



# inmarsat

The mobile satellite company

UKSBAS Testbed Phase 1: EL#3 -019

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17-June-22

gmv NSL

GOONHILLY

# UK SBAS Testbed context

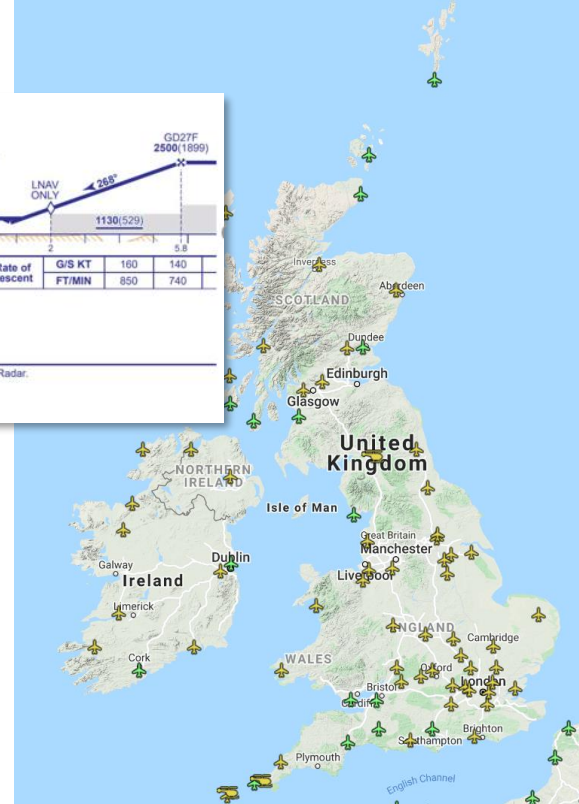
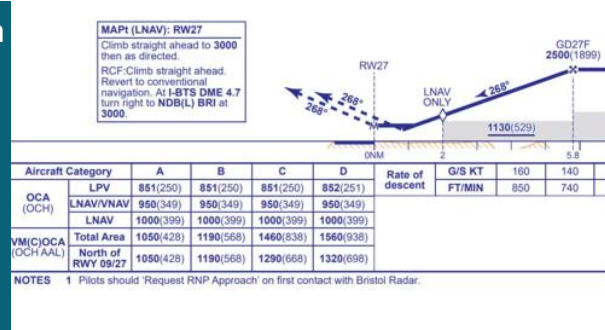
## Rapid setup of testbed to broadcast UK SBAS Test SIS

▶ **25-JUN-21: EGNOS Working Agreements with ESSP are suspended/terminated: UK has withdrawn from EGNOS programme**

- LPV approach procedures are unavailable
- LNAV or LNAV/VNAV minima unaffected

▶ **UK Airports: pre-2021 baseline**

- 41 **operational** approach procedures at 19 UK airports
- 112 **planned** approach procedures at 55 UK airports
- result: 72 UK airports with EGNOS-enabled approaches at/by 2025; incl: 4 **planned** Point in Space Approaches (PinS)



# Background

## Team Members and Schedule

- ▶ Inmarsat, London (David Hill, John Loizou, George Newton)
  - ▶ [uksbas@inmarsat.com](mailto:uksbas@inmarsat.com)
- ▶ GMV NSL, Nottingham (supported by GMV in Madrid)
- ▶ Goonhilly Earth Station Ltd, Cornwall
- ▶ Project KO 21 October 2021
- ▶ 9 month duration for Phase 1
- ▶ Signal in Space transmissions began 6 April 2022
- ▶ Commissioning complete, 11 May 2022
- ▶ Signal transmissions currently until end of June 2022 (may be extended). PRN 158 is allocated to UK Space Agency for UK SBAS Testbed until end of 2022.

