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Building a modern NOC for ground segment

Thomas Wegener[a]*, Per Gustav Porsanger[b]*

[a] *Kongsberg Satellite Services, Prestvannveien 38 | 9011 Tromsø, Norway, thomas.wegener@ksat.no*
[b] *Kongsberg Satellite Services, Prestvannveien 38 | 9011 Tromsø, Norway, per.gustav.porsanger@ksat.no*
* Corresponding Author

Abstract

The rapidly expanding satellite industry presents opportunities for ground station providers, as well as challenges to provide increased service demand. An escalating number of satellites are being launched every year, having witnessed a record-high amount in 2022.
The amount of payload data is increasing, and most use cases require high throughput, low latency, and real-time connectivity.
The NOC is the hub to ensure operational success, provide service management and deliver value for the customers.
The paper will address how KSAT consider modern NOCs will need to adapt, to remain the central part of the value chain for tomorrow's satellite owners and customers.

Keywords: Automation, Standardization, Self-service, Scalability

Nomenclature

This section is not numbered. A nomenclature section could be provided when there are mathematical symbols in your paper. Superscripts and subscripts must be listed separately. Nomenclature definitions should not appear again in the text.

Acronyms/Abbreviations

Kongsberg Satellite Services (KSAT)
Network Operations Center (NOC)
Ground Station-as-a-Service (GSaaS)
Earth Observation (EO)
Graphical User Interface (GUI)
Infrastructure-as-a-Service (IaaS)
High Power Amplifier (HPA)
Machine to machine (M2M)
REpresentational State Transfer (REST)/(RESTful)
application programming interface (API)
Radio Frequency (RF)
Radio Frequency Interference (RFI)

1. Introduction, why NOCs need to adapt

In 2022, a record high number of 2455 satellites were launched into space [1] For KSAT alone, being one of world's largest ground station provider with mere 270 antennas, they experienced a 35% growth in number of contacts, reaching over a million total in 2022. According to their forecasted market analysis, with new customers and new missions, these numbers are to escalate and reach a staggering 2 million contacts rolling year average in 2024.

In the past, most missions brought unique design, and required customized solutions. System specific maintenance, monitoring and equipment hosting, remains a big part of the ground station service. Thus, NOCs consists of highly competent operators, able to handle a variety of complex systems. However, with the current increase in demands, while calling for high quality services at lower costs, the current modus operandi is not sustainable and does not scale well with market.

If NOCs are to apply the same level of attention to all contacts and services as per today, the operational teams will need to have continuously organic growth to match the market. In addition, the different systems would soon outgrow available screen space, provide information overload, and lead to decreased response time and proficiency.

Based on market growth and service demands, NOCs will need to adapt and scale operations quickly, if they are to remain competitive, and deliver value to incumbent and new customers.

2. How we can evolve

One way to address this challenge in increased service demand, is standardization. Most new-space customers can work with a standard baseline ground station product. A global deployment of standardized equipment for multi-mission use have been done to meet the new space market. As the market grows, the ground stations can expand to match. When customers need customization, NOCs may offer tailormade solutions and charge premium. Tailormade solutions consist of dedicated antennas, customer backend, hosted equipment, dedicated technical personnel, closed environments, elevated levels of monitoring, support, and security and much more. Customization can also be applied to a standard baseline with add-ons for those who require additional services. Standardization will bring prices down and enable the industry to benefit further, as well as simplifying NOC environment and promote scalability.

Once standardization is in place, automation could be enabled efficiently. Every repeating task that can be controlled by rules, levels, or other parameters, should be automated. An example of this, is automatic signing of contacts, based upon parameters, with no need for manual interaction. To further improve, machine learning algorithms can be configured to detect and predict faults while analyzing quality of service by accessing big-data structures. This could be utilized by NOCs to prevent service loss, and to improve systems by preventive maintenance.

Systems can be developed to self-correct when exceeding threshold values or failing, alert operators if needed, and log event data for later trending and root-cause analysis. Smart, autonomous systems will ensure that failed services are restored, and operations are moved on to a redundant path. However, the best AI, or automated self-correcting system, can never fully replace the need for human interactions. The requirements for and purpose of the operator will change, but they will still be needed to analyze and understand the context of undefined events, solve problems, and define new rules for systems to act upon. The operator's knowhow, creativity, and ability to communicate will be even more important as systems are developed to become autonomous.

2.1 Evolving the business

Evolving the business is a continuous process, requiring us to change our mindset and a willingness to adapt. New challenges can be seen as obstacles or opportunities. Fulfilling all customer's requirements is not necessarily benefitting anyone, not even the board of individuals designing the requirements. Generic solutions can enable cost-driven development and benefit both the satellite owners, customers, as well as the ground network to grow rapidly.

