Bristow Helicopters UAS Prototype Service – Trials Airspace Update

15 January 2022

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  - Integration of S-100 location data with third party software.
  - Automated detect and avoid capability via - OEM derived ADS-B Transponder / Software.
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- Trials Airspace Proposal submitted to CAA.

Introduction

- Three programme objectives have been set for the UAS PS to demonstrate, that are required to deliver and field a UAS SAR capability.

  1. Determine the optimal payload / sensor for a UK SAR(UAS) capability.
  2. Optimise the employment of UAS for UK SAR.
  3. UAS Integration and dynamic deployment within UK Airspace.

- To achieve objective 3 – BHL committed as part of Trials Airspace Proposal - Phase 3, Stage 1a: To test and evaluate novel electronic conspicuity technologies (included in next slide).

Introduction

- Novel electronic conspicuity technologies included as part of trial airspace proposal:

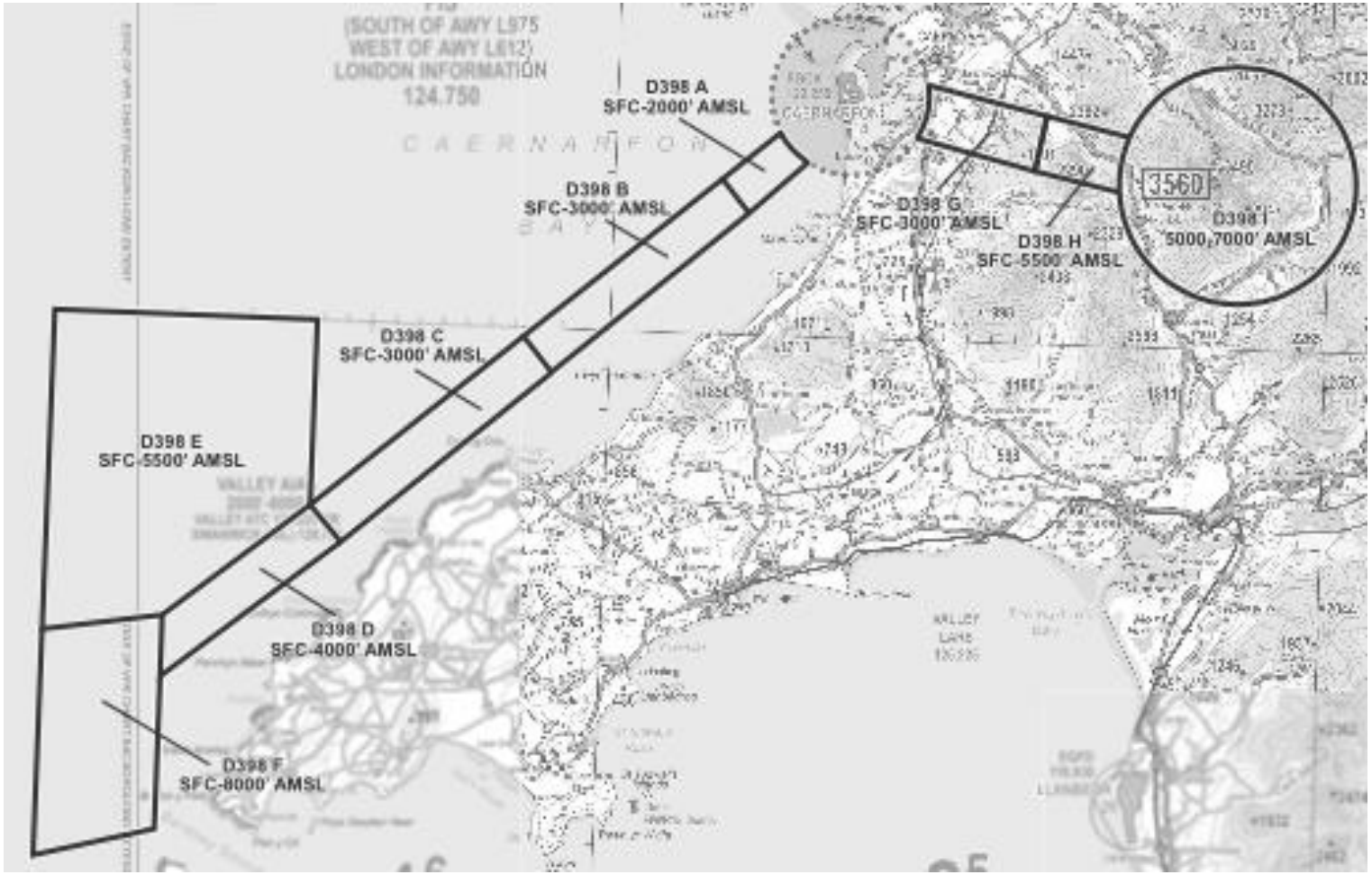
Item	Trial Activities Included	Technology
1	Integration of S-100 location data with third party software to improve situational awareness.	Development of software to integrate [redacted].
2	Automated detect and avoid capability via - OEM derived ADS-B Transponder / Software.	[redacted]– Mode S ADS-B [redacted]
3	Airspace surveillance systems.	[redacted] - common airspace surveillance picture
4	Air-to-air communications system, to enable communications between UAS platform and other air users (VHF rebroadcast).	[redacted]

Introduction

- This update sets out the progress to date, activity undertaken and the evidence case for what has been achieved.

Item	Trial Activities Included	Technology	Status
1	Integration of S-100 location data with third party software.	Development of software to integrate into [redacted].	On hold – Transponder use delayed due to CAA approvals.
2	OEM derived ADS-B Transponder / Software with automated detect and avoid capability.	[redacted] – Mode S ADS-B ([redacted]	On hold – Transponder use delayed due to CAA approvals. • Detect – Completed • Avoid – Not started
3	Airspace surveillance systems.	[redacted]	Completed • Mobilisation - Completed • Evaluation - Completed
4	Air-to-air communications system.	[redacted]	Paused - OEM technical issues.

Introduction – TDA Complex



Integration of S-100 location data

with third party software.

Location Data

End of Trial Update

- The development and evaluation of the ability to share location data from the UAS through third party applications based based on the [redacted] [redacted] on the S-100.
- The approval to use the [redacted] – Mode S ADS-B (In/Out transponder on the S-100 in the TDA complex was withdrawn by the CAA from 6 Jan 21 to 22 Oct 21.
- Consequently the development and evaluation was placed on hold, until the TDA complex was closed.

Automated detect and avoid

capability via - OEM derived ADS-B

Transponder / Software.

Detect and Avoid

Aim

- Demonstrate that the [redacted] Mode S, ADSB (In/Out) transponder coupled with the Schiebel 7.14 software has the potential to enhance airspace situational awareness.

Approach

- In order to achieve this in measured and balanced way, the trial approach comprises two elements of detect and avoid of co-operative aircraft. (Set out in next slides).

Detect - Trial

Objective

- The transmission of S-100 location to other ADS-B capable air users.
- The detection by GCS of other ADS-B capable air users within the airspace.

Testing regime / Activities

- Installation:
  - [redacted] transponder onto S-100 UAS in accordance with OEM procedures.
  - Software 7.14 onto the S-100 and Cube (GCS) in accordance with OEM procedures.
- S-100 location shared through ADS-B network, evidenced through third party applications – FlightRadar 24, 360 Radar, ADS Exchange.
- Accuracy of the S-100 location validated by ATSU secondary surveillance radar.
- Detection of S-100 by other co-operative air users / ATSU.
- Detection of other co-operative air users by S-100 GCS.

Detect - Progress

- Installation of software 7.14 (30 Sep 20). – Pass.
- Installation of Beta version of the [redacted] transponder installed (8 Mar 21). – Pass.
- Ground test detection capability (8 Mar 21). – Fail.
  - Co-operative air user unable to ‘see’ S-100. Raised with OEM, likely due to software altitude settings, advised to air test.
- Air test detection capability (9 Mar 21) – Fail.
  - Co-operative air users able to ‘see’ S-100 – Pass.
  - Other co-operative air users in North Wales displayed in North America on software - Fail
    - Raised with OEM, after analysis of computer log files, OEM determined a software bug, which required software patch circa 3 months to rectify.
- Installation of version 1.0 of the [redacted] transponder installed (11 Jun 21) - Pass
- Installation of software 7.14 patch (14 Jun 21) – Pass.
- Ground test detection capability (15 Jun 21) – Pass.
- Air test co-cooperative air users detection (22 Jun 21). – Pass.

Detect – Progress (Transponder installation)

Detect – Progress

- Live flight trials conducted over period 14 Apr 21 to 29 Jun 21 (Sorties: UAS062, 063, 064, 067, 071, 078, 079).
  - S-100 location shared through ADS-B network - evidenced through third party applications – FlightRadar 24, 360 Radar, ADS Exchange – Complete.
  - Accuracy of the S-100 location validated by ATSU – Complete.
  - Detection of S-100 by other co-operative air users / ATSU – Complete.
  - Detection of other co-operative air users by S-100 GCS – Complete.

- **Aim:** Demonstrate the capability of the UAS fitted with [redacted] ADSB In/Out transponder improves situational awareness by publishing UAS location information into the ADSB network – **Complete**

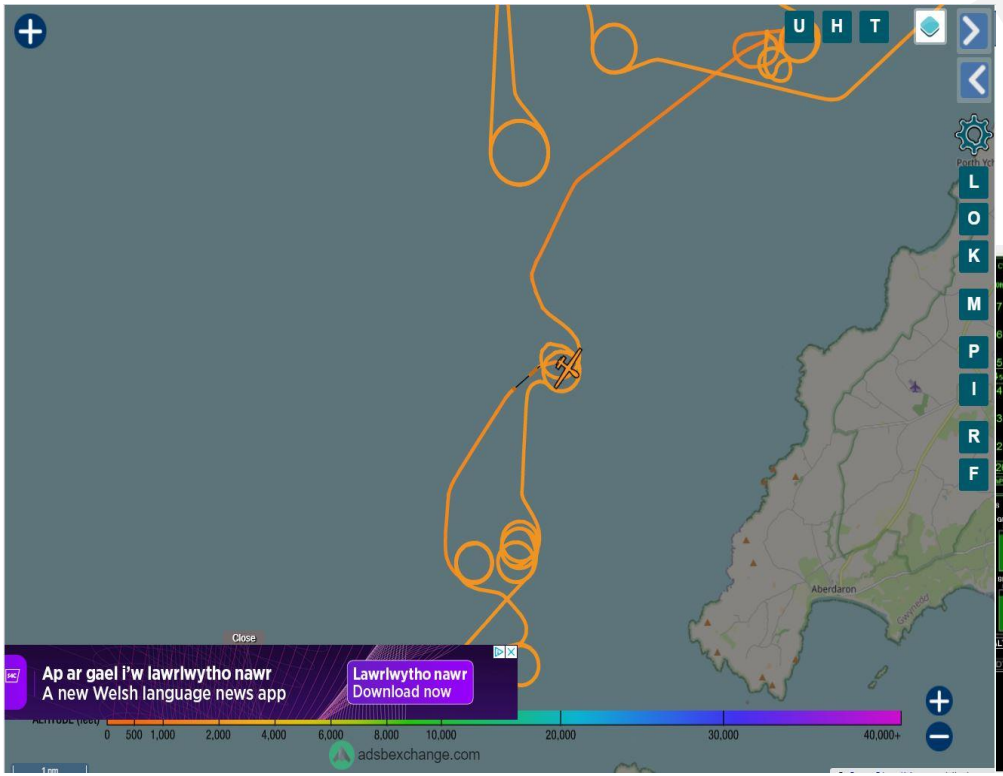
Evidence: UAS062

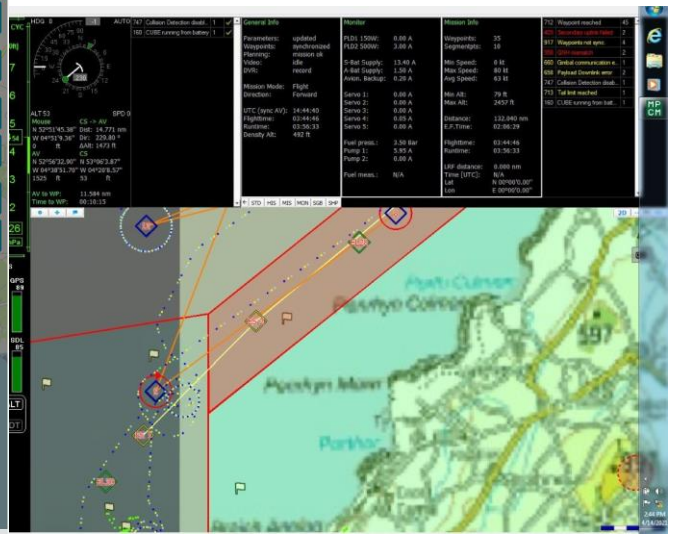
Sortie Objective: Demonstrate the capability of the UAS fitted with [redacted] ADSB In/Out improves situational awareness by publishing UAS location information into the ADSB network.

- Activities
  - UAS location data published through ADSB Network.
  - UAS location published through ADSB network verified by RAF Valley Primary Radar.

