Milton Keynes City Council

Regulators Pioneer Fund

DronePort:MK - Regulating Uncrewed Aerial Vehicles within Smart City Environments

Final Report

Table of Contents and Figures

CONTENTS

FIGURES

1. Version Control

Version Number	Date	Author	Description
1.0	04/04/25	SMCCL	Issued after internal review
2.0	23/04/25	SMCCL	Updated with further consortium review comments
3.0	08/07/25	SMCCL	Updated with DSIT feedback

2. Glossary

Acronym	Meaning
AAE	Atypical Airspace Environment
ATZ	Aerodrome Traffic Zone
CAA	Civil Aviation Authority
CAN	Controller Area Network
CAV	Connected and Autonomous Vehicle
ConOps	Concept of Operations
DX	Data Exchange
FRZ	Flight Restriction Zone
FS&I	Future Safety & Innovation
GCR	Ground Control Room
GCS	Ground Control System
GDPR	General Data Protection Regulations
GIS	Geographic Information Systems
GPS	Global Positioning System
IP	Intellectual Property
OSC	Operating Safety Case
PNT	Positioning, Navigation and Timing
RAMS	Risk Assessment and Method Statement
RIO	Regulatory Innovation Office
SAP	Situational Awareness Platform
TRA	Temporary Reserved Area
UAS	Uncrewed Aerial System
UAV	Uncrewed Aerial Vehicle
UGV	Uncrewed Ground Vehicle
UTM	Uncrewed Traffic Management

3. Executive Summary

Background

Milton Keynes has a well-established reputation as an 'urban laboratory', embracing new technologies, fostering, cultivating and stimulating innovation and working in collaboration with public- and private-sector partners to create new technological, commercial and operational models to deliver better long-term outcomes.

Our Smart City vision anticipates connected autonomous vehicles (CAVs), robots and unmanned aerial vehicles (UAVs) working in concert to deliver services including health and safety, security, delivery and hospitality. Having invested in ground-based autonomous service delivery, we believe it is right to extend our work and integrate airborne vehicles and services. Our DronePort:MK project was designed to do that by identifying and testing demand for such services, exploring technological solutions to allow safe and secure operations, leveraging and extending our Smart City infrastructure assets, in order to contribute to the ongoing development of the regulatory framework.

Looking forward, we see opportunities to introduce airborne services that realise new and different use cases that unlock new technical, commercial and operational innovation and our DronePort:MK project is a first step towards that vision, re-affirming Milton Keynes as the city where 'ideas become reality'.

Project Costs and Timeline

The total cost of the DronePort:MK project was: **£1,000,000**, the total grant was: **£1,000,000.**

The **19-month** project ran from: **September 2023** to **March 2025** (inclusive); originally scoped as an 18-month project, a 1-month extension was granted through a project change request.

Consortium Membership

The consortium included the following organisations, with roles briefly described below:

- **Milton Keynes City Council:** project sponsor and lead
- **Smart City Consultancy:** testbed provision, project management, engagement and outreach
- **Cranfield University:** detailed use case development, technological assessment and high-level architecture, Safety Case development (Medical Delivery)
- **Satellite Applications Catapult:** high- and low-level design activities, including security aspects, and exploration into the interplay between the ground- and air- plane, CAV's and UAV's

In addition to the consortium partners, two procurement exercises were undertaken by Milton Keynes City Council, supported by the wider consortium, in accordance with Public Sector Procurement Policies in order to secure additional expertise in terms of drone operations and the enabling technologies:

- Procurement of an experienced drone services provider
- Procurement of an experienced Situational Awareness service provider

Rationale or Demand

At its heart, the DronePort:MK project was conceived through the recognition that significant advantages could be derived through use of drone services and that these could benefit, not only the private, but public sector – speeding up service delivery, reducing cost and carbon intensity and enhancing the experience of both service users and the teams who deliver these services.

In all forms, autonomous vehicles require a solution that improve safety and security through enhanced situational awareness, e.g., through advanced, real-time data aggregation that interconnects a broad-range of sensor, mapping and other data.

Whilst ground-based autonomous operations, using CAVs are now readily deployable, through a combination of technological, regulatory, industry and operational advancement, the same could not be said for drone operations.

Airspace regulators remain concerned with safe autonomous air-based operation, and associated navigational risks, e.g., obstacles, other traffic, hazards etc., as well as the potential ground risks, however, the cautionary approach has limited progress, restricted investment, blunted innovation and impacted the UK's global readiness to compete in an emergent, but high-growth sector.

To deliver commercially-viable autonomous services, whether ground- or air-based, removing the local operator is key. In terms of CAV's, whilst current regulations require an onboard safety-user-in-charge, the regulatory landscape is evolving to enable removal of onboard safety operators by 2027. This is driving the CAV sector to develop remote monitoring and tele-operations solutions, technology-based safety and situational awareness platforms and wider operational capabilities that anticipate this change and that are designed to ensure the industry is ready for the new remote operating model envisaged.

The equivalent within the drone sector is moving to BVLOS – or Beyond Visual Line of Sight operations, where similar requirements to assure and oversee the safe operation of uncrewed drone operations are anticipated, with similar requirements to remotely monitor, control, oversee and assure the services, and provide enhanced situational awareness in order to achieve Safety Case approval and build acceptance and trust – for regulators, stakeholders and local citizens alike.

What we did and how we did it

DronePort:MK was designed to reassess this challenge from a different position – that of a Local Authority with certain regulatory powers, supported by a team of world-class partners with deep domain experience – with a view to exploring alternative approaches to assuring safety and security of drone operations within a city environment, and building the demand case for such services. We took a 4-phase approach to our work, summarised below:

- **Definition:** activities included use case definition, scenario modelling and prioritisation, initially for Medical Delivery and Asset and Infrastructure surveillance, but also in other City Council service areas, e.g., incident response, housing and wider Highways activity
- **Technology:** technical assessments and requirements definition for the data platform, sensors and positioning and timing services; development of a target architecture and high- and low-level design (inc. security aspects); procurement activities were undertaken along with work to develop the CAV/UAV integration activity
- **Product:** preparatory operational verification and operational validation work, including route mapping, planning, risk assessments etc., development of the Concept of Operations and Operating Safety Cases, legal assessments, stakeholder management, engagement and

communication, provision of the Ground Control System and Control Centre integration, test flights to prove the concept; test missions to explore CAV/UAV integration

- **Demonstration:** Asset and Infrastructure Surveillance missions were operated in Central Milton Keynes, using a mini drone with spotters to capture inspection data from a number of vantage points in the Open Category; these flights recorded data that provides baseline photogrammetry to support a Digital Twin of the city for Milton Keynes City Council

Key Outcomes

As well as the different project outputs, the key outcomes from the project were:

- Definition of a Target Technical Architecture designed to ensure Local Authority Oversight and Assurance of drone operations in City Centre environments
- Development of a demand pipeline, demonstrating the 'pull' from Local Authorities for drone-based services, covering multiple services and departments and the potential benefits that can be afforded
- Proof of Concept work demonstrating the value of drone operations in City Centre environments to support development of a Digital Twin
- OSC prepared and submitted to the CAA to support the Medical Delivery use case, subject to establishment of the Cranfield Airport TRA
- OSC prepared and submitted to the CAA for Highways use case, subject to establishment of the Cranfield Airport TRA
- Local Authority readiness to support future drone operations in accordance with current regulation and legislation

Problems Encountered

The following problems were encountered during the project:

- Collectively the consortium under-estimated the challenges of securing approval and this work was left too late in the project
- A number of technology integration challenges were observed, due to the proprietary or emergent nature of some of the technology components

Lessons Learned

In terms of wider lessons learned, these are summarised below:

- There is public interest in provision of drone-based services, from service providers, citizens and industry, as well as local landowners
- There is a significant level of demand and a rich set of use cases identifiable within the public sector (Local Authority, Health and Social Care etc.)
- These use cases have the potential to transform how services are delivered and will enable efficiencies, both in terms of resources and methods
- Further, adoption of drone-based services will contribute significantly to Net Zero
- There is value in exploring UAV / CAV interplay for a wider set of use cases, building on the proof-of-concept work undertaken in this project
- For the public sector, a multi-service approach is sensible, driving utilisation and enabling the costs of the drone network and associated infrastructure to be shared

