National Beyond visual line of sight Experimentation Corridor

Final Airspace Change Proposal

25 June 2021

Cranfield NBEC ACP – Final Proposal

Table of contents

Glossary

ACP	Airspace Change Proposal
AGL	Above Ground Level
AIP	Aeronautical Information Publication
ATC	Air Traffic Control
ATZ	Air Traffic Zone
BVLOS	Beyond Visual Line of Sight
CAA	Civilian Aviation Authority
DAA	Detect and Avoid
DACS	Danger Area Crossing Service
DAAIS	Danger Area Activity Information Service
DAP	Directorate of Airspace Policy
GA	General Aviation
ILS	Instrument Landing System
NATMAC	National Air Traffic Management Advisory Committee
NBEC	National Beyond visual line of sight Experimentation Corridor
NOTAM	Notice to Airmen
OSC	Operational Safety Case
SPL	Sound Pressure Level
TDA	Temporary Danger Area
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

Document History

Version	Date issued	Change log
V 1.0	31 March 2021	Initial issue
V 2.0	13 May 2021	• Glossary update • Added sections 1.1, 1.2 and 1.3 to provide more detail on Background, Statement of Need and Scope of ACP • Added detail in section 2.2.2 for the two ceiling heights of the TDA and mention of the acoustic noise measurements taken. • Added section 2.2 to describe final ACP volume proposed. • Added final ACP volume details in section 5.0. • Added Section 6.0 References
V 2.1	14 May 2021	• Added mention of DAAIS provision in section 3.0 and section 4.0 Airspace communication
V 2.2	28 May 2021	• Added document control table • Added Figure 5 • Section 4 on Airspace Communication to include first and second bullet points introducing the provision of DACS and DAAIS and clarifying that DACS will be procedural
V2.3	15 June 2021	• Added section 2 to specifically address Airspace Trials Requirements in CAP1616 • Added references [3]-[5] • Amended acronyms in Glossary
V2.4	25 June 2021	• Provided more details on the trials plan in section 2.1 as per CAA request • Re-numbered figures to allow for additions in section 2 • Added reference [6] - trials plan

1.0 Introduction

1.1 Background

The operation of Unmanned Aerial Vehicles (UAVs) is widely recognised to be limited globally by challenges associated with gaining regulatory approval for flight Beyond Visual Line of Sight (BVLOS) from the UAV's Remote Pilot. This challenge extends from unmanned aircraft flights having to follow the same 'see and avoid' regulatory principles with respect to collision avoidance as for manned aircraft. Due to the technical challenges of UAVs and Remote Pilots (RP) being adequately informed of potential traffic threats, this requirement effectively prohibits BVLOS UAV flights in uncontrolled airspace, unless a specific UAV operational airspace is segregated from manned aviation traffic. On the other hand, gaining regulatory approval for BVLOS flights in non-segregated airspace requires a significant body of evidence which can only be built with flight trials, i.e. there is a need that such flights are conducted in the first place.

Cranfield University and Cranfield Airport in collaboration with industrial partners (Aveillant, Blue Bear Systems Research, Thales and Vodafone) are developing a UAV corridor, also known as the National BVLOS Experimentation Corridor (NBEC), in Class G airspace around Cranfield Airport Airspace that will be used for demonstrating a surveillance-based Detect-and-Avoid (DAA) capability and other navigational technologies.

The NBEC project is part of a Sandbox initiative with the Civil Aviation Authority's (CAA) Innovation Hub and completed the Sandbox planning phase at the end of October 2020. It aims to develop navigational and operational capability for operating UAVs when BVLOS of the remote pilot – i.e. for when unmanned aircraft are flying out of sight. This project aims to better understand the requirements for unmanned aircraft operating BVLOS in UK airspace and to develop a DAA ecosystem for unmanned aircraft. This is necessary to help enable future services in the UK such as rapid low-cost aerial medical deliveries and to validate technology and procedures for such use-cases.

1.2 Statement of Need

The NBEC consortium is seeking to undertake an incremental series of drone flight trials in support of a navigation research programme, to test drone tracking and identification technologies using a complimentary mix of space, ground and on-board sensing capabilities. This will enable a composite situational awareness picture to be generated for the proximate airspace including non-cooperative traffic. Currently it is not possible to operate drones BVLOS without an acceptable DAA or mitigating solution. Ground based sensing systems (e.g. Radar, Radio Positioning System (RPS) and ADS-B) have been installed to address the DAA requisite during the trials allowing conspicuity and data fusion performance information to be gathered. This will in turn enable a body of evidence and documentation set to be compiled to support an Operational Safety Case (OSC) application for subsequent BVLOS flight operations in Class G airspace in the same area.