Evidence: UAS062

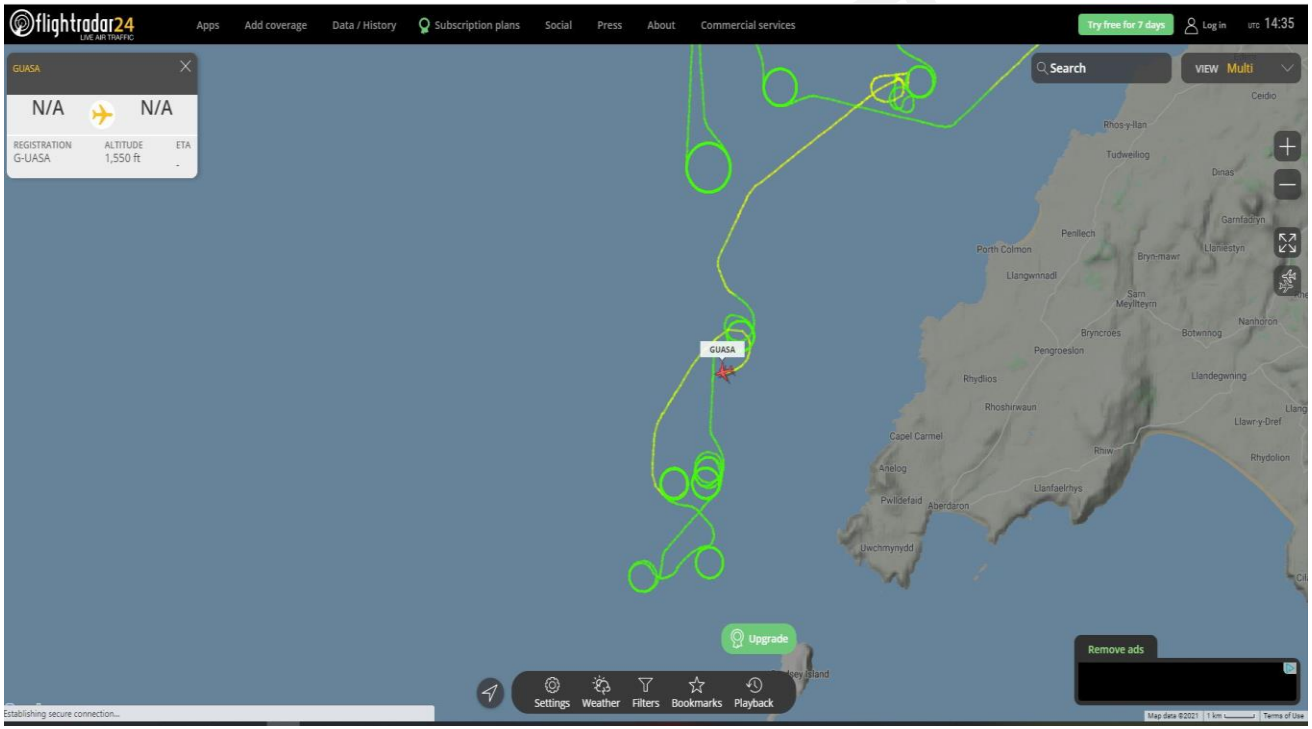
- **UAS location data published through ADSB network – ADSB Exchange.**
  - Location displayed within GCS: N52º56’32.90 W04º38’51.70
  - Screen shots from ADSB Exchange, showing UAS ivo N52º56’32.90 W04º38’51.70





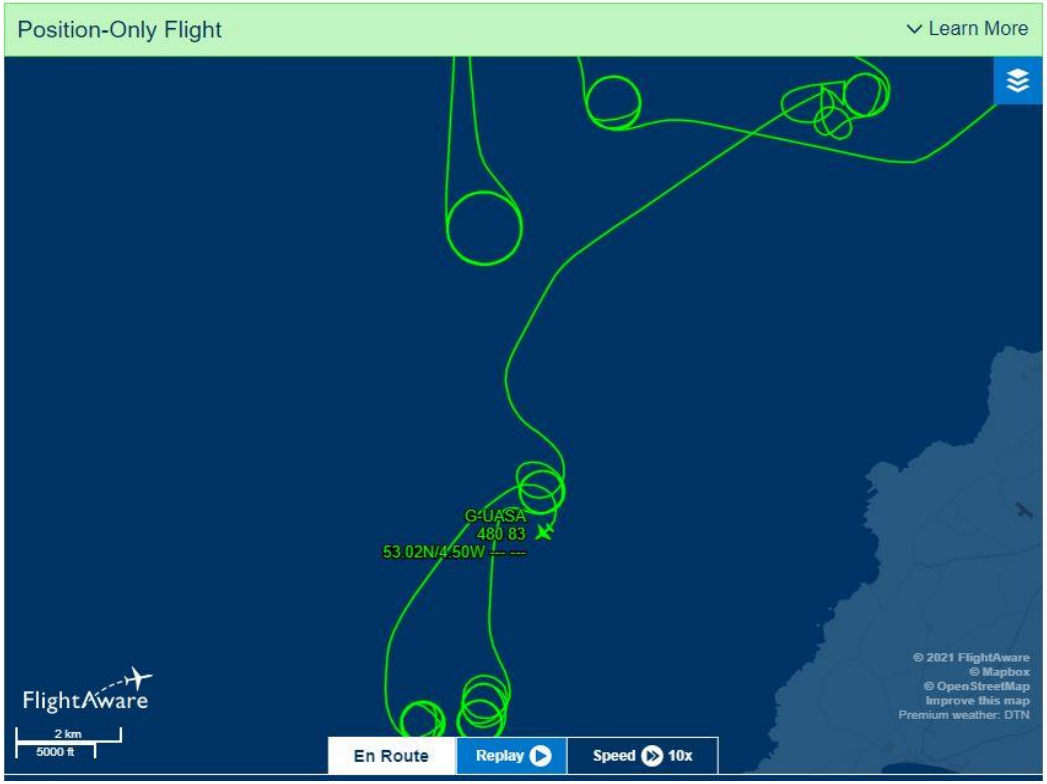
Evidence: UAS062

- **UAS location data published through ADSB network – Flight Radar 24.**
  - Location displayed within GCS: N52º56’32.90 W04º38’51.70
  - Screen shots from Flight Radar 24, showing UAS ivo N52º56’32.90 W04º38’51.70



Evidence: UAS062

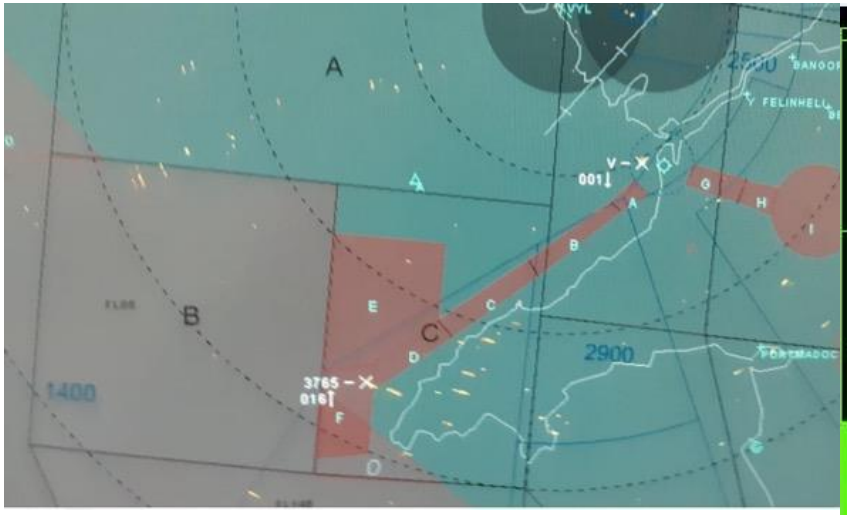
- **UAS location data published through ADSB network – Flight Aware.**
  - Location displayed within GCS: N52º56’32.90 W04º38’51.70
  - Screen shots from Flight Aware, showing UAS ivo N52º56’32.90 W04º38’51.70



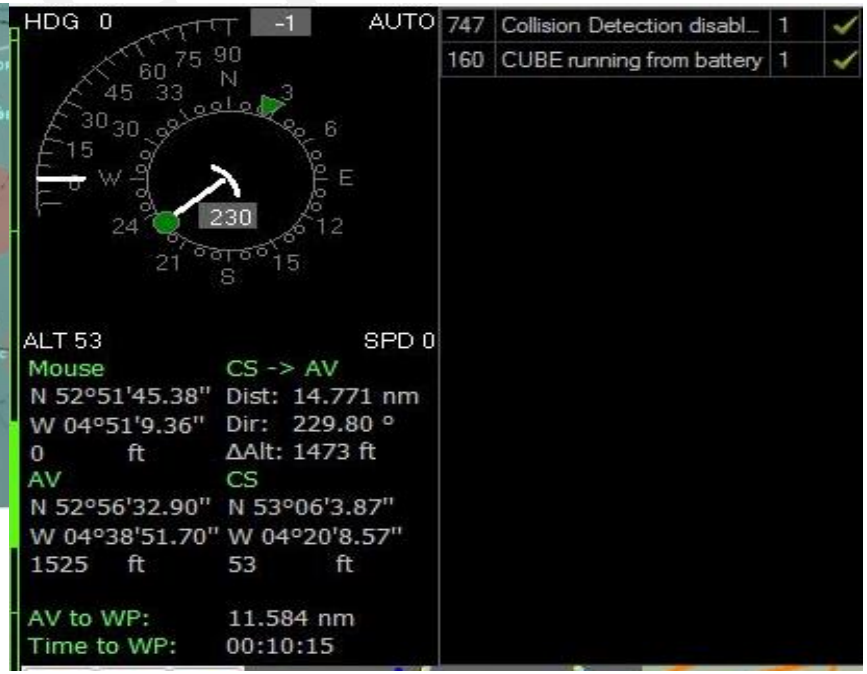
Evidence: UAS062

- Accuracy of the S-100 ADS-B location validated by ATSU (RAF Valley - Secondary Surveillance Radar (SSR)).

Screen shots from RAF SSR, showing UAS ivo N52º56’32.90 W04º38’51.70



Location displayed within GCS: N52º56’32.90 W04º38’51.70



Evidence: UAS064

Sortie Objective: Demonstrate the capability of the UAS fitted with [redacted] ADSB In/Out improves situational awareness by publishing UAS location information into the ADSB network.

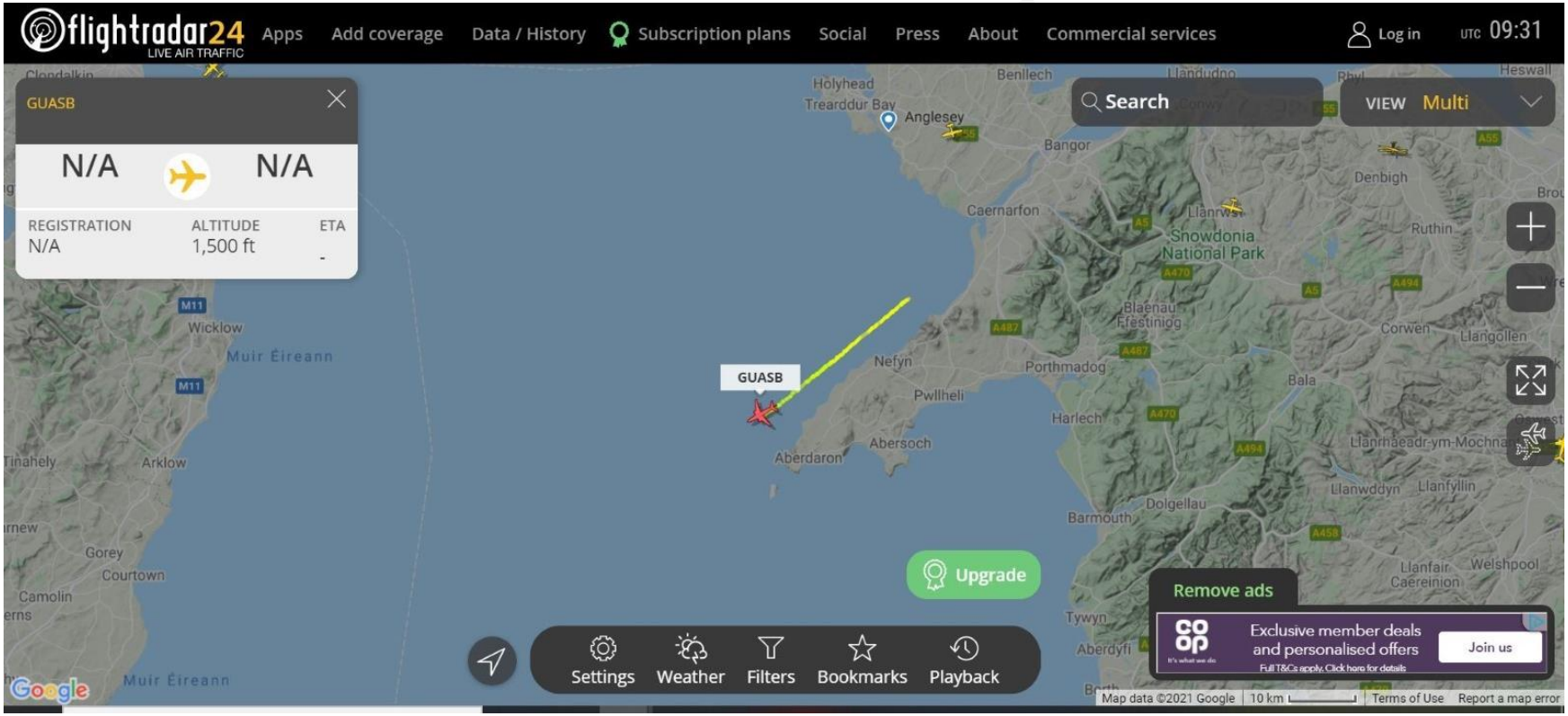
- Activities
  - UAS location data published through ADSB Network.
  - UAS location published through ADSB network verified by RAF Valley Primary Radar.

Evidence: UAS064

- **UAS location data within GCS.**

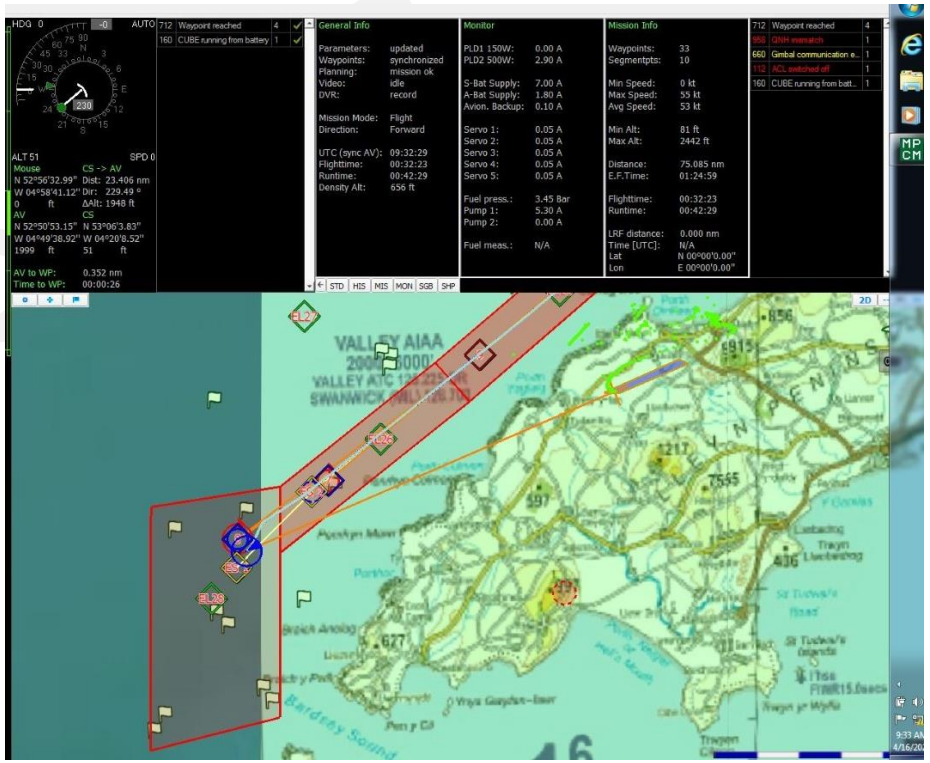
Evidence: UAS064

- **UAS location data published through ADSB network – Flight Radar 24.**



Evidence: UAS064

- **Accuracy of the S-100 ADS-B location validated by RAF Valley Secondary Surveillance Radar (SSR).**



