



International Civil Aviation Organization

WORKING PAPER

A41-WP/513

TE/187

12/9/22

(Information paper)

English only

ASSEMBLY — 41ST SESSION

TECHNICAL COMMISSION

Agenda Item 31: Aviation Safety and Air Navigation Standardization

APPROACH FOR THE DEVELOPMENT OF UTM REGULATORY FRAMEWORK

(Presented by Saudi Arabia)

EXECUTIVE SUMMARY

This paper provides an overview of the implementation of NEOM unmanned aircraft systems (UAS) traffic management (UTM) system in the Kingdom of Saudi Arabia, which offers an opportunity for cumulative operating experience in advanced air mobility (AAM) and unmanned aircraft systems (UAS) technologies, and for the validation of the concept of operations (ConOps) for the UTM architecture. It also highlights the approach used by the General Authority of Civil Aviation (GACA) to develop an initial regulatory framework for UTM considering the outcomes of on-going development and experience gained, ICAO UTM guidance material, as well as UTM regulations and specifications developed by Contracting States, leading organizations, and Standards developing Organizations (SDOs). This approach will ensure an easy bridging from high-level requirements to detailed means of compliance and guidance for UTM implementation.

<i>Strategic Objectives:</i>	This paper relates to the Safety and Air Navigation Capacity and Efficiency Strategic Objectives.
<i>Financial implications:</i>	Without any financial implications
<i>References:</i>	ICAO Unmanned Aircraft Systems Traffic Management - A Common Framework with Core Boundaries for Global Harmonization - Edition 3 ¹

¹ <https://www.icao.int/safety/UA/Documents/UTM%20Framework%20Edition%203.pdf>

1. INTRODUCTION

1.1 Under the implementation of Vision 2030 adopted by the Kingdom of Saudi Arabia, a new city is being developed in NEOM, a region in the northwest of Saudi Arabia on the Red Sea, as a city of the future and a thriving model of excellence for environmentally friendly, seamless, and sustainable modern life.

1.2 The development of NEOM City is based on several green and environmental initiatives covering the whole infrastructure, facilities, and transportation. NEOM's advanced air mobility (AAM) is one of the ambitious projects aiming to integrate AAM/UA into NEOM's multimodal mobility system. The primary aim of this project is to offer flexible inter-regional (between NEOM's regions) and intra-regional (within NEOM's regions) connectivity supporting the movement of people, goods, and services without the need for extensive conventional and road infrastructure. This project is considered as a major opportunity to accelerate the adoption of AAM as well as boost sustainable air transportation ecosystem in the Kingdom of Saudi Arabia.

1.3 NEOM's AAM project is developing optimized and innovative solutions aimed at becoming a global and regional reference to enhance transportation with the highest safety and sustainability standards. To support the development of the unmanned traffic management (UTM) concept in NEOM, GACA is conducting a comprehensive review of the regulatory framework related to AAM and UA (e.g., sUAS, RPAS, eVTOL and eSTOLs), infrastructure and regulatory requirements, airspace structure, personnel qualifications, digital communications and their design, certification, and airworthiness. GACA is also promoting the use of higher levels of automation to support not only safe, secure, and efficient AAM/UA operations but also proven capabilities that will bring a significant change in air mobility using innovative technologies. Additionally, GACA is developing a National Air Navigation Plan (NASP) considering the ICAO Global Air Navigation Plan (GANP) aviation system block upgrade (ASBU) framework, AAM operations, and their requirements encouraging air navigation innovation initiatives.

2. NATIONAL UTM CONCEPT OF OPERATIONS DISCUSSION

2.1 AAM/UA operations will be a foundation of inter-regional and intra-regional transportation in NEOM City. Therefore, a Concept of Operations for NEOM UTM has been developed based on global, and regional research, best practices, lessons learned, and available source of standards and specifications.

2.2 The definition of a UTM concept is supporting the integration of AAM/UA movement within and between NEOM's regions, such as NEOM Bay Airport, NEOM International Airport, The LINE, TROJENA, Gulf of Aqaba, OXAGON, and NEOM islands. The NEOM UTM concept has the flexibility/scalability to meet the evolving regulatory requirements of the Kingdom of Saudi Arabia, alongside the rapid development of technology capabilities of systems and aircraft over the coming years. Details on NEOM UTM vision and achievements are provided in the Appendix of this paper.