# UK SBAS Testbed objectives/results

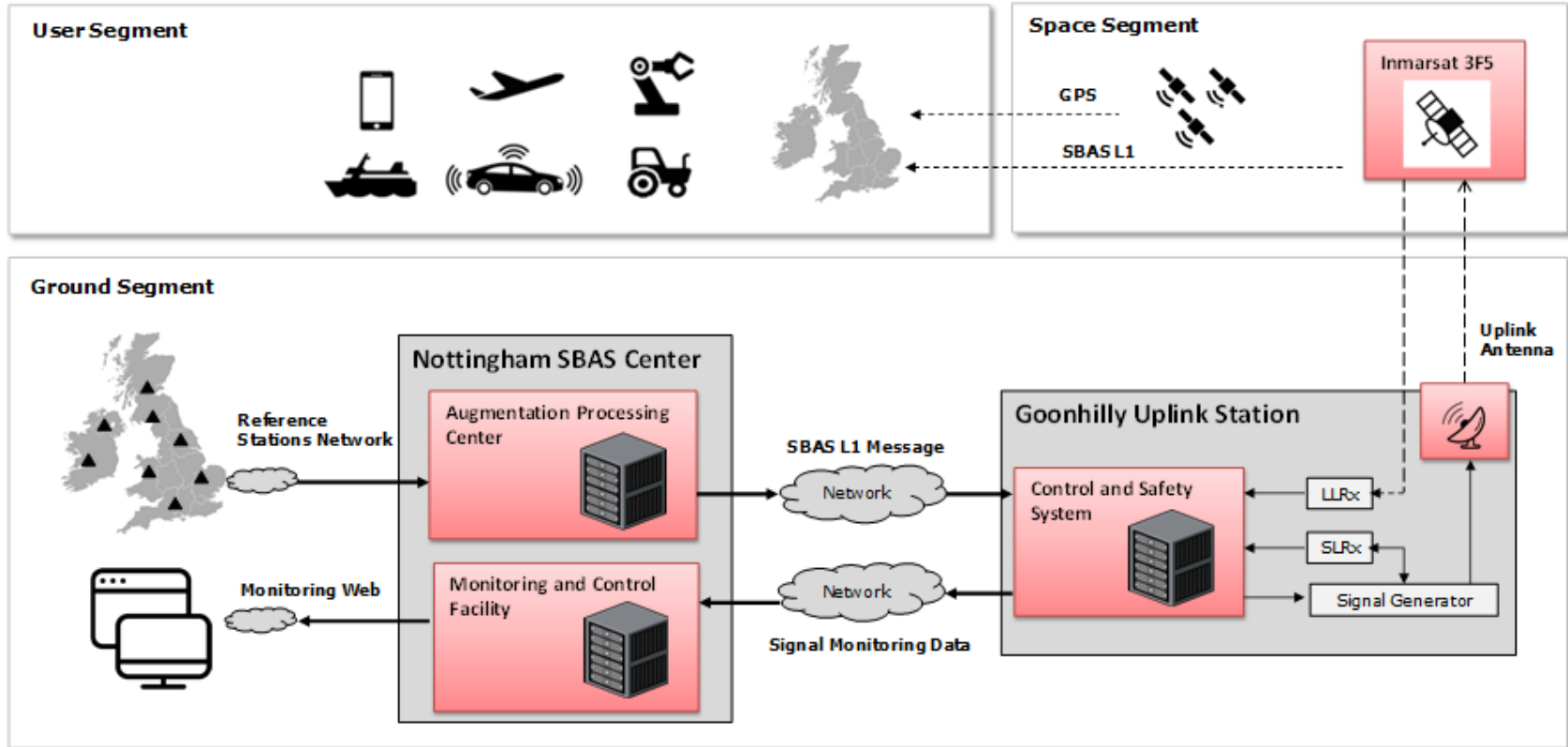
## Rapid setup of testbed to broadcast UK SBAS SIS

- ▶ Achieve the deployment, integration and operation of the (Phase 1) demonstrator which can continue operations for future users (Phase 2++).
- ▶ Demonstrate interoperability of UK SBAS and EGNOS performances noting that EGNOS is an operational safety of life services and UK SBAS Testbed is a demonstrator platform.
- ▶ Deliver a test signal which will help industry and users take the initial steps towards the future provision of integrity services.
- ▶ Deliver an initial, end-to-end infrastructure to support future prototyping of the delivery of innovative services to next generation applications and user communities.
- ▶ Identify/verify a dedicated interface within the SBAS data processing schema to provide maritime integrity data sets for initial experimentation of maritime protection approaches.
- ▶ Secure a PRN code in the range 120-158 to enable on-going use of the test platform by UK organisations, companies, and institutions in the development of capabilities, applications and services.
- ▶ Deliver a roadmap for the evolution of UK SBAS capabilities, services and applications.

