



Autonomous networks:

in search of best practice

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the big picture

In the past couple of years we have published reports that have set out clearly the challenges for communications service providers (CSPs) in the face of increasing network complexity, limited return on investment in 5G and growing expectations for improved customer experience. Our annual [telco revenue growth Benchmark reports](#) have highlighted how difficult it is for CSPs to establish new revenue streams and drive operational efficiency in order to compete with more agile start-ups and hyperscale cloud service providers. More recently, the emergence of AI has proven highly disruptive, but also represents significant opportunities for operators.

This report draws on some of our research this year to explore how AI and, more explicitly, automation can address these challenges. It looks at what CSPs are doing in terms of network automation both within TM Forum's member community and more widely, and attempts to identify some of the best practices of operators striving to go beyond simple automation to implement autonomous networks (AN).

As part of this new research we conducted a survey which drew responses from 111 individuals at 82 companies (see section 2). Among the primary drivers for those respondents to implement AN are improving customer experience/satisfaction; simplifying operations and maintenance and improving personnel efficiency; and increasing resource efficiency

and utilization of network and IT. Among large operators – those with more than 100 million customers – 100% said supporting agile service delivery and accelerating time to market/monetization was the most important driver.

But there are many other reasons. Autonomous networks are not simply a technical evolution; they represent a transformative change in how networks operate, adapt and serve CSPs and their customers. Whereas automation relies on predefined rules, network autonomy involves intelligent systems making independent decisions – without input from humans.

In brief, much of the value for CSPs lies in the ability of AN to address three critical areas:

- **Operational efficiency.** AN optimizes resource

management through autonomous processes, managing network complexity and enabling CSPs to significantly reduce manual interventions and operational costs.

- **Customer experience transformation.** Customers demand reliable, seamless connectivity and personalized services. AN, based on an intent-driven architecture, enables CSPs to meet these expectations by proactively managing network quality and delivering service level guarantees.
- **Revenue and innovation potential.** AN unlocks new business models, such as [network-as-a-service](#) (NaaS), enabling CSPs to monetize their networks beyond traditional connectivity.

Moving up the AN levels

TM Forum is at the forefront of industry-wide collaboration to drive the deployment and evolution of AN technology, processes and business models. At the heart of that work is the [Autonomous Networks Project](#).

Ultimately, CSPs need to be able to scale orchestration of zero-touch, zero-wait and zero-trouble services end to end across different network domains (for example, radio access, fixed access, core, IP, optical transport and data center/cloud networks). This requires automation of the entire service lifecycle, from ordering to fulfillment, activation, orchestration, management, assurance, optimization and billing.

In conjunction with its community of CSP and solution provider members, the Forum has developed a six-level taxonomy for CSPs to measure their progress in implementing autonomous networks. Each level has a set of characteristics describing the evolutionary stage of the CSP's journey from manual to fully autonomous operations (see graphic).

According to TM Forum's definition, Level 4 autonomous networks represent a major shift from traditional human-defined automation processes to true autonomous decision-making. This is a significant leap from Level 3, where machines assist humans in decision-making but still rely on human oversight.

Today, most operators are between Levels 2 and 3. But until recently it's been difficult to gauge CSPs' progress deploying AN because there was not a standardized way to evaluate and compare implementations. That changed in 2024 with further standardization of TM Forum's methodology and tools for evaluating AN levels, as we'll see in sections 2 and 3 of this report.

Autonomous network levels



5

Fully autonomous network:

The system has closed-loop automation capabilities across multiple services, multiple domains (including partners' domains) and the entire lifecycle via cognitive self-adaptation.

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 via AI modeling and continuous learning.

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, closed-loop management via dynamically programmable policies.

2

Partial autonomous network:

The system enables closed-loop operations and maintenance for specific units under certain external environments via statically configured rules.

1

Assisted operations and maintenance:

The system executes a specific, repetitive subtask based on pre-configuration, which can be recorded online and traced, in order to increase execution efficiency.

0

Manual operations and maintenance:

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

Industry collaboration on AN

More than 60 CSPs worldwide have signed TM Forum's [AN Manifesto](#), pledging to work towards Level 4 autonomy, and dozens are participating in the Forum's AN level evaluation. Even more have participated in [AN Catalyst proof of concepts](#). More widely, across the telecoms industry, more than 120 AN standards and research projects have been initiated, with multiple standards development organizations and open-source groups working to define and deploy ANs (more on this in section 6).

Within TM Forum's [Autonomous Networks Project](#) many CSPs have outlined their AN visions and strategies, and 24 have carried out internal AN level assessments. A handful of CSPs have publicly stated they are adopting AN Level 4 "high-value scenarios", aiming to reach Level 4 for operational flows in some domains from 2025 to 2027.

At Level 4, the network can self-manage, self-optimize and handle complex tasks. To achieve this level of autonomy, CSPs need to translate their customers' business goals, or "intents", into network requirements that can be fulfilled without customers needing to understand the underlying infrastructure.

Dave Milham, TM Forum's Chief Architect, describes this transition: "Moving to AN Level 4's intent-based interfaces is a move from prescriptive supervision automation to declarative, delegated autonomy, in which AI does the reasoning."

Transitioning from automation to autonomy is a significant business and technology challenge. In November 2024, TM Forum published a blueprint framework for achieving AN Level 4, which emphasizes AI being embedded into all domain design, operation and processes, such as closed-loop orchestration, to enable intent-based services. Section 3 provides an overview of that blueprint.

"It is vital that AN leverages intent, so that instead of selling technology CSPs are selling connectivity that can be tailored to business outcomes," said TM Forum CTO George Glass in his keynote address at Innovate Asia24. The importance of intent in AI-driven networks and services is discussed further in the next section.

This inter-dependency between AI and AN is at the heart of an on-going industry dialog around 'AI for networks, versus networks for AI'. AI is critical for the evolution of AN, but AN is also critical to support future AI-driven demands on connectivity – in other words, ensuring that networks are AI-ready. CSPs must

adopt AI for networks, shifting from static, rules-based network automation to AI-enabled, dynamic orchestration across multiple network domains – from 5G RAN to IP transport and optical core.

We look at the role of AI in autonomous networks in the next section, as well as the business case for AN.

Read this report to understand:

- The business goals and visions driving AN adoption
- Which areas CSPs are prioritizing for AN implementation
- The relationship between AI and intent-based automation
- The blueprint for achieving AN Level 4
- How AN best practice is being defined in real-world network deployments.

To learn more about how CSPs are transitioning to Level 4 autonomous networks read TM Forum's Journey Guide:



section 1:

the business case for autonomous networks

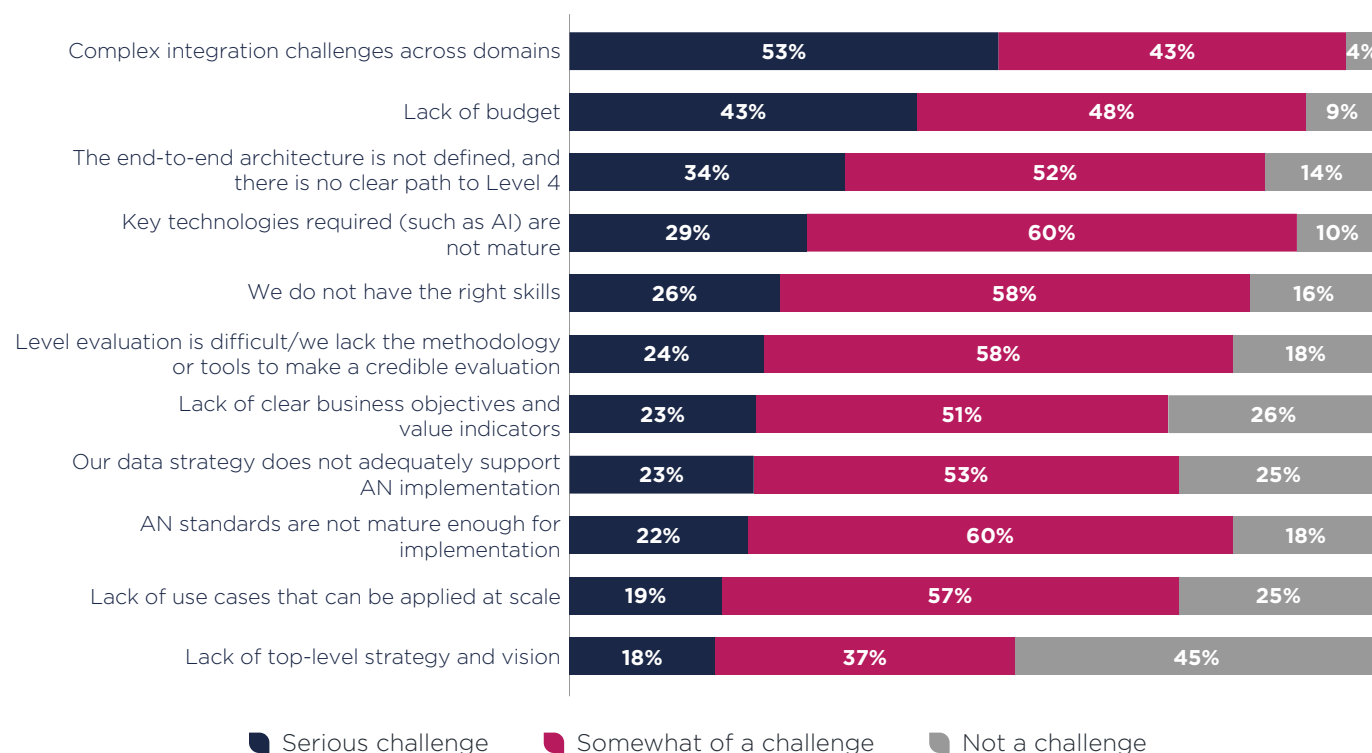
For most CSPs, adoption of AI comes with a dual focus: using AI to optimize their networks (as part of their transformation towards AN); and ensuring that their networks can support the dynamic requirements of emerging – and potentially revenue-generating – AI-powered applications.

In our survey for this report, we asked about the challenges CSPs face when implementing AN. The top three challenges are complex integration challenges across domains, lack of budget, and a lack of a clear path to Level 4 AN.

Anton Reynaldo Bonifacio, EVP, Chief Information Security Officer and Chief AI Officer, Globe Telecom, speaking at Innovate Asia24, emphasized the importance of establishing an AI-first culture to tackle some of

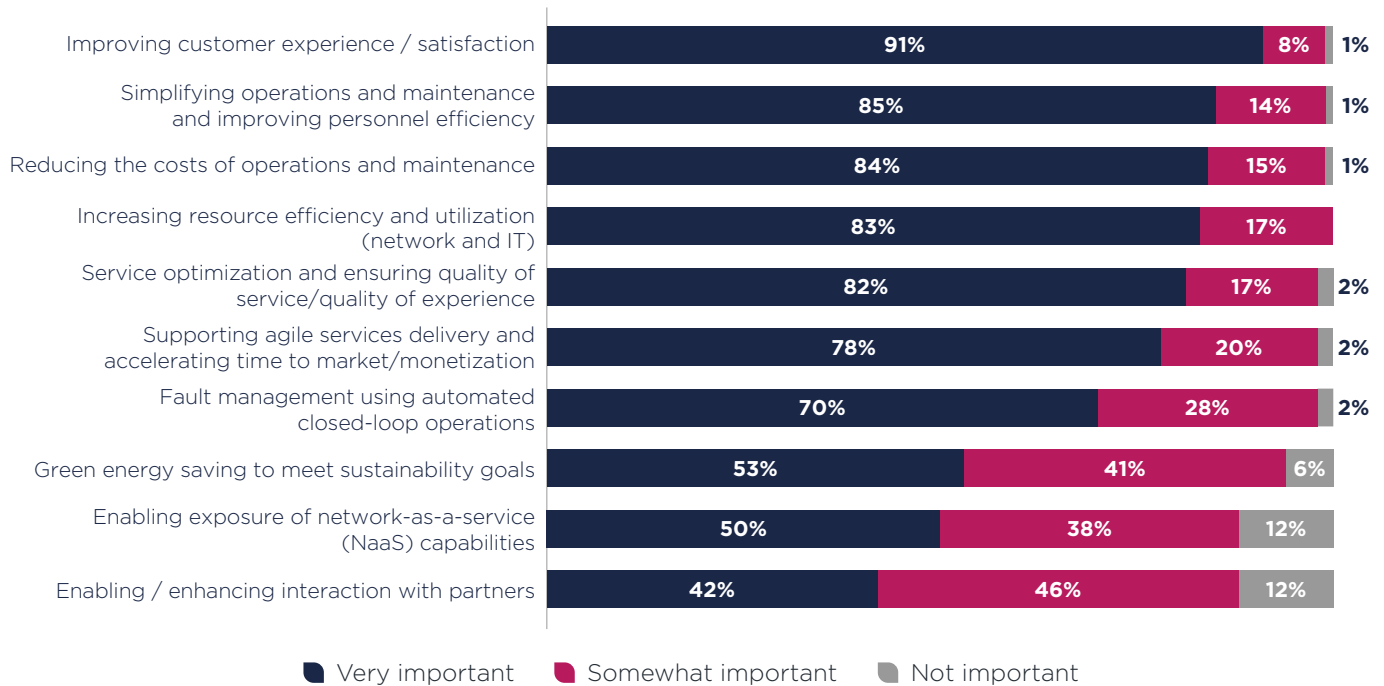
the inherent challenges and enhance growth and security in autonomous networks. In Globe's case, this is based on a democratized, bottom-up approach that is more tactical than strategic.

AN challenges



TM Forum, 2024

AN drivers



TM Forum, 2024

“We equip employees with AI capabilities to use where they feel it is appropriate rather than dictate use cases to focus on,” said Bonifacio. “Not ‘chasing ROI’ but considering AI in terms of employee, team, business or customer impact. It is important to have a ‘playground’ approach to allow for some openness to explore, but within safety net parameters, with no risk to customers.”

The ability to scale use cases for AN implementation is critical to the business case. 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 CSPs need to be able to scale orchestration of zero-touch, zero-wait and zero-trouble services, end-to-end across network domains. This requires automation of the entire service lifecycle, from ordering to

fulfillment, activation, orchestration, management, assurance, optimization and billing.

“We have an end-to-end service operation management layer on the top of the five different technical domains, and we are specifying for each year the technical maturity level requirements,” said Dr. Lingli Deng, Director and Researcher at China Mobile, [in an interview for TM Forum Inform](#). She said China Mobile is using its end-to-end service operation layer as the catalyst to drive overall development of technical AN capabilities.

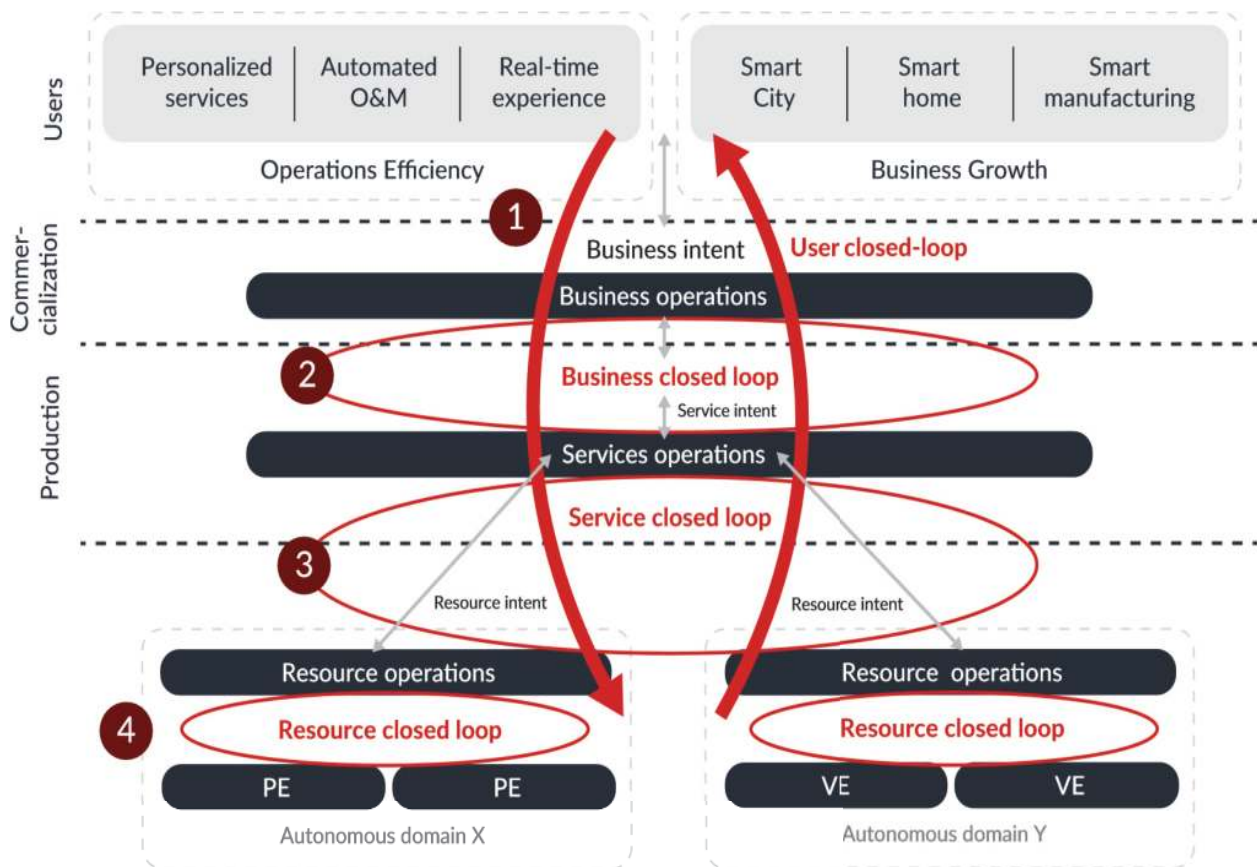
Despite the implementation challenges, ANs are crucial for CSPs to realize the full business potential of their infrastructure investments. In our survey, we asked respondents about their AN implementation drivers.