2.3 At its core, the NEOM UTM concept is guided by several governing principles that are determined to be essential in enabling a safe, efficient, robust, equitable, and community-friendly system architecture and operational design, including:

- a) regulations and operations of the airspace concept are guided by performance and risk-based approach to enable diversity of technology as well as accelerated adoption of innovative technologies without adversely affecting the safety of the current aviation system;
- b) the operational concept is defined to enable the most suitable hardware and software to be allocated to each use case in an optimal and future-proof way;
- c) the concept introduced is scalable and designed to be sufficiently open and flexible for future innovations, which will enable robustness and evolution through 2030+; and
- d) in the short and mid-term, air traffic services (ATS) interaction with the AAM/UA operations will be kept at a minimum with gradual and phased-approach integration between UTM and ATM. This is to ensure safe integration and interaction between UTM and ATM in the kingdom of Saudi Arabia. However, unusual, abnormal situations, and emergency conditions will be managed through specific arrangements between the ATS service provider and UTM operators.

2.4 Based on the advancement of NEOM UTM ConOps, a national UTM framework is being developed by the General Authority of Civil Aviation (GACA) involving the main stakeholders (air navigation services provider (Saudi Air Navigation Services (SANS)), and NEOM) considering the following principles:

- a) use of phased approach to validate AAM/UA operations where the initial phase must focus on segregated operating environment and lower risk operations;
- b) use of risk-based approach to approve and authorize AAM/UA operations with requirements on substantial operational testing and trials. Use of an integrated approach for approving and authorizing flying operations which combines airworthiness, technical, operational, and environment requirements;
- c) the AAM/UA operators must coordinate with the concerned parties to identify sensitive areas, locations, and facilities that must be protect from low-level flying operations with adoption of minimum altitudes, daylight hours, visual flight rules (VFR) rules, visual meteorological conditions (VMC), and avoidance of interference with operations and traffic patterns at any aerodrome or heliport as main conditions to authorize low-level flying operations and support safe activities;
- d) systematic use of approved flying zones and areas for specific and recurrent AAM/UA flying activities such as training and low-level flying routing as means of traffic segregation and conflict resolution measures;
- e) use of static or dynamic flying zones/areas of permanent and temporary basis considering AAM/UA performance, traffic, environment, and manned aircraft movements;

- f) the growth and integration of flying operations of AAM/UA should be based on data-driven solutions and consideration of proven and validated automated system solutions for the traffic deconfliction and overall management of activities;
- g) the publication of accurate aeronautical information, charts, and plotting of UAS flying zones/areas and flight routing with usage of platform for registration, data-exchange, and surveillance supporting safe flying operations through coordination with specialized government agencies;
- h) use of phased approach for the certification of operators and providers involved in AAM/UA operations as main means for ensuring compliance with the safety, technical, operational, environment requirements, and setting of sustainable organization for these operations;
- i) development of robust resilience and contingency arrangements to recover from unexpected failure or weather fluctuations and continue an AAM/UA flight operation despite loss or corruption of one or more datalinks or connections;
- j) the regulatory framework should include requirements for certification of UTM system providers, AAM/UA operators, and acceptance or authorization of UTM systems; and
- k) need for seamless integration between all accepted and authorized UTM systems including sharing flight plans by AAM/UA operators, real-time broadcasting & Remote ID identification data, updates to operational flight plans, and other critical components that are essential to the functioning of a scalable system.

2.5 GACA regulatory framework for UTM is considering NEOM UTM as use case, ConOps, initial operating experience for AAM/UA flights management and work in progress to identify initial technical and operational requirements for UTM systems considering the governing principles described in §2.4. This framework is also contemplating ICAO UTM guidance material, the best practices developed by Contracting States, leading organizations, and Standards developing Organizations (SDOs).

2.6 Moreover, GACA is monitoring RTCA and EUROCAE specialized Working Groups (WG) and Sub-Groups (SG) such as WG-105/ Unmanned Aircraft Systems (UAS), WG-105/ SG-1/Detect and avoid, WG-105/ SG-2/C3 and security, and WG-105/ SG-3/UTM which are expected to produce key deliverables related to Technical Specifications and Minimum Operational Performance Standards for the safe operations and integration of AAM/UA into the aviation system and for the provision of UTM services.