- Services can only become commercially-viable once operating BVLOS; a much broader market opportunity exists and this would be economically significant
- The ability to secure BVLOS approvals, whilst possible, remains challenging and potentially restricts the number of industry players who can contemplate engagement
- The current approaches to regulatory approval are challenging for smaller operators, even when public funding is available to support collaborative R&D projects such as this
- These risks, taken together, risk stifling the industry within the UK, with operators attracted to other territories or use cases that do not present such high barriers to entry
- Other regulatory approaches, e.g., use of a TRA is likely to offer a lower barrier to entry, and appear essential to enable at-scale services to both mobilise and operate
- Other considerations in terms of enabling approval include creating low-risk flight paths as part of the planned environment, e.g., drone corridors to form part of future city planning
- Technology exists that can enable Local Authorities to cost-effectively provide a level of oversight and assurance, e.g., through the Smart City Control Centre, or equivalent
- Establishing a Smart City Control Centre visualisation and monitoring system for tracking the position of all uncrewed aircraft within the airspace over the city is seen as critical
- Such a solution would include a cost-effective, simple to deploy and operate situational awareness air space monitoring system (and associated sensor network) in place, rather than traditional UTM systems, or radar-based networks
- Any solution will require reliable, secure, and suitable communications infrastructure
- Further work is needed to demonstrate that the new technology is safe, secure and reliable
- To secure lasting benefits, work should also continue to drive for a more permissive regulatory environment, to share best-practice and to support scale-up
- The newly formed Regulatory Innovation Office (RIO) could play an instrumental role in driving these changes; the recent RIO and FS&I engagement letter regarding CAA priorities for UAS is seen as a positive step in enabling future project work
- There is value in comparing the different regulatory approaches across the CAV and UAV sectors, both have similar challenges, but the pace of change is significantly different

Next Steps

In terms of next steps, Milton Keynes City Council will continue to develop its thinking in terms of service transformation through use of drone-based services, supporting development of commercial and business cases, and seeking ways to build on the Digital Twin work.

Smart City Consultancy have developed their ‘Autonomy-as-a-Service’ proposition, a reusable blueprint designed to deliver autonomous services, whether ground- or air-based and enabling central assurance and oversight functions.

Finally, Cranfield Airport continue to develop their TRA proposals, which would enable further work to be undertaken locally, as part of a follow-on project, and the OSCs prepared for the Medical Delivery and Highways use cases could be enacted.

4. Background

Milton Keynes has a well-established reputation as an 'urban laboratory', embracing new technologies, fostering, cultivating and stimulating innovation and working in collaboration with public- and private-sector partners to create new technological, commercial and operational models to deliver better long-term outcomes.

Our Smart City vision anticipates connected autonomous vehicles (CAVs), robots and unmanned aerial vehicles (UAVs) working in concert to deliver services including health and safety, security, delivery and hospitality. Having invested in ground-based autonomous service delivery, we believe it is right to extend our work and integrate airborne vehicles and services. Our DronePort:MK project was designed to do that by identifying and testing demand for such services, exploring technological solutions to allow safe and secure operations, leveraging and extending our Smart City infrastructure assets, in order to contribute to the ongoing development of the regulatory framework.

Looking forward, we see opportunities to introduce airborne services that realise new and different use cases that unlock new technical, commercial and operational innovation and our DronePort:MK project is a first step towards that vision, re-affirming Milton Keynes as the city where 'ideas become reality'.

This document summarises the project achievements and learning, and is designed to disseminate learning from the project.

5. Project Costs and Timeline

The total cost of the project was: **£1,000,000**
The total grant was: **£1,000,000**

The **19-month** project ran from: **September 2023** to **March 2025** (inclusive).

Originally scoped as an 18-month project, a 1-month extension was granted through a project change request.

6. Consortium Membership

The consortium members were as follows.

Partner	About
www.milton-keynes.gov.uk	**Milton Keynes City Council:** at the forefront of leading Smart City innovation, the Council have successfully delivered a number of projects, in areas that include 5G communications, self-driving vehicles, robotics and drones, establishing Milton Keynes as an 'urban laboratory' that deploys new technology for the benefit of our citizens. Our role as project sponsor and lead is to catalyse activity, and undertake related citizen and stakeholder engagement work to assure success. We also led the relevant procurement activities for the drone and sensor providers required to support the technical aspects. Finally, as an asset-owning Unitary Authority with powers of both a non-metropolitan county and district council combined, our role is to provide specialist legal and regulatory advice and to identify demand for, and barriers to delivery in order to inform project outputs and outcomes. We exercise a number of regulatory functions per Legislative and Regulatory Reform Act 2006 definitions and work to HM Treasury's Managing Public Money Handbook and associated Public Sector Procurement Policies.

Partner	About
SMART CITY CONSULTANCY www.smartcityconsultancy.co.uk	**Smart City Consultancy:** from our base in Milton Keynes, we deliver Smart City projects, working with a range of public- and private-sector organisations; with a decade of Smart City project experience and unparalleled access to Smart City testbeds, showcase, demonstration and control centre environments and facilities; our projects include creation of smart, connected environments, and safe, secure deployment of autonomous vehicle, drone and robotics solutions. As well as undertaking all reporting and financial management on behalf of Milton Keynes City Council, we provide the testbed and other facilities and undertake wider outreach, educational and engagement activities to ensure learning from the project is shared and disseminated as widely as possible.
Cranfield University www.cranfield.ac.uk	**Cranfield University:** we pioneered use of unmanned aerial vehicle test corridors and contributes facilities such as the Digital Aviation Research and Technology Centre, researching digital aviation and transport, the Multi-User Environment for Autonomous Vehicle Innovation Facility, supporting rapid development of ground and airborne autonomy, a Timing Innovation Node, providing resilient timing services and the Drone Innovation Hub, pioneering work with industry to develop and deploy scalable, commercially-viable solutions that safely manage airborne vehicle interactions through Project Blueprint – part of the UKRI Future Flight challenge - aiming to provide regulators, technology providers and operators with a blueprint for UK-wide rollout of beyond visual line of sight drone operations. Our role on the project was to undertake detailed use case development and to explore technological solutions that could enable drone flights as part of a Smart City environment, working to develop the necessary Safety Cases to enable future flights.

Partner	About
CATAPULT Satellite Applications www.sa.catapult.org.uk	**Satellite Applications Catapult:** we have established the Westcott DronePort in Buckinghamshire and bring expertise and experience in advanced communications technology and ground- and air-based autonomous vehicle deployment. The DronePort provides shared innovation spaces and extensive test facilities, including runways, vertical test stands, safety cages, hangars and other infrastructure needed to prove new drone technologies, as well as wider industry access. Our role on the project was to explore the inter-play between CAVs and UAVs, testing the co-operative capabilities and exploring related use cases that could be deployed in the future as well as high- and low-level design activities (inc. security aspects).

Figure 1 - Consortium Membership

In addition to the consortium partners, two procurement exercises were undertaken in the following areas in order to secure additional expertise in terms of drone operations and the enabling technologies. These activities were led by Milton Keynes City Council, supported by the wider consortium, in accordance with Public Sector Procurement Policies:

- Procurement of an experienced drone services provider
- Procurement of an experienced Situational Awareness service provider

7. Scope

This document addresses the requirements for a 'Final Report' and is designed to help communicate key findings and learning that may be shared with key stakeholders.

8. Rationale or demand

At its heart, the DronePort:MK project was conceived through the recognition that significant advantages could be derived through use of drone services and that these could benefit, not only the private, but public sector – speeding up service delivery, reducing cost and carbon intensity and enhancing the experience of both service users and the teams who deliver these services.

In response to unparalleled city growth and expansion, within Milton Keynes, we have progressively developed our Smart City capabilities to transform city-wide travel, transport and logistics. Having consolidated our (ground-based) mobility-as-a-service offering, including autonomous vehicle deployment, we plan to extend this to autonomous drone-based services, creating a full autonomy-as-a-service solution.

In all forms, autonomous vehicles require a solution that improve safety and security through enhanced situational awareness, e.g., through advanced, real-time data aggregation that interconnects a broad-range of sensor, mapping and other data.

