5G NETWORK ANALYTICS AND NWDAF

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1. EXECUTIVE SUMMARY

There is a growing belief in the industry that if operators can move value creation into software, they can compete effectively in a digital economy. This digital economy is underpinned by the fourth industrial revolution, which fuses physical, digital, and biological worlds. This combination highlights that data, and their optimum use, will be the bedrock on which to create new value. Total production in the digital economy will be a function of conventional factors of production (land, labor, and capital), but also technology and data. With data and analytics becoming a crucial production element, smart storage and use of data become key strands that provide both challenges and opportunities.

At present, less than 2% of data generated have been stored. Within that, less than 10% have been analyzed and applied. In other words, 98% of the means of production is not being used. That is significant in terms of productivity and innovation gains. In telcos, there is agreement that with 5G, the direction of travel is huge amounts of data and insights. That is the fuel that will be fed into algorithms and commercial decision-making. A first step in that journey for telcos is to build a data infrastructure underpinned with the right analytics standards and functions. This infrastructure should include data collection, storage, processing, and an understanding of the economic specifics of data and analytics.

With the data becoming a key component in a digital economy, Communication Service Providers (CSPs) must better understand what type of data they have and the value. This is especially required early in the journey when telco-specific standards are still maturing. Network Data Analytics Function (NWDAF), for example, is a 3rd Generation Partnership Project (3GPP)-based analytics function designed to provide analytics to drive actionable insight. NWDAF focuses on the 5G Core (5GC). It helps CSPs obtain some clarity in terms of the business value they get from data and analytics, albeit from an operations standpoint. This is timely and bodes well for a rapidly changing marketplace with new entrants emerging, namely cloud companies. (Section 5 discusses NWDAF in more detail.)

Software and cloud companies (*e.g.*, Google, Amazon, and Apple) leverage Big Data and analytics to move forward and reach decisions rapidly for their global operations. By contrast, in the telco sector, there are hundreds of CSPs and vendors, each of which competes, innovates, and moves in a different direction and at a different pace. But with 3GPP-specific standardization, CSPs and vendors have the opportunity to adopt the same standard to move in the same direction, albeit at different speeds. A significant aspect underlying the industry's transformation is the importance of achieving cohesiveness. To that end, standards like NWDAF may be a first step in the right direction. It enables the industry to place data and analytics at the heart of its innovation model. Also, it serves as a stepping

stone for CSPs to build analytics functions that can potentially propel them forward to ride the growth wave associated with the digital economy.

Generating data at the edge and processing it locally for local decision-making will create new revenue opportunities for technology suppliers

Going forward, in a digital economy where apps and Application Programming Interfaces (APIs) rule supreme, CSPs will need to become much more app aware by applying analytics at multiple "stations" of the network, spanning core, transport, and edge locations. According to some experts, most data in the coming years will come from edge deployments and terminals. Also, 50% of the data generated at the edge will be processed locally for local decision-making, a trend that is expected to create new revenue opportunities for technology suppliers.

2. MARKET TRENDS AND TELCO ANALYTICS BACKGROUND

2.1. CURRENT MARKET DEVELOPMENTS

Policy management, operational intelligence and analytics functions, and decision-making will need to also align with the distributed nature of telco network ecosystems

A growing cloudification and disaggregation of telco networks introduces inherent complexities and operational challenges. Hardware and software components in 5G networks are located in different networks, spatially separated by any distance and in entirely different geographies, or potentially in the same building or room. This is especially relevant for Virtual RAN (vRAN) environments where CSPs' Data Centers (DCs) increase in number from today's 100 to potentially 1,000s, Virtual Machines (VMs) proliferate from 100s to 1,000s, and networks shift from 10s in core environments to 100s at the "edges." In such networks, policy management, operational intelligence and analytics functions, and decision-making will need to also align with the distributed nature of the ecosystem. Though there is more flexibility provided, there is an element of risk that CSPs need to understand.