2.7 It is expected that GACA regulatory framework will be based on an iterative approach based on the on-going development and evolution of AAM/UA and UTM concepts and operating experience. It will incorporate, at least the following provisions and rules:

- a) initial requirements on certification and operational approval of UTM, supporting increasing capability and complexity of operations over a period of time. These requirements will refer to UTM/AAM/UA industry standards (SDOs) system and operational performance requirements to support certification and operational

approvals, with focus on system protocols, data exchange, communications, and interoperability;

- b) development of Specific Operations Risk Assessment including hazard analysis and safety engineering modeling and analysis tools to validate the performance of complex software and hardware used in the deployment of UTM system;
- c) initial requirements on operator/pilot training and human factors with details on knowledge, skills, and abilities to be competent for jobs and tasks associated with AAM/UA flights management;
- d) initial requirements on AAM/UA capabilities, performance, and manoeuvrability covering communication, performance-based navigation, and detect and avoid;
- e) requirements on UTM System architecture framework including principal elements, functions, interfaces of the system, communications, and monitoring/surveillance capabilities, including decisions for spectrum, data exchange, and cybersecurity standards. These requirements will also cover rules on adapting architectural function and components over time as new UTM features and capabilities, and associated requirements for their development, testing, and validation;
- f) rules for geographical zones data provision, identification, and management of static no-fly zones (including critical infrastructure) and static restricted zones;
- g) requirements on UTM management system related to the provision of all necessary data to enable safe traffic operations (information management), airspace management required for optimum use of airspace in collaborative manner, and monitoring of the airspace operations on a strategic and tactical levels (traffic management). These requirements will mainly cover:
 - 1) the planning of UAS movements at strategic level to validate and approve FPLs so that each flight can be conducted safely, and the airspace is utilized most efficiently;
 - 2) the monitoring and surveying the airspace to provide situational awareness and to be able to give traffic or geofencing alerts to the airspace users when needed; and
 - 3) contingency arrangements to manage trajectory deviations, weather phenomena impacting the performance of AAM/UA, and safe termination of flight in case of outages/failures;
- h) requirements on services such as dynamic configuration of airspace including temporary restrictions of access, geofencing (static and dynamic), weather and associated restrictions, terrain and obstacle data, flight planning and changes, separation and conflict management, and emergencies and contingency arrangements;

- i) standards for communications, network identification service of AAM/UA supporting tracking, monitoring, and surveillance system that can fuse multiple sensors data to enhance situational awareness on AAM/UA traffic;
- j) standards for detect and avoid, traffic information situation data exchange, flight planning services, authorizations and monitoring using UTM system;
- k) requirements on ground infrastructure enabling UTM system including setting of vertiports, AAM/UA hangar and maintenance areas, and associated recharging infrastructure; and
- l) requirements on airspace and ground facilities used for safe AAM/UA flight testing covering zoning, surveillance and communications technologies/networks, real-time data sources for detect and avoid, traffic coordination, access to data updates (e.g., weather), and operational procedures.

3. CONCLUSION

3.1 The implementation of NEOM UTM, in the kingdom of Saudi Arabia, offers an opportunity to gain an operating experience in AAM/UA and operations, and to validate the ConOps in preparation for a robust, flexible, and future-proof UTM architecture.

3.2 Currently, initial UTM services are being piloted at NEOM in sandbox style environment enabling testing different flying technologies including AAM and sUAS in a small scale. The feedback collected from several internal and external stakeholders is used to improve the platform usability.

3.3 Based on the progress made for the deployment of NEOM UTM system, GACA started an iterative process to develop an initial regulatory framework for UTM considering the operating experience, ICAO UTM guidance material, UTM regulations and specifications developed by Contracting States, leading organizations, and Standards developing Organizations (SDOs). This approach will ensure an easy bridging from high-level requirements to detailed means of compliance and guidance for UTM implementation.

3.4 Through ongoing work, GACA will be able to develop a well-balanced UTM system and operational performance requirements leading to certification and operational approvals of AAM/UA flights and progressive integration between UTM and ATM.

3.5 The Assembly is invited to take note of the information provided in this paper and encourage States and regions to exchange information on the regulatory framework related to Advanced Air Mobility (AAM) and UTM.

