



UK GENS Programme

Final Presentation

**Douglas Hudson
John S Glover**

08 June 2022

© CGI IT UK Ltd 2022

The copyright in this document is vested in CGI IT UK Ltd.

This document may only be reproduced in whole or in part, or stored in a retrieval system, or transmitted in any form, or by any means electronic, mechanical, photocopying or otherwise, either with the prior permission of CGI IT UK Ltd or in accordance with the terms of ESA Contract No. 4000132607/20/NL/MP.

UK GENS Programme Final Presentation (GNSS Event Notification System)

01

Origins of the
GNSS Event
Notification
System (GENS)

02

Governance of
the GENS
capability
development

03

Key Directions
from GENS
Programme
Governance
Group

04

Achievements

05

Findings

06

The Future

Acknowledgements

The GENS Project has been sponsored by the UK Space Agency and has been funded through the ESA NAVISP Element 3 programme

<https://navisp.esa.int/project/details/116/show>

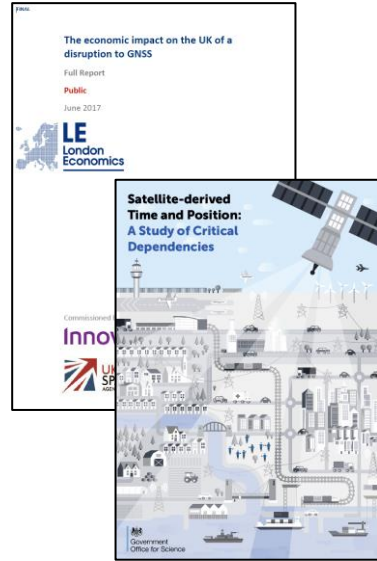
Stefano Binda, ESA Technical Officer, who provided oversight and guidance

Steve Hancock, Ordnance Survey, who acted as External Product Owner for verification of User Stories and Feature Development



Origins of the GENS project

- *The economic impact on the UK of a disruption to GNSS* – London Economics
- *Satellite-derived Time and Position: A Study of Critical Dependencies* – Blackett Review
- *PNT Strategy Group Interim Report – April 2020* which defined five recommendations



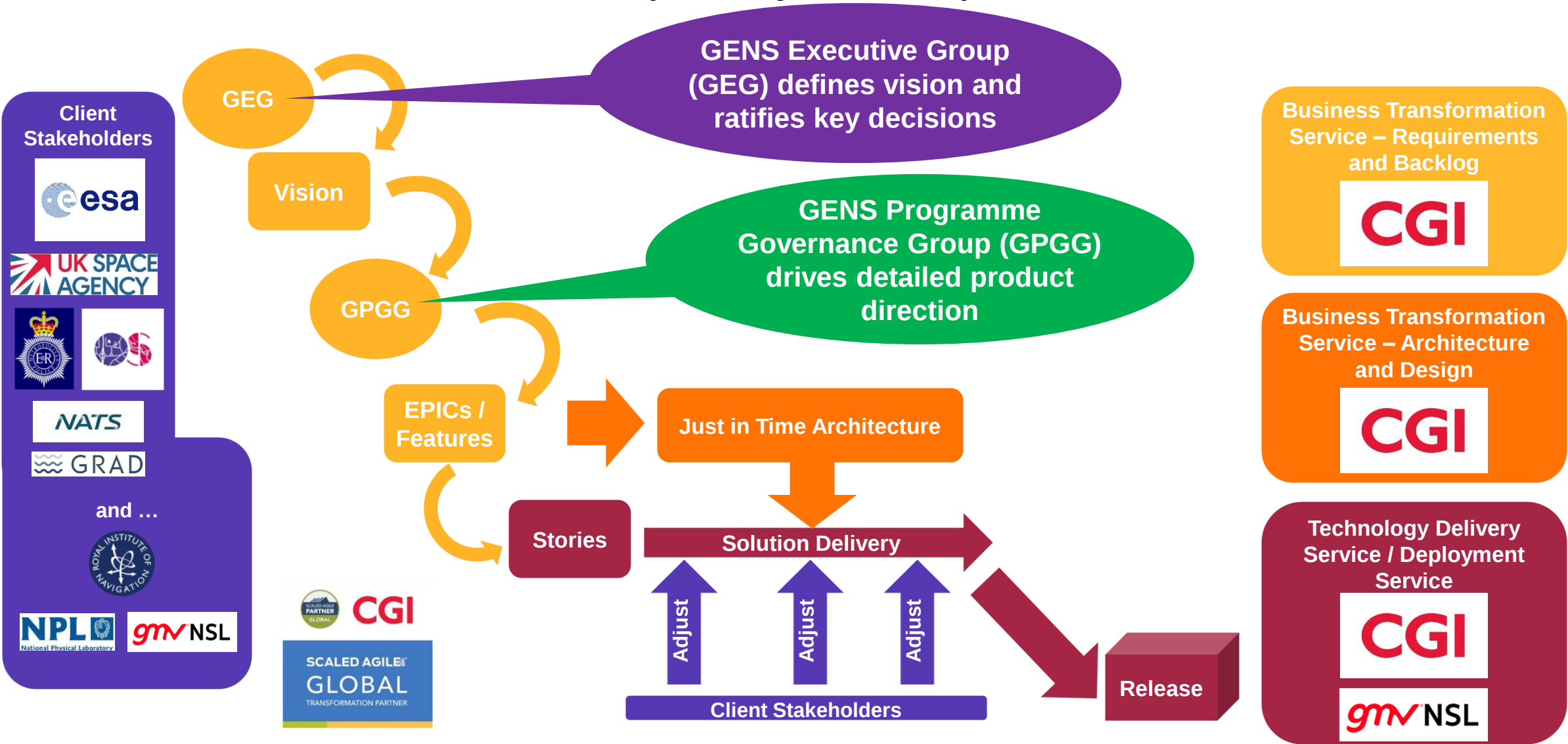
1. Further work is needed to undertake a deeper investigation of all sectors.
2. There is an urgent need to develop a comprehensive PNT strategy and to consider the establishment of a PNT Programme Board.
3. A detection and monitoring capability to enable effective reporting and recording of PNT disruption is required.
4. There is a need to significantly improve awareness of PNT issues in the UK and to enhance skills, education and training provision.
5. A further area of study into the potential use of legislation, regulation and standards should be initiated.