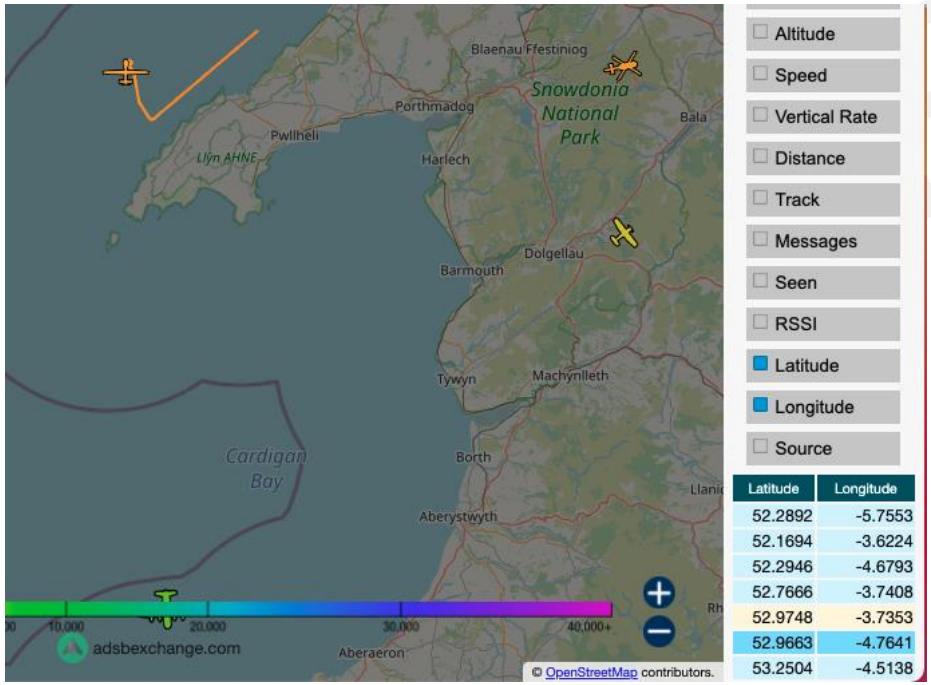
Evidence: UAS067

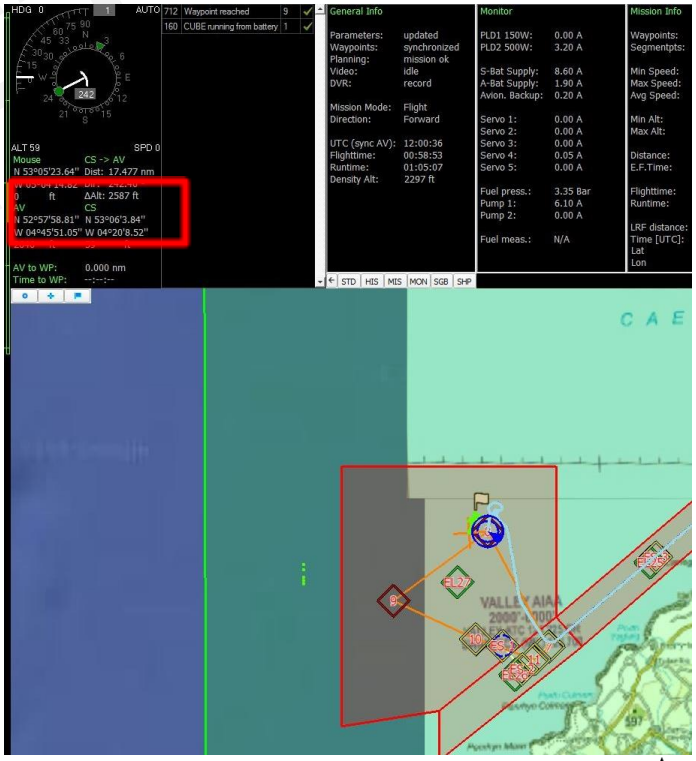
Sortie Objective: Demonstrate the capability of the UAS fitted with [redacted] ADSB In/Out improves situational awareness by publishing UAS location information into the ADSB network.

- Activities
  - UAS location data published through ADSB Network.
  - UAS location published through ADSB network verified by RAF Valley Primary Radar.

Evidence: UAS067

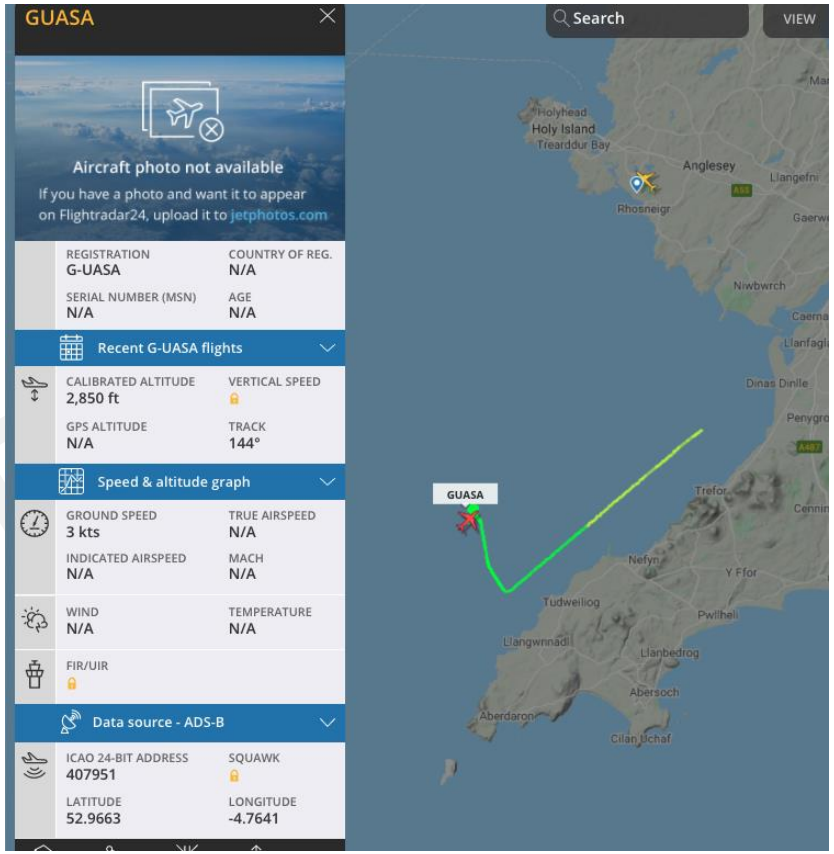
- **UAS location data displayed within GCS.**
  - ADSB Exchange – Lat & Long: N52.9663. W004.7641 Flight Radar 24 – Lat & Long: N52.9663. W004.7641
  - MPCM – Lat & Long (Red Square): N52°57’50.01 W004°45’51.06 / converted to Decimal Degrees: N52.9638 W004.7641





Evidence: UAS067

- ADSB derived improvements to airspace situational awareness.



Evidence: UAS071

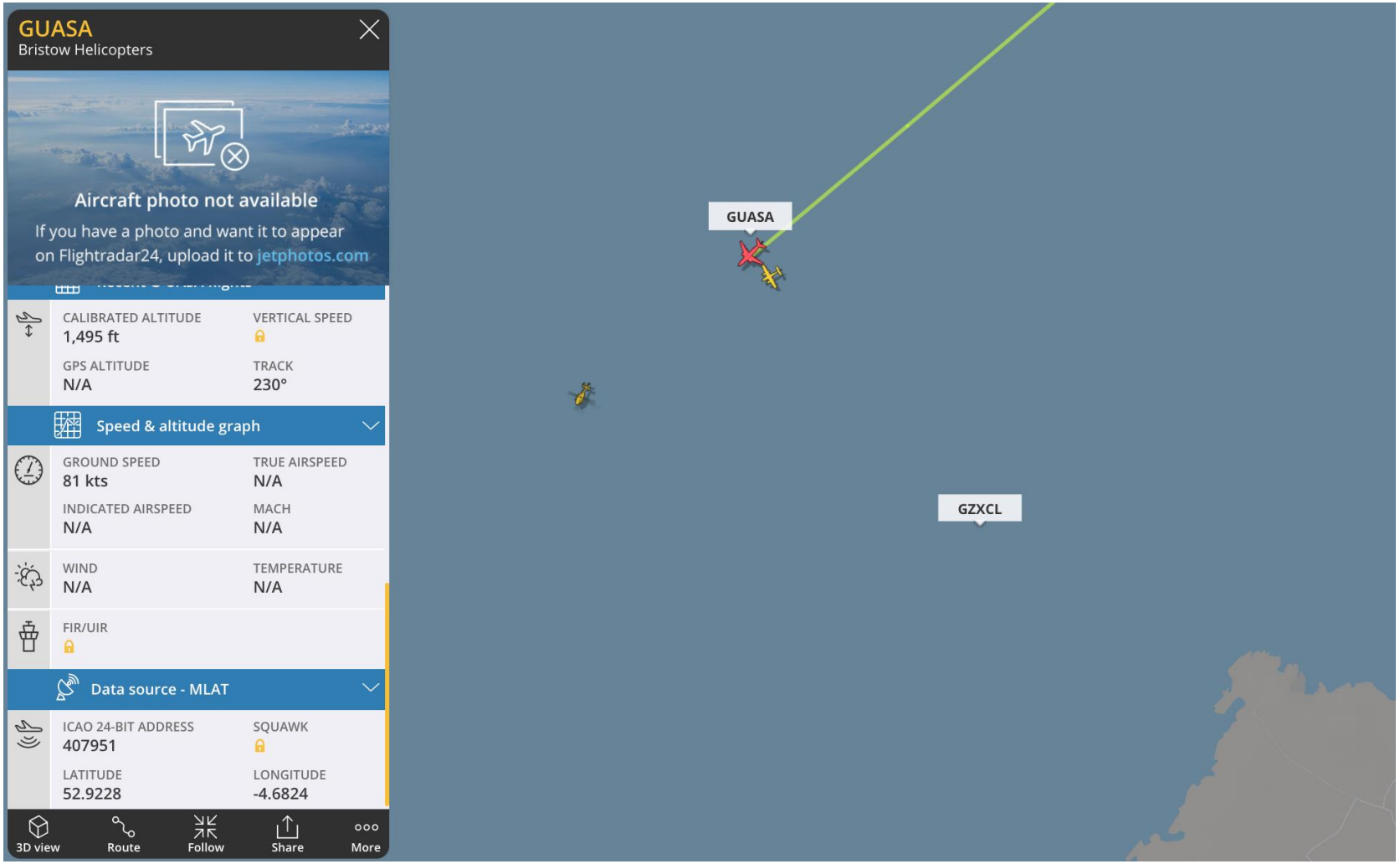
- **Activity:** The sortie was undertaken in accordance with the plan (slides 10 – 12), with no deviations.
  - C/S Bristow Unmanned established within D398 transit corridor, on a heading of 230°, altitude 1500 ft ”*pressure setting*”, and speed 90 kts.
  - C/S CG937 closed on UAS heading and speed, at 2 to 3 rotor discs distance.
  - C/S CG22 closed on C/S Bristow Unmanned and C/S CG937.
  - C/S Blade1 positioned to North of C/S group to take photos.

- **Airspace Segregation:** UAS remained within segregated airspace complex throughout the duration of the sortie.

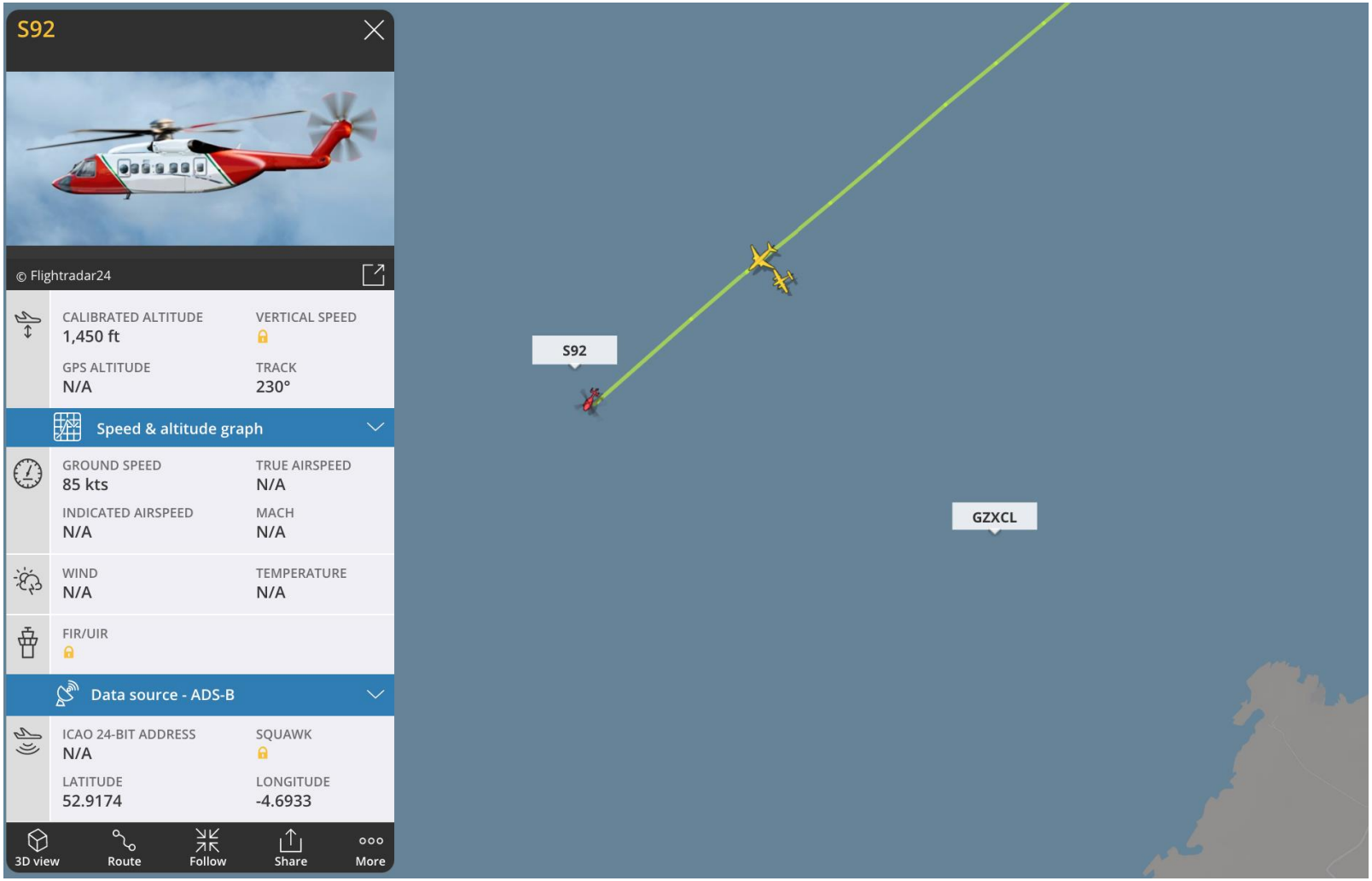
Evidence: UAS071

- Objectives achieved:
  - Conduct a sortie with a variety of aircraft types for a media exploitation opportunity, to demonstrate spectrum of Maritime and Coastguard Agency Assets.
    - Media Photos included within slides 15 – 17.
  - Demonstrate prebriefed procedural deconfliction, to enable the activity to take place.
    - Situational awareness derived through the ADSB network and evidenced through third party web based application; FlightRadar24 - included within slides 18 – 27.
  - Demonstrate viable communications with the co-operative aircraft types and ATSU, to enable the activity to take place.
    - Viable VHF Airband (8.33/25 kHz) communications were achieved between activity call signs (CG937, CG22B, Blade1 and Bristow Unmanned) and ATSU (RAF Valley), during the activity. Included within slide 28 - 29.