1.3 Airspace Change Scope

The proposed NBEC extends from Cranfield Airport's Air Traffic Zone (ATZ) North East towards Blue Bear's Twinwood facility between Oakley and Clapham (see Figure 1).

The routing of the corridor has been designed such that it minimises overflight of congested areas, road, railways etc. and avoid noise-sensitive areas. The corridor is mostly located under the Instrument Landing System (ILS) approach to Runway 21 at Cranfield Airport. Thereby, the suggested corridor and ensures that traffic patterns do not change and follow the same routes as are available currently (i.e. following the ILS path to/from Runway 21 at Cranfield Airport).

As the Cranfield ATZ itself will still be functioning (i.e. the ACP will only apply outside the ATZ – outside the red circle in Figure 1), UAV flights would be sequenced with normal landing/take-off flights where appropriate, and thus normal flying patterns should be expected. The only difference would be the additional 1-2 UAV flights per day expected.

Unmanned Aircraft routing and operational procedures have been developed in conjunction with Cranfield Airport's Air Traffic Control (ATC).

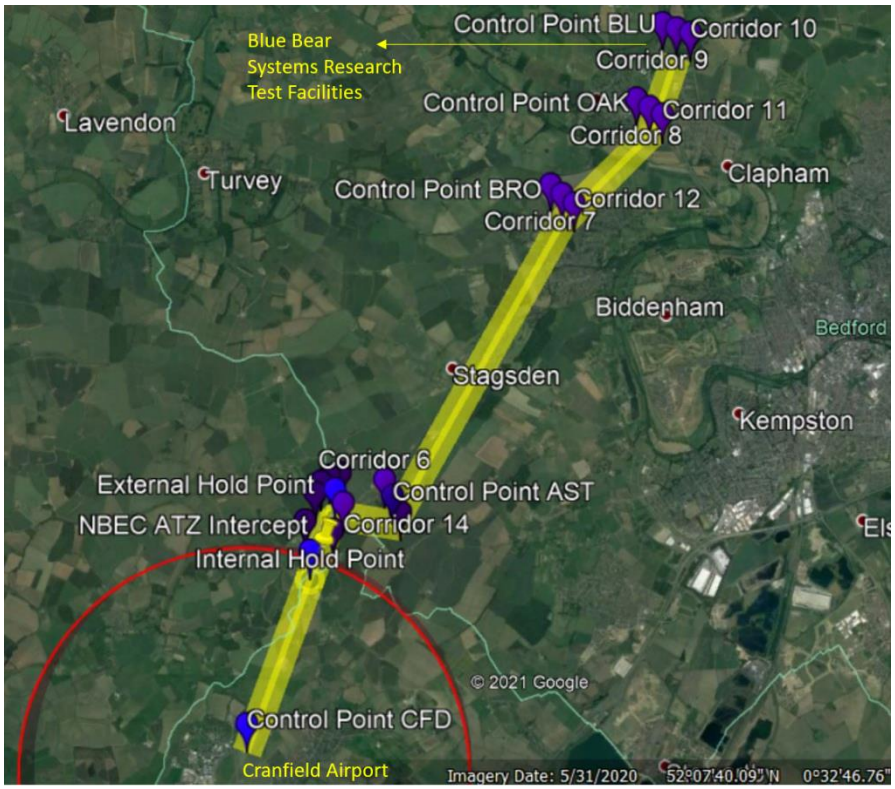


Figure 1: NBEC airspace volume

This document describes the final application for a temporary change to airspace is in accordance with CAP 1616 – Airspace Change and CAP 722 – Unmanned Aircraft System Operations in UK Airspace, in order to conduct flight trials within the NBEC and prove surveillance-based DAA capability and other navigational technologies performance. It includes a detailed proposed NBEC route together with a suggested volume of encompassing airspace within which to segregate the UAV flights. The design takes into account the feedback from the targeted engagement activity [1], and subsequent discussion with the CAA Directorate of Airspace Policy (DAP).

It is envisaged that the temporary airspace corridor will be used for 1 or 2 UAV flights per day over the 90-day period of its validity, currently anticipated to be between 02/07/2021 to 29/09/2021 inclusive. Flights will be for research purposes and are primarily related to navigation and location-identification themes. Flights are not aimed at collecting visual images or video, and unmanned aircraft may not even carry cameras. Flights are also not for repetitive commercial/logistics, or for military purposes. Flights will take off and land from Cranfield Airport under the Airport's control.

2.0 Trial Plan

2.1. Overview

The NBEC ecosystem currently consists of a 3D Holographic radar, a Radio Positioning System (RPS), an Unmanned Traffic Management (UTM) system that integrates to Air Traffic Control (ATC) and its ADS-B capability. The aim of the trials for which the ACP is requested is to validate the performance of this integrated ecosystem and demonstrate that it can be used to enable routine BVLOS drone operations in non-segregated airspace.