Perhaps unsurprisingly, the top-rated AN driver relates to

enhancing customer experience. Autonomous networks can help CSPs understand subscriber behavior and take proactive measures to improve customer satisfaction. For instance, AI-powered analysis enables CSPs to assess network performance, such as latency at the customer level, predict failures and improve network reliability.

In a keynote address at Innovate Asia24, Shanti Juanita Johari, CCO, Consumer Strategy and Business, Telekom Malaysia, spoke about driving a service culture through AI and AN. “We’ve made a customer promise to restore fixed broadband faults within 24 hours or your money back – quite a bold service differentiator. ‘Owning’ that promise is important: to drive a customer-centric culture within Telekom Malaysia and get employees thinking about the customer impact of automation activities.”

Intent-based, closed-loop management



TM Forum, 2024

He added that doing so has changed the internal perspective, from “a fear of losing money, to positive conversation about what we stand to gain. Engineering teams are motivated by tougher KPIs, and we are now implementing this type of promise in other areas of the business.”

The next two leading drivers for our survey respondents are interconnected: operational simplicity and cost efficiency. ANs enable CSPs to optimize operations and maintenance, reduce operational expenditure, and improve profitability – all key benefits while revenue from traditional telecoms services remains static. With autonomous networking, CSPs do not have to

use resources to conduct routine tasks such as provisioning and fault detection, lowering costs and time to rectify problems.

Intent-based networks

Intent is the driving force of AN, communicating requirements, constraints and preferences to an autonomous system, enabling CSPs to set the goals and parameters for AI models without prescribing specific actions. This allows the network to adapt more fluidly, and enables CSPs to turn their customers’ business goals, or intents, into instructions for the network that can be fulfilled without customers needing to understand the underlying infrastructure – abstracting its

complexity and communicating with customers using a common language or ontology that can also be machine readable.

The graphic shows the interaction of intents across a CSP’s operational layers. Intent-based management is baked into the AN journey at least as early as Level 3 of the six-level model described earlier (conditional autonomous networks) and becomes essential at levels 4 and 5 – highly and fully autonomous networks, respectively.

To be viable, intents must be grounded in data: observed, measured and controlled intents with which to drive the autonomous system, and verifiable under dynamically changeable conditions. And to manage these

processes the data must be accurate and easily accessible.

To automate the full lifecycle of services, intents are combined with closed-loop management. Closing the loop means collecting/analyzing data to figure out how networks can be optimized and implementing those changes in an automated way.

Intent can be expressed at various operational layers (business intent, service intent and resource intent, for example). In TM Forum's [AN Reference Architecture \(IG1251\)](#), intents guide the closed loop control process, which is a continuous process of monitoring, analyzing and adjusting performance to improve the quality of experience for end users and automate the full lifecycle of services.

"Intent... is our dream, our aspiration, but it depends on the maturity of the infrastructure itself," said Indra Mardiatna, [CTO of Indonesian operator Telkomsel, in an interview](#) with TM Forum Inform. "Maybe some use cases we can get to that level by 2025, but in some very complex cases [we] require more power... and more data, and we need time."

Using intent for slicing

Network slicing will be one of the first use cases for intent-based automation to enable the creation of multiple virtual (or logical) networks within a shared physical infrastructure. As network slices proliferate, CSPs will need to manage and orchestrate network resources. AI can help manage this complexity by predicting traffic flows and requirements, network issues and outages, and sending instructions to different network functions about solutions.

"Network slicing brings management, operations and maintenance complexity," says

Yessie Yosetya, Director and Chief Enterprise & Corporate Affairs Officer at XL Axiata. "Multi-dimensional management of hardware, resources, slice definition and applications are required. Only ANs can scale up to the demands of provisioning and maintaining the slice in real time."

CSPs will need intent-driven orchestration to support dynamic slicing. Whilst initial deployments of slices in the network can be done without full automation, to repeat this at scale, and handle different customer requirements, it will need to be intent-driven.

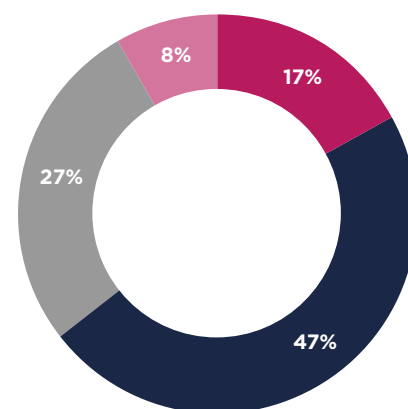
The role of GenAI in ANs

Generative AI (GenAI) will play an increasingly important role in AN, working together with other AI and machine learning technologies. Machine learning can be used to identify patterns in data, predict results based on historical information and make decisions, while GenAI is well suited to tasks requiring high creativity and innovation, such as intelligent Q&A for routine operations and maintenance tasks and complex network configuration.

Our survey asked respondents whether GenAI is being introduced into network operations. In total, 64% of respondents said they had either already implemented it or were planning to do so. But that still leaves one third who think that GenAI is either not mature enough for use in network operations yet or should not be used in mission-critical network functions (see pie chart above).

Combined, "traditional" AI and GenAI will be able to identify constantly changing network requirements and generate optimal network configurations. They can also help CSPs improve network performance and reliability by generating code and

CSPs' introduction of GenAI into network operations



- We have introduced GenAI in network operations
- We plan to introduce GenAI
- Generative AI is not mature enough for use in network operations yet
- The trustworthiness of GenAI is too uncertain for use in mission-critical network functions

TM Forum, 2024

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. China Telecom, for example, [is using GenAI to build a digital twin of its network](#) to enable root cause analysis.

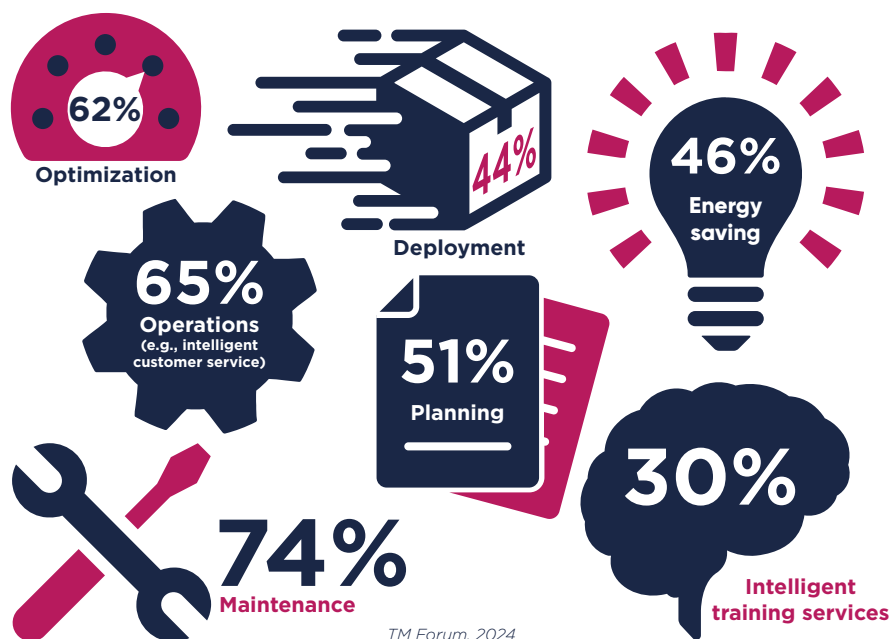
We asked CSPs how they are already using GenAI in the network. The majority (74%) said they are using it for network maintenance, such as automated troubleshooting and risk prediction. A high proportion are also using it for network operations, such as intelligent customer service, and network optimization, such as risk identification and automated verification of optimization (see graphic on the next page). We'll look at some differences in how small and large operators view GenAI in the next section.

Indeed, GenAI has multiple other potential applications for network operations:

- **Decision-making.** By interpreting complex, unstructured data such as field engineer reports, GenAI can refine AI models for better resource allocation and fault diagnosis.
- **Natural language interaction.** GenAI can provide intuitive interfaces for CSPs, allowing interaction with systems using natural language queries such as “How can I improve service quality in this area?”
- **Service innovation.** GenAI can analyze market trends and suggest new service offerings or network configurations tailored to emerging customer needs.
- **Security and fraud detection.** GenAI can be used to analyze terabytes of network data to detect anomalies, enhance security and improve fraud detection.
- **Software coding.** GenAI models can be trained on large code repositories to give completion prompts as developers write code, or to generate new code.
- **Real-time language translation.** It can also translate languages in real time, such as documentation, HR questions, summarizing meetings and so on.

[In an article for TM Forum Inform](#), Usman Javaid, Chief Products and Marketing Officer, Orange Business and Bruno Zerbib, the company’s Group CTIO, argue that networks need to change to accommodate a new era of GenAI and quantum computing. “Network service providers must lay the foundations, standards, and roadmap for a network for AI that is distributed, scalable, secure, and energy efficient,” they

How are CSPs using GenAI in the network?



say.. “This is why... TM Forum members are collaborating on an industry-specific data reference architecture, encircling both emerging AI-enabled business models and supporting networks.”

Data is key

In [TM Forum’s Modern Data Architecture Project](#) members are collaborating on a telecoms-specific data reference architecture, incorporating emerging AI-enabled business models. The project comes from the need to modernize data architectures to support the rapid evolution of AI and help define cutting-edge AI-enabled telecoms operations. The ultimate aim is to realize zero-touch efficiencies for a fully AI-enabled data architecture.

Lack of an adequate data strategy was rated as a serious challenge or somewhat of a challenge for AN implementation by 76% of respondents to our survey. Indeed, establishing a robust data culture within the CSP is critical.

“A strong data foundation is fundamental to intelligent operations. It underpins our

whole analytics and automation strategy,” says Olivier Simon, SVP Smart Network & Data, Orange Innovation Group. “For example, network performance is accessible to marketing employees as an automated data model, and customer complaint data can be referenced by network engineers. We refer to this as a ‘data democracy’ of multi-domain data sharing.”

For Orange, this has already increased usage of AI in the network, and the operator is also now increasingly using GenAI for multiple tasks including:

- Trouble ticket summarization
- Technical documentation retrieval for field engineers
- Natural language query on service issues
- Retrieving text logs for network clusters
- Correlating with previously successful network fixes.

In the next two sections we provide more analysis around the survey carried out for this report, giving CSPs’ perspectives on implementing AN.

section 2:

survey results – where are CSPs on the AN journey?

CSPs are making progress implementing autonomous networks, but the journey is taking longer than expected. When we began surveying operators about AN [at the beginning of 2020](#), no respondents reported that their companies had reached Level 3, and only 4% said they had reached Level 2. However, at the time about 40% saw a clear path to reaching Level 4 within four years. Now that we've reached that 2024 milestone, only 19% of respondents to the survey for this report said their companies have gone beyond Level 2 AN, and just 5% claimed they have reached Level 4 (see graphic below).

There are some caveats to consider in analyzing this data. Most importantly, respondents are self-reporting their progress, and we do not know how each of their companies evaluates its AN level. For example, we believe it is highly unlikely that 5% of respondents' companies have achieved Level 4 AN – at least in terms of overall network autonomy. We intended for the question to mean the average level achieved in the telco's network operations overall, but it's possible that when answering some respondents thought about a single domain or process where they have achieved Level 4.

The ambiguity highlights the pressing need for standardization of how operators assess their progress in achieving network autonomy. Indeed, until very recently true benchmarking of CSPs' AN levels was not even possible. In 2021, TM Forum's AN Project created the [Autonomous Network Levels Evaluation Methodology \(IG1252\)](#) to help operators self-assess their progress based on the levels defined in the guide. But even though the methodology has been updated

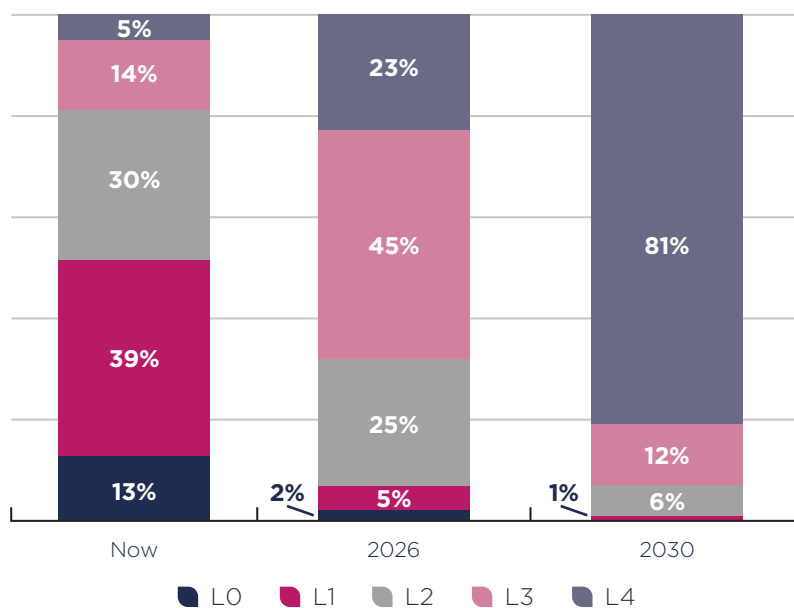
over time, detailed scoring for specific network domains and scenarios was never standardized.

A group of operators and suppliers participating in the AN Project changed that in 2024 with a series of workshops to further define AN level evaluation methodology and develop a more comprehensive self-service assessment tool. The team began with fault management in radio access and core networks

because an internal survey of project members identified those as key scenarios.

The latest results from TM Forum's assessments show that the average AN level score for fault management was 2.5 in the core network and 2.8 in the RAN. See section 3 for anonymized charts comparing CSPs' results and for more about the AN Project's efforts to improve standardization of AN level evaluation.

CSPs' AN levels now and in the future



TM Forum, 2024

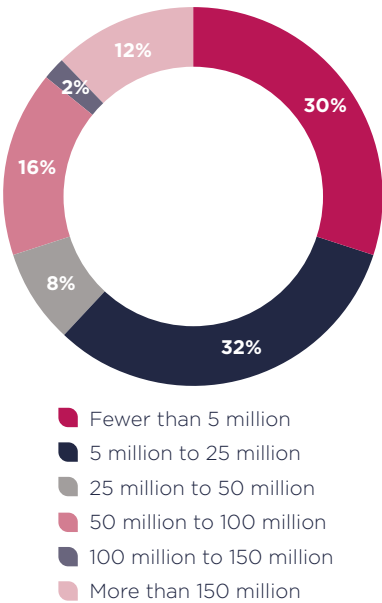
Who are the AN Benchmark respondents?

While this is TM Forum’s first autonomous networks Benchmark report, we have been surveying CSPs about AN since 2020. Each time, we have asked some of the same questions in the same way in order to gauge progress and changes in sentiment over time. However, while some survey respondents are the same from year to year, many are different. The demographic data below shows the scope of our 2024

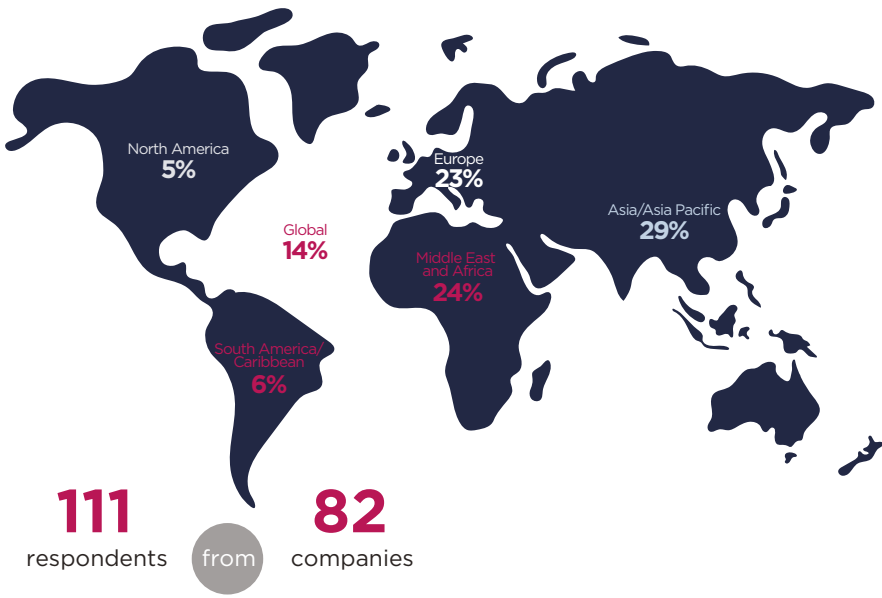
survey. More than 60% of respondents work for small operators – those serving 25 million subscribers or fewer. We define mid-sized CSPs as serving between 25 million and 100 million customers and large as serving more than 100 million. Because of the high number of respondents from small companies, we have analyzed some questions in this section by size of company, given that small operators often have

different needs and priorities than large ones. This year we also asked questions specifically about GenAI because of its fast-growing adoption among telcos and because AI in all its forms is necessary to achieve Level 4 AN – the level at which operations shift from traditional human-defined automation processes to true autonomous decision-making.