# UK SBAS Testbed Key Features

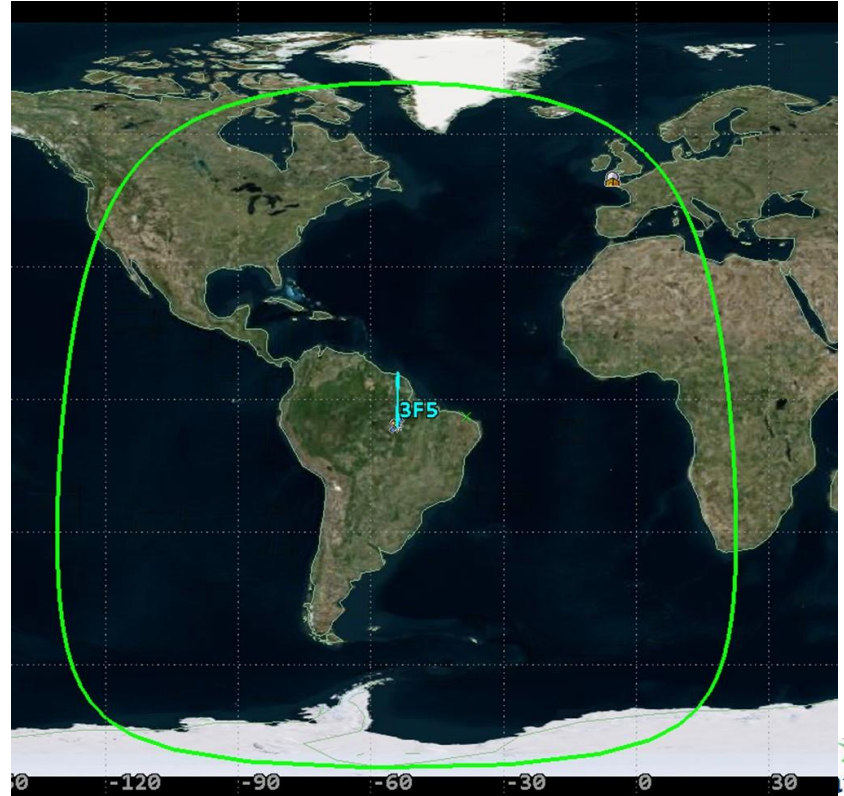
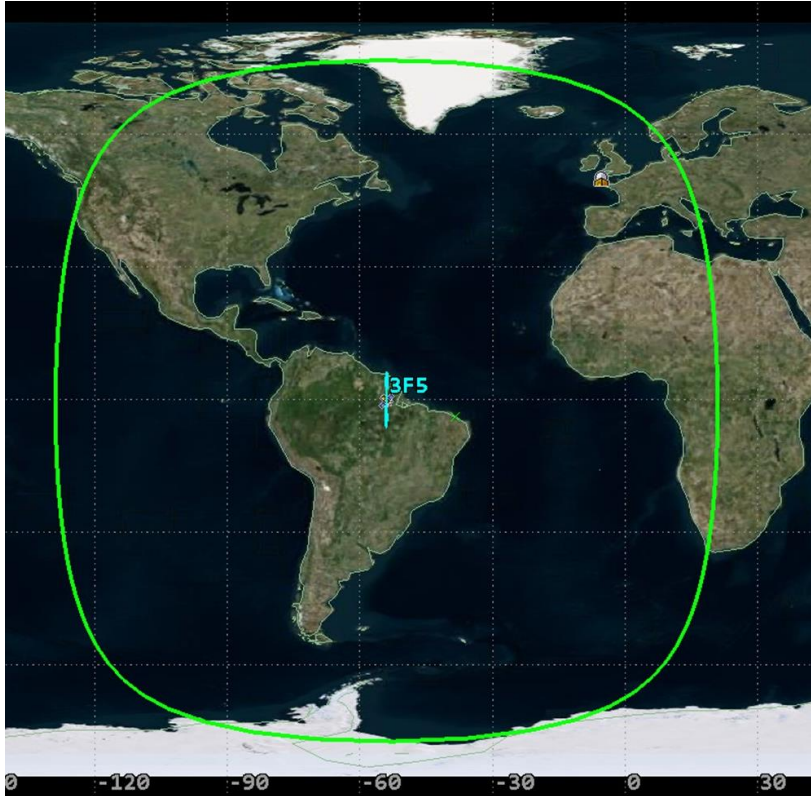
- GPS observations from Ordnance Survey Continuously Operating Reference Stations (CORS) and IGS stations.
- L1 SBAS data message only (no ranging signal), transmitting MT0/2 every 6 seconds, and Message Type 27.
- **PRN 158**, Service Provider ID #9
- SBAS Transponder on Inmarsat 3F5 spacecraft, 54°W (6° inclination)
- Relatively low power signal, max EIRP 27.5 dBW at Edge of Coverage (approx. 1 dB below minimum signal power specified in ICAO SARPS for operational system).