Whilst ground-based autonomous operations, using CAVs are now readily deployable, through a combination of technological, regulatory, industry and operational advancement, the same could not be said for drone operations.

Airspace regulators remain concerned with safe autonomous air-based operation, and associated navigational risks, e.g., obstacles, other traffic, hazards etc., as well as the potential ground risks, however, the cautionary approach has limited progress, restricted investment, blunted innovation and impacted the UK's global readiness to compete in an emergent, but high-growth sector.

To deliver commercially-viable autonomous services, whether ground- or air-based, removing the local operator is key. In terms of CAV's, whilst current regulations require an onboard safety-user-in-charge, the regulatory landscape is evolving to enable removal of onboard safety operators by 2027. This is driving the CAV sector to develop remote monitoring and tele-operations solutions, technology-based safety and situational awareness platforms and wider operational capabilities that anticipate this change and that are designed to ensure the industry is ready for the new remote operating model envisaged.

The equivalent within the drone sector is moving to BVLOS – or Beyond Visual Line of Sight operations, where similar requirements to assure and oversee the safe operation of uncrewed drone operations are anticipated, with similar requirements to remotely monitor, control, oversee and assure the services, and provide enhanced situational awareness in order to achieve Safety Case approval and build acceptance and trust – for regulators, stakeholders and local citizens alike.

DronePort:MK was designed to reassess this challenge from a different position – that of a Local Authority with certain regulatory powers, supported by a team of world-class partners with deep domain experience – with a view to exploring alternative approaches to assuring safety and security of drone operations within a city environment, and building the demand case for such services.

Like many others in the sector, we believe the case for adoption is clear and we believe, that with the right regulatory, technical and operational approaches in play, the benefits outlined in the Skies without Limits (PWC, Jul'22) and other sectoral analysis could be realised. These include a £45B contribution to the UK economy, net cost savings of £22B, carbon reductions of 2.4M tonnes and 650K new jobs. Locally, our work with self-driving shuttles, delivery robots and early drone experiments shows the potential for large-scale drone deployment, offering new, innovative service opportunities, creating greater citizen and business choice and improved, more efficient and highly automated services that drive productivity in areas as diverse as building inspections and movement of emergency medical supplies.

9. What we did and how we did it

We took a 4-phase approach to our work, summarised in the diagram below. Here we summarise each of the phases, what we did in each phase and how we did it.

	Definition - ***what do we think we will do?***	**Technology** – ***what do we need to do it?***	**Product** – ***operational verification – is the product right?***	**Demo** – ***operational validation – is it the right product?***
Main activities	Technical studies	Technical risk mitigation excluding any qualification or industrialisation; early experimentation and testing	Development, qualification, verification and industrialisation, no customer or end-user involvement	Validation in operational environment – includes customer or end-user involvement

Figure 2 – Four-phase delivery approach

<u>Definition</u>

The primary focus in terms of definition was to identify and define the detailed use cases and requirements that would act as the main focus for and guide the project.

Two immediate areas of opportunity were identified, in terms of long-term ambitions. These were:

- City-wide medical delivery across the city, either for scheduled, time-critical or emergency delivery of medicines, medical samples, supplies etc. between locations that include hospitals, GP surgeries, hospice and other healthcare settings, as well as emergency attendance at incidents as part of a first responder activity on a 7x24x365 basis
- City-wide proactive and emergency asset and infrastructure surveys, including full integration with the infrastructure and asset management and maintenance schedules operated by Milton Keynes City Council and its highways infrastructure sub-contractor or used as of a reactive investigation, e.g., following a collision, other incident or event, or a notification or report of suspected damage or potential decay

Milton Keynes University Hospital and Milton Keynes City Council Highways Department were engaged to undertake an intensive review of potential opportunities and to add more detail, including wider operational insights, service or user needs etc., into the use cases as well as to support detailed scenario mapping.

Milton Keynes University Hospital is a district general hospital serving the City of Milton Keynes and the surrounding area of Buckinghamshire, Northamptonshire, Bedfordshire and Oxfordshire. It is located in the Eaglestone neighbourhood, and opened in 1984. It is managed by Milton Keynes University Hospital NHS Foundation Trust. The hospital has an association with the University of Buckingham Medical School and has a track record of delivering new service innovation, for example, piloting the use of drone technologies and service robotics at its main site (see diagram below).

Figure 3 – Milton Keynes University Hospital

Annex A shows an extract from the outline use case material developed with Milton Keynes University Hospital. This was used as the basis for development of the detailed use cases.

Alongside the development of the detailed use cases, the following scenarios were also identified to aid prioritisation and selection for the latter phases of the project.

Scenario	Title	Scope
1	Medical Delivery: MK University Hospital to known fixed point (Willen Hospice)	Base use case: planned operations
2	Medical Delivery: Biological samples – Willen Hospice to MK University Hospital	Dangerous Goods
3	Loss of a drone carrying drugs and / or biological samples between MK University Hospital and Willen Hospice	Abnormal operating conditions: incident management
4	CAV to UAV Communication: Emergency Supply of Medical equipment	Ground- and air- plane interaction
5	Emergency Medical Delivery to an un-surveyed location	Unplanned operations
6	Emergency Medical delivery: Biological samples from un-surveyed location to MK University Hospital	Unplanned operations: Dangerous Goods
7	Emergency Medical delivery to an unknown site – responder at the scene, no ambulance	First responder support
8	Medical Delivery illegal interception and/or interference	Abnormal operating conditions: safety / Security

Figure 4 – Scenario Development – Medical Delivery

In terms of Asset and Infrastructure Surveys, a similar approach was taken with Milton Keynes City Council Highways Department. As a unitary authority, Milton Keynes has significant Highway Infrastructure and Assets under its stewardship. Milton Keynes comprises >2500KM of carriageways, mainly as part of an innovative high-speed, grid road network that includes c.120 roundabouts, c.800 bridge structures, c.57,000 streetlights, c.4500 lit signs and over 100 other structures. The assets also include c.1800KM of footways and c.400KM of traffic-free, shared use routes known as 'Redways', as well as 300 covered walkways in central Milton Keynes. Together, Milton Keynes Highway Infrastructure assets are valued at >£6BN. Milton Keynes also has extensive green spaces requiring wider vegetation management, ensuring trees and plants do not encroach onto footpaths and highways.

Ringway, a provider of specialist highway services provides reactive, routine and cyclical maintenance of these assets, as well as street lighting, inspections, winter operations etc. on behalf of Milton Keynes City Council. Here the scenarios were identified as follows:

Scenario	Title	Scope
1	Highways Incident Reported by a Member of the Public.	Quick response
2	Highways Incident - Immediate Response	Emergency response
3	Highways Inspection	Routine ongoing inspection

Figure 5 – Scenario Development – Asset and Infrastructure Surveys

Following this work, the following areas were agreed as the focus areas for the remainder of the project:

- Medical Delivery: focus on medical deliveries between Milton Keynes University Hospital and Willen Hospice
- Asset and Infrastructure Surveys: development of a baseline set of photogrammetry to support a future Digital Twin for Milton Keynes City Council, enabling routine ongoing

inspection and condition surveys in order to facilitate reactive response and/or proactive response as part of a predictive repair and maintenance programme
- CAV/UAV interaction: emergency supply of medical equipment

Whilst these two use cases (and underlying scenarios) would form the focus for the remainder of the project, further work was also undertaken with other Milton Keynes City Council Departments, in order to identify other potential areas where drones could add value. This work was designed to further develop the demand view (and associated use cases) for a future drone-based service, and demonstrate current state of the art capabilities in order to inform potential commercial cases, developed either within the public or private sector. Annex B summarises the real-world impacts / outputs from these workshops which were held with representatives from the wider Highways, Incident Response and Housing teams.

Finally, as part of the DEFINITION phase, a Stakeholder Map was developed to support forward-looking project activity (see Annex C).