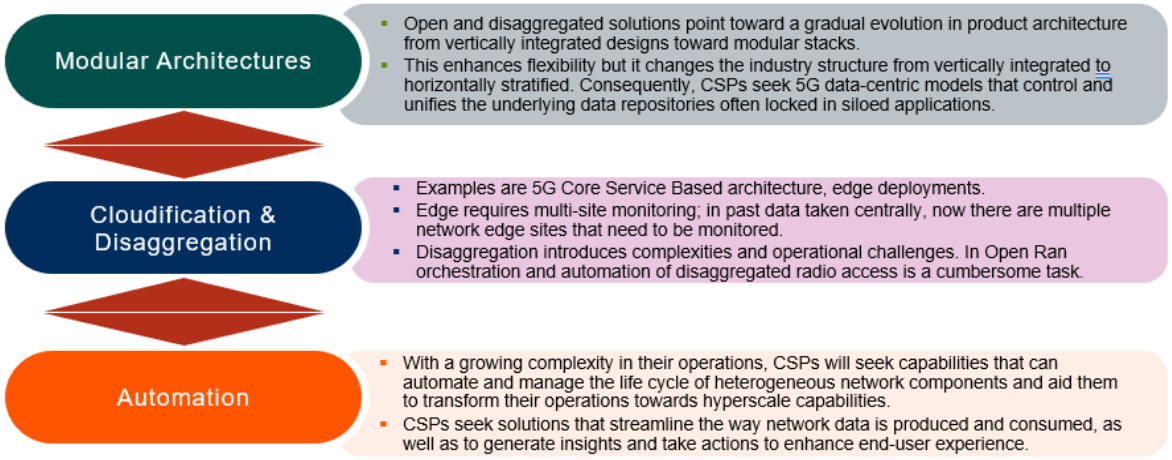
When looking at disaggregated value chain and modular architectures, there are typically two approaches to de-risk business for CSPs. The first approach, as discussed in ABI Insight A Changing Telco Landscape from Core to Edge Networks, is to create pre-validated blueprints that aim to certify components from different vendors. Alternatively, CSPs can place data, analytics, and AI at the heart of their innovation model, product design for life cycle management, orchestration, and automation. Broadly speaking, CSPs' investments in Big Data and analytics solutions fall under two categories:

1) When possible, buy out-of-the-box models that improve execution and results of their product logic and operations.

2) Buy analytics and Big Data models that positively impact business results; for example, improve market share, improve revenue/sales, and/or explore new revenue streams.

Figure 1: Market Trends in Telcos

(Source: Cisco)



2.2. INDUSTRY PAIN POINTS FOR BIG DATA AND ANALYTICS

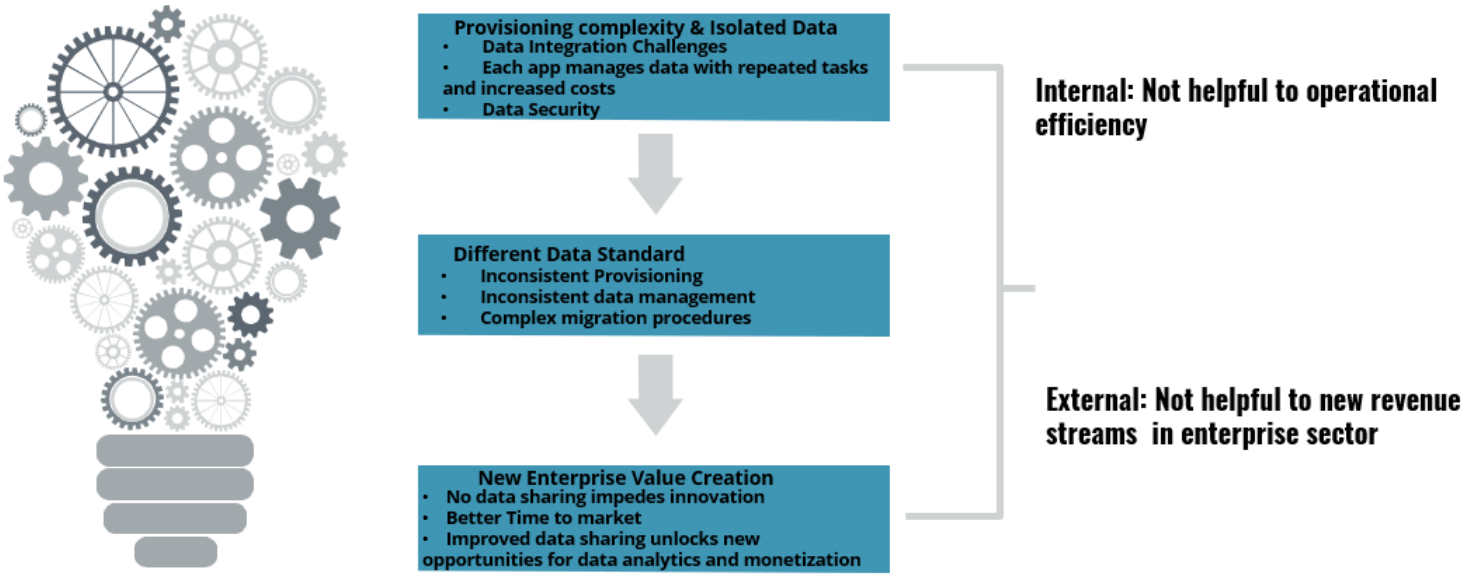
The use of CDRs in network and operational processes must be reviewed and adjusted in line with different functions for revenue assurance, analytics, etc.