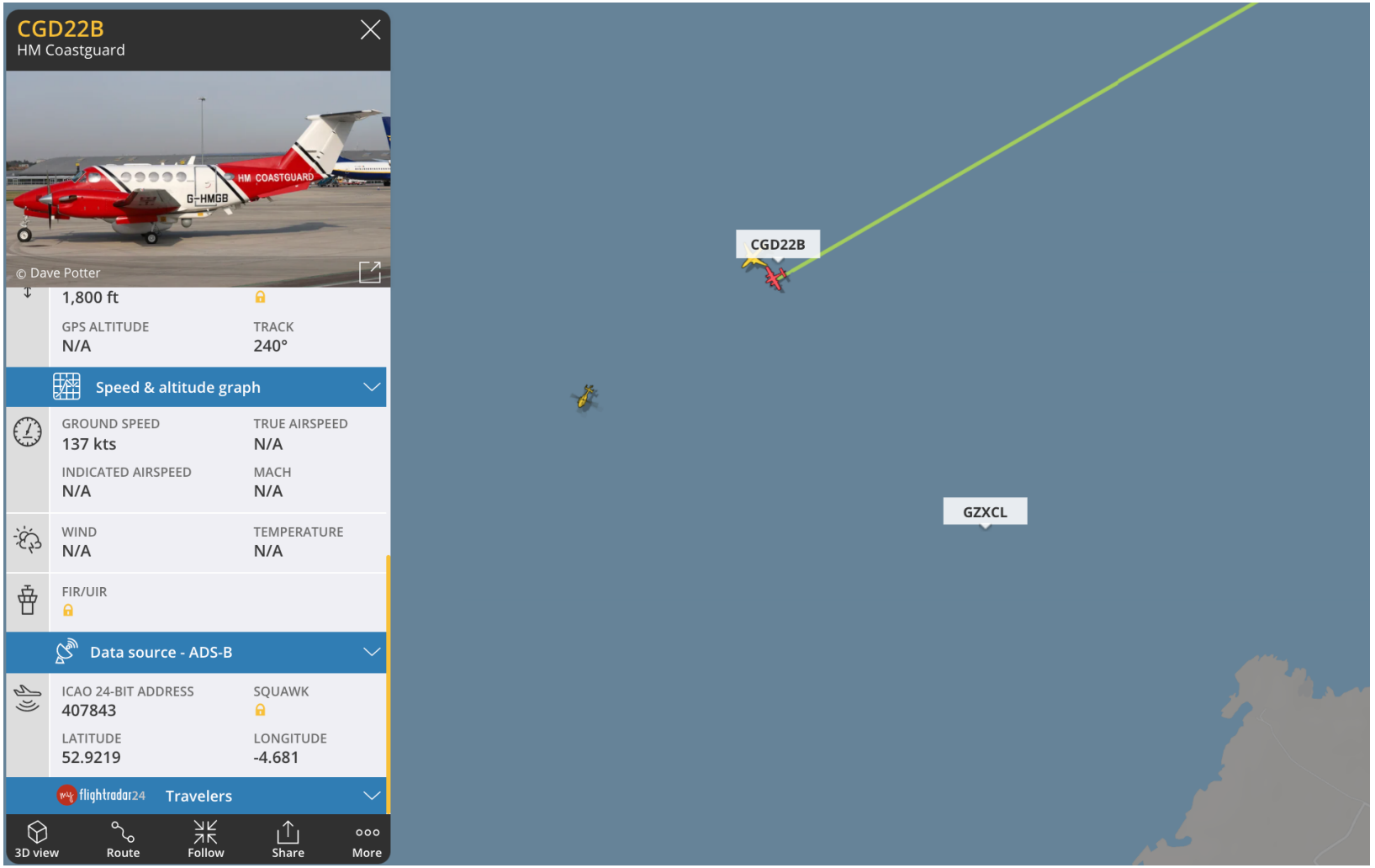
Evidence: UAS071



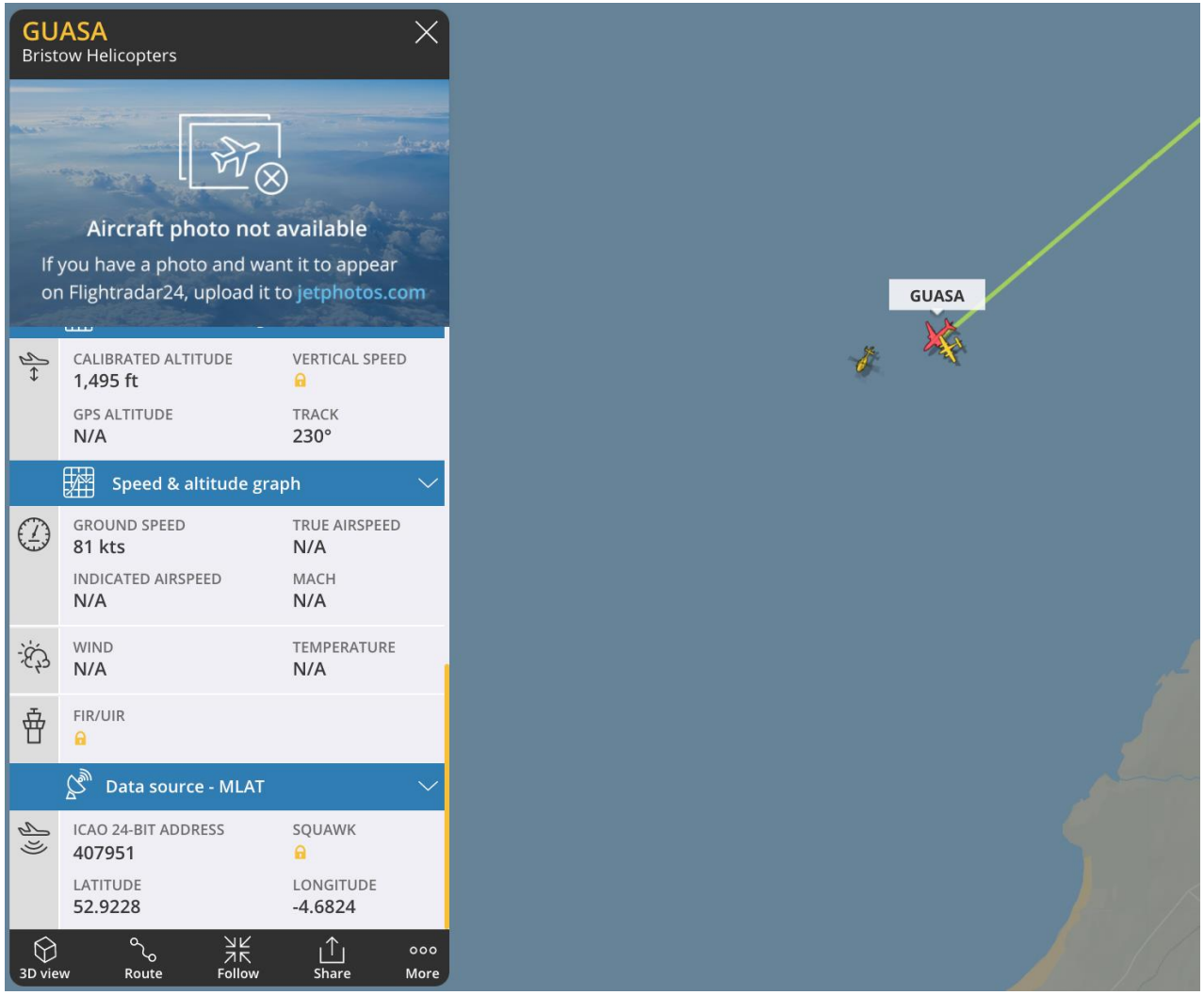
Evidence: UAS071



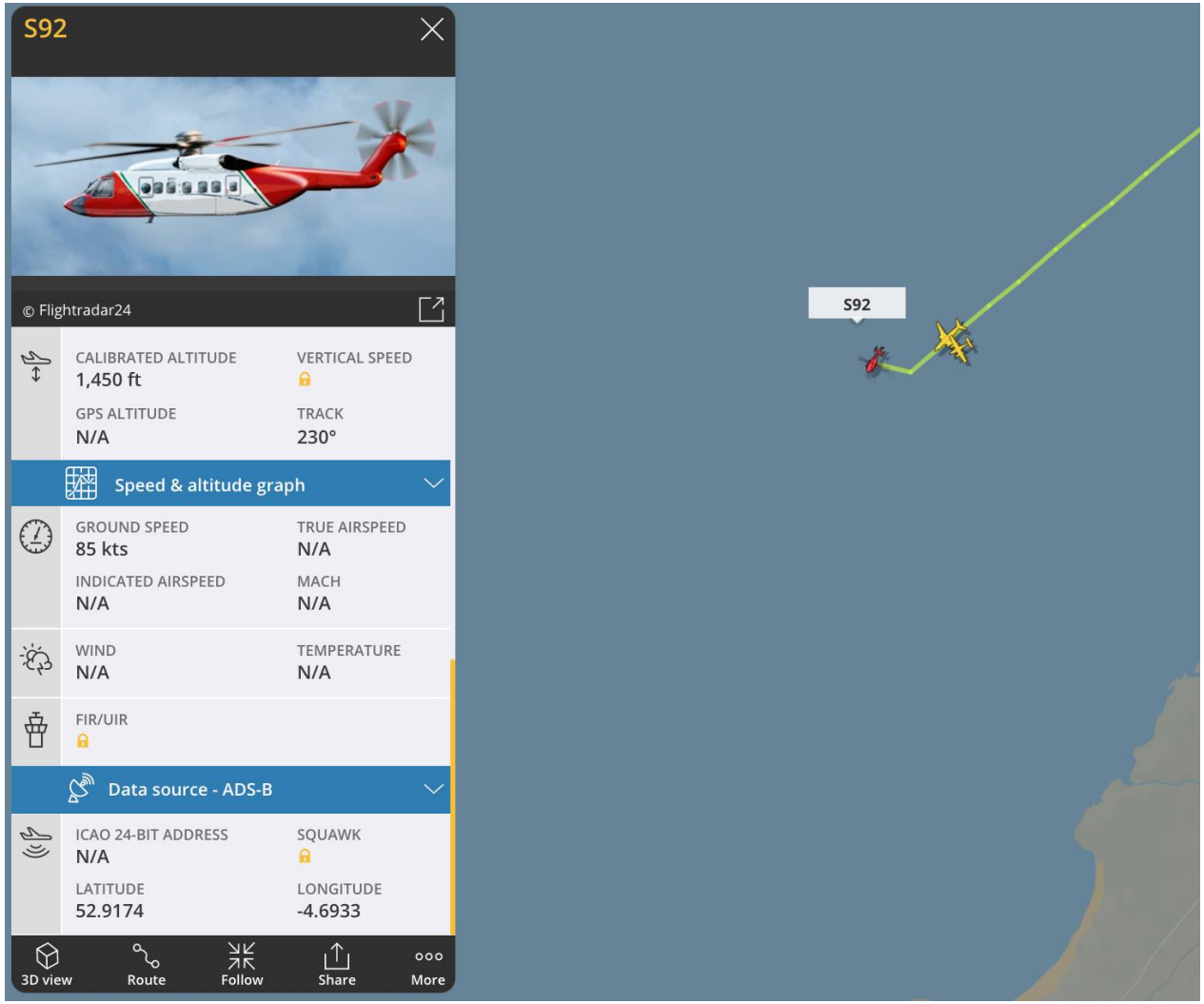
Evidence: UAS071



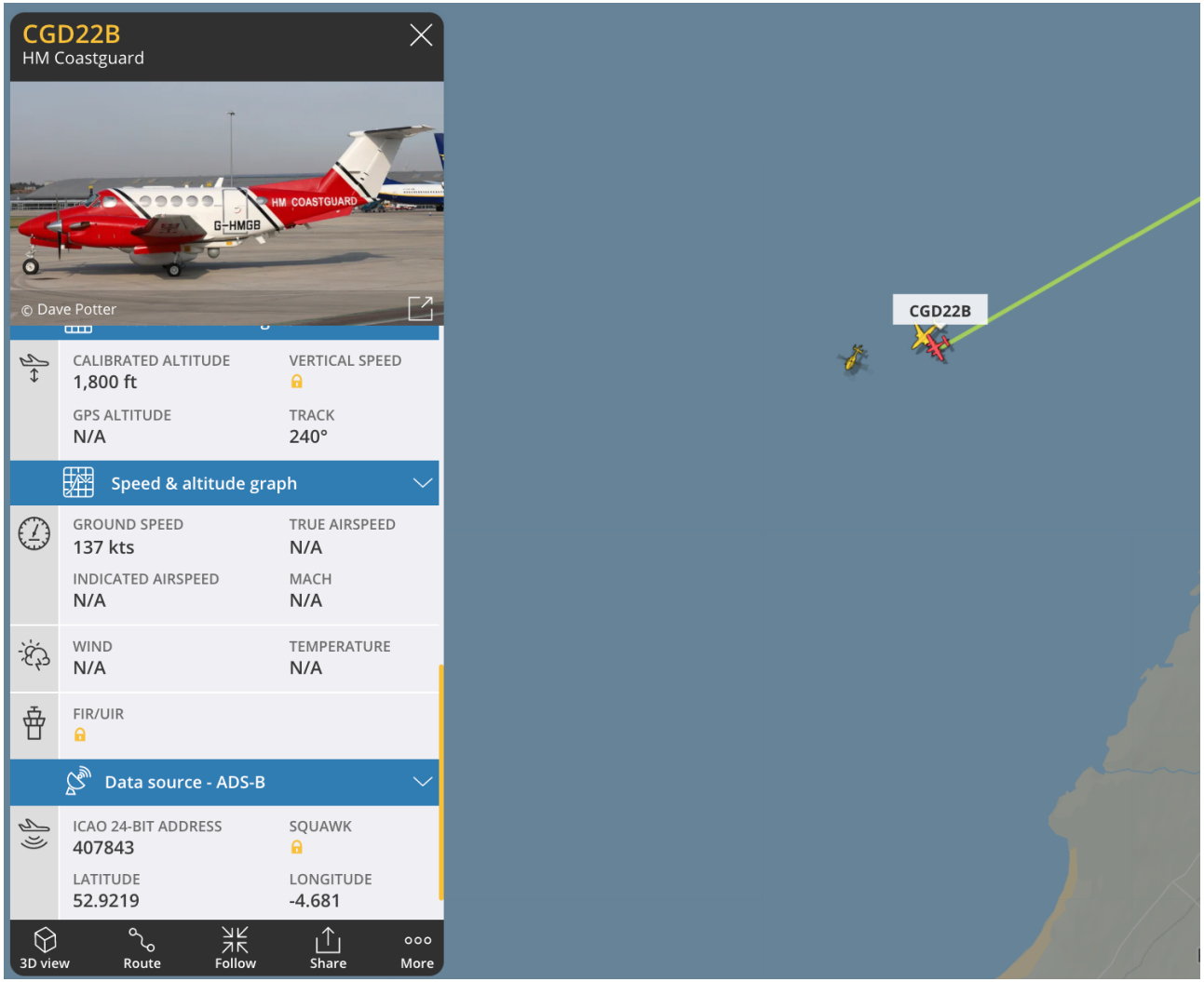
Evidence: UAS071



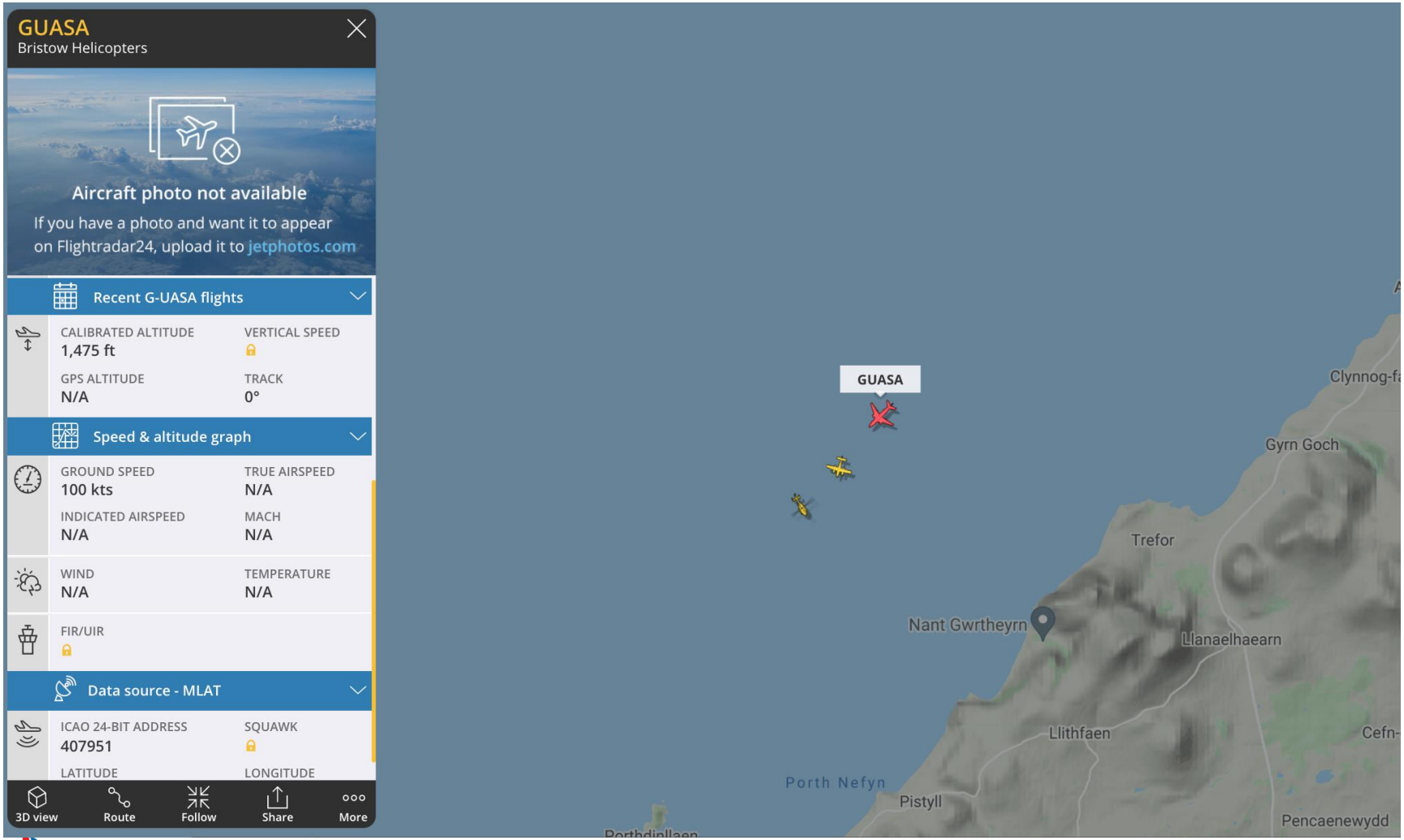
Evidence: UAS071



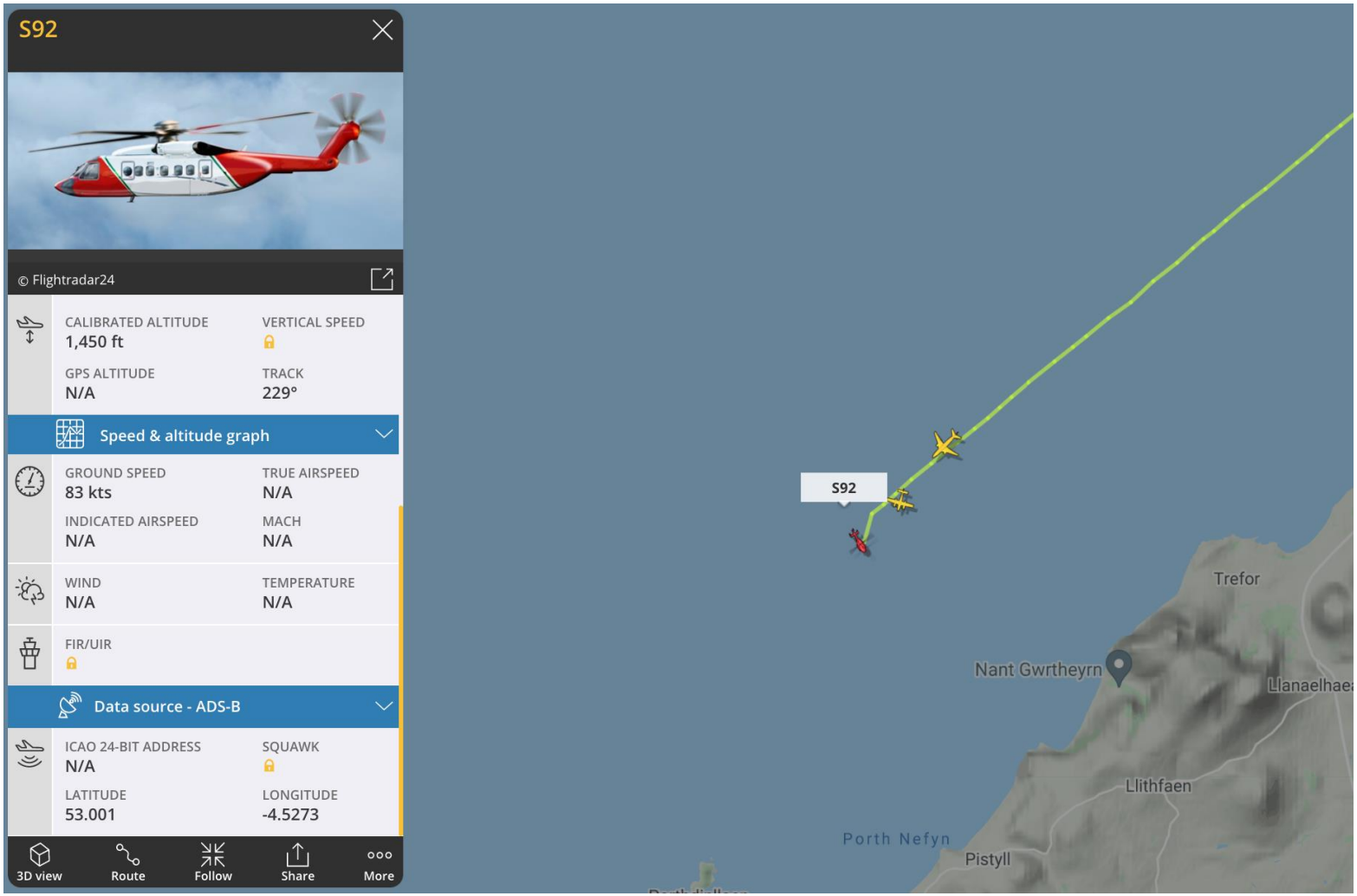
Evidence: UAS071



