GSMA

MNO Drone Services Business Models

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Contents

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1 Executive Summary

This paper explores the potential for mobile operators to support a wide variety of services in the uncrewed aerial vehicle (UAV)[1] market. In particular, the paper considers potential business models to help operators understand how to capture new value and to make the right investments in infrastructure.

Although there are a lot of activities globally that demonstrate how mobile services are beneficial to UAV solutions, there are still a lot of uncertainties around the appropriate business models and monetisation due to the nascent state of the market and associated regulations.

Business opportunity for UAV

UAVs are now being used across various industries to provide innovative solutions to various problems. The leading application for third-party UAV service providers is offering mapping and surveying services, often to produce 3D models of landscapes, construction sites, mines and more. This helps clients to make informed decisions, saving time and reducing the risk of potential mistakes. UAV technology provides a cost-effective and efficient solution to traditional mapping methods, making it a popular choice for businesses across various industries.

Companies are also using UAVs to cost-effectively capture high-quality images and videos for marketing, promotional or internal use, helping them to reach a wider audience, increase brand exposure and ultimately lift revenue. UAV technology allows businesses to access previously inaccessible or difficult-to-reach areas, providing a unique perspective and capturing stunning visuals.

UAVs equipped with 5G technology can offer enhanced capabilities and performance. 5G can provide UAVs with faster data transfer speeds and low latency connections, enabling real-time data transmission and decision making. This opens up a host of new use cases for UAVs in various industries, including agriculture, delivery services, inspection, and emergency response.

5G technology has been tested in various projects around the world and shown to improve UAV performance. As 5G continues to mature and become more widely available, we are likely to see increased adoption of 5G-enabled UAV in various industries, leading to a new era of innovation and growth.

UAV use cases

Cellular-connected UAV use cases can be divided into three categories: basic connectivity services, value add services and full provision services.

Basic Connectivity Services

- **Aerial connectivity for command and control communications (C2-Coms):** The established mobile networks could provide the connectivity between the UAV and the ground station required for C2-Coms. Depending on the use case and the respective flight path, UAVs may operate above the usual level of optimised coverage provision. Therefore, specific efforts and investments from MNOs may be needed to ensure very robust transmission to perform C2-Coms under nearly all circumstances
- **Aerial connectivity for payload transmissions:** Although the altitude aspect of providing connectivity for flying mobile devices represents a specific challenge, there is a strong case for using mobile networks to enable UAVs to transmit images,

[1] UAV are sometimes referred to as drones

video and other payload data to third parties during flight. Beyond pure connectivity, MNOs can offer cloud services with storage, processing and even analytics functions.

☐ **Dedicated quality of service for UAV operations:** A mobile network employed by a UAV will need to deliver a specific quality of service to meet the needs of C2-Coms and any payload transmissions. Furthermore, specific network features can be introduced to improve particular aspects of the network's performance, either in general or related to specific users and/or application.

☐ **Network Remote ID and SIM-based identity:** An MNO could provide SIM-based identification services to UAV operators.. A MNO could also provide identification information to USSPs, air authorities and CIS users. The addition of such services would strengthen the total MNO proposition, making the telco even more relevant in the ecosystem.

Value Added Services

☐ **Positioning augmentation services:** MNOs could provide positioning services through their cellular networks that could augment GPS information. Some operators already provide real-time kinematic positioning services (RTK) to correct for common errors in GPS systems. These services could be adapted for use in UAVs.

☐ **Onboard UAV-based and edge-based computer vision:** An MNO can provide low-latency and stable connectivity to enable an UAV to stream video or images in real time or near real-time. These images would then be analysed by AI in real-time to enable computer vision to identify objects, count livestock, look for infrastructure defects, or other tasks that would normally require human eyes and analysis. To reduce latency, the MNO could host the computer vision applications in an edge location near to where the UAV is operating.

☐ **High resolution topographical information services:** UAVs can be used for flexible, efficient and low cost geographic information mapping. For example, UAVs could obtain high-resolution imagery in small and difficult flight areas, enabling surveying and mapping for engineering construction projects. MNOs could provide the connectivity required to transmit high-resolution video and image information in real-time.

☐ **Multi-UAV orchestration:** When multiple UAVs are used on a mission, their operations need to be coordinated. MNOs could provide UAV automation as a service (AaaS), paid for on a usage basis as part of an end-to-end solution. Alternatively, MNOs could monetise discrete parts of the overall AaaS value chain, such as connectivity/application hosting/data storage and processing in cases where the end-to-end service is provided by a third party.

☐ **Hyper-localised weather services:** MNOs can rent out real estate on their infrastructure, such as cell towers and transmission sites, to enable a weather provider to mount a localised weather station. Alternatively, MNOs could sell hyper-localised weather services as a standalone data service to UAV operators and to SDSPs, or as an integrated supplementary data service to U-Space service providers/UTM service suppliers.

☐ **People density data:** Regulators generally don't allow UAVs to operate above crowded areas, for safety reasons. Mobile devices capture hundreds of location-related data points per day, depending on how active their user is. Therefore, mobile networks can generate datasets that individual MNOs can accurately extrapolate to the broader population to provide location-specific insights. MNOs can provide people density datasets to UAV operators, U-Space service providers (USSPs) and other UAS service providers, through a public API-stack, which could be paid for via a subscription or on the basis of consumption.

☐ **3D coverage data:** A UAV operator needs to know the quality of cellular coverage in areas where it is planning or is executing BVLOS operations. Such information is important for a timely SORA[2] approval for "ad hoc" flights. MNOs can obtain 3D coverage data directly from their RAN infrastructure providers, from cellular network planning and design tools solution providers, or by engaging with companies that provide turnkey solutions and are specialised in aerial RF modelling and standards-based exchange of such info with ANSPs (air navigation service providers).

[2] SORA: Specific Operating Risk Assessment

☐ **Air traffic information data:** As they generally have commercial control over mobile tower infrastructure, MNOs could facilitate the installation of the specialised receivers needed to capture air traffic information data. MNOs could also provide connectivity services between receivers and backend servers running the processing software used to derive the concrete air traffic information data. This could eventually be supplemented by a GUI service and/or API in order to deliver raw or processed data.

☐ **Airspace surveillance:** UAV/UAS flying at low altitudes (below 3,000 feet) need to be coordinated by airspace surveillance services, which could be enabled via a variety of low cost ground/on-pole/on-cell tower receivers (standalone or network connected). MNOs can provide real estate on their towers for the installation of these lightweight receivers. They could also transmit the collected data via their cellular networks to airspace surveillance application servers and potentially even host such application servers, either as a standalone or integrated with SDSP and UTM application servers.

Full Service Provision

To support specific use cases, MNOs can package together basic connectivity and value added services into a full service proposition. Examples of such use cases include:

☐ **On-demand coverage, cell-on-wings:** On-demand cellular coverage can be delivered using an airborne communication base station system installed on multiple types of flight platforms, such as large fixed-wing UAVs, medium-sized UAVs, and tethered UAVs. This service could be used to restore emergency communications in disaster areas or to supplement existing terrestrial infrastructure for a specific event or purpose. The MNO could offer a service contract based on pay-per-use and annual settlement to government departments or entities who need extended coverage (such as geological exploration companies).

☐ **Logistics/delivery services:** Cellular-enabled UAVs could be used to deliver food, medicines and other goods to inaccessible areas that are difficult to reach via road. MNOs could charge usage fees for its communication network and UAV operation management system. Municipal governments could subsidise such services in some circumstances.

☐ **Automated infrastructure inspection and critical assets monitoring:** UAVs can be a very cost-effective means to inspect infrastructure and monitor critical assets. An MNO could provide connectivity that complies with stringent SLA requirements to support video/imaging and C2-Com, and applications hosting, as well as enabling BVLOS and AI-based processing of the captured images. The MNO could be paid per mission or on a subscription basis for the services it enables.

☐ **Flight management system:** A flight management system can use cellular connectivity to operate UAVs BVLOS. Such a system is designed to remotely create flight paths using 3D maps and sky weather forecasts, remotely start, pause, control UAV flight, share real-time UAV footage (where available) from anywhere and ensure the safety of UAVs during remote flights. A 5G network can be used to build an end-to-end flight management system, which isn't constrained by the limited control distance of self-built data links, and other technical problems, such as slow data processing rate and poor real-time performance.

☐ **U-Space service provider/UTM services supplier:** UAVs operating in cooperative and non-cooperative airspace need to comply with BVLOS regulations and make themselves known to other UAVs and manned aircraft in civil airspace. Therefore, such UAVs need to be integrated with the UTM system governing airspace in the relevant geography. An MNO could act as a supplementary data service provider (SDSP) to enrich basic UTM services and enhance an ANSP's ability to govern and manage the airspace.

Timelines and key learnings

The use cases analysed in this report have been identified by the contributors to this paper as achievable in the short and mid term. However, in some cases, the full business model is not yet fully clear for an economic sustainable solution, partly due to the uncertain regulatory environment or because other stakeholders in the value chains are primarily start-ups. Moreover, not all use cases are applicable to all regions.

For each use case, a MNO will need to make certain investments and the business model will be successful only if there is a fair compensation for all stakeholders in the value chain. Some of the use cases will also be driven by the readiness of 3GPP Specifications, as some of the capabilities are not yet ready to be moving to service commercialisation.

Based on the contributors' experience, each use case will have a different implementation timeline.
The table below summarises their views of a realistic timeframe for deployments in different regions.

	NORTH AMERICA		EUROPE				APAC		
	TELUS	VERIZON	SWISSCOM	DEUTSCHE TELEKOM	KPN	TELIA	CMCC	TELSTRA	KDDI
Aerial Connectivity for C2		■	■	■	■	■		■	■
Aerial Connectivity for Payload		■	■	■	■	■		■	■
QoS: Dedicated Vs Shared Resources/Best Effort			■	■	■	■		■	■
Network Remote ID & SIM-Based Identity		■	■	■	■	■			■
Positioning Augmentation		■	■	■	■	■		■	■
Onboard UAV-Based and Edge-Based Computer Vision	■		■	■	■	■	■	■	■
High Resolution Topographical Information Service			■	■	■	■		■	■
Multi-Drone-Orchestration	■		■	■	■	■		■	■
Hyper Localised Weather Services	■		■	■	■	■		■	■
People Density Data			■	■	■	■		■	■
3D Coverage Data			■	■	■	■		■	■
Air Traffic Information Data			■	■	■	■		■	■
Airspace Surveillance	■		■	■	■	■	■	■	■
On-Demand Coverage - Cell on Wings			■	■	■	■		■	■
Logistics/Delivery Services			■	■	■	■		■	■
Automated Infrastructure Inspection and Critical Assets Monitoring			■	■	■	■	■	■	■
Flight Management Systems			■	■	■	■		■	■
U-Space Services Provider/UTM Services Supplier	■		■	■	■	■	■		■

KEY Up to 1 year ■ 1 to 3 years ■ 3 years + ■

The analysis conducted for this reported generated the following generic key learnings:

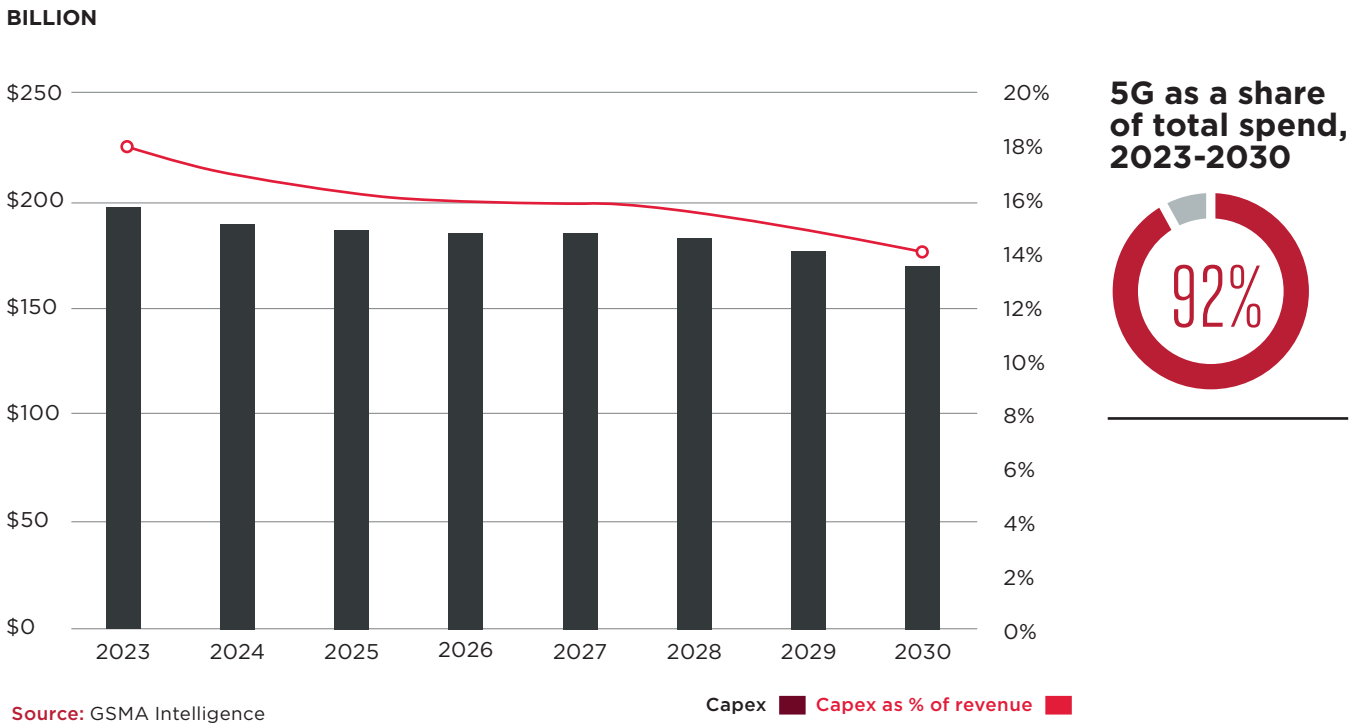
- It is clear that mobile communication is an essential enabler for UAV data transmission, and there are several additional services that MNOs can offer.
- The ability of MNOs to provide airspace coverage, particularly with 5G, could enable BVLOS at scale to be achieved with automated flight approvals based on risk assessment (e.g. SORA).
- Each country will have different spectrum rules that need to be respected by the UAS service provider (or manufacturer or operator) and MNOs will be impacted if those rules are not properly followed.
- MNOs should engage with the different stakeholders, such as the UAS operators, UAS service providers (e.g. USSP), but also the regulatory authorities and business partners early on.
- Stakeholders should follow closely the development of the national regulatory and authority entities since their actions, plan and timeline can have a direct impact on UAS services and operation in their country.
- Exchanging learnings across countries can help to achieve SORA approval for telco services, such as the people density and coverage information.
- The UAS market is highly dynamic: technology, regulation, standards are rapidly emerging, while socio-economic and geopolitical factors may impact the commercialisation of UAS services.
- The mobile community is able and willing to support connected UAS operations, but as MNOs need to cater for the specific needs of UAS they may be required to make specific investments.
- It can be effective to identify and focus on enabling more routine missions and think about business models that incentivise more missions, rather than implementing a pure data-transaction model
- For the same set of UAS services, try to identify different revenue streams that can be of value.

2 Introduction

Mobile technology has been part of our lives for more than four decades. According to the latest GSMA Mobile Economy report[3], in 2022 mobile technologies and services generated $5.2 trillion of economic value added, which constitutes 5% of global GDP. The GSMA expects this figure to grow almost $1 trillion by 2030 to reach $6 trillion. All sectors of the global economy, including aviation, will benefit from the rollout of 5G, with services and manufacturing experiencing the most impact.

Globally, mobile network operators (MNOs) are set to invest $1.5 trillion in their networks between 2023 and 2030. About 92% of this spend will be on 5G (see Figure 1).

Figure 1
Global mobile operators capex between 2023-2030

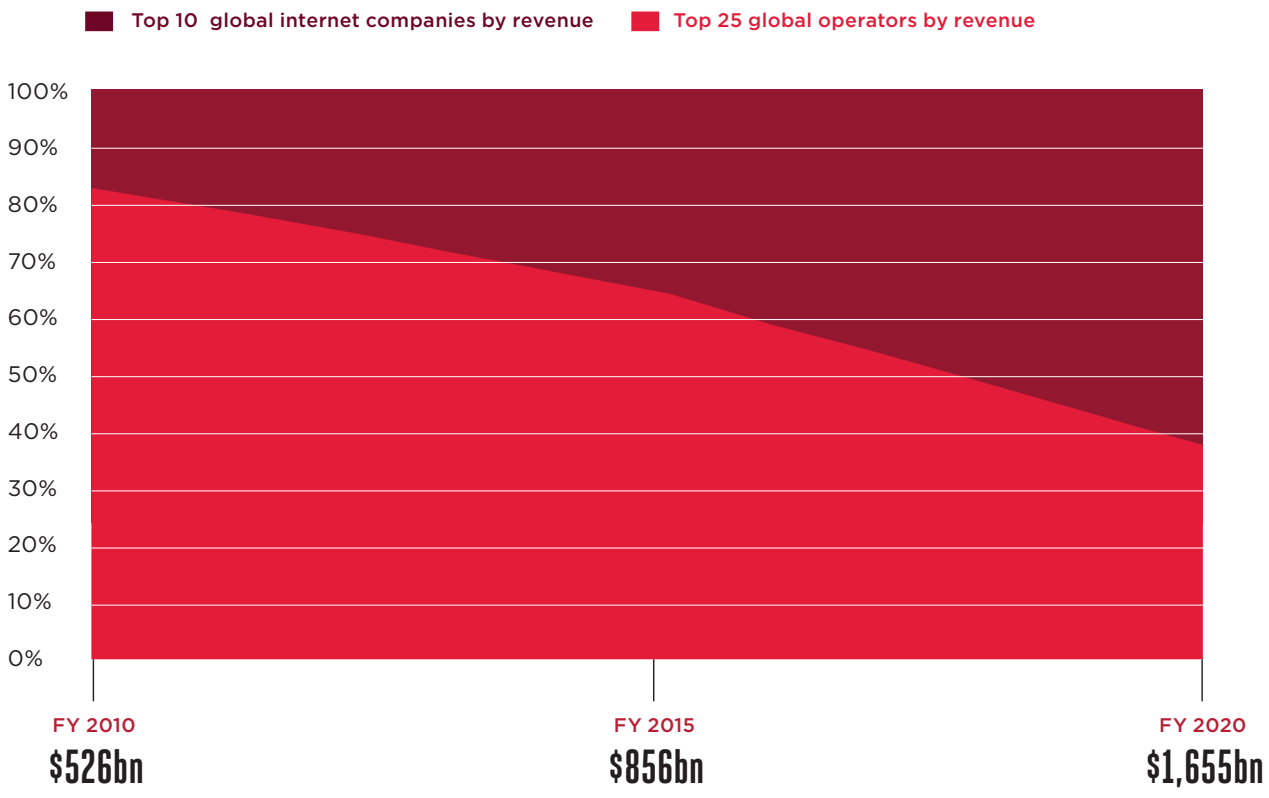


Source: GSMA Intelligence

[3] The Mobile Economy 2023 - https://www.gsma.com/mobileeconomy/wp-content/uploads/2023/03/270223-The-Mobile-Economy-2023.pdfs

The introduction of 4G and now 5G is opening up new markets for mobile connectivity. In particular, mobile operators are increasingly connecting a wide range of devices, appliances, machines and vehicles, helping to build the so-called Internet of Things. This trend is opening up new revenue opportunities at a time when there is a growing shift of economic value away from operators towards internet giants (see Figure 2), which have leveraged new technologies and delivery models to capture a rising share of engagement and value.

Figure 2
Economic value shifted to internet companies

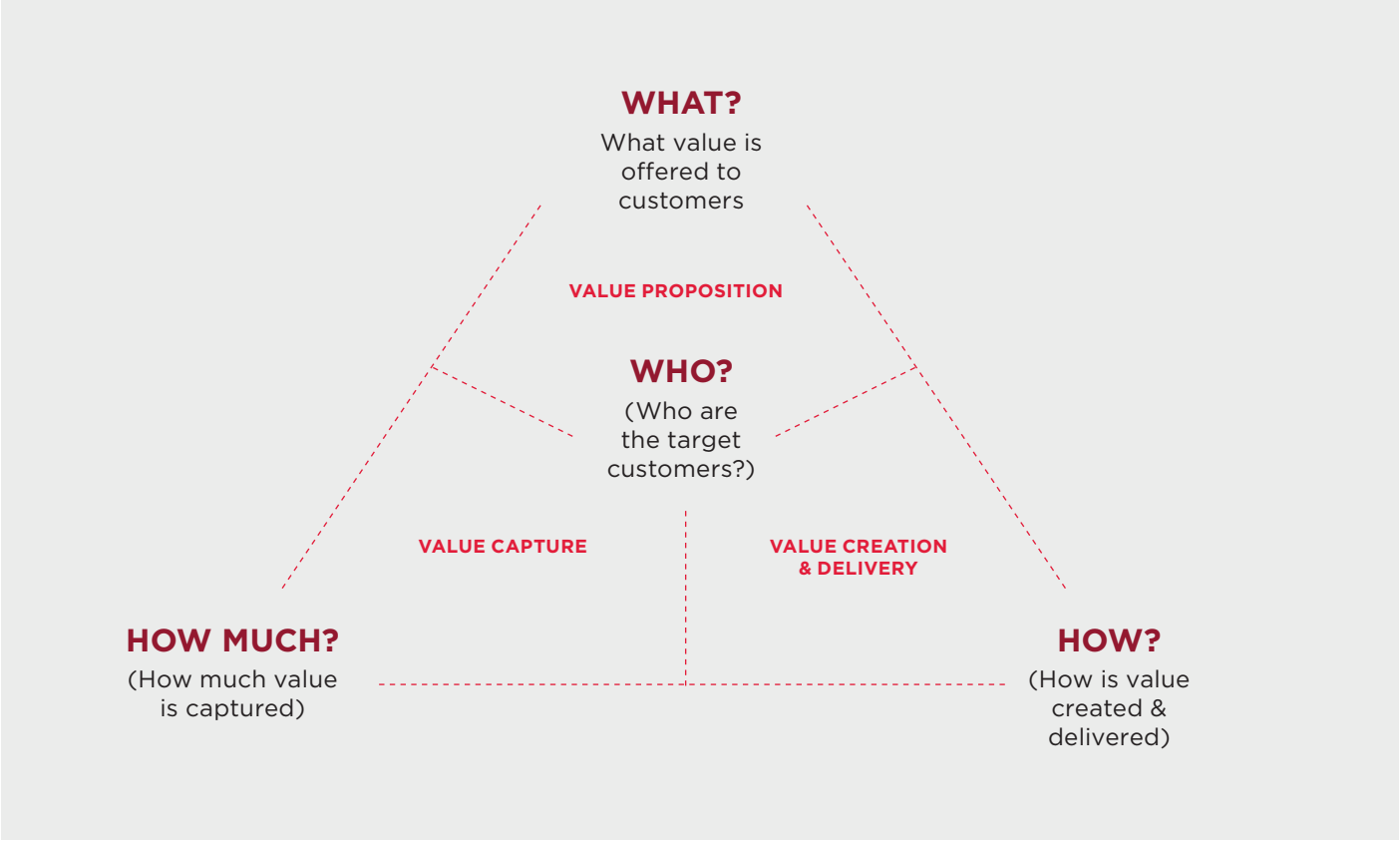


Source: Company results, GSMA Intelligence

The business model ontology proposed above can be used to establish the relevant cellular value chain components and should provide answers to the following questions: Who? What? How? and How much? as depicted in Figure 3.

Figure 3

Source - IEEE ACCESS "5G Business Models for Mobile Network Operators—A Survey"



Note: Chapter 4 leverages some of the cellular value chain and cellular business model frameworks' referenced in this chapter to create a corresponding cellular-connected UAV value chain and cellular-connected UAV business models.

Cellular-connected UAV can be considered a specific case of the cellular-enabled "Internet of Everything" subset.

3 Market Analysis

Moving beyond the hype bubble, the UAV market has reached a phase where there is a better understanding of both the capacities and the limitations of the technology. Some UAV companies are now profitable.

In 2022, the global UAV market was worth approximately US$30.6 billion, with an estimated compound annual growth rate (CAGR) of 7.8% until 2030, according to UAV Industry Insights (see Figure 4). This figure encompasses both the commercial and the recreational markets. When analysed separately, the commercial market is set to expand at a faster rate of 8.3%, while the recreational market may contract in many regions around the globe. Nevertheless, the global UAV market as a whole (commercial and recreational) will be worth US$55.8 billion by the year 2030, according to UAV Industry Insights.

Figure 4
UAV Market Size by Total and Regions 2022-2030
(Source: UAV Market Report 2022-2030 by Drone Industry Insights)

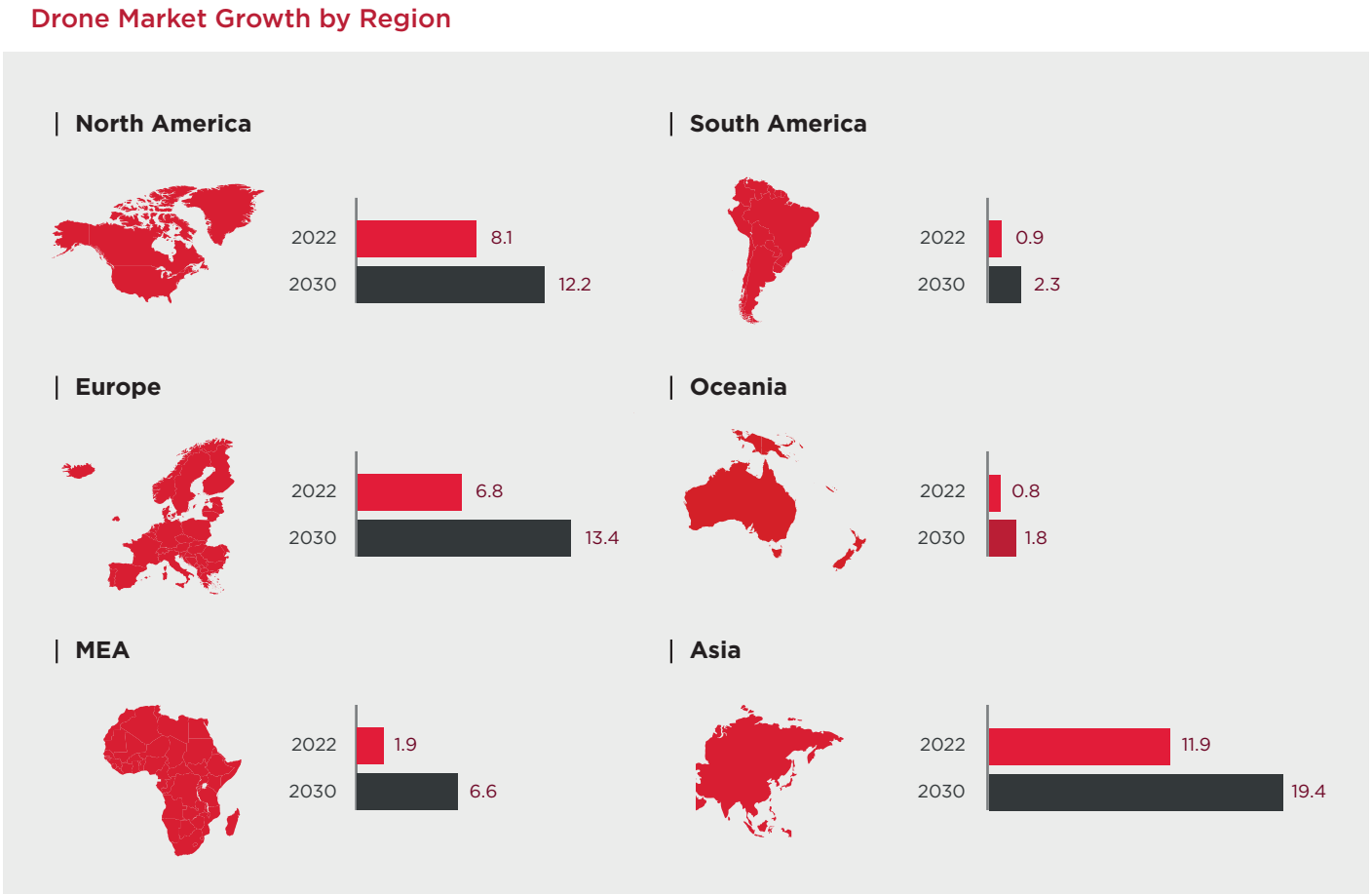
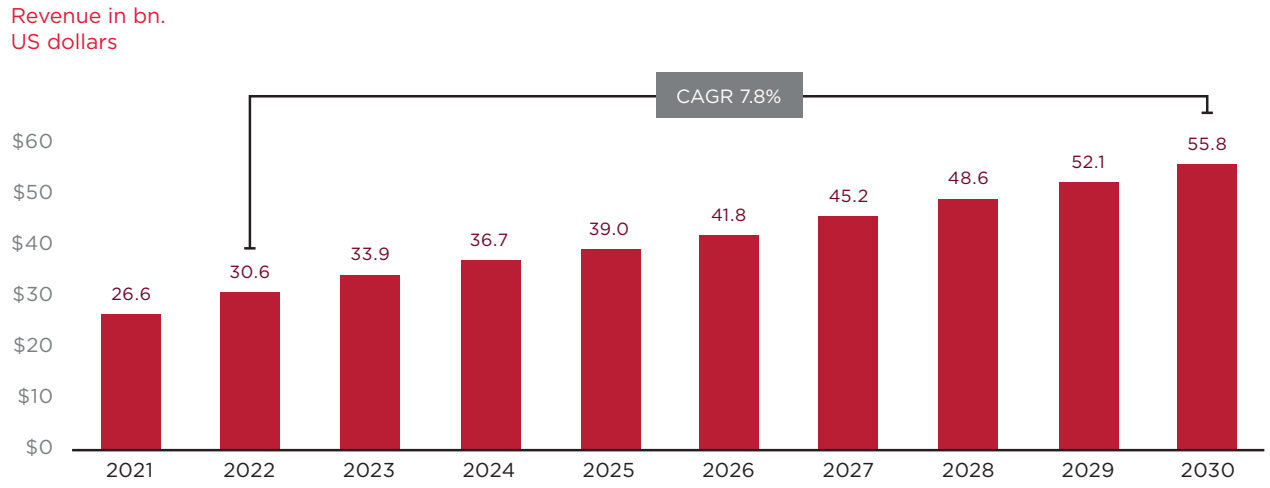


Figure 4

UAV Market Size by Total and Regions 2022-2030

(Source: UAV Market Report 2022-2030 by Drone Industry Insights)

Total drone market 2022-2030



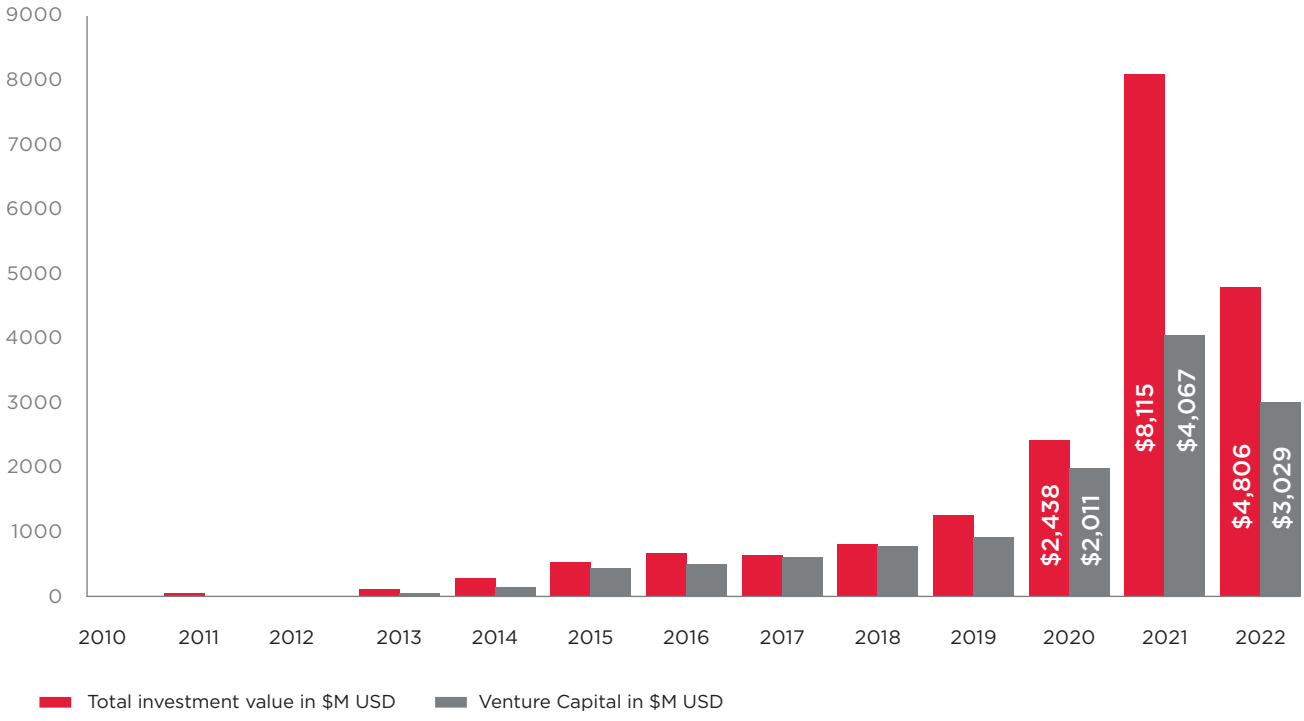
Source: UAV Market Report 2022-2030 by Drone Industry Insights

Another very promising sign for the market is that investments into the UAV industry continue to grow (see Figure 5). From 2012 until 2021, there was a steady annual increase in investment (with the exception of 2017), according to UAV Industry Insights, peaking in 2021 in terms of both total investment value and venture capital value. Almost half of the total investment value in 2021 was represented by acquisitions and Initial Public Offerings (IPOs) of advanced air mobility (AAM) vehicle manufacturers developing electric vertical takeoff and landing (eVTOL) craft. That year also saw major venture capital investments in small UAV companies. In terms of investments by value, the leading beneficiaries in 2021 were US passenger UAV/eVTOL manufacturers, which completed initial public offerings (IPOs) or formed special purpose acquisitions companies (SPACs).

Figure 5

Total and Venture Capital Investment into the UAV industry

(Source: Drone Investment Database 2023 by Drone Industry Insights)



The year 2022 showed a small decrease in both total and venture capital investment. This can be explained first by the lower number of IPOs and SPACs in the eVTOL industry (since most of the major players already entered the financial markets in 2021). However, the crisis in Ukraine and the pandemic-related shortage of resources, as well as interest rate increases, also had a major impact on investment in the UAV industry. Investors are more uncertain and cautious than was the case a few years ago.

Business Cases for UAV Technology

Looking beyond the macro level market numbers, UAVs are being used across various industries to provide innovative solutions to various problems. The top application for third-party UAV service providers is offering mapping and surveying services. UAVs gather aerial data that is used to produce maps and 3D models of landscapes, construction sites, mines and more. This helps clients to gain a comprehensive understanding of the land and make informed decisions, saving time and reducing the risk of potential mistakes. UAV technology provides a cost-effective and efficient solution to traditional mapping methods, making it a popular choice for businesses across various industries.

Companies are also using UAVs internally, primarily for photography and filming. This entails capturing high-quality images and videos for marketing, promotional or internal use. UAV technology allows businesses to access previously inaccessible or difficult-to-reach areas, providing a unique perspective and capturing stunning visuals. UAVs can provide an affordable, safe and efficient solution and help businesses improve their image, reach a wider audience, increase brand exposure and ultimately lift revenue.

Additionally, UAVs equipped with 5G technology can offer enhanced capabilities and performance. 5G technology improves efficiency by providing UAVs with faster data transfer speeds and low latency connections, enabling real-time data transmission and decision making. This opens up a host of new use cases for UAVs in various industries, including agriculture, delivery services, inspection, and emergency response. For example, in agriculture, 5G UAVs equipped with sensors and cameras can transmit real-time data to farmers, allowing them to make informed decisions about crop management and optimisation.

5G technology has been tested in various projects around the world and shown to improve UAV performance. Some of these include: enabling location-based solutions (e.g. geofencing), creating digital twins for increased safety and performance, delivering data in real time with AI-enabled UAVs, and increasing efficiency in industries, such as logistics, mining, agriculture and more. As 5G technology continues to mature and become more widely available, we can expect to see increased adoption of 5G-enabled UAV in various industries, leading to a new era of innovation and growth.

Core Takeaways for 2023

Overall, the key lessons from the past three years relate to the industry's stability. Whether before, during or after the pandemic, the global UAV industry has continued to grow at a steady pace. This has built confidence both within and outside of the industry. It signals that the unrealistic hype about UAVs is over and the trust is there.

The second core lesson for this year relates to regulation. While many regulations have indeed been passed and will begin to take effect, other standards for advanced missions will need more progress for the industry to become scalable. UAV technology cannot be used to its full potential until BVLOS (beyond visual line of sight) and other types of advanced missions become the norm rather than the exception. Therefore, it is no surprise that respondents in this year's **Drone Industry Barometer** once again selected "rule-making authorities" as the top market-driving actor.

> The top application for third-party UAV service providers is offering mapping and surveying services.

4 End-to-End Value Chain

This chapter provides a high-level description of the potential of cellular-connected UAVs' end-to-end activities and stakeholders involved in the services that are described in chapter 5.

Table 1: Stakeholder terminology

Stakeholder Type	Description	Provided services/activities
Service provider (leveraging UAVs for delivering service(s))	The entity/organisation that is offering a service to a final customer or a third party	■ Surveillance ■ Inspection ■ Deliveries ■ Disaster response ■ Connectivity (for several purposes) ■ Positioning (verification, augmentation) ■ Aviation traffic management (ATM) ■ U-Space/UTM service
Supporting service provider	The entity/organisation that provide services that are supporting the main service. They might be optional or mandated by local regulation.	■ Education & training ■ Insurance ■ Consulting ■ Certification entity
Authorisation authority	The entity that provides authorisation. Each stakeholder might require a different set of authorisations to be provided for the execution of a given service.	■ Civil aviation ■ Local municipality ■ Spectrum authority
Connectivity provider	The entity that provides connectivity for the final service	■ Terrestrial network (public, private) ■ ISM ■ Satellite ■ GNSS ■ Radar ■ Multi-modal connectivity

Stakeholder Type	Description	Provided services/activities
Data provider	Any entity that contributes to the final service by means of providing data relevant to the correct execution of the service	■ Traffic information ■ Weather information ■ Crowd information ■ Coverage information ■ Topographical information
Specialised workforce	An entity that provides a well-defined skillset or operation needed for the execution of the service.	■ UAV pilot ■ UAV operator ■ Safety manger ■ other
Systems integrator	The organisations providing a bespoke solution that is fit for purpose for their customers	■ Software integrator ■ Hardware integrator ■ E2E solution integrator
Software provider	The entity that contributes relevant software to the final service	■ AI modelling ■ 3D mapping ■ Path optimisation ■ Orchestration software ■ IoT SAFE
Cloud, data storage provider	The entity that provides cloud and storage services	■ Cloud provider
Infrastructure provider	The entity that provides the infrastructure needed for the service to operate	■ Tower company ■ MNO ■ Municipal entity
UAV manufacturer	The supplier of the UAV, which may have the necessary equipment already embedded	■ UAV supplier
UAV hardware and components supplier	Any supplier of hardware or components that are necessary to provide the full end service	■ Propellers ■ Cameras ■ Gimbals ■ Modules ■ Batteries ■ Motors ■ Antennas ■ Payloads

5 Use Cases

This chapter considers cellular-connected UAV use cases in three categories: basic connectivity services, value add services and full provision services.