A41-WP/513
TE/187
Appendix
English only

APPENDIX

NEOM UTM VISION AND ACHIEVEMENTS



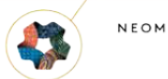
NEOM UTM VISION AND ACHIEVEMENTS

1. NEOM – CITY OF THE FUTURE DRONE ENABLE 2022 SYMPOSIUM – RFI RESPONSE

Jun 30, 2022

Strictly Confidential

All Rights Reserved



NEOM is born from the ambition of Saudi Arabia's Vision 2030 to see the country develop into a pioneering and thriving model of excellence in various and important areas of life. It is a region in northwest Saudi Arabia on the Red Sea being built from the ground up as a living laboratory – a place where entrepreneurship will chart the course for a New Future for Saudi Arabia.

Aligned to NEOM's vision of a future that is environmentally friendly, seamless, and sustainable, NEOM's Vertical Mobility Initiatives are looking to shift the paradigm towards electric air mobility to form a transport mode that offers flexible regional connections without the need for road infrastructure.

NEOM is in a unique position to accelerate the adoption of Advance Air Mobility (AAM) given that it is starting on an empty canvas. NEOM's Air Mobility Sector is creating optimized and innovative solutions aimed at becoming a global reference point to enhance human traveling quality, with the highest safety standards and an eye on being environmentally friendly. While many cities around the world are considering such innovative AAM concepts, existing infrastructure and regulations are preventing them from faster and broader deployment and adoption.

2. NEOM UTM CONCEPT OF OPERATIONS

AAM operations will be a cornerstone of NEOM. Therefore, a Concept of Operations for NEOM UTM has been developed based on global best practices from the United States as well as the European Union, and in alignment with cutting-edge organizations such as NASA, GUTMA, and ASTM.

The definition of a UTM concept allows internal development projects inside NEOM, such as NEOM Bay Airport, NEOM International Airport, TROJENA, OXAGON, THE LINE, NEOM islands, and Gulf of Aqaba to be aligned. The NEOM UTM concept has the flexibility/ scalability to be amended as per the regulatory requirements of the Kingdom of Saudi Arabia, alongside the evolving technology capabilities of systems and aircraft, and as the standards of AAM mature over the next few years.

At its core, the NEOM UTM concept is guided by several principles that are determined to be essential in enabling a safe, efficient, robust, equitable, and community-friendly system architecture and operational design, including:

- Regulations and operations of the airspace concept are guided by performance and risk-based constructs to enable diversity of technology with accelerated time-to-market without adversely affecting the safety of current aviation system.
- The operational concept is vehicle and technology agnostic to enable the most suitable hardware and software to be allocated to each use case in an optimal and future-proof way
- The concept introduced is scalable and designed for technological uncertainty and thus can be sufficiently open and flexible for future innovations in the space, which will enable robustness through 2030+
- In the short and mid-term, Air Traffic Control (ATC) interaction with the AAM operations will be kept at a minimum. The reason is to ensure minimal increase in controller workload and staffing with UTM/ATM interaction, which will only take place during off-nominal and emergency conditions

3. NEOM UTM ARCHITECTURE AND AIRSPACE MANAGEMENT

A national level UTM Architecture is being developed by the General Authority of Civil Aviation (GACA) and Saudi Air Navigation Services (SANS). NEOM's UTM system architecture will ensure a seamless integration with the national level UTM systems including flight plans by UAS operators, real-time broadcasting & Remote ID identification data, updates to operation plans "Flight Plans", and other critical components that are essential to the functioning of a scalable system when it's established.

NEOM will ensure that sensitive information exchanged between the USPs, sUAS and UAM operators is anonymous and adheres to privacy and data protection regulations of KSA. In addition, it will ensure that the quality, integrity, continuity, and accuracy of information exchanged adheres to aviation-grade safety and security standards.