Delivery



Stakeholders

Governance of the GENS capability development



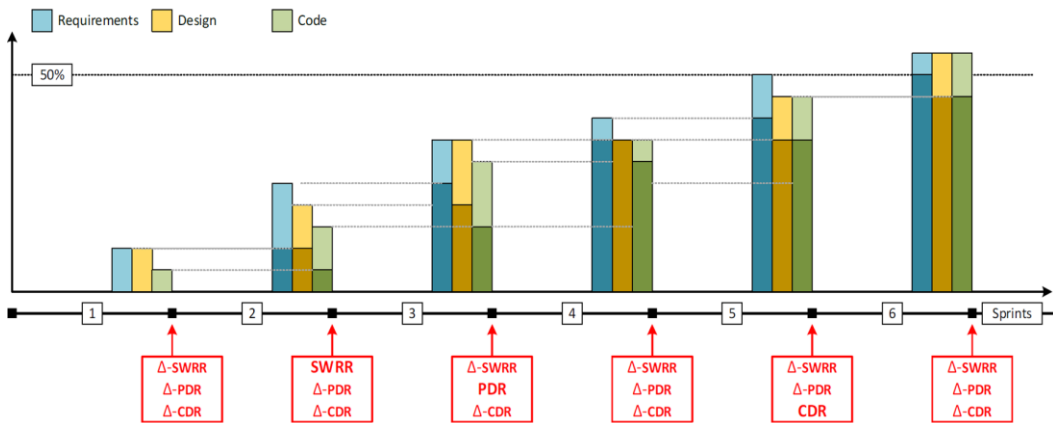
GENS Business Vision

The GENS Executive Group (GEG), formed from UK Authority, ESA Technical Officer and CGI developed, reviewed and ratified the vision for GENS:

1. Develop Guidance Documentation for HMG stakeholders, CNI, and UK industry more widely, to understand the threats to, and mitigate the vulnerabilities of, services that depend on GNSS.
2. Build the foundations of a national GNSS event monitoring and incident management capability through an initial GENS capability demonstrator that generates improved understanding of threats and impacts to protect and defend GNSS.
3. Explore the long-term strategy and identify opportunities for sustaining GENS as an enduring capability for the UK.
4. Prioritise a backlog of GENS features that create value for HMG stakeholders, CNI, and UK industry more widely, bearing in mind opportunities to drive towards an enduring capability.

Agile Development and Alignment to ESA Milestones

Aligned to Model 4: Sprint driven lifecycle with formalisation from *ECSS Agile Development Handbook*, ECSS-E-HB-40-01A



Agile Event	ESA Milestone	Description
PI Planning	System Requirements Review (SRR)	Ahead of the PI Planning event, the Epics, Features and stories planned for development at the 12-week activity will have been reviewed and agreed with the business, analogous with the principal objectives of an SRR.
PI Planning	Preliminary Design Review (PDR)	Ahead of PI Planning, the architectural runway and detailed story definition and acceptance criteria planned for the PI will have been communicated, analogous with the principal objectives required for PDR and CDR.
	Critical Design Review (CDR)	
Sprint Review	Qualification Review (QR)	The Sprint Review for each sprint will demonstrate the functionality developed in the Sprint and provide results of testing against story acceptance criteria for those Stories “done” facilitating closure and acceptance of the review.
Software Release Test Review Board	Acceptance Review (AR)	Following the end of each Programme Increment, a Software Release datapack will be issued with supporting requirement, design, test, release and coverage artifacts for the release baseline.

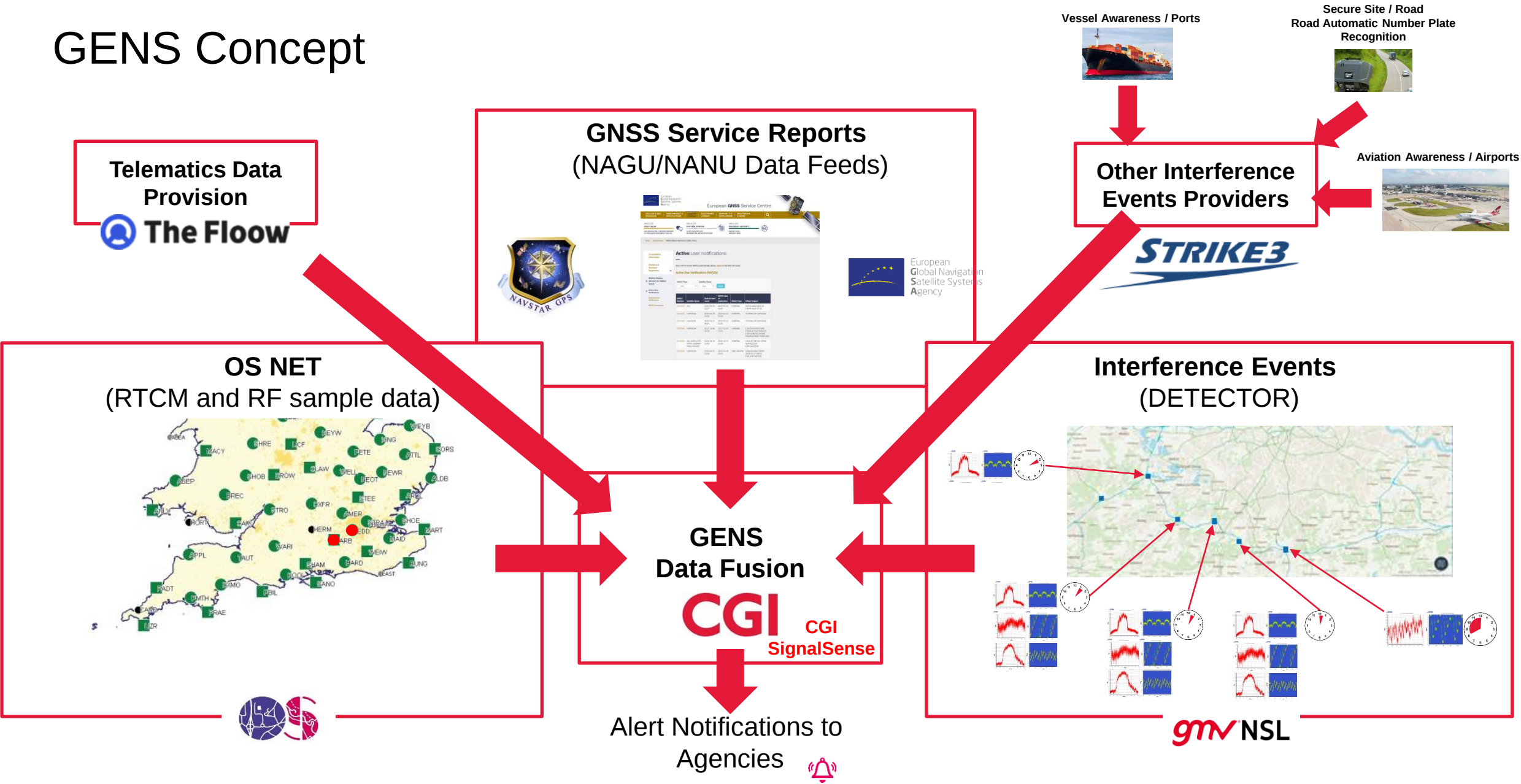
PI Planning Review				Sprint Review					Sprint Review					Sprint Review					TRB
1	2	3	4	5	6	7	8	9	10	11	12	13							
Programme Increment																			
PI Planning	Sprint 1			Sprint 2			Sprint 3			Innovation and Planning									