# Architecture



# Inmarsat 3F5 coverage to 5° mask angle

Nominal, and at maximum southerly excursion



# UK SBAS Testbed Service Area

MT27 Service Area (implemented into firmware)



Latitude 1: 65.00 (Unit: degrees; +North, -South)  
Longitude 1: -15.00 (Unit: degrees; +East, -West)  
Latitude 2: 45.00 (Unit: degrees; +North, -South)  
Longitude 2: 5.00 (Unit: degrees; +East, -West)

# www.uksbas.org

Public pages, and more detailed pages (send request for credentials to [uksbas@Inmarsat.com](mailto:uksbas@Inmarsat.com))

The screenshot displays the MagicMonitor interface for two testbed locations: UK NOTTINGHAM A and UK NOTTINGHAM B. The interface is divided into a left sidebar and a main content area.

**Header:** MagicMonitor logo, navigation icons (home, eye, TestbedUkSbas), and logos for inmarsat, GOONHILLY, gmv NSL, and gmv.

**Sidebar:** A circular profile icon with the letter 'T', the text 'TESTBEDUKSBAS', a red button for 'UK NOTTINGHAM A', and a list of menu items: HOME, SBAS DEFINITION, REAL TIME, SBAS ARCHIVE, and KPI ANALYSIS.

**Main Content Area:** Two panels, one for UK NOTTINGHAM A and one for UK NOTTINGHAM B. Each panel shows the following components:

- Time:** 2022/05/12 14:39:07 (UTC + 01:00) for A and 2022/05/12 14:38:57 (UTC + 01:00) for B.
- Status Indicators:** Four green buttons labeled 'SIS OK', 'QOS OK', 'REC OK', and 'AVA OK'.
- Charts:** A red line chart for 'SIS Status' and another for 'QoS(Meters)'. The 'SIS Status' chart shows a red line at the 'Available' level. The 'QoS(Meters)' chart shows a red line fluctuating between approximately 14:00 and 14:30.
- Map:** A map of Europe with green arrows pointing to various locations, including the UK, Germany, and Ukraine.

# Technical Update

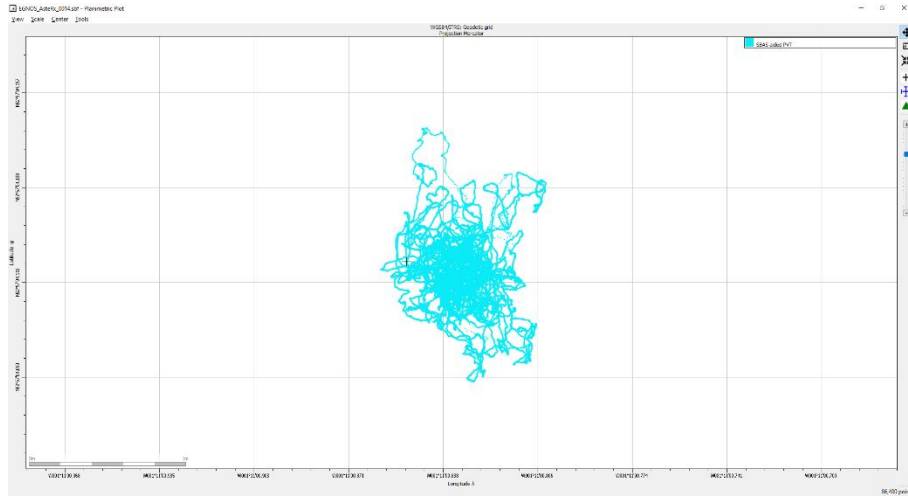
Current Status: Commissioning complete; Demonstration activities in progress

- ▶ Inmarsat 3F5 is an old spacecraft, launched in 1998. The frequency translation between C-band uplink and L-band downlink had drifted a *lot*. Final offset was set at 2.912 kHz greater than initially expected.
- ▶ Uplinking from a station close to edge of coverage (EoC), and introducing closed-loop control from near EoC of a substantially inclined GEO requires very fine control of antenna pointing.
- ▶ Feeding Navigation Overlay Frames (NOF) to the Uplink Station using the public internet rather than a Leased Line leads to short service dropouts.
- ▶ However, even with a reduced power signal at low elevation angles, useful augmentation can be provided using components requiring little or no new development.

