wireless internet access and TV) and instead focus on customer experience. When an operator tries to sell multiple access technologies, product managers for each type must build, maintain and grow their customer base. This can lead to cannibalization of markets and often leaves customers confused when

Intent-driven AN down to the commercial level

An ongoing project called [Intent-driven autonomous networks](#) is developing a new [intent API](#) that can potentially replace other existing APIs and an [intent ontology](#), which is vocabulary to express requirements in a way that can be understood by a customer and at the same time be machine readable for systems. The team is using an end-to-end use case that supports dynamic pricing for connectivity services based on availability of network resources and a maximum price that an enterprise customer is willing to pay.

In the example, a user's requirements are matched to network services and then to 5G network slice resources. The customer's pricing constraint is met by a business intent of the service provider to offer budget pricing whenever network utilization is low, because at that time the available resources aren't generating revenue. This creates a demand-based pricing scheme in the business layer and further intent to introduce requirements in the service and

resource management layers. All these details of how the solution gets implemented are transparent to the customer.

The latest phase of the project is championed by AIS, China Mobile, China Unicom, TIM, Sparkle and Telenor Group. A previous phase also included Orange and Vodafone as sponsors.

"It's quite interesting because it's taking the intent all the way to the commercial level," says Vodafone's Thomas. "And the other interesting thing is that it's not just a one-time fulfillment of the intent – there's a negotiation and the intent API has a language, an ontology, for how to actually communicate and negotiate the customer's intent."

Watch the video below to learn more:



different CSP product groups try to upsell their technology to the same customer or when the customer tries to move services.

"This reality and experience is a result of the architecture, with its underlying siloed structures of telco access technologies which is very heavy in capex and opex to maintain the spaghetti of OSS-to-EMS interfaces," says NaaS Compass' Mayer, who is leading the project.

Standards development organizations (SDOs) like Broadband Forum, ONF, ETSI, 3GPP and O-RAN are enhancing their specifications to help expose

capabilities via APIs to third-party software applications like orchestrators, which replace traditional proprietary EMS. But even so, the enhancements are still technology focused, rather than focusing on the customer.

"By converging and abstracting the different access technologies and aligning the network access standards with OSS and BSS standards from the TM Forum, we can hide the complexity of the access network, easily overlay value-added applications and define more customer-focused products," says Mayer.

The Catalyst team found that the converged access model provides significant cost benefits by reducing the number of interfaces and EMS platforms. “It’s an average of \$30 million a year per EMS system,” says Mayer, adding that most large CSPs have 30 to 100 EMSs. The savings include staff and marketing costs plus the cost of proprietary APIs.

In the next phase of the project the team plans to add intent-based management to the NaaS platform.

Watch this video to learn more about the project:



Focus on customers

Another ongoing project that’s using the new intent API is [Translating customer needs into service and network intent](#), which is championed by KDDI Research, Orange, Telus and Verizon. A previous phase of the Catalyst also included BT.

The team is using 5G network slicing in a B2B2X use case, a live broadcast service for pop-up events that requires live streaming with quality-of-service guarantees. The intent capture phase allows the customer, an event organizer, to outline their needs (the business intent) using a self-service portal.

The new Intent API is used to construct the initial phase of the intent lifecycle into the interface with service order management. This helps CSPs overcome a persistent challenge they are facing: cumbersome and time-consuming manual processes in order management. TM Forum will be publishing a case study of this project in July.

Autonomous networks hyperloops for vertical use cases

Now in its fourth phase, the [Autonomous networks hyperloops](#) Catalyst has been looking at how to create ANs using intent, closed loops, 5G network slicing and AI to enable smart vertical use cases such as distance learning/education, smart farming and smart stadiums. In this phase, the team is adding smart manufacturing and emergency services, with a use case for delivering pop-up mobile networks in the event of a natural disaster. It is also focusing on the global architecture needed to support the use cases and the role for new technologies like metaverse and digital twins.

The project is championed by Orange, NTT, Chungwa Telecom and Verizon, and Christian Maitre, Group Director in Charge of Development and Strategy of Smart Cities at Orange, has been involved from the outset. “We think that the important point is to understand how we can manage the automation at any level for all this connectivity with verticals,” he says. “It was

important for us to say we need to have a standard architecture of closed loops for everything – that’s why it’s called hyperloops. Hyperloops look at how to automate, and intent is why to automate.”

At DTW 2023 the team will show a use case for a pop-up mobile network – a small 5G base station that can be dropped by drones into an area experiencing a natural disaster such as an earthquake. It will also explore using metaverse visualization to help teams on the ground navigate a geography that could look very different from how it’s depicted on maps because of destruction.

Read [the team’s white paper](#) and watch the video to learn more:



Zero-touch marketplace

Another project called [Zero-touch digital marketplace](#), now in its fifth phase, is using NaaS, intent and network slicing to develop a digital ecosystem platform that CSPs can use to sell connectivity and other services provided by partners across verticals. The team has demonstrated smart healthcare applications (for example, connected ambulance and hospital asset tracking), reduction of energy consumption in smart spaces (buildings and other facilities), improved fan experience in a stadium and gaming use cases.

In this phase, championed by Colt, Verizon and stc, an area of focus is on how to enable intent-based, closed-loop autonomous operations to deliver connectivity-as-a-service (CaaS). In the example, the team will show service degrading, which necessitates finding replacement connectivity. A new [suite of CaaS APIs](#) will be used to enable the closed-loop operations using intent and potentially generative AI.

In the next section, we look at the potential for generative AI and some challenges around the use of data.

section 6:

large language models shine the spotlight on AI's potential – and risks

Hype about generative AI and large language models (LLMs) like ChatGPT is at full throttle. Many expect the technology to be revolutionary in the same way that the internet and iPhone have been, but at the same time scientists have been sounding the alarm about generative AI's potential to [cause harm](#) and [possibly even human extinction](#). CSPs are getting started with generative AI and believe it will help them improve customer experience and AIOps. But they are wary of "[hallucinations](#)" – incorrect or inaccurate responses to questions or tasks – and realize that the new technology will only be as useful as the data it relies on.