When onboarding new customers, a contractual process takes place. By involving operations and technical team in this early phase, the customer needs could be defined, with the generic solution in mind, for how to best deliver the service. With a standard solution, customers may find that all or most of their enquires are met. If customization is needed, these requirements should be carefully assessed. If they provide shared value for other customers, the generic model could be expanded, or if not, a tailormade solution is developed. The goal is to minimize tailored solutions, as they are both costly to develop and maintain, as well as complicates service delivery.

Creating product teams secures consistent efforts on development and maximizing value for all parties. As the customer requirements and market conditions are fast-changing, continuous change will be important. For the ground network supplier, it is vital to have close interaction with your customers, to understand their needs and use that information to improve your business decisions. Having av cross-functional team working together with customers to develop products, can results in better products, faster time-to-market, improved collaboration, customer satisfaction and open business opportunities. At the same time, having set routines for maintenance, patching, updates, and replacements of products, secures quality and minimizing risk to operations.

2.2 Evolving teams and individuals

The operations center environment is complex and packed with screens showing all kind of information. A NOC is normally responsible for several ground stations, each consisting of multiple antennas with thousands of different components.

Simplification of the operations environment will allow operators to focus on key information and anomaly handling, ensuring service deliverables. Integration of systems into aggregated systems, and supported by simplified GUIs, will enable operators to utilize unified work processes and commands efficiently. This will also reduce time needed for training and competence, to manage each individual system. Taking into use an event-based architecture will structure and simplify information flow to highlight real-time activities and events. This could increase situational awareness and attention to what is important at any time, thus reducing response time and improving proficiency.

Today, NOCs main tasks include system monitoring, event management and troubleshooting. However, due to complexity of systems (number of, variety and different versions), lack of time and sufficient procedures, on-call technical support are often utilized. With automated system-monitoring and simplified event-based operations environment, focus could be directed to anomaly handling and to handle most 1st line technical support.

With automatization, we are utilizing the strengths of machines and humans in best way. Machines have a number of advantages compared to humans, including:

1. Processing speed: Machines can process information at much faster speeds than humans, allowing for faster analysis of data and quicker decision-making.
2. Accuracy: Machines can be programmed to be much more accurate than humans when it comes to performing calculations or analyzing data.
3. Memory: Machines have much greater memory capacity than humans and can store vast amounts of information.
4. Endurance: Machines can work for much longer periods of time without needing rest or breaks like humans do.
5. Consistency: Machines are able to perform the same task over and over again with no decrease in accuracy or efficiency.

In comparison, human strengths include:

1. Intuition: Humans possess a unique ability to make decisions quickly and accurately based on instinct and experience. This is something machines cannot do.
2. Creativity: Humans have the ability to come up with innovative ideas, find solutions, and think outside the box. Machines are limited in this regard.
3. Empathy: Humans are able to empathize and connect with others, which enables us to understand their emotions and respond accordingly. Machines don't possess this capability.
4. Adaptability: Humans have the ability to adjust to different environments, tasks, and situations. Machines are usually designed for a single purpose and are not as flexible or adaptable.
5. Human Touch: Humans possess the ability to provide a personal touch that machines cannot. This is especially true in fields such as healthcare or education, where human interaction is essential.

Humans tend to love problem-solving because it is a way of exercising their creativity and intelligence. Being able to solve a problem or figure out a solution gives us a sense of accomplishment and satisfaction. It also helps developing our problem-solving skills, which can be useful in many areas of life. Problem-solving can also provide a sense of control and autonomy, as well as a feeling of pride when we are able to solve a problem. By utilizing machines at their strengths, we can make them carry out the routine tasks and let people focus on creative and problem-solving processes.

Enabling the NOC to focus on troubleshooting rather than monitoring nominal operations, leads to a massive change process. The work tasks, roles, responsibility and competencies for both operations and technical teams, are altered. Changing work processes and responsibilities can affect humans in a variety of ways. On one hand, it can lead to greater job satisfaction, improved performance, and retention of personnel. On the other hand, it can lead to increased stress and anxiety, as well as confusion and frustration among employees as they attempt to adjust to new roles. With increased efficiency, it can also lead to excess capacity, as businesses may no longer need certain positions or roles that were once necessary. Thus, employees will be subject for change and need to adapt. For the ground network provider, managing the change process should be of uttermost importance.

2.3 Evolving customer interactions

Customer satisfaction and a good customer experience with the service management are important for NOCs. When customers are in need for support, they should be able to reach out to the NOC for any reason and experience an efficient and unified service provider. This is achieved by;

- Personalized and efficient interactions
- Enable self-service through customer portal
- Offer multiple channels of communication and focus on flow of information between Customers - NOC – Technical teams.

Customers want to experience service, response, priority, and acknowledgments. When customers call to a busy NOC, they should be met by a professional and service minded team. As the first line of support, NOC should have reliable procedures enabling operators to solve most known problems firsthand. If there are a need to escalate requests and anomalies, the on-call support team should be easily available and be able to communicate status and progress of work with NOC, so they can keep end customer updated. With an increasing number of requests, incidents and calls, the risk of customers experiencing a degradation in the level of support is increasing.