Basic Connectivity Services

5.1 Aerial Connectivity for C2

Use Case Description

Command and control communications (C2-Coms) between the UAV and the operator is pivotal for safe and controlled operation of UAVs.

Even in automatic or autonomous operation, C2-Coms have to be available to allow intervention in any part of the flight to react on unforeseen events. This could involve relaying information from the UAV to the operator to display the state of the UAV and current flight patterns (telemetry data) and commands from the operator to the UAV, if required by the situation.

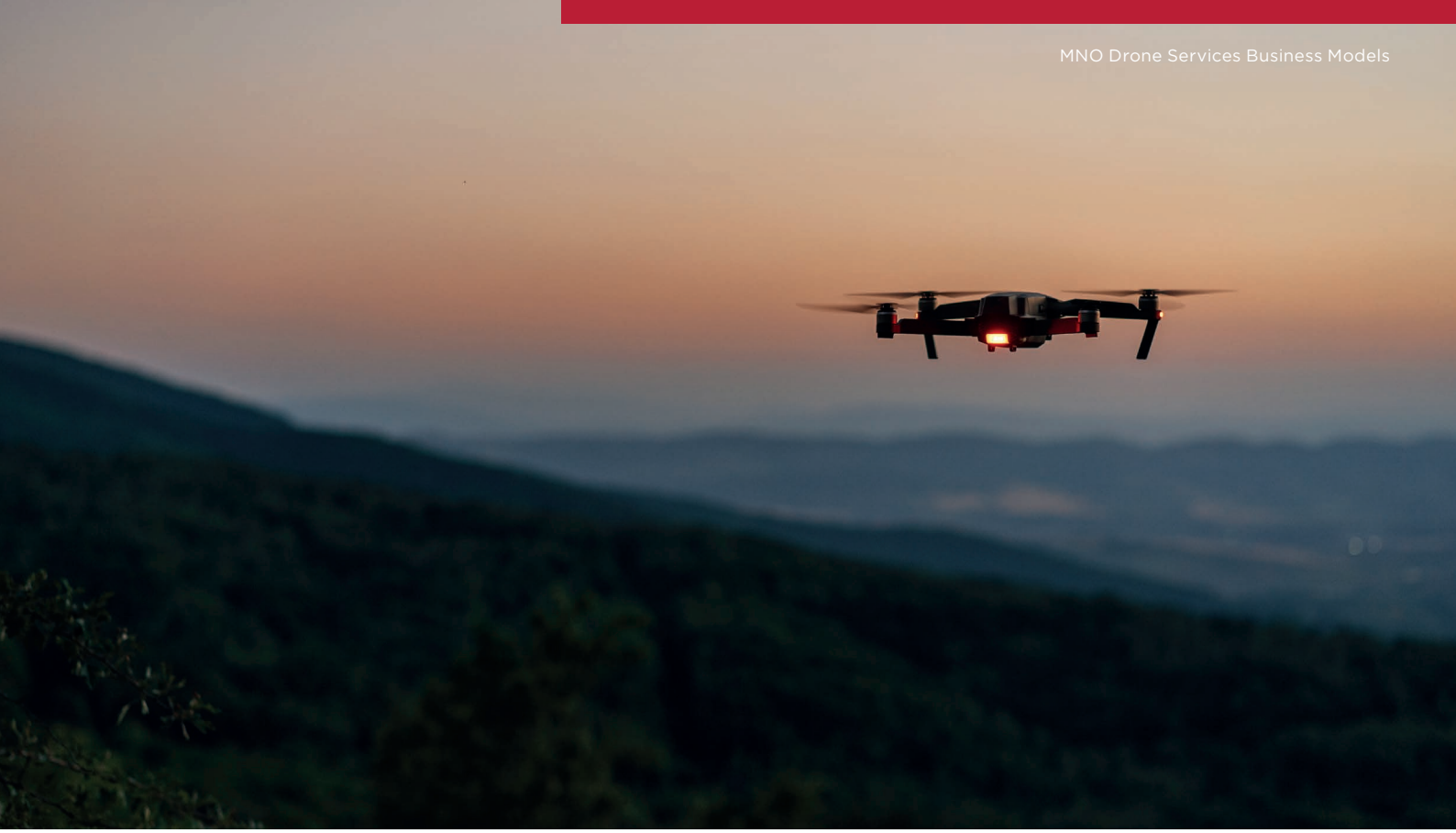
In fact, C2-Coms are an overarching element for all UAV operations for any kind of purpose and mission. Accordingly, telecommunications requirements for C2-Coms are quite extensive, in particular with respect to availability and security.

Stakeholders

Secure and controlled operation of UAVs is – beyond the immediate interest of the operator itself – subject to regulation by the appropriate authorities. This may include guidelines as to which data has to be transmitted by the UAV to monitor flight operation at any point of time, and what level of availability and security of the transmission has to be fulfilled etc. This might be further differentiated depending on the kind of operation (line of sight versus beyond line of sight), areas, size and type of UAV and other reasonable aspects, which define different hazard levels of UAV operation. In essence, the regulation for the data-exchange between the UAV and the operator already defines the basis for the C2-Coms and its realisation.

UAV manufacturers routinely enable communication between the UAV and the ground station or remote control to allow for interaction between the operator and the flying device. This can be anything from a straightforward radio remote control up to highly sophisticated and secure communication to allow for a large amount and variety of data to be transmitted to the operator and vice versa to enable complex operation commands to the device.

The telecommunication equipment may be provided by the UAV operator itself or sourced from specialised vendors of radio units. Furthermore, it may follow specific standards from remote control units, WLAN/Wi-Fi, mobile networks or industry standards for connected devices.



The established mobile networks represent a quite appealing option for providing the connectivity between the UAV and the ground station even for the ambitious purpose of C2-Coms. Mobile networks:

- are an established, highly available and well proven resource,
- provide in most regions wide area coverage,
- work at reasonable altitudes for most commercial UAV applications,
- are based on worldwide standards and spectrum with corresponding vendor support.

It would be logical to use mobile networks for the purpose of data transmission between UAV and the ground station in general, and for the specific purpose of C2-Coms as well.

MNOs' Role in the Value Chain:

From an MNO's perspective, data transmission for C2-Coms has special requirements. Since communications for C2 is essential for UAV operations, there is a need for a just-in-time transmission without range limitations, which is not provided by remote radio or WLAN/Wi-Fi based transmission technologies. Mobile networks can meet these requirements.

Given the essential role of C2-Coms, the value of such transmissions and the related demands - availability, security and reliability – are high.

Since telemetry from the UAV and commands to the UAV are not data-intensive, throughput should be not the major issue for this use case – other than payload for specific UAV use cases as discussed in section 5.2.

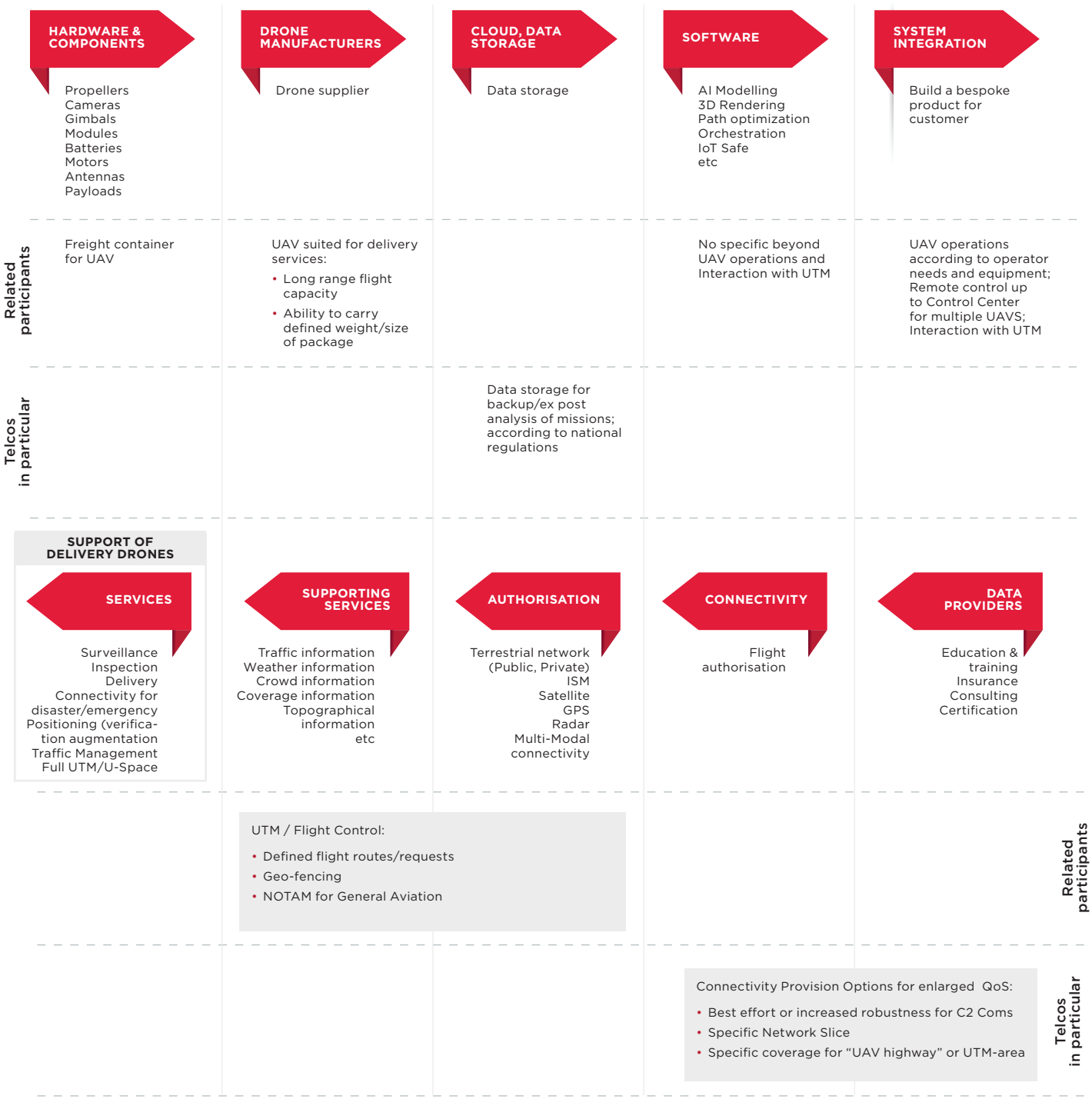
By delivering connectivity for C2-Coms, telcos can be an essential partner for UAV operators as well as for UTM (unmanned traffic management) providers. Both parties need such data transmission to perform their business.

However, environmental influences on radio transmissions mean there remains some risk that connectivity gets lost during operation. Even with the capabilities of public mobile networks there is still a need for procedures that define appropriate fall back activities by the UAV, if connectivity gets lost, either intermittently or completely. Figure 6 shows how an MNO can fit into the value chain for C2-Coms.

Figure 6

Aerial Connectivity for C2 Value Chain

Consideration for Transport Scenario as example for "C2 Coms" - Use Case



Potential business models for MNOs:

The provision of connectivity for C2-data-transmission has to consider the following:

- Depending on the use case and the respective flight path, UAVs operate above the usual level of optimised coverage provision. Therefore, specific efforts and investments from MNOs are needed, in particular to ensure very robust transmission to perform C2-Coms under nearly all circumstances.
- An MNO's toolset includes a number of technologies that can meet very sophisticated demands for C2-Coms. However, there is a need to consider the cost-value ratio to match specific demands and usage scenarios with the efforts to serve the still nascent market for UAV operations.

Telcos in various countries have demonstrated in multiple test operations that they can provide C2-Coms with the requested availability and reliability. That puts MNOs in a position to become mobile service providers for UAV and UTM operators.

MNOs can even provide specific security mechanisms for data transmission beyond the already inherent technologies, if requested by users.

Figure 7 shows a business model canvas (a strategic management template for developing and |documenting business models) for the provision of C2-Coms to support UAVs.

Figure 7
Aerial Connectivity for C2 Business Model Canvas

Key Partners
- UAV manufacturers
- UAV operators
- UTM provider and operators
- U-Space operators/ administrators

Key Activities
- Calculation of Bus. Model
- Fair description of network capabilities for UAV-Operations, Consultancy

Key Resources
- Network capabilities in altitude
- Sales & Customer Service capabilities for UAV-operators
- Consultancy and coverage know how for UTM/U-Spaces

Value Proposition
- Just-in-time data transmission (connectivity)
  - for UAV-Operator
  - for UTM support of UAV operations
- Connectivity with high availability/ robustness even in standard altitudes for UAV-operations
- Additional Quality of Service features if required

Customer Relationships
- Connectivity/data transmission provision with defined service-level
- Special UTM support with specific services/ implementations

Channels
- Direct sales
- Wholesale to specific providers for UAV-operators and/ or UTMs and U-space providers

Customer Segments

C2 Coms for UAV operators
- Private
- Commercial
- Public
- C2 Coms for UTM-operators/U-space providers

Business models
- B2C
- B2B
- B2B2C

Cost Structure

UAV-Operator:
Hardware/Integration: Connectivity modules in UAV/Sensors; Price of connectivity

Telco:
Standard mobile network => Tarif according to sales offers for UAVs/ aerial connectivity; Special network layer => special prices for customer(s).
Special QoS-parameters => specific prices

Revenue Streams
- Connectivity charge according to contract;
- Compensation share for additional implementations
- Charge for specific QoS parameters
- Charge for specific additional services

5.2
Aerial Connectivity for Payload

Use Case Description

"Payload" describes the data-transmission between an UAV and a remote station, which could be the related ground-station of the UAS (unmanned aircraft system) or a server independent of the UAS. Distinct from C2-Coms (see section 5.1), payload transmission could involve the transmission of data generated by sensors, cameras or other communicating devices on board of an UAV. Capturing this data is generally the purpose of the UAV mission.

However, given the multitude of potential services UAVs can perform, the amount and structure of payload vary significantly. In some cases, the UAV operator may decide to transmit the payload data during flight or they may download the data after the UAV mission is complete.

The options can be summarised as:

- Pure flight operation or no payload generation in UAV-operation => no payload-transmission.
- Non time-critical data, but available network => option for UAV operator to send data already during flight operation or alternatively to store data on memory-chip.
- Non time-critical data and data transmission exceeds capabilities of local network => on board-storage and data-download after UAV mission operation.
- Time-critical data and available network => UAV operator sends data already during flight operation.
- Time-critical data, but data-transmission exceeds capabilities of local network => benefits of UAV cannot be realised.

Stakeholders

The payload data transmission is in first instance defined by the needs of the UAV-operator. The UAV will be equipped with devices designed to support the use case, and they may require specific handling regarding any data-transmission.

Device suppliers provide equipment for UAVs that reflect the restrictions for size and weight, and the fact that there may be some distance between the UAV and the target objects it is investigating.

These devices may be attached to an UAV as separate units with their own transmission-modules or be integrated into the UAV. In principle, the operator of the payload-application could even be a separate entity, with the UAV operator focused solely on transporting the equipment in the operations area. Therefore, either the UAV operator or the application operator could be the customer for the data transmission.

The data from sensors and cameras might be subject to some further post processing by the operator or even third parties, which might require a specific level of quality with respect to accuracy, completeness or granularity of data. There will also be a need to capture meta-data, such as location and time, to get the full benefit of the operation. These factors might trigger requirements for the transmission as well.

MNOs will need to provide connectivity with an adequate service level to meet the requirements for such data transmissions during flight operations.

MNOs' Role in the Value Chain

Compared with C2-Coms, the payload data transmission could be less standardised and regulated as it could relate to a wide variety of different use cases with different implications for the payload communications. Furthermore, communications take place between the UAV and the operator or a third entity, which is working with the data generated via the UAV.

In a number of use cases, there will be a need for just-in-time transmission, particularly from professional users of UAVs fulfilling their core business. Different payload applications will make different requests on the network in terms of throughput, availability, quality of services and other factors.

For MNOs, the altitude aspect of providing connectivity for flying mobile devices represents a specific challenge. UAVs may operate at altitudes beyond the coverage provision, which is usually optimised to provide terrestrial services. Even so, in terms of aerial coverage, capacities and capabilities, technical and economic efficiency, and use of established technologies, there is a strong case for using mobile networks to provide transmission capabilities for UAVs. Furthermore, telcos have the know-how and technology to provide coverage even in new areas beyond the traditional scope of terrestrial mobile networks given a convincing business rationale.

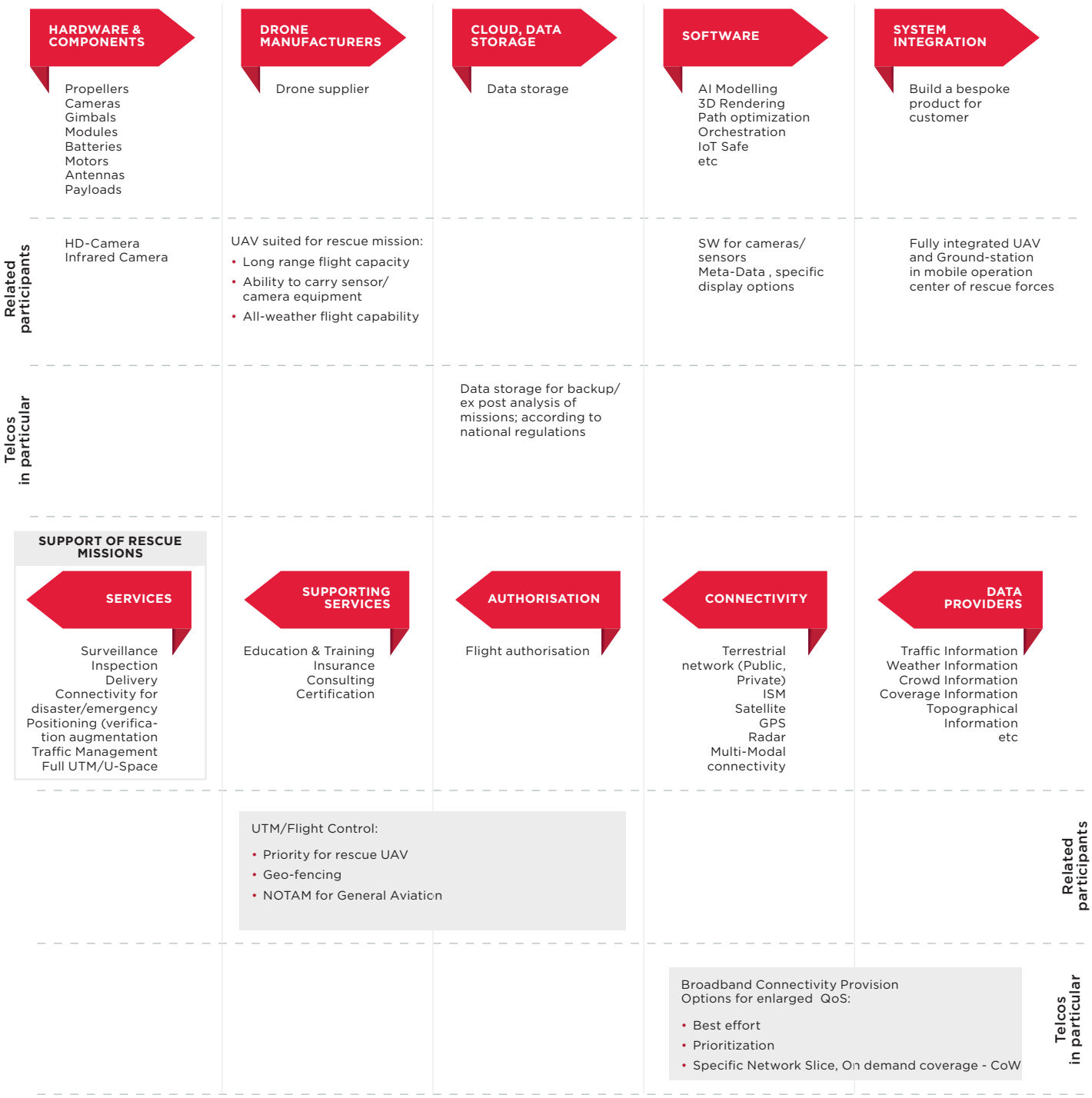
Beyond pure connectivity, mobile network operators are in the position to offer further capabilities to support UAV operations in general or specific use cases with UAVs. These capabilities include cloud services with storage, processing and even analytics functions. To support UAV operation, an MNO can also provide network-based supplementary services such as coverage maps or network-based positioning services.

The value chain for aerial connectivity for payload transmissions is depicted in Figure 8.

Figure 8

Aerial Connectivity for Payload Value Chain

Consideration for Rescue Scenario as "Payload" - Use Case



Potential Business Models for MNOs

The existing mobile infrastructure already provides a sound base for the provision of payload communications. Nevertheless, there is need to consider the special requirements for connectivity for payload-data-transmission.

Depending on the use case and the request for the data exchange, the required capacity and throughput can reach very high levels, in particular if 4k video transmission is involved and/or a number of devices are used in parallel to generate and directly forward data to the ground station. While mobile networks already need to deliver high capacity and fast throughput for terrestrial services, UAV communications extend the three-dimensional coverage requirement.

As mobile devices at altitude, UAVs cause specific effects in the network. On the one hand they do not follow given structures of – so far – mainly two-dimensional movement patterns. As a result, they can create quite different handover relations between serving cells which are not adjacent anymore. This has to be analysed with regard to soft handover and continuous connectivity while changing serving cells.

On the other hand, devices at altitude may have a different serving cell compared to those in the same area, but at ground level. This could result in interference effects.

Without specific arrangements in the network, those effects can even degrade overall network performance. Such effects emerge, in particular, for broadband data transmission at altitude, meaning they are more likely to impact payload-transmissions than C2-Coms, which tend to be narrowband.

Given these considerations, the provision of payload communication represents a service of special value that can be offered by MNOs.

Depending on the requirements, this service can be provided with different performance levels by:

- Handling UAV connectivity in the existing terrestrial mobile network as a baseline;
- Providing enlarged quality of service (QoS) features, in particular for improving payload data transmission by various means considering the specifics of UAVs as terminal devices;

up to:

- Establishing and operating dedicated altitude networks, which create specific coverage areas with optimised altitude-coverage to support UAV operations with payload transmission

These different options apply respectively as well for C2-Coms.

- Beyond connectivity, MNOs can support UAV operations with further supplementary services, such as:
- Providing 3D coverage maps showing predicted coverage/throughput of network in altitude layers (see section 5.11);
- Offering cloud services to optimise latency for service with very short response times, with general data storage and processing capabilities.

Nevertheless, providing sound coverage for a multitude of payload services with a high variety of requirements remains a quite complex and challenging effort compared to the value of the UAV operations market. Given the complexity of the subject, MNOs can play an essential role in consulting with UAV operators, developers of equipment and government authorities who intend to establish a future proof regulatory framework for UAVs.

Figure 9

Aerial Connectivity for Payload Business Model Canvas

Key Partners

- UAV manufacturers
- Sensor / camera-Device Manufacturers

Key Activities

- Calculation of Bus. Model
- Sound description of network capabilities for UAVs, Consultancy

Key Resources

- Network capacities in altitude
- Sales & Customer Service-capacities for UAV-operators

Value Proposition

- Just-in-time data transmission (connectivity)
- For UAV-operators which need / like to have data already during flight
- Based on established technology/wide-spread availability

Customer Relationships

- Standard Connectivity provision with usual service-level
- Special UAV-operator support with specific services/ implementations

Channels

- Direct sales
- Wholesale to specific providers for UAV-operators

Customer Segments

- Private
- Commercial
- Public
- B2C
- B2B
- B2B2C

Different combinations possible

Cost Structure

UAV-Operator:
Hardware / Integration: Connectivity modules in UAV /Sensors; Price of connectivity

Telco:
Standard mobile network => Tarif according to sales offers for UAVs based on given network costs; Special network layer => special price for customer(s).
Special QoS-parameters => specific prices

Revenue Streams

- Connectivity charge according to contract;
- Compensation share for additional implementations
- Charge for specific QoS parameters

5.3
QoS: Dedicated Versus Shared Resources/Best Effort

For both C2-Coms and payload transmission purposes (see sections 5.1 and 5.2), UAVs may need a specific quality of service (QoS) from a mobile network. This could have different dimensions depending on the purpose and use case.

The network itself has to be assessed with regard to its coverage, its average availability over time (availability of 99.x %) and the capacity it can provide based on its configuration and technical design. Beyond these basic figures, each communication has to be assessed with the performance that can be provided under the framework conditions that apply at the time the data transmission is requested.

Use Case Description

As C2-Coms is essential for safe operation of the UAV, availability, reliability and fail-safety are high priorities. However, due to the current design of C2-Coms data streams, specific requirements on throughput and latency are of less significance.

Therefore, the network needs to provide a robust data communications channel which works even under less favourable conditions.

While payload transmission might be essential for a successful mission, it has less significance with respect to the safe operation of the UAV itself. On the other hand, the requirements are much more diverse and manifold and dependent on the specific UAV use case.

Depending on the mission, the payload transmission might be optional, in particular when mission data can be stored on a memory chip (e.g. for measurement or imaging flights) and analysed after the flight. Transmission during the flight might create a time advantage, but if transmission fails, success of the mission isn't endangered.

However, the situation is different when data transmission during the flight a necessary to run a successful mission. This is particularly the case in security and/or surveillance missions, such as inspections where a specialist on the ground directly observes and assesses infrastructure based on the transferred images or video stream. These missions will generally use high resolution cameras and sensors, which require a high level of throughput from the network to deliver the requested results and show all the high resolution details of the images.

Stakeholders

For C2-Coms, the UAV manufacturer defines the interaction between the UAV and the ground station and specifies the transmission accordingly. The communication link-specific equipment generally employs standards-based modules from specialist vendors.

Regulation for UAV operations may require specific processes and standards to integrate UAVs into the airspace, while dictating how interaction between UAV operators, the UAVs and a UTM shall apply. These regulations may include requirements for network availability as well.

For payload communications, the UAV manufacturer may integrate the necessary equipment into the UAV or the UAV operator may equip the UAV with sensors and other devices, with their own connectivity module, for a specific mission. In principle, the UAV manufacturer or the ad-on-equipment manufacturer will define the requirements for the data transmission and adopt an appropriate solution.

MNOs' Role in the Value Chain

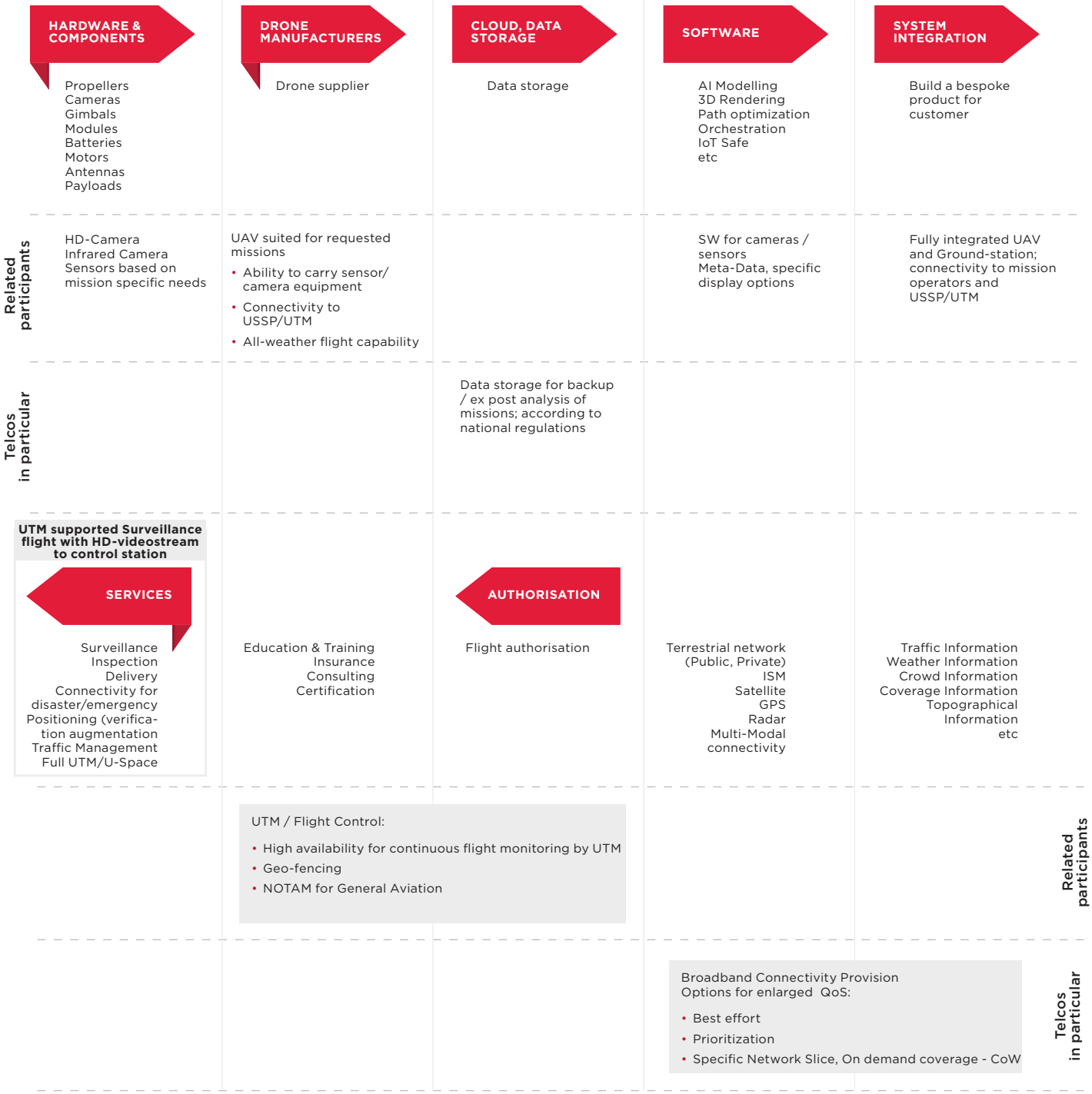
A mobile network employed by a UAV will need to deliver a specific quality of service, which as discussed above, depends on a number of factors. Furthermore, specific network features can be introduced to improve specific aspects of the network's performance, either in total or related to specific users and/or usages.

Many trials and test operations have demonstrated that for UAV operation at altitude, terrestrial mobile networks can be used for C2-Coms and payload transmission with good results. However, these existing networks are not optimised for UAV operation at altitude and current UAV operations are mainly handled in the same way as earthbound connectivity provision for mobile devices. Figure 10 shows how a MNO can fit into QoS value chain for UAVs.

Figure 10

QoS: Dedicated Versus Shared Resources/Best Effort Value Chain

Consideration for Security Surveillance-flight with UTM-support as Scenario to underline QoS for C2 and payload



Potential Business Models

Given the different levels of QoS depending on the specific use case, MNOs can use their large toolbox to create solutions even for very demanding requirements, as described in Sections 5.1 and 5.2.

In principle, the more a network is dedicated and designed for UAV operation, the better specific requirements can be fulfilled. Without specific consideration of this special group of devices, UAV operators and/or regulators might ask for higher performance figures and QoS levels than provided with the established terrestrial mobile networks.

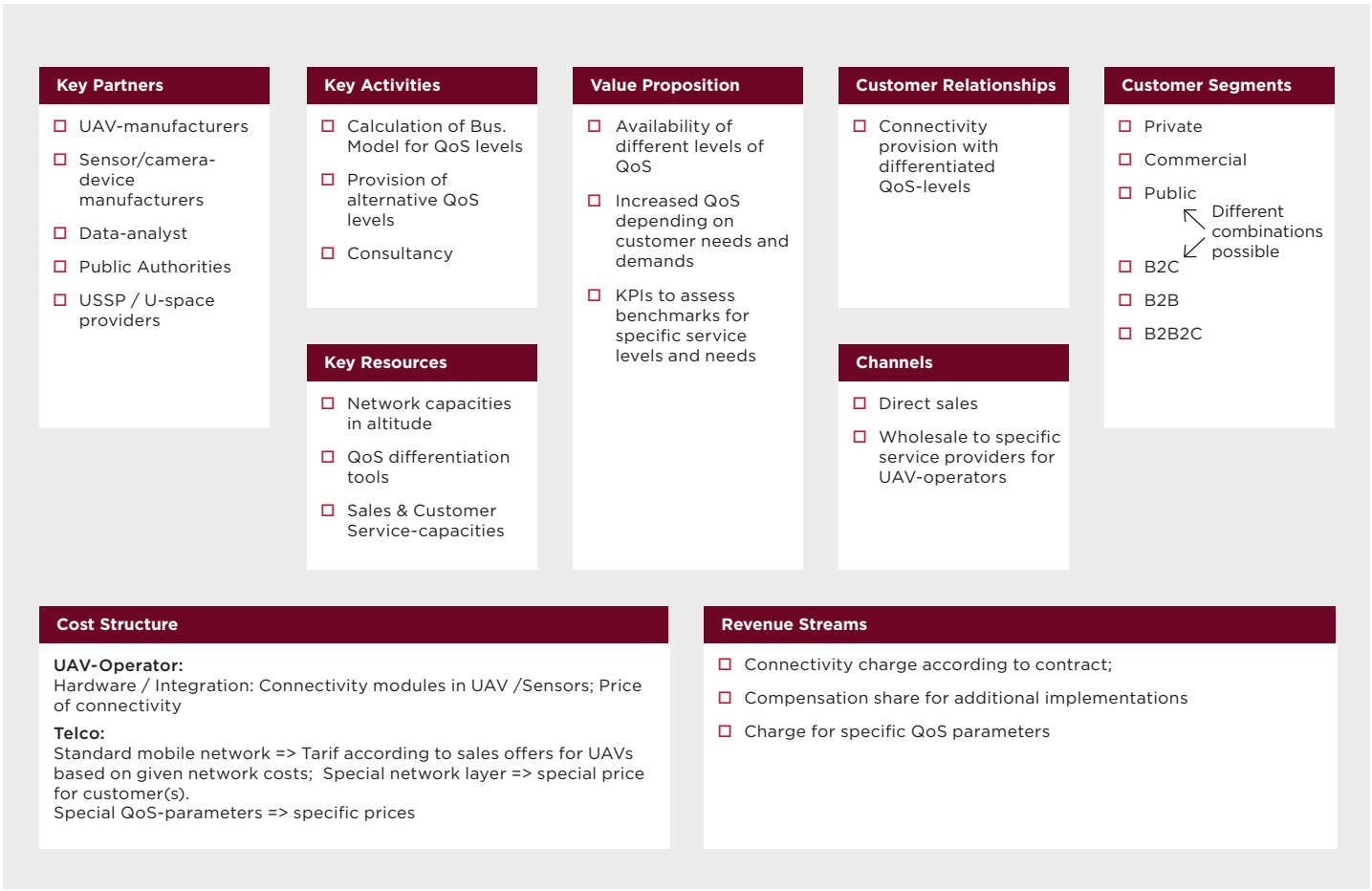
Current 5G technologies offer some tools to provide specific performance for applications and user groups, such as slicing to optimise latency, throughput or other features that are of interest to a specific user group. Campus networks can be deployed on request with special consideration for UAV traffic in that area and optimised network coverage in that spot. In principle, specific network layers for UAV operation can be rolled out in line with regulation and aligned with terrestrial coverage provision to provide optimised coverage for UAVs in the airspace. All these measures are possible from a technical standpoint; however, they have to be applied in a way that enables all parties to run a sustainable business from an economic perspective as well.

Beyond those network configurations and deployments, the provision of additional network information can increase QoS level as well, simply by making the user aware of existing resources and capabilities. In this context, 3D coverage maps (see Section 5.11) can provide very helpful information for UAV operators and UTM operators by showing – under a number of framework assumptions and related notifiers – the average mobile network coverage in airspace. That allows UAV operators to make an initial assessment if a planned mission with data transmission during flight can be performed with good results. For UTM operators, it is essential to know in which areas data transmission is likely to be reliable, as any loss of connection with a UAV might mean an emergency-situation with defined procedures to follow. Figure 11 shows a business model canvas for the provision of QoS for UAV operations.

> the more a network is dedicated and designed for UAV operation, the better specific requirements can be fulfilled

Figure 11

QoS: Dedicated Versus Shared Resources/Best Effort Business Model Canvas



5.4
Network Remote ID & SIM-Based Identity

Use Case Description

A UAV Remote ID[4] mechanism can enable a UAV to provide identification and location information to other parties. In manned aviation, several technologies are used, mainly based on ADS-B, for these purposes. In unregulated airspace, pilots tend to use VFR (visual flight rules) to prevent collisions. For UTM, however, existing technologies cannot always apply, and visual object detection is not always possible. Several options are available:

- The first would be adopting, if possible existing aviation technologies.
- Secondly, a Remote ID could be broadcast by the UAV using transponders, for example, via Bluetooth low energy (BLE), which would require a receiver to process the UAV information.
- Another option is for the UAV to send the Remote ID to the internet, CIS or USSP using a cellular connection. This data would be transmitted, in flight, in addition to C2-Coms data or payload data, and would be available for everyone who wants to know (open data).