- Per year
- 4 Programme Increments
 - 12 Sprints

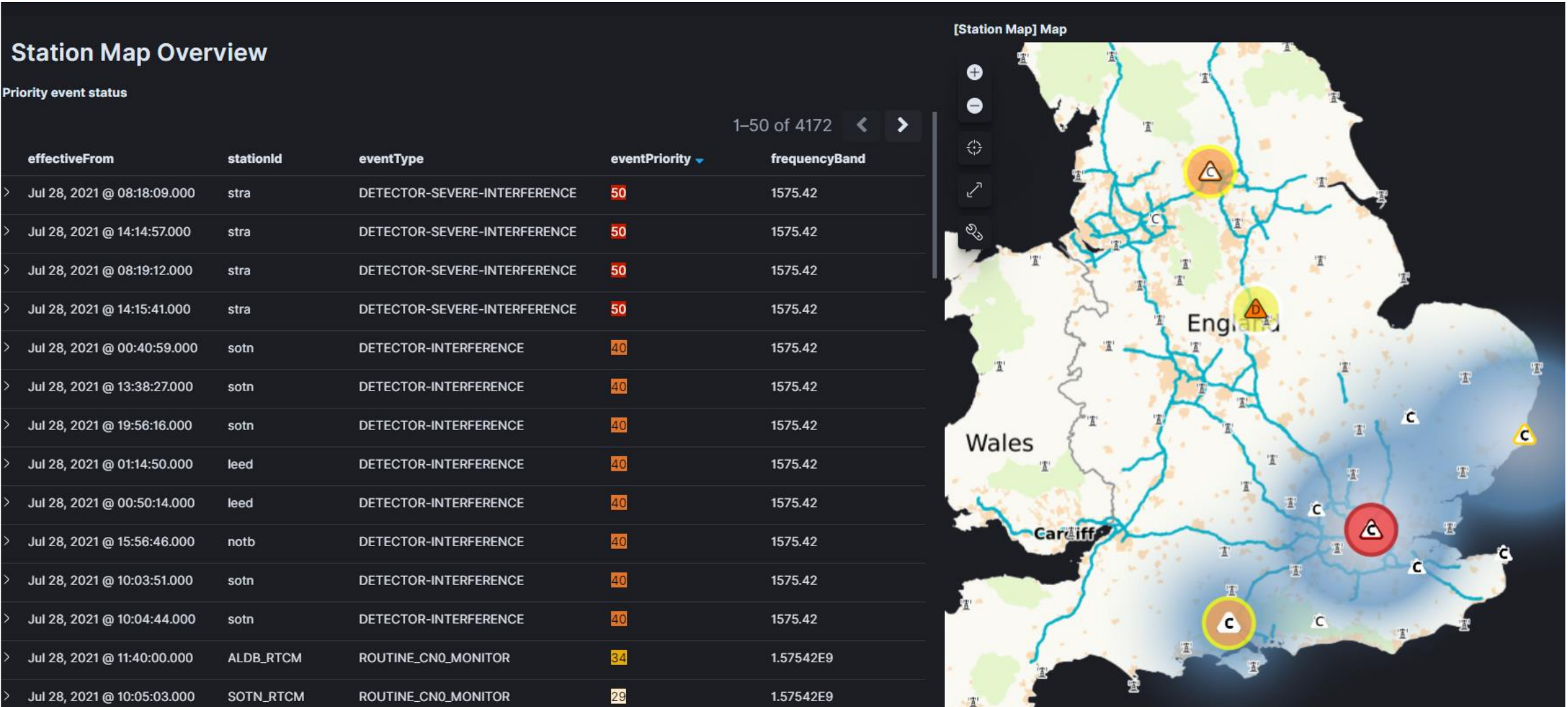
Key Directions from GENS Programme Governance Group

Identification	1	Prioritise identification of interference-related GNSS incidents
Situation Awareness & Trend Analysis	2	Live situation awareness is just as important as long-term monitoring of threats for trends
National GNSS IDM	3	Build the foundations of a national GNSS event monitoring and incident management capability
Notify via Service Providers	4	Preferred approach for end user notification to be via respective service provider
End User Impact	5	Need to understand the severity of an incident and the impact it may have on actual end users
Locate and Attribute	6	Develop capabilities to localise and attribute GNSS incidents