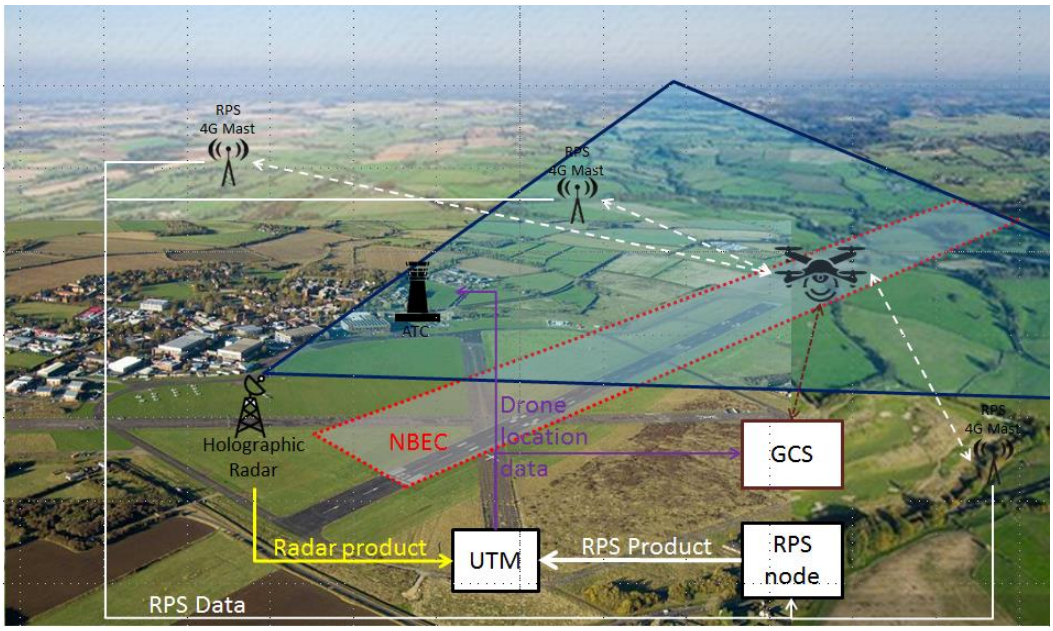


Figure 1: NBEC Components

The test strategy consists of gathering sufficient evidence incrementally to support an operational approval by the CAA's regulatory team to enable routine non-segregated BVLOS flights in uncontrolled (Class G) airspace. The test plan focuses primarily on incorporating a DAA ecosystem solution in order to support the flight trial series, addressing the CAA's requirements [5].

Gaining regulatory approval for BVLOS flights in non-segregated airspace requires a significant body of evidence which can only be built with flight trials, i.e. there is a need that such flights are conducted in the first place. The NBEC consortium aims to conduct a number of flight trials within the Cranfield ATZ initially and then extending beyond the ATZ, within the corridors and towards Blue Bear's Twinwood facility between Oakley and Clapham (see Figure 1). The aspirational end-point for these trials will be CAA's approval of an OSC allowing non-segregated BVLOS flight over the full length of the NBEC, with the subsequent completion of such flights.

The trial steps are aimed at providing incremental evidence to support that event, some of which will be carried out within current OSC (EVLOS) permissions, and some will step beyond those thus integrating a systematic process towards the program's ultimate goal.

Referring to Figure 3 below, the trials have been broken down into 4 steps as summarised below.

1) BVLOS in ATZ (closed to other traffic)
2) BVLOS in ATZ (open to other traffic)

3) Segregated BVLOS in NBEC (with Temporary Danger Area [TDA]) – this is the trial for which the present ACP relates to.
4) Non-segregated BVLOS in NBEC (no TDA)

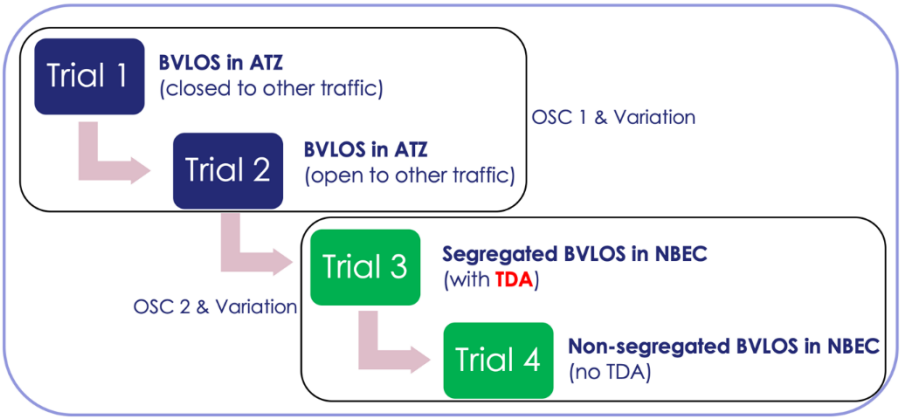


Figure 3: Test trials

The ACP requested by this present document relates to trial 3.