Technology

During the technology phase, the following technical assessments were undertaken, relating to the various technology components required to establish safe and secure drone operations. This work was completed by Cranfield University:

- Data Platform: functional and non-functional requirements, high-level architecture, data flow definition, monitoring and visualisation capabilities, system integration and testing considerations, and security and compliance considerations etc.
- Position and Time: requirements relating to position and time dissemination and synchronisation services, implementation options, integration and testing etc., this included use of hybrid solutions designed to overcome limitations of more traditional systems, and offering greater levels of resilience and reliability
- Sensors: requirements relating to sensor systems and surveillance technologies, a review of different sensing and surveillance options, along with recommendations for implementation, integration and test results, this included use of advanced multi-sensor fusion technologies designed to improve sensing and surveillance capabilities in high-risk areas

The diagram below outlines the proposed architecture in respect of oversight and assurance of future drone services.

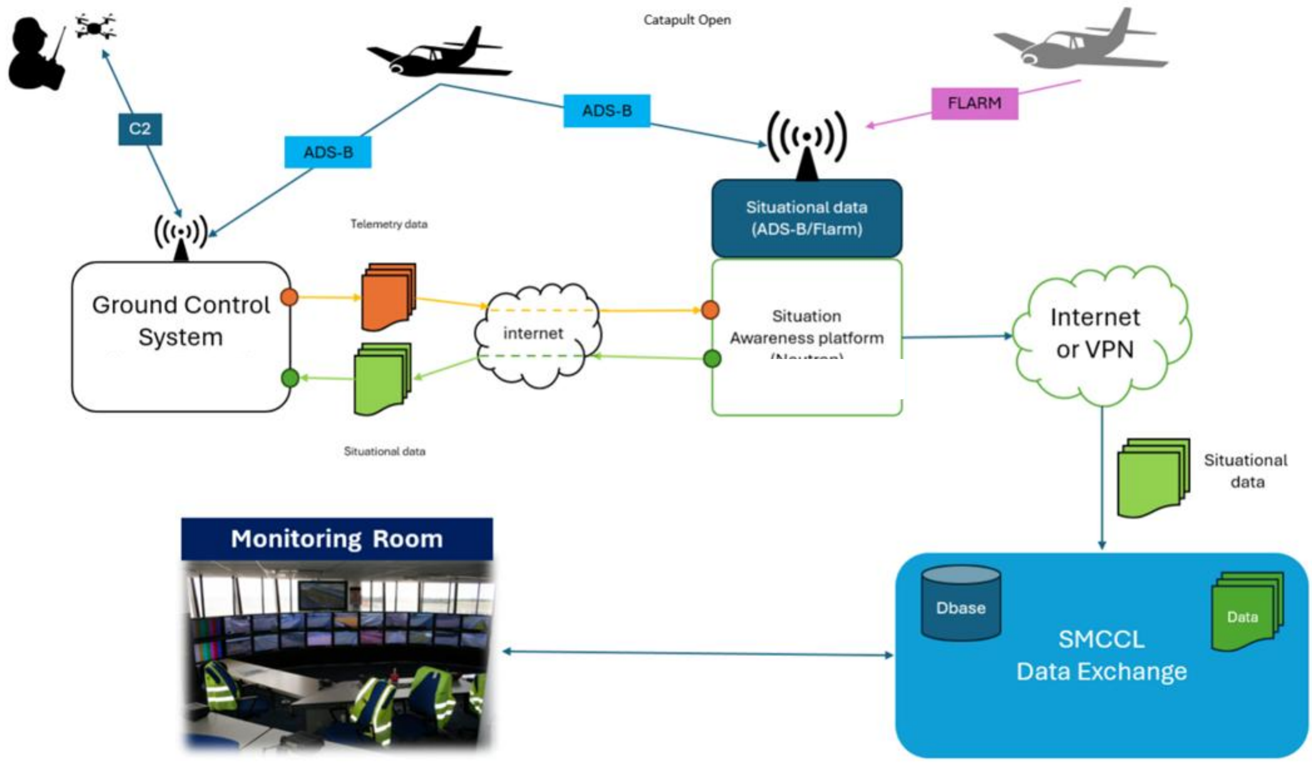

Figure 6 – Proposed Assurance and Oversight Architecture (Source: Satellite Applications Catapult)

Each component is described briefly below:

Component	Description
Monitoring Room	The Monitoring Room is the primary centre for overseeing drone operations. It receives and displays near-real-time data on specified drones, including their take-off points, landing points, and flight paths, to support situational awareness. While the Monitoring Room serves as a visualization and alerting hub, it does not control the drones directly. It is envisaged the Monitoring Room would form part of the Smart City Consultancy Smart City Control Centre environment, designed to oversee and assure autonomous services operating in and around the city, on behalf of the City Council.
Drone Ground Control System (GCS)	The GCS is a software-based ground station operated by drone operator that runs on a computer and communicates with drones wirelessly. It monitors the UAV's real-time performance, position, and other telemetry data, simulating a cockpit experience. Operators can use the GCS to view live video streams from the drone's cameras, issue new mission commands, and set operational parameters, giving them a virtual cockpit-like control for data collection during missions.
Situational Awareness Platform (SAP)	The SAP provides real-time detection of aircraft and drones operating nearby by receiving ADS-B or FLARM broadcasts. This data is then aggregated with GCS data, creating a unified and clear overview of aerial operations within the designated airspace, which aids in identifying potential safety risks in real time.
Data Exchange Platform (DX)	Acting as the central data repository, DX aggregates, mediates, and transforms data from the SAP and GCS, preparing it for visualization in the Monitoring Room. This platform uses APIs and connectors to retrieve data and ensure it is accessible for further processing and analysis, allowing the Monitoring Room to display the latest drone operation data accurately.

Figure 7 – Assurance and Oversight – Component Description (Source: Satellite Applications Catapult)

The data flow begins with data collection at both the GCS and SAP levels. The GCS continuously streams data from active drones, such as their current position, flight parameters, and live video. Meanwhile, the SAP gathers nearby aircraft data through ADS-B and FLARM signals, combining it with GCS information to enhance situational awareness.

Both GCS and SAP data are then transmitted to the Data Exchange (DX) platform, where they undergo mediation and transformation to ensure they meet the Monitoring Room's visualization requirements. DX consolidates this information and sends it to the Monitoring Room, where the data is displayed, allowing operators to monitor and assess ongoing drone activities in near real-time, aiding in incident response, situational awareness, and regulatory oversight.

As part of the TECHNOLOGY phase, two procurement exercises were undertaken in the following areas. These activities were led by Milton Keynes City Council, supported by the wider consortium, in accordance with Public Sector Procurement Policies:

- Procurement of an experienced drone services provider
- Procurement of an experienced Situational Awareness service provider

Novel solutions were sought in both cases.

In terms of the drone services provider, a drone-in-a-box provider was selected, since such a model lent itself to the long-term goals of the City Council to reuse an easy-to-deploy, scalable shared infrastructure platform to support multiple use cases, services and Departments. The Automated Drone Station (ADS) that sits at the heart of the drone-in-a-box solution is shown in the diagram below:

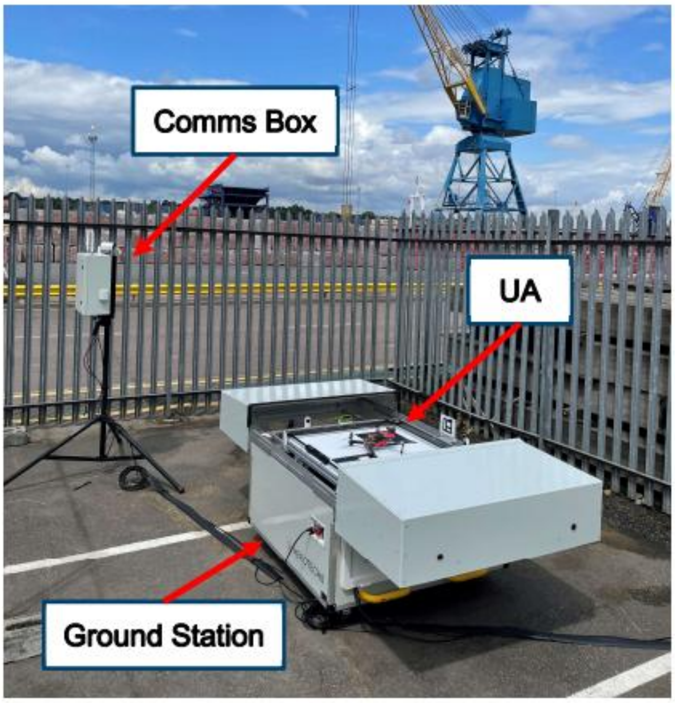

Figure 8 – Automated Drone Station (Source: drone services provider)

In terms of the Situational Awareness service provider, an open-source public network provider was selected, as this was seen as offering an open, extensible, scalable and cost-effective solution for integrating drones into a city's transport infrastructure and the wider assurance and oversight environment envisaged in the architecture shown above. The solution was easy to deploy and coverage was provided through use of private housing upon which the sensor system is mounted (see example below).