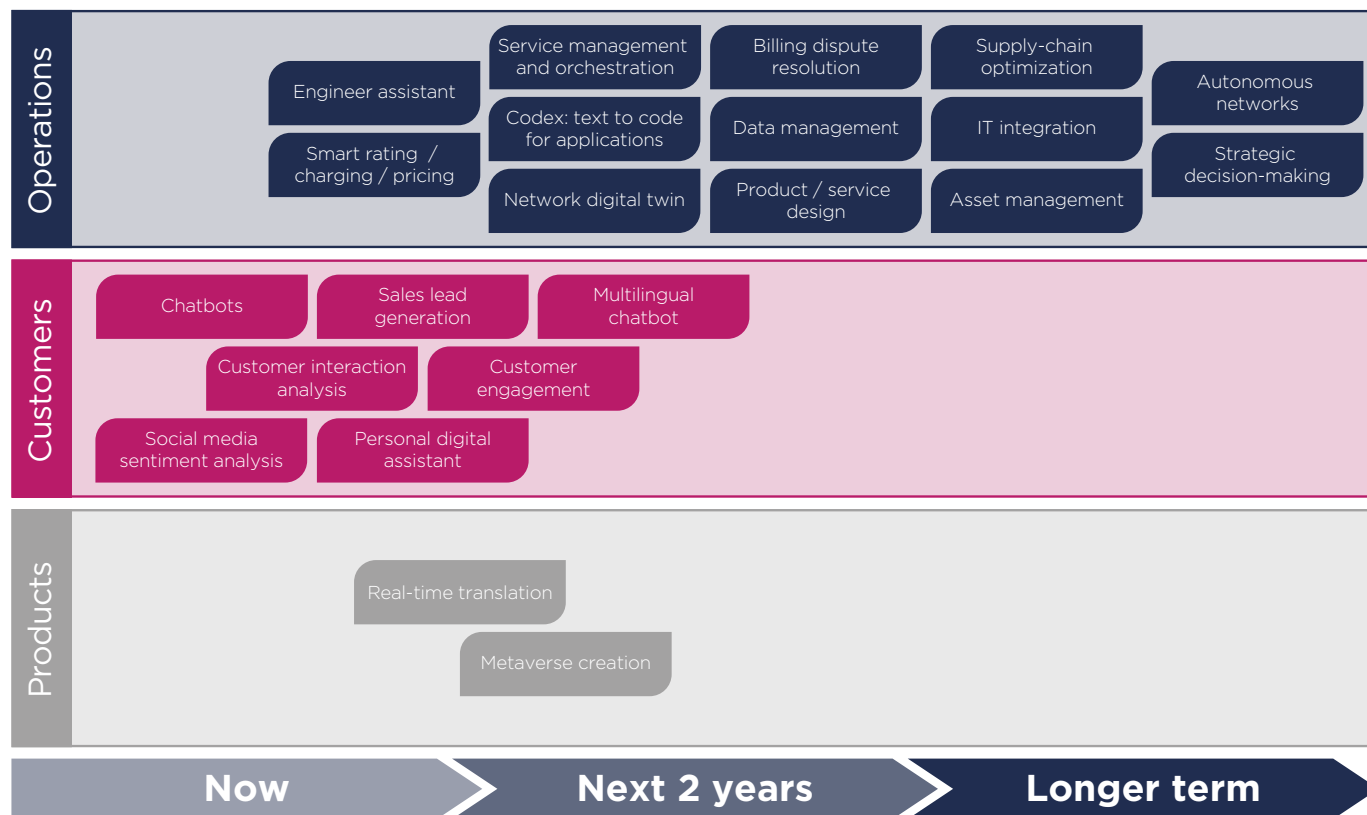
Generative AI refers to any machine learning model capable of dynamically creating output after it has been trained. The algorithms create new content based on patterns learned from existing data. LLM is a type of generative AI that can understand and generate human-

like language – [OpenAI's ChatGPT](#) (now at [version 4](#)) is the most well-known example. ([Read this blog](#) for a good primer on generative AI and LLM).

The graphic on p.30, created collaboratively by TM Forum and Bain & Company, shows some of

the current applications for generative AI in customer experience, operations and product management, along with future use cases. Use of the technology in autonomous networks or for strategic decision-making are likely still years away.

Generative AI will be introduced in phases



TM Forum, 2023

Bain & Company [classifies generative AI use cases](#) into “Horizon 1” and “Horizon 2” and urges CSPs to prioritize applications that are simple with minimal risk and then move on to more complex (and more valuable) applications. Horizon 1 apps might include generating sales scripts for call center agents, rapid testing and learning in marketing (which is still reviewed by humans), or automating routine code generation in IT. Horizon 2 apps might include creating a real-time testing tool for marketing, or an AI assistant for field technicians that can provide guidance in real time based on photos, voice cues or text.

CSPs are already beginning to use generative AI to augment the jobs that human customer service agents perform. Our recent report [Counter intelligence: using AI to](#)

[improve customer experience](#) explains how operators are using AI in general to improve customer experience (CX) and highlights some pitfalls of generative AI.

Read the report to find out more:



For this report we did not ask a question in our survey specifically about generative AI, but we discussed it in interviews. All the operators we spoke with said they have concerns about generative AI's tendency to hallucinate and/or return responses that may not be appropriate.

Some of the CSPs that Telco+ works with tested the use of ChatGPT to respond to customers' inquiries but stopped because the AI delivered inappropriate material in response to a test question from a young student. “ChatGPT is a great tool, but it doesn't know whether the user is an 11-year-old student or an adult,” says Telco+'s Luukkonen. “Here in Asia, there is a lot of sensitivity around inappropriate material and also around race and religion because our countries are so diverse, so we're a little afraid of the technology.”

Orange's Leboucher sees hallucinations as a significant obstacle. “We need to understand in depth when that happens and how we can mitigate this kind of risk if we want to apply [generative AI] to network automation,” he says.

Focus on AIOps

But AI also has many positive applications. Potential AIOps use cases for generative AI follow, some of which are also non-generative AI applications in AIOps.

■ **Network optimization and management** – generative AI can help telcos improve network performance and reliability by generating code and analyzing data to detect network problems. For example, an LLM can generate network topology diagrams or build a digital twin based on text descriptions, and learn patterns from historical data to identify anomalies and the root cause of problems. It can also automate troubleshooting and predictive maintenance. China Telecom, for example, is building its own generative AI system to find the root cause of network problems (see box above right).

■ **Field operations** – generative AI can use data to enable dynamic and real-time routing to optimize routes for technicians. This will reduce travel time and fuel costs and improve service delivery. Leboucher envisions using the technology for network operating centers, service management centers and field operations. “By leveraging all the capacity of machine learning and graph representations of the network, we could drill down into problem resolution,” he explains. “Then we can feed the information to technicians in a way which is easy for people on the ground to understand so that they can be as efficient as possible in problem solving and interaction with customers.”

■ **Security and fraud detection** – generative AI can be used to analyze terabytes of network

China Telecom builds its own ChatGPT-like system

China Telecom is using generative AI to build a system for analyzing and addressing the root cause of faults in its network. The company is taking a ChatGPT-like approach to analyzing text and generating answers, but it is using its own [knowledge graph](#) (a collection of interlinked structured and unstructured data), rather than the publicly available data sets used for training LLMs like ChatGPT and Google Bard.

“LLM can perform well in summarizing, reasoning and content generation, but due to its probabilistic nature it is clearly limited in scenarios that require a high accuracy of results,” Qian

Bing, R&D Director, China Telecom [told TM Forum recently](#). “Combining large-scale knowledge graphs with LLM will become a future technology trend.”

Knowledge graphs on their own are limited because network engineers can only query knowledge that has been extracted through the graph. By adding an LLM, the engineer can look up and summarize more answers based on information that wasn’t extracted. “Between the knowledge graph and the ChatGPT-type system you can find an answer, but you need to be confined by expertise. You cannot be prescriptive enough,” says Bing.