The details of the trial plan have been discussed with both the CAA Innovation Hub and the CAA UAS Team, which have commented and agreed in principle that it can meet our aims [6]. The trials plan agreed has included the description of the DAA Ecosystem to be used at each step, as required by CAP1861a. The planning stage of the Innovation Sandbox process has completed and the OSC has been submitted to the CAA UAS Team.

2.2 Trial 3 details

2.2.1 Objective of Flight Trials 3 Series

BVLOS UAV flights in Class 'G' airspace will be the culmination of all of the simulation, tests and flight trials carried out in previous trials step (not related to this ACP but important pre-requisite steps) and the successful execution of this element represents an important milestone in the acceptance of UAS operations integrated into the wider, open airspace.

Even though there are currently no specific performance requirements set for BVLOS, ground infrastructure or DAA for UAS and UTM, the first baseline the NBEC consortium has adopted was based on existing manned aviation requirements [3], [4], understanding that these would be ratified as evidence is gathered (starting from previous trial steps).

These flight trials will be carried out with the UAS operation under BVLOS conditions, with a TDA in place. The aim is to gather enough evidence of the ecosystem performance (incl. DAA Ecosystem as per CAP1861a [5]) that will allow to proceed to Trial 4, BVLOS in NBEC without TDA.

2.2.2 Entry Criteria

The entry criteria for these trials will include:-

- All required safety documentation

- Permission from the CAA to operate in accordance with OSC BVLOS in NBEC already submitted to UAS Team
- NOTAM placement for the NBEC trials corridor and TDA in place
- For each individual test flight:
    - Flight plan definition with ATC approval
    - UAS Operator with appropriate operational permission
    - Suitable Meteorological. forecast

2.2.3 Output of Tests

Trial outputs will include:

- Report(s) that document the performance of the systems, processes and procedures in place, particularly the ones that comprises the DAA ecosystem presented as per CAP1861a and agreed with CAA Innovation Sandbox;
- Information to be presented to the CAA to demonstrate the robustness of the systems and the operational processes and procedures used to manage the UAV traffic into and out of the Cranfield Airport ATZ / Class 'G' Airspace of the NBEC corridor.

2.2.4 Exit Criteria

Exit criteria for these tests will be the point where the system and flight management processes and procedures have fully demonstrated their ability to manage BVLOS UAV operations to and from the Class 'G' / ATZ airspace regions.

2.2.5 Trial Notable points

Trial Notable points include:

- UAV's will operate BVLOS
- The trials will take place within Cranfield airport's ATZ (under the control of the Cranfield ATC) and in Class 'G' airspace
- Trial phase 1 & 2 will have been completed
- Holographic Radar and Radio Positioning System (RPS) conspicuity and data fusion performance information will be gathered, to provide evidence of their performance in supporting the DAA Ecosystem as required by CAP1866a [5]
- UAV GPS logs and ADS-B conspicuity and data fusion performance information will be gathered, to provide evidence of their performance in supporting the DAA Ecosystem as required by CAP1861a [5]
- Trials outputs will be used to improve system performance & inform the CAA of capability
- Cranfield Airport's ATC will be involved in the detailed test plan generation
- A significant number of flight trials may be undertaken in order to generate the weight of evidence to demonstrate the effectiveness of the solution assessed

2.2.6 Acoustic Noise measurements

Cranfield has installed acoustic noise recording equipment in order to demonstrate the Impact of noise of the UAV trials. Noise measurements are currently being recorded and initial tests have demonstrated that the noise levels introduced by the UAV to be flown are negligible [2]. The Sound Pressure Level (SPL) acoustic noise as heard at 200 feet and 400 feet Above Ground Level (AGL) overhead passes was shown to be significantly less than the acoustic noise a standard fixed wing aircraft would emit. This is the expected height range of flight within the NBEC TDA. The initial testing

conducted by Cranfield demonstrated that the UAV SPL acoustic noise is barely above background wildlife levels, with little variation in magnitude when at 400 feet AGL cruise height with the autopilot engaged.

3.0 Airspace requirements and definition

The final ACP has been designed such that to solely request the minimum segregated airspace necessary to enable the safe operation of UAV flying the path as shown in the image below when outside the ATZ.

The corridor is mostly located under the Instrument Landing System (ILS) approach to Runway 21 at Cranfield Airport and as such follows existing air traffic routes, minimising disruption to both air traffic and surrounding areas.

3.1 Proposed NBEC route

Figure 4 shows the proposed NBEC flight path routing which has been reviewed and updated slightly from the initial proposal in order to minimise overflight of residential areas, and to be coherent with operational procedures developed with Cranfield ATC.