Figure 9 – Example Sensor Installation (Source: Situational Awareness Services Provider)

Finally, in the TECHNOLOGY phase, the following work was undertaken by the Satellite Applications Catapult:

- High- and low-level design work, including security aspects, building on the architectural work undertaken by Cranfield University, and considering the enabling connectivity requirements

Additionally, Satellite Applications Catapult focused on the use case relating to ground- and air-interaction between a CAV and UAV, exploring the interplay between the two planes, e.g., to support an autonomous, first responder response to an incident. Two aspects were explored:

- Coordination between CAV and UAV to deliver services (through integrated End-to-End Operations)
- Enhancing safety and security (through the Telemetry Data Integration)

To explore this, Satellite Applications Catapult sought to develop a common communications, monitoring and control stack enabling 3rd party CAVs and UAVs to communicate with each other through a central control system, with the potential to remotely monitor and control the two different autonomous systems via the same interface, with the different telemetry systems shown side by side and the same human machine interface used to control both systems. Satellite Applications Catapult procured the necessary hardware (including an Uncrewed Ground Vehicle and drone) and software and undertook test and integration work to demonstrate the concept.

To support this work, the UAS was procured as a fully functional and system-agnostic platform with pre-existing C2 (command and control), telemetry, and video communication functionalities. However, to facilitate coordinated operations, research and development were undertaken to integrate its communication capabilities with the UGV and Ground Control Station (GCS).

The Harrier industrial aircraft drive options offering payload capacities to 15kgs. It has a removable top that opens to access its flight electronics and a spot to add other onboard components, as shown below. The components utilised are all commercially available, off-the-shelf items widely adopted in the UAV industry.

Figure 10 – Drone Modifications (Source: Satellite Applications Catapult)

In terms of the UGV, the Bunker Mini ground vehicle, featuring a CAN bus interface, allows users to perform further development and implement applications across diverse fields. The diagram below shows the modifications undertaken. The Cube Orange autopilot was utilised to improve situational awareness. An extremely precise GPS system is also used to enhance detect-and-avoid capability.

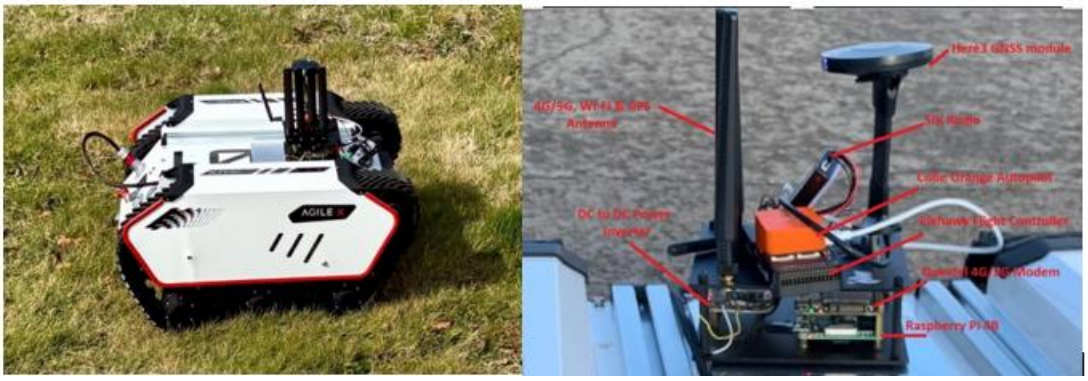

Figure 11 – UGV Modifications and Development work (Source: Satellite Applications Catapult)

In terms of the Ground Control Station (GCS), this included a remote controller, a laptop running the flight software, and a radio. Mission Planner software offers real-time fleet visibility and control, improving efficiency, safety, and regulatory compliance and was chosen for its stability, features, and ease of integration (see diagram below).

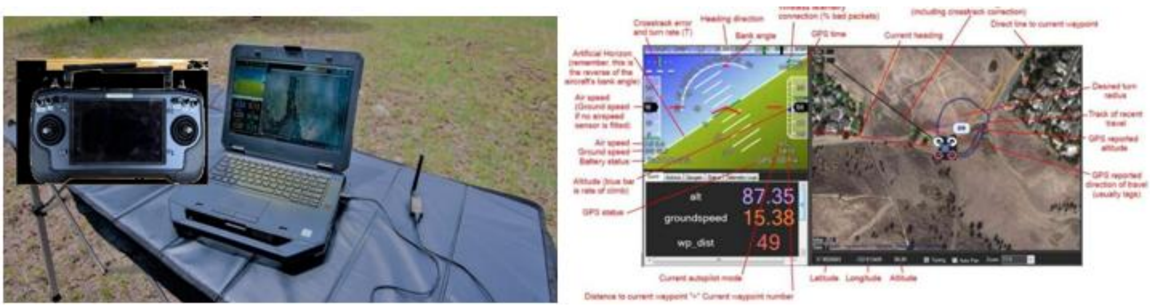

Figure 12 – GCS hardware components and Mission Planner Flight Data Screen (Source: Satellite Applications Catapult)

Cranfield University's contributions relate to Surveillance Technology and resilient positioning and time dissemination. These factors are seen as essential to ensuring safe and beyond-visual-line-of-sight (BVLOS) drone operations in low-altitude urban airspace using multi-sensor integration and robust time synchronization.

In the Surveillance Technology deliverable, we provide detailed implementation and analysis of multi-sensor surveillance systems for urban airspace target detection, which supports safe multi-UAV operations.

In the Resilient (Hybrid) Platform PNT deliverable, we developed an air-ground collaborative framework, demonstrating how UAVs can maintain time synchronization and sensor fusion using onboard and ground-based alternative communication technologies when GNSS signals are degraded or blocked in urban environments.

These two validated capabilities are key enablers for secure and efficient BVLOS UAV operations in complex city airspaces.

Product

To support the operational verification and operational validation work, a number of activities were undertaken in the PRODUCT phase. These included:

- Route mapping, planning, site surveys, hazard mapping and risk assessment / mitigation etc. for both use cases (Cranfield University – Medical Delivery, drone services provider – Asset and Infrastructure Surveillance)
- Development of the Concept of Operations (ConOps) for both the Medical Delivery and Asset and Infrastructure Surveillance Use Cases (Cranfield University, in conjunction with the drone services provider)
- Development of the Operating Safety Cases (OSC) for both the Medical Delivery and Asset and Infrastructure Surveillance Use Cases (Cranfield University – Medical Delivery, drone services provider – Asset and Infrastructure Surveillance)
- Stakeholder Management, Engagement and Communication (Milton Keynes City Council)
- Legal Assessment of current regulatory frameworks (Milton Keynes City Council)
- Provision of local GCS by Situational Awareness services provider and integration with NEPTUNE™ Smart City Control Centre Visualisation Software, developed by Electronics, Computers and Systems Limited
- Test flights to prove the concept (Cranfield – Medical Delivery, drone services provider – Asset and Instructure Surveillance)

In addition, Satellite Applications Catapult undertook test missions with the integrated UAS, UGV and GCS at the Drone Test and Development Centre, located at Westcott Space Cluster. This work assessed how the UAS, UGV and GCS worked in unison to deliver co-ordinated mobility and used a combination of mobile internet (4G/5G) and Starlink-powered Wi-Fi to ensure constant communication and control (C2 link). Although the UAV could autonomously navigate all waypoints accurately, safety protocols dictated it would hover at each until manually instructed by the pilot to proceed. The UGV was manually programmed to follow a set route via waypoints.

The aircraft successfully sent back real-time telemetry information like its location, altitude, speed, battery level to control station using RF links. This was designed to replicate a UAS following a UGV on a set route. This was followed by a 'Return home' scenario where the UAS, in the event of a loss of communications, returned to the start location. The UGV can be successfully located using GPS and this information transmitted to the GCS, together with telemetry data through a variety of communications systems. Accordingly, the UAS and UGV were shown to concurrently have two-way communication with the Ground Control Room (GCR) for telemetry (see diagram below).