5G networks place new requirements on network efficiency and reliability. For example, it is expected that there will be an over 10-fold increase in Call Data Records (CDRs) from 4G to 5G. That is because with 5G, in addition to network elements, CDRs will also be generated by the converged charging system. The use of CDRs in network and operational processes must be reviewed and adjusted in line with different functions for revenue assurance, analytics, *etc*. In addition, there will be a massive increase in devices and connections extending to 5G New Radio (NR). For many use cases, there will be 24/7 service for communication anytime, anywhere. The complexity is further exacerbated when considering that there will be 100X more connected end points and a heterogeneous network topology driven by Mobile-Access Edge Computing (MEC), enterprise services, and 5G private networks. There will be time-sensitive applications that require dynamic network resource allocation based on cloud-native and hybrid environments.

Furthermore, with multi-vendor deployments, as is the case with 5GC, consistent application Quality of Experience (QoE) and stringent Service-Level Agreement (SLA) requirements are critical for new services (*e.g.*, Enhanced Mobile Broadband (eMBB), Massive Machine Type Communication (mMTC), and Ultra-Reliable Low-Latency Communication (URLLC)). With ecosystem disaggregation and best-of-breed deployments, operational costs are expected to explode. Some vendors contend that a lack of automation can potentially increase network operations costs by 100% to 130% further drives that point home. To be able to meet SLA performance and reliability in increasingly complex ecosystems, analytics, orchestrations, and closed-loop assurances will be required.

Figure 2: Data Processing Challenges and Solutions

(Source: ABI Research)



With 2G, 3G, and 4G networks, CPSs focused on fault management Key Performance Indicators (KPIs) for reactive troubleshooting. With 5G, centralized analytics will be baked into call-flows for zero-touch, closed-loop service assurance, and intelligent remedy through flexible policies. There are three challenges that the explosive growth of data introduces. They are as follows:

- **Insufficient Capacity**: Scalability and Total Cost of Ownership (TCO) of storage become pressing issues as massive data need to be stored.
- **Isolated Data**: Service silos result in dispersion and isolation of data and, therefore, low analytics efficiency of diversified data. This is particularly acute in telcos.
- **Complex Management**: Massive, diversified data call for simple and more automatic data life cycle management.

3. CSPS' BIG DATA AND ANALYTICS PRIORITIES

3.1. TELCO PRIORITIES

CSPs seek to become data-driven and AI-powered companies to improve efficiency, revenue growth, service quality, and competitiveness. Change management is critical and constitutes the bulk of CSPs' efforts in that journey. CSPs seek new processes, ways of working, and cross-functional collaboration to manage risk as they embrace Big Data and analytics technologies. Furthermore, CSPs seek to capture context along their data journey to address key priorities as highlighted in Table 1. A key pillar

for CSPs to address these priorities is the ability to apply analytics at multiple "stations" of the network dynamically and to consume and process contextual data in very large quantities of measurements and events across a fragmented and disparate variety of data sources.