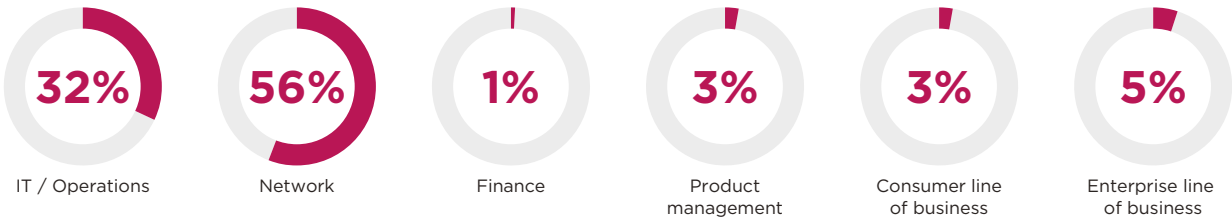
Size of CSP



Where are respondents from?

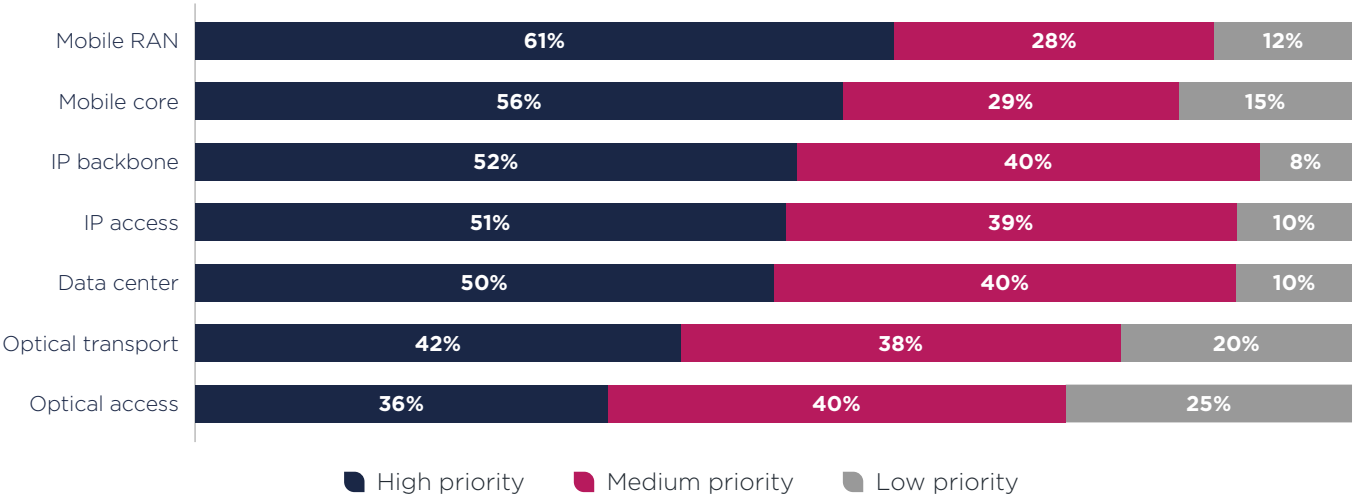


Respondents’ roles



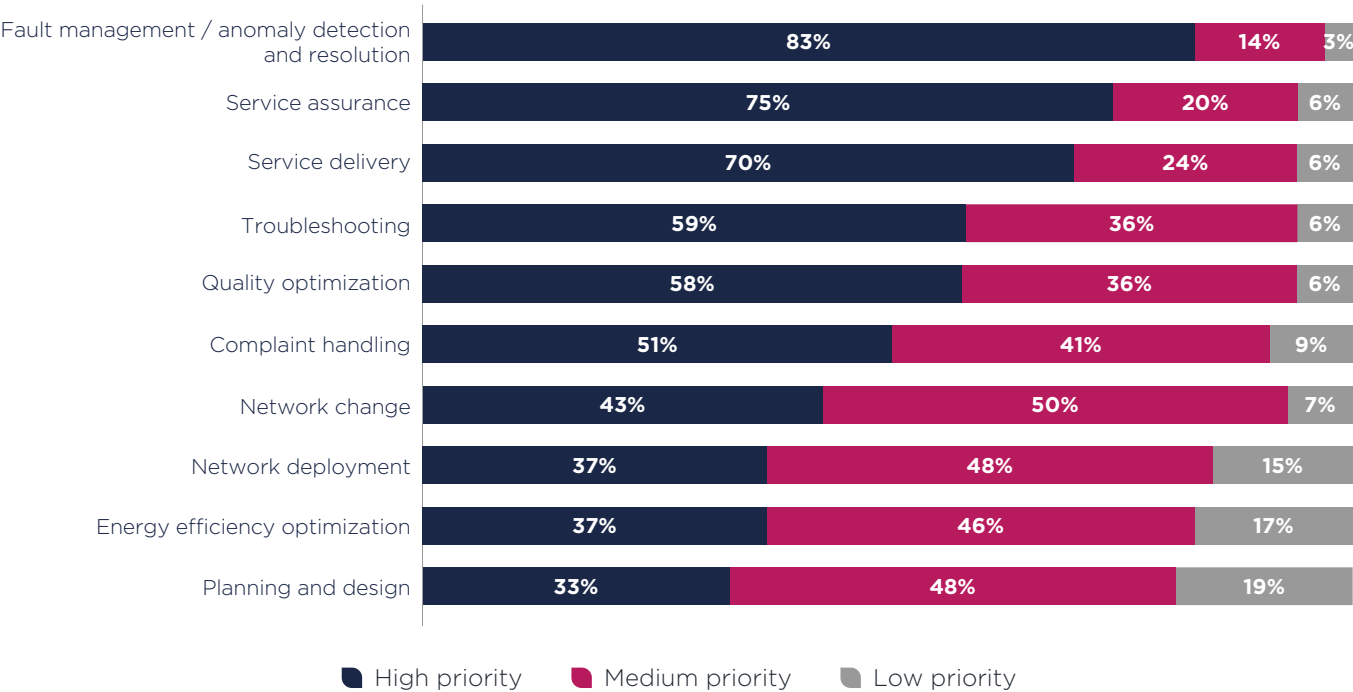
TM Forum, 2024
Note: Some graphics throughout the report do not add to 100% because of rounding.

Network domains CSPs are addressing first



TM Forum, 2024

Processes CSPs are addressing first



TM Forum, 2024

Domains and processes

Our survey results reinforce the AN Project team’s decisions about which domains and processes to focus on first. We found that the highest-priority domain is the mobile network followed by the IP network, with the highest-priority

processes being those that focus on improving customer experience, such as fault management, service assurance and service delivery (see graphics). Focusing on the mobile network first makes sense because of its complexity (see sidebar on page

15) and the potential for savings on energy consumption. The radio access network (RAN) accounts for about 80% of mobile network energy consumption, for example. In addition, guaranteeing customer experience in mobile networks is challenging today.

RANs are prone to outages because of complex infrastructure and environmental factors such as weather and physical obstructions. Automation can address these issues to improve customer experience and satisfaction.

As a network director for a UK-based telco [told Capgemini Research Institute](#): “RAN takes precedence due to frequent incidents. With numerous data centers and thousands of base stations, there’s a significant opportunity for workload reduction. In critical areas like data and voice in the core, operators maintain a conservative approach due to higher risks... The focus on RAN is driven by lower risk and greater automation opportunities, resulting in significant savings.”

The IP network is a high priority for telcos, too, in part because it is easier to automate than other domains. The IP network “by design has been implemented like an autonomous network with the routing protocols”, explained

Telenor’s Terje Jensen, SVP, Global Business Security Officer, [during a recent webinar about AN](#). “That’s probably one of the most advanced network domains, which is fundamental for the whole internet.”

When it comes to processes, telcos are focusing first on those that can improve customer experience, which in turn can lead to lower opex. “We are focusing on fault management – preventing, identifying, isolating, fixing and checking that the fault is fixed and the service is restored,” said Alexis Koalla, Director, Operations Strategy and Transformation, Orange, in the same AN webinar. “So, we are monitoring the KPI of the efficiency – the time we take to fix or to identify or to build the configuration – and indirectly this will save money for operations.”

Overcoming challenges

Two important conclusions we can draw from the answers to our survey question about AN

levels are that telcos of all sizes overwhelmingly want to achieve Level 4 autonomy, and they’re optimistic they will get there within this decade. A full 81% of respondents predicted that their companies will achieve Level 4 by 2030.

We’ve discussed telcos’ potential optimism bias in our [Digital Transformation Trackers](#). That phenomenon, which is the [scientifically described](#) propensity to overestimate the likelihood of positive events while underestimating the probability of negative ones, is almost certainly at work here, as survey respondents have overestimated their company’s ability to achieve Level 4 year after year. The empirical evidence from TM Forum’s assessment pilot points to the optimism bias as well (see page 21).

The reasons telcos have failed to meet their Level 4 goals to date are numerous – we highlighted the main challenges CSPs are facing in the chart in section 1 on

China Mobile uses AN and digital twins to reduce wireless network complexity

Wireless networks are complex for many reasons that make them difficult and costly to manage. The behavior of radio signals can be affected by physical objects and environmental conditions, leading to issues like interference and fading. Management of the limited radio frequency spectrum adds complexity because it requires efficient allocation to avoid interference. And users are constantly on the move, requiring seamless handovers.

In an effort to reduce such complexity, China Mobile Fujian is working with its supplier ZTE on a closed-loop, intelligent network optimization solution based on digital twins – a virtual model that

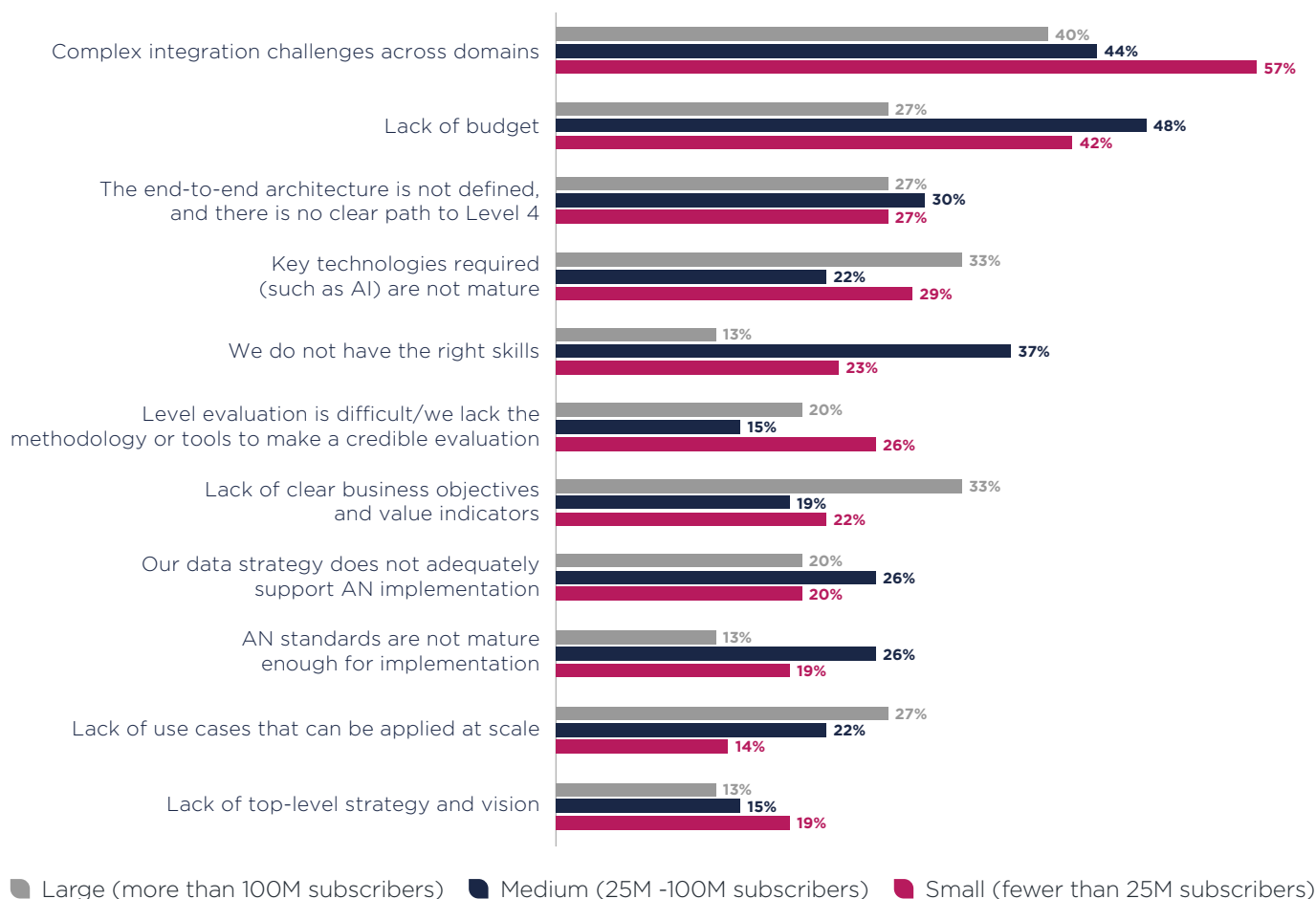
replicates network infrastructure and systems, allowing operators to monitor, simulate and optimize the network in real time. The solution builds high-precision twin models to conduct quantitative pre-evaluations on KPIs like network coverage, capacity and interference.

The results so far have been impressive. Compared with traditional methods, China Mobile Fujian’s digital-twin approach has reduced labor costs by about 25%. The cost of vehicles and equipment is down 29%, and the number of dispatching field work orders has been reduced by 34%. In addition, the network optimization cycle has been shortened by 70%.

China Mobile Fujian has applied its digital twin-based AN solution in a variety of settings. For example, it has been used to improve and enhance the network performance of major traffic intersections in Fujian.

After optimizing the networks of 25 intersections covering 30,000 customers, users’ network speed has increased from an average of 12Mbps to 18Mbps, and the number of complaints per 10,000 users has dropped from five to two. The company has also provided experience guarantees for 15 large-scale sporting events or concerts.

Serious AN challenges by size of company



TM Forum, 2024

page 7. The graphic above gives a more granular view of that data by looking at the most serious challenges by size of company.

The complex integration challenge posed by cross-domain automation is the biggest obstacle for every size of operator. Two key factors make it challenging: the vast number of legacy systems that most operators have throughout all network domains, and a legacy cultural mindset. TM Forum's AN Project advocates network abstraction via network-as-a-service (NaaS) and the use of business, service and resource intents to facilitate end-to-end,

cross-domain management. But this type of transformation is a huge shift for most telcos, and it takes time.

In Capgemini's report, which drew heavily on TM Forum's AN definitions and methodologies, the company asked about cross-domain skills. The survey of 335 telco executive respondents, which was conducted late in 2023, found this to be the second-largest skills gap when it comes to deploying AN, behind AI and machine learning skills. Having multi-disciplinary or cross-domain skills means that employees must have a combination of expertise, such as network engineers with

skills in data analytics or data analytics experts with network domain knowledge.

"This is a tough ask, as these skills have historically been developed in specialized silos," Capgemini says, noting that in the initial phases of the AN journey operators are likely to require more data, AI and automation skills. Later on, monitoring, problem-solving and decision-making skills become more important, it says.

Among the other challenges, budget is unsurprisingly a bigger concern for small and mid-sized telcos. They simply cannot justify hefty spending on new

technology like AI or to acquire the necessary skills for AN.

Among large operators, it's worth noting that nearly a third of respondents said they are concerned about being able to identify clear business objectives and value indicators for AN. This is somewhat surprising, given the potential for AN to cut operational costs and boost customer experience. TM Forum has identified several high-value scenarios in its work on the AN Level 4 Industry Blueprint. We'll look at some of them in the next section.