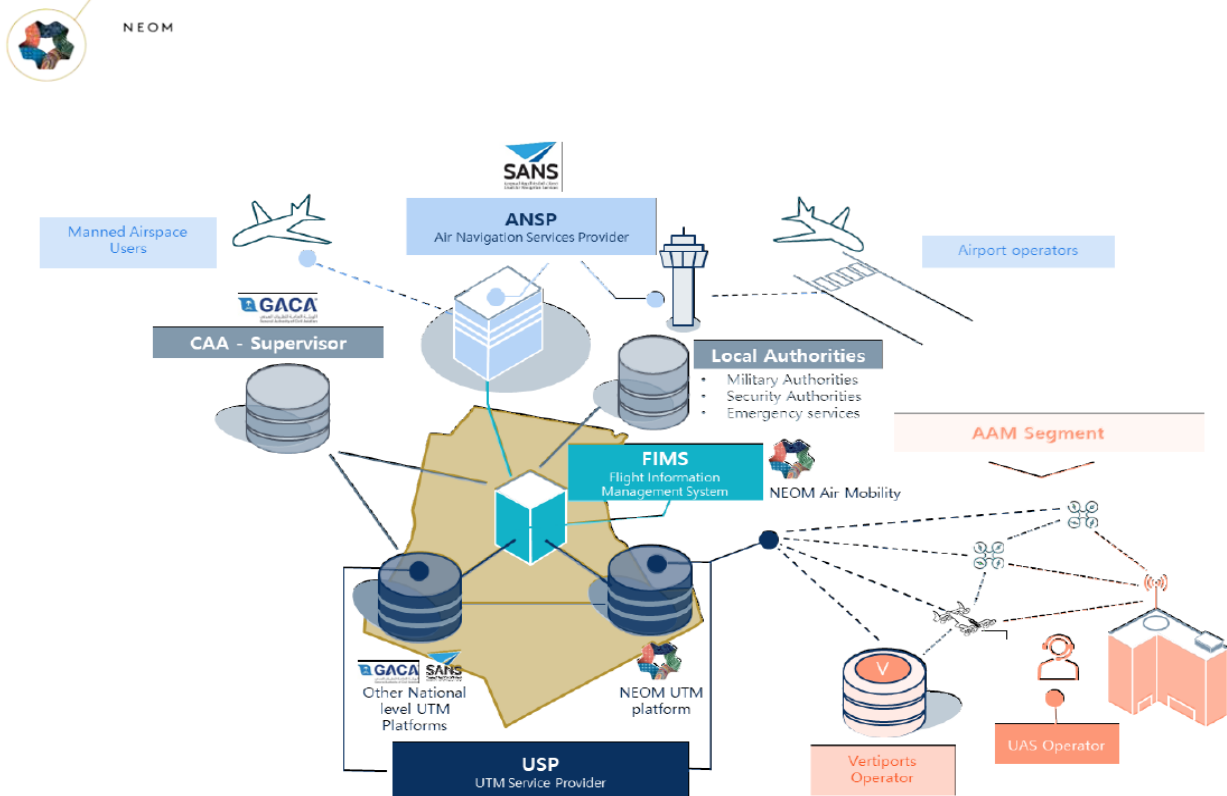


Figure 1: High-level UTM Architecture targeted by NEOM

One of the enabling airspace concepts for AAM and UAS operations are the Active UTM Participation Mandated Zones (UTM-PMZs) which are static and/or dynamic airspace volumes where all vehicles are required to establish digital two-way communication with the NEOM-UTM platform through all flight phases. This ensures predictability, operational efficiency, and high capacity at AAM routes.

UTM-PMZs will be along high-density routes, terminal operations around vertiports and any other routes, areas, altitude layers that the Competent Authority such as GACA, SANS, or NEOM pre-determine. UTM-PMZ are to be static or dynamic in nature as their airspace geometries are expected to change temporarily with vehicle performance, traffic, environment, and incoming sensitive/critical operations as affecting factors.

4. NEOM UTM IMPLEMENTATION APPROACH

NEOM is implementing a sandbox style environment where initial UTM services are being tested at limited scale. NEOM's UTM Platform currently presents the following functionalities:

- **E-Registration:** Giving full visibility on all the sUAS operating within Neom's airspace
- **Remote ID services:** Enabling real-time information about the sUAS location and other identity information in the UTM airspace
- **Operation Planning Management:** Enabling sUAS operations within the UTM space that conform to regulations and directives
- **Digital authorization:** Enabling NEOM to approve or reject any sUAS flight request
- **Traffic information:** Enabling real-time location of the sUAS traffic in the UTM airspace
- **Geo-awareness information:** Feeding airspace and geographical information to UTM participants
- **Macro-weather:** Feeding real-time weather information to UTM participants
- **Conformance monitoring:** Allowing sUAS operations to be supervised throughout all flight phases
- **Strategic deconfliction:** Ensuring operational compatibility across the planned sUAS operations



Two active UTM-PMZ zones have already been settled and are located over NEOM Community 1 and NEOM Community 2. These are key areas for AAM operations and have been previously approved by GACA for sUAS operations. In these zones all sUAS are mandated to participate in NEOM UTM Platform and to be tracked in real time.