Stakeholders

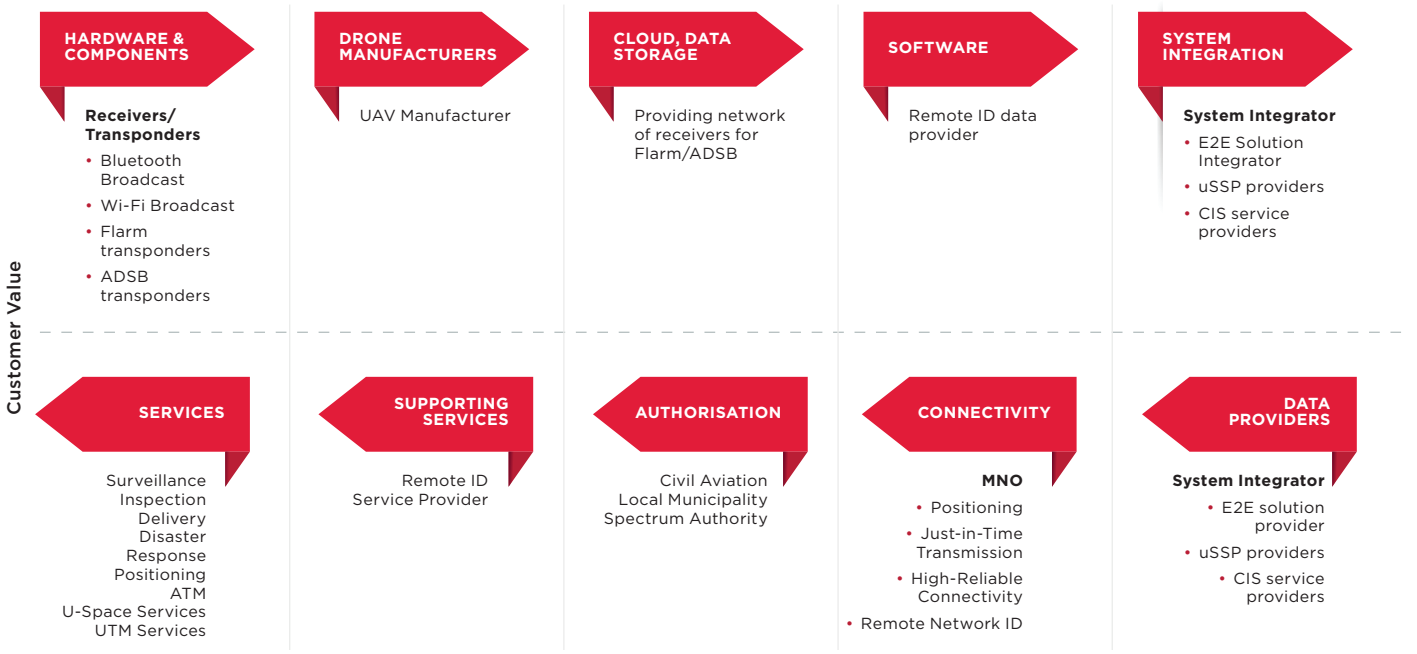
First of all, it is important that the responsible bodies in each market accept UAV identification based on the SIM as a technical solution. MNOs would also need to support this approach and UAV operators and USSPs (U-Space service providers) would need to be able to receive the Remote ID information.

From a technical implementation standpoint, the solution would be either retrofitted or integrated into the UAV. In case of an integrated solution, UAV manufacturers would be essential to adoption of the solution. A retrofitted solution would be supplied by a Remote ID device manufacturer or service provider. Figure 12 shows the stakeholders in the value chain.

[4] Note: UAV Remote ID is generally of two types: broadcast (or direct) and network and it is also one of the mandated services for UAV in some countries.

Figure 12

Network Remote ID & SIM-Based Identity Value Chain



MNOs' Role in the Value Chain

Especially for UAV use cases in the BVLOS and real time data processing domain (where cellular connectivity is already integrated), an MNO could provide SIM-based identification services to the UAV operator. Additionally, an MNO could provide services towards users or requestors of the identification information (USSPs, air authorities, CIS users) for easy integration. The addition of such services would strengthen the total MNO proposition, making the telco even more relevant in the ecosystem.

Potential Business Models

Assuming that the UAV is already using MNO connectivity, MNOs can provide Remote ID services, along with other QoS, to the UAV operator. The MNO could also provide Remote ID services to the UTM service providers. Figure 13 shows a business model canvas for the provision of Remote ID services.

Figure 13

Network Remote ID & SIM-Based Identity Business Model Canvas

Key Partners

- UAV Manufacturers
- UTM Providers
- U-Space operators
- Regulator
- Remote ID Service providers

Key Activities

- Provide Remote ID service
- Broadcast Remote ID information or transmit Remote ID information to the internet

Key Resources

- Radio transmission
- Transmitter, either integrated or retrofitted

Value Proposition

- Trusted player that enables identification to 3rd parties
- Remote ID transmitted to central system
- Low impact on UAV (sim only)
- Combi offer with connectivity for payload & command & control

Customer Relationships

- Drone operators
- Manufacturers
- UTM providers
- USSP's

Channels

- Indirect (by UAV manufactures))
- Direct to
  - UAV operators
  - USSP's

Customer Segments

- BVLOS drones
- VLOS drones in CTR zones

Cost Structure

- In case of retrofit solution: tag & installation
- Platform for secure sharing of network ID

Revenue Streams

- VAS service on top of connectivity for sharing of network ID to drone operators
- Monthly subscription towards USSP's

Value Added Services

5.5 Positioning Augmentation

Use Case Description

Accurate real-time positioning information is essential for a UAV to operate and navigate autonomously without direct guidance from a ground operator. This is especially critical for beyond visual line of sight (BVLOS) operations.
UAV platforms today typically receive position information for outdoor navigation, both laterally and vertically, from the global positioning system (GPS). Location information derived from GPS is fairly accurate, but is subject to errors due to signal interference, satellite path and timing errors, as well as calculation and rounding errors. As a result, position information computed using GPS signals can have inaccuracies of tens of meters or more. Even at its most accurate, GPS typically cannot pinpoint locations to less than 3 meter accuracy.

The basic accuracy limitations and general errors associated with GPS might be acceptable for UAV navigation in some environments. However, in dense urban or industrial environments with many closely spaced buildings and obstructions, in addition to multiple flight-restricted areas, GPS positioning inaccuracy could be untenable. Therefore, there is a need to provide UAV position augmentation services that can compensate for inherent GPS positioning errors.

There is already a precedent for GPS error correction for airborne vehicles in the form of wide area augmentation services (WAAS), which provide GPS error correction for suitably equipped manned aircraft. However, WAAS-compatible equipment can be expensive and bulky, making it unsuitable for UAV usage. Additionally, WAAS utilises satellite transmission for distributing GPS error compensation information, meaning that the error compensation signal itself is subject to satellite-related transmission errors.

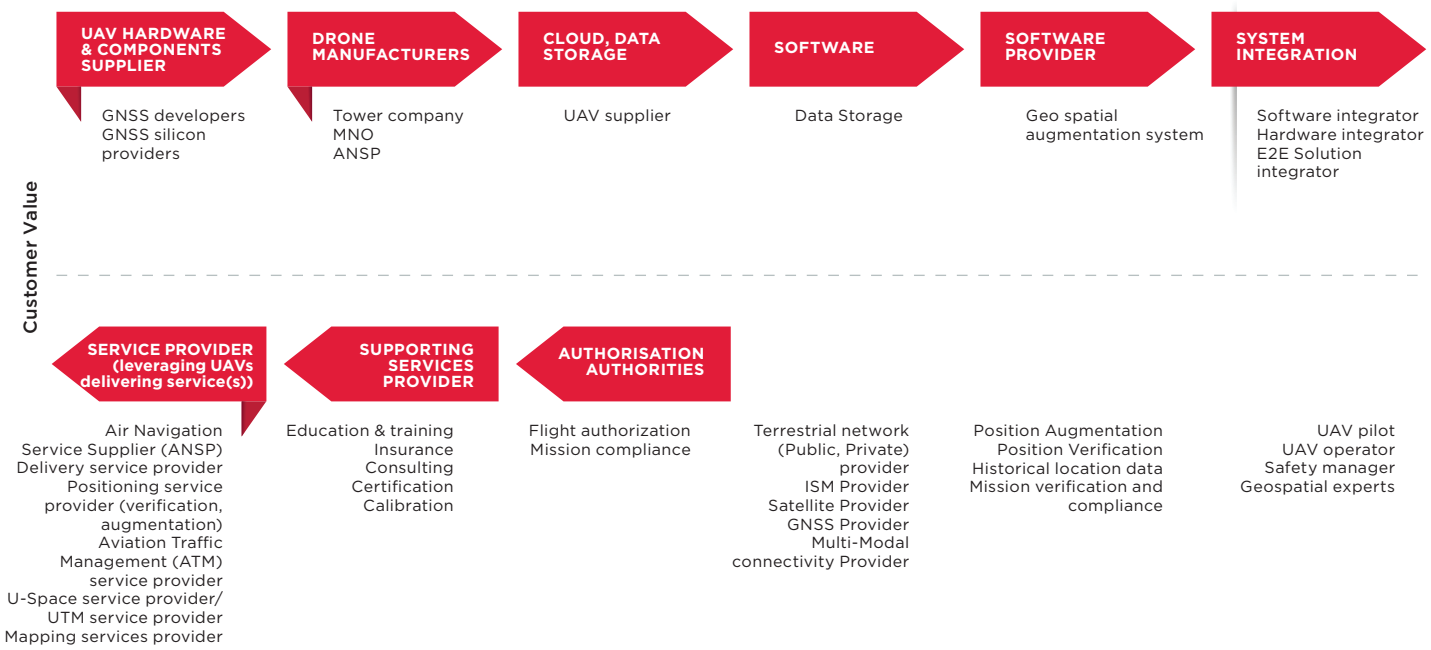
Therefore, MNOs have an opportunity to provide a terrestrial-based GPS position augmentation service through their cellular networks. Some operators already provide real-time kinematic positioning services (RTK) to correct for common errors in GPS systems. These services could possibly be adapted for use in UAVs.

Stakeholders

UAV manufacturers would need to equip their UAVs with the necessary technology to receive and process GPS error correction signals, while UAV operators would need to subscribe to position augmentation services for their suitably-equipped UAVs. Regulators could potentially provide standards for levels of accuracy required when utilising position augmentation to permit certain types of operations.

There is a need to provide UAV position augmentation services that can compensate for inherent GPS positioning errors.

Figure 14
Positioning Augmentation Value Chain



MNOs' Role in the Value Chain

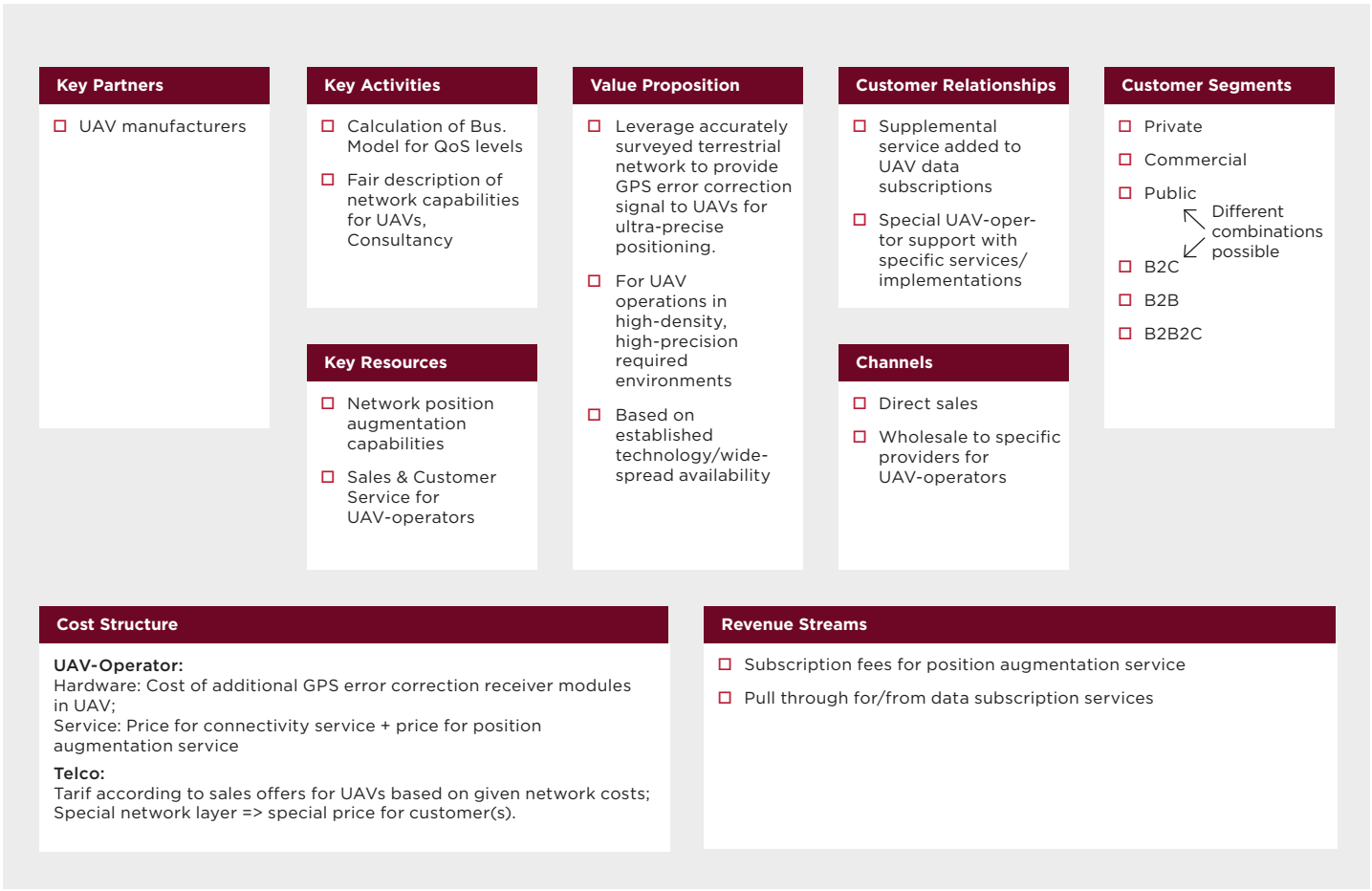
MNOs would provide position augmentation services to UAV operators that work with suitably-equipped UAVs.

Potential Business Models

MNOs could offer subscription services for UAV operators to purchase position augmentation services. These would be in addition to their airborne cellular data communications subscriptions. Figure 15 shows a business model canvas for a positioning augmentation service.

Figure 15

Positioning Augmentation Business Model Canvas



5.6
Onboard UAV-based and Edge-Based Computer Vision

Use Case Description

UAV-based computer vision solutions offer benefits for several business sectors, as well as for public services entities. The solutions generally use AI models to interpret live video feeds from cameras on-board UAVs.

Such solutions can identify objects, count livestock, look for infrastructure defects, and essentially achieve any task that would normally require human eyes and analysis.

Applications for UAV-based computer vision include everything from tracking farm animals, to identifying vehicles, evaluating electrical lines, and finding leaks or flares in industrial settings. It can be used for everything from workplace safety to ouch-less check-in, and fall detection to inventory analysis. Any visual task can be replicated with AI training and be quickly added to existing video systems.

Compared to human workers, those systems can monitor larger areas and more visual data – with dramatically greater speed and accuracy – for a fraction of the cost.

Thanks to recent technological advancements in GPUs, it's become easier to run powerful AI models at the edge, a trend which is likely to accelerate in the next few years. As it operates close to the data source, an edge-based computer vision inference engine can generate responses in milliseconds, and process multiple video feeds simultaneously.

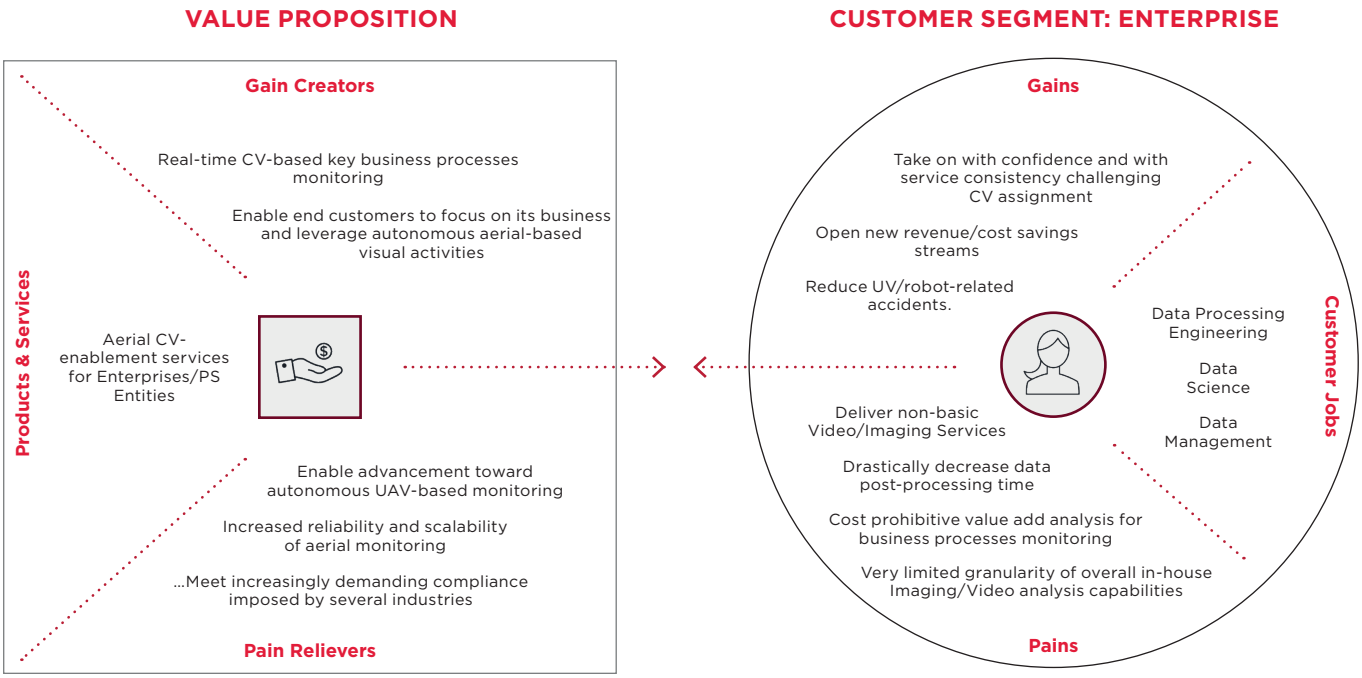
Edge-based computer vision is typically managed from the cloud, employing either standard AI models and custom AI models that include image classification, object detection, human detection, action logging, tracking and more. Standard AI models are ready now and custom AI models are quickly trained and deployed. An end-to-end computer vision solution often integrates with GPU processors designed for AI and robotic applications.

As many medium-to-small enterprises and most public service entities are not in a position to have a full in-house computer vision solution, they could consume computer vision as a service from MNOs. An MNO can provide end-to-end connectivity, edge application hosting, video traffic aggregation and delivery services for an UAV-based and edge-based computer vision solution optimised to work in conjunction with MNO's systems.

For more details on the overall value proposition for this use case, please see Figure 16.

Compared to human workers, those systems can monitor larger areas and more visual data – with dramatically greater speed and accuracy – for a fraction of the cost.

Figure 16
Onboard UAV-based and Edge-Based Computer Vision Value Chain



Stakeholders

The value chain for this use case could include:

- Enterprise and public agencies looking for advanced video and images analytics. Capabilities provided as a service, rather than building them in-house.
- Computer vision ISVs/platform providers with AI modelling capabilities. Computer vision application hosting providers, such as public cloud service providers.
- Video camera and computer vision appliance makers.
- MNOs as connectivity providers for IoT endpoints (various cameras and sensors) and for computer vision application(s) hosting.
- MNOs as an end-to-end solution provider for computer vision-enabled use cases.
- System integrators in cases where video/images are collected from across organisations to derive contextual information.

Stakeholder mapping for this use case is presented in Figure 17.

Figure 17

Onboard UAV-based and Edge-Based Computer Vision Stakeholder Analysis

STAKEHOLDERS

Onboard UAV-based/ Edge-based Computer Vision

PRIMARY/CONNECTED

Those who have an economic or a contractual relationship.

- Enterprises/PS Entities
- MNOs
- CV Application Hosts
- Cloud providers
- SW ISVs
- UAV Operators

SECONDARY/EXTERNAL

Those who are not directly connected to the use case but are still interested in or could be impacted by the use case.

- Governments
- Industry specific regulatory entities
- Public Safety entities
- Advocacy groups
- Local communities

MNOs' Role in the Value Chain

Some of the key roles for MNOs in this use case include:

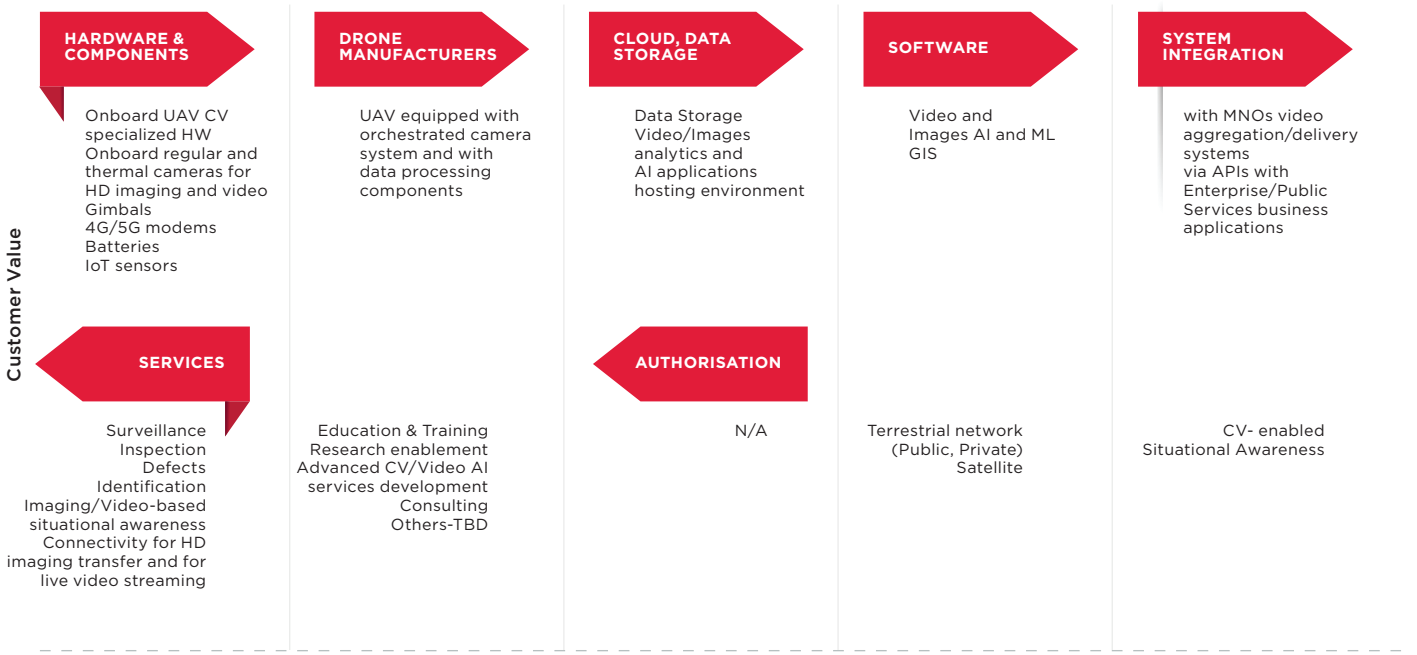
- Connectivity provider for video and images traffic delivery from IoT end points/aggregation points and connectivity for edge hosting environment.
- Application hosting provider for computer vision apps (at the edge and in the cloud).
- End-to-end security provider for video/images aggregation/delivery and for computer vision-enabled outcomes toward end-enterprise or public sector users.

The overall value chain for this use case is presented in Figure 18.

Figure 18

Onboard UAV-based and Edge-Based Computer Vision Value Chain

Value Chain Stakeholders: Onboard UAV-based/Edge-based Computer Vision



Potential Business Models

An MNO could provide data services to UAV operators or a broader solution to end enterprise/public sector customers.

An MNO could capture a significant portion of the overall value created by stakeholders with an interest in UAV-based/edge-based computer vision services by positioning itself as a provider of live video streaming or near-real time HD image delivery services, edge-based computer vision applications hosting and as system integrator.

For more details on the business models for this use case, please see Figure 19.

Figure 19

Onboard UAV-based and Edge-Based Computer Vision Business Model Canvas

Key Partners

- MNO
- Computer Vision Provider
- Video hosting & storage provider
- UAV Operator

Key Activities

- MNO
- Computer Vision Provider
- UAV Operator

Key Resources

- Data Scientist
- Business Analyst
- Drone Operator
- Network Engineers
- Product, Sales, and Customer Service

Value Proposition

- Ingest real-time video data and derive insights
- Use insights to trigger tasks and real-time adjustments on a workflow
- Identify anomalies in video
- Unlocks true automation and BVLOS value proposition
- Lowers labour costs

Customer Relationships

- Value-add to traditional services such as surveillance & inspection

Customer Relationships

- Direct-to-consumer
- B2B

Customer Segments

- Enterprise Public & Private
- Mid-Market Public & Private
- Townships & Municipalities

Cost Structure

3 Models:

1. Create your own data models (coding required) – high upfront capex, high opex, high degree of flexibility
2. Create your own data models (code-free) – low upfront capex, medium opex, medium degree of flexibility
3. Data models created for you by a provider – low upfront capex, high opex, medium degree of flexibility

Revenue Streams

- Tiered subscription
- Professional services for professional services
- Collecting & monetizing data for interested parties

5.7
High Resolution Topographical Information Service

Use Case Description

A powerful complement to traditional aerial photogrammetry, the use of UAVs for geographic information mapping is flexible, efficient, low cost, and has a wide range of applications. For example, UAVs can be used to obtain high-resolution imagery in small and difficult flight areas, enabling surveying and mapping for engineering construction projects.

UAVs can greatly improve the efficiency of collecting terrain data, which can be used to efficiently build accurate 3D models, intuitively reflect landforms, buildings and other information, and assist designers in scientific planning. Potential users include:

- Government branches
- Construction companies
- 3D modelling companies
- Equipment manufacturers and vendors
- Geographical surveying and mapping enterprises
- MNOs

MNOs' Role in the Value Chain

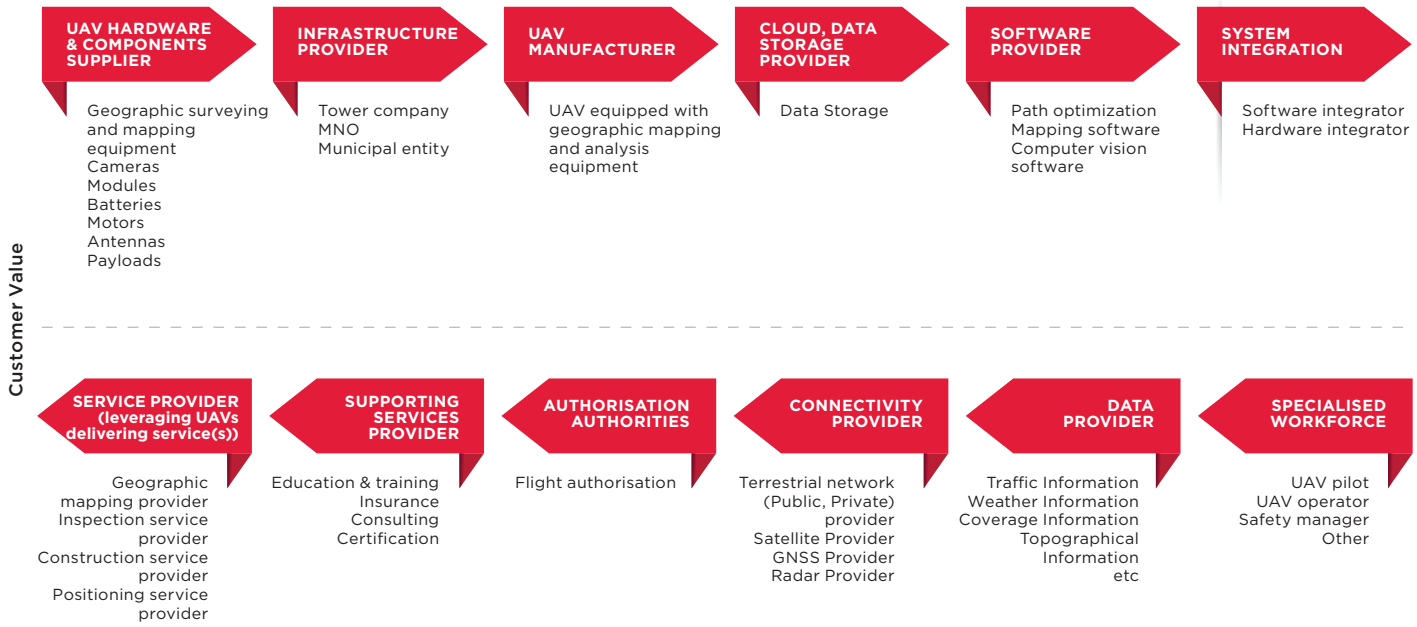
MNOs can provide low-latency and stable 5G connectivity to transmit high-resolution video and image information in real-time. They can also suppress the signal interference of UAVs in the air by using air interference optimisation technology. Air interference optimization technology can significantly improve signal interference issues, thereby meeting the application requirements of low latency, large bandwidth, and high reliability.

Figure 20 shows the potential value chain for this use case.

Figure 20

High Resolution Topographical Information Service Value Chain

Value Chain Stakeholders



Potential Business Models

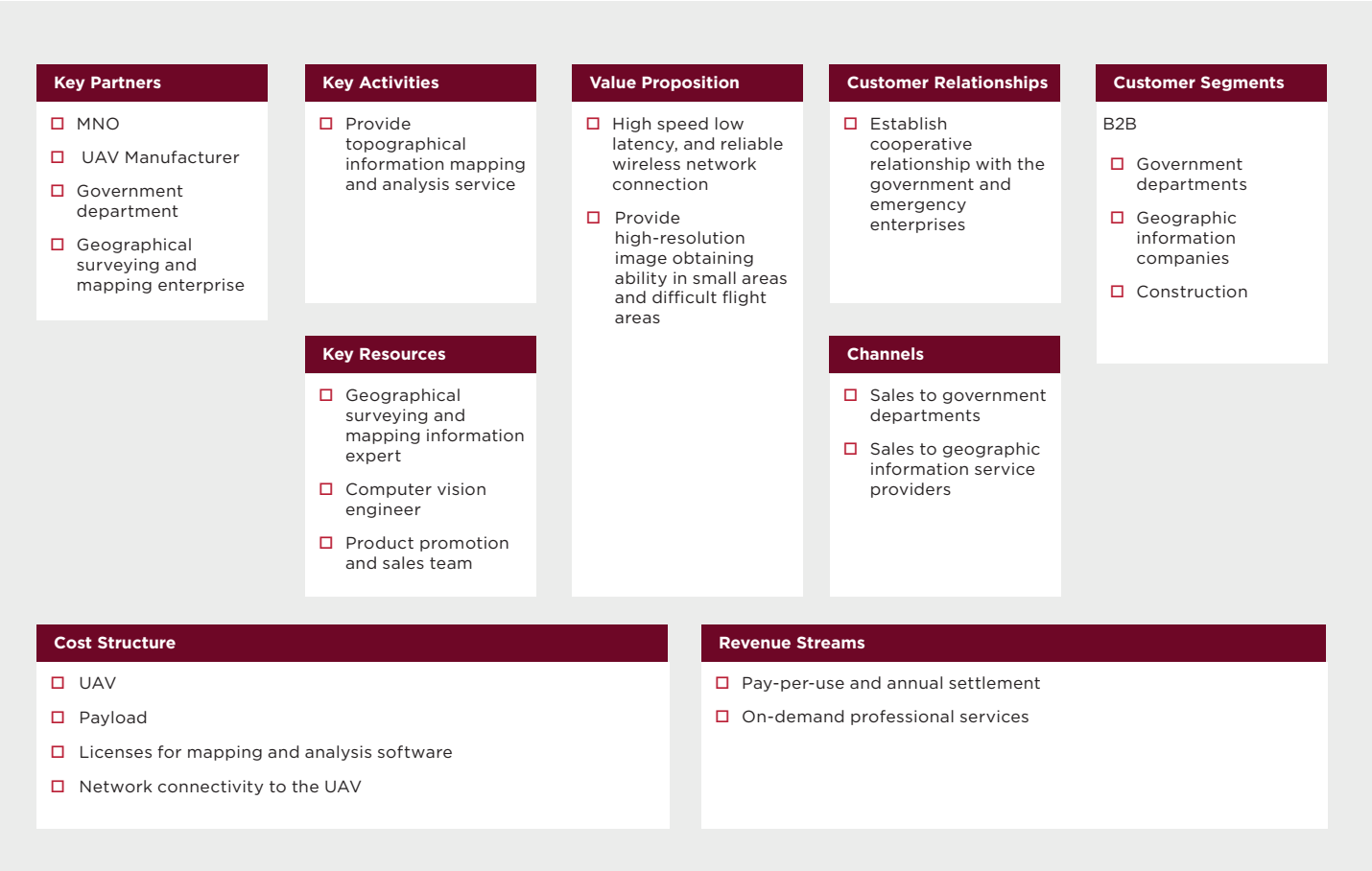
MNOs can could monetisze UAV-networking as a service via pay-per-use/pay-per-mission as part of an end-to-end solution.

MNOs can also sell airborne signal Air interference optimization services to UAV operators.

In addition, MNOs can sell network-connected UAV management and operation cloud platforms to 3D modeling companies or constructions, and provide corresponding data storage and processing services. Figure 21 shows a business model canvas for this use case.

Figure 21

High Resolution Topographical Information Service Business Model Canvas



5.8
Multi-UAV Orchestration

Use Case Description

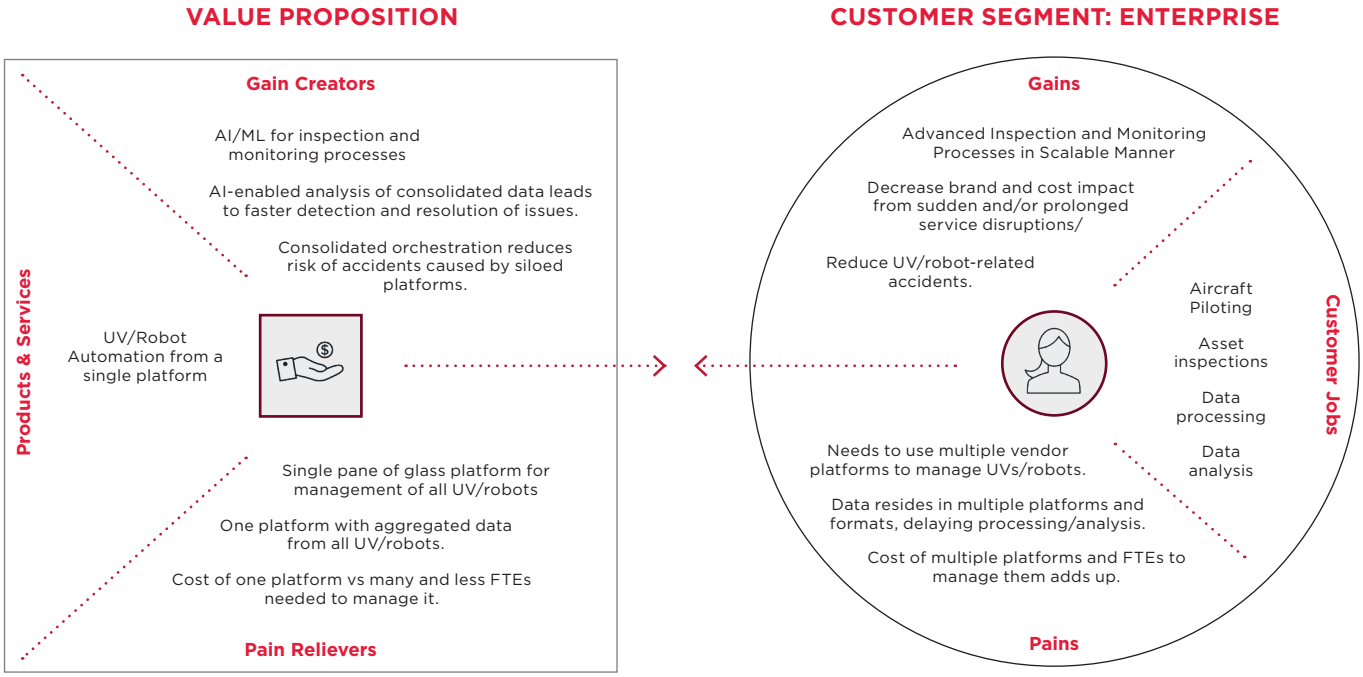
The GSMA estimates that 17 million commercial UAVs will be utilised worldwide by 2026. Integrating with, and coordinating the work of, a varied fleet of UAVs will require standardised orchestration software that can easily be integrated into a variety of specific platforms.

A multi-UAV orchestration solution could provide UAV users with:

- ☐ A single pane of glass platform for management of all UV/robots.
- ☐ One platform with aggregated data from all UV/robots.
- ☐ Low operating costs
- ☐ AI/ML for inspection and monitoring processes.
- ☐ AI-enabled analysis of consolidated data, which leads to faster detection and resolution of issues.
- ☐ Consolidated orchestration reduces risk of accidents caused by siloed platforms.