Lessons learned

This year we asked survey respondents an open-ended question: What is the most important lesson you've learned

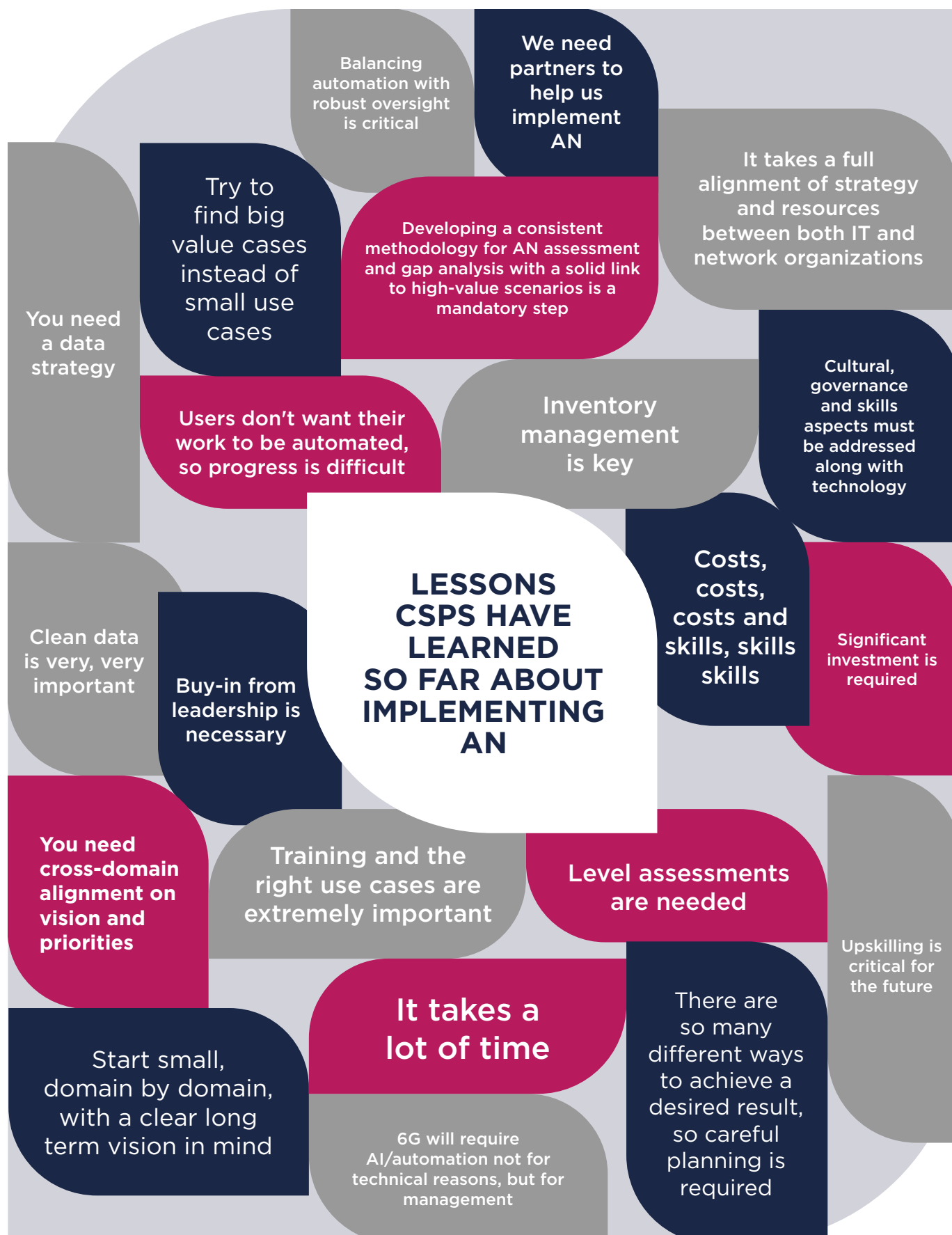
so far in implementing autonomous networks? Many operators offered similar advice such as the need to focus on developing a data strategy and acquire skills. Ensuring buy-in from leadership and alignment of strategy and resources across the business were other suggestions offered by multiple respondents.

The infographic on the next page shows many of the responses. The piece of advice that we think sums it up best is: "Start small, domain by domain, with a clear, long-term vision in mind." We would add: Be realistic and be patient – because you can't reach Level 4 overnight.

In the next section we look at how organizations are working to build consensus and define standards for autonomous networks.



Nearly a third of respondents from large operators said they are concerned about being able to identify clear business objectives and value indicators for AN.



section 3:

creating a blueprint for Level 4 autonomous networks

TM Forum is one of several standards development organizations and open-source groups that are defining and evolving autonomous network concepts, standards, implementation methods and use cases to build consensus across the telecoms industry. Here we look at some key parts of the vision defined by TM Forum's AN Project, with particular focus on the group's creation of a blueprint for Level 4 high-value AN use cases. This section of the report is primarily taken from TM Forum's [latest AN guide](#), with the addition of some further analysis of our survey results.

We've already discussed CSPs' goals to deliver zero-wait, zero-touch and zero-trouble experiences for consumers and businesses through intelligent infrastructure and AI-enabled operations, which is TM Forum's vision for AN. We've also explained what it means for a CSP's operations to be highly autonomous and the role for intent.

To help CSPs implement AN, the AN Project has also developed a framework and target architecture, which consists of guiding architectural principles, a business architecture, and the technical and formal reference architectures needed to realize AN. Using all these tools, CSPs that are already leveraging TM Forum's [Open Digital Architecture](#) (ODA) can integrate autonomous capabilities into their existing frameworks, transforming ODA into composable, self-managing

systems organized as autonomous domains.

The AN Framework is an out-of-the-box implementation methodology to help CSPs plan and deploy AN in an efficient and systematic way. It consists of four key elements:

- Key effectiveness indicators (KEIs) to measure the benefits of implementing AN use cases
- AN level evaluations to measure progress
- Reference and technical architectures to guide implementation
- An AN roadmap to plan capability deployment.

Measuring value

Key effectiveness indicators, or KEIs, measure the business value and operations effectiveness of autonomous networks. The AN KEI system included in the

AN Framework is based on three sources:

- The [balanced scorecard](#) theory (a widely used KEI creation tool)
- CSPs' practical experience with KEIs
- TM Forum's indicator framework as described in [TM Forum Metrics Framework \(GB935\)](#), [TM Forum Metric Definitions \(GB988\)](#) and other standards documents.

This value-driven system focuses on both effectiveness and efficiency. TM Forum members have also created the AN KEI Framework (explained in [Autonomous Networks Effectiveness Indicators – IG1256](#)), which allows CSPs to add, delete or modify indicators to develop their own KEI system.

In the Level 4 Blueprint, TM Forum has expanded the KEIs

outlined in the AN Framework to include a three-layer AN Indicator Framework that also uses key business indicators (KBIs) and key capability indicators (KCIs) to measure the value of use cases. KBIs measure the business value

of AN use cases and can be used to demonstrate this value to executives. KCIs are used to set capability development objectives and guide all departments and operating companies in developing them.

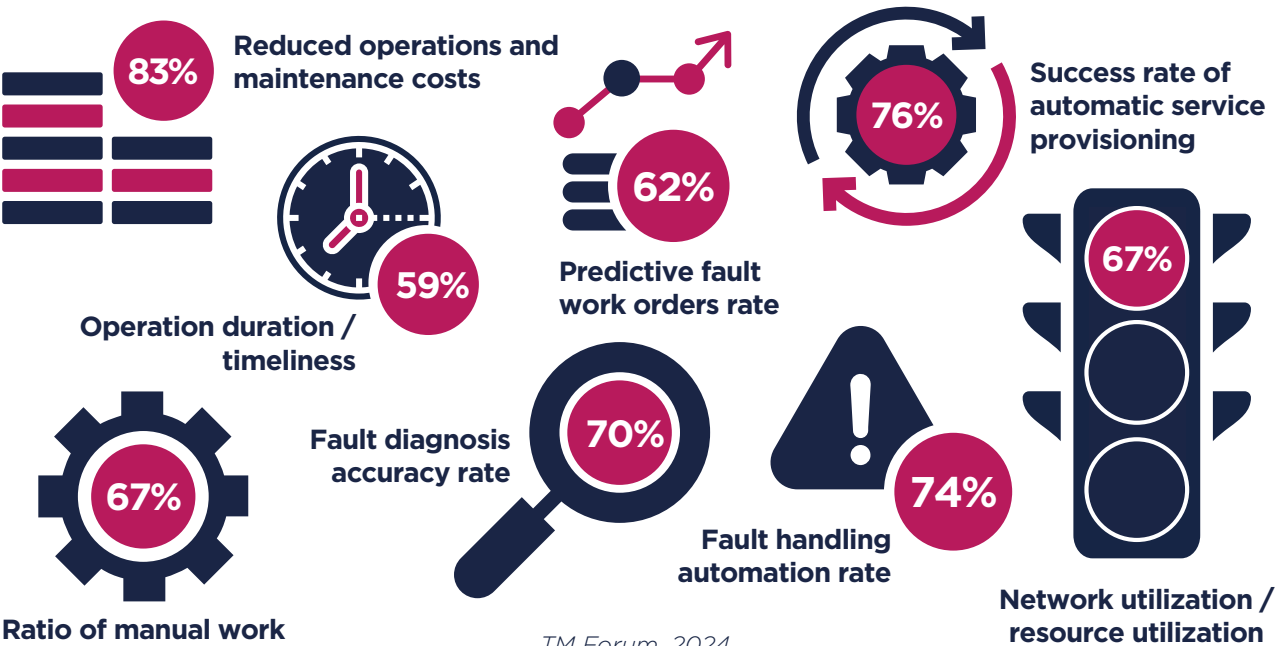
In our survey, we asked respondents how they measure effectiveness from a customer experience perspective and from an operational efficiency perspective. The results are shown in the graphics below.

Top customer experience improvement indicators



TM Forum, 2024

Top operational efficiency improvement indicators



TM Forum, 2024

Comparing apples to apples

The AN Framework’s methodology for assessing AN levels, which we discussed briefly in section 2, is defined in the [Autonomous Network Levels Evaluation Methodology \(IG1252\)](#). It describes the evaluation approach and operation flows, task evaluation criteria, scoring method and so on. An evaluation tool ([GB1059](#)) enables CSPs to measure the current level of autonomy of their operations. The first step is identifying “evaluation objects”, which are determined by selecting an operational use case based on services domain, network technology domain and operational flows.

To complete the assessment, operators use a questionnaire that evaluates cognitive activities in the network like intent handling, awareness, analysis, decision and execution (or IAADE). Each of these activities includes a set of tasks to be measured.

In order to enhance its evaluation questionnaire and further standardize how AN levels are assessed, the AN Project team used the professional grading standards provided by standards

development organizations such as 3GPP and ETSI, with added weighting and detailed scoring criteria. The image below shows a sample question based on 3GPP’s published standards in the RAN and core.

TM Forum conducted two phases of an assessment pilot in 2024 using the enhanced evaluation tool, with two dozen CSPs participating. AIS, Antel Uruguay, China Telecom, Elisa, Globe Telecom, IOH Indonesia, MTN Group, Orange, etc, Telecom Argentina, Telefónica and Telkomsel performed self-evaluations along with a dozen more companies that asked to remain anonymous. MTN, Orange and Telefónica evaluated the scenarios in multiple countries.

Anonymized results for fault management in the RAN and core network for both phases of the pilot are shown in the graphics on the next page. Overall, the AN levels achieved remain relatively low considering the commitment of operators to reach Level 4 within the next year or two, with most scores clustered between Level 2 and Level 3. Core network stability was also assessed, achieving a higher average of Level 3.5.

“Overall, the AN levels achieved remain relatively low considering the commitment of operators to reach Level 4 within the next year or two, with most scores clustered between Level 2 and Level 3.

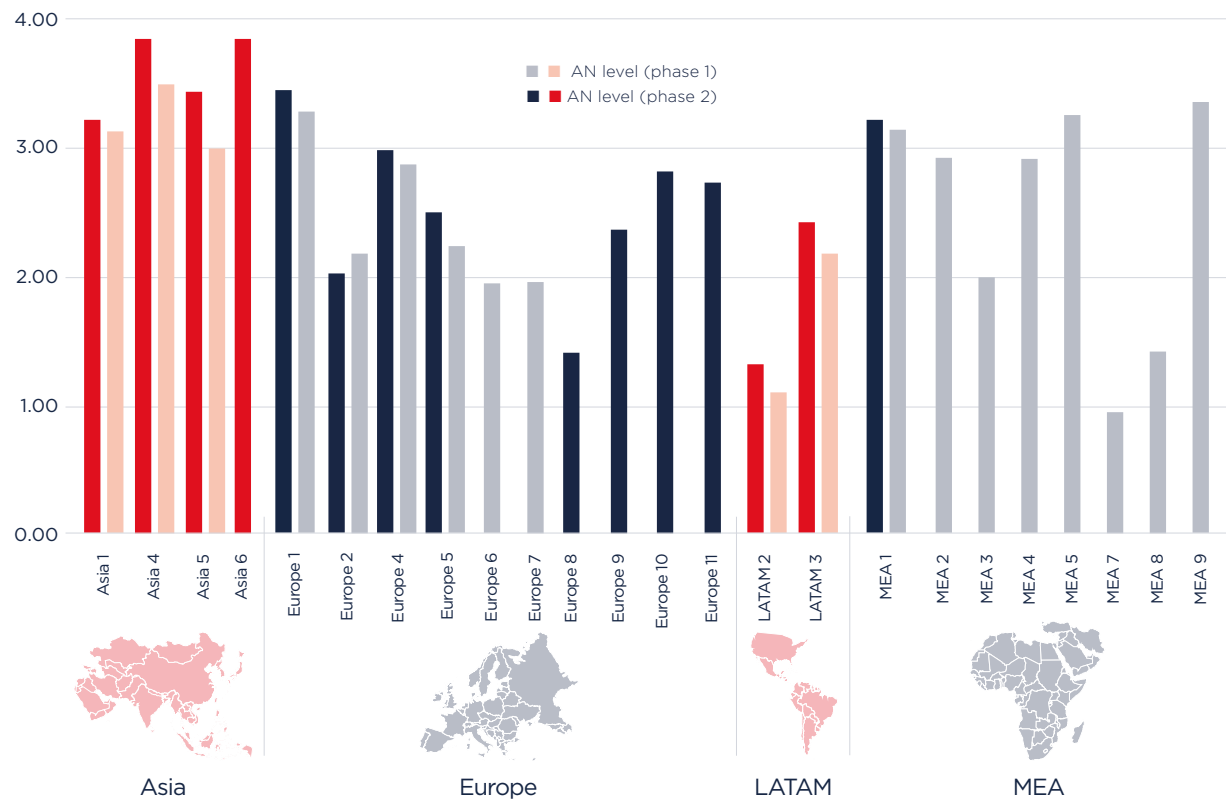
AN level evaluation sample question

Autonomous Levels	L1 Manual Operations & Maintenance	L2 Assisted Operations & Maintenance	L3 Partial Autonomous Networks	L4 Conditioned Autonomous Networks	L5 High Autonomous Networks	L6 Full Autonomous Networks
Core Network	P	PIS	PIS	PIS	PIS	PIS
RAN	P	P	PIS	PIS	PIS	PIS
Service Domain	P	P	P	PIS	PIS	PIS
Operational Flows	P	P	P	PIS	PIS	PIS
Application	NA		Selected scenarios		PIS	

High-Value Scenario	Cognitive Activity (IAADE)	Service Capability	Weight	Question	Option A	Option B	Option C	Option D	Answer
RAN Fault Management	Awareness	Data collection	5%	Does the wireless network fault management system support automatic data collection in various fault scenarios? Fault scenarios include NE disconnection or out-of-service, cell faults, and fronthaul network faults.	Yes. The system can automatically collect data(alarm, configuration, and performance data etc.)	Partially. Data collection rules or templates are manually defined. The system can automatically collect data(alarm, configuration, and performance data etc.)	Partially. Manually select data collection items. The system can automatically collect data(alarm, configuration, and performance data etc.)	No. People use the system to collect data	B
		Alarm filtering	5%	Does the wireless network fault management system support automatic alarm filtering in various fault scenarios? Fault scenarios include NE disconnection or out-of-service, cell faults, and fronthaul network faults.	Yes. The system can automatically filter out invalid or redundant alarms.	Partially. Manually define alarm filtering rules. The system automatically filters out invalid or redundant alarms.	Partially. People use the system filter out invalid or redundant alarms.	No. People filter out invalid or redundant alarms.	A