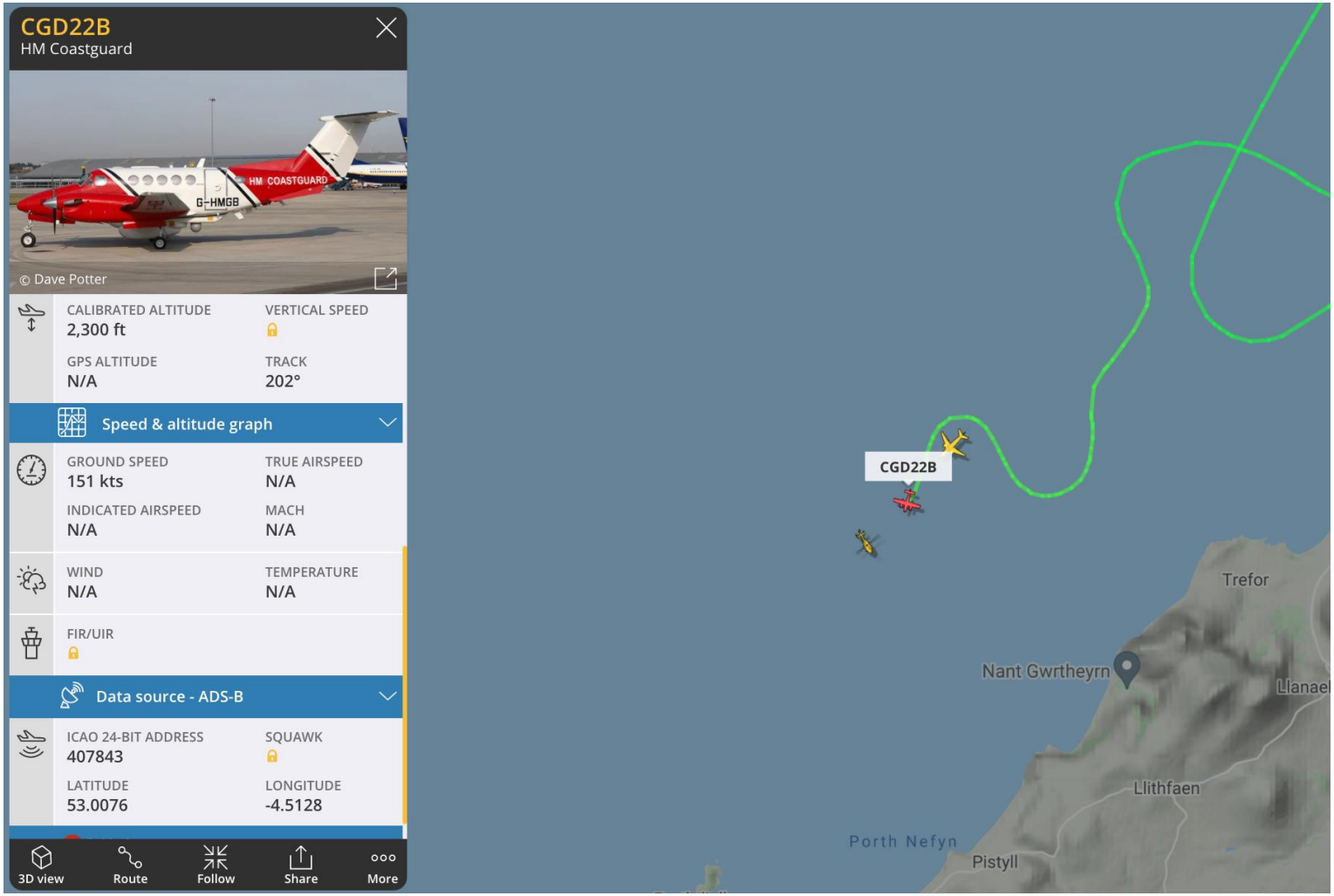
Evidence: UAS071



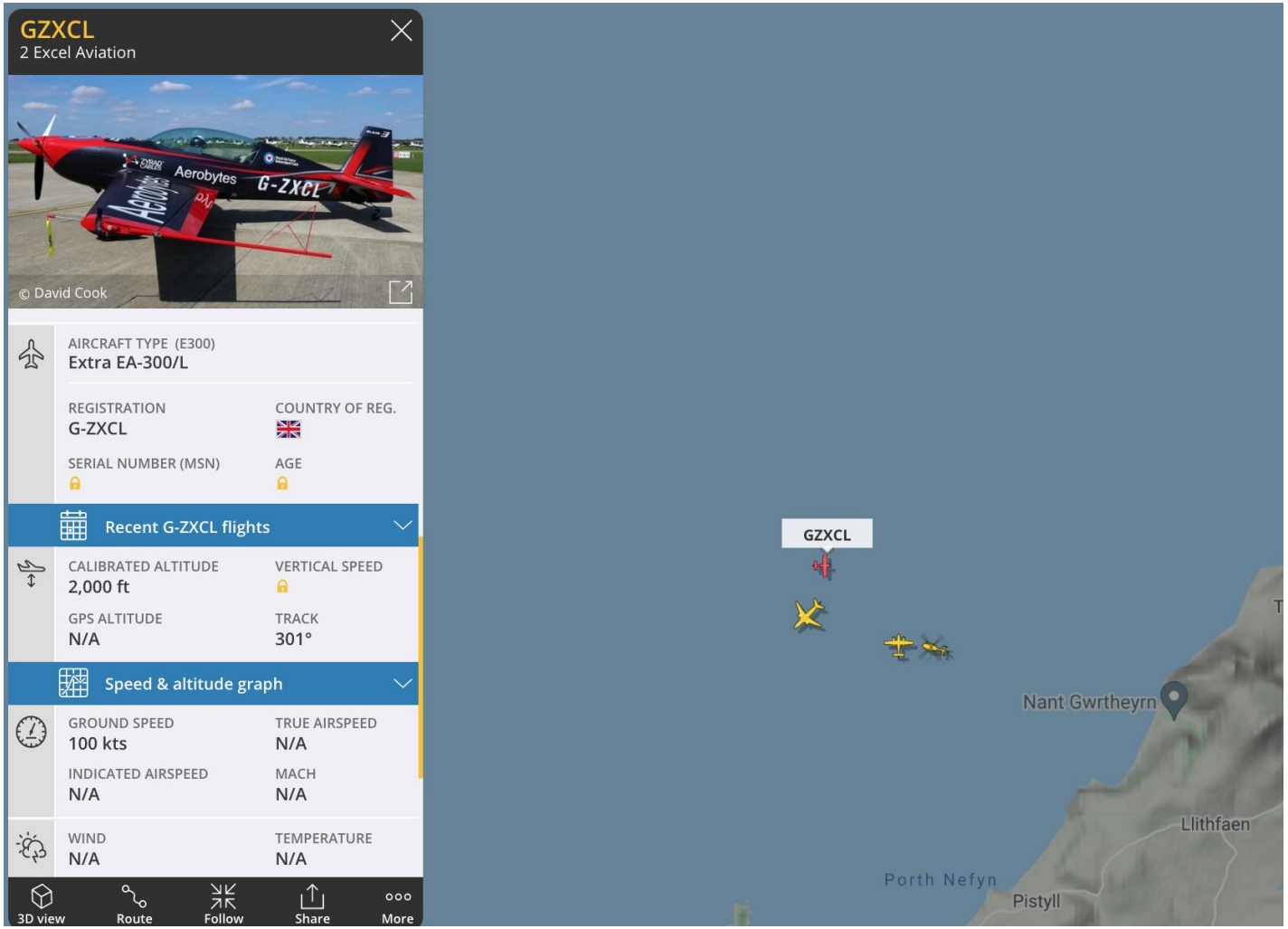
Evidence: UAS071



Evidence: UAS071



Evidence: UAS071



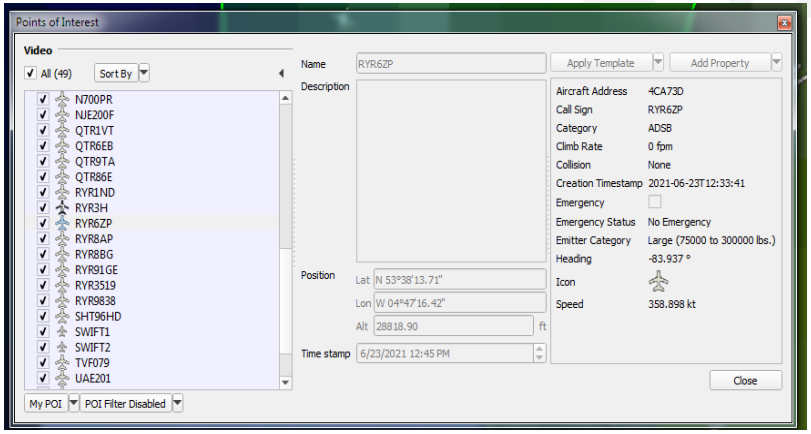
Evidence: UAS078

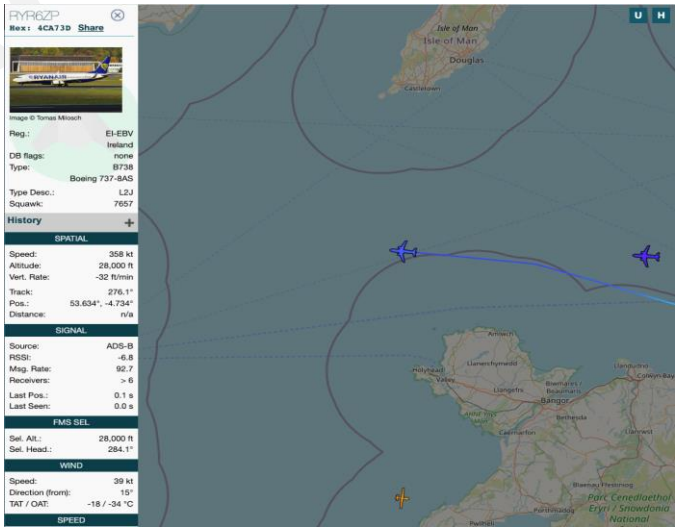
Sortie Objective: To validate [redacted] ADS-B altitude readings on MPCM within GCS.