For more details on the overall value proposition for this use case, please see Figure 22:

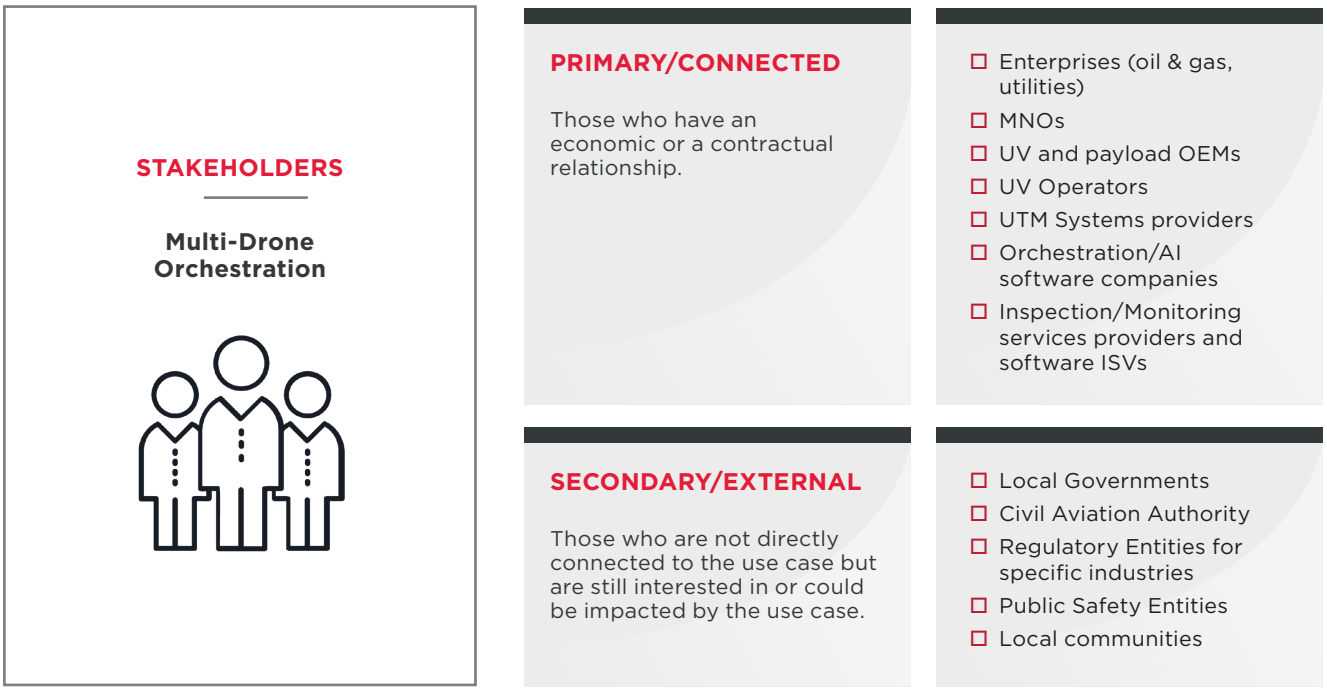
Figure 22
Multi-UAV Orchestration Value Proposition



Stakeholders

The stakeholders mapping for this use case is presented in Figure 23:

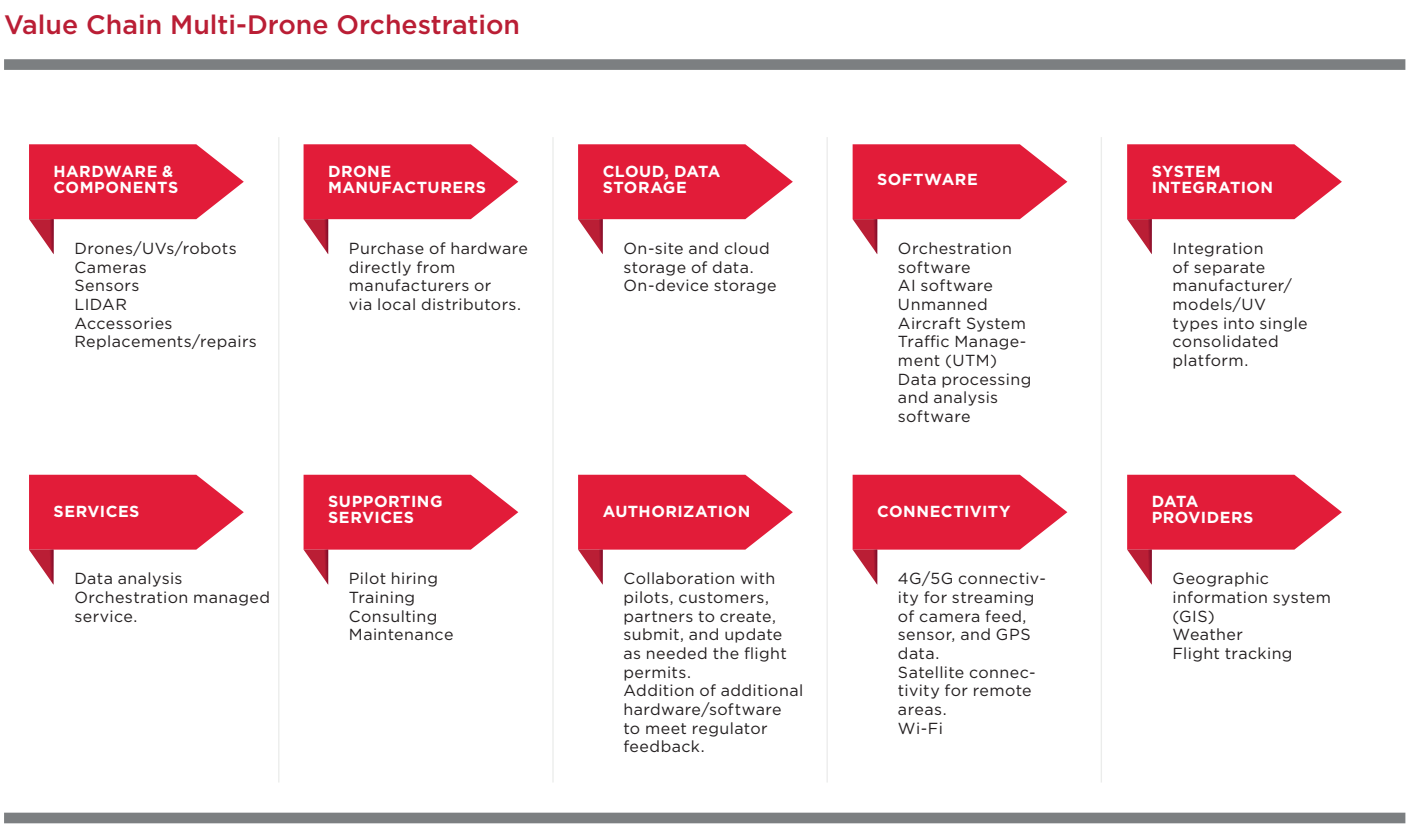
Figure 23
Multi-UAV Orchestration Stakeholder Analysis



MNOs' Role in the Value Chain

MNOs could provide edge computing processing power and high reliability and quality network coverage to areas where this use case will be deployed. The overall value chain for this use case is presented in Figure 24:

Figure 24
Multi-UAV Orchestration Value Chain



MNOs could monetise automation as a service (AaaS) via pay-per-use/pay-per-mission as part of an end-to-end solution. Alternatively, MNOs could monetise discrete parts of the overall AaaS value chain for this use case, such as connectivity/ application hosting/data storage and processing in cases where the end-to-end service is provided by a third party.

An MNO could capture a very significant portion of the overall value created by stakeholders that have an interest in AaaS services. The MNO needs to positions itself as the primary provider of connectivity for UAVs/robots and for on-board servers for road vehicles with stringent reliability requirements. Additional value can be obtained from complementary services, such as applications hosting, and as system integration of customer UV/ robot systems. MNOs could also monetise APIs.

For more details on business models related to this use case please see Figure 25:

Figure 25
Multi-UAV Orchestration Business Model Canvas

Key Partners
- UV OEMs
- Payload manufacturers (cameras, LIDAR, sensors)
- Orchestration / AI software companies
- UV Operators
- UTM Systems & USSP Services Providers
- Inspection/ Monitoring services providers and software ISVs

Key Activities
- Orchestration of all unmanned vehicles (ground or aerial)
- Cross-sale of MNO services

Key Resources
- Drone pilots
- AI/ML experts
- MNO brand and sales team

Value Proposition
- Packaged solution for orchestration of UVs, along with connectivity.
- MNO brand can be leveraged to gain government regulator support for inspection flight permits and PoCs.

Customer Relationships
- Direct relationship with MNO or key partner sales team.

Channels
- Direct sales
- Sales via key partners

Customer Segments

B2B with focus on three key segments:
- Oil and gas
- Mining
- Construction

Cost Structure
- UAV: Drone and payload
- 4G/5G connectivity to the drone
- Licenses for AI/ML software
- Human resources: Pilots, analysts, technicians, and developers.
- Sales commissions

Revenue Streams
- Managed hardware and orchestration software
- Managed UV monitoring and control (centralized control centre)
- On-demand professional services
- Cross-sell of other MNO services
- Monetization of APIs

5.9
Hyper Localised Weather Services

Use Case Description

It can be difficult for a remote pilot of an UAV to know what local weather at UAVs' flying altitudes is about to occur with the current weather system used by the aviation industry. This uncertainty produces what is known as a "Weather Tax" on operations of UAVs in terms of extra costs, resource planning, uncertainty around efficiency etc.

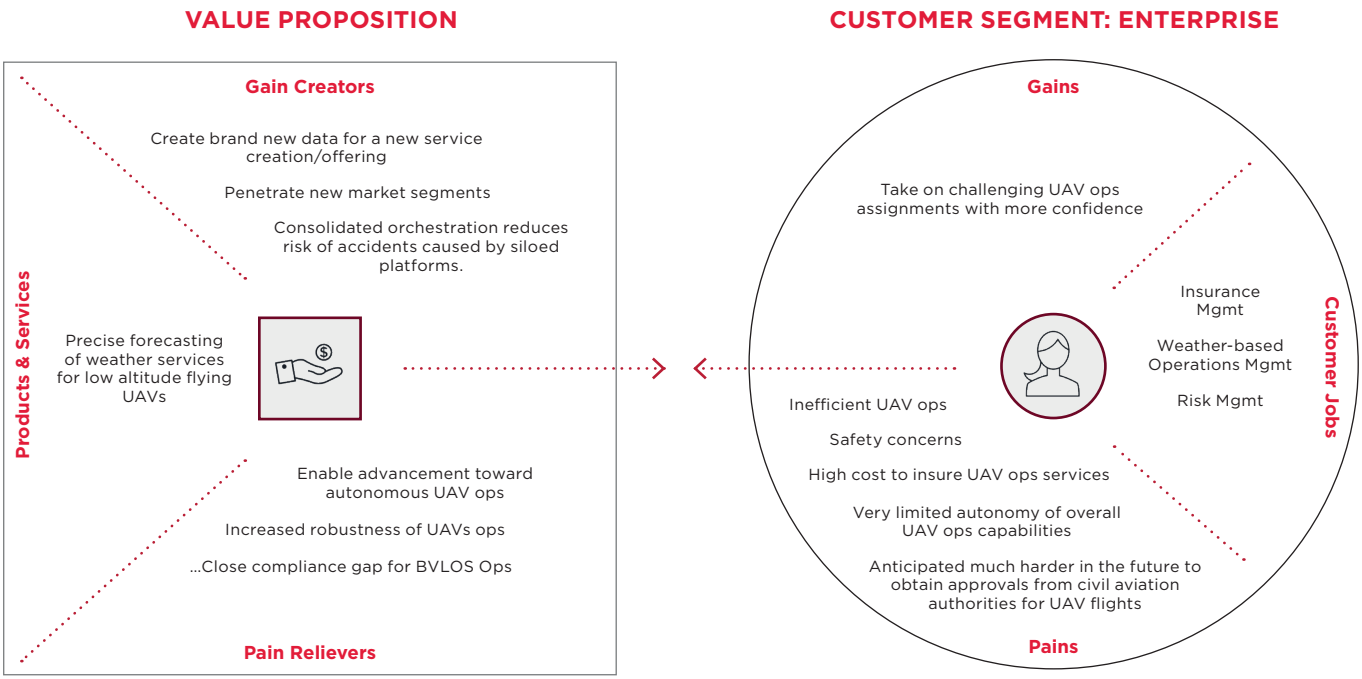
Hyper localised weather services allow for low-altitude (sub 3,000 feet) weather readings to inform safe and cost-effective UAV missions both in rural and urban settings. These solutions entail the deployment of ground-based low-altitude weather sensing technology and on-board UAV sensors that promise to transform weather accuracy. Hyper localised weather services leverage existing infrastructure ,such as cell towers, transmission sites and retail buildings, to create a network of sensors and micro-weather stations. UAV pilots and systems can then assess changes in weather conditions in real-time.

The key benefits to UAV operators that decide to leverage hyper-localised weather services include:

- Take on challenging UAV operational assignments with more confidence.
- Penetrate new market segments.
- Capture new data for a new service creations/offering.
- Enable advancement toward autonomous UAV operations.
- Increased robustness of UAVs operations.
- Close compliance gap for BVLOS operations.

For more details on the overall value proposition for this use case please see Figure 26:

Figure 26
Hyper Localised Weather Services Value Proposition



Stakeholders

Potential stakeholders for this use case include:

- ☐ Real estate owners (of commercial buildings, cell towers, bridges etc.) where sensors can be mounted
- ☐ UAV operators
- ☐ UTM providers
- ☐ FIMS (facilities and information management system) providers
- ☐ ANSPs (air navigation service providers)
- ☐ Civil aviation authorities
- ☐ Local/state/provincial governments (departments of transportation)
- ☐ Meteorologists
- ☐ Sensor/micro weather station manufacturers and providers
- ☐ Weather sensor companies
- ☐ UAS test ranges
- ☐ National meteorological services
- ☐ Research institutes
- ☐ Users of UAV-based services (like deliverers of last mile, inspection companies etc.)

Stakeholder mapping for this use case is presented in Figure 27:

Figure 27

Hyper Localised Weather Services Stakeholder Analysis

STAKEHOLDERS

Hyper-localized Weather Services for UAV apps

PRIMARY/CONNECTED

Those who have an economic or a contractual relationship.

- MNOs
- Low-altitude weather services providers
- Micro-weather station Manufacturer
- UAV Operators
- UTM SS and SDSPs

SECONDARY/EXTERNAL

Those who are not directly connected to the use case but are still interested in or could be impacted by the use case.

- Local Governments
- Civil Aviation Authority
- Real estate leasing entities
- National/Integrated weather service providers
- Cloud and Edge SPs
- Weather sensors OEMs/ ODMs

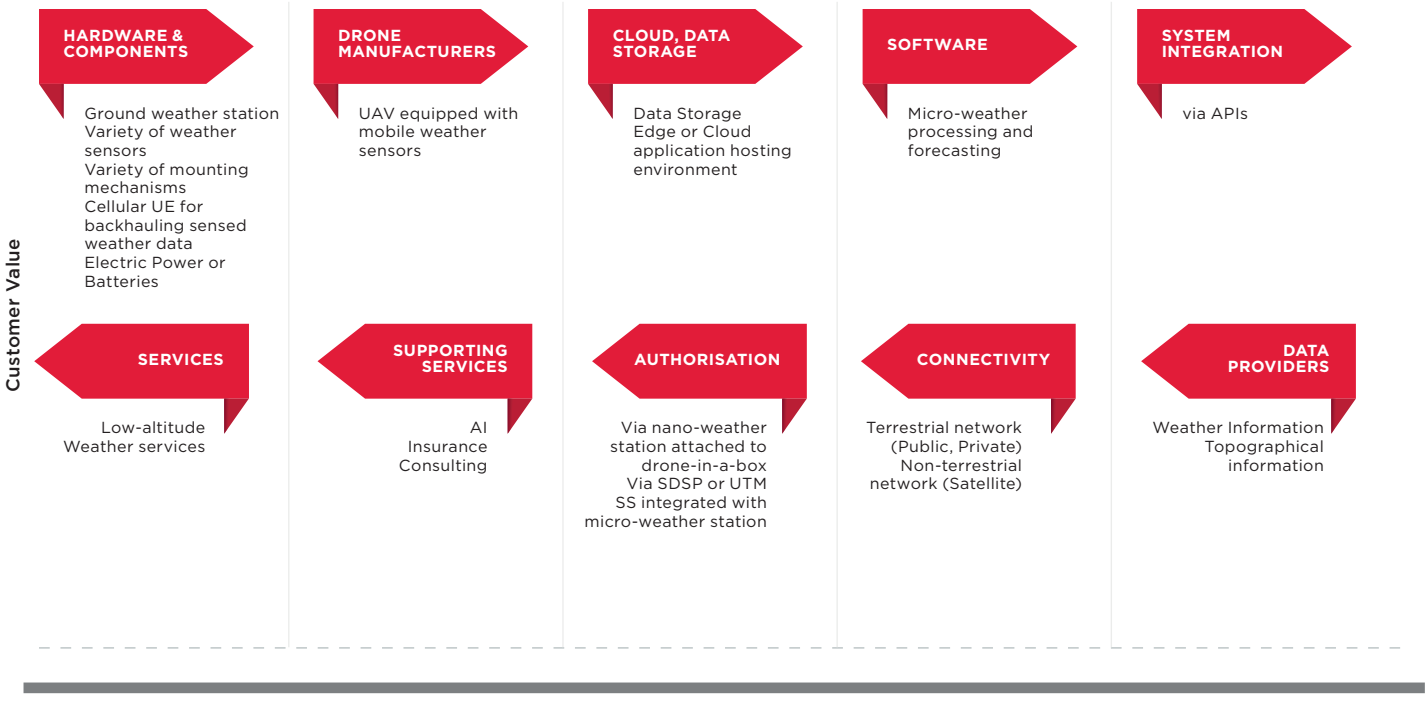
MNOs' Role in the Value Chain

To support hyper-localised weather services, the MNO would generally play the role of data provider, though it can also just be a provider of real-estate and backhaul connectivity, as in the case of airspace surveillance discussed in section 5.13. However, more ambitious MNOs can also become an SDSP (a supplementary data service provider) for hyper-localised weather services.

The overall value chain for this use case is presented in Figure 28.

Figure 28

Hyper Localised Weather Services Value Chain



Potential Business Models

MNOs can rent out real estate on its infrastructure, such as cell towers and transmission sites, and even on its office buildings, to mount a localised weather station to low-altitude weather service providers

MNOs can also sell hyper-localised weather services as a standalone data service to UAV operators and to SDSPs. Further, MNOs could sell hyper-localised weather services as an integrated supplementary data service to U-Space service providers/UTM service suppliers.

MNOs could capture a moderate portion of the overall value created by stakeholders with an interest in hyper-localised weather services by positioning itself as a leasing entity for micro-weather hardware, a provider of backhaul connectivity, and a system integrator for integrated weather service providers.

For more details on potential business models for this use case please see Figure 29:

Figure 29

Hyper Localised Weather Services Business Model Canvas

Key Partners

- Low-altitude weather solution provider (HW + platform SW+PS)
- SDSP or UTM SS
- Integrated weather service provider
- UAV operators whose fleet is equipped with mobile weather sensors

Key Activities

- Micro-weather network roll-out
- Micro-weather services operations

Key Resources

- Micro-weather ground and onboard UAV stations
- Data SMEs sales team

Value Proposition

- Efficient Weather Tax management for UAVs operations

Customer Relationships

- Position this micro-weather services as value-add services toward UAV operators

Channels

- Direct Digital to non tier1 UAV operators
- As supplementary data service to UTM-enabled tier1 UAV operators

Customer Segments

- UAV operators from public/private sector
- Tier1 UTM SS
- Advanced SDSPs

Cost Structure

- Real estate
- SW licence and hosting
- Support (HW, SW and for E2E solution)

Revenue Streams

- Transactional based on APIs consumption
- Subscription-based

5.10
People Density Data

Use Case Description

For safety reasons, regulators don't allow UAV flights over crowded areas. This safety measure can be facilitated through the provision of people density datasets to UAV operators/UTM systems to avoid flight routes over areas with crowds on the ground.

The SORA[5] guidelines specify the GRP (ground risk process) to assess the risk of people getting struck by a UAV (in the case of the loss of UAV control)
.
Mobile devices capture hundreds of location-related data points per day, depending on how active their user is. Therefore, mobile networks can generate datasets that individual MNOs can accurately extrapolate to the broader population to provide location-specific insights. Through this data, MNOs can analyse population movement between different parts of a city, via an origin-destination matrix (ODM), which can show, for example, where people commute to and from each day. MNOs can also analyse the people density in different parts of the city at different times of the day.

Another way to generate people density data is to use utilise available network attributes monitoring the number of registered mobile devices in a specific geographic area and getting over-exceed capacity alerts or notifications for that area. These notifications or alerts could then be exposed to the stakeholders (e.g. UAV operators) either as a notification alert (situational awareness) or as a complementary data to the national UTM for flight planning and/or flight permission process.

Stakeholders

Potential stakeholders for this use case include:

- ☐ Infrastructure owners (e.g., MNOs, municipalities)
- ☐ Regulatory bodies (e.g., ANSP, CAA)
- ☐ UAV operators
- ☐ U-Space service providers (USSPs) and other UAS service providers

Through this data, MNOs can analyse population movement between different parts of a city, via an origin-destination matrix (ODM)

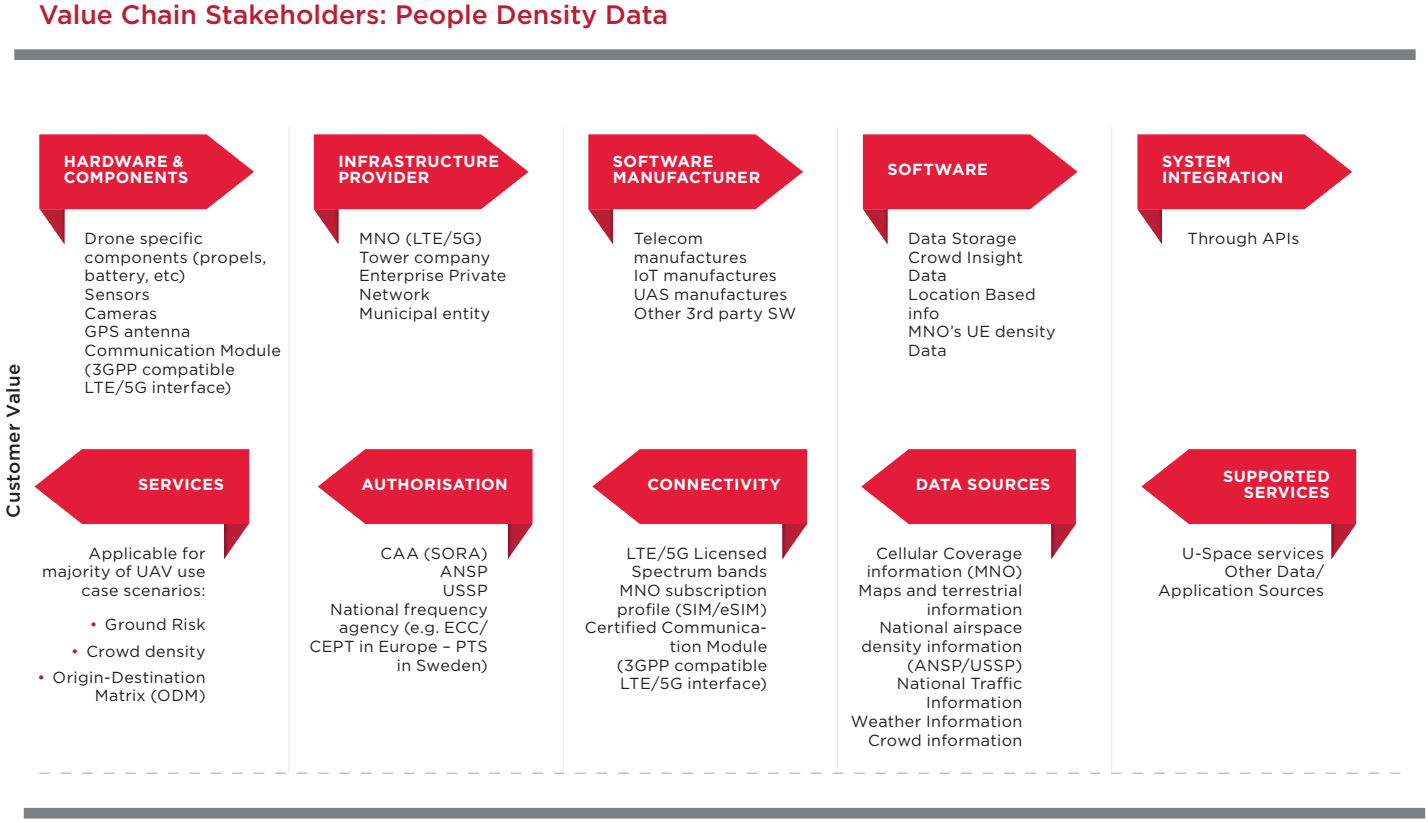
[5] Specific Operation Risk Assessment guidelines (http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_doc_06_jarus_sora_v2.0.pdf)

MNOs' Role in the Value Chain

There are several opportunities for MNOs to participate in the value chain for people density data services, which is shown in Figure 30. They could:

- ☐ Act as a complementary service / data provider
- ☐ Expose datasets by using:
  - ☐ Origin-destination matrix, people movements
  - ☐ Possible exceeding alerts of maximum number of registered UEs in a network slice

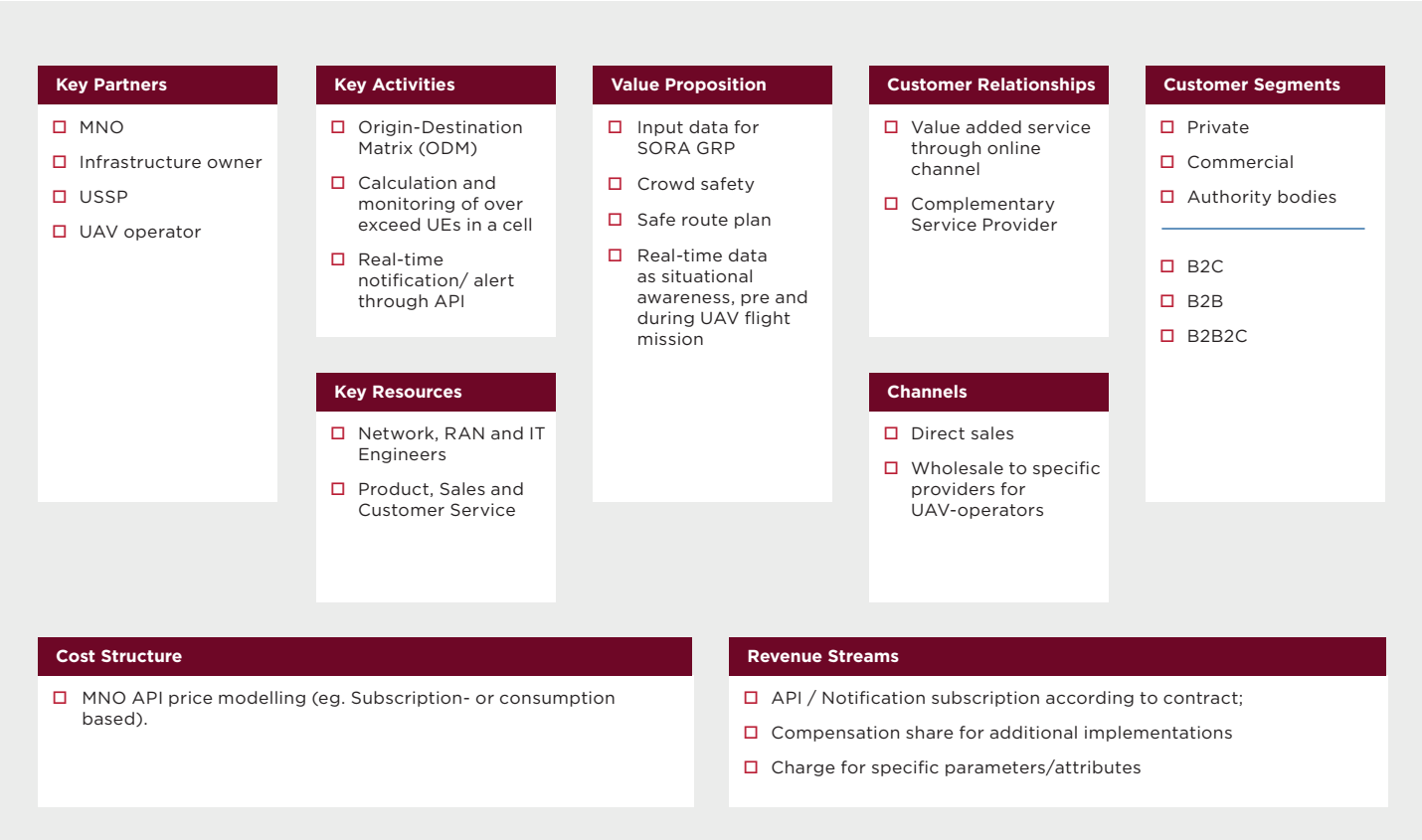
Figure 30
People Density Data Value Chain



Potential Business Models

MNOs can expose datasets as part of the situational awareness data to UAV operators, U-Space service providers (USSPs) and other UAS service providers. They can expose these data sets through a public API-stack, based on the MNO API price modelling (e.g. subscription-based or consumption-based). A potential business model canvas is shown in Figure 31.

Figure 31
People Density Data Business Model Canvas



5.11
3D Coverage Data

Use Case Description

3D coverage data provides information/insights about cellular connectivity in an area where a UAV operator is planning or is executing BVLOS operations. Such information can enable evaluation of the probability of maintaining cellular connectivity BVLOS, which is important for a timely SORA approval for “ad hoc” flights.

3D coverage information is SORA-critical for UAV steering or telemetry data transmission. It may also be service-critical with respect to live payload data transmission, for example, for infrastructure inspection or surveillance video data transmission. It is relevant for BVLOS operations expecting “live, without relevant delay” data transmission between an UAV and a remote station, which could be the related ground-station of the UAS or a server independent of the UAS.

Stakeholders

MNOs can obtain 3D coverage data directly from their RAN infrastructure providers, from cellular network planning and design tools solution providers, or by engaging with companies that provide turnkey solutions and are specialised in aerial RF modelling and standards-based exchange of such info with ANSPs (air navigation service providers).

The most effective approach depends on the readiness of MNO’s partners and the costs incurred by commercial rollout of a 3D coverage service for a specific geographical entity. Although turnkey solutions may be less attractive at present, they are likely to align with the other two approaches within a reasonable timeframe.

As UAV operators, spectrum regulators and even civil aviation authorities may regard 3D coverage as a basic cellular connectivity service, rather than a value added service, MNOs may need to explain there is a third dimension to cover and new sets of interference and capacity management issues to address.

Stakeholder mapping for this use case is shown in Figure 32:

Figure 32

3D Coverage Data Stakeholder Analysis

STAKEHOLDERS

3D Coverage Data

PRIMARY/CONNECTED

Those who have an economic or a contractual relationship.

- MNOs as C2CSPs
- 3D Coverage solution providers (ISVs and Sis)
- U-Space SP/UTM SS
- SDSPs
- UAV Operators
- ANSPs
- Civil Aviation Authority

SECONDARY/EXTERNAL

Those who are not directly connected to the use case but are still interested in or could be impacted by the use case.

- Local Governments
- Civil Aviation Authority
- Real estate leasing entities
- National/Integrated weather service providers
- Cloud and Edge SPs
- Weather sensors OEMs/ ODMs

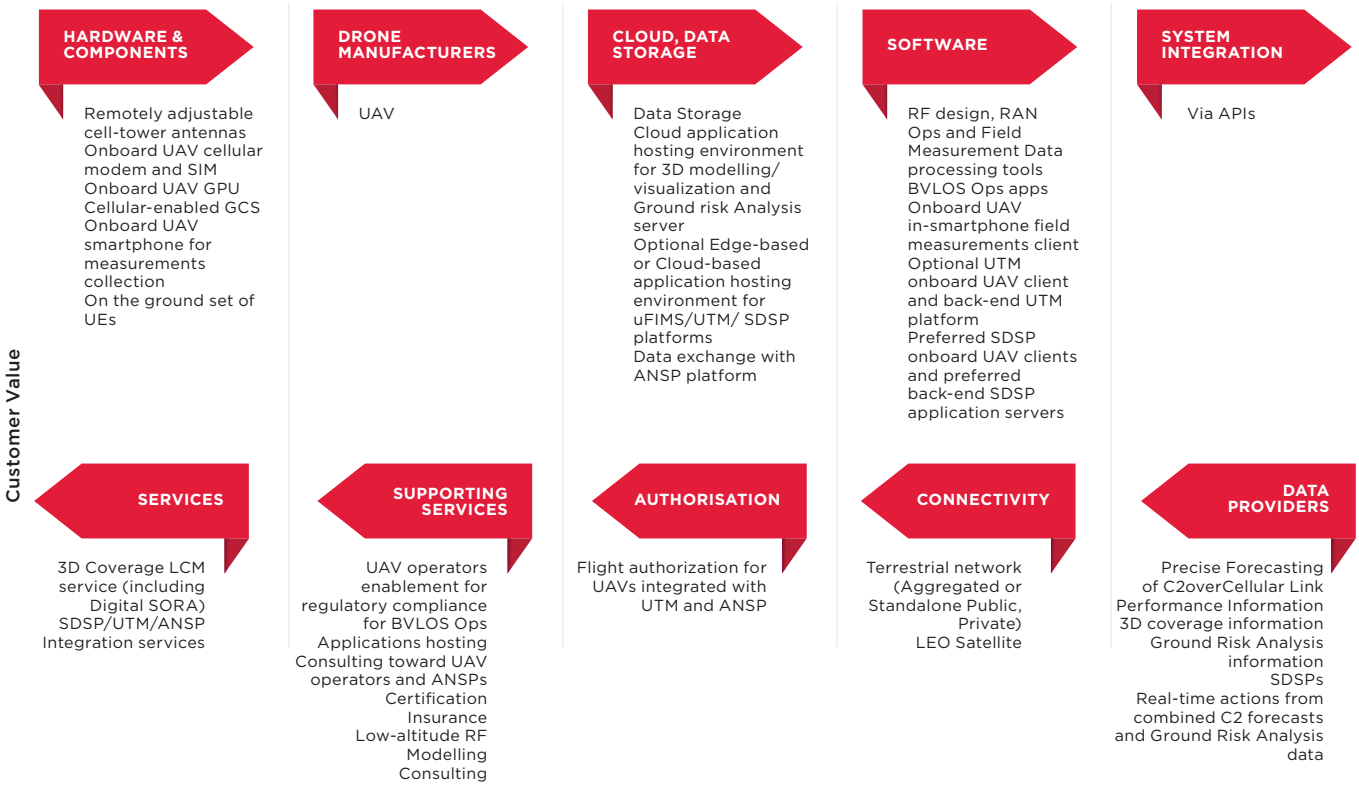
MNOs' Role in the Value Chain

The MNO should be able to provide 3D mobile coverage information during the flight planning and execution phases to an UAV operator.

The value chain for this use case is shown in Figure 33:

Figure 33
3D Coverage Data Value Chain

Value Chain Stakeholders: 3D Coverage Data



Potential Business Models

The provisioning of mobile connectivity for the air is generally not foreseen in MNOs' licenses or their planning processes. In cases where spectrum regulation allows MNOs to provide 3D coverage information, this data can be commercially bundled in different ways to meet expectations in the local market.

For more details on business models for this use case please see Figure 34:

Figure 34
3D Coverage Data Business Model Canvas

Key Partners
- BVLOS-enabled UAS
- 3D Coverage Solution Provider
- USP/USS and SDSP(s)
- Cellular NEPs

Key Activities
- Integration with MNO's and ANSP's systems
- 3D Modelling-Visualization-Data Exchange

Key Resources
- UAV Ops Centre Engineers
- UAV Operators with RF expertise
- ATM/UTM/SDSP SMEs

Value Proposition
- MNO provided 3D Coverage services
- MNO as C2CSP or as integrated SDPS or even as UTM SP

Customer Relationships
- Position set of UTM/ SDSP services as value add services toward UAV operators and ANSP(s)

Channels
- Direct Digital to UAV operators
- As value add data service to SDSPs/ UTM SPs/ANSP(s)

Customer Segments
- UAV operators from public/private sector
- C2CSP SPs (if not an MNO on its won)
- ANSPs
- USPs/USSs

Cost Structure
- Modelling Services
- SW licence & hosting
- UAV-based Field Measurement Service
- Support (HW, SW and for E2E solution)

Revenue Streams
- Transactional based on APIs consumption
- Mission-based 3D Coverage Solution-as-a-Service)
- Subscription-based

5.12
Air Traffic Information Data

Use Case Description

As UAVs become the prevailing air traffic in the lower airspace (below 3,000 feet), air traffic information data is required to ensure safe manned and unmanned vehicle management in this airspace. Such an air traffic management solution needs live manned and unmanned air traffic data to allow ATM and UTM solutions to recommend reasonable flight path decisions and to allow operators to steer their vehicles to avoid any collision risks.

UAVs are set to increase air traffic significantly in most developed countries. Switzerland, for example, has 8.7 million inhabitants and about 600,000 companies employing about 4.5 million persons. Many of these companies are likely to deploy UAVs in the "open" airspace, which is already used by 3,132 registered aircraft (as of 2021). Just over half of these were airplanes, followed by gliders, helicopters and free balloons.

Existing air traffic control systems generally operate in the vicinity of big airports and the airspace above 3,000 feet, with a focus on air traffic separation. The information these systems employ is expensive and is of limited information value for the airspace below 3,000 feet which UAVs will share with helicopters, gliders and balloons.

The UAV market will require air traffic information at a reasonable price level in the lower airspace and regions not well covered today by traditional systems. High tower infrastructure providing RF umbrella or broadcasting networks represent ideal locations to install specialised receivers for transponder, flight alarm (FLARM), Wi-Fi and Bluetooth broadcasts. Signals from air vehicles can also deliver different air traffic data to requesting parties using the Mobile Network Remote ID system described in section 5.4.

Stakeholders

Air traffic information data could be provided by telecoms operators, in cooperation with tower companies where necessary, at reasonable costs, by reusing existing tower infrastructure. Multiple entities may be interested in this type of data and could even play a business development role by pushing the civil aviation authority to grant the usage of the delivered data based on its proven exactness for separation, as well as for information purposes. Today small airports already use such data, available from organisations, such as 24 Flight Radar, for separation purposes.

Other potential customers include ANSPs, CIS data providers, U-Space service providers, small airports, UAV operators and pilots, as well as companies with a specific safety and security need, are also potential stakeholders.

Civil aviation authorities would play a decisive role in commercialising such air traffic information data, since a simple certification process has to be established so that potential users are legally covered when using this data for implementing their service and operational processes. Proving the quality of such data on a regional level (e.g. by getting them certified based on FOCA test cases without passing an extensive and costly EASA certification process) would allow telcos to supply air traffic information data cost-effectively.

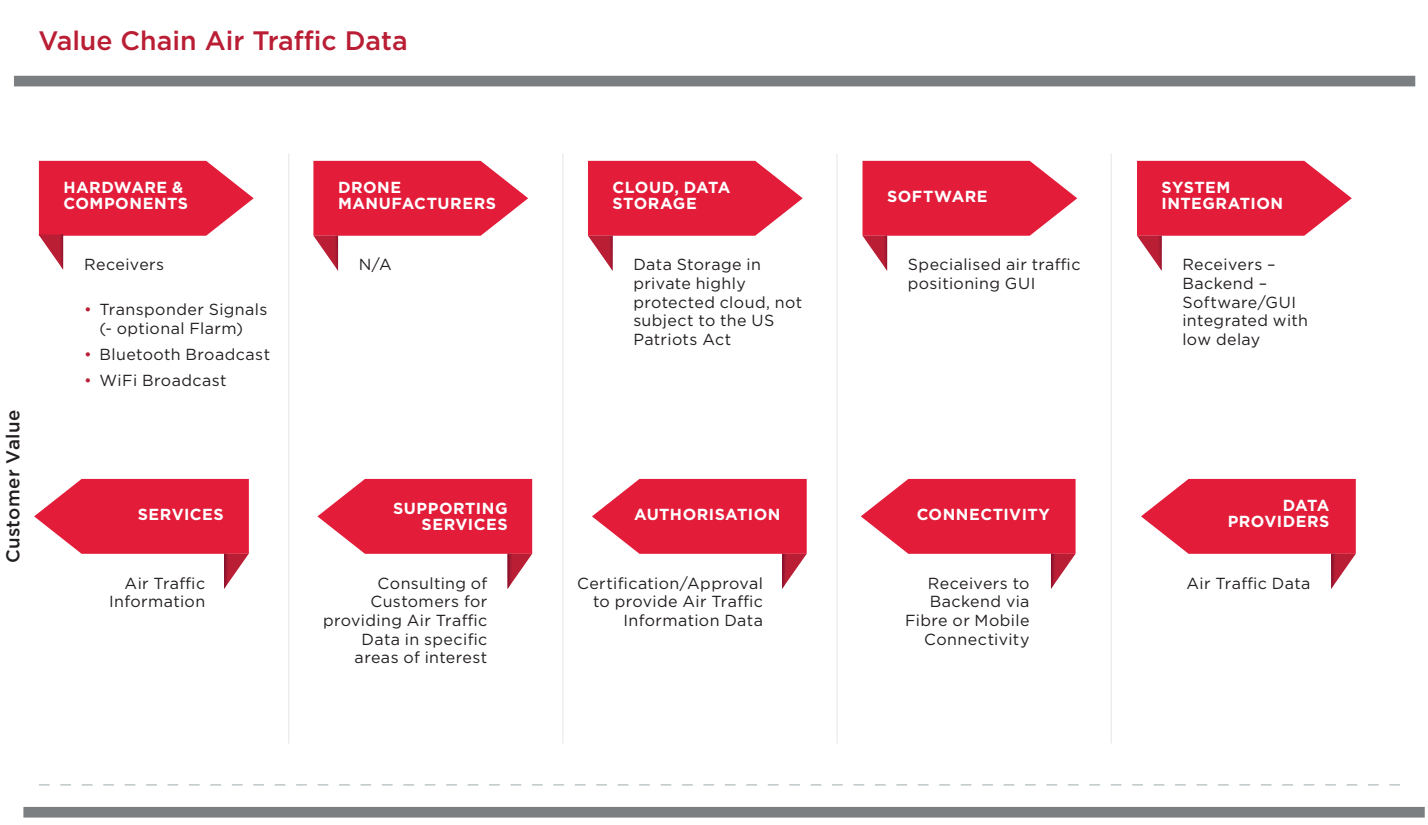
ANSPs may have an influencing or political role since, in most cases today, they (often aligned with the military) more or less provide such data, for manned air traffic at least, as a monopolistic data provider and would not want to lose this role.