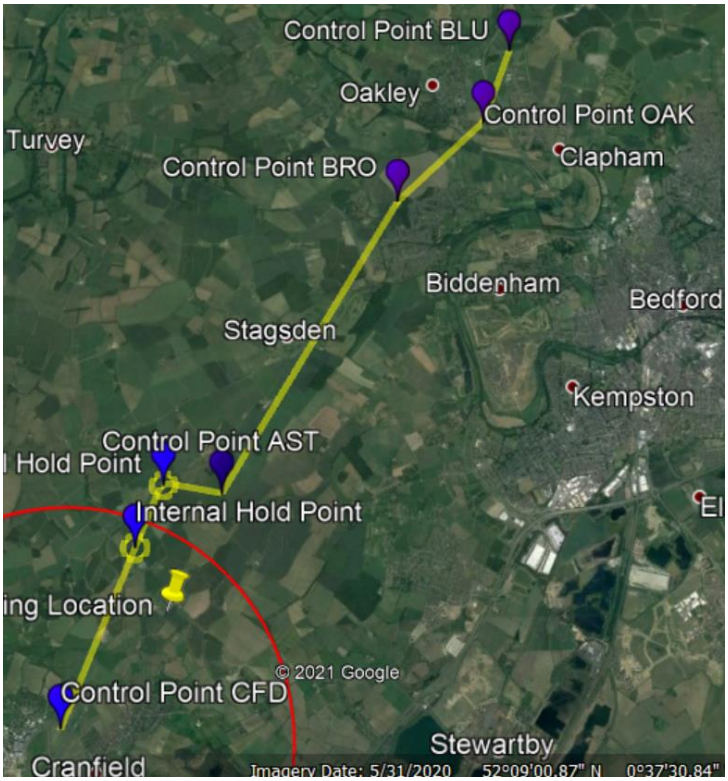


Figure 4: NBEC flight path routing

This includes two 400 metre diameter circular hold points (small yellow circles), one inside the ATZ and one just outside.

The UAV will deviate from this route solely for the purposes of conducting a 180° turn to either side which can be comfortably completed within a radius of 100 metres, and to accommodate expected actual positional accuracy variation compared to a flight plan path, which is known to be <50 metres laterally.

3.2 Suggested NBEC segregated airspace

It is proposed that the airspace corridor is sized such that all UAV operations can be confidently conducted within a defined volume of airspace whilst minimising both the impact to other airspace users and overflight of residential areas.

3.2.1 Corridor width

Recognising the requirement for the UAV's turning radius and the inherent flight plan profile following accuracy, a corridor of width 300 metres would be the minimum required to contain the UAV flight. It is requested that this be increased to 500 metres to provide clear safety margins either side of the minimum required width. This aligns with the request in the initial proposal to the CAA ACP process.

3.2.2 Corridor height

Flight plans for the UAV will not exceed 400 feet AGL, with this height being the typical target height.

Given that most manned aviation traffic would not normally be operating <500 feet in the area of the proposed corridor airspace, the requested ceiling height for the corridor is 500 feet AGL, in order to allow a minimum of 100 feet buffer between the UAV flights and other airspace users.

The proposed NBEC flight path routes over a descending landscape away from Cranfield Airport's ATZ. This is shown in Figure 5 along with proposed airspace volume's effective bottom surfaces identified.

Figure 5: NBEC flight path elevation and assumed ground heights

Trials conducted by Cranfield Airport have demonstrated that at the heights that the UAV is expected to fly at, the acoustic noise is barely above background wildlife levels, with little variation in magnitude when at 400 ft AGL cruise height with the autopilot engaged [2]. Hence the UAV sound would be barely noticeable at these heights.

3.3 Final ACP requested

In order to minimise complexity and impact to manned aircraft, the proposed airspace has therefore been split into two sections with different ground heights – 300ft Above Mean Sea Level (AMSL) and 200 AMSL. The furthest-most section away from Cranfield ATZ has a ground height of 100 feet lower than the inner section. This is shown in Figure 6 (Cranfield Airport ATZ is the red cylindrical volume and the proposed NBEC airspace is the yellow 'stepped' volume).