- Activities
  - Compare third party aircraft data between that displayed on the S-100 MPCM and ADS-B Exchange.

Evidence: UAS078

- **UAS location data published through ADSB network – ADSB Exchange.**
  - Location displayed within GCS: N53º38’12.01 W04º46’52.16
  - Screen shots from ADSB Exchange, showing UAS ivo N53º38’2.4 W04º44’2.4
    - 1.68nm difference (screen shot delay)
  - Altitude and airspeed displayed within GCS: 28,819ft / 359Kts
  - Screen shots from ADSB Exchange: 28,000ft / 358Kts
    - 8-900ft difference in altitude observed.





Evidence: UAS079

Sortie Objective: To validate [redacted] ADS-B altitude readings on MPCM.

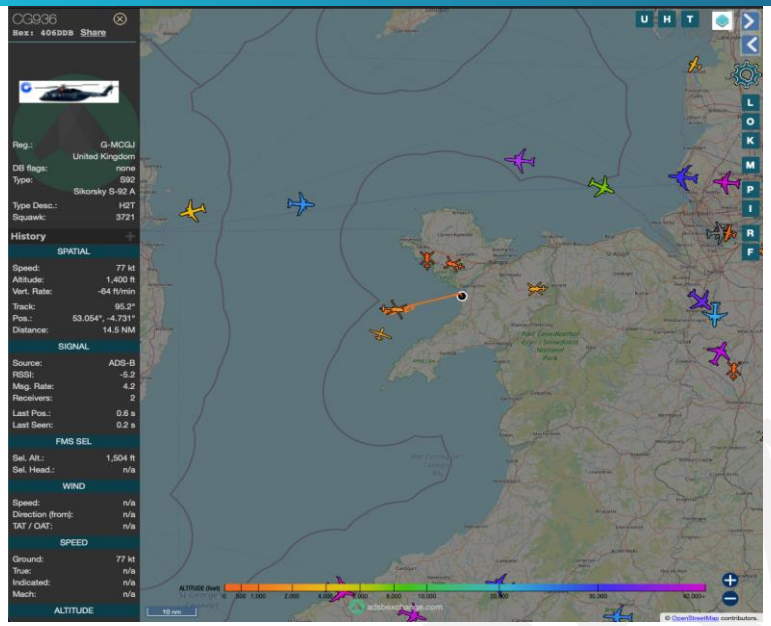
- Activities
  - Compare third party aircraft data between that displayed on the S-100 MPCM and ADS-B Exchange. Specifically a third party aircraft at known altitude and pressure setting to compare against MPCM and ADS-B Exchange.

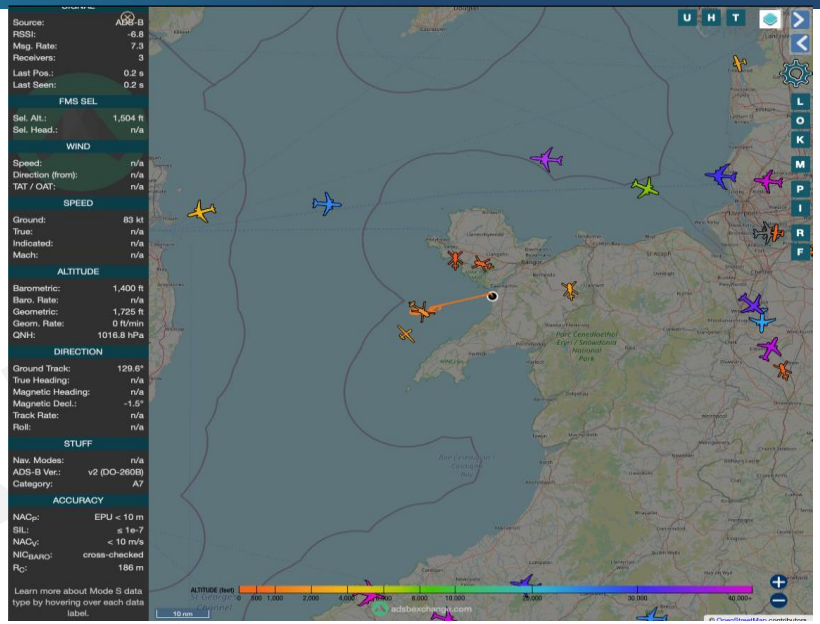
Evidence: UAS078

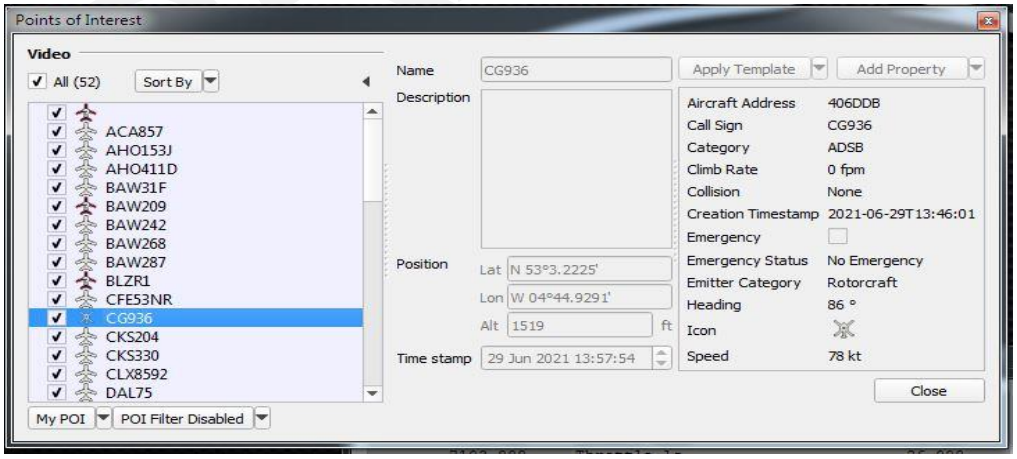
- **UAS location data published through ADSB network – ADSB Exchange.**
  - Location displayed within GCS: N53º03’13.35 W04º44’55.74
  - Screen shots from ADSB Exchange, showing UAS ivo N53º3’14.4 W04º43’51.6
    - 0.64nm difference (screen shot delay)
  - Altitude and airspeed displayed within GCS: 1,519ft / 78Kts
  - Screen shots from ADSB Exchange: 1,400ft / 77Kts
    - 8-900ft difference in altitude observed.

S-92 Altitude	S-92 Pressure Setting	MPCM Altitude Readout	ADSB Ex Barometric Alt	ADSB Ex Geometric Alt	ADSB Ex Pressure Setting	S-92 1013 Adjusted Altitude
1000	1017	1020 (observed 1012-1069	900	1200	1016.8	1014
1500	1017	1519 (observed 1519-1545)	1400	1725	1016.8	1514
2000	1017	2070 (observed 2044-2070)	1925	2250	1016.8	2039
3000	1017	3044 (observed 3044-3067)	2900	3225	1016.8	3014

Evidence: UAS078







Avoid – Trial

Objective

- Evaluate conflict / collision warning. In this version of the software the avoiding action is characterised by the UAS autonomously reducing forward velocity when a conflict is detected.
- Evaluate the S-100 collision avoidance capability for cooperative, ADS-B capable air users.

Testing regime / Activities

- Installation:
  - Software 7.14 onto the S-100 and Cube (GCS) in accordance with OEM procedures. (Completed under detect activity).
- Conflict / collision warning provided by UAS Operators through the graphical user interface & airspace picture, when approach by another air user:
  - Head-on, tail-on, port side and starboard side.
- Avoiding action taken by UAS as a result of a conflict / collision detected when, approach by another air user:
  - Head-on, tail-on, port side and starboard side.

Avoid - Progress

- This trial and evaluation element was placed on hold due to the removal by the CAA of previous approval to use the [redacted] transponder within TDA complex (AIC 010/2021).
- Approval to use the [redacted] transponder was withdrawn by the CAA on 6 Jan 21. It was not until the 22 Oct 21 that the CAA approved its use so that the transponder could be evaluated. The 9 ½ month delay resulted in missing the optimal meteorological weather over the summer required for test serials. [redacted] BHL ceased UAS operations in NW Wales shortly after receipt of approval, and hence the 'Avoid' technology was not evaluated.

Detect & Avoid - Summary

Detect

- The Detect capability provided by the [redacted] transponder and Software 7.14 was evaluated within the constraints of the period CAA approvals were in place.
- The capability was found to provide a robust situational awareness tool for the UAS operators, and other air users with connectivity into the ADSB network.

Avoid

- The Avoid capability provided by the [redacted] transponder and Software 7.14 was unable to be evaluated due to removal of CAA approvals, within the trial window.

References

- 20210414-SPTS-424-UAS062
- 20210415-SPTS-424-UAS063
- 20210416-SPTS-424-UAS064
- 20210506-SPTS-424-UAS067
- 20210518-SPTS-424-UAS071
- 20210623-SPTS-424-UAS078
- 20210629-SPTS-424-UAS079

Airspace surveillance systems -

[redacted]

Airspace surveillance system

Aim

- Establish and demonstrate that a [redacted] airspace surveillance system, generates a common airspace picture, thereby enhancing airspace situational awareness.

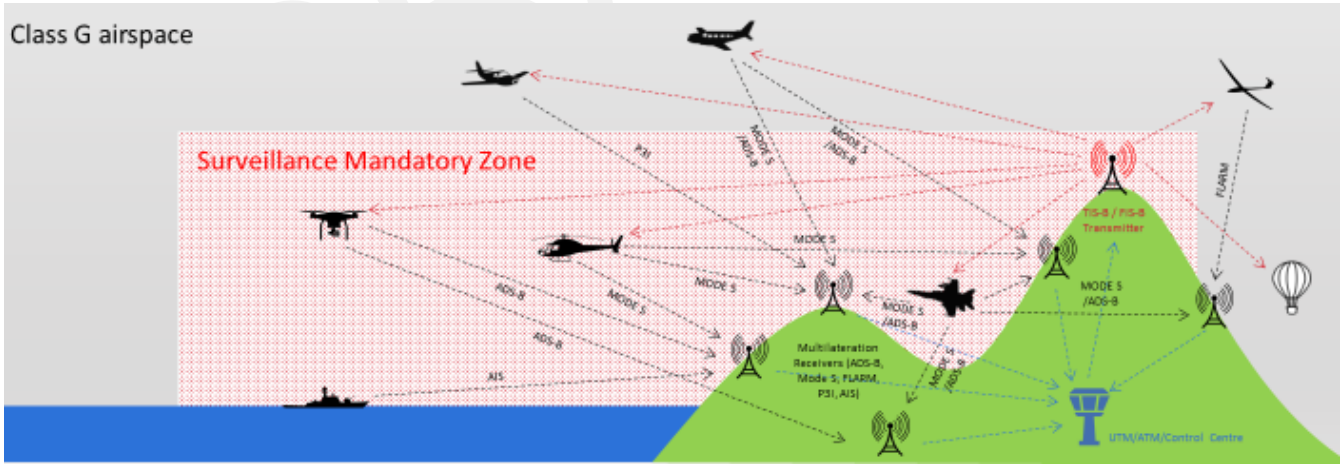
Approach

- In order to achieve this in measured and balanced way, the trial approach comprises five elements of enabling activities, mobilisation, implementation of [redacted] system infrastructure and live trials with co-operative aircraft. (Setout in next slides).

Introduction: Airspace Surveillance System

[redacted]Airspace Surveillance System

- [redacted]integration to give air/maritime picture (situational awareness).
  - Sense and share multi-sensor surveillance picture to generate a known air traffic environment.
- Surveillance mandatory zone established to support BVLOS operations.



Trial - Enabling activities

Objectives

- Enhance UAS GCS communications infrastructure to support air trials with other aircraft with the TDA complex.
- Siting survey with [redacted] to establish locations and infrastructure requirements to establish airspace surveillance system.

Testing regime / Activities

- Installation:
  - Second Airband VHF system.
  - Airband VHF system integration within GCS.
- Demonstrate viable Airband VHF communications:
  - ATSU and other co-operative air users (S-92), and airspace management with DAAIS/DACS.
  - Other co-operative air users in a complex scenario for real-time coordination.
  - ATSU and co-operative air user (S-92) at same time, to enable real-time multi air asset tasking and coordination.
- Conduct siting survey on the Llyn Peninsular and Snowdonia national park to identify suitable locations for [redacted] transmission and receiving stations.

Trial – Mobilisation

Objective

- Agree provision of [redacted] surveillance system.
- Confirm CAA evidence criteria for transponder mandatory zones via future airspace working group.

Testing regime / Activities

- Agree scope and duration of [redacted] surveillance system.
- Contract negotiations.
- Define live trial objectives based on CAA airspace surveillance evidence requirements.

Trial – Implementation

Objective

- Establish a [redacted] based airspace surveillance system.

Testing regime / Activities

- Installation:
  - [redacted] transmitter and receivers.
  - [redacted] system feed into the GCS and third parties as agreed.
- Develop live trial programme.

Trial – Live sorties

Objectives

- Evaluate airspace situational awareness provided by [redacted] system.

Testing regime / Activities

- Validate positional information from [redacted] system via ADS-B network throughout TDA complex.
- Evidence enhanced situational awareness provided by [redacted] system, through live trials.