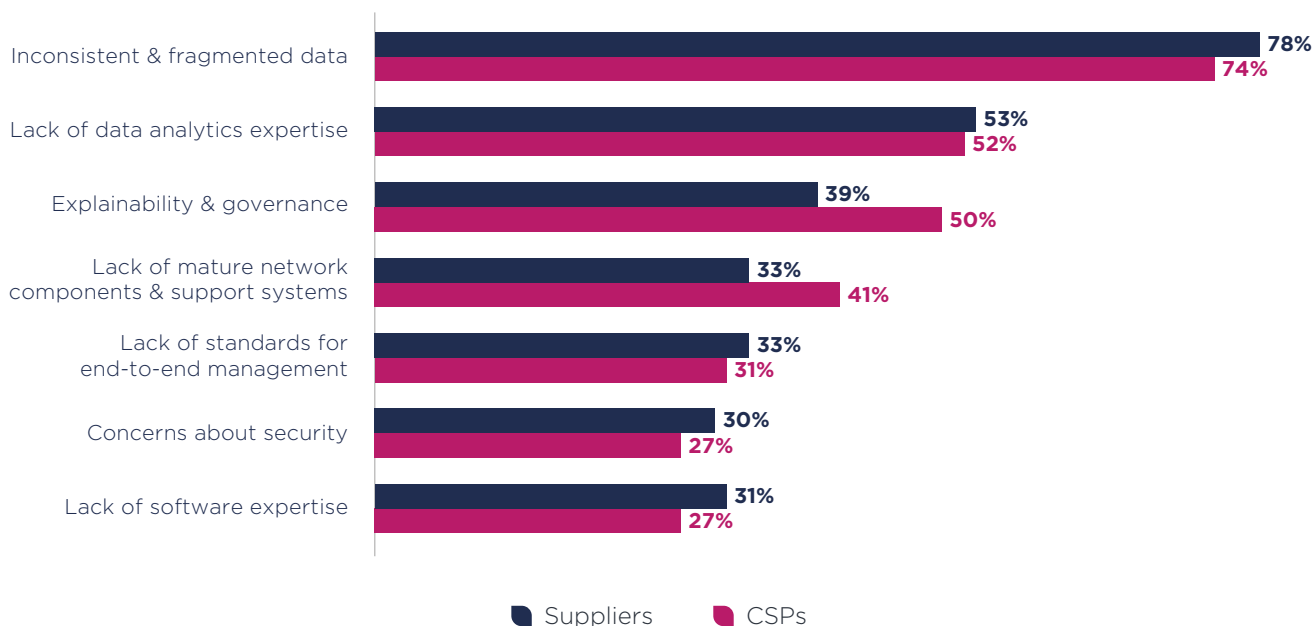
data to detect anomalies, enhance security and improve fraud detection. For example, it can identify fraudulent activity such as SIM swap attacks or unauthorized access to customer accounts.

■ **Writing software code** – generative AI models can be trained on large code repositories to provide code completion suggestions as developers write code or to generate entirely new code. For example, a model could analyze context, infer a developer’s intentions and generate suggestions for completing code snippets, or it could be used by non-technical staff to create code from scratch. Generative AI can also be used to refactor code and debug it. AT&T recently announced that it is giving employees access to a tool called Ask AT&T, which relies on ChatGPT. The first use case is “helping our coders and software developers

across the company become more productive” writes Andy Markus, AT&T’s Chief Data Officer, [in a blog](#). Upgrading legacy software code and environments is another use case it is exploring, along with support for customer care agents, translating customer and employee documentation from English into other languages, answering HR questions, and summarizing meetings and action items.

■ **Real-time language translation** – Leboucher sees this as an interesting use for generative AI: “When you want to create shared capacity in a telco that can be used by different affiliates, people are often using different languages. At some point, if we’re able to translate languages in real time and very efficiently, we can solve [the Babel problem](#).”

Challenges to implementing AIOps



TM Forum, 2023

Dealing with data

As China Telecom's Bing notes, a significant obstacle for operators to overcome with generative AI or any other type of machine learning is access to – and quality of – data. It is by far the top AIOps challenge, according to our survey (see graphic above). In fact, the top three obstacles are related to data.

“AI can be only as good as the data it has – it needs to learn,” says Luukkonen. “And we need quality data to really make it happen.”

Before joining Telco+ in 2021, Luukkonen was a partner in Accenture's telecoms practice for many years. In his role now he is helping multiple CSPs in the Asia-Pacific region transform into digital service providers. He spends “every day on data topics” asking the same questions: “How do we extract the data? What are the data models? How do we build APIs to the data? How near real time does it need to be? Can we

write back to the BSS from the digital twin – and how do we make the data consistent so that the AI has a holistic view and really is a digital twin... It's amazing the amount of discussion around it, because it's so fundamental to being able to be AI-driven.”

Finding the right skills to support the data strategy is also difficult. Data engineers who can extract data from systems are not so hard to find, but hiring data architects who can develop the data strategy, decide how to structure data and apply governance is difficult because they are in high demand everywhere, according to Luukkonen.

SingTel created a data analytics unit called DataSpark, which provides mobility data solutions to enterprises and helped to monetize the telco's data. The division was moved into NCS in 2021. “They actually know how to market and manage the data, which we on the OSS/BSS side

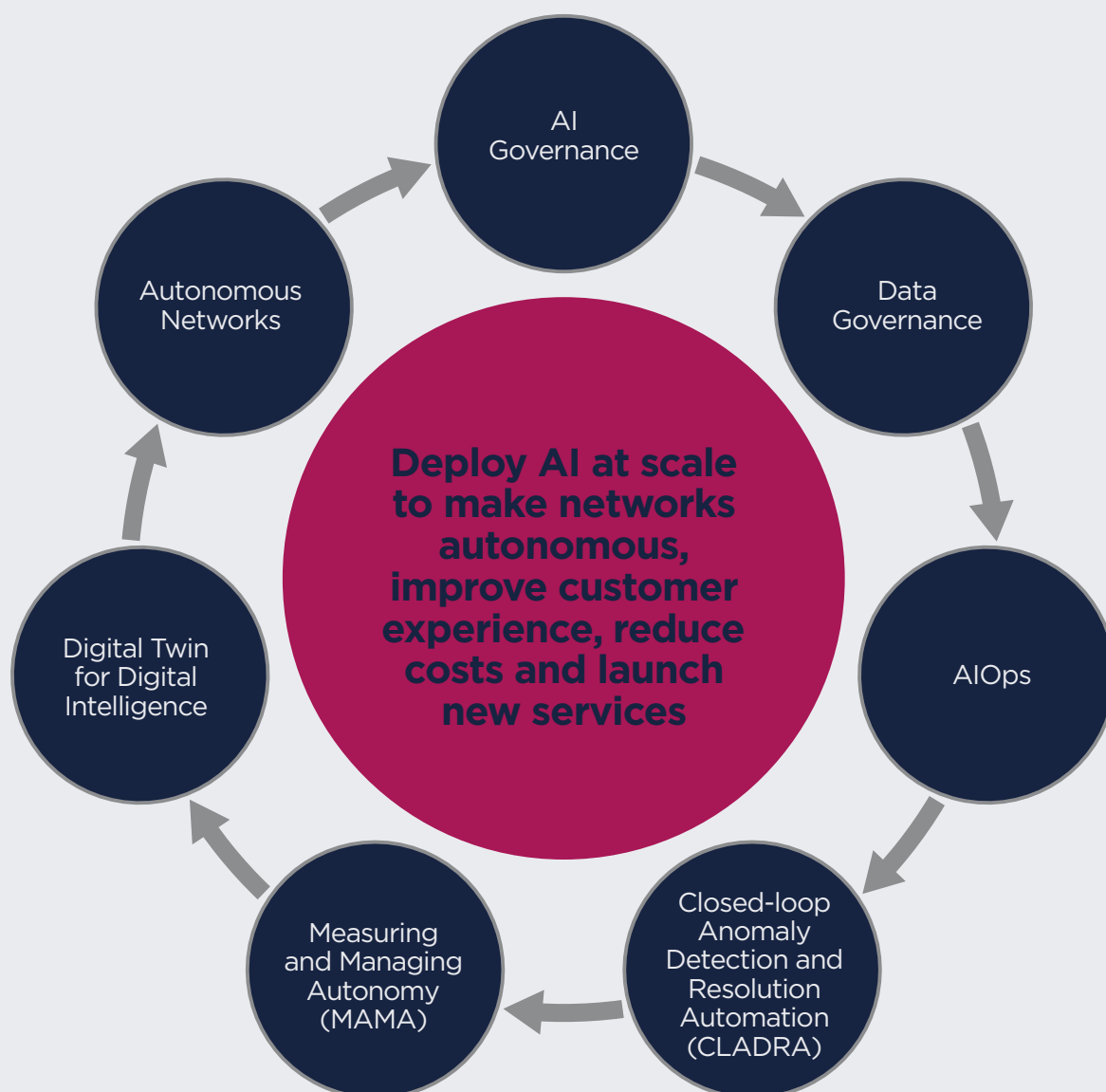
didn't understand,” Luukkonen says. “When you're building your data architecture, you need to have a product management mentality.”