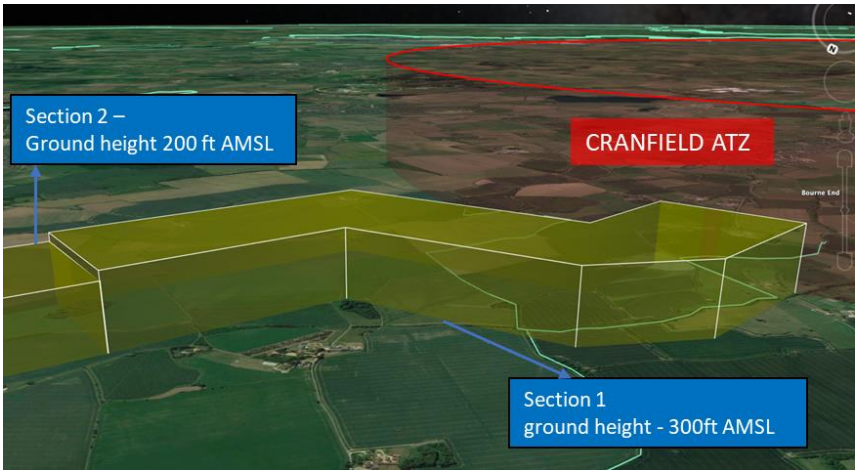


Figure 6: NBEC flight path Sections – assumed ground heights

The details of the two-section updated proposed airspace volume are shown in Figure 7.

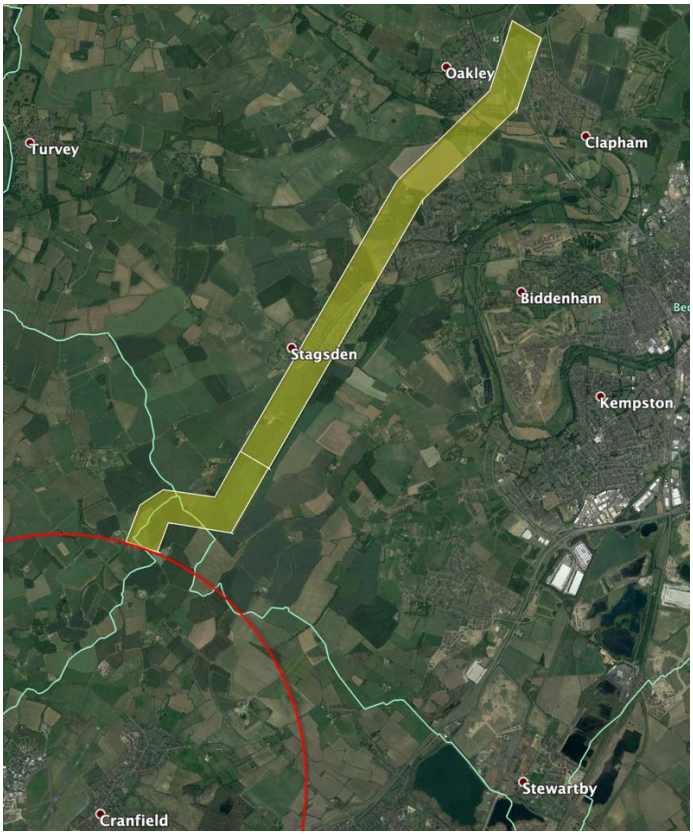


Figure 7: NBEC ACP final volume

Thus, the specific locations and heights defining the final ACP are shown in tables 1 and 2.

Section 1 (adjacent to ATZ) Surface to 800ft AMSL [500AGL]		
Point	**Latitude**	**Longitude**
1	520610N	0003544W
2	520625N	0003535W
3	520619N	0003445W
4	520651N	0003414W
5	520659N	0003437W
6	520637N	0003458W
7	520641N	0003539W
8	520634N	0003558W
9	520616N	0003610W

Table 1: NBEC Section 1 airspace volume coordinates

Section 2 (furthest from ATZ) Surface to 700ft AMSL [500ft AGL]		
Point	**Latitude**	**Longitude**
1	520651N	0003414W
2	520905N	0003204W
3	520952N	0003044W
4	521029N	0003023W
5	521038N	0003046W
6	521002N	0003107W
7	520915N	0003225W
8	520659N	0003437W

Table 2: NBEC Section 2 airspace volume coordinates

This information is available as a .KMZ file, which has been sent by email to the Airspace Regulator (Technical) – Airspace Utilisation overseeing this proposal.

4.0 Intended operations overview

UAV flights will operate inside the NBEC, typically departing from and returning to Cranfield Airport or Blue Bear's Twinwood facility. Additionally, operations will be conducted from locations along the NBEC, subject to permission from respective landowners.

Separation from manned aircraft will be achieved through communication with Cranfield ATC when inside the ATZ, and through remaining within the requested segregated airspace (i.e., within the corridor) when outside of the ATZ.

Communication will be maintained with Cranfield ATC at all times enabling the UAV to be separated from instrument approach traffic outside of the ATZ.

UAV operators will have specific Operational Authorisation from the CAA for BVLOS type flights in the segregated corridor.

Note that UAV flights within the proposed NBEC corridor are for the primary purposes of testing novel surveillance and navigation technologies. Such technologies are being tested in parallel to the UAS' GPS-based navigation. The UAS will be operated with no onboard connection between its flight control and navigational systems to such new technologies, and is therefore not reliant on them in any way for its own navigational purposes.