Figure 13 – UAV and UGV telemetry data on the GCR Dashboard (Source: Satellite Applications Catapult)

During the inter-working testing, it became clear that direct two-way communication between the UAS and UGV is limited due to an intellectual property (IP) issue. Further work to fully realise this opportunity has also been identified, with respect to the inter-play between cellular networks, satellite operators and aircraft domains.

Demonstration

It should be noted that the OSC relating to the Medical Delivery use case is predicated on the establishment of a Temporary Reserved Area (TRA) overseen by Cranfield Airport. This aspect remains in the planning and approval stage, so whilst the OSC was prepared and submitted, no DEMONSTRATION flights relating to the Medical Delivery use case were possible within the project time scales. Further work will also be needed with regard to Hazardous Goods approvals.

However, approval was secured to fly Asset and Infrastructure Surveillance missions in Central Milton Keynes, using a mini drone with spotters to capture inspection data from a number of vantage points in the Open Category.

Flights to record the Digital Twin were undertaken, with the resultant data retained by the Milton Keynes City Council GIS team (see example flight data capture below). This data will be used in the development of a baseline set of photogrammetry to support a future Digital Twin for Milton Keynes City Council, enabling routine ongoing inspection and condition surveys in order to facilitate reactive response and/or proactive response as part of a predictive repair and maintenance programme.

The data included:

- raw orthophoto plans, which contain unprocessed aerial images
- processed orthophoto plans, which are refined versions optimized for analysis
- point cloud data in .laz format (a collection of 3D points representing objects or terrain; laz is a compressed version of the .las LIDAR Data Exchange Format).
- geospatial data stored in GeoJSON format

Figure 14 – Example Flight Data Capture (Source: MKCC)

All flights and missions across Milton Keynes were undertaken in accordance with the CAA CAP2320 Drone and Model Aircraft Code, and subject to Milton Keynes City Council review and approval. This includes evidence of relevant operator competency, operator registration/authorisation, risk assessment and method statements (RAMS), OSC, insurance, landowner permissions and GDPR policies as well as flight schedule and drone platform details as required.

In terms of the GIS data captured, this was handled in accordance with Milton Keynes City Council Data Protection and Privacy policies, with Milton Keynes City Council acting as the Data Controller and the drone services provider acting as Data Processor.

10. Key Outcomes

As well as the different outputs summarised in the previous section, the key outcomes from the project were:

- Definition of a Target Technical Architecture designed to ensure Local Authority Oversight and Assurance of drone operations in City Centre environments
- Development of a demand pipeline, demonstrating the 'pull' from Local Authorities for drone-based services, covering multiple services and departments and the potential benefits that can be afforded
- Proof of Concept work demonstrating the value of drone operations in City Centre environments to support development of a Digital Twin
- OSC prepared and submitted to the CAA to support the Medical Delivery use case subject to establishment of the Cranfield Airport TRA
- OSC prepared and submitted to the CAA for Highways use case, subject to establishment of the Cranfield Airport TRA
- Local Authority readiness to support future drone operations in accordance with current regulation and legislation

11. Problems encountered

The following issues were observed during the project:

- Collectively the consortium under-estimated the challenges of securing approval and this work was left too late in the project; this should be commenced sooner, and CAA engagement should be secured from the start of any future project

  To address this, during the project, we maintained regular contact with the CAA, and once it became clear approval timelines would extend beyond the length of the project, we used alternate, regulatory-compliant approaches to achieve the project outcomes

- A number of technology integration challenges were observed, due to the proprietary or emergent nature of some of the technology components; consideration should be given to this in any future projects, and use of open, standards-based platforms should be considered as well as early integration, inter-working and inter-operability testing

  To address this during the project, we undertook iterative development cycles, and adapted the designs to address the interworking issues identified; these issues included work to ensure the relevant drone transponders were tracked by the ground surveillance system, and work to integrate the CAV/UGV/GCS

12. Lessons Learned

The following lessons were learned as part of the project:

- There is public interest in provision of drone-based services, from service providers, citizens and industry, as well as local landowners, such as the Parks Trust
- There is a significant level of demand and a rich set of use cases identifiable within the public sector (Local Authority, Health and Social Care etc.)
- These use cases have the potential to transform how services are delivered and will enable efficiencies, both in terms of resources and methods; the data collected through this project has significant value in terms of establishing a Digital Twin
- Further the adoption of drone-based services will contribute significantly to the Net Zero agenda
- There is also value in exploring UAV / CAV interplay, both in terms of the use cases identified and beyond, building on the proof-of-concept work undertaken in this project
- Other potential UAV / CAV use cases include using CAVs to deliver to distribution hubs, with last-mile, drone-based delivery or connecting the sensory and other telemetry data across the two planes (ground- and air-) in a way that delivers additional safety, security or other controls, akin to a V2X model of operation, e.g., using drones to survey CAV routes for foliage, pot holes or other environmental issues that could impact smooth operation of the CAV service – establishing an 'Autonomy-as-a-Service' model
- For the public sector, a multi-service approach is sensible, enabling the costs of the drone network and associated infrastructure to be shared, and enabling the network to be highly utilised through a mix of cost-service missions, including a mix of reactive, proactive, and routine activities

- Services can only become commercially-viable once operating BVLOS; if this is achievable, there is a much broader market opportunity, and the economic significance of these and other private sector use cases is magnified substantially
- The ability to secure BVLOS approvals, whilst possible, remains challenging; the amount of time taken to secure approval, coupled with the level of expertise required, restricts the number of industry players who can contemplate engagement
- The current approaches to regulatory approval are challenging for smaller operators, even when public funding is available to support collaborative R&D projects such as this
- These risks, taken together, risk stifling the industry within the UK, with operators attracted to other territories or use cases that do not present high barriers to entry in terms of regulation
- Other regulatory approaches, e.g., use of a TRA is likely to offer a lower barrier to entry, and appear essential to enable at-scale services to both mobilise and operate; there are two OSC's submitted that require the Cranfield Airport TRA, demonstrating demand and need for TRA approval; once the TRA is established, these projects are ready to commence operation
- Other considerations in terms of enabling approval could include creating low-risk flight paths as part of the planned environment, for example, including green corridors as part of future planning activities that also enable flight paths across the city; simplifying future BVLOS approvals
- Technology exists that can enable Local Authorities to cost-effectively provide a level of oversight and assurance, e.g., through the Smart City Control Centre, or equivalent; the Smart City Data Exchange and ECS NEPTUNE™ visualisation platform offers a viable solution to meet this need
- Establishing a Smart City Control Centre visualisation and monitoring system for tracking the position of all uncrewed aircraft within the airspace over the city is seen as critical
- Such a monitoring solution would include use of a cost-effective, simple to deploy and operate situational awareness air space monitoring system (and associated sensor network) in place but, for these purposes, would not need to be a full Uncrewed Traffic Management (UTM) system or require use of radar, both of which could be cost-prohibitive and introduce significant technical and operational complexity
- Ultimately, any solution will require reliable, secure, and suitable communications infrastructure and a highly resilient positioning, navigation and timing (PNT) solution
- Further work is needed to demonstrate that the new technology is safe, secure and reliable
- To secure lasting benefits, work should also continue to drive for a more permissive regulatory environment, to share best-practice and to support scale-up
- The newly formed Regulatory Innovation Office (RIO) could play an instrumental role in driving these changes and the recent RIO and FS&I engagement letter regarding CAA priorities for UAS is seen as a positive step in enabling future project work
- There is value in comparing and contrasting the different regulatory approaches being undertaken across the CAV and UAV sector, both of which have similar challenges, but where the pace of change is significantly different; through such a review, it may be possible to identify cross-sector learning, identifying new ways to overcome the specific sector challenges faced by UAV operators

13. Next Steps

Milton Keynes City Council will continue to develop its thinking in terms of service transformation through use of drone-based services (including potential future use of Atypical Airspace), and support the development of future commercial and business cases in this area, and seek ways to build on the early Digital Twin work undertaken on the project.