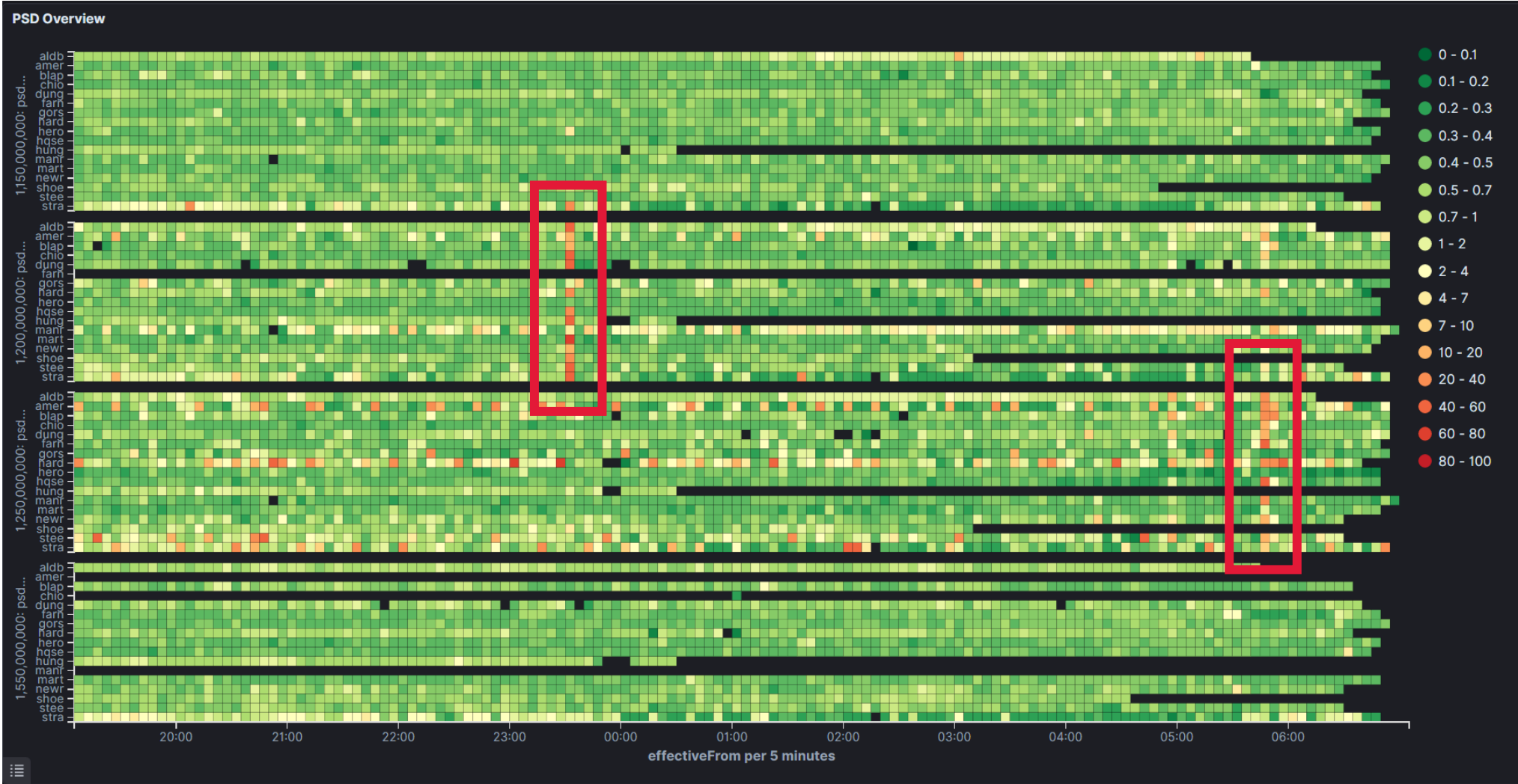
GENS Concept



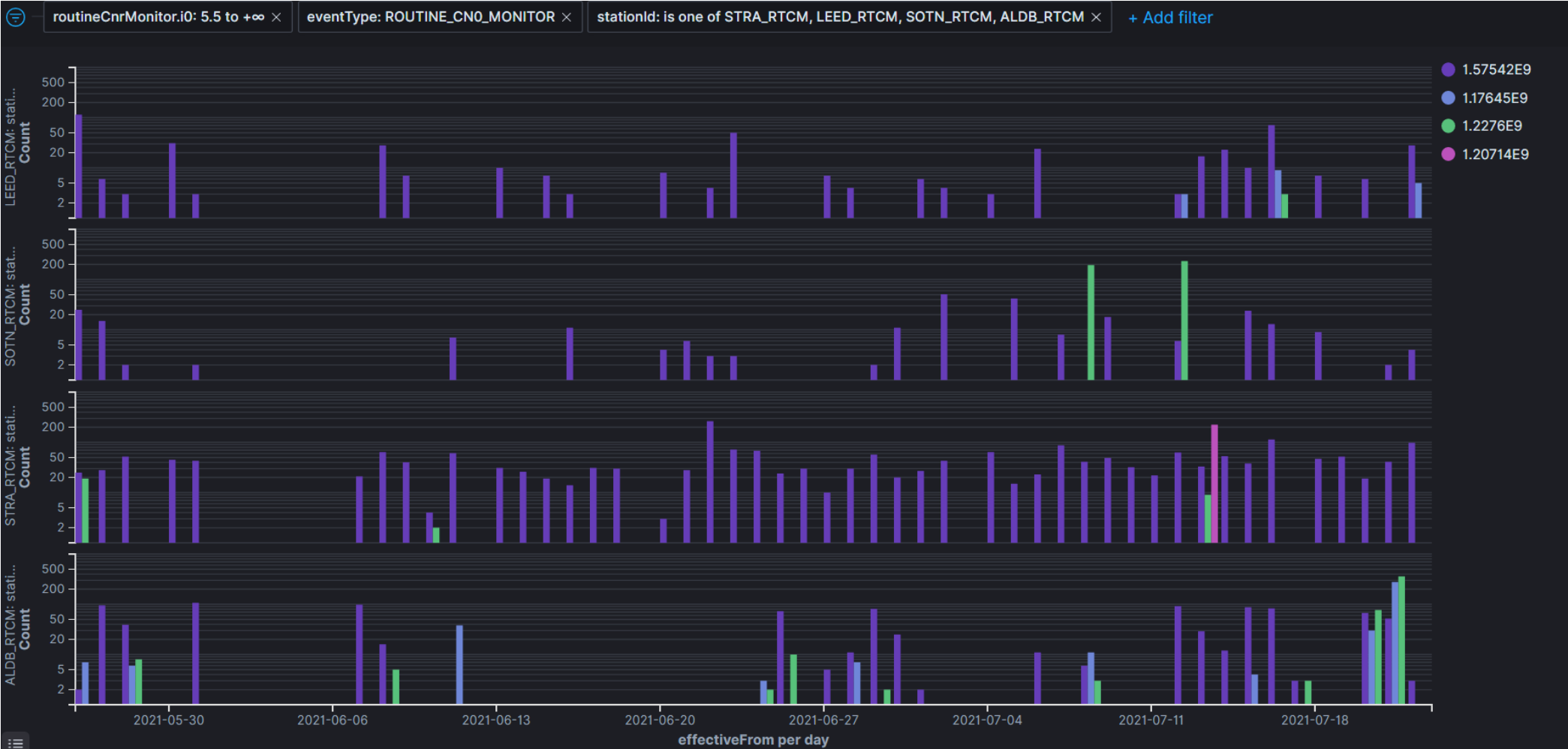
GENS Incident Dashboard



GENS Incident Timeline Overview

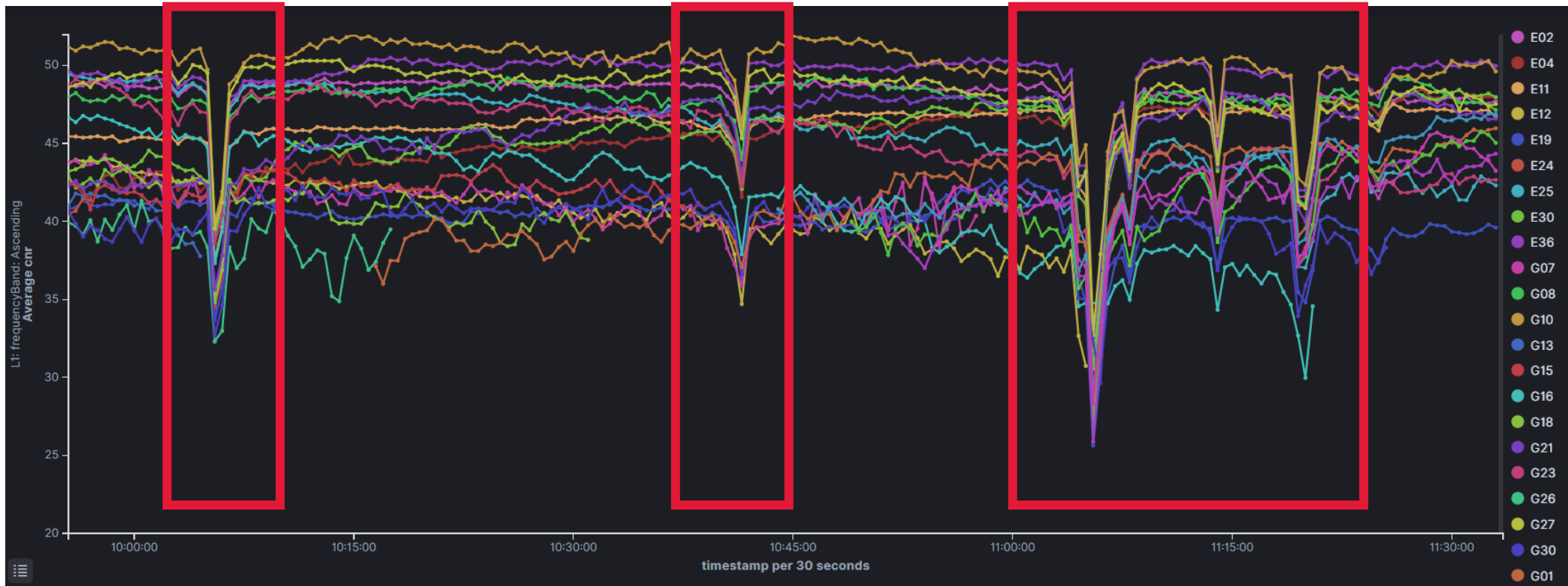


Manual Exploration of Data Trends



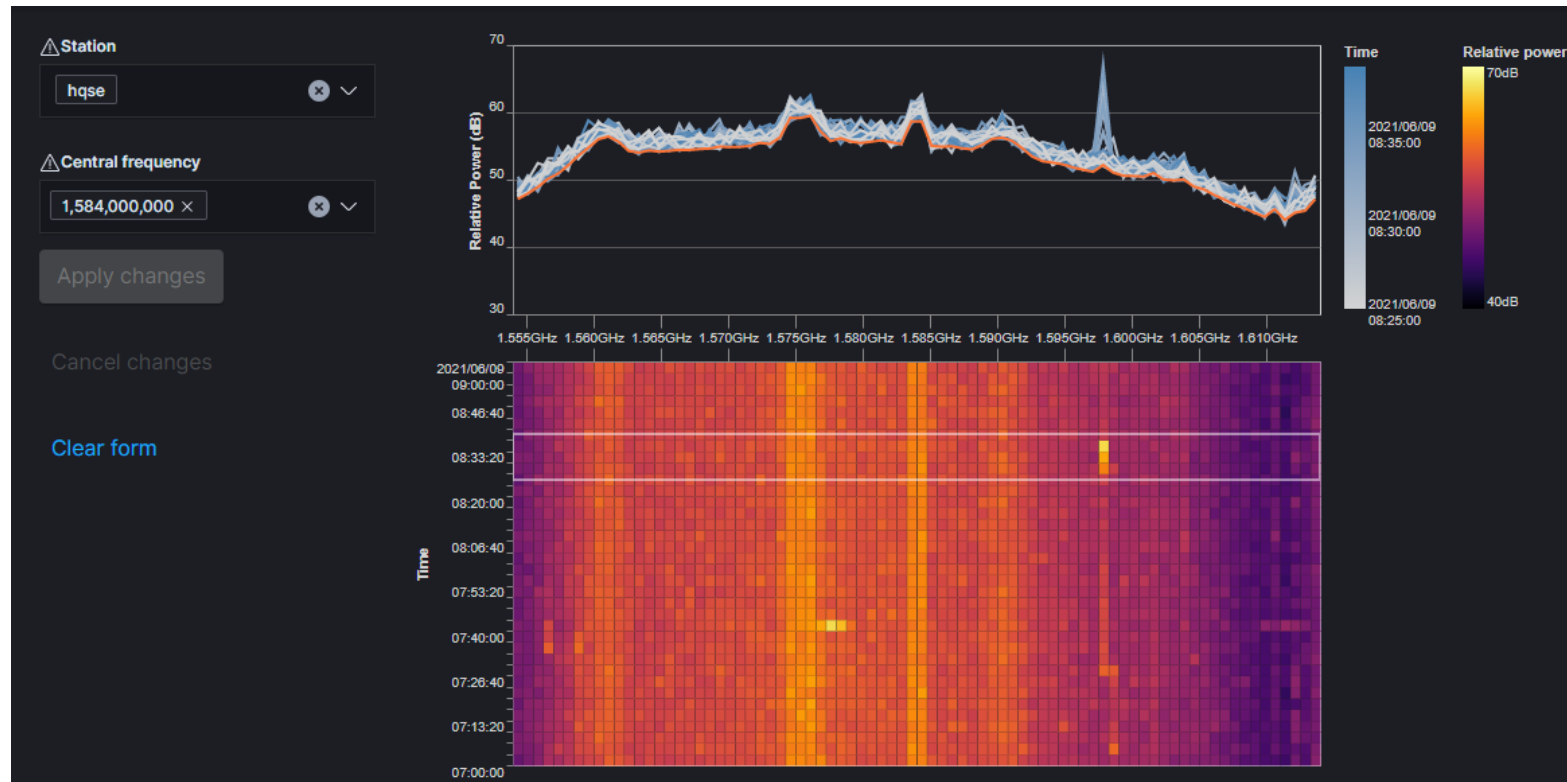
Interference Detection and Characterisation from RTCM Data

- ✓ C/N₀ anomaly detection
- ✓ Satellite signal loss detection
- ✓ Accuracy performance monitoring
- ✓ GPS L1/L2/L5
- ✓ Galileo E1/E5A/E5B/E5AB
- ✓ RINEX compatible for historical analysis



Interference Detection and Characterisation from RF Sample Data

- ✓ PSD anomaly detection
- ✓ Characterisation of event
- ✓ Detects narrowband and wideband interference
- ✓ Dynamic impact can be visualised
- ✓ Continues working when RTCM lost