Manual support for nominal activities is time-consuming and inefficient. To support the customers more efficiently, they need to be provided with an easy-to-use platform for self-service. The portal offers customers access to schedule contacts, monitor ongoing contacts and check post-pass reports of completed contacts, through a RESTful API. This also allows for maximum utilization ot the ground station network. The customers are enabled to develop their own interfaces. Customers can choose to implement the ground segment monitoring into a satellite control environment, allowing full overview, and fast troubleshooting.

Enabling self-service will empower customers to fulfill their needs and experience more insight, which in turn should promote client satisfaction. At the same time, NOC can spend less time on manual support, allowing them focus on anomaly handling and technical support. Further this will allow technical recourses to work proactively and perform statistical issue trending and preventive maintenance, to further boost proficiency.

The portal gives customers a precise and interactive information flow. A real time view of upcoming and ongoing operations as well as insight into support history and incident management. The incident management process is transparent, sharing the latest information from all parties involved, to the end customer. The goal is that the portal becomes a one-stop-shop that offers everything needed to onboard new customers and cater all existing ones.

Many customers have questions or requests that still require NOC's first line immediate response. This level of support is more available and ready to respond when most of the inquiries reaching the NOC is handled by the portal, ticketing systems and API's.

2.4 Evolving systems

KSAT's multi-mission 3,7 m antennas are standardized and support multi customer. They are offered as GSaaS to customers through the global ground station network. Standardization of ground stations ensures equal performance on all sites and seamless integration of a mission across the network.

All backend systems connected to the 3,7m antennas consists of the same hardware and software components. Once a customer is onboarded to one antenna or site within the network it is in practice onboarded to the entire network. Connectivity between the sites and customers are standardized through an IPsec SD-WAN solution.

Dataflow solutions for low- and high-rate data distribution to customers are delivered either to a cloud solution or into a datacenter. More backend infrastructure is available as software-defined containerized solutions. IaaS allows for quick deployment, replacements, and repairs.

The ground stations need to have sufficient antenna capacity to have redundancy and support ad hoc / on-demand request above the aggregated customer commitment. If any system need maintenance or for other reasons have downtime, traffic can be moved to other systems, utilizing the "backup through antenna pool concept". Hot spare backends are connected, and services are ready to be started, configured and available to go into operations at all sites.

All sites, antennas and backend are delivering system metrics, the metrics are watched over by an AI. Machine learning algorithms are developed to monitor antenna and satellite performance trends. The AI looks for discrepancies from normal behavior based on historical data.

Example trends:

- How is the antenna output power performance over time
- The input power and signal characteristics (signal & power graphs) tends to be stable over time for healthy satellites. Aim to trend this signal and help detect if we see signs of decreased performance: this can be used to help notify satellite owners detect anomalies before they occur.
- Detect discrepancy in satellite signal and categorize and automatically notify whether there is a satellite RFI.

The development of machine learning AI systems is continuous work in progress – and additional algorithms for new measure points to be included in the future.

The KSAT Controller acts as a utility tool. One of the controller's main tasks is to monitor, evaluates and act on anomalies on ongoing contacts. Signal quality, pointing, HPA values, health statuses, data transfer, configurations, etc. The controller act if required. If anomalies are detected this is either self-corrected by the controller or escalated to the engineering team. Controller self-correct certain systems to improve performance:

- Crashed SW,
- HPA adjustments,
- RF matrix adjustments

Controller improvement is a permanent task. The aim is to automate operations of all contacts and run operations 'lights off'. Avoid manual monitoring of successful passes, and only react on anomalies. For incidents that require immediate human attention, the systems alert operators in the NOC. Alarms and notifications are generated into an incident management system. For critical anomalies a triage process is called for, to determine root cause analysis, optimization, path forward and improvements.

Satellite contacts are automatically signed by the system, based on parameters, and contact metrics. The contacts are signed as success or failure based on system status alarms (network, antenna, backend, configuration management, scheduling system etc.) and contact performance (antenna tracking, satellite & antenna metrics, network connectivity).

Antenna reservation is made available to customer through a M2M RESTful interface utilizing modern protocols which offers access to all antennas across all ground stations in the network through the same interface. The APIs are described in "Adapting ground station networks for automatic M2M operations" [2]

3. Conclusion

The satellite market will continue to grow, and new technologies develop rapidly. NOCs need to adapt their operations quickly to remain competitive and deliver value to customers. In order to scale with the market growth, ground station provider needs to simplify products and utilize standardized solutions.

Moving ahead, KSAT will continue to modernize their entire ground station network. All antennas, infrastructure and backend will be modernized and implemented into a common ground network. In parallel, all systems and tools for NOCs will become standardized and allow for automatization of nominal operations. Aggregated information and alerts will turn NOCs focus to anomaly handling. Customers will be supported by modern communication channels and self-servicing. The goal is to provide world class support, with optimized proficiency, if NOCs are to remain the central part of the value chain for tomorrow's satellite owners and customers.

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