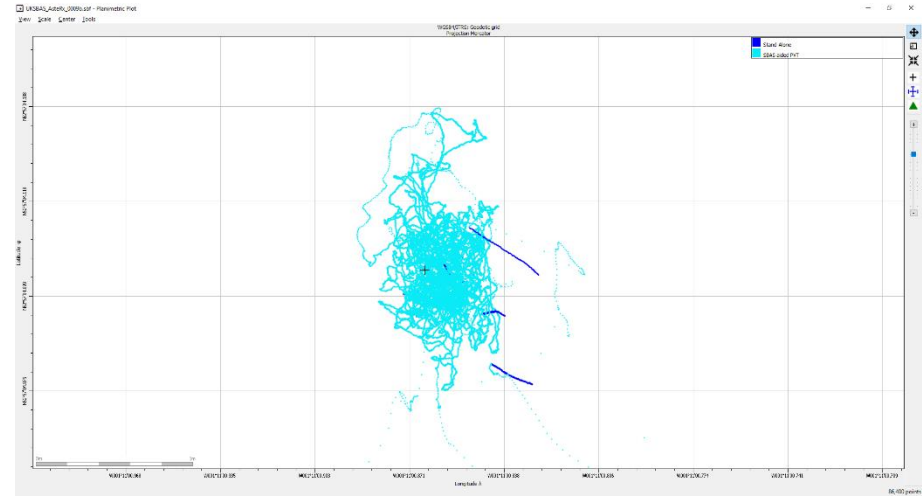
# Static Testing of Positioning Performance

Example real-time results output by Septentrio receiver on 27th May 2022

Horizontal position errors



EGNOS

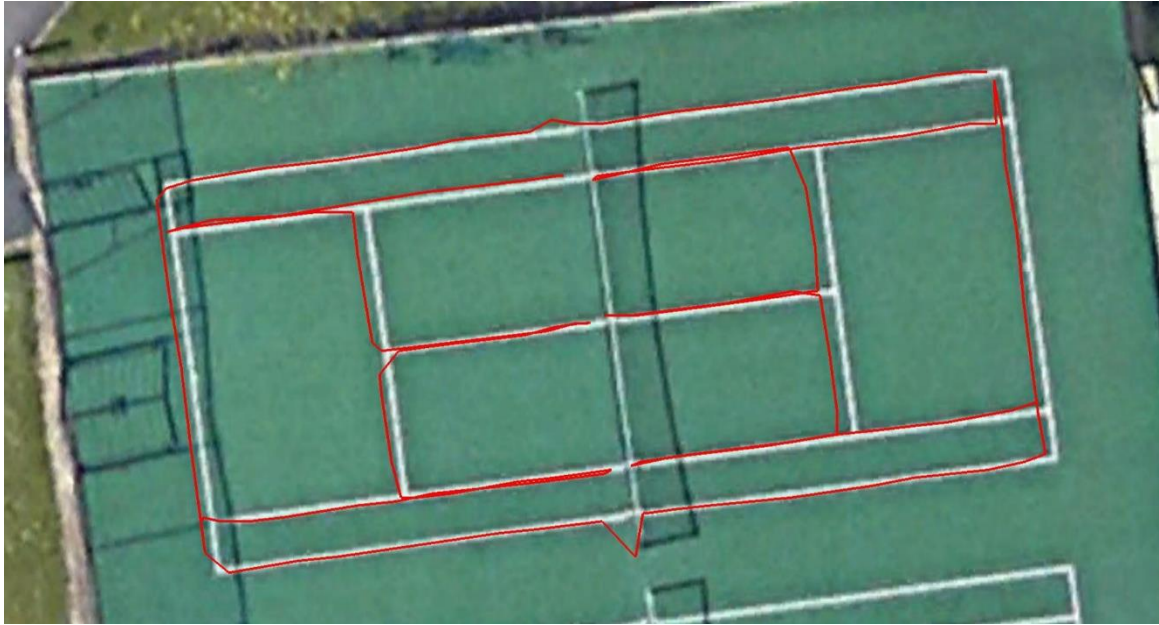


UK SBAS Testbed

GPS+EGNOS (Left) and GPS+UKSBAS (Right) - similar level of error except when stand-alone mode and for short periods when corrections return (until get full set)

# Initial Performance Tests

## Walking survey of tennis court



EOS Arrow Receiver

UK SBAS + multi-  
constellation L1 GNSS

Antenna “worn” in a cap  
and the lines are walked,  
multiple times.

Very good reproducibility  
of path walked.