The platform is currently being successfully operated since 2021 and, on average, 5 to 10 sUAS flights are being requested, analysed, approved, and performed per day. Feedback from users and other stakeholders are being collected for the continues improvement of safety and efficiency.

New advanced UTM functionalities are planned to be embedded gradually in the coming years, including tactical deconfliction, micro-weather, 4D trajectory planning, counter UAS and integration with public safety bodies and Ministry of Defence. In the long term, NEOM UTM Platform shall enable a full overview picture of NEOM airspace, being able to approve flight plans track in real time cooperative and non-cooperative sUAS operations as well as AAM.

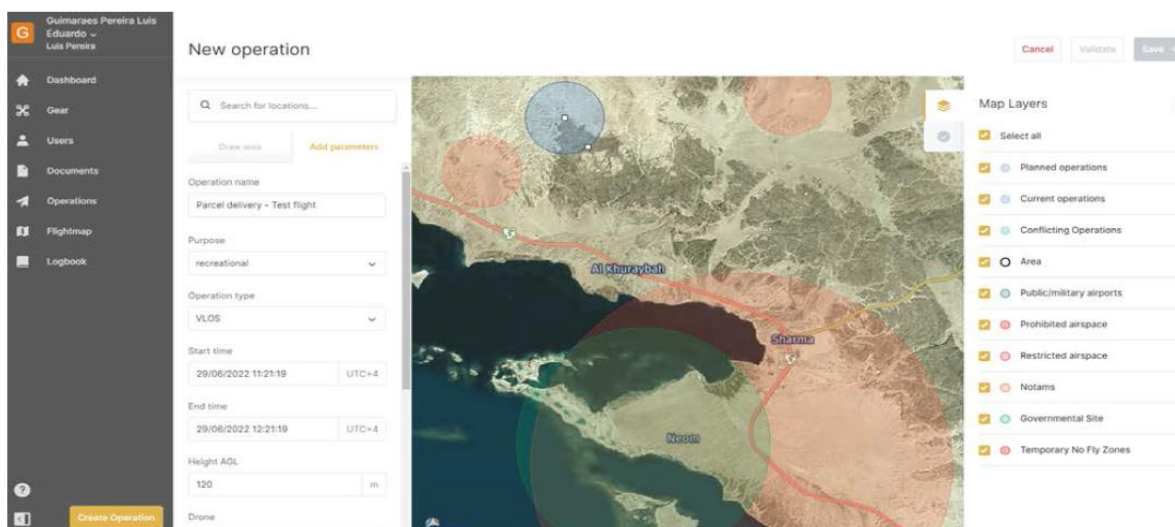


Figure 2: Screenshot of NEOM UTM Platform

5. KEY ACHIEVEMENTS

5.1. Set-up of UTM-PMZs

As per GACA's regulations, flight authorization is needed for all non-recreational sUAS flights in Saudi Arabia. The authorization typically can take up to 90 days to be issued by GACA manually. NEOM, however, has managed to reserve two airspace areas where sUAS flights can be conducted without the need of a previous authorization from GACA administration, since flights in these areas are pre-approved by GACA and supervised daily by a NEOM trained member of staff via the NEOM UTM.

Flights at NEOM UTM-PMZs are fully compliant with related GACA regulations and need to be conducted by either a certified GACAR Part 107 remote pilot and registered sUAS or for recreational purposes under GACAR Part 101 subpart E. However, the approval process of these flights is now performed through NEOM UTM Platform, and usually take less than 12 hours.