Data and network KPIs will increase by a thousand-fold, requiring a concerted effort from telcos to tightly integrate NFs and service assurance

An equally important aspect is the ability to build manageable data lakes enabling analytics for cross-domain, cross-technology datasets (dynamic and static) and insights. Data and network KPIs are expected to increase by a thousand-fold. This requires a concerted effort from the wider telco ecosystem for a tight integration of Network Functions (NFs) and service assurance. From an assurance perspective, vendors will need to assure multiple layers:

- **Assure the App Layer**: Vendors need to assure the app layer with lower network layers. This means connecting the app domain to the underlying communication assurance data where the cross-layer, cross-technology assurance view is key.
- **Assure the Software Stack**: Vendors should assure the software stack (containers, VMs) together with the communication apps.
- **Support Different Commercial Models**: Assurance needs to support different kinds of partnerships and business models, including Software-as-a-Service (SaaS), Network-as-a-Service (NaaS), Infrastructure-as-a-Service (IaaS), MEC, *etc*.

Table 1: CSPs Priorities for Data and Analytics Tools

(Source: ABI Research)

Key Priorities	Description
Smarter Networks	CSPs are looking to build smarter networks by eliminating the back doors that can give rise to (invisible) dependencies between apps and workflows. Further, it is not possible to build smarter and more efficient networks unless specialized and hardwired processed are cognified and digitized with intelligence and analytics. There are typically four layers where CSPs seek to embed intelligence in their networks: infrastructure layer, network layer, apps, and services layer. Each of these layers is a significant standalone domain that requires data and AI, beginning from life cycle management of radio elements, to automating the compute infrastructure and capacity, and to managing the capabilities they will deliver and services that run on top.
Reinvented Customer Experience	CSPs should address the siloed structure across their departments. With the analytics and Big Data intelligence, they should seek to foster an agile, data-driven culture where employees focus on delivering services and solutions based on a full picture of customers' needs and preferences. Furthermore, CSPs will be required to meet stringent SLAs for performance and reliability; increasingly for different flavors of the same service, and to ensure that operators can manage a number of different services with a high QoE.
Greater Operational Efficiency	Today's telco networks are still being managed with Operations & Maintenance (O&M) processes that date back to the 1980s. Further, another challenge is a growing complexity of today's networks with diverse cellular generations and O&M. The diversity increases the chances of human error. For example, 70% of network faults come from wrong input from O&M staff. Additionally, a lack of automated analytics can potentially increase network operations by 100% to 130%. Consequently, CSPs should use Big Data and analytics to emulate Over-the-Top (OTT) players that use advanced technology characterized by high efficiency and low cost.
Responsible and Sustainable Data and AI	The creation of Big Data and analytics platforms is not only a design challenge, but also a governance challenge. The success of responsible and sustainable data and analytics also hinges on framework-based governance, *i.e.*, an all-around step-by-step approach that governs and upholds core ethical values throughout the Big Data model formulation process in both short-term and long-term manners. All potential loopholes and downfalls need to be scrutinized and accounted for under such a framework to limit adverse impacts on future suppliers, partners, customers and end users. Furthermore, governance bodes well for CSPs to push for high commonality between diverse infrastructure platforms, replicate use cases between different markets to have uniform support, and centralize a lot of infrastructure functions.

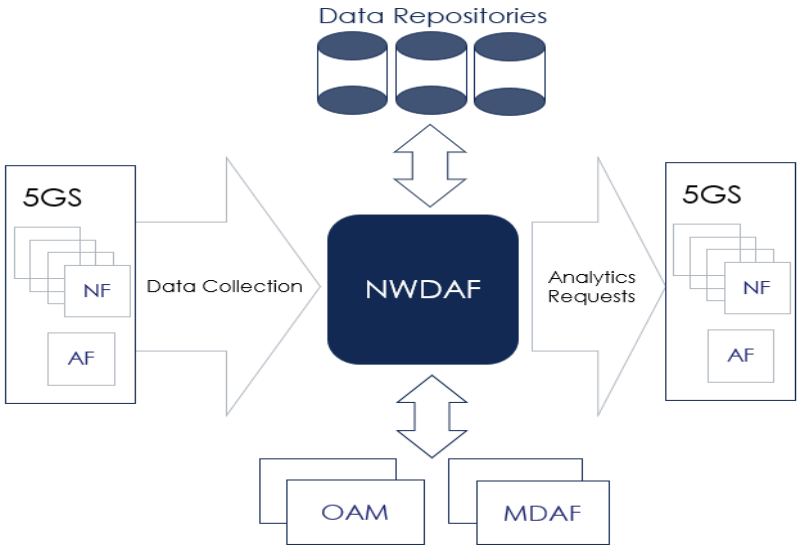
4. 5G DATA ANALYTICS STANDARDS AND NWDAF