Rahul Kumar, Senior Partner and Global Industry Leader – Telecommunications and Media Industries at IBM Consulting, agrees and says access to data, governance of it and explainability are all key to scaling AI. “There is no AI without IA, which is information architecture,” he says. “The pain points around data architecture and governance absolutely are a big barrier for mass-scale adoption of AI across the board.”

The graphic on the following page shows some of TM Forum's projects and resources designed to advance autonomous networks.

And in the next section we look at the importance of standards to next-generation networks and why collaboration is key to reducing complexity.

Collaborate on autonomous networks and AI



TM Forum, 2023

CSPs and their suppliers are working together in many TM Forum projects to advance autonomous networks. **The graphic above includes links to the projects**, which use and build on TM Forum's ODA and Open APIs.

Teams working in these areas are creating autonomous network and AIOps frameworks, maturity models, APIs and tools to help CSPs scale solutions. "To implement AI and automation you've got to make sure you're ready from a business and technology point of view," says Aaron Boasman-Patel, TM Forum's VP of AI, Labs and Innovation. "On the business side, leadership, vision and changing culture are all important. On the technology side, end-to-end model management for AI is critical, and for autonomous networks, the architecture is key."

To learn more and find out how you can get involved, please contact [Aaron Boasman-Patel](#).

section 7:

standardization is becoming more important – why collaboration is key

A huge number of standards bodies and open-source groups are working on the deployment and management of next-generation telecoms networks (see table on p.36). But even when operators adopt standards, differences in how they implement them can sometimes make interoperability difficult. As CSPs push to monetize technologies such as 5G, they are hoping for more collaboration among projects to reduce complexity and avoid re-inventing the wheel.

During a recent [panel discussion](#), KPN's Fouladi outlined a significant challenge for the telecoms industry: "We all go to conferences on GSMA and CAMARA, and we all sign up for standardized APIs. In the past ten years we have put a humongous amount of capex into changing all of our applications to be software defined. We've made massive investments in 5G, which is about openness of our network... So, we're speaking the openness

language throughout our industry, but our industry has a core part of its DNA that is not working well enough together to be able to be globally competitive."

The push to automate services like 5G network slicing at scale and implement autonomous networks more widely is highlighting the important role that standard protocols, open architectures and open APIs play in helping telcos become more competitive. For example, two relatively recent additions to the long list of

groups working on telecoms interoperability – the [O-RAN Alliance](#) and [the CAMARA Project](#) – were born largely from CSPs' need to monetize 5G.

The O-RAN Alliance is developing standards for the service management and orchestration portion of the Open RAN architecture (see the box on the next page). These standards are being designed to interoperate with the [TM Forum Open APIs](#) already in place in many CSPs' service operations environments.

The CAMARA project was jointly founded by GSMA and the Linux Foundation and sits within the latter's organization. GSMA focuses on how network capabilities support service APIs and aligns the service API roadmap with those of network and cloud vendors. Its [Open Gateway initiative](#) aims to drive universal adoption of APIs designed to expose network capabilities without the need for end-user developers to understand telecoms network technology or terminology.

The Open Gateway APIs are being developed in the CAMARA project. TM Forum is supporting this initiative through its collaboration with CAMARA, which includes a joint Catalyst proof of concept championed by a dozen CSPs (AT&T, Axiata Group, Dialog, Ncell, XL, Orange, TIM, Telefónica, Telenor Group, Telstra, Verizon and Vodafone Group). The Catalyst will be demonstrated at Digital Transformation World in September.

To learn more about the joint Catalyst, read this report:



Reducing complexity

CSPs need to agree on a common architecture and open interfaces in order to automate ordering, provisioning, orchestration and assurance of services across multiple domains including mobile RAN and core, multi-access edge computing (MEC), IP and optical networks.

Why is Open RAN important?

Open RAN aims to enable interoperability between different components of the radio access network (RAN), including base stations, radios and control units. In effect, CSPs are applying the same kind of transformation that has happened in IT operations – moving to the cloud and adoption of open APIs and AI – to mobile network operations. The open interfaces are needed to connect service-level intelligence stored in OSS/BSS with network functionality.

Using this approach in the RAN lowers the cost of entry for

suppliers and opens the door to startups. Operators argue that this will reduce costs, encourage innovation and eliminate vendor lock-in.

Read our report on Open RAN to learn more:



“5G slicing is the first time our mobile networks will include customer-specific requirements; there are learning and re-use opportunities from how the fixed-access domain has enabled this,” says Vodafone’s Thomas. “And we need better collaboration between the standards organizations to agree their respective roles in driving end-to-end standards.”

The table spanning the next two pages, which is by no means exhaustive, shows some of the key, open-source projects and standards development organizations (SDOs) that CSPs and their suppliers are supporting. The sheer number of initiatives illustrates complexity that mirrors what CSPs are grappling with in their own businesses as they apply lessons learned in IT transformation to the network.

Joining any one of the groups usually involves spending money on membership and the commitment of an employee’s (or multiple employees’) time. Sometimes a single staff member has responsibility for a company’s participation in more than one group.

But implementing the standards and open interfaces doesn’t always guarantee interoperability. [According to Gedeon at Telus](#), “the devil is in the detail on the cost” to achieve true interoperability for an effort like Open RAN. “Nobody can afford 200 or 300 people to get [the standards] to work,” he says. “I think the level of maturity, in terms of seamless, is not quite there, but we’ve definitely made inroads.”

Pairing up

Orange’s Laurent Leboucher is an active and long-time TM Forum member. He is also an NGMN board member. He sees an opportunity for the two groups to collaborate on a “horizontal operating model” that leverages a common telco cloud stack. Projects Nephio and Sylva are doing work to advance the telco cloud stack, while TM Forum’s ODA provides a framework, common language and design principles to promote interoperability of software components, which are accessed through [Open APIs](#).

The idea would be for CSPs to implement on top of the common stack GitOps at scale and pipelines for network functions and network services chains that aggregate different network functions. “If we want to do that, we need to define this operating model so that everyone understands it in detail and so that we can also map roles onto this operating model,” says Leboucher.

Leboucher and Thomas, who together pioneered TM Forum’s API program, envision TM Forum playing a unifying role in intent-based automation similar to the one the organization has played in adoption of standard APIs.

“For all these use cases, defining intent-driven management is necessary,” Leboucher says. “The Forum has some very interesting

assets because it traditionally brings together IT for telco. Now, we need to bring those IT practices to the network with network vendors.”