The following clarifications have been made to the initial design following the targeted engagement work:

- The airspace will be activated by NOTAM.
- NOTAMs will include contact details including Cranfield ATCs telephone number and frequency.
- NOTAMs will be published at least 24 hours in advance.
- Cranfield ATC will provide both a Danger Area Crossing Service (DACS) and a Danger Area Activity Information Service (DAAIS) as described in the next section.
- UAV flight path routing has been adjusted to minimise residential overflight.

5.0 NBEC activation and communication strategy

Airspace operational requirements and considerations

- The corridor will not be active at weekends.
- The corridor will only be active during hours that Cranfield ATC is active.
- It is the intention that preferred activation times and days of the week will be utilised, however it is too early to define the exact details at this stage.
- Flight durations are anticipated to be 1-2 hours in duration
- It is anticipated that there will be 1-2 flights per day when the corridor is active.
- All UAV flights will require permission from Cranfield ATC to operate in either Cranfield's ATZ or the NBEC corridor TDA, and will be under the control of ATC whilst inside the ATZ.
- UAV flight routing inside the ATZ will be pre-agreed with Cranfield ATC.
- Potential hold points inside and outside the ATZ have been identified and agreed with Cranfield ATC.
- UAV remote pilots will have communications availability with Cranfield ATC at all times (using radio-telephone and/or phone as required).
- Cranfield ATC will hold a copy of the UAV Eventualities Procedure for reference.

Cranfield ATC will therefore know if a UAV is airborne and if it is inside or outside the ATZ and in the NBEC airspace.

Cranfield ATC will not know the specific location of the UAV other than position reports provided by the remote pilot.

Airspace activation

- The NBEC TDA will be activated by NOTAM.
- Cranfield ATC will file all NBEC NOTAMs.
- NOTAMs will normally be filed by the end of the week that precedes the activation week (expected to be by the Friday before).
- Activation will be cancelled as soon as the NOTAM TDA is no longer required, and where relevant at the end of the preceding day, e.g., if unsuitable weather is forecast.

Airspace communication

- Cranfield ATC will provide both a Danger Area Crossing Service (DACS) and a Danger Area Activity Information Service (DAAIS).
- The DACS will mirror the Approach service and will be Procedural. The intended basis will be of 'singular occupancy' i.e. If the DA is active then crossing will be denied. In case of priority aircraft requiring crossing clearance, essential traffic information will be passed and a crossing clearance given. It is expected that the UAV pilot may, depending upon the flight profile and position, elect to land or hold at a position to deconflict. This information will be passed to update the essential traffic information. Note: The details of this will be decided with further safety assessments and discussion with pilots.
- The DACS will be in accordance with AIP ENR 5.1.3.3, that is:
    - When the DA activity permits, provide a clearance for an aircraft to cross the Danger Area under a suitable type of service. It should be noted that, dependent on the activity, it may be possible to accommodate a crossing of a DA during its notified hours of operation.
    - The crossing clearance is only in relation to DA activity. The provision of deconfliction advice and/or traffic information in relation to other traffic, either inside or operating close to the DA, will be in accordance with the scope of the specific ATS provided, i.e., Deconfliction Service, Traffic Service or Basic Service.
    - Where possible, the pilot should provide the DACS Unit with an estimated crossing time. When used by a DACS Unit, the term 'active' means that the DA is notified as active and there is activity taking place.
- Cranfield ATC will provide a Danger Area Activity Information Service in accordance with AIP ENR 5.1.3.4, that is:
    - to provide requesting aircraft with an airborne update of the activity status of a participating Danger Area whose position is relevant to the flight of the aircraft.
- NOTAMs will contain Cranfield's active frequency and telephone number.
- A scheduled airspace activation plan will be provided to Cranfield local operators, the BGA, the BHGA, and the MOD low flying cell, following approval of the ACP (note this would be subject to change).

6.0 Summary of Final ACP

In summary the final design of the Temporary Airspace Change proposed is detailed in Figures 8 and 9, and tables 3 and 4.

Although flight plans for the UAV will never exceed 400 feet AGL (with this being the typical target height), the ceiling height for the corridor is requested to be 500 feet AGL, in order to allow a minimum of 100 feet buffer between the UAV flights and other airspace users. This translates to a ceiling height of 800 feet AMSL for Section 1 (adjacent to ATZ) and 700 feet AMSL for Section 2 (away from ATZ).