4.1. WHAT IS NWDAF AND WHY IS IT IMPORTANT?

Specified in 3GPP as part of the 5G Service Based Architecture (SBA), NWDAF is a standards-based analytics function designed to provide a broad and deep set of analytics to drive actionable insights. NWDAF provides real-time, operational intelligence to requesting NFs in 5GC (*e.g.*, policy control function, unified data management, *etc.*) for network automation, service orchestration, and operational events. NWDAF consumes KPIs (*e.g.*, load, control, and user statistics) from NFs, processes this stream of information in real time, and provides predictions to NFs and other systems *via* subscriptions and pull interfaces.

Figure 3: Automating a 5G Network with NWDAF

(Source: Guavus)



NWDAF provides operational intelligence and analytics information from three perspectives:

- **Service Experience**: NWDAF analytics information supports flexible service requirements and guarantees service experience. It can provide metrics by user, application, and service type, and the tracking it uses extends across application type, device group, or geographic location.
- **Network Operational Intelligence**: Automatic network management, network fault prediction, service assurance, and fulfilment remain key "network-centric" application areas. The types of observed events here include measuring Quality of Service (QoS) sustainability, performance (throughput, latency, and jitter), and tracking network load, congestion, and anomalies.
- **User Device Connectivity Behavior**: NWDAF also provides real-time operational intelligence to track device mobility and device communication patterns, and detect abnormal usage.

4.2. STANDARDS AND 3GPP NWDAF ROADMAP

NWDAF is one standard, among a few others, that offers both statistical analytics (current and past state) and predictive analytics (future state). Other standards are Near-Real-Time Radio Intelligent Controller (Near-RT RIC) and Non-Real-Time Radio Intelligent Controller (Non-RT-RIC) for Open RAN (O-RAN) analytics and Operations Support System (OSS)-level standards. The level of adoption for each standards remains to be seen, but Figure 5 presents 3GPP's roadmap for NWDAF. Regardless of the standard that predominates, the industry should seek to define an information data model. In other words, industry bodies should establish a data model that facilitates an accurate and detailed description for internal topology, procedures, and life cycle of slices spanning the core network and the RAN.

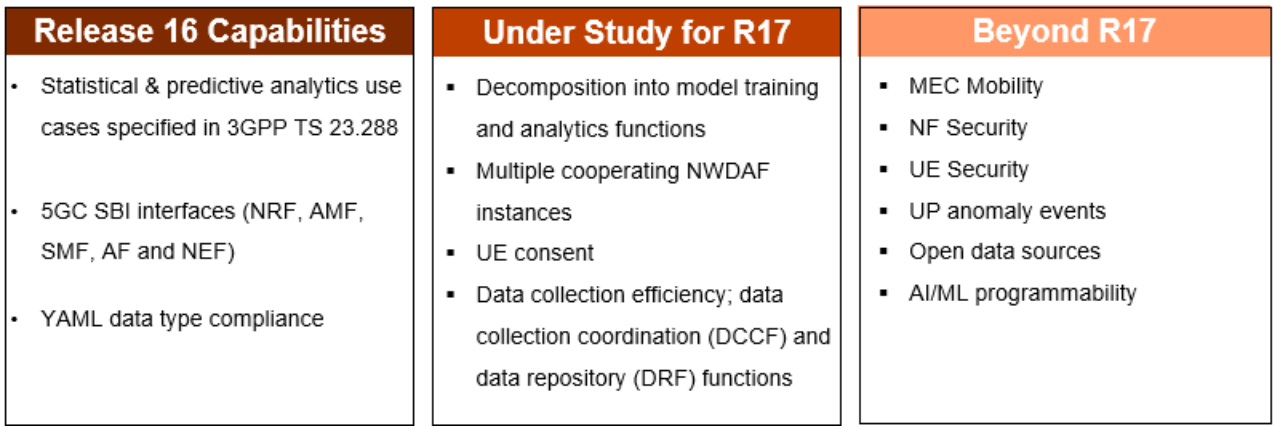
A common data standard eliminates data normalization, defines common semantics for KPIs, and develops common operational models for orchestration and automation