MNOs' Role in the Value Chain

As they generally have commercial control over mobile tower infrastructure, MNOs could provide the telehousing services for installing the specialised receivers needed to capture air traffic information data. MNOs could also provide connectivity services between receivers and backend servers, delivering minimal latency and cloud services for transmission of the raw data and processing software used to derive the concrete air traffic information data. These services could eventually be supplemented by a GUI service and/or API in order to deliver raw or processed data for further processing in potential customers' business applications.

Figure 35 shows the potential value chain for this use case.

Figure 35
Air Traffic Information Data Value Chain

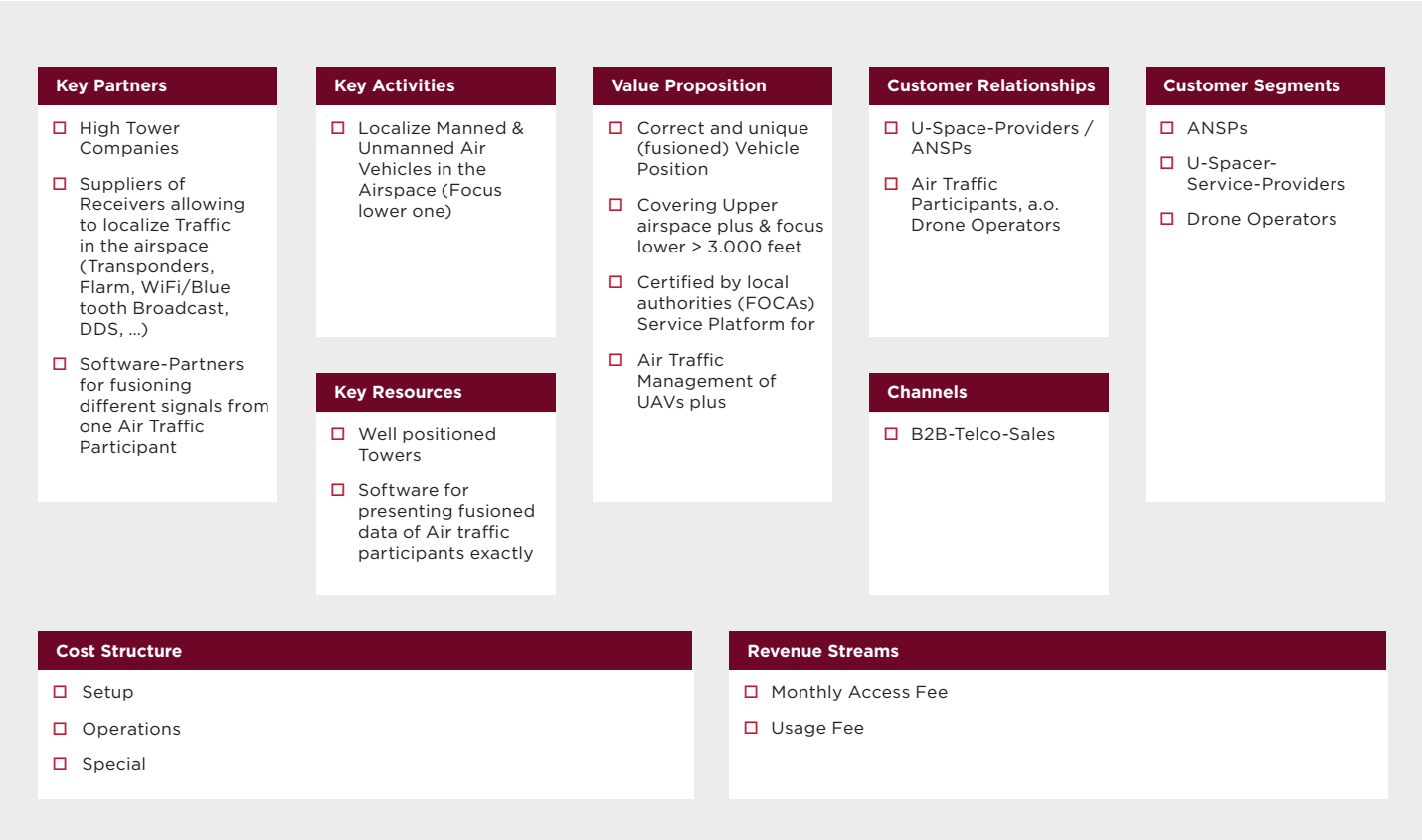


Potential Business Models

As they generally have commercial control over mobile tower infrastructure, MNOs could provide the telehousing services for installing the specialised receivers needed to capture air traffic information data. MNOs could also provide connectivity services between receivers and backend servers, delivering minimal latency and cloud services for transmission of the raw data and processing software used to derive the concrete air traffic information data. These services could eventually be supplemented by a GUI service and/or API in order to deliver raw or processed data for further processing in potential customers' business applications.

Figure 36

Air Traffic Information Data Value Chain



5.13
Airspace Surveillance

Use Case Description

UAV/UAS flying at low altitudes (below 3,000 feet) need airspace surveillance services. These services can be enabled via a variety of low cost ground/on-pole/on-cell tower installable receivers (standalone or in network connected) - based on one of ADS-B Mode S and Mode A/C/FLARM/UAT-technologies - that can support a cooperative air traffic detection strategy tailored to the characteristics of a specific airspace.

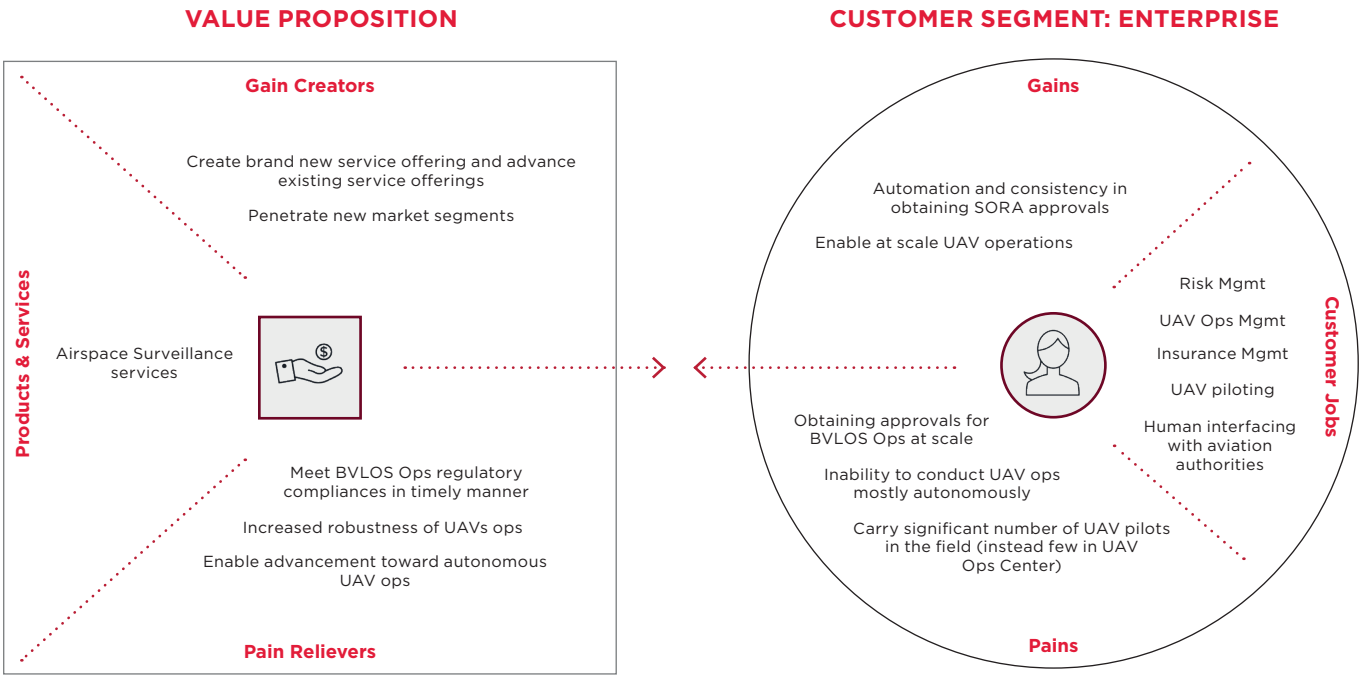
MNOs can enable airspace surveillance services by providing real estate on their towers for the installation of these light-weight low-cost receivers.

They can also transmit the sensed data via their cellular networks to airspace surveillance application servers and eventually even host such application servers, either as a standalone or integrated with SDSP and UTM application servers.

These airspace surveillance services will enable UAV operators to comply cost effectively with regulatory requirements by ATM on top of just pure UTM. These services could also open up a new data revenue stream for MNOs and help them penetrate into the SDSP domain.

For more details on the overall value proposition for this use case please see Figure 37.

Figure 37
Airspace Surveillance Value Proposition

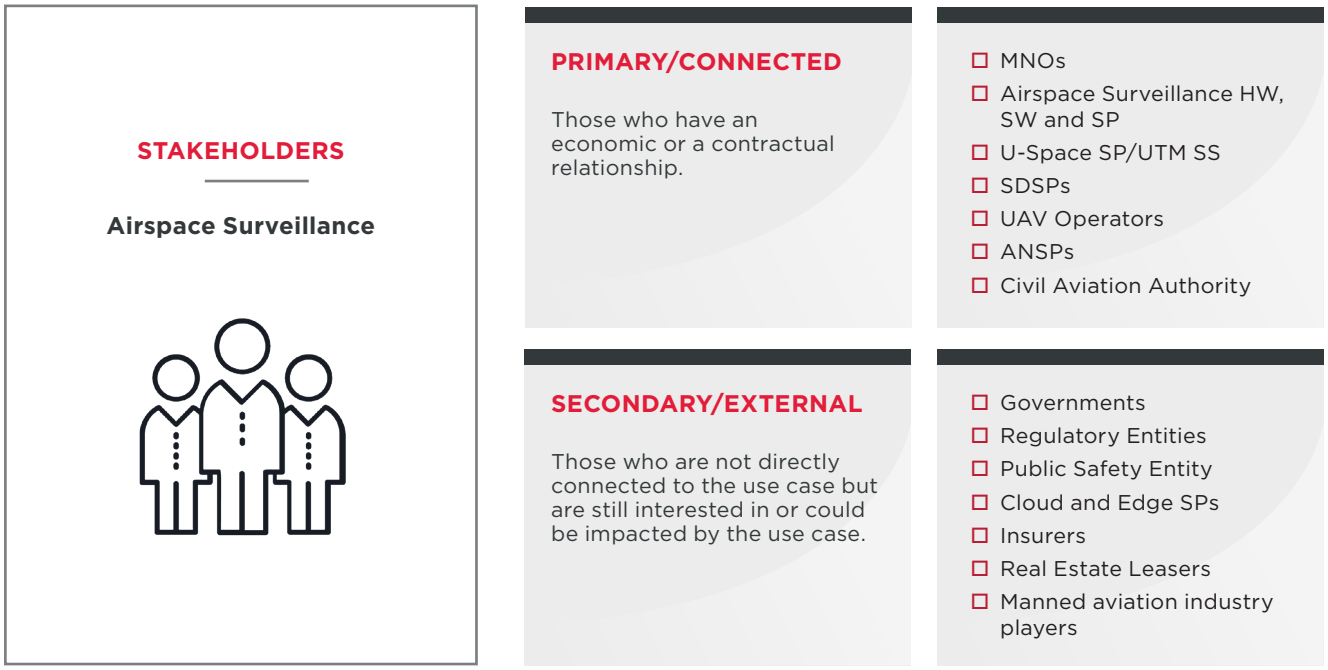


Stakeholders

The stakeholder value chain for airspace surveillance is quite wide, encompassing a variety of entities, as shown in Figure 38:

Figure 38

Airspace Surveillance Stakeholder Analysis

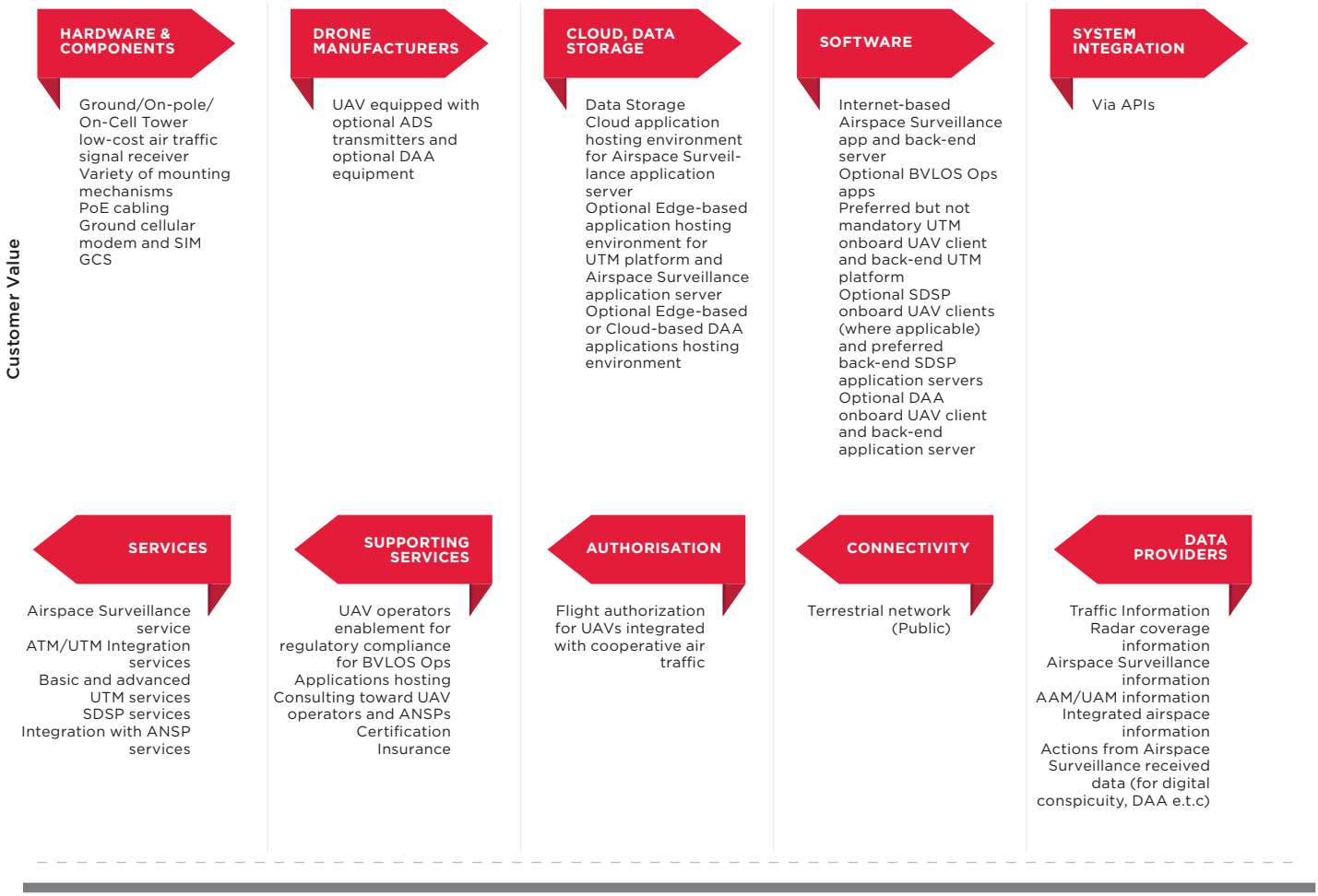


MNOs' Role in the Value Chain

In this use case, a MNO can play multiple roles, such as provider of real estate, provider of backhaul connectivity, application hosting provider and even provider of end-to-end airspace surveillance services as standalone services or integrated with U-Space/ UTM services, as explained further in section 5.18.

The value chain of stakeholders for this use case is shown in Figure 39.

Figure 39
Airspace Surveillance Value Chain



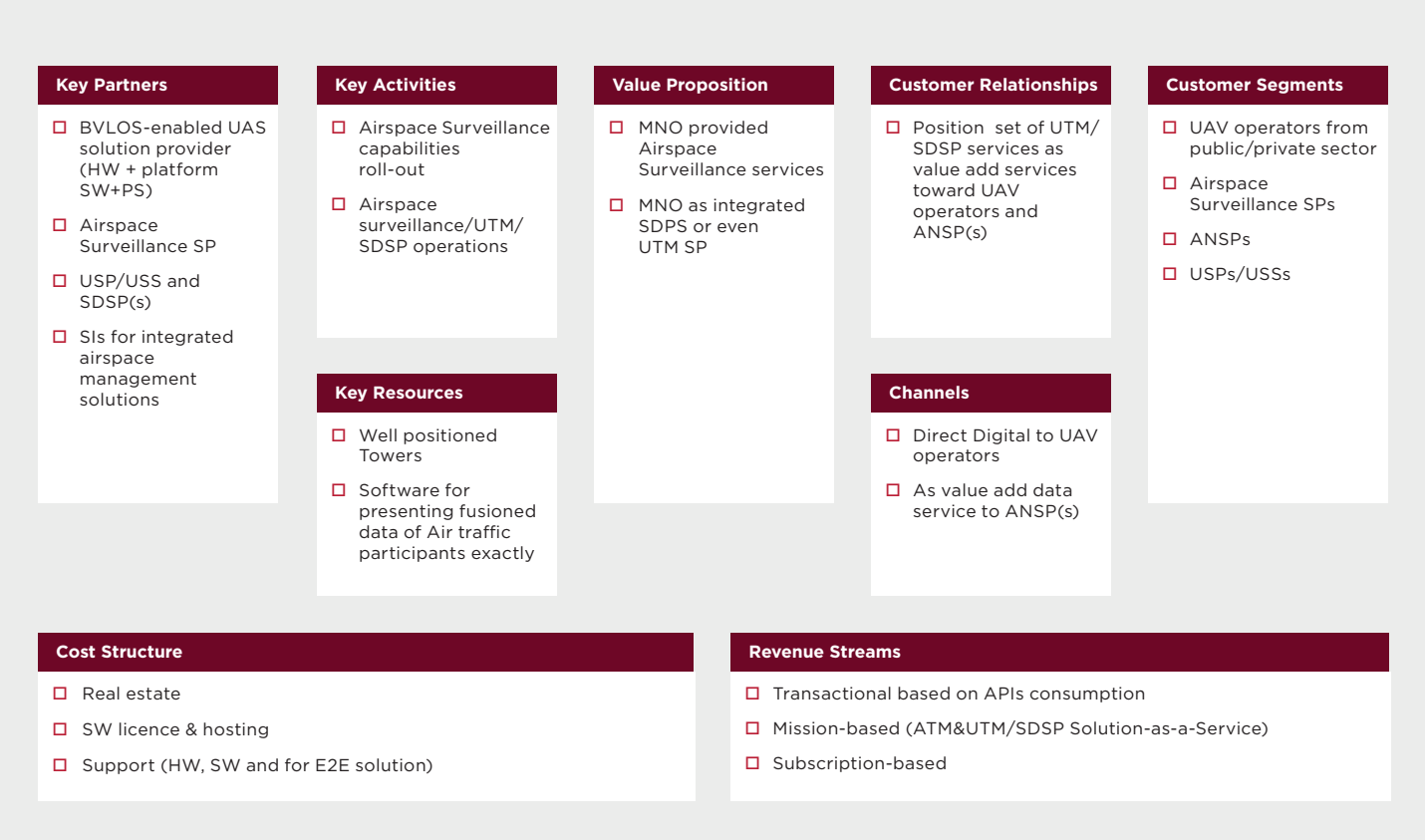
Potential Business Models

From an MNO's perspective, an airspace surveillance service can be deployed in a variety of flavours:

- as a pure basic service - the MNO provides only real-estate and/or backhaul connectivity,
- as a value-add service - the MNO provides sensed and processed data to third parties,
- as an end-to-end airspace surveillance service provider

There are, therefore, several options related to viable business models for airspace surveillance, as depicted in Figure 40.

Figure 40
Airspace Surveillance Business Model Canvas



Full Service Provision

5.14
On-demand Coverage - Cell on Wings

Use Case Description

Road, power and network interruptions caused by disasters can have a great impact on people's safety and properties in the disaster-stricken areas. The combination of UAVs and communication technology to provide on-demand coverage makes it possible to quickly restore emergency communication.

On-demand coverage can also be used to provide additional network coverage on top of a given network deployment for a limited time. Since UAVs have good manoeuvrability, a "cell on wings" solution can be employed when flight approval, terrain, weather and other conditions are appropriate.

Depending on the scenario, on-demand coverage can be delivered using a multi-dimensional communication support system that integrates high-altitude, mid-air, low-altitude, and ground systems. The airborne communication base station system would be installed on multiple types of flight platforms, such as large fixed-wing UAVs, medium-sized UAVs, helicopters, and tethered UAVs, which can provide all-round communication support, in different scenarios.

Stakeholders

As shown in Figure 41, potential stakeholders include:

- Emergency administration
- Fire administration
- Police department
- Equipment manufacturers and vendors
- Satellite communication service company
- MNOs

MNOs' Role in the Value Chain

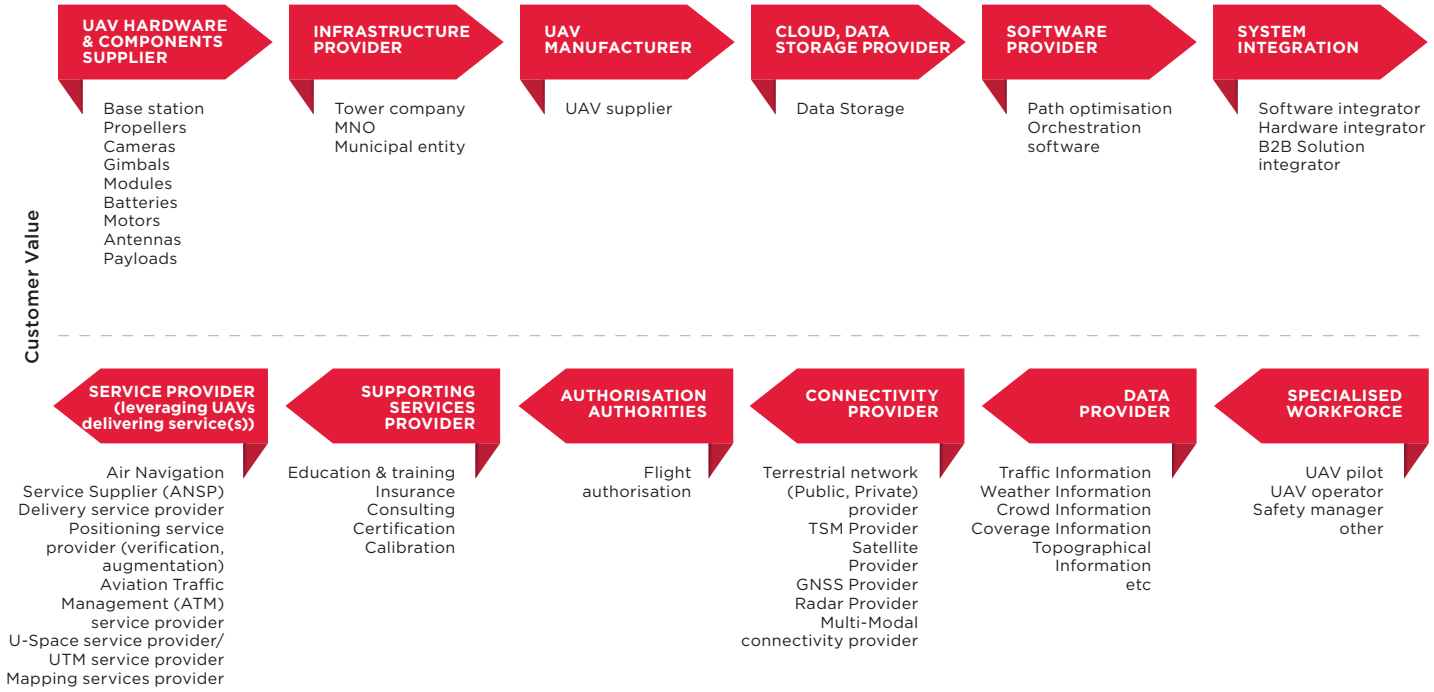
The MNO could provide base station and communication services that can be carried by various types of flight platforms (such as large fixed-wing UAVs, medium-sized UAVs, helicopters, tethered UAVs, etc.). The MNO would operate the UAVs in this case.

The goal is to achieve stable and continuous communication network coverage in scenarios, such as earthquakes, floods, and forest and grassland fires. In this way, MNOs can provide communication networks for reconnaissance or rescue UAVs.

Figure 41

On-demand coverage - Cell on wings Value Chain

Value chain stakeholders



Potential Business Models

The main purpose of this service is to guarantee emergency communications in disaster areas by using large-scale fixed-wing UAVs with integrated communication base stations, communication services, and management platforms. The MNO could offer a service contract based on pay-per-use and annual settlement to government departments or entities who need extended coverage (such as geological exploration companies). People with communication needs (such as those in disaster areas) would benefit from the service. Figure 42 shows a business model canvas for this use case.

Figure 42: On-demand Coverage - Cell on Wings Business Model Canvas

Figure 42
On-demand Coverage - Cell on Wings Business Model Canvas

Key Partners
- MNO
- UAV manufacturer
- Government department

Key Activities
- Provide wireless communication service
- Analysis of network data

Key Resources
- Well positioned Towers
- Software for presenting fusioned data of Air traffic participants exactly

Value Proposition
- The air base station which can provide stable, high reliability and low delay communication services
- Provide on-demand wireless network coverage in any legal area

Customer Relationships
- Establish cooperative relationship with the government and emergency enterprises

Channels
- Sales to government departments

Customer Segments

B2B
- Government departments
- Emergency enterprises

Cost Structure
- UAV
- Payload
- Base station
- Network connectivity to the UAV

Revenue Streams
- Pay-per-use and annual settlement
- On-demand professional services

5.15 Logistics/Delivery Services

Use Case Description

UAVs can be used to transport goods from one point to another, such as between distribution centres or from one distribution centre to the end-user's location. When transporting goods to mountainous areas or remote islands, for example, using automobiles, trucks, ferries or planes is not always the optimal solution in terms of cost performance and time.

In such cases, it may be possible and cost-effective to use UAVs that can easily carry goods, such as mail-order deliveries, food and medicine. In the event of a disaster, when roads and ground transportation are cut off, transporting emergency supplies by UAV can be a very effective solution.

Stakeholders

In order to implement logistics/delivery services using cellular-enabled UAVs, the following stakeholders could be involved:

- MNOs.
- UAV manufacturers to develop and provide dedicated UAV equipment for transporting goods.
- Logistics service providers, which use the UAV operation management system and communication network to utilise cellular-enabled UAVs. The provider could employ a B2C, B2B or B2B2C business model.
- UAV depot (delivery base/warehouse) operators to store or collect and manage the goods carried by the UAVs. They will also provide a UAV take-off and landing facility (UAV stand).
- Local governments may provide subsidies for regional reconstruction to those involved in UAV-related businesses and services
- End users of delivery services
- Goods providers/suppliers

Figure 43 shows the potential value chain for logistics and delivery services.

MNOs' Role in the Value Chain

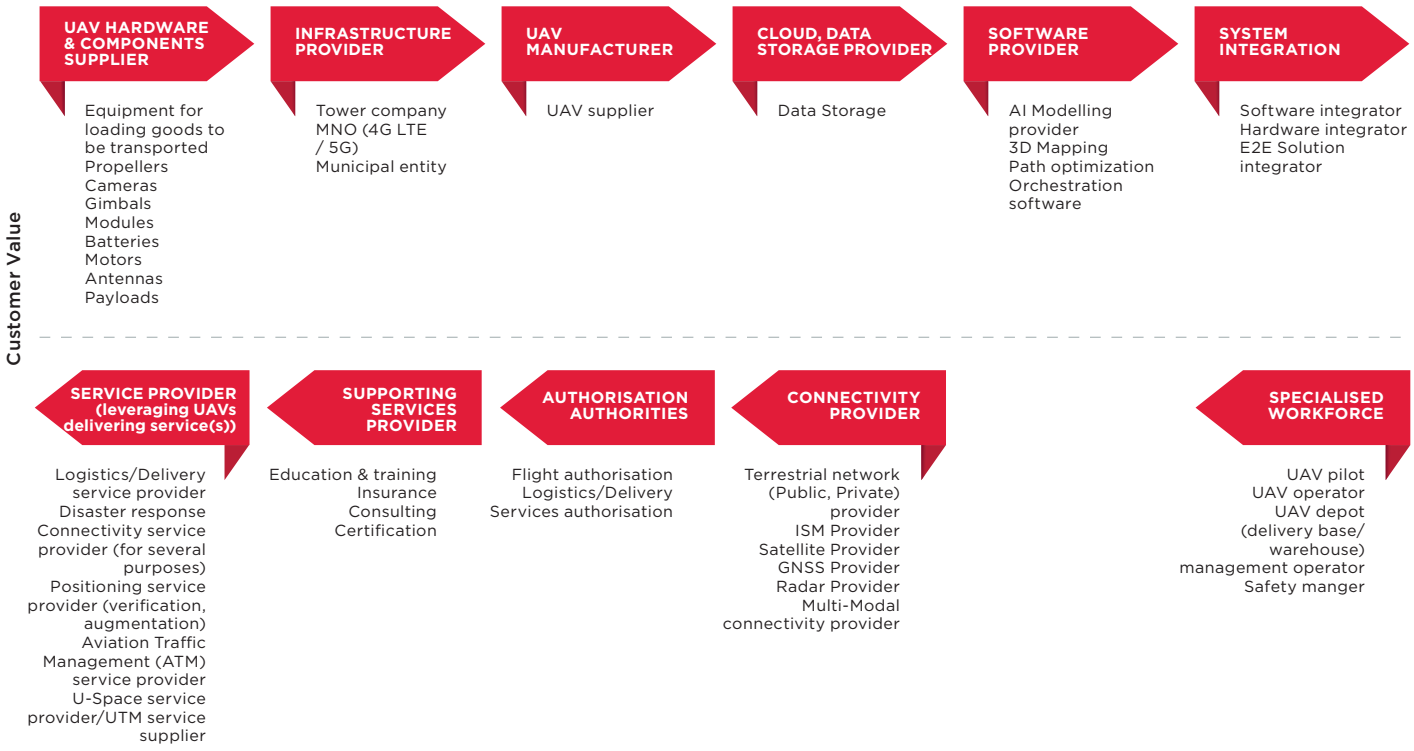
In order to remotely manage UAV operations in a BVLOS environment, a cellular network with good quality, high reliability and low latency can support C2-Coms, RemoteID and any necessary payload transmissions (as discussed in sections 5.1, 5.2 and 5.4). As UAV-based logistics/delivery services become more widespread, it may become necessary to manage the operation of a large number of UAVs within a small area. MNOs will therefore need to accommodate a large number of UAVs in the network and provide a high-quality, high-reliability, low-delay communication network.

MNOs could also provide a drone operation management system to implement remote control and autonomous flight management of UAVs, and provide these services to end users. However, they may have to compete with service providers that specialise in this area.

Figure 43

Logistics/Delivery Services Value Chain

Value Chain Stakeholders: Logistics/Delivery Services



Potential business models

Various business models could underpin logistics/delivery services using cellular-enabled UAVs. These include:

- Service usage fee (separate from the cost of the delivery itself), which could be a pay-as-you-go model or a subscription model.
- Usage fee for communication network and UAV operation management system
- A communication connection fee for the communication network used by the UAV to implement logistics/delivery services and a usage fee for the UAV operation management system.

If the MNO provides these services as a package, these costs will be paid by the service provider to the MNO.

The service providers would also be required to pay UAV depot (delivery base/warehouse) operators for their management and operation costs. The MNO/service provider that purchases/rents the dedicated UAV equipment will pay the cost to the UAV equipment provider. Finally, municipal governments could provide subsidies for regional recovery to those involved in UAV-related businesses and services.

Figure 44 shows a business model canvas for this use case.

Figure 44
Logistics/Delivery Services Business Model Canvas

Key Partners
- MNO
- UAV Manufacturer
- Logistics Service provider
- Goods provider/ supplier

Key Activities
- Providing delivery services
- Storage of deliveries
- Management and operation of UAV stands (departure and landing equipment)

Key Resources
- Network, RAN and IT Engineers
- Product, Sales and Customer Service

Value Proposition
- Cellular network with good quality, high reliability and low latency
- High-speed, large-capacity network for the stable transmission of high-quality video
- Manage the operation of a large number of drones within a small area

Customer Relationships
- Logistics Service provider
- Goods provider/ supplier

Channels
- Wholesale to Logistics Service provider, Goods provider/supplier

Customer Segments
- Private
- Commercial
- Authority bodies
- B2C
- B2B
- B2B2C

Cost Structure
- Usage fee for communication network and UAV operation management system: Service provider to MNO
- UAV depot (delivery base/warehouse) management and operation cost: Service provider to UAV depot (delivery base/warehouse) management operator
- Purchase of dedicated UAV equipment/payment of rental fee: MNO/Service provider to UAV Manufacturer

Revenue Streams
- Service usage fee (separate from the cost of the delivery itself): End User to Service Provider

5.16
Automated Infrastructure Inspection and Critical Assets Monitoring

Use Case Description

Enterprises in a variety of industries are required by law to regularly conduct high quality inspections of their infrastructure and monitor critical assets. Examples are power generation sites, electrical power substations, oil and gas pipelines, power grids, railways, wells, bridges and aqueducts.

As a proactive means to ensure business continuity, infrastructure inspection is an integral part of operations for many industries, and it is one that requires the dedication of substantial resources and funding. UAVs and mobile robots are quickly transforming the way this task is performed, as they offer many advantages given their versatility, ability to carry multiple sensors and most importantly, their ability to make the overall operation safer and faster.

Enterprises that decide to leverage UAV-based automated infrastructure inspection and critical assets monitoring services can benefit from:

- Advanced/improved inspection and monitoring processes in a scalable manner.
- AI/ML for inspection and monitoring processes.
- Expanded lifespan of infrastructures and assets.
- Compliance to specific industry regulatory asks

Smaller UAVs have proven to be ideal for routinely inspecting infrastructure and monitoring critical assets, such as cellular towers, bridges, underground mines, power plants, substations and even ports. This type of site inspection and critical assets monitoring is typically performed with an UAV pilot on the ground with a direct line of sight to the UAV or with some basic level of autonomy on the UAV to allow a minimum level of BVLOS for the UAV to be able to reach the most inaccessible areas of the infrastructure.

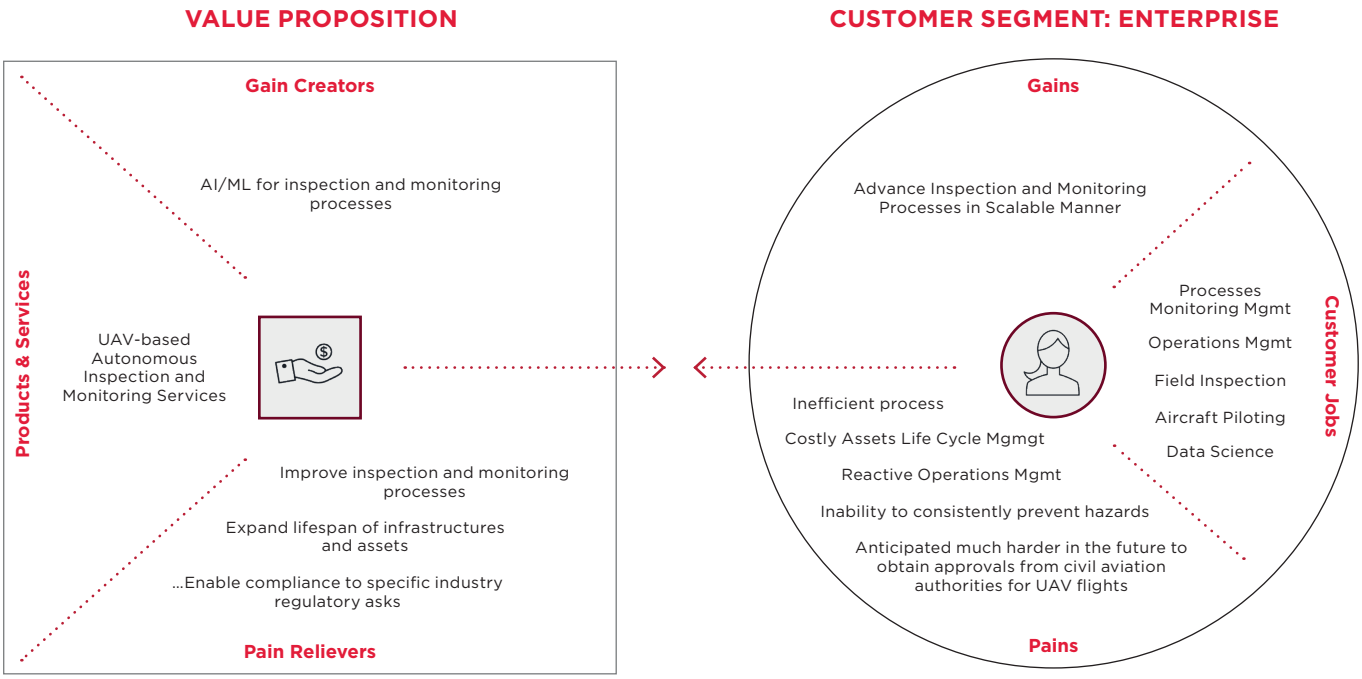
Mid to large size UAVs are more suitable for linear long infrastructures inspections, such as pipelines, power transmission lines, and railways, where the use of such UAVs is a much cheaper, faster and safer alternative compared to the use of crewed aerial vehicles or driving along those infrastructures. In this case, it is pragmatic to fly such UAVs leveraging BVLOS capabilities if not flying them autonomously. The more complex UAV operations require advanced aerial connectivity with SLAs in place and advanced hosting of non-payload (C2-Coms) applications performance to successfully and safely perform the operations.