Through the work on the project, Smart City Consultancy have developed their 'Autonomy-as-a-Service' proposition, a reusable blueprint designed to deliver autonomous services, whether ground- or air-based and enabling central assurance and oversight functions. This proposition brings together state-of-the-art technology, and unparalleled operational insight designed to address perceptual challenges from the public, situational awareness challenges etc. associated with autonomous vehicles, drones and robots. The Smart City Consultancy proposition is designed to overcome these commonly observed challenges, offering a turnkey solution that can be deployed anywhere in order to drive adoption, deployment and sustainable operation (see diagrams below which both outline the A-a-a-S proposition and show early integration work with the NEPTUNE™ Smart City Control Centre dashboard application, developed by ECS).

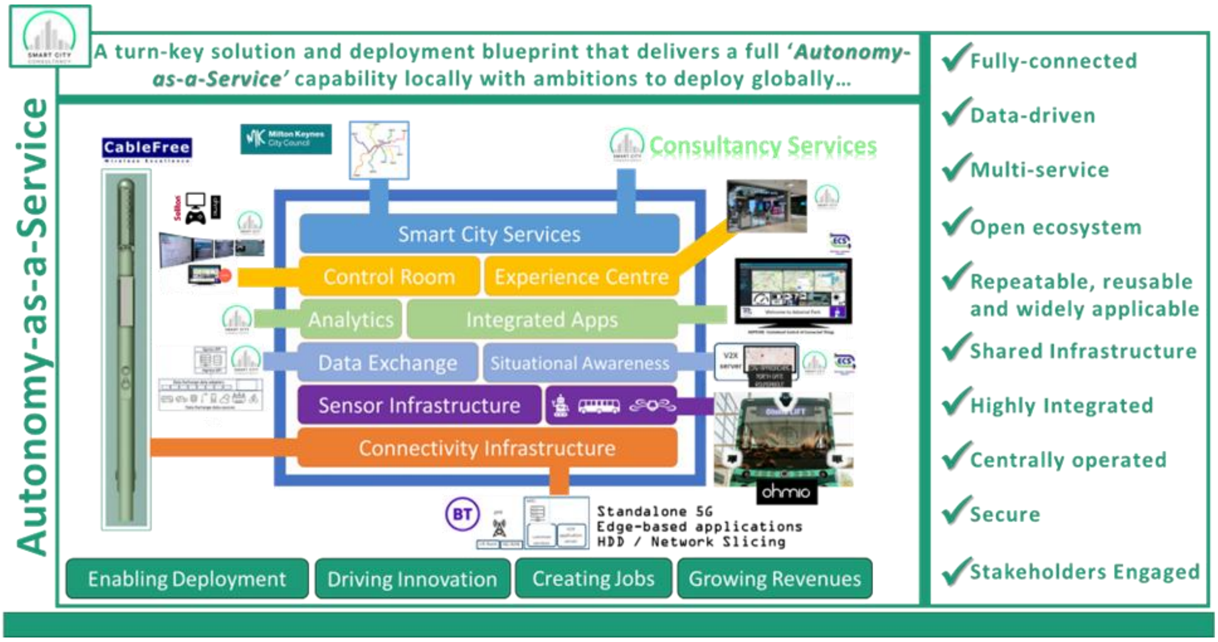

Figure 15 – Autonomy-as-a-Service Proposition (Source: SMCCL)

Figure 16 – Integration of sensor data into NEPTUNE Smart City Control Centre dashboard (Source: ECS)

Finally, Cranfield Airport continue to develop their TRA proposals, which would enable further work to be undertaken locally, as part of a follow-on project, and the OSC prepared and submitted for the Medical Delivery use case means there are now two OSC's submitted that require the Cranfield Airport TRA, demonstrating demand and need for TRA approval; once the TRA is established, these projects are ready to commence operation and could be enacted. The TRA Airspace Volume is shown in the diagram below with the proposed flight area of operation shown by the white circle. The purple section is the combination of Cranfield Airport's Aerodrome Traffic Zone (ATZ) and Flight Restriction Zone (FRZ) stubs. The blue section is the TRA volume.

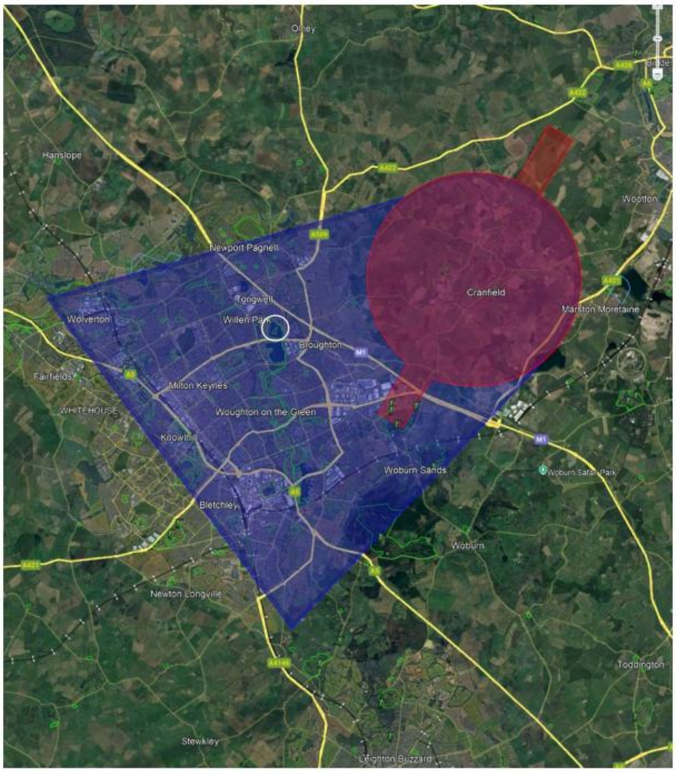

Figure 17 – Proposed TRA (Source: Cranfield University)

14. Conclusion

There is undoubtedly significant service, user, economic and net zero benefits from adopting drone services and there is significant demand in the public sector for such a transformation. Through the DronePort:MK project, we have been able to identify this demand, develop detailed use cases and assess the technology required to deliver the first vanguard of these newly transformed services, relating to Medical Delivery and Asset and Infrastructure Surveillance.

However, the challenge remains a regulatory one, which risks jeopardising the potential afforded, and whilst current regulation does enable BVLOS operation, the barriers to entry remain high.

Alternative approaches must be rapidly pursued if the promise of drone technology is to be delivered and the race is on to ensure the UK positions itself strongly in this new and emergent sector, where other territories and use case may be more attractive to commercial operators, and where the barriers to entry are lower.

If this opportunity is embraced and the regulatory challenges can be successfully navigated to create a more permissive regime, Milton Keynes, like others, stands ready to embrace this exciting technology, delivering innovative new approaches to public sector service delivery and opening the skies above Milton Keynes to support private sector investment as part of our thriving tech sector and as the city where ‘ideas become reality’.

15. Acknowledgements

In addition to the commitment and support from across the consortium partners, we would like to acknowledge the extensive support from the DSIT team.