Works remains to be done, particularly on a common standard for data format, which may raise challenges for data unification. A common data standard eliminates data normalization, defines common semantics for KPIs, and develops common operational models for orchestration and automation. These benefits are bound to have a positive the ripple effect for CSPs and suppliers:

- **Select Best-of-Breed Products**: Enterprise verticals are likely to have varying requirements for NWDAF analytics. CSPs should have the option to pick best-of-breed products, and suppliers should compete on the ability to innovate and ensure product quality.
- **Potentially Reduce Integration Work**: A widely adopted standard, such as NWDAF, can potentially reduce the level of custom system integration required and achieve faster time-to-market, while reducing initial and ongoing costs.
- **Productize Analytics**: Suppliers can better productize analytics, orchestration, and automation functions based on common 5G operational scenarios and use cases.

Figure 4: 3GPP NWDAF Roadmap

(Sources: Guavus, ABI Research)



4.3. USE CASES FOR NWDAF

Data volumes are growing exponentially and the types of data that CSP must collect and analyze are set to also grow. NWDAF will play a key role in providing intelligence for several operational use cases,

but also potentially feeding strategic planning and decisions. One (or multiple) NWDAFs can support multiple Operations, Administration, and Maintenance (OAM) functions spanning the 5GC and applications for automation and orchestration management and operational intelligence. Data collection and analytics come from multiple data sources, including 3GPP Service-Based Interface (SBI) and non-standard sources to support various use cases as shown in Table 4. Guavus' Open NWDAF provides a good example for what can be considered as three key features or enhancements that a 5G analytics function should have regardless of the use case:

- **Flexibility**: Deploy at the right points in the network for optimal efficiency and performance. Also, a variety of deployment options is important to meet diverse requirements.
- **Scalability**: Adopt advanced AI/Machine Learning (ML) in the 5GC or cloud to achieve scale, and high-performance data collection, aggregation, and parsing in centralized and edge environments.
- **Extensibility**: In addition to 3GPP specific standards, 5G analytics functions should ingest non-standardized and plug into non-native analytics algorithms.

Table 2: Select NWDAF Use Cases

(Source: Sandvine, 3GPP)

Use Case	Overview
Network Performance	NWDAF can provide network and User Equipment (UE) performance and congestion-related statistics and predictions for its consumers to understand how network conditions are impacting QoE and make intelligent policy decisions to improve network performance and subscriber QoE. Key application areas are network performance analysis, user data congestion, policy optimization, and automated congestion management.
Service Experience	The 5GC is, to a large extent, a service business today, as the 5GC has a new service-based architecture, new NFs, and new APIs between it and the Container-as-a-Service (CaaS) layers that were not present in the past. Consequently, a key use case for NWDAF is to effectively facilitate the digital transformation of operations and deliver a superior service experience.
Load Analysis	With this use case, NWDAF can provide real-time operational intelligence in the form of load-related statistics and predictions for network slices and NFs making up those slices to its consumers to adjust NF resources and/or select the optimum traffic path or slice, ensuring efficient resource utilization. Key application areas are NF load analysis, load balancing, and slice load analysis.
Service Assurance	NWDAF helps provide current and expected service experience insights in the form of statistics or predictions to enable operators to deliver and assure network and next-generation service performance. Key application areas are observed service experience, QoS sustainability analytics, and application-aware performance optimization with flexibility to accommodate a rich array of services with heterogeneous (Quality of Service (QoS)) needs.
User Equipment Behavior Analysis	NWDAF provides insight into UE behavior with respect to mobility and usage patterns to enable prediction-driven UE control and management to optimize and protect networks from unexpected behavior and improve subscriber QoE. Key application areas are UE communication analytics, UE mobility, UE expected behavioral parameters, and UE unexpected behavior.