There are different ways MNOs can contribute to UAV-based automated inspections and critical assets monitoring. They can add value through connectivity, edge computing and supplementary services to enable industries to unlock the full power of infrastructure inspection and critical assets monitoring.

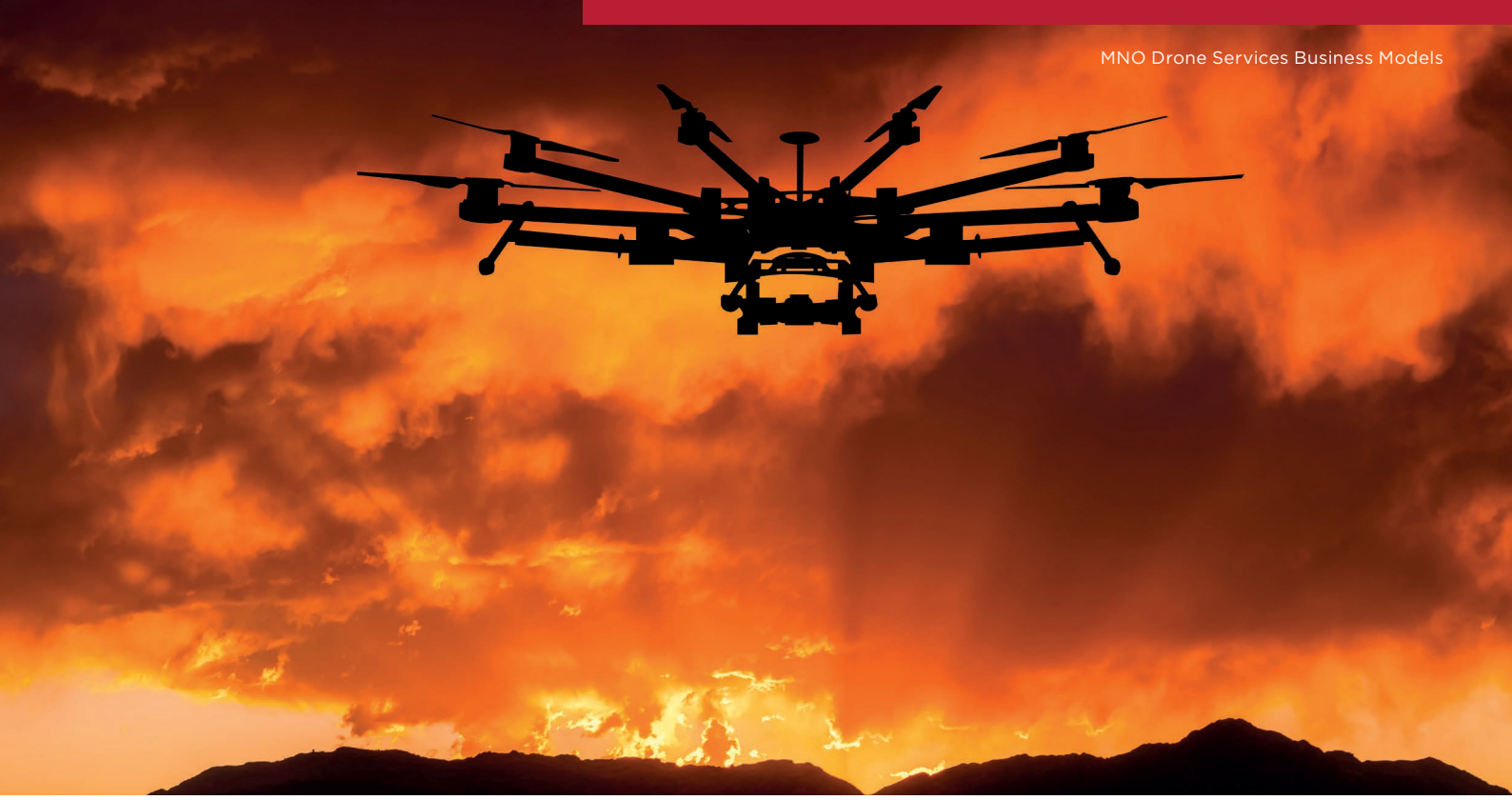
For more details related to the overall value proposition for this use case, please see Figure 45.

Figure 45

Automated Infrastructure Inspection and Critical Assets Monitoring Value Proposition



Note: The use of UAVs for perimeter surveillance, which isn't covered in this version of the whitepaper, is a special case of aerial inspection and aerial computer vision, which are both covered in this whitepaper



Stakeholders

The following businesses could leverage UAV-based services for inspections and monitoring

- Oil & gas companies
- Electrical power distributors (utility companies)
- Power generation companies
- Railway operators
- Port operators

Aerial-based inspection and monitoring specialists could leverage UAV operator's flying services or their own UAV operations to conduct in-field video/images data collection, along with infrastructure and offline/online post processing and presentation to end-enterprise customers.

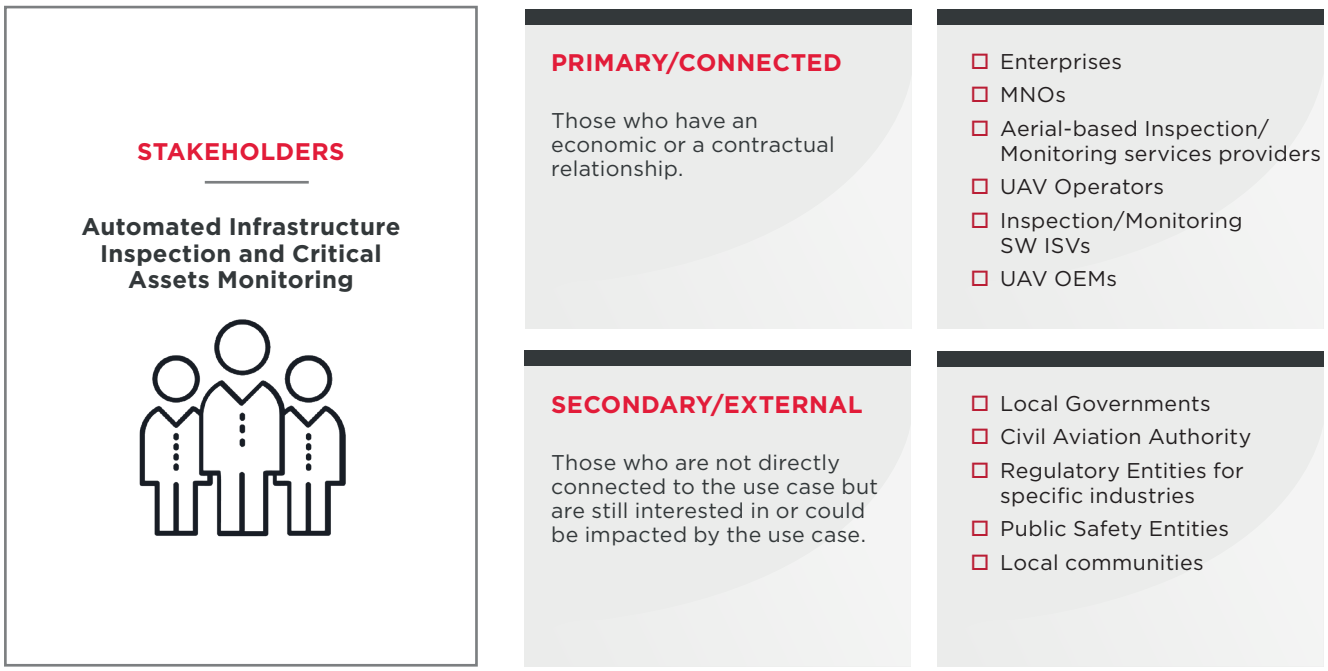
In addition to MNOs, other key stakeholders include:

- Civil aviation authorities
- Local/regional/state/provincial/national governments (department of transportation)
- Energy regulatory entities
- Public infrastructures regulatory entities
- Public safety entities, such as police, emergency services, roads maintenance etc.
- Local communities where infrastructure to be inspected is located

Stakeholder mapping for this use case is presented in Figure 46:

Figure 46

Automated Infrastructure Inspection and Critical Assets Monitoring Stakeholder Analysis



MNOs' Role in the Value Chain

Some of the key MNO roles in this use case could include

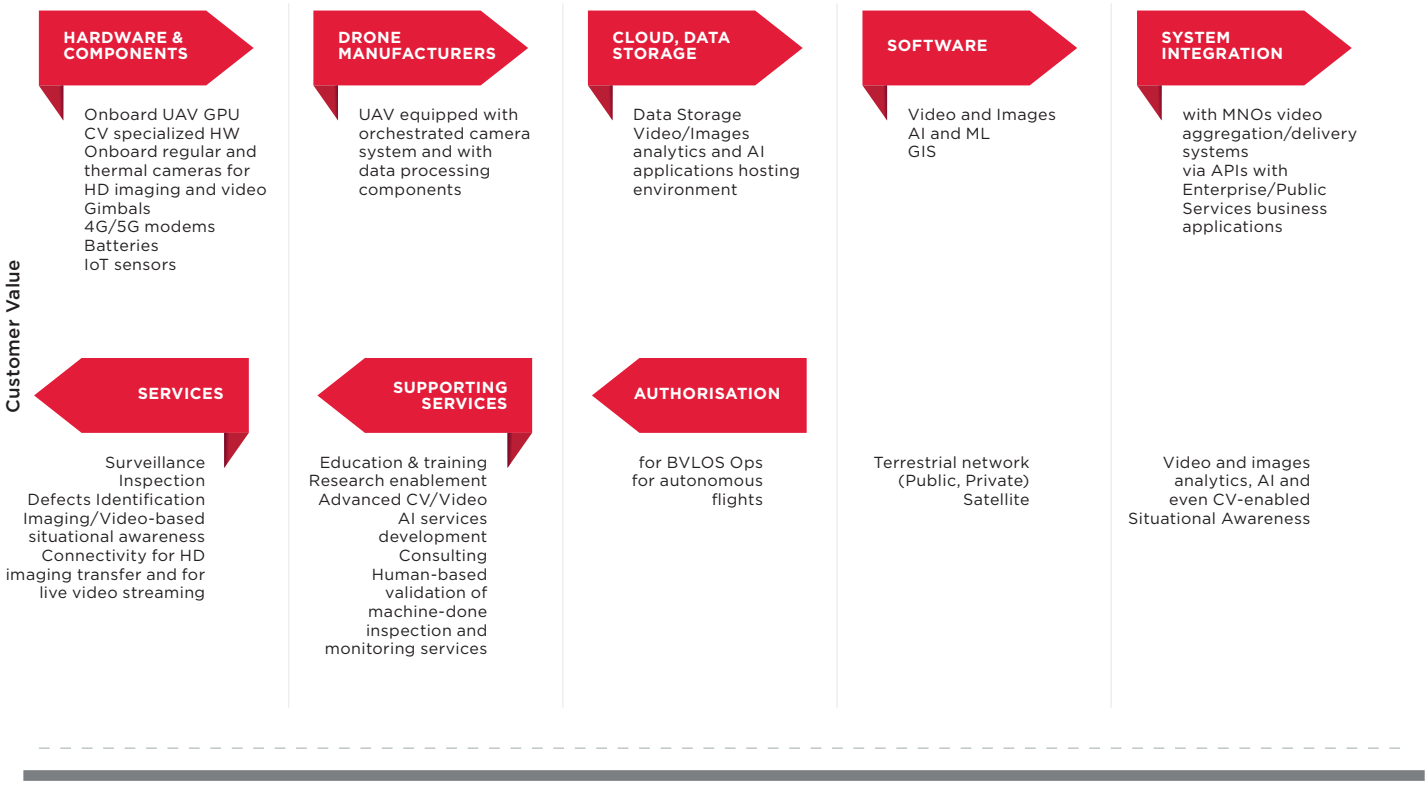
- Enabler of connectivity services for BVLOS operations/live video streaming or HD image transfers.
- Provider of close to real-time computer vision services (either on-board the UAV, at the edge or in MNO-enabled private cloud if required).
- Provider of other AI and visualisation services

The overall value chain for this use case is presented in Figure 47:

Figure 47

Automated Infrastructure Inspection and Critical Assets Monitoring Value Chain Analysis

Value Chain Stakeholders: Automated Infrastructure Inspection and Critical Assets Monitoring



Potential Business Models

An MNO could capture a significant portion of the overall value created by stakeholders with an interest in automated infrastructure inspection and critical assets monitoring services, by positioning itself as a provider of connectivity with stringent SLA requirements to support video/imaging and C2-Com applications hosting, as well as an enabler of BVLOS and AI.

The MNO could be paid per mission or on a subscription basis for the services it enables.

For more details on the business model for this use case, please see Figure 48:

Figure 48

Automated Infrastructure Inspection and Critical Assets Monitoring Business Model Canvas

Key Partners

- UAV OEMs
- Payload OEMs/ ODMs (cameras, LIDAR, sensors)
- Computer Vision ISVs

Key Activities

- Inspection of infrastructure and analysis of data
- Cross-sale of MNO services.

Key Resources

- UAV operators/pilots
- AI/ML experts
- Inspection experts
- MNO brand and sales team

Value Proposition

- End-to-end solution for capture, storage, and analysis of inspection data.
- MNO brand can be leveraged to gain government and industry regulator support for inspection flight permits and PoCs.

Customer Relationships

- Direct relationship with MNO or key partner sales team.

Channels

- Direct sales
- Sales via key partners

Customer Segments

B2B with focus on few key segments:

- Oil and gas
- Mining
- Construction
- Power generation companies
- Electrical power distribution including grid and substations
- Railway operation entities

Cost Structure

- UAV: Drone and payload
- 4G/5G connectivity to the UAV
- Licenses for AI/ML software
- Human resources: Pilots, analysts, technicians, and developers.
- Sales commissions

Revenue Streams

- Re-sale/ one-time rental/subscription for hardware and software
- Managed inspection services (hardware, pilots, data capture, processing, insights, and reporting)
- On-demand professional services
- Cross-sell of other MNO services

5.17
Flight Management Systems

Use Case Description

A flight management system can use a cellular network to operate UAVs beyond visual line of sight. Such a system is designed to remotely create flight paths using 3D maps and sky weather forecasts, remotely start, pause, control UAV flight, share real-time UAV footage (where available) from anywhere and ensure the safety of UAVs during remote flights.

By using a 5G network, it is possible to build end-to-end flight management systems, which can unify organisation, management and control of UAV information resources. With access to real-time data, AI can be applied to realise intelligent flight management services.

A 5G cellular-connected UAV flight management platform can solve the bottleneck of the limited control distance of self-built data links, and other technical problems, such as slow data processing rate and poor real-time performance.

Stakeholders

As shown in Figure 49, potential stakeholders for this use case include:

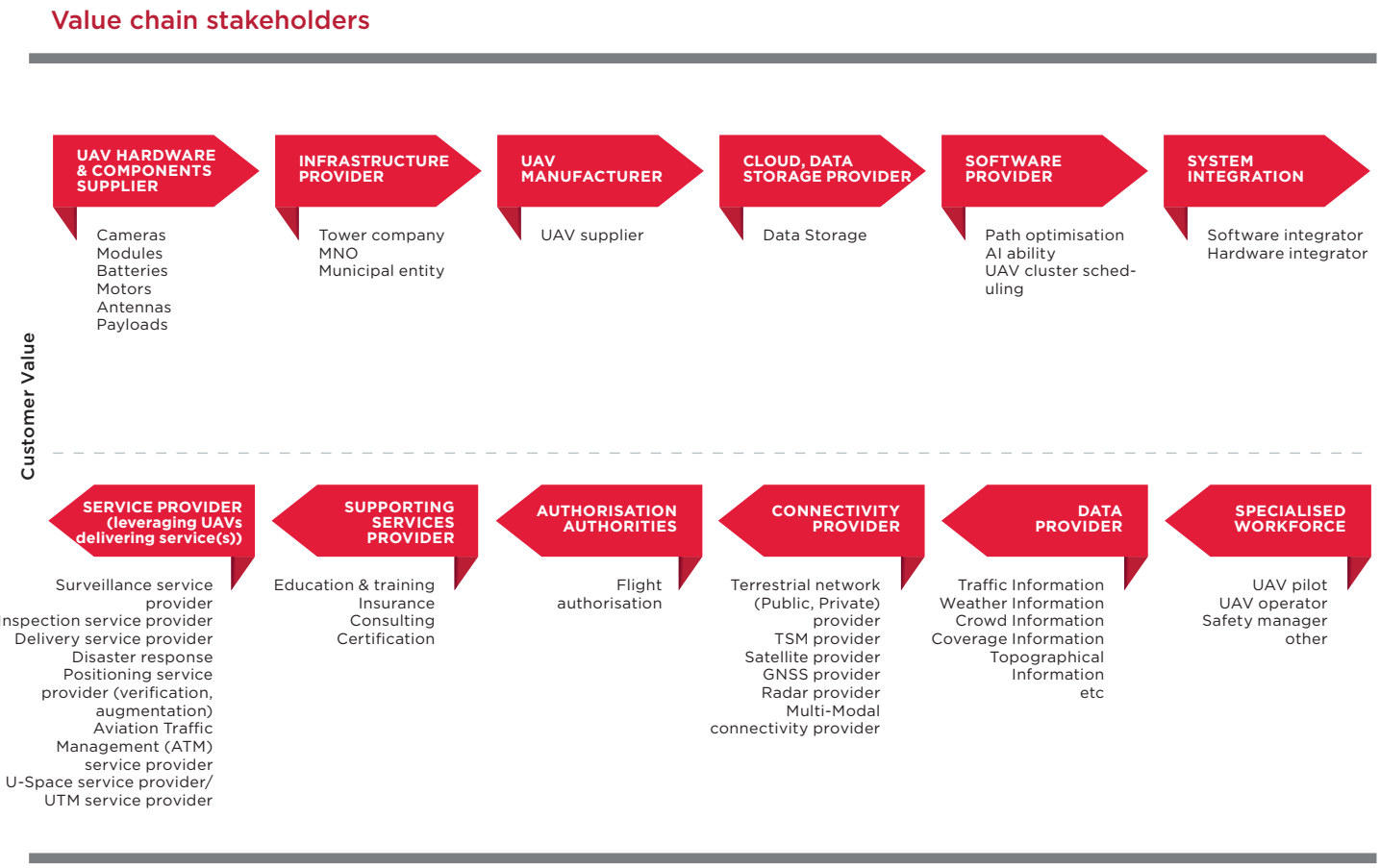
- MNOs
- UAV manufacturers
- UAV operators
- System integrators
- UAV flight management system developers
- UAV flight management system operators
- UAV flight management system users (enterprise or government agency)

MNOs' Role in the Value Chain

MNOs can provide the infrastructure to support satellite communication, 4G/5G, private data link and other modes. MNOs can also provide user authentication mechanisms and positioning capability via a 5G network, which can support the safe flight and management of UAVs.

Figure 49

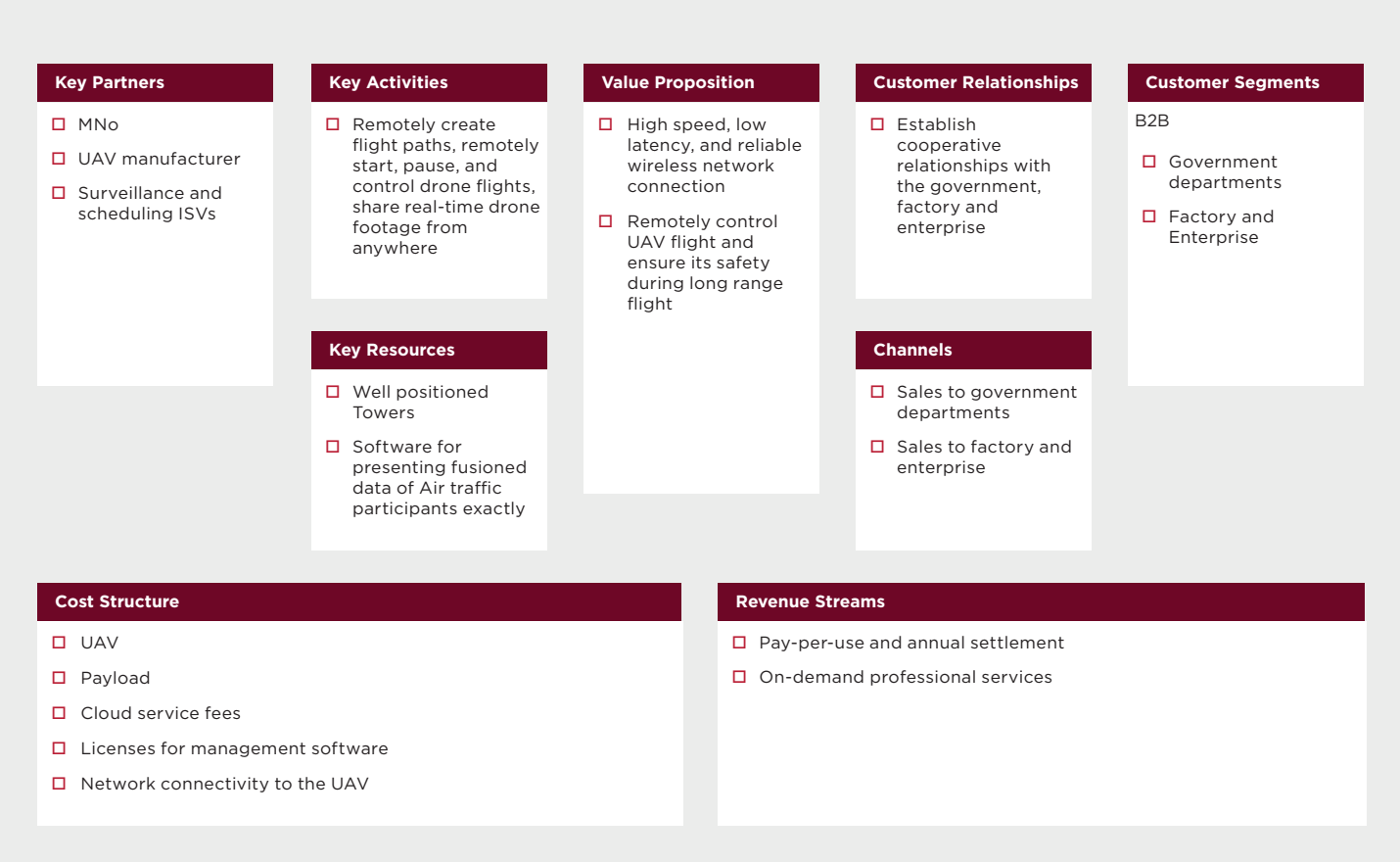
Flight Management Systems Value Chain



Potential Business Models

MNOs and other players can create value by providing dedicated UAV equipment, network services, cloud services, flight control and management services, system operation and maintenance services, data transmission services, data storage services, and data processing services. It should be feasible to provide standardised products and solutions for government and enterprise customers. Figure 50 shows a business model canvas for this use case.

Figure 50
Flight Management Systems Business Model Canvas



5.18
U-Space Services Provider/UTM Services Supplier

Use Case Description

UAVs operating in cooperative and non-cooperative airspace need to comply with BVLOS regulations and make themselves known to other UAVs and manned aircraft in civil airspace. Therefore, such UAVs need to be integrated with the UTM system governing airspace in the relevant geography. An MNO could act as a supplementary data service provider (SDSP) to enrich basic UTM services and enhance an ANSP's ability to govern and manage such airspace.

Uncrewed aerial vehicle traffic management (UTM) is much more than just a UAV tracking technology. It provides an infrastructure that supports automation in the UAV ecosystem. An open scalable UTM platform can enable authorised authorities to implement UAS services in collaboration with existing service infrastructure. Standardised UTM interfaces allow for the transmission of multiple and varied UAS information, including telemetry flight data monitoring and management within the planned and operational authorised flight volumes, corridors and routes, in a safe and efficient manner.

UTM is designed to enable cooperative traffic management and enhance the existing air traffic management (ATM) systems by resolving some of the challenges with non-cooperative, surveillance-based systems.

UTM relies on the desire of most UAV operators to share operational intent and contribute live tracking data to the ecosystem for the purpose of improving overall safety. The challenge for UTM is to connect UAVs into the ecosystem with aerospace precision.

Key benefits to UAV operators and ANSPs that decide to leverage MNO-enabled and MNO-operated UTM and SDSP services could include:

- Automated and consistent in obtaining SORA approvals.
- Enable UAV operations at scale.
- Create new service offerings and advance existing service offerings.
- Penetrate new market segments.
- Meet BVLOS operations' regulatory compliances in a timely manner.
- Optimise use of highly skilled staff.

For more details on the overall value proposition for this use case, please see Figure 51.

Figure 51

U-Space –Services Provider/UTM Services Supplier Value Proposition for the UAV Operator

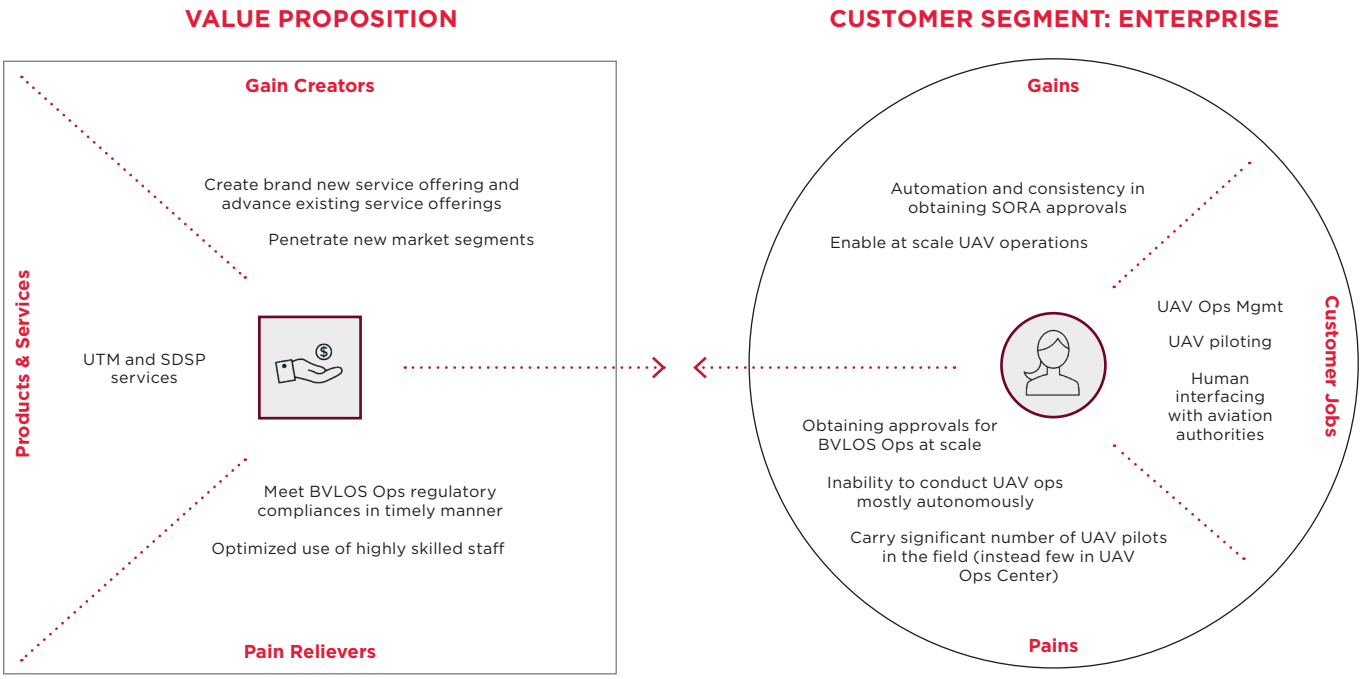
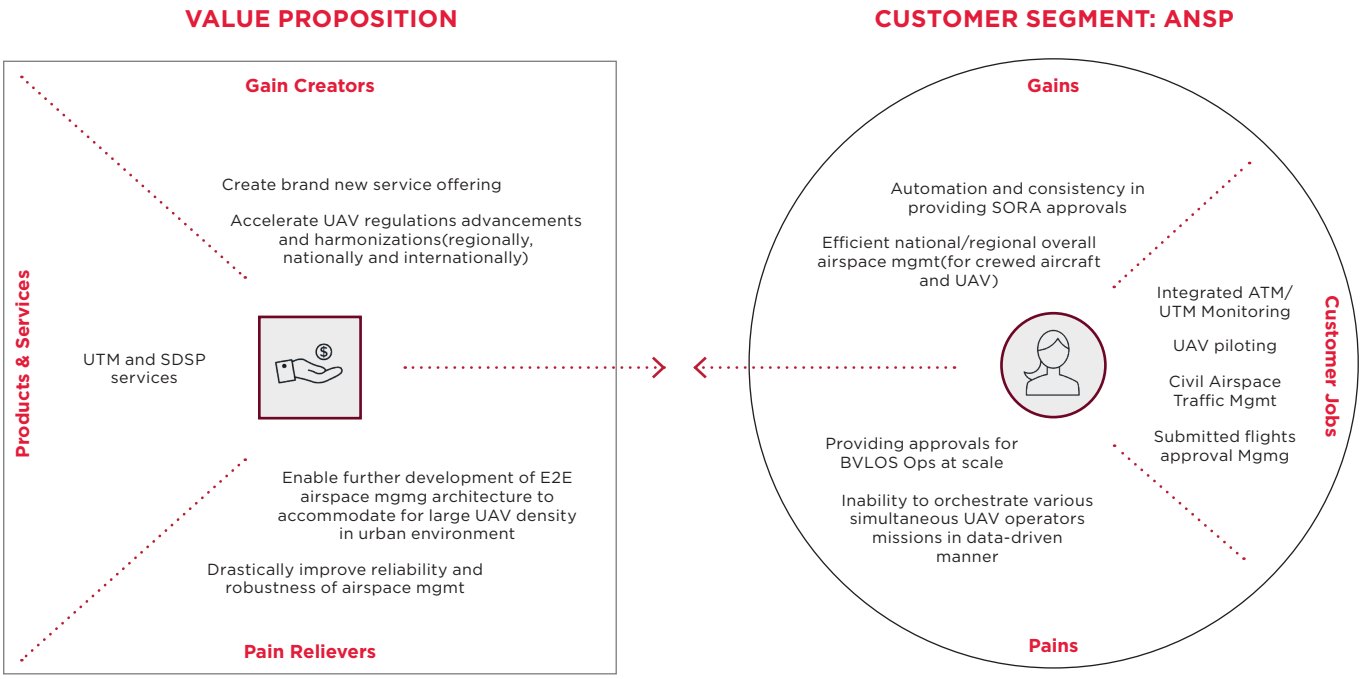


Figure 52

U-Space –Services Provider/UTM Services Supplier Value Proposition for ANSP



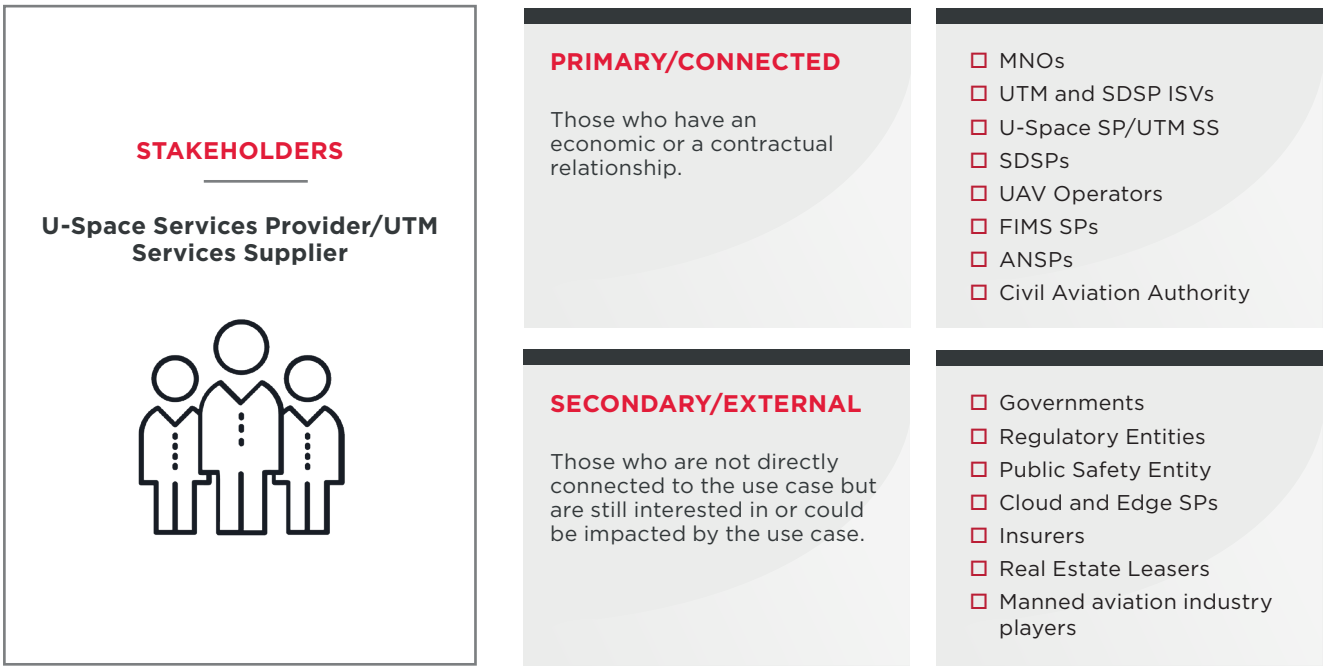
Stakeholders

As shown in Figure 53, potential stakeholders for this use case include:

- MNOs as UTM/SDPS service suppliers
- UAV operators for BVLOS operations and AAM operations
- Enterprise end-customers of UAV-based services
- UTM and SDSP platform providers
- UTM and SDSP ISVs
- ANSPs
- FIMS for UAVs service providers
- TM service providers
- Civil air regulators
- UAV OEMs

Figure 53

U-Space –Services Provider/UTM Services Supplier Stakeholder Analysis



MNOs' Role in the Value Chain

Some of the potential roles for MNOs in this use case are:

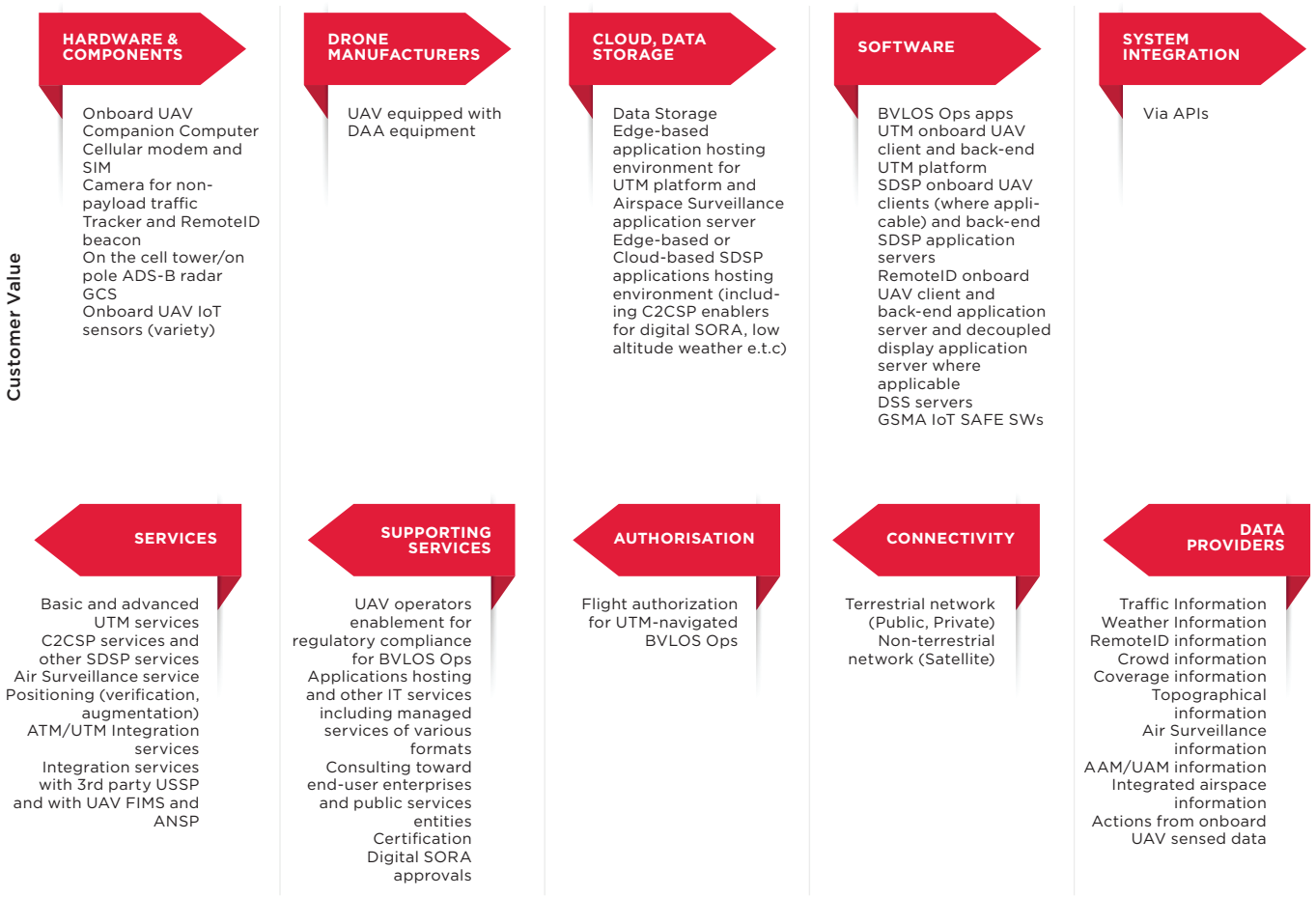
- ☐ Enable BVLOS operations via cellular network(s),
- ☐ Provide end-to-end security for all services,
- ☐ Host UTM/SDPS application servers in an edge computing environment,
- ☐ Provide basic UTM services and advanced UTM services (leveraging SDSP feeds)
- ☐ Provide networked Remote ID services (see section 5.4)

The overall value chain for this use case is presented in Figure 54:

Figure 54

U-Space –Services Provider/UTM Services Supplier Value Chain

Value Chain Stakeholders: U-Space Services Provider/UTMK Services Supplier



Potential Business Models

Some of the potential business models for this use case include direct sales to ANSPs and UAV operators, indirect sales to FIMS, and systems integration services to UAV OEMs.

For more details on business model for this use case, please see Figure 55:

Figure 55

U-Space - Services Provider / UTM Services Business Model Canvas

Key Partners

- BVLOS-enabled UAS solution provider (HW + platform SW+PS)
- USP/USS
- SDSP(s)
- SIs for integrated airspace management solutions

Key Activities

- C2CSP capabilities roll-out
- UTM/SDSP operations

Key Resources

- UAV Ops Centre Engineers
- UTM SMEs

Value Proposition

- MNO provided UTM and SDSP services
- MNO as integrated C2CSP

Customer Relationships

- Position set of UTM/SDSP services as value add services toward UAV operators and ANSP(s)

Channels

- Direct Digital to UAV operators
- As value add data service to FIMS SPs and ANSP(s)

Customer Segments

- UAV operators from public/private sector
- USPs/USSs
- ANSPs
- FIMS SP

Cost Structure

- Real estate
- SW licence & hosting
- Support (HW, SW and for E2E solution)

Revenue Streams

- Transactional based on APIs consumption
- Mission-based (UTM/SDSP Solution-as-a-Service)
- Subscription-based

6 Key Learnings

Timelines

The use cases analysed in chapter 5 have been identified by the contributors to this paper as achievable in the short and mid term. However, in some cases, the full business model is not yet fully clear for an economic sustainable solution, partly due to the uncertain regulatory environment or because other stakeholders in the value chains are primarily start-ups. It should also be considered that not all use cases are applicable to all regions.