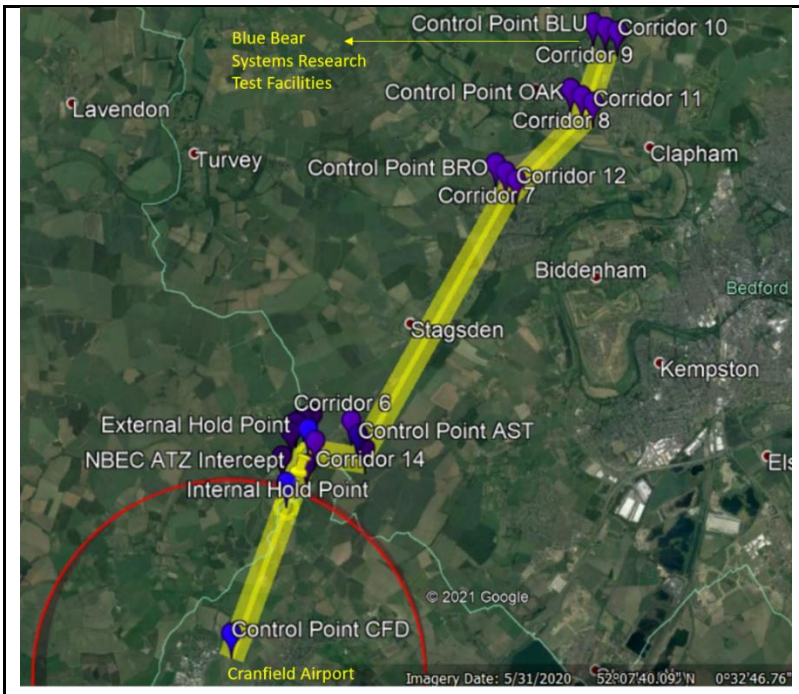
NBEC Airspace Volume	Characteristics
	• Airspace volume defined by latitude / longitude coordinates detailed in Table 1 • Corridor width of 500 metres maximum • Corridor height 500 feet AGL

Figure 8: NBEC Final ACP Overview

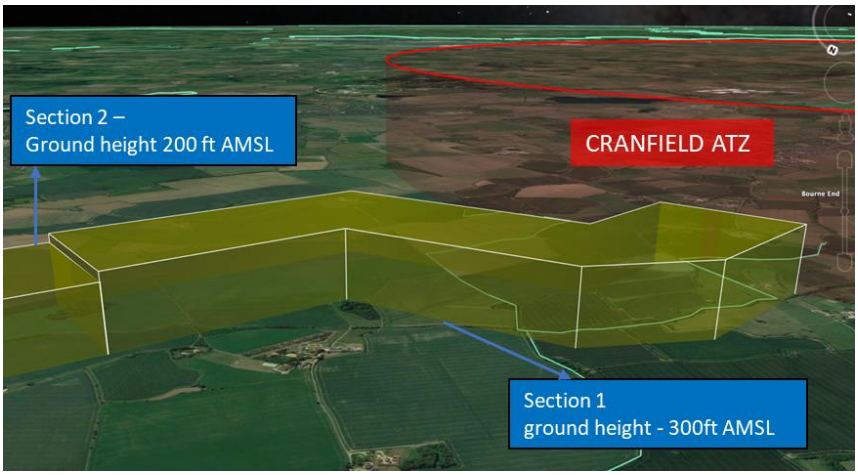


Figure 9: NBEC Final ACP Overview – Sections ground heights

Section 1 (adjacent to ATZ) Surface to 800ft AMSL [500AGL]		
Point	**Latitude**	**Longitude**
1	520610N	0003544W
2	520625N	0003535W
3	520619N	0003445W
4	520651N	0003414W
5	520659N	0003437W
6	520637N	0003458W
7	520641N	0003539W
8	520634N	0003558W
9	520616N	0003610W

Table 1: NBEC Section 1 airspace volume coordinates

Section 2 (furthest from ATZ) Surface to 700ft AMSL [500ft AGL]		
Point	**Latitude**	**Longitude**
1	520651N	0003414W
2	520905N	0003204W
3	520952N	0003044W
4	521029N	0003023W
5	521038N	0003046W
6	521002N	0003107W
7	520915N	0003225W
8	520659N	0003437W

Table 2: NBEC Section 2 airspace volume coordinates

7.0 References

[1] National Beyond visual line of sight Experimentation Corridor Airspace Change Proposal - Targeted Engagement report78, 28 May 2021

[2] National Beyond visual line of sight Experimentation Corridor Airspace Change Proposal - Acoustic Noise Measurements, 12 May 2021

[3] CAA CAP670 Air Traffic Services Safety Requirements June 2019.

[4] EUROCONTROL Specification for ATM Surveillance System Performance (Volumes 1 & 2), Ed. 1.1. September 2015.

[5] CAA Innovation Hub CAP1861A, "Detect & Avoid Ecosystem for BVLOS in Non-Segregated Airspace", October 2020.

[6] NBEC Trials Plan In support of the CAA 'Sand Box' Study Version 5, 22nd September 2020.