Annex A – Outline Use Case

Criteria	Requirement
Location	Standing Way, Eaglestone, Milton Keynes, MK6 5LD
Contact:	Dr Oliver Pearce
Land	The land is privately owned
Airspace	Shared airspace
Route	The intention is to operate drone delivery services between hospital buildings within the perimeter and to adjacent medical sites, such as the Saxon Clinic
Flight Path	Flights will initially be point-to-point / hub-and-spoke, i.e., from a central distribution hub to the target location and return; there may be multiple distribution points and target locations in the future, and the solution should be easily extensible and with the ability to local program the flights
Distance	Typically, flights <2km (return journey) will be required
Flight volume	Initially: up-to 10 deliveries / day over a minimum of 6 weeks; volumes could increase over this period
Speed	Drone speeds of between 10 - 40 km / h anticipated
Flight time	TBD, dependent upon final flight parameters – volume, speed, distance, trial length etc. but intention is to demonstrate safety of these services in city environments so maximising flight hours is seen as an important consideration
Terrain	Largely flat, but need to navigate across built-up land with multiple buildings, road users, pedestrians, street furniture in a busy environment etc.
Weather	Drones must have the ability to operate in a typical UK weather profile; there are no location specific weather conditions
Take-off and landing points	Pop-up or drone-in-a-box facilities, no permanent infrastructure in place
Garaging	Secure garaging facilities will be provided
Charging	Suitable charging facilities will be provided
Sensor locations	Space, power, comms, access to street furniture or buildings / rooftops will be made available to support sensor deployment
Frequency	Initially on-demand, with a turnaround time of c.30 mins to prepare for flight; opportunity to establish scheduled flights, e.g., every 90 mins on a circular route in the future with the potential to add drones to the fleet to drive extra capacity
Operational hours	Initially Monday to Friday, 08:00 – 18:00; potential opportunity to extend in the future to cover weekends or out of hours, but this would be subject to further review

Criteria	Requirement
Payload	<5kg, mixed package sizes, and multiple packages in one delivery; a minimum payload space of c.35 x 25 x 13 cm (i.e., the size of a typical shoebox) is proposed; option to refrigerate if required
Dangerous goods	Yes – medical supplies, samples, medicines etc. it should be possible to securely transport the payload, e.g., through an externally locked unit; it should be easy to clean and disinfect the unit, and separate different contents where possible
Winch	A winch system is acceptable
Safety	Flight path crosses busy public area – pedestrians, cars, vulnerable people, emergency vehicles etc. audible or visual alerts upon landing and take-off and/or the ability to communicate from the control centre(s) to those on the ground are preferable; a full safety case will need to be developed and agreed with key stakeholders; all work to be undertaken in accordance with MKUH H&S policies
Security	Cargo must be transported securely, i.e., in a locked compartment; all work to be undertaken in accordance with MKUH Security policies
Data protection	Preference to have **<u>no</u>** video feed on the drone for data protection; all work to be undertaken in accordance with MKUH data protection and privacy policies; there may be a requirement to transport paperwork (e.g., patient notes) as part of the delivery and this must be securely stored whilst in transit
Regulatory model	Our aim is to operate a model as close to BVLOS as possible; necessary regulatory approvals will need to be secured as part of the project
Sensor infrastructure	The sensor infrastructure should be easy to configure and maintain, support flexible deployment, require only a small foot-print and be self-powered where possible; the drone must be compatible with our preferred sensor network and situational awareness platform, e.g., e.g., via transponder, radar etc.
Connectivity	The project will ensure all necessary connectivity to support local drone operations are in-place.
Remote Operations	Drone mission operations to be undertaken autonomously and remotely operated by trained pilots; specialist drone maintenance to be undertaken by provider
Local training	Local staff to be trained in the loading / unloading of the drone, readying for take-off, landing, local route programming, re-charging and incident management; staff will be provided to undertake these activities either from MKUH or the project team itself
Centralised Monitoring and Control	The service will be overseen, monitored and controlled from a centralised Smart City control room, located in Central Milton Keynes, which will form part of a wider Smart City demonstration and trial capability. The control centre will collect relevant multi-sensory inputs from the drone, take-off and landing points and other sensor information, e.g., CCTV imagery and contextual data; these multi-sensory inputs will be aggregated and processed as required in order to provide a near-real-time 360^{o} view of live operations. The drone and sensor environments must provide feed information to this control centre via the Smart City Data Exchange platform; emergency override capabilities should be included, e.g., to stop the mission or to communicate with those in vicinity of the drone

Criteria	Requirement
Site Constraints	As part of the pre-trial work, the drones should be operated outside of normal working hours (e.g., weekends and evenings) when the area is quieter, moving to weekday working as part of the trial; note proximity of hospital to A421; planning or other permissions may be required to deploy sensor infrastructure; flight paths to be designed to reduce flights over or across pedestrian areas where possible
Communications	Approach to undertaking all related site communications and engagement activities, including any signage will need to be agreed with MKUH and the project team; publicity will be agreed with MKUH and the project team
Additional Infrastructure	Working space for the project team will be provided.
Hospital systems integration	No integration with hospital systems is required at this stage.
Branding	The drone may be branded with NHS or MKCC livery as part of the project
Trial Impacts and Benefits	We will work with MKUH to assess the benefits and impacts of the project; these could include cost savings, service improvements, carbon reductions etc. in order to support the case for ongoing adoption as part of a wider sustain plan

Figure 18 – Outline Use Case – Medical Delivery

Annex B – Wider Demand View

Figure 19 – Wider Demand View

Annex C – Stakeholder Map

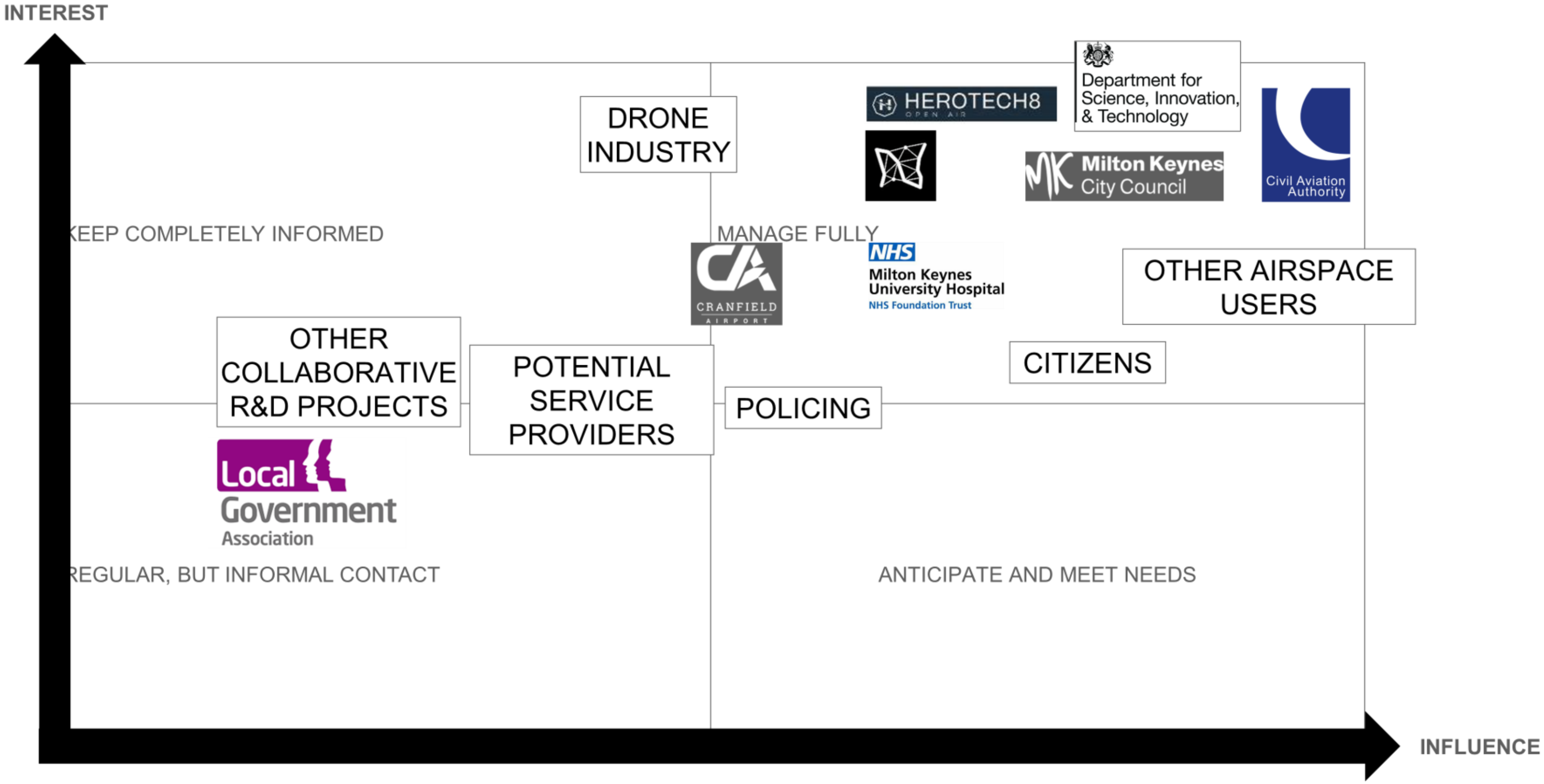

Figure 20 – Stakeholder Map