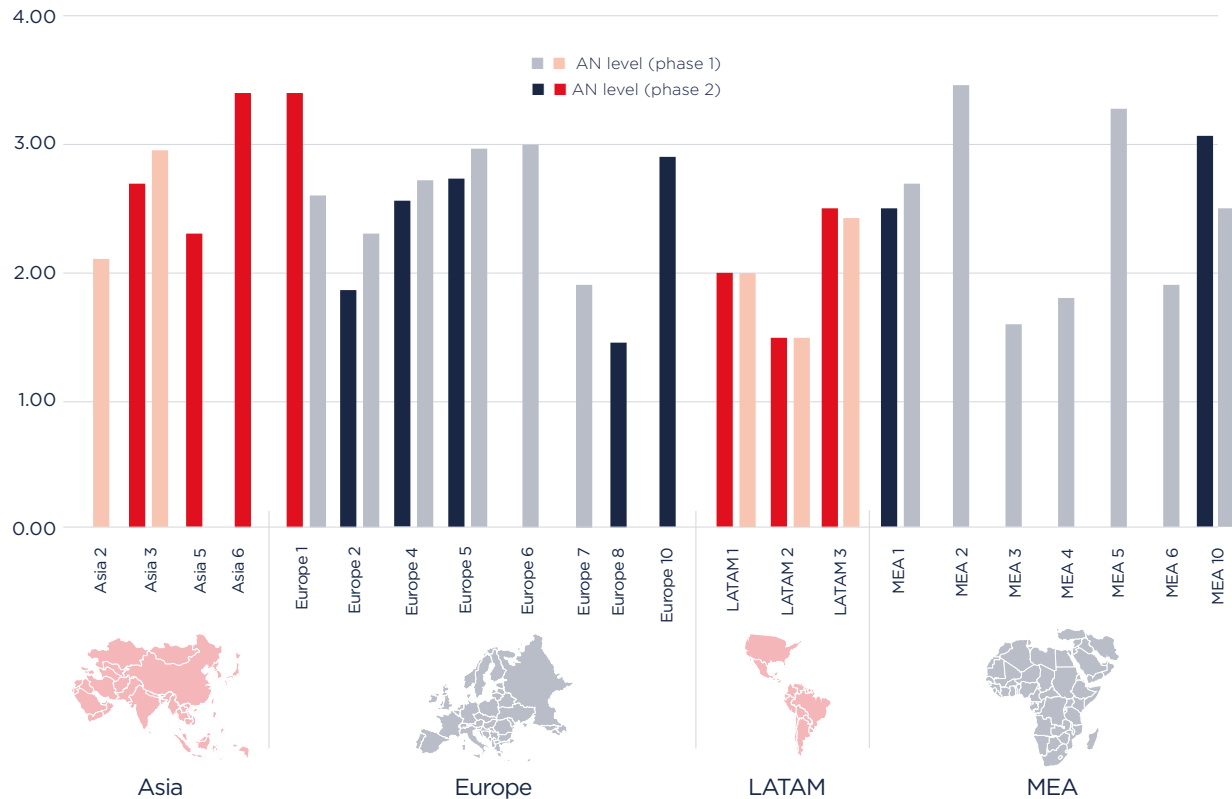
TM Forum, 2024

AN level evaluations for fault management in the RAN



TM Forum, 2024

AN level evaluations for fault management in the core network



TM Forum, 2024

Level 4 needs AI

TM Forum sees Level 4 autonomous capabilities as critical to helping CSPs reach their business goals, which include:

- Faster time to market (one week or less for new services) and realization of NaaS
- Creation of digital employees to increase the number of devices maintained per person and reduce the onsite maintenance workload by thousands of person-years
- Reduction of energy consumption and carbon-dioxide emissions
- Improvement in customer experience through minute-level service delivery and fault rectification, and better SLA compliance.

The blueprint’s reference architecture calls for full-stack AI operating across all layers of the AN Framework, with collaboration across all the layers

supporting automated, closed-loop network operations.

In analyzing our survey for this report, we looked at attitudes toward the use of GenAI by size of company and found some interesting divisions. Perhaps understandably, many more large operators have introduced the technology into network operations than small ones. But more eye-catching was the revelation that none of the large CSPs questioned the trustworthiness of GenAI for use in mission-critical network functions (see graphic).

One probable explanation for smaller operators not embracing GenAI is the fact that often there is little or no hyperscaler presence in developing countries where many small telcos operate. The big hyperscalers like AWS, Google Cloud and Microsoft Azure offer scalable infrastructure and advanced AI tools that lower the barriers to adoption. Without

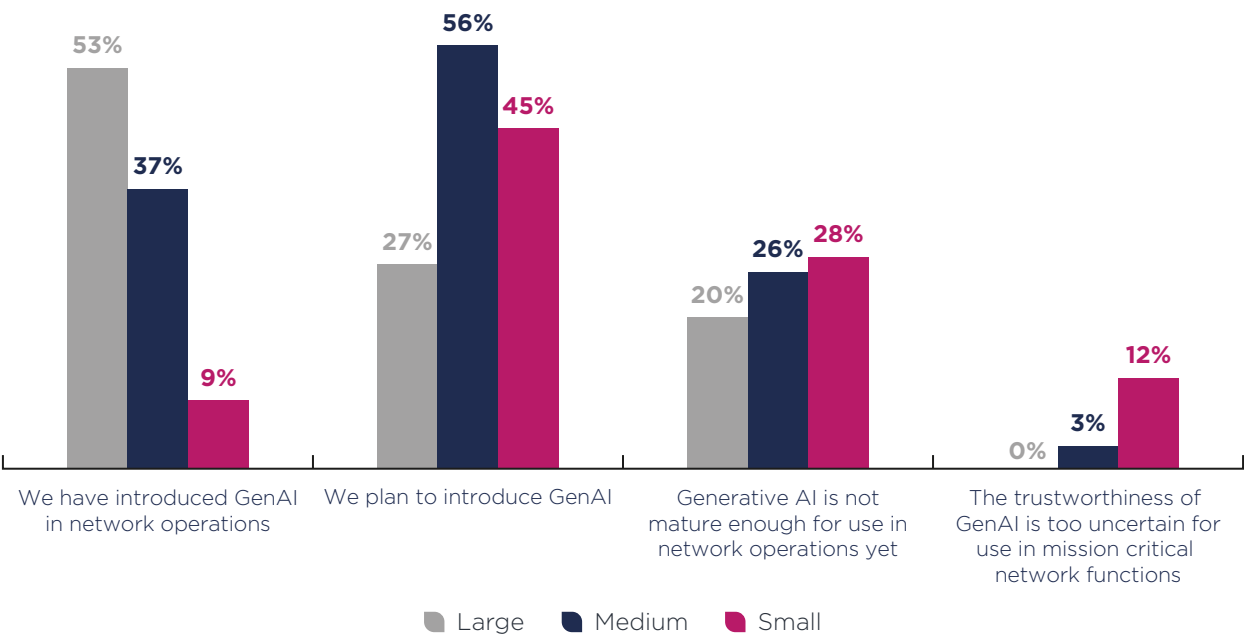
these resources, small operators may not be able to find the skills they need or make the hefty investments required. In addition, small CSPs often are not able to integrate data for use by LLMs.

But even in the face of these challenges, a handful of respondents from small CSPs say their companies are already using GenAI, and close to half plan to.

High-value scenarios

Identifying Level 4 high-value scenarios enables CSPs to define the practice scope of autonomous networks, which in turn will enhance their return on investment and help them achieve business and operational improvements. Scenarios are use cases that combine an operation flow and a network domain – for example, fault management on the RAN – and Level 4 scenarios are those that are likely to have maximum impact.

Introduction of GenAI by size of company



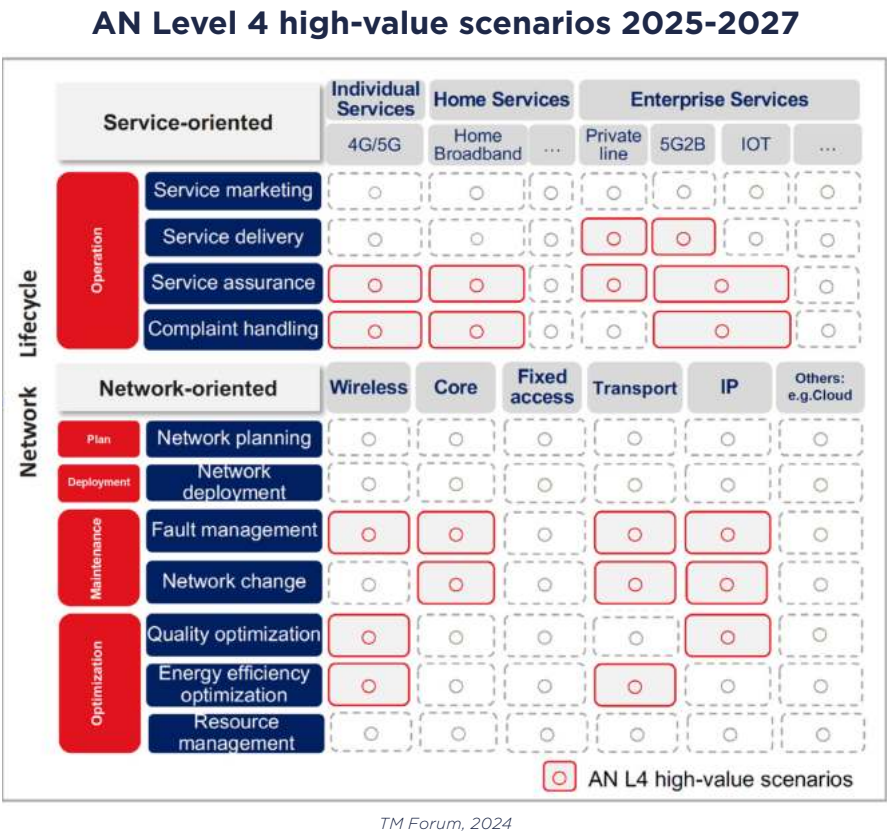
TM Forum, 2024

The AN Level 4 Industry Blueprint recommends that CSPs take two steps to identify high-value scenarios:

- Clarify the scope of key services and networks by aligning them with end-to-end network operation processes identified in the AN Framework
- Thoroughly analyze the cost, the human resources required, the potential impact on cybersecurity operations and the technical feasibility to identify the most promising scenarios.

The graphic opposite shows the high-value scenarios AN Project members have identified as priorities for the next two years. For example, service assurance and fault management across most domains are viewed as key, while network planning and deployment are not yet high priority.

In September 2024, TM Forum launched a special type of Catalyst proof of concept called the [Autonomous Network Innovation Pioneer Project](#) to study AN Level 4 high-value scenarios. That team’s first implementations were demonstrated at Innovate Asia24. The goal for each scenario is first to identify gaps between the current level of automation in CSPs’ networks and Level 4



TM Forum, 2024

autonomy. Then, the teams design solutions, implement and test them, and finally verify the achievement of AN Level 4.

In the next section we look at the progress operators have made in moving towards AN Level 4, detailing some of the success stories and best practice implementations.

“Identifying Level 4 high-value scenarios enables CSPs to define the practice scope of ANs, which in turn will enhance their return on investment.”

section 4:

success stories – AN best practice in action

TM Forum's AN Framework, including the [Autonomous Network Levels Evaluation Methodology](#), enables both network and service operational transformation and provides a platform for innovation. But autonomous networking capabilities must be aligned with value outcomes and, as we've seen in our survey results, many service providers are concerned about being able to demonstrate the business value of implementing AN. But early adopters are making progress. In this section we share examples of AN best practice in action, and the benefits CSPs are seeing from implementation.

As shown in our survey, CSPs have predominantly focused their AN activity so far on improving network performance, working towards TM Forum's model for zero-X (zero-wait, zero-touch, zero-trouble) and self-X, (self-serving, self-fulfilling, self-assuring) AN capabilities. Automated orchestration, potentially combined with technologies such as digital twin simulation, can help operators increase operations and maintenance (O&M) efficiency by reducing dependency on manual intervention and supporting

core network agility without sacrificing stability.

As explained in previous sections, CSPs participating in the AN Project are using TM Forum's assessment methodology to gauge the AN level of organizations and processes. stc in Saudi Arabia, for example, has worked with consultants to apply TM Forum's six-level scale in order to evaluate several network operations processes as part as an overall digital transformation initiative. The company calls the model "critical to the success of our digital transformation".

Orange has created a taskforce to drive AN acceleration, combining top-level project ownership with domain-level expertise – RAN, core, IP, cloud and so on – to support evolution across each network within the group, share experiences and solutions, and create a cross-domain learning culture. Its initial task was a realistic assessment of its network operations maturity, using TM Forum's Autonomous Network Levels Evaluation Methodology to establish a baseline for each of its 25 networks.

According to Asser el-Nahas, AN Practice Lead, Orange, the operator is at Level 2 on average, and higher in some areas. Level 2 is defined as “partial autonomous network”, where closed-loop operations and maintenance is enabled in some environments; Level 3 introduces alarm filtering, as well as new root cause analysis and monitoring capabilities.

Speaking at Innovate Asia 2024, Indra Mardiatna, CTO of Telkomsel, said that joining TM Forum’s [AN Manifesto](#) – through which companies agree to follow the ODA-aligned [Autonomous Networks Architecture](#) to accelerate the adoption of network automation – helped the CSP to shift from AN Level 1.8 to Level 3 for some operations in 2023. Telkomsel is now investing in more analytics to prepare for AN Level 4, with the possibility of some scenarios achieving this in 2025. But, Mardiatna added, through this process Telkomsel uncovered about 6,000 discrepancies in its network which needed to be addressed to continue AN progress.

Zain, which has also signed the Manifesto, is encouraged by the service and operational benefits that AN is delivering, notably around reducing network and operations complexity. [In this video interview](#), recorded at DTW24-Ignite in Copenhagen, Zain’s Mohammed Jaber Al-Tarawneh, Head of IP and Transmission, and Raad Abu Dayeh, Transmission and IP Network Manager, discuss the company’s AN strategy with Dean Ramsay, Principal Analyst at TM Forum. They explain how increased intelligence and automation is enabling Zain to respond to changing connectivity demands and enhance customer experience.

“The main advantage of autonomous networks for us as a

mobile operator is reducing network complexity and optimizing operational complexity, automating some tasks currently done manually,” says Jaber Al-Tarawneh. “The other important part is to enhance user experience [against] network quality of experience indicators, particularly for new 5G use cases and applications, which add new challenges to our network.” He adds that in 2023 the company accelerated its autonomous network practices “and put many use cases into commercial use”.

Watch the video:



Focus on fault management

The AN Project recently conducted a survey to determine which domains and processes (scenarios) to target first for level evaluation. Fault management – that is, fault monitoring combined with detection and resolution – was chosen by the majority of participants. This is not surprising. Effective fault management

ensures higher network reliability and customer satisfaction by quickly identifying and resolving issues – and even preventing them. It can also cut operational expenses by reducing the need for manual intervention and speeding up repair times.

In a case study contributed to TM Forum’s [latest AN Journey Guide](#), MTN explained its approach to overcoming fault management challenges in a multi-vendor environment. With the company’s consumer and enterprise businesses growing rapidly, MTN needed to provide end-to-end O&M and increase reliability of its transport network across Africa, where it has operations in more than 16 markets. Across operating companies, MTN is aggressively deploying automation and software-defined networking (SDN) in its core network as it seeks to improve customer experience in alignment with its [Ambition 2025 strategy](#).

At the same time, MTN’s operating companies had experienced more than 4,000 faults and 3,000 fiber service cuts over the course of a year, typically taking a day to demarcate faults and another three days to rectify them. To address its goals and improve fault management, MTN adopted a framework for its transport network domain which seeks to ensure that network design and planning adhere to the key performance parameters of the transport network: availability, reliability and latency.

MTN’s operating companies are deploying domain controllers in the IP, optical and microwave networks, together with critical, value-driven use cases. The operator opted for a hierarchical controller to enable abstraction, network slicing and end-to-end



The main advantage of [AN] for us as a mobile operator is reducing network complexity...”

**Mohammed Jaber Al-Tarawneh,
Telkomsel**

orchestration, with multivendor and multidomain visibility of its IP, optical and microwave networks.

This meant working with three different vendors to implement an autonomous network that delivers

self-monitoring, self-healing and self-optimization capabilities. For example, in the past, faults were handled by IP and optical network teams independently in different systems. Now, multi-layer faults are diagnosed, demarcated and

located automatically in one system. MTN South Africa has deployed the solution with promising results, including a reduction in fault demarcation time from one day to just five minutes.

China Mobile uses GenAI to help move up the levels

As we've reported in our research throughout 2024 CSPs, and in particular large operators, are embracing GenAI across their businesses. While many of the earliest uses have been in the customer contact center, increasingly operators are applying the technology in network operations and maintenance (O&M). [China Mobile's use of GenAI to increase automation in O&M](#), for example, won a TM Forum Excellence Award in 2024.

China Mobile has a total of 190 million subscribers in its Guangdong, Beijing and Fujian provinces, where the company has been working to develop a GenAI solution to help with work order optimization, field testing and performance optimization of 4G and 5G networks. By leveraging GenAI and LLMs, the operator is achieving an accurate understanding of users' intentions, which are then translated into intelligent orchestration of network operations. As a result, China Mobile is saving about \$7 million a year and realizing an 80% reduction in knowledge acquisition time, as well as a 72% increase in data analysis efficiency, all of which is bringing the company closer to its goal of achieving a [highly autonomous network](#) by 2025.

China Mobile was looking to address three main challenges with the GenAI solution it has developed with its vendor partner Nokia:

- **Cut the time it takes to query knowledge bases when trying to resolve faults.** A large amount of knowledge about telecoms network operations exists in various manuals, case libraries and reports, making it difficult to run queries. Indeed, it was taking China Mobile's engineers an average of five to ten minutes to find information, with some complex cases taking more than an hour.
- **Reduce the cost of daily data analysis.** In O&M there are many temporary and personalized data analysis requirements, which are labor-intensive and must be completed by highly paid experts. In the Guangdong province alone, there are more than 3,000 tables in China Mobile's big data platform. With more than 400 engineers conducting data analysis tasks every day, the cost of data analysis was about \$6.8 million a year.
- **Improve DevOps development.** Managing diverse and dynamic business requirements in network operations demands significant time from software engineers, often spanning several days or even weeks. This results in low efficiency and high costs, with around 200 software engineers working in the three China Mobile provinces.