4.4. FIVE-STEP ACTION PLAN FOR TELCOS

Increasingly, there is growing interest among the CSP community to build out their data science teams. They are hiring data scientists to monetize applications and analytics. The type of capabilities that the operations team typically have within CSPs is also evolving with conversations around AI/ML metrics, the kind of algorithms, and the type of modes that can make a material change to CSPs from both operational and revenue perspectives. Furthermore, with experience-based value propositions

expected to increase in importance for CSPs, some in the industry are calling for CSP NOCs and Security Operations Centers (SOCs) to be transformed into customer experience centers.

To that end, Telefónica, for instance, uses Big Data and AI/ML to modernize its NOCs. Rakuten goes a step further with its decision to rename its NOC to a Service Operations Center. Singtel leverages automation capabilities and network slicing to make the foray into the B2B market. A common underlying pattern behind these examples is that they are using Big Data and analytics to drive effective business decisions. Broadly speaking, CSPs must consider the steps listed in Table 7 to better use the power of Big Data and analytics.

Table 3: Five-Step Action Plan for Telcos

(Source: ABI Research)

Steps	Description
Assess current digital technology capabilities	At first, CSPs should aim to understand current digital and Big Data capabilities and identify key leverage points; places in their operations where a small change in terms of data and connected business insights can drive a large shift in behavior.
Bolster data literacy competencies	Next, CSPs should seek to create Big Data and analytics champions across their organizations. The demand will be for levels of human capital that embrace Big Data, analytics, and AI to monitor performance, align decisions, and act with confidence. Many CSPs are already developing data and AI skills across their employee base. Orange, for example, claims that 70% of Orange's employees will have undergone data and AI awareness training by 2023.
Establish key use cases	Equally important is for CSPs to identify top use cases, particularly for 5G. These use cases need to be assessed on business impact and level of complexity in terms of datasets and skills required to deliver them.
Build a 5G data architecture	CSPs should work with key stakeholders to meet their main requirements in terms of seeing data in new ways, discovering insights, and unlocking new opportunities. Key dimensions, such as augmented data discovery, intelligent notifications, and self-service analysis are some of the key pillars for a data platform and 5G analytics functions, such as NWDAF that aids the shift toward a data-driven organization.
Start fast, experiment, learn, and adjust	CSPs should leverage data platforms and analytics solutions that are available today by pursuing early pilot projects with Minimum Viable Products (MVPs). Commercial benefits will accrue with later iterations once product maturity is in place and suppliers fully operationalize MVPs.

5. PROFILES OF SELECT COMMERCIAL ENTITIES

5.1. USE CASES

Ultimately, NWDAF and similar standards may have to go beyond providing real-time operational intelligence

Use cases for 5G analytics platforms and NWDAF fall within some broader buckets as shown in Table 8. They span traditional churn analysis, real-time analytics to optimize the network, management of OSSs/Business Support Systems (BSSs), areas like fraud and cyberthreat management, ways to monetize the cloud and Software-Defined Network (SDN) in their network, *etc*. Ultimately, NWDAF and similar standards may have to go beyond providing real-time operational intelligence. After all, seeking operational efficiencies does not necessarily amount to a strategy for new value creation.

There are three imperatives to a new cycle of technological innovation that CSPs, in collaboration with vendors, need to achieve a successful commercial uptake of NWDAF: drive growth and/or seek operational efficiencies with a better execution of current use cases; institute new business models; and create entirely new use cases for new growth. With a growing importance for best-of-breed

solutions, CSPs are seeking to drive decision-making at the edge to be more agile and combine both structure and unstructured data. With NWDAF and broader analytics tools and platforms, CSPs should partner with vendor partners on the following strands:

- Improving subscriber QoE, creating different flavors of the same service, and ensuring that CSPs can manage several different services with a high quality of experience are key long-term considerations for CSPs. Transforming operations, for example, alleviates operational complexity and reduces costs; driving real-time decision-making for an operationalized transformation of their core business.
- Balance Capital Expenditure (CAPEX) and performance.
- Pursue data monetization use cases and unlock additional value for CSPs that sit on vast pools of mostly network-related data that remain unexploited.