If you are interested in finding out more about TM Forum’s work on AI and autonomous networks please contact [Aaron Boasman-Patel](#).

Snapshot of SDOs and others working on telco interoperability

Organization	Focus
3GPP	Consortium of seven SDOs from around the world that is creating protocols for next-generation mobile networks; responsible for developing 5G non-standalone (NSA) and standalone (SA) specs.
Anuket	Linux Foundation project formed by the recent merger of two other open-source projects: the Cloud iNfrastructure Telco Taskforce and OPNFV; goal is to deliver a common model, standardized reference infrastructure specs, and conformance and performance frameworks for virtual network functions (VNFs) and cloud-native functions (CNFs).
Broadband Forum	Develops next-generation IP network specs focusing on architecture, management and digital CPE to help CSPs deploy and manage hybrid networks from a single IP-centric platform; the group has used Domain Context Specialization to extend TM Forum Open APIs for use by its members.
CAMARA	Joint effort between GSMA and the Linux Foundation to provide a single, centralized repository for end-user APIs, including those developed by TM Forum; focuses on how to expose mobile network capabilities via APIs for external consumption by developers outside telecoms.
Cloud Native Computing Foundation	Linux Foundation project that aims to establish a vendor-agnostic community of developers, end users and IT technology and service providers to collaborate on open-source cloud-native computing projects.
ETSI	ETSI’s standardization activities focus on Europe. Example include Zero-touch Network & Service Management (ETSI - ZSM), Experiential Networked Intelligence (ETSI - ENI) and the ETSI ISG NFV working group, which develops requirements and architecture for virtualization of network functions.
IETF	Develops internet standards; CSPs use IETF’s NETCONF protocol to install and manage the configuration of network devices, while the YANG data modelling language describes the configuration changes.
ITU	Specialized UN agency that promotes the shared global use of radio spectrum, facilitates international cooperation in assigning satellite orbits, and assists in developing and co-ordinating worldwide technical standards.
GSMA	GSMA’s Open Gateway initiative aims to drive universal adoption of APIs designed to expose network capabilities without the need for developers to understand network technology or terminology; work includes drafting recommendations on mapping between CAMARA APIs and technical APIs from bodies like 3GPP, IETF, ETSI NFV and TM Forum.
Linux Foundation	A subsidiary of Linux Foundation called LF Networking is the umbrella organization supporting Anuket, ONAP and other projects focusing on networking; another subsidiary, LF Europe, is home to Sylva, which aims to build an open-source cloud software framework.
MEF	Standardizes Carrier Ethernet services so that enterprise LANs can extend across WANs; added extensions to the Open APIs to create its LSO and Sonata APIs and now offers an API blending tool that relies on TM Forum Open APIs.
Nephio	Joint project of the Linux Foundation and Google Cloud focusing on cloud- and intent-based automation; goal is to simplify deployment and management of multi-vendor cloud infrastructure and network functions at scale.
NGMN Alliance	Association of mobile network operators focusing on network management, disaggregation, sustainability, and 5G and 6G use cases.
Open Config	informal working group of network operators and vendors working on dynamic, programmable infrastructure; promotes a vendor-neutral model for network management that uses YANG data modelling.

TM Forum, 2023

Organization	Focus
ONAP	Linux Foundation project formed when AT&T's ECOMP open-source project merged with the Open Orchestrator initiative, which was pioneered by China Mobile and China Telecom and supported by Orange; charter is to develop an open-source platform for managing and orchestrating virtualized networks.
ONF	Founded in 2011 by Deutsche Telekom, Facebook, Google, Microsoft, Verizon and Yahoo! to focus on promoting the adoption of software-defined networking (SDN) through open standards development.
O-RAN Alliance	Founded by AT&T, China Mobile, Deutsche Telekom, NTT and Orange to develop fully interoperable mobile networks by focusing on interworking between different components of the RAN, including base stations, radios and control units; is developing standards for Open RAN service management and orchestration that interwork with TM Forum Open APIs.
Sylva	Linux Foundation Europe project that aims to create a new, open-source, production-grade telco cloud stack; goal is to develop a common cloud software framework and reference implementation to reduce fragmentation of the cloud infrastructure layer for telecoms services.
Telecom Infra Project	Engineering-focused initiative led by Meta (Facebook) to bring CSPs, infrastructure providers, systems integrators and other tech companies together to collaborate on development of new technologies; is working on open RAN solutions to accelerate uptake.
TM Forum	Develops the Open Digital Architecture and Open APIs (see p.45), which provide programmable access to capabilities in OSS, BSS and online charging systems; more than 70 Open APIs are available and widely implemented under the Apache 2.0 license.

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additional features & resources

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Achieving Commercial Agility through Automation

Monetising the network and beyond

CSPs are stuck between a rock and a hard place, with too many goals and too few resources to deliver them. Digital transformation remains a significant hurdle for CSPs planning to diversify their market offerings, expand beyond the network connection, and achieve operational efficiencies through automation. However, the complex nature of legacy systems often impedes progress, meaning CSPs should consider a different approach to their transformation strategy.

Hansen believes in order to accelerate new business models, monetise the network and realise new revenue opportunities beyond core network connectivity, **CSPs must place priority focus on the systems and processes which improve their commercial agility, explicitly their ability to create, sell and deliver new offerings to market.**

Unlocking Transformation Potential

The crux of the issue lies in the tightly coupled nature of their legacy systems.

Just like a house of cards, if an IT department attempts to modify one aspect of the stack, they risk destabilising the entire structure. Meaning, what started out as a modest enquiry into improving the backend, results in being knee deep in documentation, a Gantt chart reaching out into the next

decade and business leaders raising an eyebrow at the proposed cost.

Instead, to drive their digital transformation forward, CSPs must take a pragmatic approach and identify which areas of their IT landscape can be modernised while continuing to use existing BSS components such as Billing, Network Management and CRM.

Building an Agile Commercial Layer

To kickstart the transformation journey, CSPs should implement an agile layer of technology focused on modernising their commercial capabilities, specifically around the creation, selling and delivery of new market offerings for consumer and enterprise customers alike.

By tackling this area of transformation first, enables a CSP to achieve commercial agility, meaning their business can



To kickstart the transformation journey, CSPs should implement an agile layer of technology focused on modernising their commercial capabilities, specifically around the creation, selling and delivery of new market offerings for consumer and enterprise customers alike.

rapidly adapt to market changes and customer demands, all while driving efficiency gains across the

business as legacy processes and ways of working are retired by introducing automation.

By leveraging TM Forum ODA principles and integrating with existing IT infrastructure, this agile commercial layer can coexist with legacy applications, allowing for more localised and successful transformation efforts without the need for a BSS reset.

Decoupling the network from the product lifecycle

An important step on the journey to achieving commercial agility is to implement ODA “Network as a Service” (NaaS) principles, allowing CSPs to decouple the product lifecycle from network technologies.

This approach standardises the exposure of network capabilities as services, abstracting the underlying complexities and employing a common suite of APIs.

The intent-based concept ensures a consistent service consumption pattern, limiting the scope of the transformation journey and facilitating rapid monetisation of new network capabilities through an automated factory model.

Building on this abstraction, provides a key feed into the agile commercial layer, which comprises of catalog-driven applications that empower the business to capitalise on existing and emerging commercial opportunities.