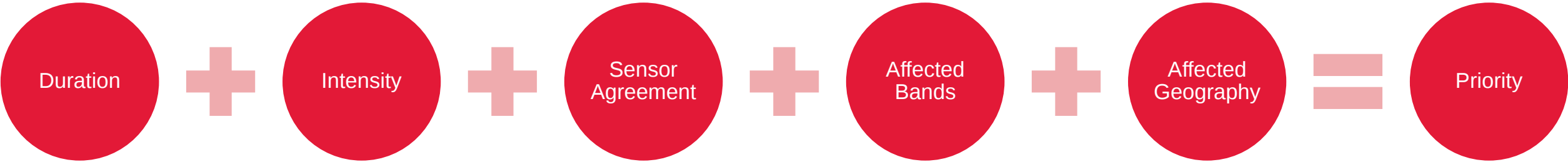
DETECTOR Event Ingestion

GENS collects DETECTOR events reporting GNSS interference within the UK from the GMV NSL STRIKE3 server

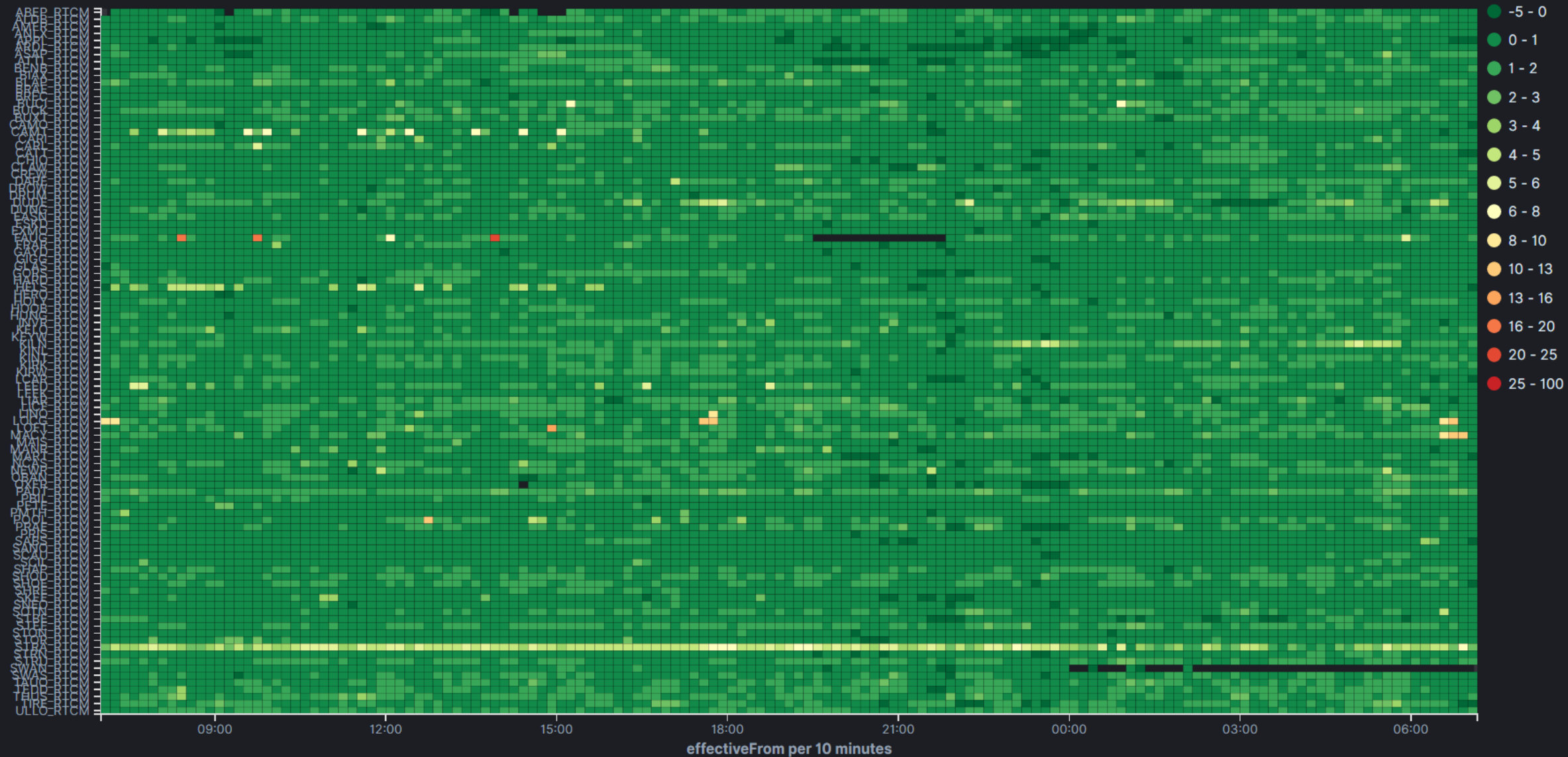
- GENS rapidly encompassed GMV NSL's DETECTOR network within UK
- GENS also compatible with any other source conforming to international STRIKE3 standard
- DETECTOR Events enabled CGI to validate detection algorithms