For each use case, a MNO will need to make certain investments and the business model will be successful only if there is a fair compensation for all stakeholders in the value chain. Some of the use cases will also be driven by the readiness of 3GPP Specifications, as some of the capabilities are not yet ready to be moving to service commercialisation.

At the same time, there have been relevant developments in the UAS industry and also in the telco industry to encourage adoption of mobile communication. Those industry initiatives could contribute to UAS market growth and the introduction of secure and interoperable services for the commercial use of UAS. Some examples of important work and initiative include:

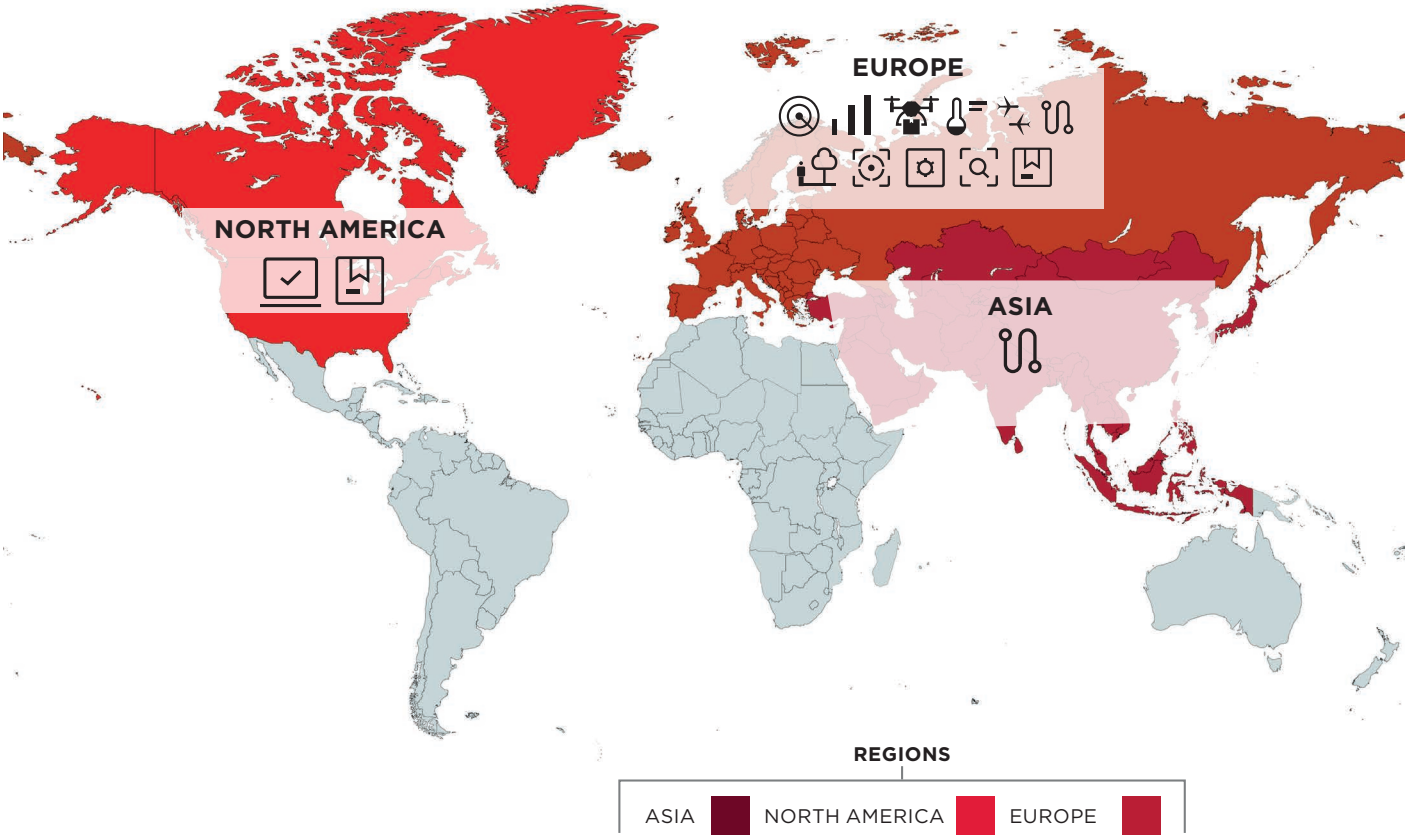
- European Conference of Postal and Telecommunications (CEPT) has harmonised technical conditions of the usage of aerial UE (UAV) for communications based on LTE and 5G bands (ECC Decision (22)07)[6].
- Aerial Connectivity Joint Activity (ACJA)[7]: A GSMA and GUTMA collaboration to build communication and cooperation, defining interoperable interfaces between the aviation and mobile network domains/systems. This group has already published several documents that are of interest for both industries and it continues to work on topics related to communication.

Based on the contributors' experience, each use case will have a different implementation timeline. Figures 55, 56 and 57 provide an aggregated overview of the use cases based on the likelihood of the business model realisation in the short, mid or long term.

[6] https://docdb.cept.org/download/4241
[7] https://www.gsma.com/iot/aerial-connectivity-joint-activity/

Figure 56

Use Case Adoption Regional Map



- Use cases to be adopted in up to one year by region

Figure 57
Use Case Representation Key

Icon	Use Case
	Aerial Connectivity for C2
	Aerial Connectivity for Payload
	QoS: Dedicated vs Shared Resources/Best Effort
	Network Remote ID & SIM Identity
	Positioning Augmentation
	Onboard UAV-Based & Edge-Based Computer Vision
	High-Resolution Topographical Information Service
	Multi-Drone Orchestration
	Hyper Localised Weather Services
	People Density Data
	Air Traffic Information Data
	Airspace Surveillance
	On-Demand Coverage - Cell on Wings
	Logistics/Delivery Services
	Automated Infrastructure Inspection & Critical Assets Monitoring
	Flight Management Systems
	U-Space Services Provider/UTM Services Supplier

Figure 58

Use Case Adoption Response Table

	NORTH AMERICA		EUROPE				APAC		
	TELUS	VERIZON	SWISSCOM	DEUTSCHE TELEKOM	KPN	TELIA	CMCC	TELSTRA	KDDI
Aerial Connectivity for C2		1 to 3 years	1 to 3 years	Up to 1 year	1 to 3 years	Up to 1 year		3 years +	Up to 1 year
Aerial Connectivity for Payload		Up to 1 year	Up to 1 year	Up to 1 year	Up to 1 year	Up to 1 year		3 years +	Up to 1 year
QoS: Dedicated Vs Shared Resources/Best Effort			3 years +	1 to 3 years	1 to 3 years	1 to 3 years		3 years +	1 to 3 years
Network Remote ID & SIM-Based Identity		3 years +	1 to 3 years	1 to 3 years	1 to 3 years	1 to 3 years			Up to 1 year
Positioning Augmentation		1 to 3 years	3 years +	Up to 1 year	1 to 3 years	1 to 3 years		3 years +	Up to 1 year
Onboard UAV-Based and Edge-Based Computer Vision	Up to 1 year		3 years +	1 to 3 years	3 years +	1 to 3 years	1 to 3 years	1 to 3 years	1 to 3 years
High Resolution Topographical Information Service			1 to 3 years	Up to 1 year	3 years +	1 to 3 years		3 years +	Up to 1 year
Multi-Drone-Orchestration	1 to 3 years		1 to 3 years	1 to 3 years	1 to 3 years	1 to 3 years		3 years +	1 to 3 years
Hyper Localised Weather Services	1 to 3 years		1 to 3 years	1 to 3 years	1 to 3 years	1 to 3 years		3 years +	Up to 1 year
People Density Data			Up to 1 year	Up to 1 year	1 to 3 years	1 to 3 years		3 years +	1 to 3 years
3D Coverage Data			1 to 3 years	Up to 1 year	1 to 3 years	1 to 3 years		3 years +	1 to 3 years
Air Traffic Information Data			Up to 1 year	Up to 1 year	3 years +	1 to 3 years		3 years +	1 to 3 years
Airspace Surveillance	1 to 3 years		Up to 1 year	Up to 1 year	3 years +	1 to 3 years	1 to 3 years	3 years +	Up to 1 year
On-Demand Coverage - Cell on Wings			1 to 3 years	Up to 1 year	3 years +	3 years +		3 years +	3 years +
Logistics/Delivery Services			1 to 3 years	Up to 1 year	3 years +	3 years +		1 to 3 years	Up to 1 year
Automated Infrastructure Inspection and Critical Assets Monitoring			Up to 1 year	Up to 1 year	3 years +	3 years +	Up to 1 year	3 years +	Up to 1 year
Flight Management Systems			Up to 1 year	Up to 1 year	3 years +	3 years +		3 years +	Up to 1 year
U-Space Services Provider/UTM Services Supplier	3 years +		Up to 1 year	Up to 1 year	3 years +	3 years +	3 years +		1 to 3 years

KEY Up to 1 year 1 to 3 years 3 years +

None of the use cases described in this document is going to be deployed in the short term globally. In North America and Australia, the focus is on the medium and longer term, with just a couple of use cases that could be realised within a year (payload and computer vision). In China, the primary focus in the short term is related to providing a traffic management system. However, the mobile community in Europe has a more optimistic view on the achievable use cases in the short term, possibly driven by progressive regulation.

In the recent report *UAVs: commercial applications and the opportunity for mobile operators*[8] GSMA Intelligence conducted a survey of 25 UAV ecosystem players on market trends, challenges and opportunities. The results highlighted that:

- 85% of mobile operators see the potential of UAS, but more than half are unclear on how big the opportunity is and how they should shape their strategies.
- 64% anticipate that the UAS space will mature between 2025 and 2027. This also aligns with the expected timings for critical regulations for UAS (e.g. BVLOS)
- 76% of the wider UAS ecosystem indicated that they expect mobile operators to provide value added services combined with support for airborne connectivity and telco capabilities, such as slicing, edge computing and network data

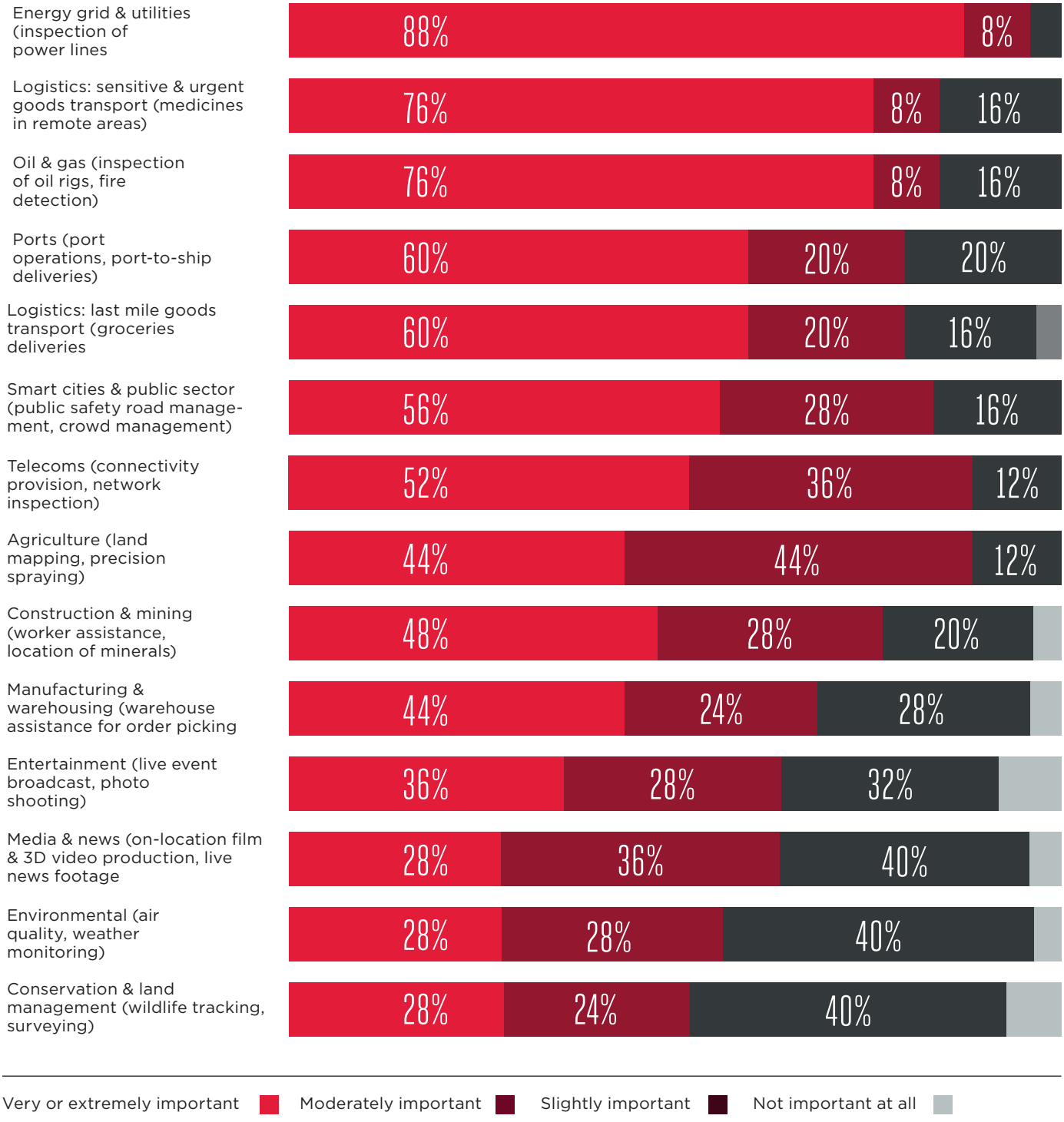
The participants see the greatest opportunities in different industry sectors: inspection of energy grids and oil and gas infrastructure, as well as the transport of urgent goods and essentials are the leading sectors in terms of revenue potential (see Figure 59).

[8] https://data.gsmaintelligence.com/research/research/research-2023/uavs-commercial-applications-and-the-opportunity-for-mobile-operators

Figure 59

GSMA Intelligence Survey Results of Revenue Opportunities for UAV Services

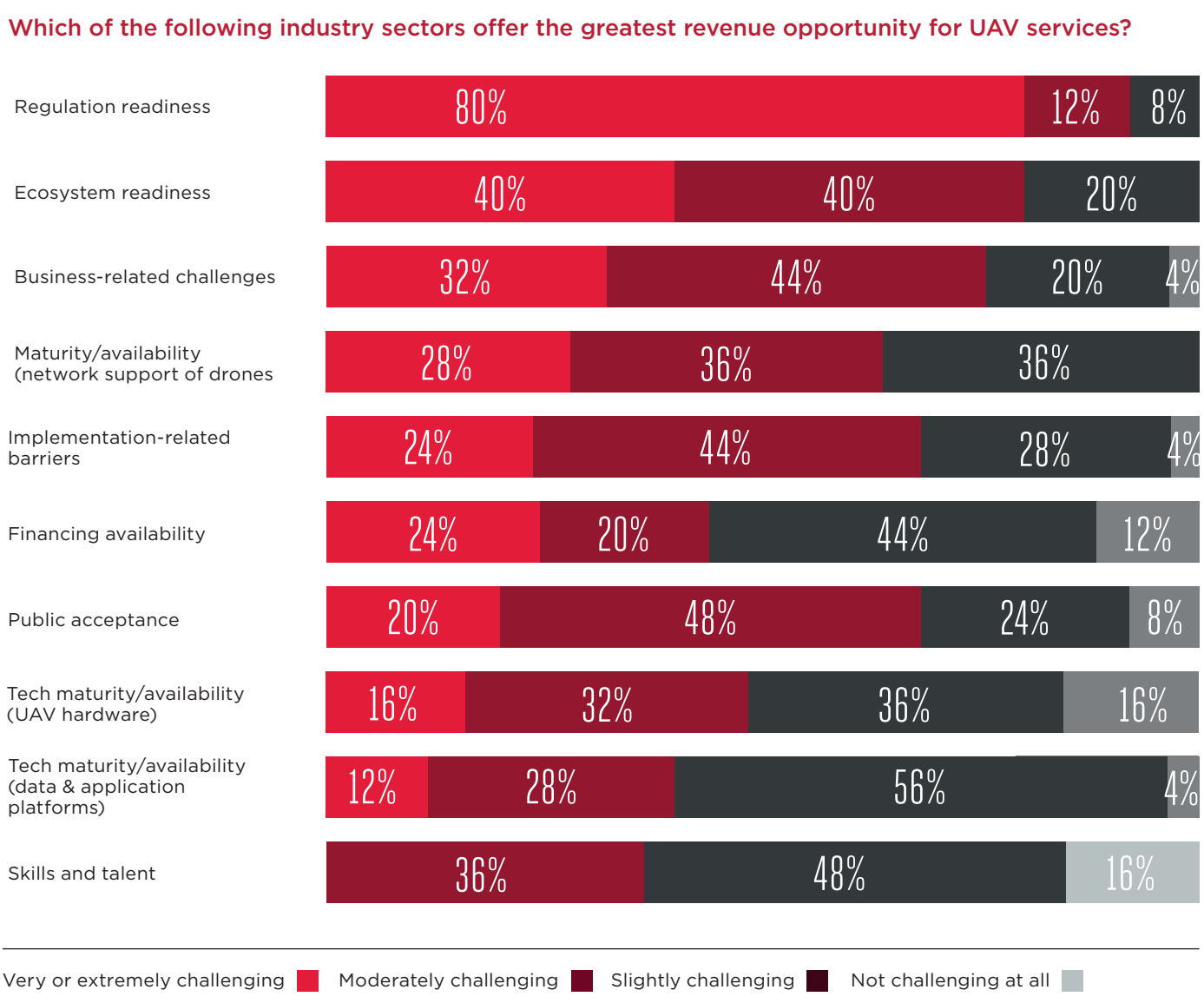
Which of the following industry sectors offer the greatest revenue opportunity for UAV services?



The survey respondents ranked regulation, ecosystem and business-related issues as the biggest challenges, just followed by the maturity and availability of mobile network support for UAS (see Figure 60).

Figure 60

GSMA Intelligence Survey Results for Adoption for UAV Commercial Use Cases in Target Markets

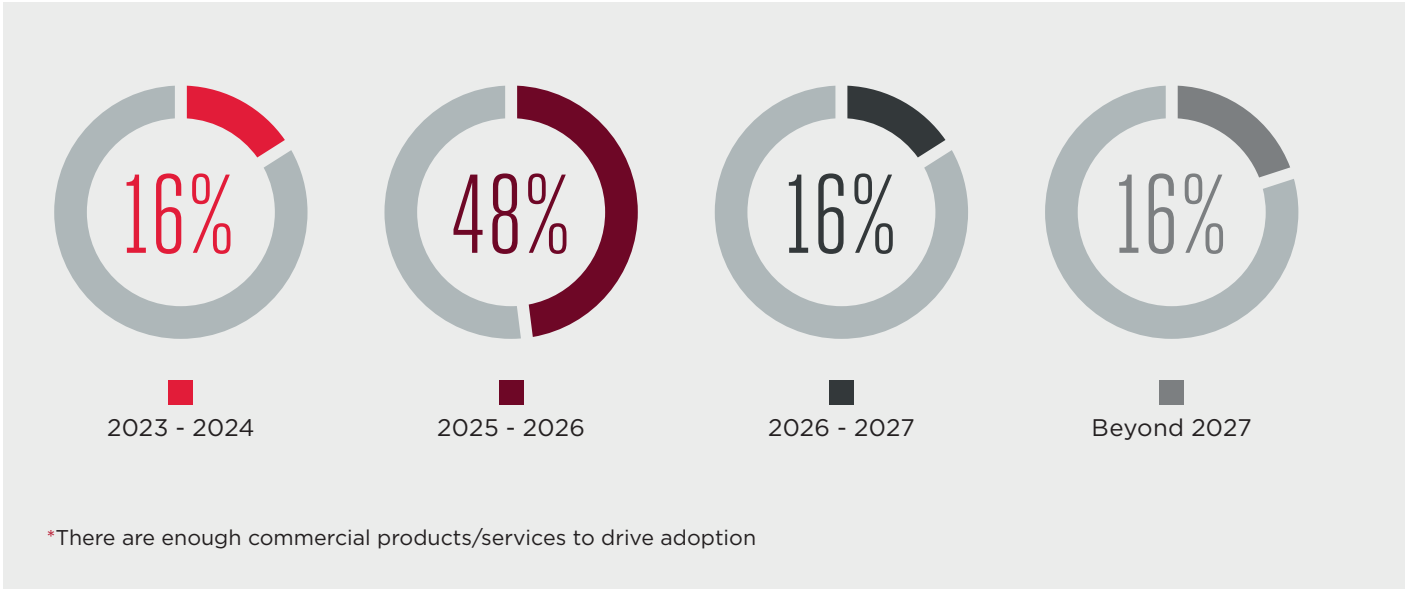


Finally, the report also highlighted the expected timeline for mainstream adoption of UAS - the consensus in the UAS ecosystem is that the market will reach mainstream adoption from 2025 (see Figure 61).

Figure 61

GSMA Intelligence Survey Results for UAV Products/Services Becoming Mainstream

Thinking about your target markets, when do you think commercial UAV products/services will become mainstream*



*There are enough commercial products/services to drive adoption

Such a timeline is also consistent with the experience shared by the contributors to this paper. While there are opportunities now, the expectation is that the market will flourish in a couple of years.

One important message is that for any commercial launch to happen and succeed in the next 2-3 years, the strategy needs to be devised today. The call to action for the telco industry is don't wait and act now.

Generic takeaways

This paper shares some of the real experiences from contributors to the broader community, particularly MNOs that are at the early stages of exploring UAS. These experiences should not be taken as guidelines at this stage.

Below are generic key takeaways derived from the analysis of the use cases:

☐ As described in the use case section, it is clear that mobile communication is an essential enabler for UAV data transmission, and there are several additional services that MNOs can offer.

☐ The ability of MNOs to provide 3D airspace coverage, particularly with 5G could be a game changer. BVLOS at scale can be then achieved with automated flight approvals based on risk assessment (e.g. SORA) underpinned by telco services, such as the 3D coverage That constitutes a base to roll out a UAS network that allows for scaling UAS services.

☐ MNOs should decide whether they want to actively support a customer in the UAS sector or not. Each country will have different spectrum rules that need to be respected by the UAS service provider (or manufacturer or operator). However, MNOs will be impacted if those rules are not properly followed, hence MNOs need to be aware of the potential impact on their network and their customers.

☐ MNOs should engage with the different stakeholders, such as the UAS operators, UAS service providers (e.g. USSP), but also the regulatory authorities and business partners, early on.

☐ Stakeholders should follow closely the development of the national regulatory and authority entities since their actions, plan and timeline can have a direct impact on UAS services and operation in their country.

☐ Exchanging learnings across countries helps to successfully position the contribution of the MNOs in providing services that help UAS operations, for example, achieve SORA approval for telco services, such as the people density and coverage information.

☐ The UAS market is highly dynamic: technology, regulation and standards are rapidly emerging, while socio-economic and geopolitical factors may impact the commercialisation of UAS services (e.g. restrictions on manufacturers or service providers may impact the scale and timeline).

☐ The mobile community is able and willing to support connected UAS operations, but as MNOs need to cater for the specific needs of UAS they may be required to make specific investments. Hence those services have to be valued accordingly and they cannot be compared to consumer services, which are generally less demanding in terms of quality and are at large scale.

☐ It can be effective to identify and focus on enabling more routine missions and think about business models that incentivise more missions, rather than simply implementing a pure data-transaction model

☐ For the same set of UAS services, try to identify different revenue streams that can be of value.

7 Next Steps

This document is intended to stimulate further discussion and encourage more MNOs and also other stakeholders to share their experience and learnings to improve and build a much greater proposition for the UAV sector. Please also take the opportunity to participate in the ongoing groups related to UAS within the GSMA (the UAV Interest Group and the Aerial Connectivity Joint Activity) so that the produced resources and guidelines reflect a truly global view.

8 Appendix

Regulation

Although regulation is not in the primary scope of this whitepaper, it is still relevant to have a brief overview of the status of the regulation for UAS in the contributors' countries, as specific regulation can influence market adoption for specific services.

The table below provides a very high-level view of some of the current topics of relevance for UAS in relation to mobile services. More specifically:

- **Remote identification:** indicate the ability to send electronically the identification of the UAV, both covering broadcast (or direct) remote identification and networked remote identification.
- **Digital (or electronic) conspicuity:** the ability to provide awareness information to other surrounding airspace users to increase safety, by means of transmitting the position of the UAV to other air space users.
- **BVLOS:** ability to conduct operations in beyond visual line of sight conditions. Is there a regulation in place for BVLOS and if there are restrictions.
- **UTM (or U-Space):** Defined rules and services to support the UAS traffic management for safe operations.

Table 2: Regional Regulatory Environment

	Regulation Items					Notes
Country	Remote Identification of UAVs (BRID/NRID)	Digital Conspicuity	BVLOS policy	BVLOS Restrictions	UTM/ UAV FIMS	
Australia	1	1	3	2	1	
Canada	1	1	3	2	1	TC as CAA is working toward RemoteID, Digital Conspicuity and FIMS
Switzerland	3	1	3	2	3	

	Regulation Items				Notes
China	3	1	3	2	3
Germany	3	1	3	2	3 regarding guidelines
Japan	2	1	3	2	3
The Netherlands	3	1	3	2	3
Sweden	2	1	3	1	2
United States of America	2	1 (started task force)	1	2	1 (started task force)

Note, the table does not cover all categories of UAS, but the primary interest is for those that can operate BVLOS and at low altitude. The input is provided by the contributors based on their best knowledge of the situation at the time of writing the document and the information could be obsolete quite rapidly.

Legend:

UAV Remote ID (Broadcast Remote ID – BRID and Network Remote ID – NRID):

1. No policy in place (neither BRID nor NRID rule is provided)
2. Policy in place, but not fully implemented (either BRID or NRID or both are defined but not fully implemented)
3. Policy in place and implemented (both BRID and NRID implemented)

Digital Conspicuity:

1. No policy in place
2. Policy in place but not fully implemented
3. Policy in place and implemented

BVLOS Policy:

1. No policy in place
2. Policy in place, but not fully implemented
3. Policy in place and implemented

BVLOS restrictions:

1. Allowed only in defined test areas
2. Allowed beyond test areas but with limitations (this could be either by means of standard scenarios or through exemptions and SORA)
3. Allowed anywhere

UTM/U-Space[9]:

1. No policy in place
2. Policy in place, but not fully implemented
3. Policy in place and implemented

[9] For the EASA Countries, even if the U-Space regulation is in place there are no countries that has a U-Space implemented at the time of the document.

External Stakeholders View

This section provides the point of view of other stakeholders on the use cases described in the main body of this report. The intention is to include inputs from a broad distribution of different type of stakeholders. However, the companies that have contributed to this section should not be regarded as a preferred choice of MNOs: this paper covers a limited set of MNOs and also a limited set of stakeholders.

The inputs below help the reader to see other prospective on the role of mobile operators and the needed services for the stakeholder providing the input. The companies listed below have been selected for a trial by MNOs or are participating in specific projects, but they are not the only stakeholders in their own field.

In some cases the monetisation aspects are not fully developed at this stage especially when the companies are startups and they might not have a fair understanding of the distribution of economic value across the full stakeholder value chain, particularly when the telecom aspect is new for them. The MNOs are expecting that over time this situation will be resolved.

It is recognised that the traditional telecom vendors are the primary key stakeholders that are helping MNOs to deliver the use cases analysed in the paper.

Use Case: Aerial Connectivity for C2

It provides the view from the company uAvionix Corporation in relation to the Use Case described in section 5.1.

uAvionix Corporation

uAvionix was founded with the mission of bringing safety solutions to the unmanned aviation industry in order to aid in the integration of Unmanned Aircraft Systems (UAS) into National Airspace Systems (NAS). uAvionix offers low SWaP TSO certified and uncertified avionics for General Aviation (GA), Defense, Airport Surface Vehicles and the UAS markets including DO362A and DO-377 compliant C2 systems, Link Executive Managers that include LTE radios and DAA sensors.

The team consists of an unparalleled engineering and management team with a unique combination of experience within avionics, surveillance, airport services, UAS aircraft development, radio frequency (RF), and semiconductor industries.

uAvionix is providing certified C2 radios and DAA sensors, systems & services, displays, autopilots and GPS to many of the major unmanned OEM, operators. The company is actively involved in global deployment of their capabilities, partnering with operators and infrastructure providers such as MNOs. uAvionix is the C2 Service Provider behind various large-scale programs such as Vantis in the USA.

Stakeholders

General Aviation Aircraft Owners, Pilots, UAS manufacturers, UAS operators, Large UAS network operators, UAM/AAM, Air Traffic Management, Regulators, Remote (UAS) Pilots, Energy & Utility Companies, Defense & Government, MNO, MVNO

Value chain description

uAvionix provides an avionics ecosystem for manned and unmanned aircraft aimed at mission critical platforms and operations. C2 and DAA avionics are currently being used by many customers and have resulted in several Beyond Visual Line of Sight waivers and SORA approvals.

uAvionix sells avionics and radios, but also providing managed C2 and DAA services, to larger operators, enterprise companies or through network partners.

Business Model description

Products & Services.
Direct to Consumer, Reseller, Distribution Partners, Service Provision

Which services would be beneficial for you that an operator can offer?

Structured responses from a list

- ☐ Managed C2 services, C2 Link and Path Diversity on ISM, C-band, LTE and SATCOM
- ☐ Detect & Avoid, dual band ADS-B ground sensors
- ☐ Detect & Avoid networks and partner deployment
- ☐ Detect & Avoid data validation, system monitoring
- ☐ Link Manager, C2 Systems, DO-362A compliant.
- ☐ Purpose built UAS LTE radios (eSim) with Link Manager
- ☐ Certified C2 airborne radios (TSO c-213a), C-band
- ☐ Certifiable C2 ground radios (C-band)
- ☐ Airborne Detect & Avoid sensors.
- ☐ Autopilots
- ☐ Electronic Conspicuity Solutions (integration of manned & unmanned)

Additional resources

Please find the following links for additional resources/explanations:

- ☐ **www.uavionix.com**
- ☐ **https://uavionix.com/products/skyline/**

Other services provided are:

- ☐ Regulatory expertise
- ☐ Aviation certification expertise
- ☐ RF expertise
- ☐ Waiver / SORA / Risk Management support
- ☐ Integration support
- ☐ Managed services

Use Case: Aerial Connectivity for Payload

It provides the view from the The Dortmund Fire Department and the German Rescue Robotic Centre in relation to the Use Case described in section 5.2.

German Rescue Robotics Center / Fire Department Dortmund

The Dortmund Fire Department (FDDO) is one of the ten largest professional fire departments in Germany. Like many other fire departments, it has already been using UAVs (unmanned aerial vehicles) for a while as a regular means of situation reconnaissance. Through the IFR (Institute for Fire and Rescue Technology), FwDO has also been involved for many years in national and international research projects to develop new technologies and processes for fire departments and other emergency services.
Here, the topic of "mobile robotics" was taken up early on, e.g. from 2008 in the AirShield project.
The Dortmund Fire Department is a founding member of the DRZ e.V. (see below) and, through the IFR, took over the coordination of the BMBF-funded project to establish the German Rescue Robotics Center (Project A-DRZ). As a partner in the follow-up project DRZ, it continues to provide support by providing input from the users' perspective, but also works on other, additional research projects on the topics of "mobile robotics" – especially UAVs – and communication technology, e.g. the 5G DOS Fire project funded by the Federal Ministry for Digital and Transport (BMDV).

The German Rescue Robotics Center (DRZ e.V.; www.rettungsrobotik.de) was founded in 2018 as a non-profit carrier of the German competence center for rescue robotics within the research project A-DRZ funded by the German Federal Ministry of Education and Research (BMBF), with the aim to create a catalyst to accelerate the transfer of rescue robotics technologies into application by networking among competent key players from science, industry and the circle of practitioners in a supra-regionally organized structure with a centrally located innovation laboratory. The tasks of the DRZ include research, transfer, training as well as standardization and certification in the field of rescue robotics, with the aim of relieving rescue and emergency forces in dangerous and health-threatening situations, minimizing the dangers of hostile environments and helping to make dangerous operations more effective.
In addition to the FDDO and the DRZ e.V., DRZ research partners from the University of Bonn, the Technical University of Darmstadt, the Technical University of Dortmund and the Westphalian University of Applied Sciences in Gelsenkirchen also contributed to this statement.

Stakeholders

Fire departments and other emergency services as users.

The DRZ e.V. as a non-partisan platform, providing connections to organizations from the rescue service as well as manufacturers of equipment and research institutions. It helps to define requirements from the perspective of the rescue services and test the developments by manufacturers and research.

Developers of advanced "aerial robotics" from academia and industry.

UAV manufacturers for production of suitable flight systems according to requirements

Sensor and camera manufacturers for production of suitable equipment according to requirement

Value chain description

UAV deployment in rescue operations

The use of UAVs is already common practice among fire departments and is often part of the emergency dispatch protocols. The UAVs transmit useful data – usually camera images – to the incident command, where tactical decisions are made based on this information, among other things. Depending on the type and number of sensors carried, very large amounts of data must be transmitted. The ability to incorporate UAVs into situational awareness has proven extremely valuable to fire departments. Until now, UAVs are typically launched by specially trained personnel at the incident site and deployed according to on-site requirements. In terms of control, the trend is towards increasing autonomy, where the operator is supported by autonomous assistance functions, e.g. in flying between designated waypoints in the target area and/or searching and detecting areas with high temperatures, i.e. sources of fire, and/or onboard detection of people. Autonomously acting systems offer distinct advantages, e.g., aerial images of the incident site can be retrieved as needed without permanently tying up forces to operate the UAV. Development is also proceeding in the direction of increasingly automated processes or powerful support systems for mission command. However, civil emergency response operations represent highly dynamic situations with corresponding challenges with regard to the development of autonomous systems. Fire departments and other emergency services participate in research and development initiatives with a focus on novel UAV systems.

The use case of a UAV autonomously flying ahead to the incident site upon an alert and transmitting images from there to the incident command, is an interesting, innovative scenario. Having visual information from the incident site already during approach enables the commanders to plan initial measures and implement them immediately upon arrival. For this purpose, the image data must be transmitted over long distances, and high-performance 4th and 5th generation civil mobile networks are particularly suitable for this purpose. Conventional UAVs operating at close range have their own radio link for data transmission, whereas autonomous systems for long-range reconnaissance are likely to rely on a separate infrastructure. However, such systems are still in an experimental phase and have yet to prove their practicality before they can be integrated into a fire department's operation. In addition, there are currently still legal challenges with regard to so-called BVLOS flights (BVLOS = beyond visual line of sight), at least within the EU. The (legal) possibility to perform BVLOS flights is a basic requirement for the operation of such a system.

From a user perspective, it would be desirable to have a fully integrated system that includes UAVs, sensors, and data analysis systems, as well as transmission and hosting on a high-performance, secure infrastructure. This should also include a powerful human-machine interaction interface, intuitive operating concepts, and supporting assistance functions, with functionality optimized across all components to deliver the best possible user experience with respect to the aforementioned criteria. In order for such systems to be effectively deployed, a reliable and powerful communication infrastructure is also required, which may be set up locally by the users themselves, but ideally is already available.

Business Model description

Work of firefighters is part of civil services and is provided in public interest.

The use of UAVs, like other technical equipment, takes place to increase the efficiency of rescue missions, to limit risks for involved rescue forces and to improve chances to rescue people and decrease damage caused to people
or objects.

Which services would be beneficial for you that an operator can offer?

1. Resilient infrastructure:
Important, especially for use in the context of civil security is high availability, reliability and suitability for everyday use: operational capability must be ensured even under adverse conditions. Key criteria with regard to the mobile wireless connection are a sufficiently high data rate for continuous transmission, including video streams in the necessary resolution, near complete coverage over the entire area, and high availability or fail-safety.

2. Dual Network Connectivity:
The "normal" civilian mobile networks are a good and often inexpensive infrastructure for mobile networking of robotic systems, both with each other and with the emergency forces. To increase the availability of cellular connectivity, straightforward connectivity across multiple cellular networks is desirable. Here, the UAV system should be provided automatic handover or parallel use of multiple networks.

3. High data transmission rates
When using advanced sensor technology (e.g., thermal cameras), a proper, ideally highly automated evaluation of data must be performed in order to specifically provide to the emergency personnel only the information that is directly relevant to the execution of the mission. This evaluation must not take up too much capacity and time. Time is a critical factor here; ideally, the processed data is transmitted "live" to the incident command. Depending on the sensor technology used this requires continuous high data transmission rates. If the data processing required to condense the information, or parts of it, takes place onboard, i.e. already on the UAV's hardware, this leads to significantly lower data volumes that have to be transmitted, and thus to less strain on a mobile communications infrastructure. However, emergency personnel should also be able to access the raw data if needed, should the automated functions not provide the desired result.

4. Prioritization / ensuring sufficient mobile communications capacity for emergency services
Rescue operations often take place in densely settled areas or near larger crowds of people. Simultaneous use of the public mobile network by a large number of people, can lead to limited availability or bandwidth (shared medium). In order to be able to use civil mobile communications as a reliable communication path for emergency services, sufficient capacity and network coverage are a primary requirement. Furthermore, the network operators must ensure functioning communications even with a large number of users. One possible solution would be to prioritize the emergency services user group.

5. Acquisition and operating costs
The cost of equipment plays an important role in civil security, too. Acquisition, maintenance and operating costs that are high in relation to the expected benefits are not justifiable in view of an often tight budget situation. Here, robotic systems are in competition with other assets , which also have to be acquired and operated. A viable cost-benefit ratio must be given, especially with limited public funds, whereby the improvement of the safety of emergency personnel is an important criterion. Communication technology, whether considered as part of a robotic system or in general, is a significant cost factor for the BOS.

6. Hardware

Communications hardware, such as radio modules carried by UAV and other robotic systems for the purpose of connecting to a cellular network, must be small in size and light in weight. The modules must consume little energy but provide large bandwidths and range. The technology must be resistant to the stresses that occur in the field; this includes exposure to water, dust, smoke, as well as mechanical impacts such as shocks or vibrations.

7. Special requirements for UAVs

Based on previous experience, special requirements for UAVs with cellular connectivity include the following:

- ☐ support for digital transmission methods for emergency services;
- ☐ sufficient capacity (bandwidth) and low latency for reliable transmission of large amounts of data, especially for high-resolution image and video transmission (e.g. HD video), as well as for sensor data;
- ☐ ideally, connectivity should be continuous within a radius of 10 km around the deployment site;
- ☐ high availability and fail-safety through a resilient infrastructure, if necessary also through redundant protection of important system components;
- ☐ the ability to switch seamlessly between different communication networks, including local ones.