Powering Commercial Agility

The adoption of a centralised enterprise product catalog (EPC) is essential for attaining commercial agility. Specifically, one that operates across service and resource domains and seamlessly consumes service definitions, partner products, and services through an automated service discovery mechanism facilitated by

TM Forum Open APIs. To effectively transform network capabilities and partner offerings into compelling market propositions, the EPC must equip a CSP with advanced product lifecycle management (PLM) capabilities. A key component of this advanced PLM should be an intuitive, reusable, and component-based graphical user interface (GUI) that streamlines the proposition development process and empowers non-technical users to create and launch new offerings with minimal reliance on IT.

Streamlining Process through Automation

To drive efficiencies during proposition development, the EPC must enable the digitalisation of core processes, such as governance workflows. The need to align and co-ordinate multiple meetings to gain consensus needs to be consigned to the past as automation is not just about expediting tasks and enabling faster execution from the reduction in human-error, it is also about moving away from legacy, in-person, process.

Furthermore, the incorporation of automation into the proposition development process, should serve as a catalyst for change by mitigating risks associated with launching new products, compelling CSPs to become customer centric. The focus shifts from *“what are we able to launch*

within the given timeframe?” to *“what do our customers want?”*

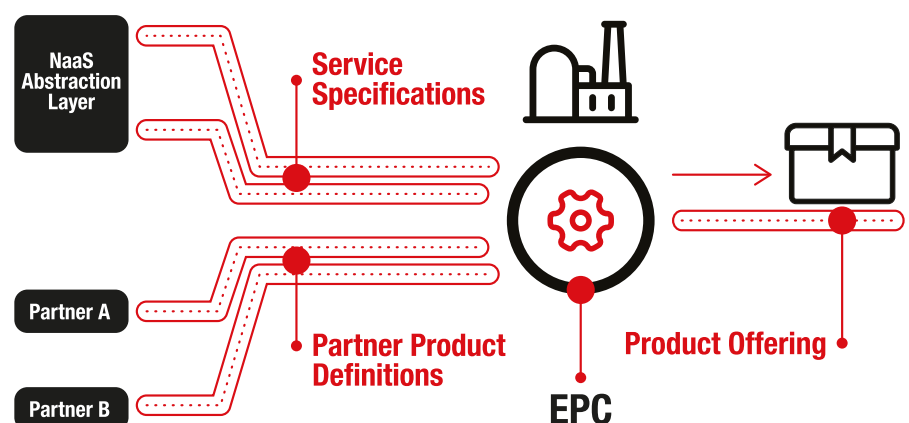
Essentially, the described EPC, disrupts the traditional triple constraint model of time, resources, and scope, and establishes a factory-like model, facilitating the rapid transformation of ideas into revenue, thus keeping the brand image dynamic and fresh.

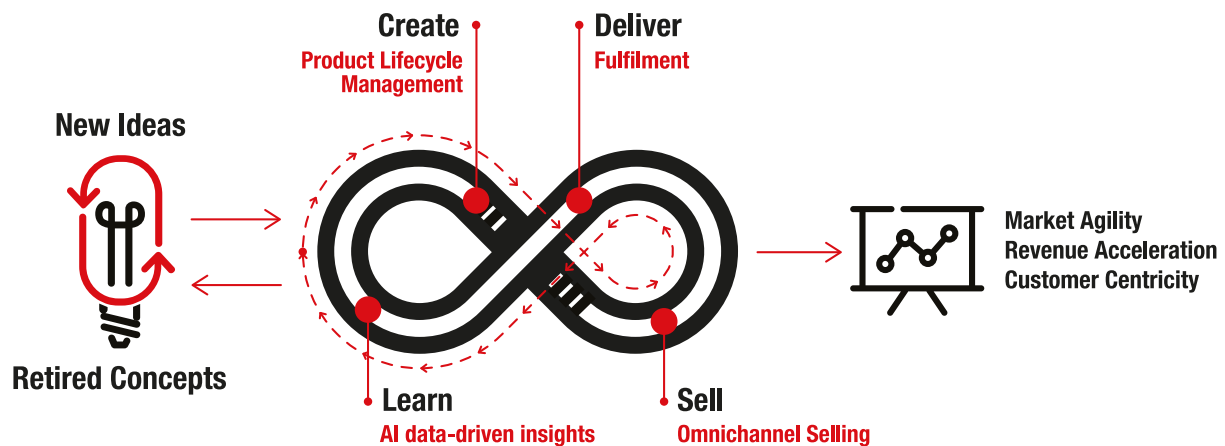
The effectiveness of this methodology stems from the standardised modelling of network capabilities, partner products and services within the EPC. Consequently, future adoption of new capabilities, products, and services becomes equally effortless, while downstream catalog-driven applications responsible for selling and fulfilment processes easily consume and process the data.

Creating an Agile Selling and Fulfilment Layer

To maintain momentum, CSPs must also implement an agile selling and fulfilment layer that matches the accuracy and efficiency realised during the proposition creation process.

A catalog-driven architecture is key to driving precision and consistency across these layers as it leverages the common data model defined in the EPC, meaning data flows smoothly through the downstream systems and accurately feeds all automated workflows.





The agile selling layer must leverage the EPC as the single source of truth for product, resource, and service data to grant CSPs the control and autonomy needed to create and implement the sales experience they originally intended to deliver. Furthermore, an agile selling layer must consist of true omnichannel capabilities, which allows for a consistent customer experience across every sales channel. This capability ensures that every touchpoint and customer interaction is as flawless as the next while giving customers the flexibility to purchase from their channel of choice.

Post purchase, the agile fulfilment layer should also utilise the same common-data model defined in the EPC, to eliminate errors such as order fallout which are traditionally caused by mismatched data between the product, sales and fulfilment domains.

These errors typically lead to increased operational costs as well as the erosion of brand equity as CSPs struggle to maintain service levels and meet customer expectations.

Therefore, as market offerings diversify and become more intricate, it is critical the agile fulfilment layer can process and orchestrate at pace, orders of any

size or complexity or risk devaluing the efficiency gains realised earlier in the process.

Creating the foundation for ML

The agile commercial layer has the capability to generate the data set needed as a foundation for building machine learning algorithms, and to also consume the insights that these algorithms produce. This consistent data set, modelled within the enterprise product catalog (EPC), and consumed by catalog-driven applications in the sales and fulfilment cycles, provides a clean, unified and real time view of the products sold, who purchased them and their buying and fulfilment journeys. This foundational data, supplemented with information from other sources, facilitates the training and implementation of advanced machine learning algorithms, which can then be used to unlock valuable insights, identify patterns, and make data-driven decisions to optimise sales strategies, improve customer targeting, and enhance the efficiency of fulfilment processes. These AI-based insights can then be consumed in real time and utilised by the agile commercial layer which empowers CSPs to drive innovation, stay ahead of the competition, and deliver personalised customer experiences.

In Conclusion

By prioritising the modernisation and automation of their commercial capabilities with an agile layer of catalog-driven technology, comprising of the key capabilities outlined above, CSPs can transcend the limitations of their wider IT landscape and seize new market opportunities without overhauling their entire stack.

Ultimately, this solution not only empowers CSPs to provide innovative new offerings, enhance customer experiences, and maintain a fresh and competitive market presence, but also with the ability to drive additional revenues which could directly fund broader transformation efforts.

About Hansen

Hansen is a global provider of software and services to the communications, technology and media industries.

Our cloud-native, TM Forum Open API compliant, suite of catalog-driven applications have helped CSPs around the world better capitalise on existing and emerging commercial opportunities.