# Lessons Learned

- Even for a testbed not providing Safety of Life services, a rigorous safety analysis and approval process is required before transmissions in GNSS frequencies can be authorised.
- High quality augmentation data can be derived using a dense network of Continuously Operating Reference Stations, such as the Ordnance Survey GB network.
- Navigation signals are much less tolerant than communications signals
  - “We need to remove another 12 Hz from the uplink centre frequency” makes our comms engineering colleagues laugh.

# Maritime Integrity Service Interface (MISI)

Internet-only delivery channel, in this phase

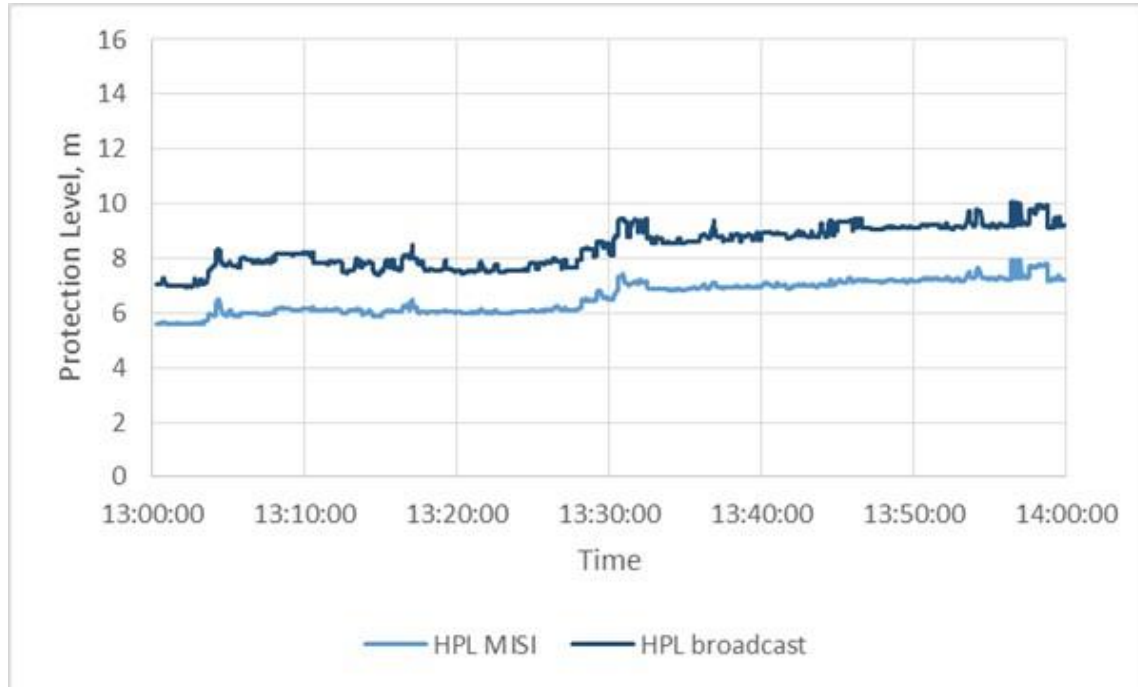
As well as delivery of SBAS-standard Signal in Space, the Testbed generates additional data sets which are posted to the uksbas.org “Maritime Area” every hour.

This data set is similar to the SBAS data, except User Differential Range Error Indicator (UDREI) and Gridded Ionospheric Vertical Error Indicator (GIVEI) values:

- Set to reflect a typical maritime integrity risk of 0.99999 (i.e. less stringent than for aviation integrity as used in SBAS signal)
- Able to accommodate Nominal and Faulted bias values in future (but set to zero in current testbed)
- Are not rounded and discretised to indicator values (0 to 15), to allow for higher precision to support R&D with new services.

# Comparison of MISI with Standard SBAS

Horizontal Protection Limits calculated using Aviation/SiS and Maritime parameters



Computed using standard RTCA MOPS HPL equations – the ‘broadcast’ HPL uses the sigma UDRE and sigma GIVE values derived from UDREI and GIVEI in the broadcast message whereas “MISI HPL” simply replaces those with the MISI sigma values.

# Future activities

To complete Phase 1, and go into Phase 2

Dynamic testing using road vehicles and drones has started.

A programme of public demonstration events in the UK is being planned,

- Events in July, August and September.
- Check [uksbas.org](http://uksbas.org) for details.

Proposal for UK SBAS Testbed Phase 2 has been submitted. If successful, activities will continue into 2023.

**Thank You**