Progress – Airspace surveillance system

- Enabling Objectives – Complete
  - Enhance UAS GCS communications infrastructure to support air trials with other aircraft within the TDA complex. [Evidence 1 – 3]
  - Siting survey with [redacted] to establish locations and infrastructure requirements to establish airspace surveillance system.
- Mobilisation Objectives – Outstanding
  - Agree provision of [redacted] surveillance system – Complete.
  - Confirm CAA evidence criteria for transponder mandatory zones via future airspace working group – Not provided by CAA, with little direction received of acceptable tolerances.
- Implementation – Complete Aug 21.
- Live Sorties – Complete Oct 21.

Trial Airspace: TDA Coverage

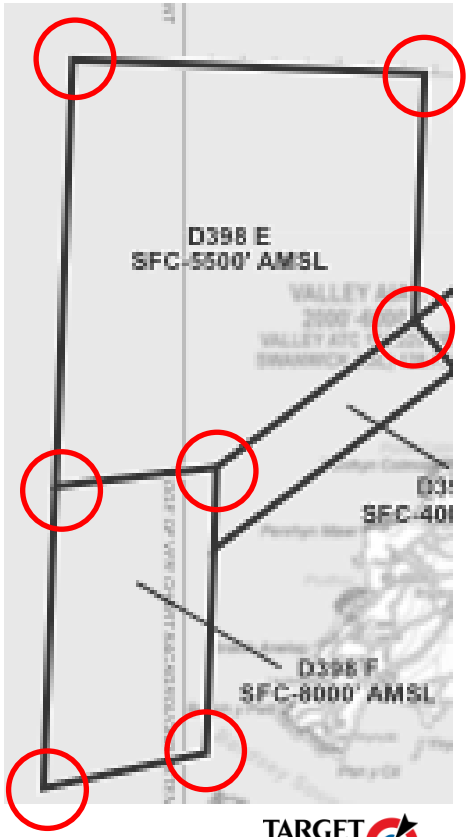
[redacted]: summary

- The Trail & Evaluation was the second opportunity the UAS PS had to evaluate the [redacted] system.
- 5 sorties totalling 14 hours were conducted over the period, using the [redacted] system to improve airspace situational awareness within the North Wales region and, more specifically, the D396 TDA complex.
- During the period 20 Sep to 10 Nov 21, outages of 5 system components were experienced, one of which had a direct impact on UAS sorties. Mitigations have been developed in part, but any system deployed in support of a Transponder Mandatory Zone (TMZ) would require redundancy of all components to provide a more robust system. Critical to this is the ability to provide operators with confidence that the system is up and running, for example the development or inclusion of system status.
- The key finding over the period was that although [redacted] provides generic airspace situational awareness, it is missing the key components of proximity / collision warnings. These components would be a critical element of any UAS 'Detect & Avoid' capability required for UAS to operate in a Transponder Mandatory Zone. Without this functionality system is of limited benefit for UAS operators.

Evidence: Enabling activities

- Demonstrate viable communications with ATSU and other co-operative air users (S-92), and airspace management with DAAIS/DACS.

Date: 22 Apr 21
Task: Communications check completed between GCS and S-92 (Coastguard 936) at 1500ft at the corners of the D398 TDA complex (marked in red).
Results: VHF communications strength 5/5.



Evidence: UAS071 - Enabling activities

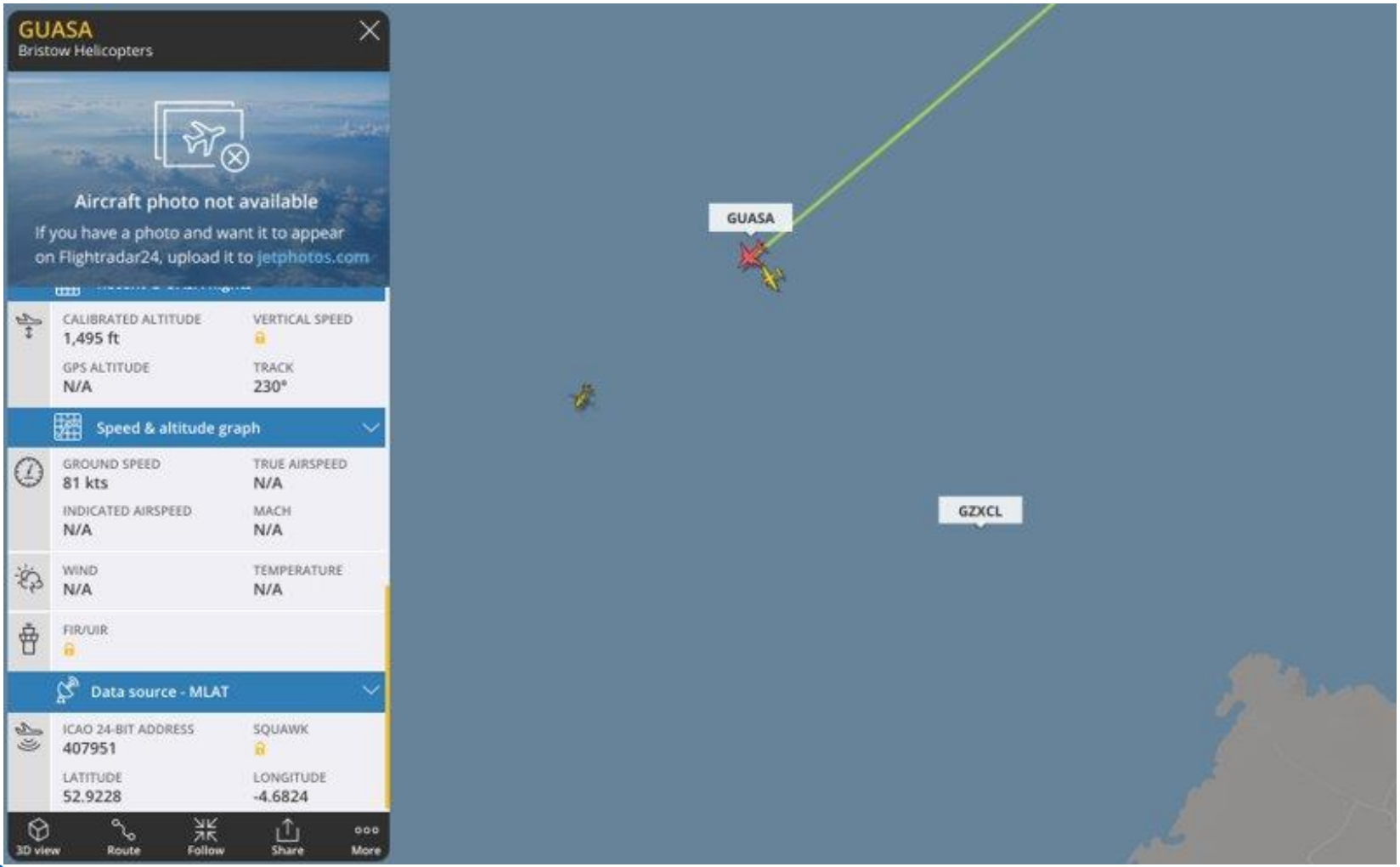
- Demonstrate viable communications with other co-operative air users in a complex scenario for real-time co-ordination.

  Date: 18 May 21
  Task: Co-ordination of aircraft for media opportunity:
  - Beechcraft 200 Super King Air (Fixed Wing) – **CG22**.
  - Sikorsky-92 in Search and Rescue fit (Rotary Wing) – **CG937**.
  - Scheibel S-100 CamCopter (Rotary Wing UAS) – **Bristow Unmanned**.
  - Extra EA-300/L (Fixed Wing) – **Blade1**.

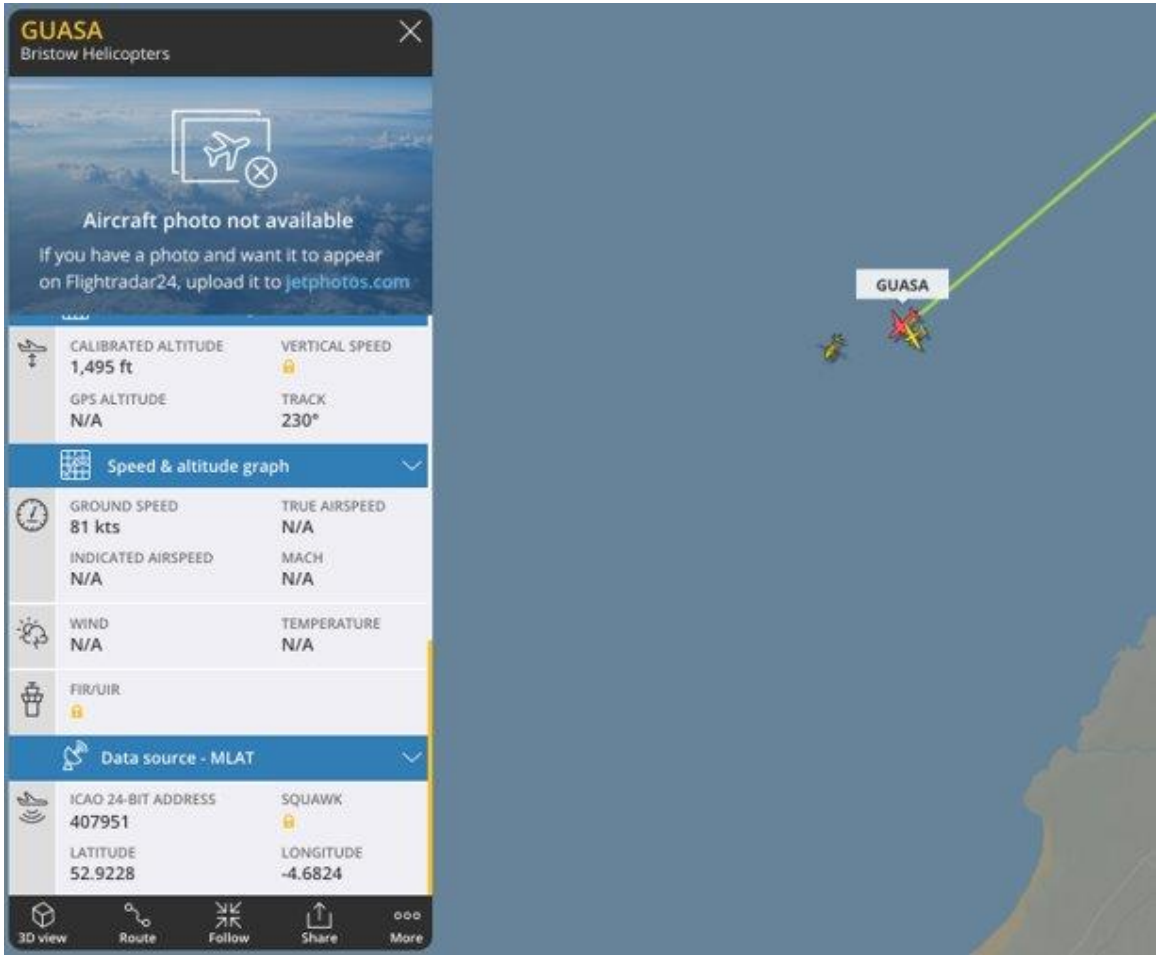
Evidence: UAS071 - Enabling activities

- Viable VHF Airband (8.33/25 kHz) communications were achieved between activity call signs (CG937, CG22B, Blade1 and Bristow Unmanned) and ATSU (RAF Valley), during the activity.
  - All aircraft made initial calls for SUTTO on Caernarfon Radio (122.255Mhz).
  - After departure CG937 maintained comms with Valley Radar (125.225MHz) for the group.
  - Inter-aircraft chat was conducted on 131.960Mhz.
  - CSO passed confirmation of heading, speed and level prior to other callsigns taking up position.
  - Blade 1 passed positioning adjustments to CG937 (i.e. up 5 feet) whilst in close proximity to Bristow Unmanned.
  - CG22B gave a warning call prior running in for fly past of UAV/S92 pair.
  - On recovery CG937 cleared with Valley Radar and all callsigns switched to Caernarfon Radio for recovery.
- **Results:** VHF communications strength 5/5 throughout sortie with all relevant C/S.