Table 4: Telco Industry Use Case Maturity Roadmap

(Source: ABI Research)

Peer Competitive Scale	Standard Among Peer Group		Common Among Peer Group	Strategic Among Peer Group		New Innovation
Use Case Name	**Customer Experience**	**Marketing & Advertising**	**Network Ops**	**Carrier Ops**	**Product Go to Market**	**IT Ops**
Customer Experience and Churn						
360° Customer View						
Dynamic Customer Profile						
Next Best Action						
Location & Context-Based CEM						
Target Audience Profile						
Context Aware Target Marketing						
Location & Context Aware Promotions						
Set-Top Box Customer Behavior						
Next Best Network Investment						
Predictive Maintenance						
Network Decommissioning/Modernization						
Dynamic Network Provisioning						
Customer Aware Network Prov (NFV)						
Cybersecurity						
Real-Time Fraud						

Peer Competitive Scale	Standard Among Peer Group		Common Among Peer Group	Strategic Among Peer Group	New Innovation	
Use Case Name	**Customer Experience**	**Marketing & Advertising**	**Network Ops**	**Carrier Ops**	**Product Go to Market**	**IT Ops**
Network Event Aggregation						
Security-as-a-Service						
Fraud-as-a-Service						
IoT/M2M—IoT Marketplace						
Personal Intelligence						
EDW Offload						
Storage Backup						

6. VENDORS: WHAT TO LOOK FOR

A key discussion point for the supplier community on the topic of analytics for automated operations is the level of certainty that network problems should be identified with to act upon automatically. There is, for example, a great deal of discussion in the industry about "root causes," but a root cause for a human operator can be much less specific than a root cause for an automated fix. This requires more data sources and more advanced analytics, AI, and ML. Many vendors, as detailed below, are going down this path; they provide real-time analytics, automated service discovery, and service impact analysis with customer impact, but the entire industry has to evolve here.

Furthermore, when ABI Research discusses ecosystem disaggregation and edge deployments from an analytics perspective, one key point is to support assurance for multi-domain, multi-technology networks and services. The challenges they have to address are three-fold:

1) Vendors should make available the right data models that will be generic enough (Meta models) for a plethora of use cases spanning network operational intelligence and new value creation for new use cases.

2) Vendors need to accompany analytics products with the right level of near-real-time updates. The near real time should be designed and built from the start, but many vendors add more and more real-time capabilities with each new version of their offering.

3) Cater to edge deployment. Edge is a different challenge that actually requires multi-site assurance (multi-site OSS). Some vendors like TEOCO address this by having a local agent at the edge that cooperates with the central system to provide the overall assurance functionality.

6.1.1. Sandvine

Sandvine claims that its Service Intelligence Engine enhances the NWDAF standard by using application classification and advanced ML capabilities to provide real-time data to unlock the true potential of 5G services

Sandvine is an application and network intelligence company that provides actionable insights to help CSPs deliver high-quality experiences to their consumer and enterprise customers. Sandvine's vision is to build technology that makes application experience delivered by its customers high quality and secure. Sandvine's Service Intelligence Engine is a 3GPP-compliant NWDAF that consumes KPIs from NFs, processes this stream of information in real time, and provides predictions to NFs and other systems *via* subscription and pull interfaces. According to Sandvine, its Service Intelligence Engine enhances the NWDAF standard by using application classification and advanced ML capabilities to provide the best real-time data that can unlock the true potential of 5G services.

Sandvine offers three deployment options for its Service Intelligence Engine: standalone NWDAF, standalone NWDAF with its active network intelligence (ANI) portal; Sandvine integrated NWDAF. Key use cases that Sandvine addresses with its NWDAF offering are 5G planning and adoption, network performance analysis, and real time subscriber insights. Sandvine's 5G use cases are designed not only to transition to 5G Standalone (SA), but also to automate 5G slicing operations. It is designed to provide CSPs with real-time visibility into how their networks are delivering service to their users and to ensure application QoE—packet loss, throughput, and latency for each application.

7. RELATED RESEARCH

AN-4897	Data Infrastructure in 5G Distributed Networks
AN-5201	5G Cloud Data Management
IN-6096	Building a Data Platform for 5G Networks
IN-5611	5G Analytics: A Tale of Modular Internet Architectures and Proprietary Telco Systems
MD-IOT5G-109	IoT Market Tracker: 5G

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