These capabilities must be supported by three-dimensional cellular coverage when UAVs are deployed. In order to reliably use the UAV as a means of operation, the network operator must provide three-dimensional connectivity information that allows a reliable assessment of the quality of service of the public mobile radio network at different altitudes. Experience from missions during the flood disaster in the Ahr-valley in Germany in summer 2021 makes it clear that UAVs can also be deployed well above 100 m flight altitude, when needed. Furthermore, data may have to be transmitted to a central ground station or guidance component, which may be located at some spatial distance from the operator or remote control unit. Even under these circumstances, continuous data transmission between the UAV, remote control unit and ground station/guidance component must be ensured.

Additional resources

Additional information about the use of UAVs for disaster response can be found at the DRZ website:

www.rettungsrobotik.de

Use Case: Onboard UAV-based and Edge-Based Computer Vision

It provides the view from the company Chooch in relation to the Use Case described in section 5.6.

Chooch

Chooch is a horizontal computer vision platform designed to train models according to bespoke use case requirements. Its unique value proposition is driven by four primary capabilities: rapid dataset generation through various techniques (such as synthetic data generation, video annotation, and smart annotation features), model training & testing, identifying both objects and actions, and programmatic edge device deployment as an inherent platform offering. These core competencies allow Chooch to compress the AI lifecycle for data annotation, training, and model deployment by an order of magnitude faster than competing platforms. Lastly, Chooch is designed for edge deployment on Intel CPU and Nvidia GPU hardware and is compatible with most models. On prediction devices, Chooch inferences objects and activities in 16 to milliseconds.

Chooch maintains over 250,000 publicly available classes that can be deployed to production for immediate inference generation. Classes and models can then be applied to logic, such as zones and dwell time, to generate video alerts which feed Chooch Smart Analytics, heat maps, and path flow analyses for an end to end, model to insight solution.

Stakeholders

Chooch serves a variety of industries, not limited to Manufacturing, Healthcare, Telecoms, Retail, and Public Transit & Services.

Value chain description

Chooch's workflow is an end-to-end data annotation, synthetic data creation, and model training solution for users to create, upload, and download datasets and models. The Product is comprised of five components that encompass the entire AI lifecycle, enhancing Time-to-Value, Proximity to Data, Insight Generation, KPI Reporting, and allows for AI Anywhere.

Business Model description

Chooch provides SaaS Licenses for the Platform, as well as for self-hosted ML-assisted labeling and model training. Additionally, Chooch maintains and is growing a robust partnership network to capture category leadership in computer vision.

Which services would be beneficial for you that an operator can offer?

- ☐ Structured responses from a list:
- ☐ Provide network connectivity to remote edge devices
- ☐ Provide network connectivity to cellular-connected UAV for onboard edge or centralized UAV-video processing
- ☐ Provide compute to run Chooch and orchestration to bring in remote streams for video processing
- ☐ Provide network security orchestration meeting customer needs
- ☐ Ability to act as face to multiple customers and potentially sell computer vision metadata to multiple parties making ROI easier to obtain
- ☐ Act as face to customers managing projects and capturing data for custom model generation

Additional resources

Please find the following links for additional resources/explanations of the Chooch product offering and how we can enable you and your customs to leverage computer vision at scale.

- ☐ Link for Chooch AI Vision Studio Brief:
- ☐ Link for Chooch Commercial Overview: **https://choochcorp.sharepoint.com/:b:/g/Ec8j_liajitHqpvoiD6duf-4ByqFpB0BKn4dSLQCyfBJ55w?e=K0cLAY**
- ☐ Link for Chooch ROI Whitepaper: **https://choochcorp.sharepoint.com/:b:/g/ERfo3YnGbPZCj_Nr5DESWHI-BiUbphz60cudIafbf8eTKYQ?e=DBebvk**

Use Case: Multi-UAV Orchestration

It provides the view from the company Unmanned Life in relation to the Use Case described in section 5.8.n 5.6.

Unmanned Life

Unmanned Life has developed the leading autonomous robotics orchestration platform, which leverages AI, 5G, and edge computing to deploy hybrid swarms of UAVs and mobile robots powering autonomous applications for Enterprises, Industries, and Smart Cities.

Unmanned Life's modular software platform is interoperable across hardware vendors and networks, scalable, and flexible in deployments. It has existing success stories in autonomous surveillance, emergency response, asset inspections, and hybrid logistics manufacturing.

Stakeholders

Typical external stakeholders include Telcos, who provide networks, capabilities as service providers, enterprises client bases, and reselling capabilities.

In addition, hyperscalers and network infrastructure providers are looking for 5G-enabled applications to offer on top of their own solutions, providing another revenue stream.

End-customers are both public and private entities, depending on the application. For example, the end-customer for the autonomous UAV-based security surveillance application could be ports, power & utilities operators, or enterprise facilities.

Value chain description

With a modular approach, the software platform enables applications for end customers depending on their needs. As an example, a customer using a fleet of platform-enabled UAVs can use the surveillance, inspection, or last-mile delivery applications. Over time, additional applications will be added to the platform via software update.

In addition, integrations to third-party software such as video management systems or AI adds a layer of customization for the end-customer.

Business Model description

Unmanned Life operates a Hybrid SaaS model, charging a fee for setup followed by a license per platform-enabled device. This ensures long-term value for clients, with support and software updates respectively.

Which services would be beneficial for you that an operator can offer?

- ☐ Configured 5G connectivity via private or public networks that provide high-bandwidth, low-latency connectivity for real-time autonomous command & control, and video streaming.
- ☐ Advanced 5G capabilities such as network slicing and Quality of Service APIs.
- ☐ Capabilities as service providers outside of network functionality (in the case of UAVs: flight permit applications, pilot provision, and more)
- ☐ Enterprise client bases
- ☐ Platform hosting solutions (Edge, Cloud, or on-premises)
- ☐ Through Unmanned Life, other operator products such as cyber security can be leveraged, benefiting both Unmanned Life and the end customer

Additional resources

- ☐ https://unmanned.life/
- ☐ https://www.ericsson.com/en/industry4-0/partners#softwareapplications
- ☐ https://www.telefonica.com/en/communication-room/telefonica-launches-autonomous-drone-fleet-management-solution-maximise-security/
- ☐ https://www.gsma.com/iot/resources/gsma-foundry-case-study-digital-eyes-in-the-sky/
- ☐ https://www.gsma.com/5GHub/indoordrones
- ☐ https://www.telus.com/en/ventures/news/unmanned-9-november
- ☐ https://unmanned.life/unmanned-life-collaborates-with-canadas-fastest-mobile-network-operator-to-test-drone-capabilities-on-5g-network/

Use Case: Hyper Localised Weather Services

It provides the view from the company TruWeather Solution Inc. in relation to the Use Case described in section 5.9.

TruWeatherSolutions Inc.

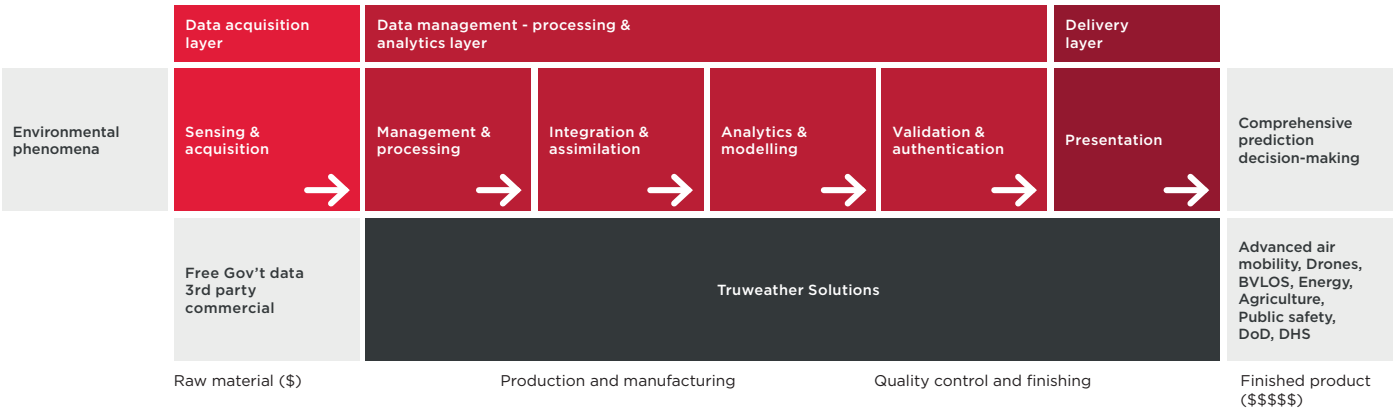
TruWeatherSolutions is a micro-weather data and analytics company focused on low altitude weather that will impact UAVs and eVTOLs safety of flight and revenue generation per aircraft. We offer weather sensors, micro-weather data and forecast services, with special weather models for urban areas, custom weather analytics tied to mission and aircraft type, and Meteorologists on-demand to assist end users in making mission critical decisions. We offer Software-As-A-Service delivered via APIs and a web portal interface.

Stakeholders

Uncrewed Traffic Management Service Suppliers, Flight Information System providers, Civil Aviation Authorities, Airspace Navigation Service Providers, OEMs, Infrastructure Providers, local and state/ provincial governments (e.g., Departments of Transportation), weather sensor companies, UAS Test Ranges, Research Institutes, (e.g., NASA), military agencies, National Meteorological Services, UAVs-As-A-Service providers

Value chain description

Weather Intelligence Value Chain



Value: **To enhance micro weather data, science discovery, dissemination & delivery to increase comprehension, predict impacts, and achieve optimal outcomes**

Business Model description

Professional Services, Software-as-a-Service, reselling data and products through resellers, such as UTMs, ANSPs, MNOs, etc. We charge per API Data or Product request. We have tiers of services, starting with a Standard API package, then adding value-added products offered through our Premium and Premium Plus offerings,

Which services would be beneficial for you that an operator can offer?

Weather data collected off of UAVs with weather sensors, derived wind data from UAVs using telemetry and flight control information.

Additional resources

www.truweathersolutions.com

If an MNO offers services to the emerging UAV and AAM industry, MNO can house weather sensors on towers, collect data from UAVs, and provide end computing resources for TruWeatherSolutions to assimilate UAV weather reports and run analytics to provide hazardous weather detect and avoid services back to the aircraft or ground stations. TruWeatherSolutions can also offer micro-weather services through potential MNO service offerings.

Use Case: 3D Dimensional Coverage Data

It provides the view from the company Dimetor in relation to the Use Case described in section

Dimetor

AirborneRF provides the bridge between MNOs and aviation systems.

AirborneRF is an analytics, data and service platform enabling beyond visual line of sight (BVLOS) UAV operations in mobile networks, by providing critical and dynamic data for answering key questions in the aviation industry, including:

- Where in the airspace is sufficient connectivity for safe BVLOS operation
- How many people are on the ground along the flight route – at the time of flight

Stakeholders

MNOs, AirborneRF, and the different stakeholders at the aviation side, incl: UAV operators, USSPs, UTM providers, authorities, SORA and other risk assessment

Value chain description

UAV operators, UTMs and authorities are in need of information about airspace connectivity and ground risk.

Through their platforms they send a request – which is handled automatically by AirborneRF, which triggers the processing of the required data at the Mobile network operator (AirborneRF is deployed at the MNOs, to make sure that no sensitive or classified data is every leaving the MNO. All processing happens in the classified data center of the MNO.).

The results are then automatically returned to the UTM, UAV operator, authority for further consideration.

By automating this process, AirborneRF enables the safe BVLOS UAV integration into a single, integrated airspace at scale.

Business Model description

Licensing model with the MNOs – so that the MNOs can sell data and value-added services to their customers, i.e. existing enterprise customers looking for IoT services in the skies (delivered by UAVs), UTM, USS/USSPs and authorities.

Which services would be beneficial for you that an operator can offer?

NOTE: we are providing white labelled solutions to mobile network operators, so that THEY can actually provide services. Thus we need

- ☐ Cooperation for the integration of AirborneRF
- ☐ Hosting and IT support
- ☐ SIM cards and connectivity for tests

Additional resources

Use cases and background information, as well as further industry news about that topic are provided on **www.airborneRF.com**

https://involi.com/leman-rid-drone-tracker

Use Case: 3D Dimensional Coverage Data

It provides the view from the company Involi in relation to the Use Case described in section 5.12.

Involi

INVOLI provides technology for the safe integration of UAVs into air traffic. Specifically, INVOLI allow UAV operators to visualize on a web platform the position of air traffic close to their UAV. These aircraft are detected by a network of air traffic receivers, more often installed over telecommunication infrastructure (LTE mast or broadcast infrastructure)

Stakeholders

UAV operators: they are the final users of our system, by using our system they are authorized to fly beyond visual line of sight, as our system lower the air risk of a UAV mission

Infrastructure providers: we install our hardware over telco infrastructure

Telcos: we use Sim card for the connectivity of our receivers

Civil aviation authority: approves the UAV mission

Value chain description

The receivers acquire the position of air traffic, we provide a stream of air traffic data for a monthly subscription.

Business Model description

Ideally, the business model would be to deploy a network of receivers on a national level, then provide the data gathered “as a service” to UAV operators.

Today instead, we do smaller deployments on demand of customers, or we sell receivers and UAV operators install them.

Which services would be beneficial for you that an operator can offer?

An operator could facilitate the provision of our system in the following way:

- Installation of our receivers
- Provision of SIM cards
- Financing the infrastructure investment for a complete deployment of our solution

Additional resources

www.involi.com
https://involi.com/g-1090-air-traffic-receivers-line
https://involi.com/air-traffic-information-data-services

Our company also provide Remote ID receivers, capable to detect UAVs, and UAV trackers to be attached directly over UAVs for remote tracking.

https://involi.com/leman-rid-drone-tracker

Use Case: Automated Infrastructure Inspection and Critical Assets Monitoring

It provides the view from the company Sees.ai in relation to the Use Case described in section 5.16.

Sees.ai

A new and critical software layer is required to realise the] full potential of unmanned flight. Spanning from the edge (enabling advanced onboard autonomous navigation & decision-making) to the cloud (assuring safe deployment by enabling central control, coordination and oversight), this layer will be central to assuring performance, safety, accountability & traceability of UAV fleet operations at scale.

sees.ai [sees.ai] is a Boeing and Techstars-backed business developing this software layer ("the OS for unmanned flight")

sees.ai [sees.ai] was founded in 18 by four senior technologists ex. Apple, C RN, Mc aren hedge funds. Leveraging the founding team's careers (which include 1 Formula 1 world championship win; two America's Cup wins; development & deployment of the world's first hybrid supercar powertrain; and developing software successfully trading billions of $$$), **sees.ai [sees.ai]** has built and tested one of the world's most advanced solutions for unmanned flight (with a particular focus on enabling complex close-quarter missions in challenging environments) and secured one of the world's most advanced UAV permissions (the most advanced BVLOS permission ever given by the UK CAA).

Focus on data capture for asset-intensive industries, defence & security today; logistics and mobility tomorrow.

Current focus use-cases are powerline/tower inspection and oil & gas (methane detection).

In detail:

Our software solution ...

- Enables remote (BVLOS) execution of complex 3D missions in challenging environments
  - Includes unknown, unstructured and evolving environments with denied or degraded GNSS and or comms,
  - Leveraging advanced onboard autonomous navigation & decision-making
  - Leveraging a ful-proprietary LIDAR visual inertial SLAM solution
- Enables 1-many control:
  - Enables single operators to remotely operate and coordinate multiple highly-automated UAVs
  - High degree of autonomy reduces operator workload to that comparable with operating a single UAV
  - Data is presented to the user in an easy to understand format, allowing multiple systems to be commanded in tandem

Sees.ai

- Enables quieter (lower RF) operations
  - High degree of autonomy enables execution of complex missions with minimum comms/without continuous comms and operator control
  - Deconfliction not dependent on RF link, meaning safe operations/immune to C-UAS EW
- Reduces human support requirements:
  - Reduces operator burden: Autonomous navigation introduces semantic/high-level tasking (the ability to instruct what the platform should do and UAV will work out the best route and safest options to achieve the mission) rather than direct human piloting
  - Removes the need for human intervention on the ground / for manned personnel at origin (UAV would be able to 'queue' for payload loading via autonomous routine)
  - Reduces operator training requirement
- Facilitates situational awareness:
  - Our navigation sensors gather a very rich amount of geospatial data which can be transmitted to the GCS in real time
- Is largely agnostic to UAS platform - as long as the platform can carry our C2 payload which weighs approx. 2kg

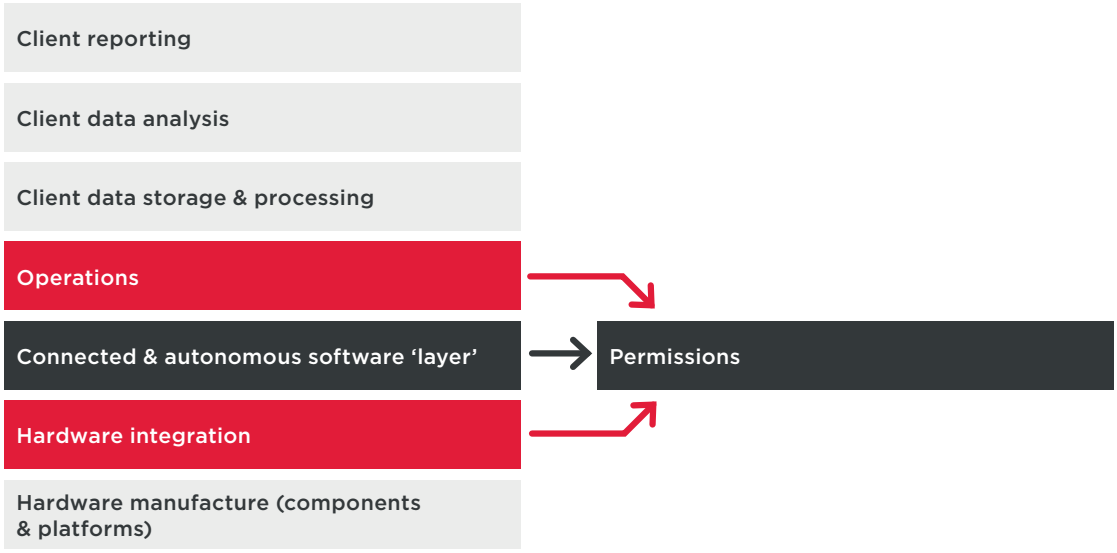
Stakeholders

Investors include Boeing, Tawazun and Techstars.

Value chain description

Sees.ai focus is on delivering the Command and Control software layer. Delivering to end customers involves some operations and integration with off-the-shelf hardware. As we progress this will be wholly done by others (e.g. UAV Service Co.s, manufacturers, end-customers) with our support.

Value chain description



Business Model description

The business model is software licencing of the Command and Control software layer. This is to hardware manufacturers/integrators, UAV Service Providers (DSPs) and manufacturers.

Which services would be beneficial for you that an operator can offer?

- ☐ Access to PoC opportunities with major asset operators/service providers to develop target use cases
- ☐ BVLOS communications technology and infrastructure
- ☐ Data and comms integration support

Additional resources

Videos:

GCS view of flight around oil & gas asset (pilot in Chichester / UAV at Fire Service Training College) **https://drive.google.com/file/d/1k0y9TcETrNZrk_m0SNBNXIX9evd5_-52/view?usp=sharing [drive.google.com]**

Overview of our work with National Grid - **https://www.youtube.com/watch?v=kAutTkMtFpQ [youtube.com]**

Flight around an electricity pylon (in sim) - **https://drive.google.com/file/d/1eLzKOkZfQO_Ah_bAWxYTg_-YohfMyKs6/view?usp=sharing [drive.google.com]**

Use Case: U-Space – Services Provider/UTM Services Supplier

It provides the view from the company OneSky in relation to the Use Case described in section 5.18.

OneSky

OneSky is a clear leader in the provision of UTM solutions, delivering U-Space capability from a secure, proven, scalable platform as well as supporting advanced capabilities for more sophisticated deployments for BVLOS and Advanced Air Mobility requirements. From deploying UTM/FIMS solutions to Airservices Australia, UTM Operations Management for Skyports advanced delivery services, the traffic management solution for the Korea AAM Grand Challenge, ConOps and Capacity Planning solutions to a variety of Vertiport organisations and analytical services for safety, mission planning and tracking to OEMs globally, OneSky is delivering the solutions needed to maintain the safe operation of UAVs in an increasingly congested and complex airspace.

UTM as an enabler

OneSky believes that UTM is far from just a UAV tracking technology, but rather an infrastructure that supports automation in the UAV ecosystem. We consider our open scalable UTM platform as the enabler for authorised authorities to transition and implement UAS services in collaboration with existing service infrastructure. Our unique UTM interfaces allow multiple and varied UAS information including telemetry flight data monitoring and management within the planned and operational authorised flight volumes, corridors and routes, in a safe and efficient manner. Our solution is based upon the latest endorsed ASTM standard and follows the secure development/deployment approaches with the ISO 270001 cybersecurity standard and GDPR compliant.

Industry leadership

OneSky's efforts originated within our parent company, Analytical Graphics inc (AG) providing advanced dynamic analytics to the aerospace and defence markets for more than 30 years. AGI recognised the opportunity to apply the same validated and proven analytics to the commercial UAS market and initiated the OneSky effort. OneSky has been developing our core UTM architecture since early 2015, beginning with our efforts on the NASA UTM programme and later efforts with the FAA's adoption of UTM concepts in the UTM Pilot Programme. We've helped these organisations innovate the ecosystem and data sharing methods and standards that are required to ensure that heterogeneous UAV fleets can seamlessly share operational data into a common ecosystem. While this work was started with OneSky and NASA in 2015, it has emerged as a global concept with standards support from the ASTM Standards Development Organisation (SDO) and industry support from the Global UTM Association (GUTMA) of which OneSky was a founding member. OneSky has helped developed the UTM methodology, including uses of UTM for Remote identification through our support of the FAA's Remote Aviation Rulemaking Committee (ARC) in 2017 and support to the Swiss Federal Office of Civil Aviation (FOCA) operational deployment of RID in 2020. Furthermore, we have deployed and tested UTM in similar urban environments through our multi-year contract with the Civil Aviation Authority of Singapore (CAAS).

OneSky

Market Differentiation

Our differentiation in the industry is rooted in our aerospace engineering heritage and 4D approach to airspace challenges. Existing communications, navigation and surveillance technology is challenged in environments where there are obstructions, like buildings and trees. In addition, the social challenges associated with integrating UAVs into the local landscape are requiring new ways of thinking about local restrictions and how to integrate these into national ATM systems. OneSky's approach is differentiated by our aeronautical experience and robust technology stack ready to facilitate safe efficient operations as reflected by our People, Philosophy, Technology and Customer Focus.

People

Having made aerospace analytical software their lifelong passion, our team is rethinking air traffic management for UAVs and developing UTM software that encourages integration into existing ATM systems. Almost half of our team was formerly with AGI and have a career thinking about dynamic operations in 4D. Over 60% of our team has aviation degrees or are FAA licensed pilots, 60% have software development degrees and we have over 175 years of experience working together and 345 years of aerospace industry experience at companies including AGI, AirMap, Altitude Angel, Boeing, Honeywell, IDS, Lockheed Martin, Wind River and the United States Air Force and Navy.

Philosophy

UTM is a system, not a single technology, and its goal is to enable cooperative traffic management and enhance the existing Air Traffic Management (ATM) systems by resolving some of the challenges with non-cooperative, surveillance-based systems.

The "magic" of UTM is based on the desire of most operators to share operational intent and contribute live tracking data to the ecosystem for the purpose of being a part of the safety. Cooperative traffic management is made possible because we now live in a connected world, and aircraft have become another node on the Internet of Things (IOT). The challenge of UTM is to connect UAVs into the ecosystem, and to do it with aerospace precision but rethink the way in which we do it. Therefore, OneSky is the right company to work with in deployment of a UTM system. We understand the legacy issues, are creating the new technology solutions and can deploy it within a modern infrastructure.

Our name, "OneSky" points to our desire to develop cooperative traffic management systems that span all levels of flight, from UAVs to commercial air traffic, to high altitude flight for air balloons and supersonic aircraft all the way to space. At OneSky, our vision is to "harmonise the Skies", and we will do this by integrating vertical systems like STM, ETM, ATM and UTM into a common ecosystem – Traffic Management - with the purpose of enhancing safety and security culture of all airspace users.

OneSky

Technology

OneSky has designed our cloud-based UTM platform around the principles of a proven, aviation grade, modelling and simulation software platform. This ensures the following capabilities are fundamental across our UTM, ensuring support for today's needs whilst the need to scale and support more advanced operations is designed into the core platform:

- 4D, because that is how the world operates
  - Accurately reflects the operational environment
  - Maximises use of the airspace vertically, horizontally and by time
  - Supports 2D, 3D and 4D visualisation without compromising capability
  - Critical for safety in low altitude operations constrained by geospatial features and terrain
  - Invaluable for Beyond Visual Line of Sight (BVLOS) operations
  - Vital for Urban Air Mobility
- Integrated
  - UTM is a system of systems, not a standalone solution
  - Stakeholders should be able to use their existing systems connected seamlessly
- Open
  - Designed for collaboration
  - Partnership approach supports innovation
  - Builds local economic benefits
  - Supports eco-system growth
- Analytics, not just data
  - Enables decision making rather than reporting
  - Consistency in processing builds trust
  - Service-based re-usable components accelerates development and innovation
  - Supports certification process

OneSky

Customer Focus

Through engaging collaboratively, OneSky provides a “right-sized” environment for all airspace users when they need it. OneSky has already developed the capabilities required over the coming 3-5 years to support BVLOS operations and advanced air mobility capabilities allowing our customers to “switch on” these features when needed. Our phased deployment approach ensures a timely deployment of a platform localised and configured specifically to ON’s needs for today and in the future. This is evidenced through the establishment of our “Future of Flight” programme and associated partners. More information can be found here: **https://www.onesky.xyz/future-of-flight-program**.

Summary

OneSky combines market leading technology, designed to integrate and scale, supported by a team of experienced aviation experts with a passion for advanced air mobility. Only the OneSky platform enables our customers to take the journey from initial U-Space compliance to advanced BVLOS operations, initial automation and the ability to scale the advanced air mobility industry.

Stakeholders

- ☐ UTM/ANSP’s for low level airspace management (FIMS,DSS,USS & Operator interfaces for GCS)
- ☐ UTM/PSU -UAM/AAM for cooperative Traffic Management from low level airspace and ATC controlled airspace for medium level airspace
- ☐ Extensible (X)TM – for Low Altitude and High Altitude Traffic Management
- ☐ Space Traffic Management
- ☐ The OneSky UTM is the foundational digital systems of systems for extensible traffic management for ETM and STM as well as the next generation of current ATM traffic management as it moves forward on digitization and automation

Business Model description

SaaS, (also on premises where required) Risk and Revenue sharing in collaboration with authoritative government or major industry agencies

Which services would be beneficial for you that an operator can offer?

Firstly, We are trying to assist by identifying services which can be considered to be deployed and monetized by any MNO in our opinion as the UAV industry, regulations and airspace access open up. Our UTM tech stack is open and MNO services can be interfaced or integrated with the MNO network.
MNO offers UAV operator services as an SDPS.

Typically such services considered by MNO's are:

- ☐ SDSP services to operators
- ☐ Connectivity service levels
- ☐ Basic UAV tracking – RID broadcast and network
- ☐ Dynamic optimized signal strength based upon routes in privileged performance airspace
- ☐ Dynamic population density maps linked to optimized signal strength.
- ☐ Routing services to ensure flight path adherence.
- ☐ Real-time transfer of the data generated by the UAV payload. Payloads can include HD, 4K and/or thermal cameras and sensors (such as LiDAR systems, which use lasers to determine variable distances). UAVs with these payloads are more likely to use 5G due to their need for large amounts of data and low latency.
- ☐ The provision of a connectivity link to an unmanned aircraft systems traffic management (UTM) system to enable command-and-control (C2)

Should the MNO decide to become a UTM/USS/P and depending on how many services each country allocates to be implemented by a qualified USS/P, in addition to the SDSP services outlined above (I expect they would be added to USS/P services offered) then the below list of possible additional USS services may be monetized by an MNO who wishes to do so, or an MNO may wish to partner with a UTM supplier for the USS/P technology stack and have a risk revenue sharing arrangement.

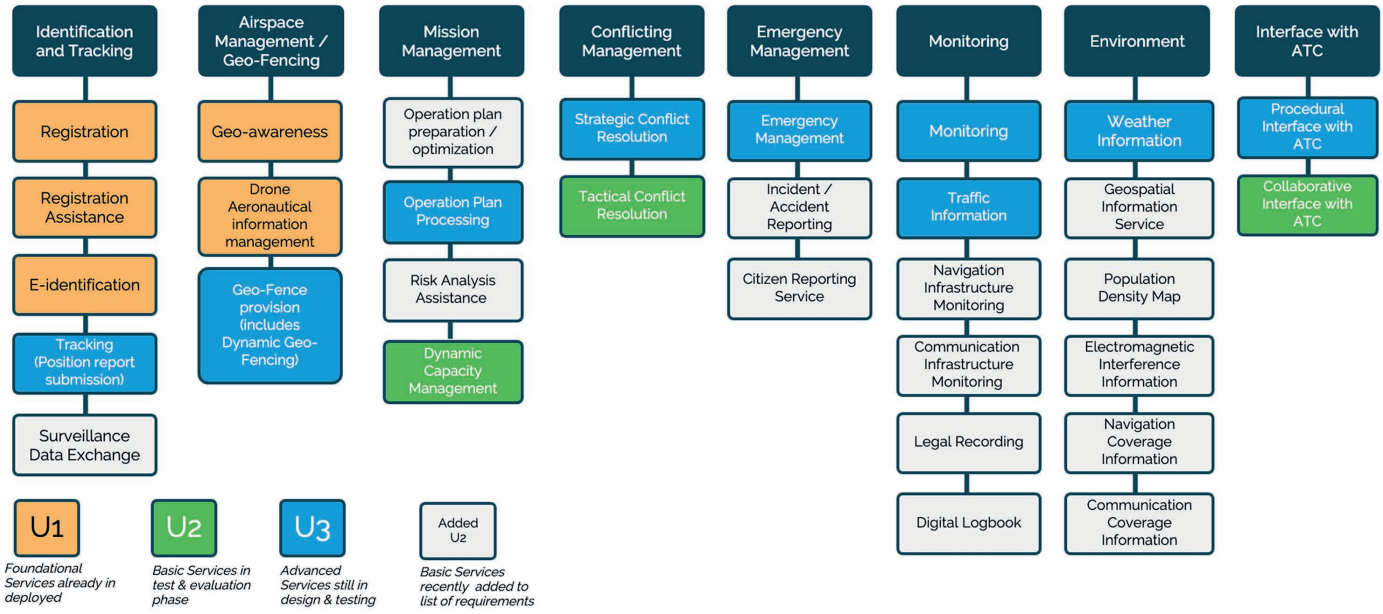
Which services would be beneficial for you that an operator can offer?

MNO Potential USS/P Services		
U1	U2	U3
e-Registration - CAA Electronic chip - MNO	Tactical geo-fencing - MNO	Dynamic geo-fencing - USSP/MNO
e-Identification - RID Drone - MNO	Live airspace data feed - Area infringement notification MNO	Tactical de-confliction - DO/USSP/MNO
Pre-tactical geo-fencing - MNO	Flight planning management - MNO	Collaborative interface with ATC - ANSP/USSP/MNO
Geo-limitation database - MNO w/ANSP	Automated FPL validation - Operations digital authorisation - Digital NOTAM MNO	ATC alert notification - USSP/ ANSP/MNO
	Weather information - Low altitude wind forecast - Weather hazard alerts MNO	Global air situation monitoring - USSP/MNO
	Traffic Monitoring - USSP/MNO	Airspace capacity monitoring - USSP/ANSP/MNO
	Radio Positioning Infrastructure - Real-time tracking - MNO	Demand/capacity imbalance detection - USSP/ANSP/MNO
	Traffic data recording - MNO	UAS traffic complexity assessment USSP/ANSP/MNO
	Air situation monitoring - Flight non-conformance detection - MNO	Dynamic capacity management USSP/MNO
	Area infringement detection - Alerting & Reporting - MNO	
	Drone aeronautical information management - UTM-relevant static aeronautical data - MNO	
	UTM-relevant dynamic aeronautical data - MNO	
	Procedural interface with ATC - MNO	
	ATC/UAS coordination procedures - MNO	
	Flight notification procedures - Emergency and contingency procedures - USSP/ANSP/MNO	
	Emergency management - Emergency alert line - Emergency assistance information - USSP/ANSP/MNO	
	Strategic de-confliction - USSP/MNO	

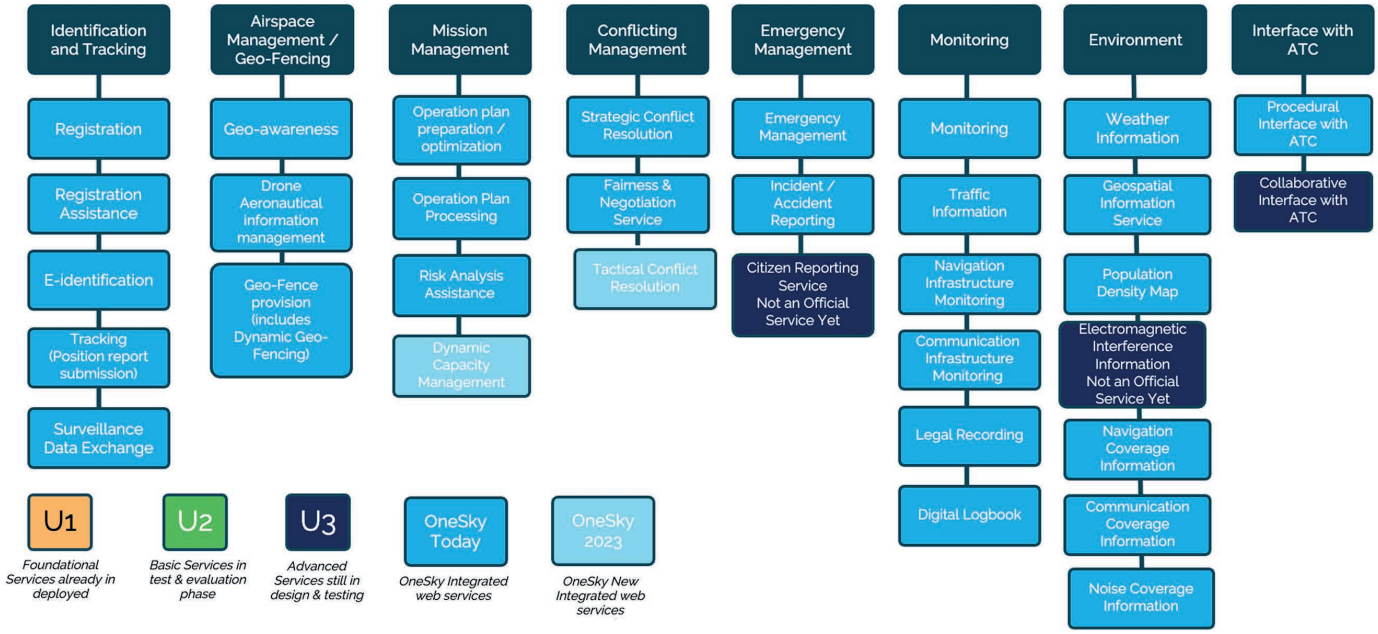
OneSky has already developed and implemented the following U Space services. **They are UTM architecture agnostic meaning can be deployed via a FIMS or a USS**. OneSky uses a DSS as an ASTM compliant directory for discovery and synchronization for multiple USS's and end to end data exchange. The OneSky UTM also has integrated multiple SDSP services from

Which services would be beneficial for you that an operator can offer?

Communication to Weather etc. Original U Space Services Map -4 years ago



OneSky's UTM Services Map today



Abbreviations

TERM	DESCRIPTION
3GPP	3GPP 3rd Generation Partnerships Project
AaaS	Automation as a Service
AAM	Advanced Air Mobility
ACJA	Aerial Connectivity Joint Activity
ADS-B	Automatic Dependent Surveillance - Broadcast
AI	Artificial Intelligence
ANSP	Air Navigation Service Providers
API	Application Programming Interface
APRU	Average Revenue Per User
ATM	Air Traffic Management
BRID	Broadcast Remote Identification
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
C2CSP	Command and Control Service Provider
CAGR	Compound Annual Growth Rate
CEPT	European Conference of Postal and Telecommunications Administrations
CIS	Common Information Services

TERM	DESCRIPTION
CNCP	Control and Non-Payload Communication
CSP	Communication Service Provider
CV	Computer Vision
E2E	Exchange-to-Exchange
eVTOL	Electric Vertical Take-Off and Landing Vehicle
FIMS	Facilities and Information Management System
FLARM	Flight Alarm
FTE	Full-time equivalent
GPS	Global Positioning System
GPU	Graphics Processing Unit
GRP	Ground Risk Process
GSMA	GSM Association
GUTMA	Global UTM Association
IoE	Internet of Everything
IoT	Internet of Things
IPO	Initial public offer
ISV	Independent Software Vendor
LTE	LTE Long Term Evolution
MEC	Multi-access Edge Computing

TERM	DESCRIPTION
ML	Machine Learning
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NEP	Network Equipment Provider
NFV	Network Functions Virtualisation
NR	5G New Radio
NRID	Network Remote Identification
FTE	Full-time equivalent
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
QoS	Quality of Service
RAN	Radio Access Network
RTK	Real-Time Kinematic
SDN	Software-Defined Network
SDSP	Supplemental Data Service Provider
SI	System Integrator
SIM	Subscriber Identification Module
SLA	Service Level Agreement
SORA	Specific Operation Risk Assessment

TERM	DESCRIPTION
SPAC	Special Purpose Acquisition Company
UA	Uncrewed Aircraft
UAS	Unmanned Aerial System
UAT	Unmanned Aerial Target
UAV	Unmanned Aerial Vehicle
UE	User Equipment
U-Space	UAS geographical zone designated by Member States
USSP	U-Space Service Providers
UTM	Unmanned Traffic Management
V2V	Vehicle-to-vehicle
WAAS	Wide Area Augmentation Services
WIFI	Wireless Fidelity
WLAN	Wireless Local Area Network

GSMA

The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change.

Our vision is to unlock the full power of connectivity so that people, industry and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

We invite you to find out more at gsma.com

Follow the GSMA on Twitter: @GSMA

GSMA Membership

GSMA is a membership-led organisation where members collaborate with industry peers and stakeholders, engage in influential discussions, and drive industry-wide initiatives that address the most pressing industry challenges and opportunities. As a GSMA Member, you'll have a seat at the table where decisions are made, specifications are developed, and the future of mobile telecommunications is shaped. Join a global community of like-minded professionals and organizations who share a common goal of advancing the mobile ecosystem for the benefit of billions of people worldwide.

Find out more: gsma.com/membership