China Mobile's GenAI solution addresses these issues by providing a natural language capability for intelligent Q&A, automation of data analysis and DevOps code generation. It is being rolled out in three phases. The first, called Intelligent Assistant, was completed in 2023 and helped the operator achieve Level 3 AN. The results detailed in this case study were achieved in this phase.

The second phase, called Expert, is happening now and will be complete in 2025. During this phase the team is building on its LLM to automatically create network configuration instructions and optimization directives in complex operations scenarios and implement solution recommendations. China Mobile hopes to reach Level 4 AN as a result. The final Master phase in 2025 and beyond will support more autonomous end-to-end operational processes with the ultimate aim of achieving Level 5.

Read the full case study:



Value creation

[In a conversation at Innovate Asia](#), Christian Maitre, CEO of Caspera-Lab, and Olta Vangjeli, Program Director for Cloud Native IT & Networks at TM Forum, discuss the Forum's AN standards work and how value creation is, as Maitre puts it, "inside the AN philosophy". He adds: "Doing things like zero-touch, flexibility, scalability, will create new types of services for B2B, B2C, B2X combined with operations for many domains: smart cities, smart finance, smart energy... AN at the core is really the engine of this."

In the video they also consider the need for clean data, and developing the skills required as operators move along the AN journey and introduce higher levels of AI into networks. Maitre, who previously led smart city strategy at Orange, was the leader of an important multi-phase Catalyst project called AN hyperloops, which has fed learnings into the AN Project (see page 32).

Measuring the value of automation and using it to drive new value, is a key focus for China Mobile. Dr. Lingli Deng, Researcher Director at the CSP, [told TM Forum Inform in 2023](#). "In addition to efficiencies from the internal operation perspective, we are also trying to set business value metrics, so that we can actually expose the automation and autonomy capabilities to our

customers, or use those capabilities to find new customers," she said.

Sustainability, in the form of energy savings, is another important part of the AN value proposition, and an area yielding positive, measurable results. For instance, the three major Chinese CSPs are already reporting significant benefits in this regard (see table on p.29 for more on their progress and plans):

- China Mobile – savings of 4 billion kilowatt hours (KWh) of electricity in 2023
- China Telecom – annual savings of 1 billion KWh of electricity
- China Unicom – monthly savings of 40 million KWh of electricity.

[In a research note for TM Forum](#), Ehsan Dadrasnia, VP, Global Telco Industry: Cloud Network Transformation & Partnership Strategy, Capgemini, echoed the value of AN to sustainability targets. "Those [CSPs] that are moving fast on autonomous networks are also realizing cost and sustainability benefits. In just the past two years, telcos have on average achieved a 20% improvement in operational efficiency and an 18% reduction in opex through autonomous networks," he said. "Those who transition to a higher-level autonomous network can expect energy reduction of somewhere

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In just the past two years, telcos have on average achieved a 20% improvement in operational efficiency ... through autonomous networks."

**Ehsan Dadrasnia,
Capgemini**

between 7.5%-15% in their network's carbon emissions. As generative AI grows in prominence, we're going to see these results improve much quicker."

As we have seen throughout this report, many CSPs are well underway on their AN journey, with a handful of operators already adopting TM Forum's AN Level 4 high-value scenarios, specifying their planned evolution paths from 2025 to 2027. The table on the next pages shows the domains and processes some of these CSPs intend to target as well as highlighting measurable points of progress.

In the next section we showcase some award-winning Catalysts focused on autonomous networks and AI.

CSPs' AN strategies and progress

CSP	AN strategy	Level 4 high-value focus	Progress and plans
	TM Forum's ODA, AN framework and AN level taxonomy are the foundation of AIS's 'Cognitive Techco' strategy	- Core network fault management - Wireless network optimization: customer experience driven - Optical and transport service assurance	Is participating in TM Forum's AN level assessment pilot; achieved L3 in the two targeted processes (RAN and core fault management); results include: - CX optimized by 10% - Traffic loss reduced by 90% in extreme scenarios - Network efficiency improved by +20% Is extending AN practices to network optimization, configuration, planning, change and other processes.
	China Mobile was the first CSP to set a goal to reach L4 on a large scale in its production network; technology function is centralized, and the company is using end-to-end service operation layer across domains to drive overall development of technical AN capabilities	- Service delivery - Network change - Energy-efficiency optimization - Service-quality optimization - Troubleshooting - Complaint handling	Achieved overall AN L3.2 in 2023; results include: - Significant improvement in customer satisfaction 80% reduction in the number of major network faults 20% increase in average number of sites maintained per person - Savings of 3,200 person-years of human labor and 4 billion Kwh of electricity - Contribution to 70 AN technical standards and 15 whitepapers - Has launched a telecoms LLM with 13.9 billion parameters, trialing applications like data self-service and AI chatbots.
	China Telecom is guided by '3-ultra Vision', considers autonomous cloud-network operations as an important stepping stone for the transformation toward 'network + cloud'	5G core network: complaint handling - IP network: network changes (intelligent online simulation) - Innovative practice of network LLM in network maintenance scenario	Is participating in AN level assessment pilot. Achieved overall AN L3+ in 2023; results include: - Return on equity up from 6.41% in 2022 to 6.93% in 2023 - Savings of 1 billion kilowatt-hours of electricity annually In 2024 aims to achieve L4 in 40% of high-value scenarios and will promote large-scale application of its LLM in the network, creating thousands of digital employees.
	China Unicom aims to implement autonomous systems across all stages of planning, development, maintenance, optimization and operations to enable digital operations, intelligent scenarios and agile services.	- Optical private lines – service assurance - Intelligent planning and construction - Intelligent energy savings in base stations - Closed-loop control of optical cable risks	Is performing ANL evaluations for 5 networks across 8 provinces focusing on high-value scenarios using GenAI; results include: 1.5 million customer complaint diagnoses per month with an 80% one-time problem resolution rate - Intelligent energy-saving systems cover 98% of base stations, saving over 40 million kilowatt-hours monthly - Open platform aggregates 2,800 capabilities, utilized over 38 billion times per month Will focus on additional high-value L4 AN scenarios in the next two years.

CSPs' AN strategies and progress

CSP	AN strategy	Level 4 high-value focus	Progress and plans
	Chunghwa Telecom has been working on closed-loop automation for specific network scenarios since 2019.	- Fault management in RAN and IP transport domains - Energy-efficiency optimization in the RAN	Since 2023, the company has expanded AN operations management to enhance customer experience and reduce operational costs; results include: - Conducted ANL assessments for fixed and mobile broadband services, achieving L3 autonomy - Developed an automated fixed broadband service rate upgrade mechanism, benefiting 1.16 million users Plans to apply AN to mobile broadband and IP transport networks, aiming to achieve L4 by 2025.
	Globe's autonomous networks strategy focuses on AN Level 4 attainment.	Core network fault management	Is participating in TM Forum's AN level assessment pilot. Globe is working on automation in the core network to ensure uninterrupted service and realize some scenarios of AN Level 4. It is continuing building a network that can self-heal, predict and prevent outages, and adapt to changing conditions in real time based on digital twins technology.
	HKT aims to bring the right digital solutions to society to accelerate growth and create a sustainable future for all.	- Wireless network optimization focusing on energy usage according to data traffic using AI technology - Optical and transport service to minimize energy consumption and improve energy efficiency through AI technology	Is participating in TM Forum's AN level assessment pilot. Focus in 2023 was on reducing 20% of HKT's total energy consumption (compared with 2018 baseline), and HKT plans to further cut energy consumption this year and in the future using innovative methods over its AN.
	MTN is implementing AN as part of its Ambition 2025 Strategy, which includes a technology framework called PACE (Platform, Agile, Connectivity and Experience). All MTN operating companies aligned with the company's AN strategy and target architecture, which is based on TM Forum's AN framework.	- Cross-domain network – fault management - IP and optical network – autonomous O&M	Participated in the AN level assessment pilot and will continue to align to the assessment for RAN, core, IP and change management. In 2023, MTN released its AN Blueprint 2.0, establishing ANL standards and developing a comprehensive use case library. In 2024, the company plans to design Version 3 of the blueprint, identifying high-value scenarios to finalize assessment criteria, effectiveness targets, processes and architecture for AN L4.
	Singtel initiated its AN program in 2023, fostering group-level collaboration to benchmark, share best practices and apply them across the group.	- Fault management and customer-complaint management - RAN energy saving and network optimization	Designated Singtel Group operator AIS as an AN coach to standardize the four key elements of the AN Framework and support operating companies in L3 and L3+ use-case deployment. In 2024, will create its AN L4 Blueprint to transition from automation to autonomy.

CSPs' AN strategies and progress

CSP	AN strategy	Level 4 high-value focus	Progress and plans
	stc has a goal to achieve ANL 4 in 2025 in some scenarios	Core network: fault management, network changes, design and deployment	Is participating in TM Forum's AN level assessment pilot. 2024 focus was on automatic network change and AIOps capabilities including: - Digital twin-based cloud-network visualization - Intelligent signaling storm simulation and emergency assistance - Pipeline-based network change and deployment automation Results included: - Fault management - CNF and cloud health status unified visualization, moving from 5+ portals to 1 and cutting fault-demarcation time from 2 hours to 15 minutes - Network changes and deployment: ultra-security (automatic execution by unified pipeline reducing 80% of manual breakpoints); high-efficiency (deploying 200+ test cases in minutes); and full scenarios for both telco-cloud and core network In 2025, stc plans to introduce foundational models for alarm analysis, an intelligent copilot and a complaint handling expert.
	Telecom Argentina drives its strategy of developing ANs and contributing to TM Forum's best practices through its Autonomous Network Transformation Office (ANTO).	- Wi-Fi optimization - Core network: network optimization	Is participating in AN level assessment pilot. Has committed to achieving its goals through a two-stage approach, with the first focusing primarily on developing technical use cases and the second aiming for more balance between technical and business domains.
	Telefónica launched a program called Autonomous Network Journey (ANJ) in 2021 to increase autonomy and transform its architecture, management of data, and organizational structure to support AN; ANJ is being applied in all operating companies in Europe and Latin America, but deployment progress varies among OpCos.	Is focusing on getting to AN Level 4 for multiple processes (O&M, optimization/configuration, testing, deployment and planning) in multiple domains (radio access, transport, IP, core, IT cloud, and fixed access networks). The company is placing high emphasis on O&M in all domains and on RAN optimization, IP deployment and transport planning.	Is participating in the AN level assessment pilot. Anticipates several key improvements in achieving AN Level 4 including : - AI-powered operations assurance, where closed-loop automation will prevent service disruptions. - Real-time optimization and decision-making, where automated systems will manage network configurations, including dynamic features like network slicing and NaaS capabilities. - Efficient planning and deployment, where real-time inventory management, scenario-based planning (e.g., 'what-if' analysis) and AI-driven optimization will streamline deployment processes.
	Telkomsel adopted AN as part of its digital innovations, aiming to reach L4 by 2025. Ensuring high service quality during peak events.	- Transport network (fronthaul optical link): fault predictive maintenance - Wireless network: fault management (cross-domain) - Wireless network: optimization	Is participating in AN Level assessment pilot. In 2023, Telkomsel's cross-domain experts, guided by the Networks Quality Digitalization Department, made significant progress towards L3. Notably, the self-assurance use case for massive events was recognized at TM Forum DTW2023-Ignite and deployed across 37 sites in Indonesia.

TM Forum, 2024

section 5:

award-winning Catalysts

In this section we look at two award-winning proofs of concept focusing on autonomous networks and AI. They are followed by a list of other Catalysts that won awards in 2024, with further information and links to help you find out more.

An award-winning TM Forum Catalyst called [Autonomous networks hyperloops](#) has revolutionized the concept of how autonomous networks should be designed and function – and in the process is helping telcos understand how to deliver a significantly more dynamic customer experience that rivals hyperscale cloud providers.

The hyperloops project, which began in 2019 and is now complete after five phases, focused on defining the global architecture needed to support a wide range of vertical use cases

and the role for new technologies like metaverse, digital twins and AI. In various phases, the proof of concept has been championed by CSPs including Chunghwa Telecom, NTT, Orange, TIM and Verizon. It won a [2024 Catalyst award](#) in the Outstanding Catalyst – Beyond Telco category, and learnings from the project have been incorporated into the AN Project’s work. Indeed, the familiar “Intent-based, closed-loop management” graphic used in many TM Forum publications and our own research reports (see page 9) originated in the hyperloops Catalyst.

The earliest phases of the project looked at how to enable smart vertical use cases such as distance learning/education and smart farming, stadiums and manufacturing. In later phases the team showed how to use intent, closed loops, 5G network slicing, AI and digital twins, to deliver pop-up mobile networks in the event of a natural disaster. Most recently it demonstrated how telcos can provide a “virtual command center”, or VCC, as a service.

“This idea of a virtual command and control center is multi-industry,” explains TM Forum’s

Chief Architect Dave Milham.

“What I like about it is that it’s not about ordering [telco] services. It’s about saying: ‘What is it that the end user actually wants?’ – not the customer, the end user – and then setting up an environment closer to what the end user really wants.”

In the VCC setup, an end user in an enterprise’s operations center is presented with a dashboard that provides a visual representation of all the assets the company has (including those owned and leased). This provides what Milham calls “situational awareness”.

“In principle, you could have an icon that starts flashing amber and says you haven’t got enough capacity on this link; it’s reached over 60% capacity’. And some AI behind it can say, ‘It looks like you’re going to run out and have severe capacity problems here’,” he explains. Then, the user is given options of either increasing the bandwidth on that link or rerouting existing traffic to free up capacity.

“But did an order or a trouble ticket appear anywhere in any of this?” Milham asks. “No. The tasks that are being presented are in the language of the person who’s running an operations center.”

Enabling this kind of dynamic ordering, provisioning and management of communications services requires completely rethinking how networks are architected, and that is one of the most important takeaways from the project, says Caspera-Labs’ Christian Maitre, leader of the hyperloops Catalyst.

As the project progressed, it became clear that the way CSPs and their suppliers were approaching AN would not scale, says Maitre. The network must become fully virtualized, software-defined and AI-driven with a “3D” architecture. “We call it ‘the onion’. You have the core and different

“

AN is still to be defined. There is a lot to still be imagined.”

**Christian Maitre,
Caspera-Lab**

layers around it in three dimensions,” he explains. “We had to create a new vision for the architecture. It’s not flat or hierarchical, but 3D.”

Perhaps the most important lesson learned from the hyperloops Catalyst is that “AN is still to be defined,” says Maitre. “There is a lot to still be imagined.”

Read the team’s whitepaper and watch the video to learn more:



GenAI powers computing network solution

Many TM Forum Catalysts have been looking specifically at how GenAI can be applied in autonomous networks. As GenAI and LLMs become integral to many telecoms processes and services, the demand for computing power will escalate exponentially. This makes efficient allocation of resources critical.

To address this challenge, China Unicom, China Mobile, China Telecom and Telecom Malaysia have been collaborating in a TM

Forum Catalyst proof of concept to streamline the use of computing power and network resources. This requires customers’ original intentions to be aligned with the capabilities and services of the computing network.

The [GenAI empowers computing force network Catalyst](#) won an award in 2024 in the Outstanding Catalyst – Innovative & Futuristic category for its creation of an AI-native computing network operation system to help CSPs schedule computing and network resources across a cloud-edge network. The solution uses advanced LLMs, multi-agent collaboration and automated code generation to understand, ask questions about and supplement the customer’s business scenarios and needs.

The idea is to autonomously create a customized computing and networking integration proposal that precisely meets the customer’s requirements. Then, the customer can refine it using an intuitive chatbot, which replaces the conventional product catalog.

The computing network solution integrates diverse resources from hyperscale cloud platforms, telco clouds and third-party services to deliver zero-touch customer experience and zero-wait and self-provisioning capabilities. Using this approach, CSPs can develop and support a unique ecosystem and revenue-sharing business model.

As a result of the Catalyst, a new workstream called Autonomous Computing Network was formed in the AN Project, says Zie Zhang, Principal Researcher, Digital Transformation Strategy Consultant, at China Unicom. The team plans to conduct Catalysts annually and is working on a guide to explain its learnings so far.

A second phase of the computing force Catalyst, which will be

demonstrated at DTW25-Ignite in June, is looking at two scenarios:

- How to create a low-energy, high-efficiency computing infrastructure using AI
- How to use new technologies such as cross-domain orchestration and heterogeneous resource scheduling to give customers a one-stop intelligent solution that uses public cloud, network services, platform services and AI.

The group also plans to contribute an API to TM Forum's [Operate APIs](#), says Zhang.

Watch the video to find out more:



In the next section we look at standards work being carried out to drive telco interoperability, and find out which organizations our survey respondents are working with.