Partner with Hansen today, achieve commercial agility, **and sell beyond the network.**



How Telcos Drive Mission-Critical Innovation and Cost Savings Through Automation

Modern telecommunications customers don't only expect flawless network performance, they demand it. For global enterprises that hold the key to human connection, the industry standard is nothing less than a fully integrated, customer-centric approach to service delivery.

How are telecommunications firms tackling these customer expectations today? By embracing AI and machine learning capabilities, developing new decisioning models, and ensuring network security and optimization with a 99.995% uptime SLA.

Why automation is vital in the telco modernization journey

AI adoption is growing at a break-neck speed, and the

telecommunications industry has a close eye on the way that automated decision-making can improve operational efficiency and reduce costs.

In the latest TM Forum Digital Transformation Tracker 7 survey, 73% of respondents agreed that operational efficiency and cost reduction were very important drivers of CSPs' digital transformation journeys, compared with 69% in 2022 and 65% in 2018. By eliminating manual tasks, and reducing errors introduced by

manual intervention, automation is improving end-to-end performance and reducing handoffs and touchpoints.

In the case of automated decision-making, it's possible to leverage large volumes of data that already exist within telco organizations, alongside data science and machine learning techniques, to generate data-driven insights and inferences to better serve customers and develop cost savings.

Three automation use cases in the telecommunications industry

Here are three ways that MongoDB's customers in the telecommunications industry can innovate with automation:

1. Service assurance processes

Telcos can proactively identify issues impacting customers, or even predict them before they occur, utilizing automated processing of large amounts of diverse data. Network automation techniques can then step in to automatically remediate the situation, and output intent that can be processed by intent-based network automation tooling.

2. Network automation

While service assurance processes can make decisions around what needs to be done, network automation tooling takes responsibility for effecting change. What's more, the demands of 5G networks will force operators to open up traditional closed systems to third parties via network APIs.

For example, these APIs can allow automated provisioning and configuration of 5G network slices. Customer expectations here will be that these operations are self-serve, and will happen in real time, making automation key.

3. Customer issue management

We've all come across chatbots used in B2C customer service experiences. As chatbots become more sophisticated, potentially leveraging modern generative AI techniques, many more customer care issues will be automated. This change will not only reduce the cost of call centers, but speed up mean time to resolution for customer care issues.

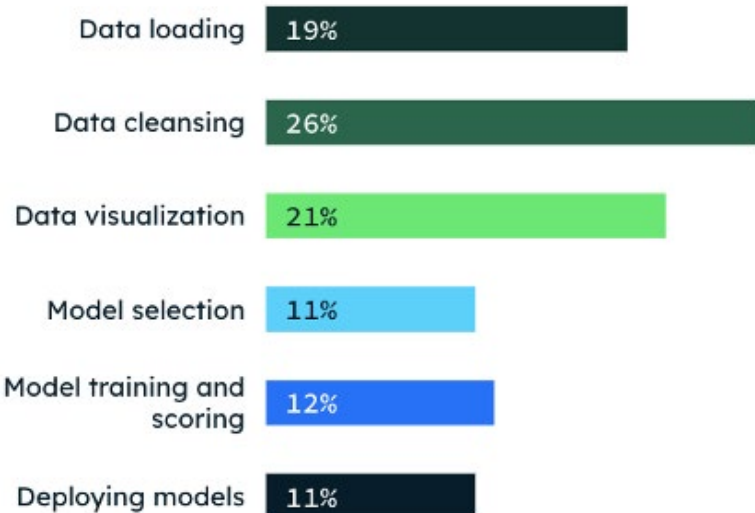


Figure 1: data processing operations for machine learning models.

The future of AI/ML-based automated decision-making in telecommunications

We've established the importance of automation for service assurance, network automation, and customer experiences. By utilizing the power of AI and data science, telcos have the opportunity to take these technologies further into the realm of network security and fraud mitigation. However, getting to automation with unstructured data is no simple task.

Studies show that more than 50% of data scientists' time is spent wrangling data, and more than 80% of all essential data is unstructured.

To build out a new AI/ML-based system, both data processing and ML capabilities must be in place. These two solutions are typically provided by different systems with clear integration points.

Any AI/ML-based solution requires large amounts of historical data to train the model. The storage and feeding of this data is usually the job of a traditional data warehouse

system. This gets complicated when decisions need to be made in real time with "live" data, such as in anti-fraud use cases.

To achieve real-time results, it's required to integrate an operational database into the architecture to stream real-time data and requests into the model and to persist the model output. In this hybrid system example, we have both operational and analytics data requirements co-existing; this interaction adds to the overall architectural complexity of the system. It's important to note that raw data cannot be used by AI models "as is." First the data must be cleaned, potentially deduplicated and turned into features. Standardized techniques are required to do this, including binning, normalization, standardization, and one-hot encoding. The aggregation pipeline provides powerful data processing capabilities that assist with this process.

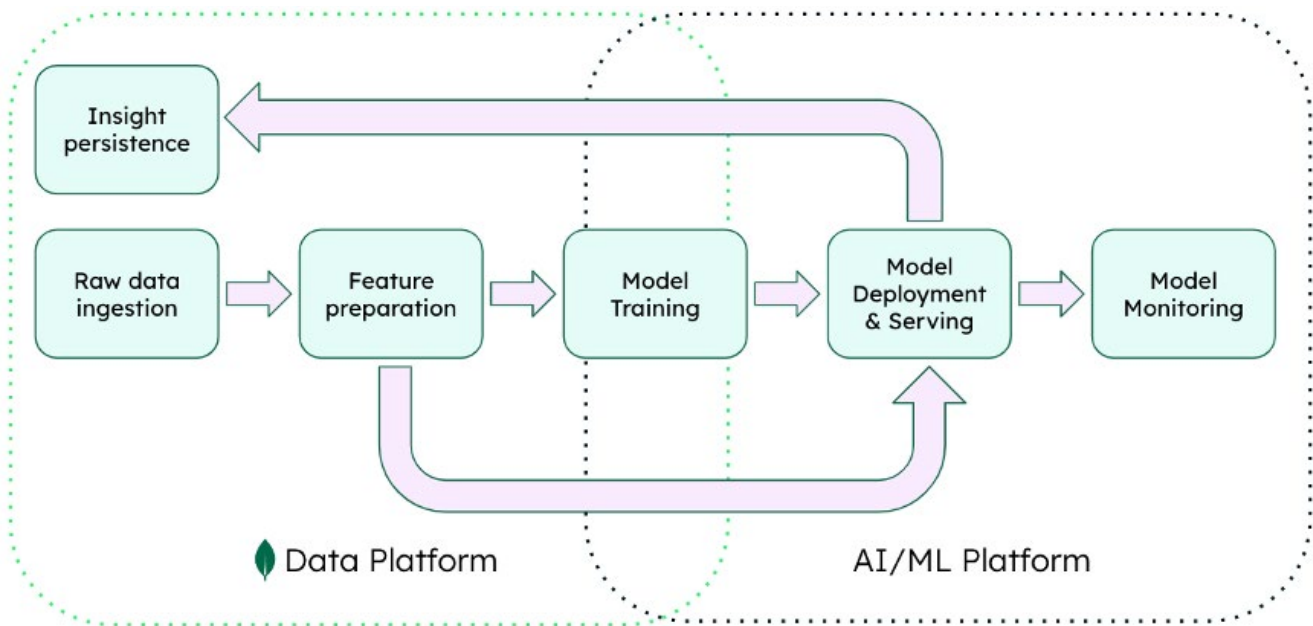


Figure 2: MongoDB's role in a machine learning pipeline.