5.2. Change on sUAS flight approvals from manual forms to the UTM Platform



NEOM

The approvals of flights over NEOM airspace used to be conducted through paper forms filled manually by sUAS operators and handed over to NEOM Government Affairs for coordination with GACA, the related security agencies, and other airspace users. This process presented several inefficiencies, including:

- “Manual” lower airspace deconfliction, with the need of analysing different operational requests coordinates and timings
- “Manual” coordination with heliport operations, involving cross checking sUAS operations with scheduled/non-scheduled helicopter flights
- Excessive exchange of e-mails and phone calls with sUAS operators for clarifying questions, submitting documentations, and issuing flight approvals

Now, the request of approvals for flights over NEOM airspace are performed through the UTM platform, which enables seamless safe automatic deconfliction with helicopter and other sUAS operations and reduce drastically the need of emails exchange and phone calls between NEOM Government Affairs and operators.

5.3. Real time monitoring of sUAS

sUAS are being tracked in real time through 2 different solutions:

1. Ground control station integration:

Currently, one sUAS operator (sUAS operation provider to NEOM) has been integrated to the UTM platform via APIs exchange with its ground control station. This enables operations to be tracked through a seamless process that does not require any additional hardware. Ground control station integration is, by far, the best solution for integrating sUAS use cases. However, it requires sUAS operators to have live internet connectivity and capability to perform the software integration for automatic data exchange. The usage of external tracking devices represents additional challenges for a broader adoption from sUAS operators.

2. External tracking device:

For all other sUAS operations, operators are required to use a real-time tracking device that broadcasts telemetry information to the UTM system

- Device size and weight: NEOM is currently utilizing a device that weights 180 grams and have a size of 126x79x20mm. Attaching the device (externally) on the sUAS impacts its centre of gravity and operational performance, especially for recreational and very sUAS
- Device attaching mechanism: for most of the use cases, a double-sided tape has been utilized for attaching the tracking device on the sUAS. This can lead to additional safety concerns in case of an in-flight incident
- User experience: Currently, a specific mobile application is needed to be utilized for setting-up the tracking device. This application is not suitable for all operating systems and represents additional steps for sUAS operators flying under NEOM UTM Platform

NEOM is currently looking into the latest tracking solutions available in the market. However, it is expected that with the development of Remote ID standards and regulations in Europe and US, the need of utilizing external tracking devices for sUAS will be discontinued.

5.4. Integration with Manned aircraft “helicopter” operations

Currently, helicopters operating within NEOM UTM-PMZ zones are remotely tracked through an external tracking device. However, software integration between NEOM UTM Platform and the helicopter operator flight system is being performed and expected to be completed in the coming months. With this integration, helicopters will be continuously tracked in the platform without the need of any additional inputs from pilots, who will be also able to visualize any sUAS activity prior and during flight.

Temporary sUAS non-flying zones around helipads are also being issued by NEOM Government Affairs and the helicopter operator during the take-off and landing of helicopters within the NEOM area.



5.5. Implementation of UTM KPIs and user's feedback

Monitoring KPIs are currently being implemented to track the roll-out and utilization of the platform. The metrics currently being analysed include lead times for flight and account approvals, number of flights performed and number of off-nominal operations.

Feedback from UTM users is collected, analysed, prioritized and discussed with the UTM service provider. Several enhancements on the platform, mostly related to improvements on the user experience have been performed since the first roll-out of NEOM UTM platform in 2021.

6. CONCLUSION

The luxury of having a 'clean slate' for implementing a best-in-class UTM, offers KSA an opportunity to be a world leader in AAM / unmanned technologies and operations. NEOM is already taking an initial pilot step to begin the pioneer in the process of integrating and enabling technologies, government and third-party organizations, and procedures to validate and perfect NEOM UTM concept of operations in preparation for a robust, flexible, and future-proof UTM architecture.

Currently, initial UTM services are being piloted at NEOM in sandbox style environment enabling testing different technologies in a small scale. Feedback is being collected from several internal and external stakeholder in order to improve the platform usability. Through a step-by-step approach, new functionalities are planned to be embedded in the coming years, with the objective of achieving a broader view of NEOM airspace, including cooperative and non-cooperative sUAS and AAM operations.

The success of the vision for the NEOM UTM will enable NEOM to deliver a mobility experience that is a showplace for the rest of the world. In so doing, the KSA can play a leadership role in unmanned technologies to capitalize on their influence and open new economic opportunities and technological advancement for its citizens and visitors alike.