Award-winning Catalysts leverage AI and GenAI

Here are some other [2024 Catalyst award winners](#) that have focused on the use of AI and GenAI in autonomous networks for you to explore:

[Accelerated service-centric autonomous network operations](#) – provides a pragmatic framework for operation transformation which integrates processes, platforms, people (organizations) and technology

[AI for customer perception network optimization](#) – anticipates customer pain points through AI-led digital twins and explores how CSPs can move to a perception-centric approach to wireless network optimization

[Autonomous networks hyperloops – Phase V – virtual command center as a service](#) – combines AI with autonomous networks and digital twins in a single interface to provide a comprehensive real-time view of operations, assets and infrastructure (see also p.32)

[GenAI empowers computing force network](#) – uses GenAI to help CSPs schedule computing and network resources across

a cloud-edge network (see also p.33)

[GenAI for AN](#) – looks at how to use GenAI to automate network maintenance

[GenAI-powered toolkit for network & service management – Phase II](#) – aims to create a knowledge graph that maps relationships between network elements, topology, faults and inventory data to enable predictive fault correlation, proactive decision-making and closed-loop automation

[Harnessing GenAI's business value for operations transformation](#) – sets out to transform O&M by boosting efficiency and network quality using AI

[Realtime intelligent customer experiences](#) – shows how AI and automation, combined with telco data, can enable personalized experiences and boost digital revenue to deliver telco growth

[Sustainability telco by green network evolution](#) – aims for net-zero carbon emissions in different geographical conditions using a digital twin and AI platform.

section 6:

collaboration on standards is key to AN interoperability

Achieving cross-domain interoperability in autonomous networks is a challenge that requires collaboration among standards development organizations (SDOs), open-source groups and other organizations. In our survey we asked respondents which groups they're participating in, allowing them to pick as many as necessary. The table on the next page shows the results for a non-exhaustive list of organizations doing work that could impact ANs.

It is not surprising that half or more are working in 3GPP, GSMA and TM Forum projects. Most companies surveyed are TM Forum members, and mobile networks are an early target for AN for reasons outlined throughout this report – primarily a desire to reduce energy consumption and improve fault management in those domains, especially the RAN.

We've discussed standards collaboration in [previous reports](#) and [articles published on Inform](#). It can be a thorny issue because politics are sometimes involved, with people understandably wanting to advance and protect their work within specific groups. For telcos and their suppliers, joining any one organization 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.

'We should simplify'

But CSPs increasingly are calling for more collaboration and alignment across groups as they seek to automate ordering, provisioning, orchestration, assurance and billing of services end to end across multiple domains, which oftentimes include their partners' networks. In [a recent interview with Inform](#), Laurent Leboucher, Group CTO at Orange, said standards bodies and other organizations need to recognize and co-ordinate overlapping work.

"I think we should simplify at some point. We don't need everybody to do the same," he says, pointing to duplication of effort between TM Forum and ETSI on zero-touch and network automation as an example.

"Within Orange when we work in forums or standards we try to keep a very consistent position in the different bodies. But it's hard because there are too many bodies," Leboucher says.

To unlock the full potential of AI-driven networks, collaboration specifically on standardization of network APIs and defining common information and data models is needed. A significant amount of collaboration is, indeed, happening on network APIs.

For more than a year, TM Forum members have been developing

SDOs/open-source groups working on telco interoperability

Organization	Focus	Respondents participating
	Consortium of 7 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.	49%
	Linux Foundation project formed by the 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 frameworks for VNFs/CNFs.	1%
	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.	19%
	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.	20%
	The China Communications Standards Association (CCSA) was established in 2002 by the Chinese Ministry of Information Industry. It is involved in international standards development as a partner of 3GPP and participant in the ITU. TM Forum and CCSA are collaborating on AN standards.	3%
	ETSI's standardization activities focus on Europe. Examples 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.	21%
	GSMA's Open Gateway initiative aims to drive adoption of APIs that expose network capabilities without the need for developers to understand network technology or terminology; work includes mapping between CAMARA APIs and technical APIs from bodies like 3GPP, IETF, ETSI NFV and TM Forum.	49%
	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.	23%
	Standardizes Carrier Ethernet services so that enterprise LANs can extend across WANs; added extensions to the Open APIs to create its LSO APIs and now offers an API blending tool .	21%
	Joint Linux Foundation and Google Cloud project focusing on cloud- and intent-based automation; goal is to simplify deployment and management of multi-vendor cloud infrastructure and network functions at scale.	2%
	Association of mobile network operators focusing on network management, disaggregation, sustainability, and 5G and 6G use cases.	3%
	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; is developing standards for open RAN service management and orchestration that interwork with TM Forum Open APIs.	17%
	Linux Foundation Europe project that aims to create a new, open-source, production-grade telco cloud stack; aims to develop a common cloud software framework and reference implementation.	3%
	Engineering-focused initiative led by Meta to bring CSPs, infrastructure providers, systems integrators and other tech companies together to collaborate on development of new technologies.	18%
	Develops the Open Digital Architecture which provides programmable access to capabilities in OSS/BSS; more than 70 Open APIs are available and widely implemented.	85%

TM Forum, 2024

Open APIs to complement network APIs from [The CAMARA project](#), with a goal of providing a standardized way for mobile operators to make the interfaces commercially available to aggregators and developers. CAMARA is an open-source project within Linux Foundation Networking that works in close collaboration with the [GSMA Operator Platform Group \(OPG\)](#). OPG brings together operators, developers and platform providers to transform multi-access edge computing (MEC) services. 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.

While CAMARA is developing the APIs to expose network capabilities such as quality on demand (QoD) and device location to developers, APIs for IT operations are needed to

automate service delivery, track usage and provide billing capabilities, so that third parties can buy the right to use CAMARA APIs. TM Forum calls these Operate APIs.

TM Forum Open APIs also support the internal processes for delivering network services via CAMARA APIs – for example, the [NaaS Open API Component Suite](#) abstracts technology-specific and vendor-specific network management APIs to a single API into the service layer above, so that configuring and managing the network can be done using a generic NaaS API rather than lots of different APIs performing the same function for different technology domains below. These interfaces are evolving to intent-based operation, where the outcome or characteristics of the service are requested via the API (high-quality video, for example) rather than the specific instructions for the technical resources delivering the service.

Orange has been active in network API and Operate API development. In September, the company, along with 11 other telcos, [announced a global joint venture with Ericsson](#) to sell network APIs.

Standardizing the right APIs requires “working backwards from concrete use cases”, Leboucher says. “That means that we cannot just do it between telcos in a closed room. It has to be together with AI players like Google, like Meta, like OpenAI, Mistral and so on – they have to be in the room,” he explains.

“Maybe the first definition will be a kind of quality observation or quality-on-demand API; maybe it will be different from the one that we thought about at the beginning, but...it’s really an industry move,” he says.

In the final section we recap the key findings from our research and give some recommendations for implementing AN best practice.

section 7:

key findings and recommendations

Throughout this report we have focused on the opportunities, challenges and best practices for CSPs as they progress their autonomous network strategies. This section recaps key findings from our research, including from our survey based on 111 respondents from 82 companies, and makes suggestions for AN planning for the future, based on our observations of industry best practice.

Key findings

- AN momentum is growing rapidly. More than 60 CSPs have signed TM Forum's AN Manifesto, pledging to work towards Level 4 autonomy, and to date 24 CSPs have carried out internal AN level assessments. Some, including China's three major operators, plus MTN, Orange and Telecom Argentina, have publicly stated they are adopting AN Level 4 "high-value scenarios" aiming to reach that stage for operational flows in some domains from 2025 to 2027. Across the industry, more than 120 AN standards and research projects have been initiated.
- Autonomous networks use AI, machine learning and advanced analytics to automate operations, including the ability to detect and diagnose network performance issues, reroute network traffic in case of network failure, and predict/prevent potential problems.
- This is a significant focus of current AN activity, rated as a high priority by 83% of our survey respondents.
- Customer experience is a critical context for measuring AN value. According to our survey 84% of respondents rate network quality satisfaction as the most important CX metric for AN capabilities together with service fault recovery duration (84%), followed closely by service delivery satisfaction (80%).
- About two-thirds of survey respondents have implemented or plan to deploy GenAI within their network operations. Nearly 75% expect GenAI to be utilized to support network maintenance use cases, such as automated troubleshooting and risk prediction, while 65% are looking to use GenAI for network operations applications such as intelligent customer service. Just over 60% plan to use it for network optimization purposes such as risk identification and automated verification of optimization.
- AI and autonomous networking can drive operational efficiency, revenue growth and CX enhancement while improving compliance, sustainability and risk management. But despite the value of AI and AN becoming better understood, not all CSPs are set up to take advantage. Legacy systems, operational complexity and organizational structures can all prevent their full value being realized.
- Integration complexity was rated as a serious challenge by 53% of our survey respondents (and somewhat of a challenge by another 43%), followed by lack of budget (43%). A third of respondents said the fact that an end-to-end architecture is not clearly defined is a serious challenge (a further 52% said it is somewhat of a challenge), and that there is no clear pathway to AN Level 4.

- Transitioning from automation to true autonomy is a significant business and technology challenge. TM Forum oversees teams working collaboratively to create and evolve autonomous network and AIOps frameworks, maturity models, APIs and tools to help CSPs scale solutions. In November 2024, the Forum published its [blueprint framework for achieving AN Level 4](#), to support CSPs with this challenge.
- To unlock the full potential of AI-driven networks, there is a need for standardized network APIs, common data models and aligning automation efforts across different standards development organizations (SDOs). This must happen in both [AI-for-network and network-for-AI scenarios](#). CSPs need to collaborate with each other and with AI players such as hyperscalers to understand how to unleash network capabilities through APIs.

Recommendations

- **A clear strategic vision is vital.** On the business side, leadership, strategy and an AI-centric culture are all important. On the technology side, end-to-end model management for AI is critical, and a target architecture for autonomous networks is necessary. As we have seen, many CSPs are using TM Forum's AN standards to define their own target network architectures as they aim for AN Level 4 and shift from static, rules-based network automation to AI-enabled, dynamic orchestration across multiple network domains.
- **Build a long-term AN business case.** While the business case is typically founded on cost-savings, and performance efficiency use cases which address immediate concerns around network performance and customer retention, it should also evolve to include AN enablement of intent-based service opportunities such as NaaS and network slicing. It is vital that AN leverages intent, so that connectivity can be tailored to business outcomes.
- **Benchmarking AN progress is required.** Many CSPs use their own standard KPIs for measuring progress – for example, how well automation efforts are improving metrics like the duration of a service disruption. Other CSPs are measuring automation success as part of an overall digital transformation project, usually using metrics such as percentage of trouble reports that are automatically diagnosed. But it is necessary for the telecoms industry to agree on how to measure successful AN deployment so that operators can benchmark their progress against their peers and support end-to-end use cases. In addition, success fuels continued investment, so being able to demonstrate positive impact on customer experience is a fundamental aspect of the AN business case.
- **Use AI for networks to create networks for AI.** AI is critical for the evolution of AN, but AN is also critical to support future AI-driven demands on connectivity, to ensure that networks are AI-ready. TM Forum's AN Level 4 Blueprint emphasizes the fundamental reliance of ANs on AI being

embedded into all domain design, operation and processes, such as closed-loop orchestration, to enable intent-based services. It provides detailed guidance on level assessment mechanisms and criteria for achieving AN Level 4.

- **High-value scenarios help CSPs focus on AN impact.** Moving to AN Level 4 is compelling as it helps CSPs unlock new, high-value scenarios that combine an operation flow and a network domain (for example, fault management on the RAN) and are most likely to have maximum impact on the operations and/or business of a CSP. Use case selection for AN Level 4 high-value scenarios is an iterative process. Accurately designing the Level 4 AN target state for high-value scenarios enables CSPs and suppliers to achieve technical breakthroughs, drive application innovation and accelerate adoption of best practices.
- **Establishing a data culture is critical.** A strong data foundation, based on data quality and multi-domain data sharing, is fundamental to AN success. Lack of a data strategy was rated as one of the biggest challenges for AN implementation in our survey (considered serious or somewhat of a challenge by three-quarters of respondents). As part of the [Modern Data Architecture](#) project, TM Forum members are collaborating on an industry-specific data reference architecture, incorporating emerging AI-enabled business models and supporting networks.

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Autonomous Networks: There's a shift in the air

Is 2025 the year?

Autonomous Networks aren't a new concept in telecom. Communication service providers (CSPs) have invested in cloud, automation, and artificial intelligence (AI) for over a decade to reach this goal. Yet...as we approach 2025, there's a noticeable shift in the air. CSPs have made tangible commitments to fully autonomous networks, including MTN Group (part of its Ambition 2025 strategy), Orange (targeting Level 4 automation by 2025), and Telefónica (via its Autonomous Network Journey

across Europe and Latin America). China Mobile, Vodafone, Telenor, T-Mobile, and Verizon are also leading initiatives to enhance network efficiency, sustainability, and reliability using automation.

Using the [TM Forum's Autonomous Network Maturity Model](#) (Levels 0-5) as a benchmark, Tier One CSPs lead in automation, but the benefits apply to telcos of all sizes. For example, [research from STL Partners](#) shows that autonomous networks can deliver an average CSP¹ a yearly benefit of \$800M, split across \$300M in capex savings, \$350M

in opex savings, and \$144M in revenue uplift from faster, more profitable services. Notably, reaching Levels 4/5 unlocks 30% of that opportunity. Thirty percent. Now that's motivation to move beyond Levels 1/2/3.

CSPs are pursuing autonomous networks for reasons unique to their business, and no "Roadmap to Autonomous Networks" should be a one-size-fits-all package. Regardless, one thing is clear: the need to automate is urgent, and the pace must accelerate.

Could 2025 be the Year of Autonomous Networks?

¹ An average CSP is defined as having revenue of US\$15.6 billion, EBITDA of US\$8.3 billion, 31 million mobile subscribers, and 12 million fixed subscribers. A CSP with larger metrics could potentially expect larger financial benefits.

First, let's talk Security

The autonomous network vision simply does not work unless the approach is secure by design. A Zero Trust approach is required, including appropriate encryption and authentication. And every network layer must incorporate real-time threat detection and response – to block unauthorized access and neutralize cyberattacks.

Security is a fundamental pillar of Nokia's [Sense, Think, Act vision](#) for autonomous networks (more on that later). For now, suffice it to say that security must be baked into every layer of the network, from physical infrastructure, cloud resources, OSS/BSS, to applications and services. This approach helps CSPs move beyond reacting to threats; they can shift to predictive security, as their networks identify and address vulnerabilities proactively.

Integrating security into the network cannot be an afterthought. It must be an integral part of the autonomous network foundation – and conversation.

Cloud-native networks are the unsung heroes

Amid the AI and automation software hype, it's easy to overlook a critical component of autonomous networks: the architecture. Building flexible, cloud-native networks is a must.

Let's look at some more numbers. According to Omdia, a staggering \$14.7 billion, or 4% of the industry's capital expenditure, is spent on network function cloudification. Why? It's simple: cloud-native networks give CSPs flexibility, resilience, and cost optimization. They can scale services in real-time, keeping up with customer demands without breaking the bank.

One CSP summed it up succinctly: "Telcos must build flexible, cloud-

native, modular network architectures, enhanced by APIs."

Such architectures allow CSPs to merge OSS/BSS, creating a unified platform for better customer experiences. For example, an EMEA CSP deployed over 400 use cases, including AI-driven Wi-Fi optimization and energy-saving applications, all built on a modular, cloud-native framework.

As one CSP said, "[Go Cloud or Go Home](#)". Cloud-native networks unlock innovation and let CSPs scale fast. By going modular and cloud-based, telcos can quickly deploy AI and improve services. Telco cloud is the engine driving network transformation.

AI + Automation: We can't mistake popular for fundamental

It's tempting to view AI as the one-stop solution for network management challenges, but it's not that simple. While AI offers immense potential for insights, decision-making, and automated actions, automation remains the backbone of operational efficiency.

Looking ahead, automation will play an increasingly significant role. By 2028, AIOps is expected to account for 26% of CSP automation investments, according to Appledore. This isn't speculative; one Tier 1 CSP in EMEA, which embraced AI-driven service assurance, reported a 75% reduction in incidents over the past decade.

Network automation roadmaps are going to differ by CSP. Key factors like cloud maturity, current automation level, and AI skill set will inform the next best steps to take. The industry's efforts to scale AI-driven use cases are wide-ranging, from dynamic pricing models to predictive maintenance. In the end, it's not about picking AI over automation,

or vice versa. It's about combining these technologies to tackle today's challenges and set the foundation for advancing automation levels tomorrow.

China Mobile: Cutting Complexity, Saving Millions

China Mobile has made significant strides toward autonomous networking with Nokia by developing an advanced GenAI solution for network operations and maintenance (O&M). This collaboration, leveraging TM Forum's frameworks for AI in operations and autonomous networks, is delivering [quantifiable results](#) across China Mobile's 4G and 5G networks in Guangdong, Beijing, and Fujian provinces, serving 190 million subscribers.