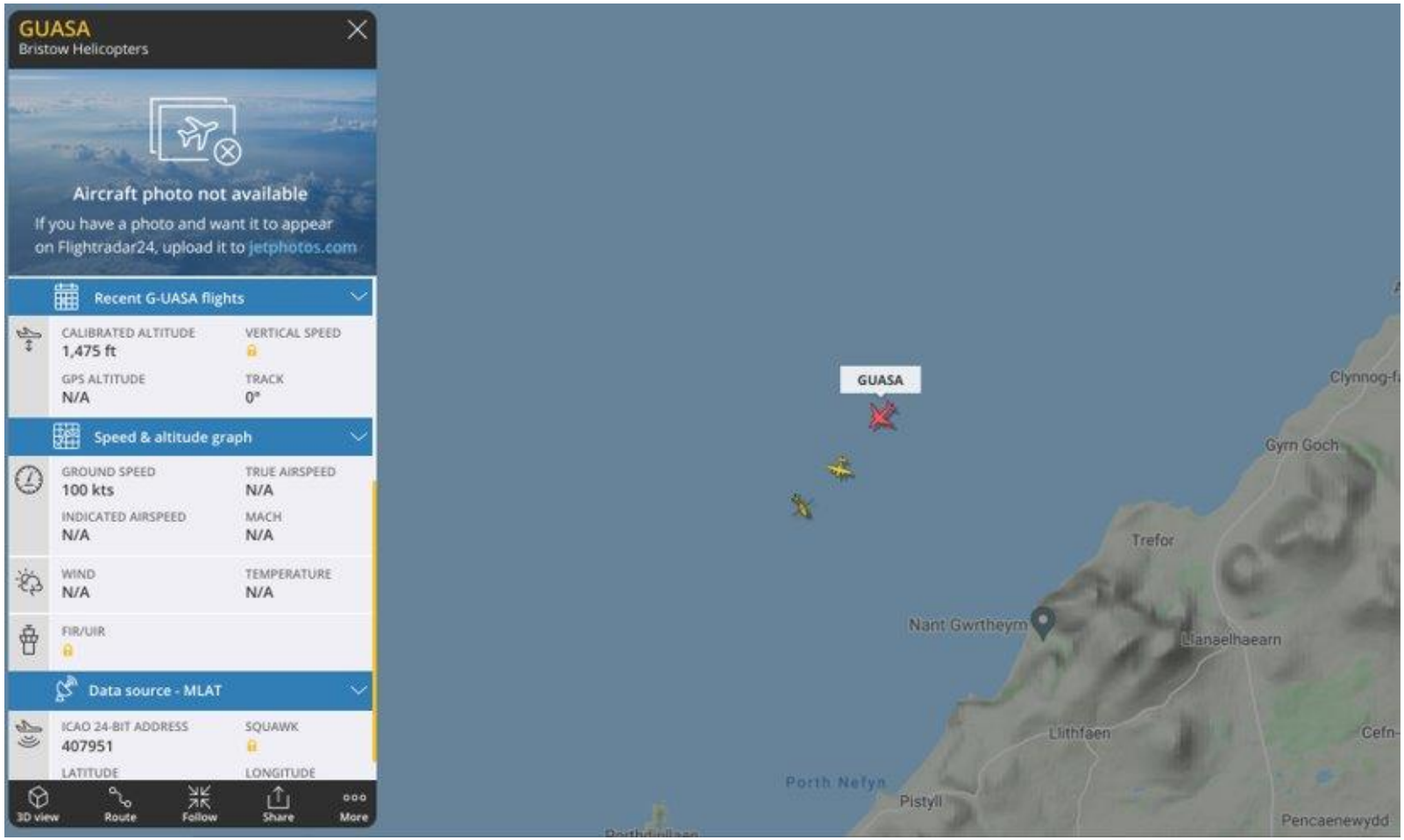
Evidence: UAS071 - Enabling activities



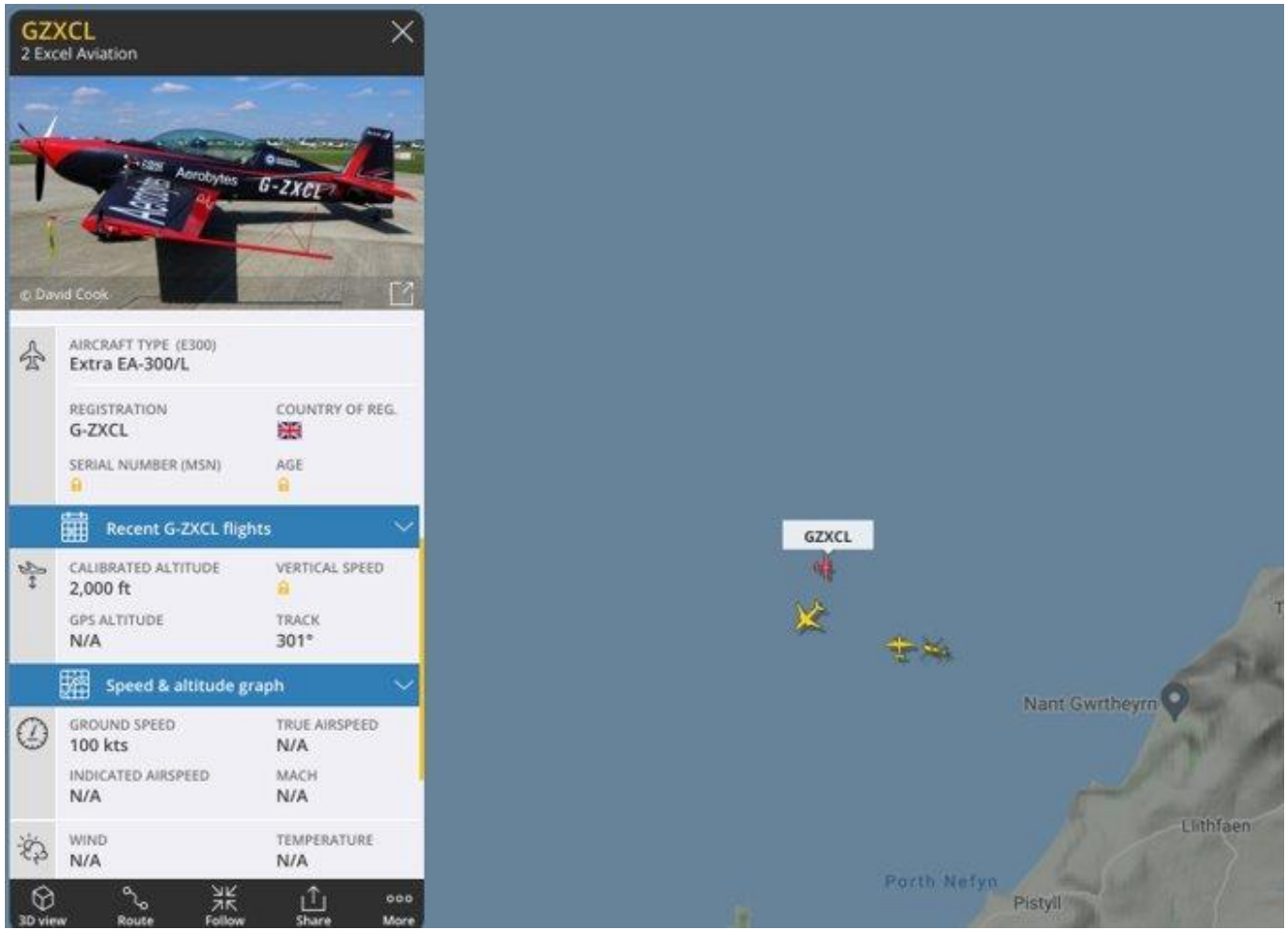
Evidence: UAS071 - Enabling activities



Evidence: UAS071 - Enabling activities



Evidence: UAS071 - Enabling activities



Evidence: UAS079 - Enabling activities

- Demonstrate viable communications with ATSU and other co-operative air users (S-92) at same time, to enable real-time multi air asset tasking and coordination.

  Date: 29 Jun 2021
  Task: Co-ordination of S-92 and UAS in real time to validate the display of altitude data within the UAS GCS for other air users via ADS-B within TDA – Area E.
  Results: VHF communications strength 5/5.

Enabling activities: Summary

- Viable communications with ATSU and other co-operative air users (S-92) at same time, to enable real-time multi air asset tasking and coordination was achieved.

References

- 20210826-SPTS-424-UAS086-MCA1
- 20210827-SPTS-424-UAS087-MCA2
- 20210828-SPTS-424-UAS088-MCA3
- 20210829-SPTS-424-UAS089-MCA4
- 20210830-SPTS-424-UAS090-MCA5
- 20210902-SPTS-424-UAS091-MCA6
- 20210903-SPTS-424-UAS092-MCA7
- 20210907-SPTS-424-UAS093-MCA8
- 20210908-SPTS-424-UAS094-MCA9
- 20210911-SPTS-424-UAS095-MCA10
- 20210915-SPTS-424-UAS096-MCA11
- 20210916-SPTS-424-UAS097-MCA12
- 20210917-SPTS-424-UAS098-MCA13
- 20210919-SPTS-424-UAS099-MCA14
- 20211006-SPTS-424-UAS100
- 20211006-SPTS-424-UAS101
- 20211013-SPTS-424-UAS102
- 20211103-SPTS-424-UAS103
- 20211111-SPTS-424-UAS104

Air to Air Communications

Location Data

End of Trial Update

- The development of an air to air communications system for the S-100 was placed on hold by the OEM, consequently this wasn't incorporated into the trial programme.

Conclusions

Conclusions

- Significant delays were experienced throughout the trial, most significantly the withdrawal of approval to trial the [redacted] transponder. This 9 month delay had a significant impact on the ability of the trial to evaluate detect and avoid capability.
- [redacted] airspace surveillance system, provides only situational awareness with no conflict warnings. The system is standalone and provides no likely route for integration into UAS flight control systems, therefore will not enable avoiding action in its current format.
- Airband VHF communications between UAS and other cooperative air users provided the ability to conduct real-time complex deconfliction.
- CAA's 'Future airspace working group' designed to establish TMZ validation requirements, did not materialise within the 2 year duration of the BHL trial in North Wales.
- CAA unable to provide direction of acceptable tolerances / performance criteria for D&A and TMZ utilisation for UAS, within the 2 year duration of the BHL trial in North Wales.

Supporting Slides

- Trials Airspace Proposal

Stage 1a – Airspace Enabling Novel Technologies

- Novel technologies to be tested and evaluated within TDA:
  - Integration of S-100 location data with third party software to improve situational awareness.
  - OEM derived ADS-B Transponder / Software with automated detect and avoid capability.
  - Airspace surveillance systems.
  - Air-to-air communications system, to enable communications between UAS platform and other air users (VHF rebroadcast).

UAS Location Data Integration

- [redacted] **software integration**
  - The integration of S-100 location data in real-time with the Airbox software applications to provide enhanced situational awareness picture.
  - The creation and electronic distribution of a ‘known air traffic environment’.

- **Testing regime**
  - Install: system to export location data, data connectivity links, airbox displays within GCS.
    - Ground test to confirm S-100 location sharing is functioning (Pass/ Fail).
  - S-100 location shared through airbox software.
    - Percentage of sorties.
  - Latency period.
    - Worst case less than 6 seconds, best case 1 second.
  - Accuracy of the S-100 location within the airbox software.
    - Horizontal error.
  - Location of other air users displayed within the software to provide known air traffic picture.
    - Number of other air users %.

Transponder / Software Evaluation

- [redacted] **ADS-B (In/Out)**
  - The transmission of S-100 location to other ADS-B capable air users.
  - The detection of other ADS-B capable air users within the volume of airspace.

- **Testing regime**
  - Install: [redacted] transponder onto S-100 UAS in accordance with OEM procedures.
    - Pass / Fail.
  - S-100 location shared through ADS-B.
    - Percentage of sorties.
  - Detection by other air users / ATSU
    - Types of air users.
    - Percentage of other air users.
  - Detection ranges for other air users / S-100.
    - Nautical Miles.
  - Accuracy of the S-100 location validated by ATSU.
    - Nautical Mile / Standard Distribution.
  - Location of other air users displayed within UAS Ground Control Station to provide known air traffic picture.
    - Number of other air users %.

Transponder / Software Evaluation…

- **Schiebel software 7.14**
  - S-100 collision avoidance capability for cooperative, ADS-B capable air users.
  - Conflict / collision warning and automated avoiding action. In this version of the software the avoiding action is characterised by the UAS autonomously reducing forward velocity when a conflict is detected.

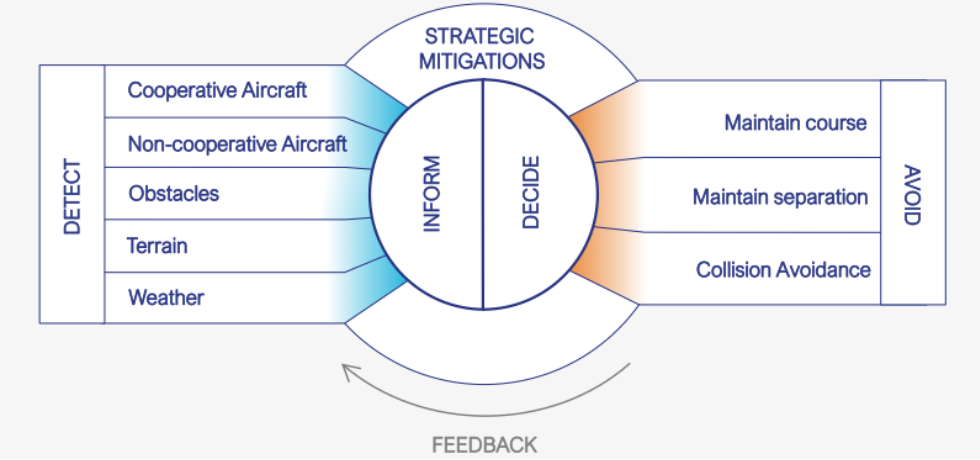
- **Testing regime**
  - Install: Software onto S-100 UAS in accordance with OEM procedures.
    - Pass / Fail.
  - Avoiding action taken by UAS when approached head on by another air user.
    - Range (Nm), heading & velocity at which collision warning received in GCS.
    - Range (Nm), heading & velocity at which collision warning received in cockpit by other air user.
    - Percentage of incidents where AV reduced forward velocity / 80%.
  - Avoiding action taken by UAS when approached tail on by another air user.
    - Range (Nm), heading & velocity at which collision warning received in GCS.
    - Range (Nm), heading & velocity at which collision warning received in cockpit by other air user.
    - Percentage of incidents where AV reduced forward velocity / 80%.

Transponder / Software Evaluation…

- **Testing regime continued.**
  - Avoiding action taken by UAS when approached from port side by another air user.
    - Range (Nm), heading & velocity at which collision warning received in GCS.
    - Range (Nm), heading & velocity at which collision warning received in cockpit by other air user.
    - Percentage of incidents where AV reduced forward velocity / 80%.
  - Avoiding action taken by UAS when approached from starboard side by another air user.
    - Range (Nm), heading & velocity at which collision warning received in GCS.
    - Range (Nm), heading & velocity at which collision warning received in cockpit by other air user.
    - Percentage of incidents where AV reduced forward velocity / 80%.

Airspace Surveillance System

- [redacted] **System**
  - The broadcast of real-time flight and traffic information to provide a ‘common air picture’ for all air users.
  - [redacted] integration to give air/maritime picture (situational awareness).
  - The system will establish a surveillance zone to mirror that of the TDA complex, to enable testing of the surveillance picture and therefore the ‘detect’ component for cooperative aircraft.



Detect & Avoid Ecosystem, CAP1861a (Oct 2020), Pg 4.

Airspace Surveillance System

- **Testing regime**
  - Siting and installation of electronic conspicuity transmitters and receiver stations to provide coverage of the TDA complexes, OEM testing.
    - Coverage and latency Pass / Fail.
  - Integrate and refine the surveillance picture within the UAS Ground Control Station[1], to provide an effective surveillance picture.
    - Pass / Fail.
  - Establish the surveillance zone within the TDA complexes to provide a surveillance picture to support BVLOS Operations, including the development of procedures.
    - Pass / Fail.
  - Test established surveillance zone when TDA complex is active and inactive, to establish the coverage and use by other air users.
    - Utilisation of air volume (Active and Inactive TDA) by other air users and transmission system in use.
  - Conduct S-100 sorties to determine the surveillance area (TDA) coverage and accuracy within the established surveillance zone.
    - Percentage of coverage provided.
    - Location accuracy of S-100 vs [redacted] and calibrated via RAF Valley radar.

[1]System to be used is currently subject to commercial discussions.
[2]To be completed in parallel to the setup of [redacted] system.

Airspace Surveillance System

- **Testing regime continued**
  - Test [redacted] station redundancy, and the resulting surveillance picture.
    - Coverage and degradation percentages.
  - Detection of S-100 and cooperative and non-cooperative aircraft within the surveillance zone.
    - Numbers of detections.
    - Aircraft types.
    - Traffic information.
  - Testing ‘avoid’ functionality of the [redacted] transponder and software 7.14 within the surveillance zone.
    - As per test regime pg. 19/20.
  - Testing new ‘avoid’ functionality if it become available during this phase period.
    - Testing requirements to be developed.
  - Development and testing of ‘avoiding’ proceedures[1].
    - Testing requirements to be developed.
    - Regulatory expectation vs capability.

[1]Yet to be defined as subject to the success of the ‘detect’ – surveillance picture and ongoing discussions with CAA as what would be acceptable avoiding action by a UAS.

Air to Air Communications

- **Schiebel Airband VHF rebroadcast system**
  - The maximum range of the S-100 UAS is greater than the range of Airband VHF communications, emanating from the GCS. Therefore S-100 operators in the GCS are currently unable to communicate with other air users in the vicinity of the S-100 aircraft unless relayed through a DAAIS in contact. GCS VHF reaches RAF Valley and transmits with readability and strength 5.
  - An Air-to-Air and Air-to-Ground Airband VHF communications rebroadcast system within the aircraft will extend the communication range significantly, thereby potentially enhancing safety:
    - Direct deconfliction between air users.
- **Testing regime**
  - Install: Airband VHF within S-100 UAS in accordance with OEM procedures.
    - Pass / Fail.
  - Ground test Airband VHF transmission and receive
    - Pass / Fail
  - Test transmission and receive ranges between other air users / S-100.
    - Nautical Miles.
  - Test robustness of the system
    - Successful communication probability.