MongoDB Atlas, the developer data platform, is capable of handling each of the above requirements from a single platform. Its analytical nodes and Data Lake allow for massive amounts of historical data storage, and service to the model for training purposes.

Real-time data can also be ingested and served through MongoDB Atlas via change streams, triggers, and integrations.

The powerful aggregation framework of MongoDB is capable of transforming raw data into usable features.

Lastly, integration patterns based on Spark, Kafka, and HTTP are supported out of the box, which greatly reduces overall architectural complexity.

Once decision-making models produce the new data output, it can be persisted back into the

transactional database automatically actioned by additional automation tooling.

Decision-making models will constantly evolve and will require new facets of data to be used. MongoDB's document model and dynamic schema naturally supports the ingestion of new types and formats of data without the need for complex schema changes.

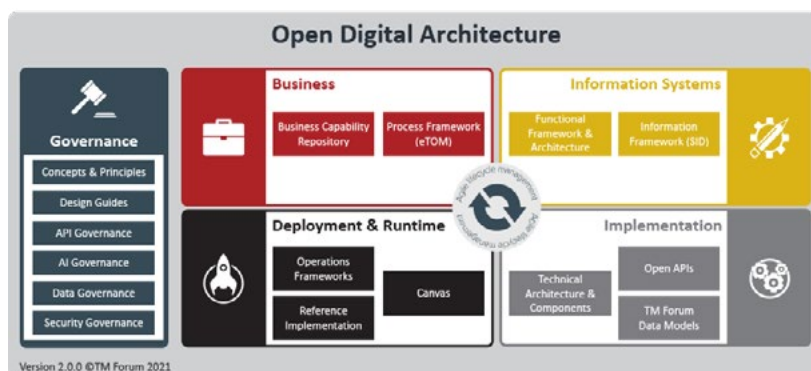
tm forum open digital framework

A blueprint for intelligent operations fit for the 5G era

The [TM Forum Open Digital Framework \(ODF\)](#) provides a migration path from legacy IT systems and processes to modular, cloud native software orchestrated using AI.

The framework comprises tools, code, knowledge and standards (machine-readable assets, not just documents). It is delivering business value for TM Forum members today, accelerating concept-to-cash, eliminating IT & network costs, and enhancing digital customer experience.

Developed by TM Forum member organizations through our [Collaboration Community](#) and [Catalyst proofs of concept](#), building on TM Forum's established standards, the Open Digital Framework is being used by leading service providers and software companies worldwide.



The framework comprises TM Forum's [Open Digital Architecture](#) (ODA), together with tools, models and data that guide the transformation to ODA from legacy IT systems and operations.

Open Digital Architecture

- Architecture framework, common language and design principles
- [Open APIs](#) exposing business services
- Standardized software components
- Reference implementation and test environment

Transformation Tools

- Guides to navigate digital transformation
- Tools to support the migration from legacy architecture to ODA

Maturity Tools & Data

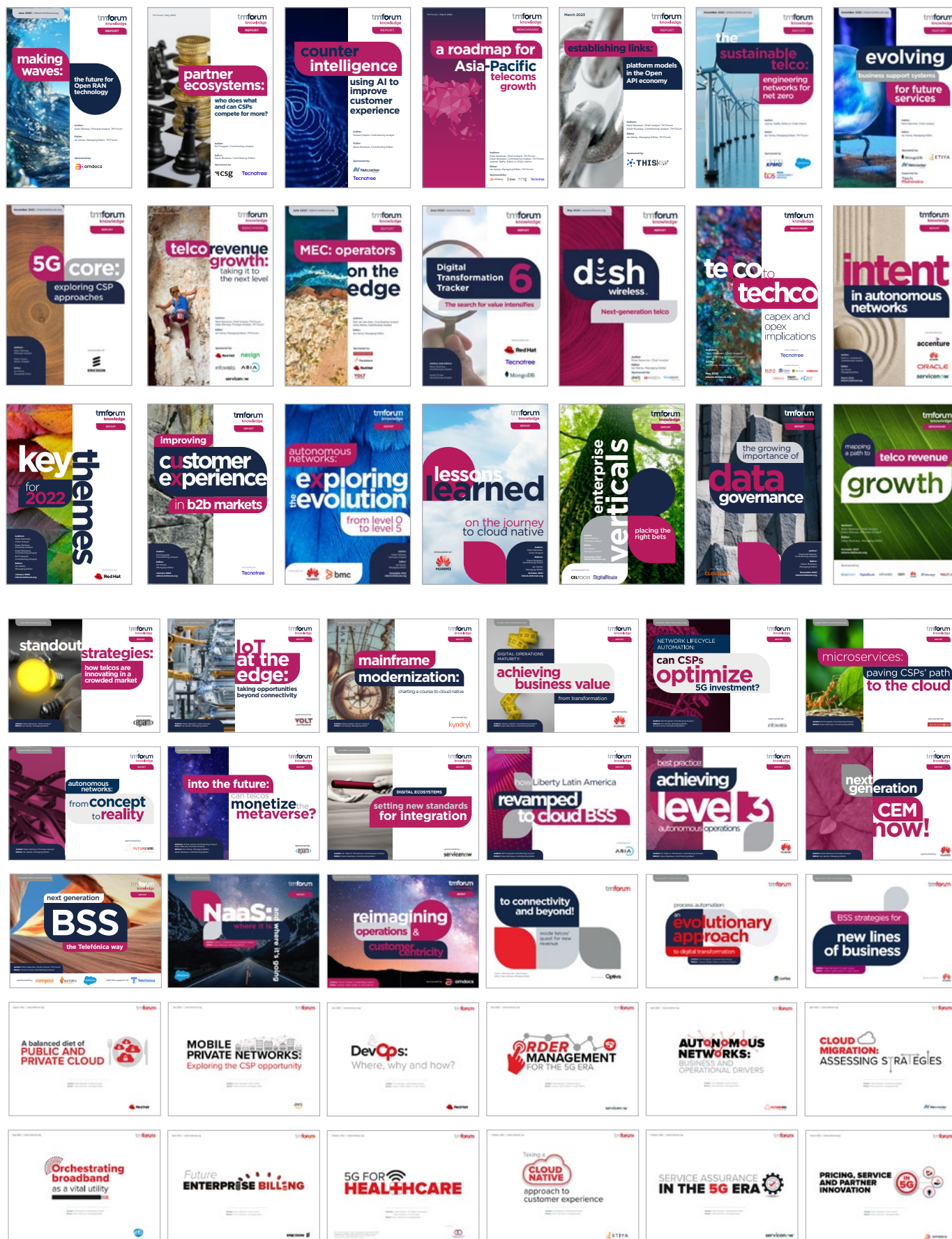
- Maturity models and readiness checks to baseline digital capabilities
- Data for benchmarking progress and training AI

Goals of the Open Digital Framework

The aim is to transform business agility (accelerating concept-to-cash from [18 months to 18 days](#)), enable simpler IT solutions that are easier and cheaper to deploy, integrate and upgrade, and to establish a standardized software model and market which benefits all parties (service providers, their suppliers and systems integrators).

Learn more about member collaboration

If you would like to learn more about the Open Digital Framework, or how to get involved in the TM Forum Collaboration Community, please contact [George Glass](#).



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