By integrating open-source large language models (LLMs) and localized knowledge centers, China Mobile is changing how engineers access and utilize critical network data. Tasks that once took hours, e.g., querying complex knowledge bases, are now completed in seconds, thanks to natural language-driven Q&A capabilities. This shift has led to:

- 80% faster knowledge acquisition, cutting query times to less than a minute.
- 72% improvement in data analysis efficiency, saving 13,545 workdays annually.
- Software development acceleration by generating DevOps code based on intent, cutting feature development time by 50%.
- \$7 million in annual savings, including \$2.9 million from streamlined data analysis, \$2.5 million in operational cost reductions, and \$1.6 million saved on reporting tasks.

For China Mobile, this partnership with Nokia is a step closer to achieving Level 5 automation.

GenAI to address the challenges of Autonomous Networks

Improving O&M efficiency for 190 million subscribers in 3 provinces

#1

Acquisition time reduced by 80%

- Before: 5-10 minutes to find cases + more time for best optimization solution
- After: < 1.5 minutes, saving 80%+ of the time

Query accuracy improved 67%

- LLM response is more comprehensive & knowledge coverage is increased by 67%

#2

Data exploration & analysis

- Transitioned from manual scripting/BI tools to automated SQL query generation via natural language.
- **Saved 10,000+ workdays** annually.

Operations report development

- Reduced average report development time from 3 days to 1 day.
- **Achieved 200% efficiency boost**, resulting in €M savings.

#3

€M annual cost saving for feature development

- Before: 9 days average feature development
- After: 5 days. **80% improvement in efficiency**

With measurable results like faster problem resolution, reduced operational costs, and streamlined development, the GenAI solution is proving to be a pivotal tool in scaling China Mobile's vision for autonomous networks.

Read [here](#) for more details on this collaboration.

Nokia's Sense, Think, Act approach to autonomous networks

At its core, the push toward autonomous networks boils down to two critical priorities for CSPs:

1. **Saving Money:** Streamlining operations to reduce costs in a world of increasing network complexity.
2. **Making Money:** Unlocking new revenue streams through innovative services like network programmability and network slicing.

For CSPs, achieving these goals requires more than incremental changes. It demands a full-stack approach that automates

everything from the network core to customer-facing applications. But here's the challenge: making this vision a reality isn't easy.

At Nokia, we understand that advancing network automation isn't a one-size-fits-all solution. Each CSP's network serves a different set of customers, with unique regional requirements and service demands. However, one constant across all CSP networks is the rising bar of customer expectations. To meet these demands, autonomous networks are the way forward.

Building on [TM Forum's Autonomous Network Maturity Model](#), Nokia's autonomous network vision combines intelligence and automation for speed, simplicity, and security. It's summed up in three key actions: [Sense, Think, Act](#). Sense with observability, Think with AI/machine learning, Act with closed-loop automation for a Zero-Touch, Zero-Wait, Zero-Trust experience.

Our multi-vendor, multi-domain strategy integrates analytics, AI,

and security to provide a uniquely comprehensive solution. Security is embedded at every level, ensuring networks are inherently protected with advanced threat detection and mitigation.

Here's how we do it:

- **Security-first design:** We deliver autonomous operations with [built-in security](#) to safeguard networks against vulnerabilities.
- **Automation across multi-vendor networks:** Our [Digital Operations](#) software solutions provide zero-touch autonomous operations, even in networks combining equipment from different vendors. This ensures seamless service orchestration and assurance, regardless of infrastructure complexity.
- **AI-driven insights:** With deep expertise in RAN, transport, core, and edge, we leverage our [AI and analytics](#) software portfolio to optimize network performance, enabling closed-loop automation and actionable insights.

Nokia Autonomous Networks: Sense. Think. Act.



■ **Network monetization:** Our [Network as Code](#) platform allows CSPs to expose APIs to developers, enabling real-time application interactions with the network. This is a game-changer for monetizing capabilities like network slicing.

2025 is shaping up to be the year of autonomous networks, and we're proud to have paved the way for [many of our customers](#) this past year. As we move closer to full autonomy, we're committed to helping CSPs build networks that sense, think and act.

What can CSPs do in 2025?

"2025 is the year of the investment for us. It's where we'll invest in our digital transformation

as well as our technology transformation." -Cathy Yao, SVP of investor relations, T-Mobile

Fully autonomous networks aren't here yet, but we're on the right track. To get there, CSPs can:

- Use AI and automation and focus on practical steps and real results.
- Build flexible, cloud-based networks to simplify connecting...everything.
- Train teams to handle the complexity of future networks.

Autonomous networks will change the way CSPs work. With the right tools, skills, and roadmap, we can create a more efficient, innovative, and profitable industry. And this is the year to start.

Click [here](#) to discover more about Nokia's Autonomous Network promise and results.

About Nokia

NOKIA

At Nokia, we create technology that helps the world act together. We put the world's people, machines and devices in sync to create a more sustainable, productive and accessible future. We are a B2B technology innovation leader pioneering networks that sense, think and act™.

ZTE

ZTE's Perspective on Autonomous Networks

As the telecommunications industry evolves to meet the demands of hyper-connectivity, autonomous capabilities are no longer a futuristic aspiration—they are a necessity. At the forefront of this transformation, ZTE has established itself as a global leader in Autonomous Networks (AN), delivering cutting-edge solutions that drive efficiency, enhance customer experiences, and open new avenues for growth. With a proven track record and a robust portfolio of innovative products, ZTE is redefining how networks are managed, optimized, and monetized.

Value of Autonomous Networks

Enhanced User Experience

By implementing ZTE's multi-agent solution, Communication Service Providers (CSPs) can deliver a superior user experience. China Mobile's successful deployments at major events have demonstrated significant improvements in efficiency and connection ratios, illustrating the solution's ability to enhance user satisfaction at scale.

Increased Operational Efficiency

The automation of complex cross-domain tasks reduces the workload on Operations and

Maintenance (O&M) teams, leading to faster issue resolution and more efficient use of resources. This transformation allows CSPs to focus on strategic initiatives rather than manual operational burdens.

Business Expansion Opportunities

Autonomous Networks enable CSPs to offer new, intent-based services dynamically tailored to user needs. This creates additional revenue streams by aligning service delivery more closely with customer expectations.

ZTE's AI-Driven Multi-Agent System Solution

ZTE's solution leverages AI to create cross-domain agents that collaborate using standardized APIs, facilitating seamless integration across various operational domains and vendor systems. Key components of this innovative solution include:

Generative AI and Large Language Models

By utilizing Generative AI and Large Language Models, ZTE's multi-agent system enables continuous learning and adaptation. This enhances the system's ability to predict and resolve network issues, ensuring proactive rather than reactive management.

Cross-Domain Integration

The solution collects and analyzes data from different network layers, providing a holistic view of the network. This integration enables more effective resource allocation and fault management, significantly improving operational reliability.

Natural Language User Interface

ZTE introduces a natural language interface that allows O&M teams to interact intuitively with the network. User requirements can be translated into immediate network responses, streamlining communication and reducing operational complexity.

Advanced Task Scheduling Algorithms

ZTE's advanced scheduling algorithms ensure that complex tasks are coordinated and executed efficiently, aligning business, network, and service processes to optimize outcomes.

ZTE's Vision for Autonomous Networks

Autonomous Networks represent a paradigm shift in network management and operations. By

leveraging AI, machine learning, and advanced automation, AN enables networks to:

- **Self-Optimize:** Continuously adapt to changing traffic patterns and service demands.
- **Self-Heal:** Detect and resolve faults before they impact users.
- **Self-Evolve:** Learn from historical data to improve performance and efficiency.

ZTE's approach to AN is rooted in practicality and results. With scalable, modular solutions, ZTE ensures that CSPs and enterprises can embark on their AN journey at their own pace, achieving measurable outcomes at every step.

Key Solutions: How ZTE Leads in AN

1. RAN Composer: The Engine of Dynamic Resource Allocation

ZTE's RAN Composer exemplifies the transformative power of AI in resource optimization. Designed for dynamic allocation of radio access network resources, it ensures seamless service delivery:

- **Real-Time Optimization:** Adjusts spectrum, power, and base station resources based on real-time demand.
- **Customer-Centric Allocation:** Prioritizes high-value services or users for premium experiences.
- **Energy Efficiency:** Reduces energy consumption by shutting down underutilized resources during off-peak hours.

2. Unified Intelligent NOC: Centralized Control for Seamless Operations

The Unified Intelligent Network Operations Center integrates monitoring, fault management, and operational workflows into a single platform powered by AI:

- **Real-Time Visualization:** Provides end-to-end visibility for faster decision-making.
- **Predictive Maintenance:** Proactively identifies and addresses faults.
- **One-Click Repairs:** Minimizes downtime with automated workflows.

3. SLA-Driven Service Management: Guaranteeing Performance Excellence

ZTE's SLA-driven service management ensures compliance with stringent requirements:

- **Service-Specific Optimization:** Monitors over 20,000 service types.
- **Dynamic SLA Compliance:** Reallocates resources in real-time to meet SLAs.
- **Proactive Assurance:** Uses predictive analytics to flag potential risks.

4. PowerPilot Pro: AI-Driven Energy Optimization

ZTE's PowerPilot Pro enables CSPs to achieve energy efficiency goals while maintaining service quality:

- **Intelligent Energy Management:** Optimizes power consumption.
- **Dynamic Adaptation:** Adjusts measures in real-time.
- **Sustainability Impact:** Reduces carbon footprint and operational expenses.

Real-World Applications of ZTE's AN Solutions

Smart Manufacturing

In a smart manufacturing park, ZTE's AI-driven fault management ensured uninterrupted operations for robotic assembly lines and AR/VR applications. This led to a 35% reduction in downtime and a 25% increase in efficiency.

Energy Sector

In an electric power park, ZTE's Unified Intelligent NOC centralized 5G network monitoring, reducing fault recovery times and ensuring uninterrupted energy distribution.

Industrial IoT

A mining enterprise utilized ZTE's SLA-driven service management for real-time connectivity of autonomous vehicles and sensors. This enhanced safety, operational efficiency, and SLA compliance.

The Competitive Edge: Why ZTE?**Proven Expertise**

With decades of telecom innovation, ZTE is a trusted partner for CSPs and enterprises in over 160 countries.

End-to-End Portfolio

ZTE offers comprehensive AN solutions spanning hardware, software, and services for seamless integration across network ecosystems.

Innovation-Driven Approach

Investments in R&D ensure ZTE remains at the forefront of AI, automation, and sustainability advancements.

Customer-Centric Design

ZTE's solutions align with customer needs, delivering measurable ROI and enhancing business outcomes.

Looking Ahead: The Future of AN with ZTE

As the telecom industry transitions to AN, ZTE is pioneering solutions that are practical, scalable, and impactful. The next phase of AN evolution will integrate General AI (GenAI) to:

- Enable natural language interaction for easier management.
- Improve intent-based networking for tailored services.
- Enhance predictive capabilities for fault management and SLA assurance.

In Essence

ZTE's Autonomous Network solutions represent the pinnacle of technological innovation and practical application. From dynamic resource allocation with RAN Composer to energy optimization with PowerPilot Pro, ZTE delivers proven, real-world benefits that address the unique challenges of CSPs and enterprises. By combining advanced AI, automation, and a customer-centric approach, ZTE is not just enabling the networks of today—it is shaping the networks of tomorrow.

Partner with ZTE to unlock the full potential of Autonomous Networks and drive your operations into the future.

About ZTE

ZTE

ZTE Corporation is a leading global provider of telecommunications solutions and services, delivering innovative technologies that power networks, enterprises, and consumers worldwide. Established in 1985, ZTE operates in over 160 countries, specializing in comprehensive end-to-end solutions across fixed, mobile, IT, AI and enterprise networks. With expertise in 5G, Autonomous Networks (AN), cloud computing, AI, and IoT, ZTE empowers customers to achieve network intelligence, operational efficiency, and sustainability. Renowned for its commitment to research and development, ZTE drives cutting-edge advancements that enable seamless connectivity and digital transformation, building a smarter, more connected future for its global partners and communities.

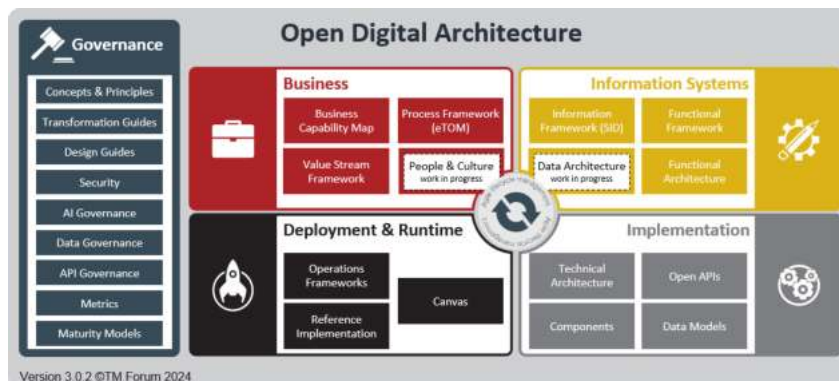
tm forum open digital architecture

A blueprint for intelligent operations

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

ODA 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](#), ODA is being used by leading service providers and software companies worldwide.



ODA includes:

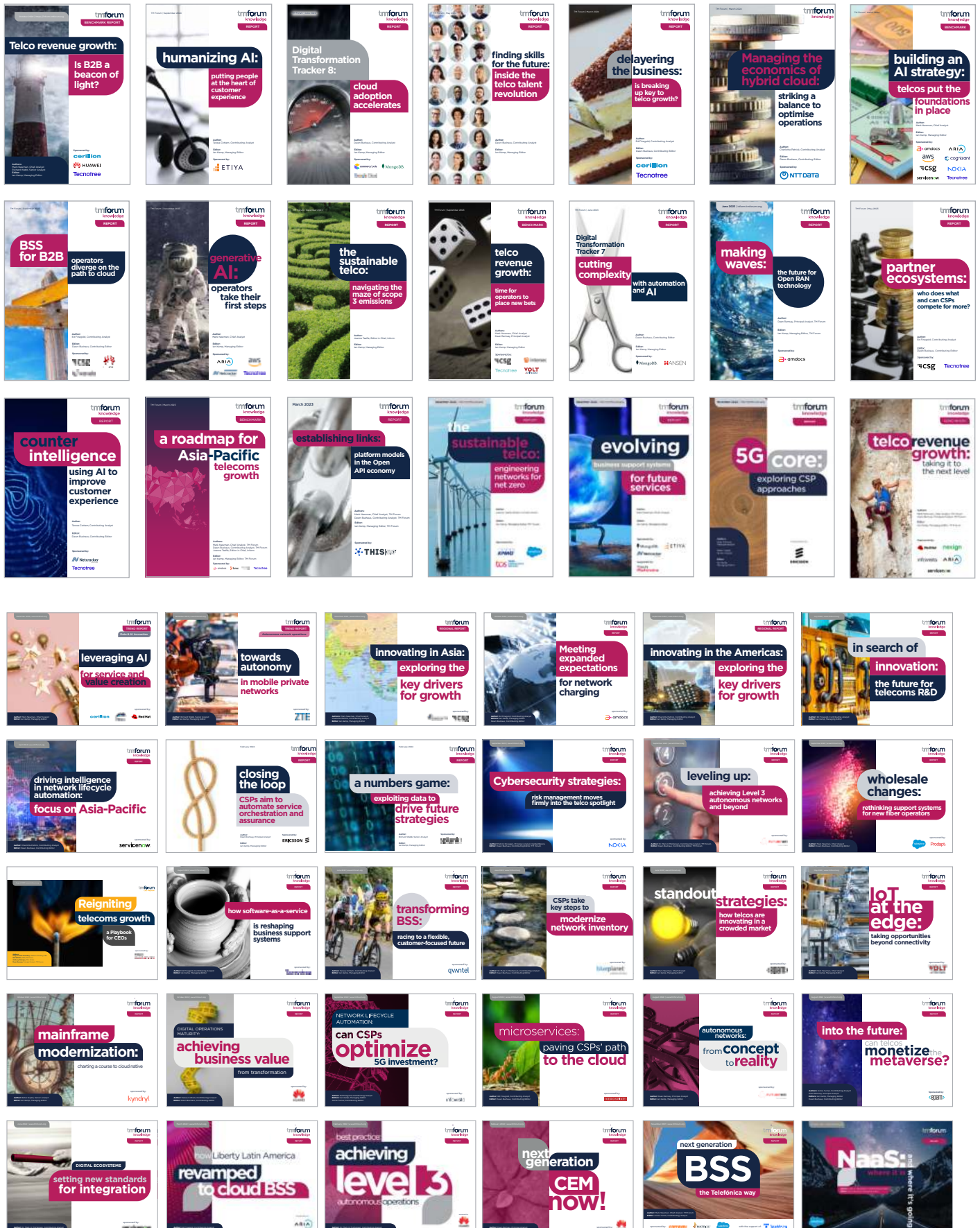
- An architecture framework, common language, and design principles
- [Open APIs](#) exposing business services
- Standardized software components
- A reference implementation
- Guides to navigate digital transformation
- Tools to support the migration from legacy architecture to ODA
- Maturity models and readiness checks to baseline digital capabilities.

Goals of the Open Digital Architecture

The aim is to transform business agility (accelerating concept-to-cash), 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 Architecture, or how to get involved in the TM Forum Collaboration Community, please contact [George Glass](#).



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on **Autonomous Network Operations**