Fusing events for GNSS Incident Prioritisation



C/NO Overview



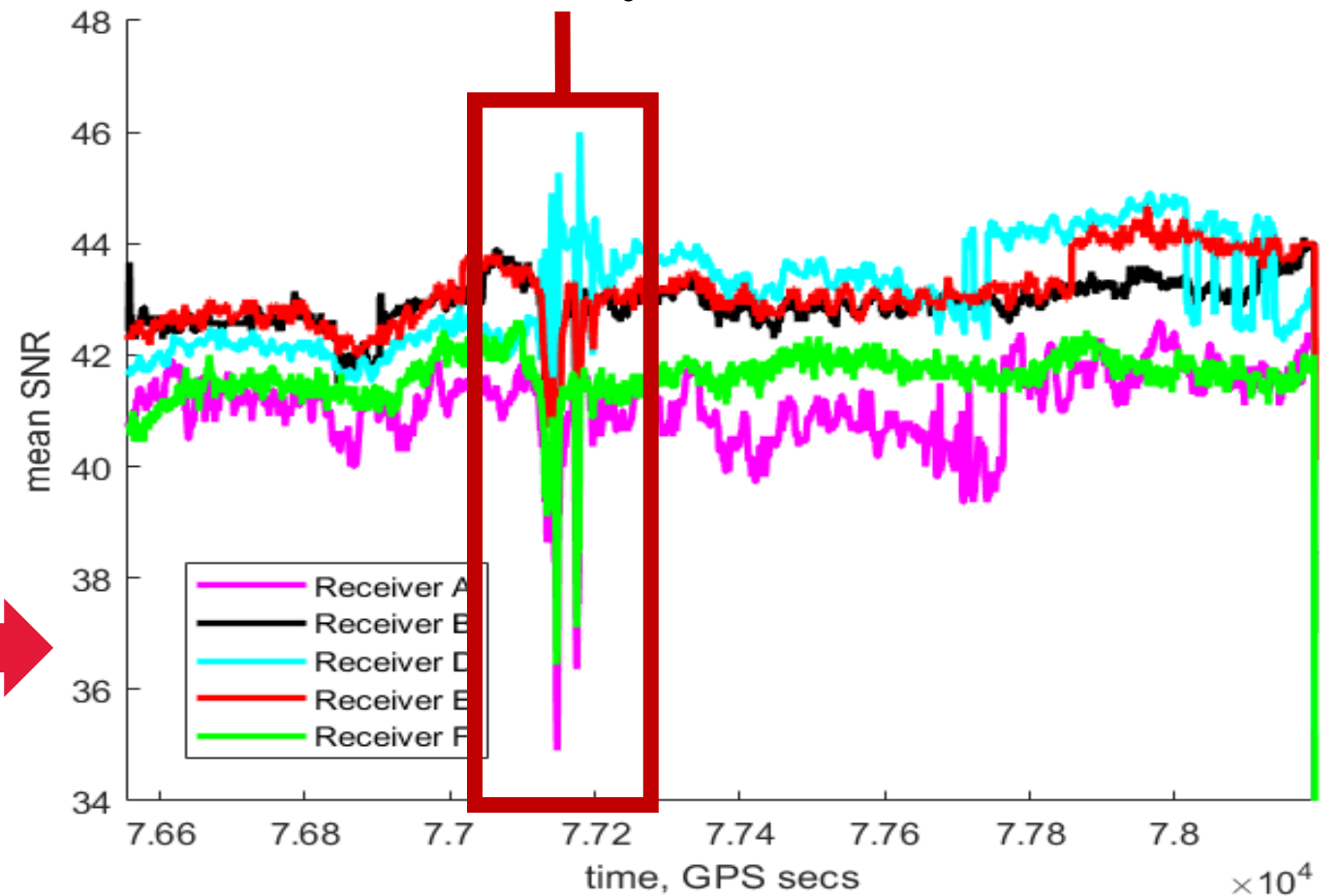
GNSS Incident Recorder and UK Government Receiver Test Bench

Incident Recorder PoC

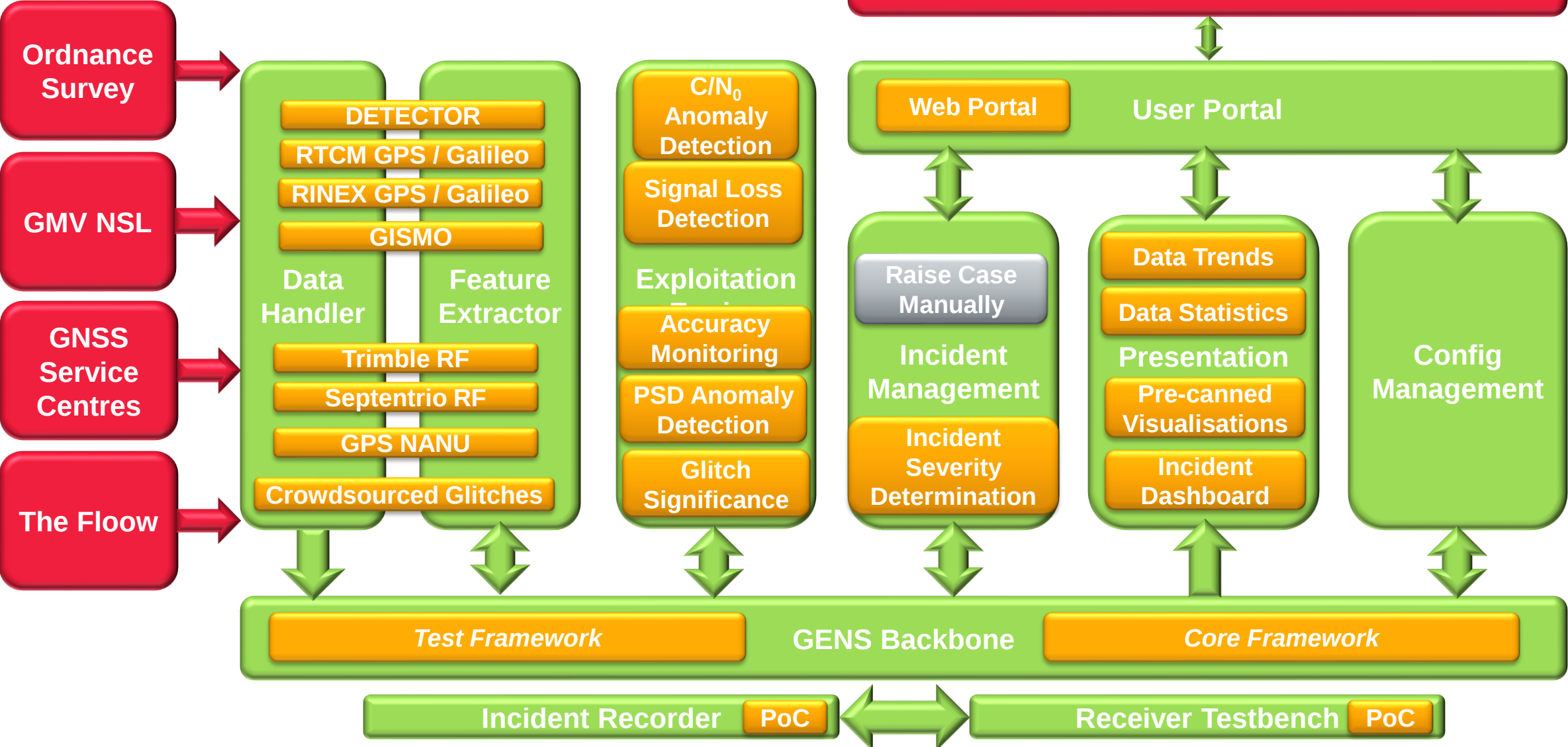


Receiver Testbench PoC

Each event affects the receivers differently with some suffering a bigger drop in C/N_0 than others



GENS Feature Summary



GNSS Guidance Document for UK Government Departments

The GENS Project created a GNSS guidance document:

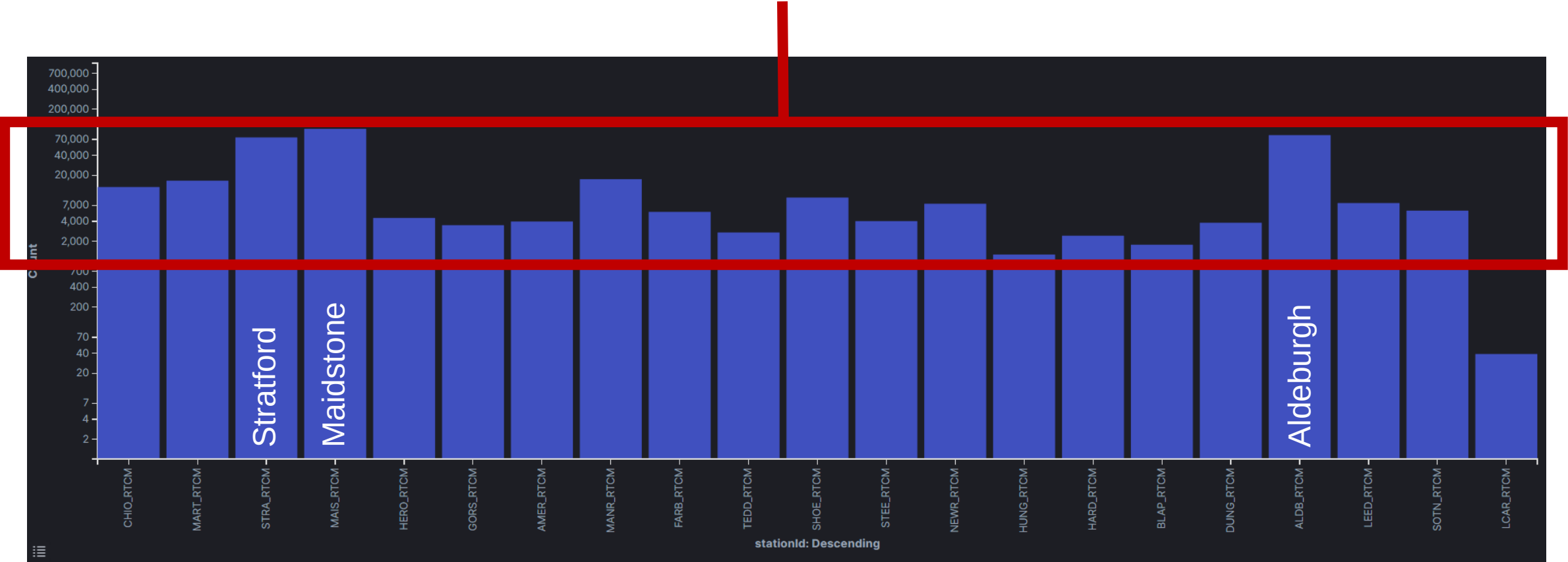
- Aimed at responsible procurers of GNSS-dependent services and systems
- Guidance to UK government departments to enable development of informed requirements, procurement, deployment and support for GNSS-based services
- Aim is to support government departments to understand what they need to ask for from industry when procuring such services
- Provides background information to support basic understanding of the technology and the threats to it, consistently across government departments
- Also relevant to providers of Critical National Infrastructure that use GNSS-based systems and services



Findings

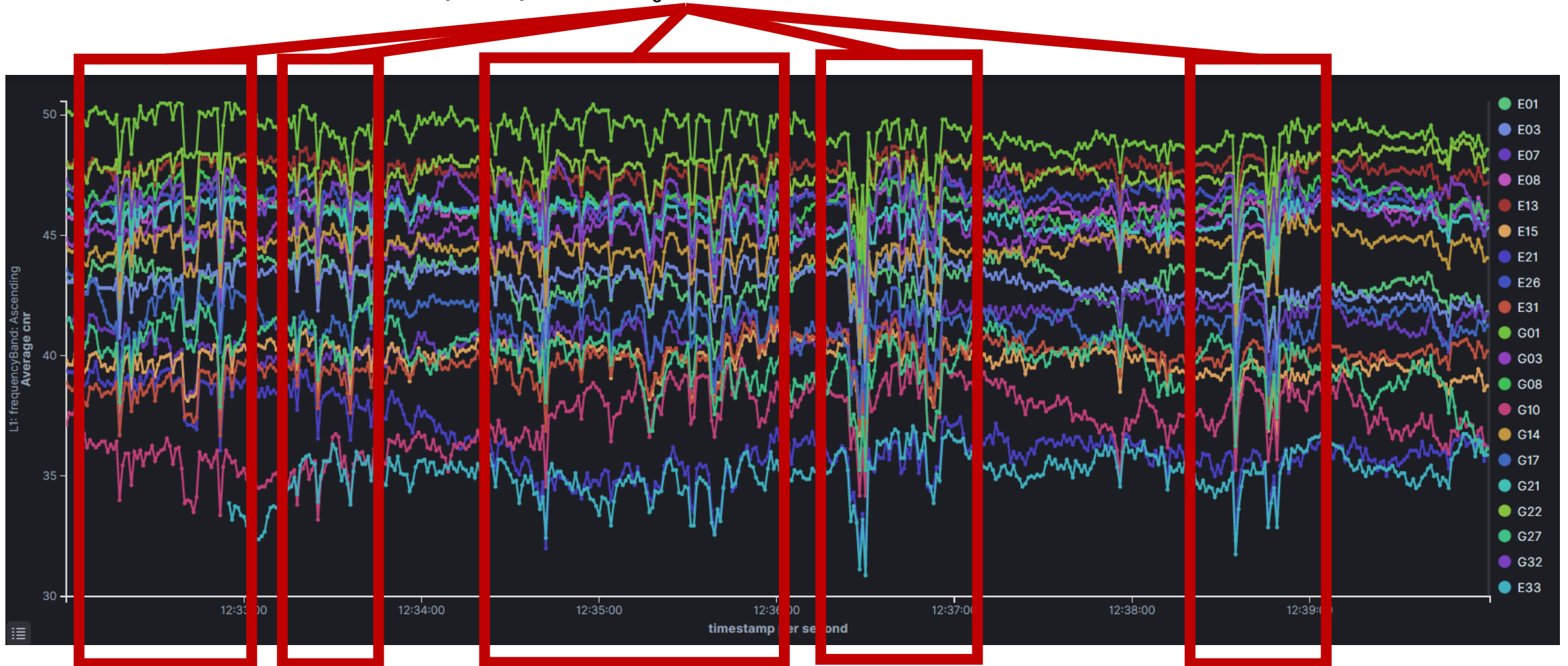
Findings: Interference is Everywhere

Every station but one had at least 1,000 seconds of interference over the initial two month period



Findings: Interference is Frequent

Sharp drops in C/N_0 several times a minute



Findings: Interference Occurred Less During Full Lockdown

England's lockdown to ease as planned on 12 April

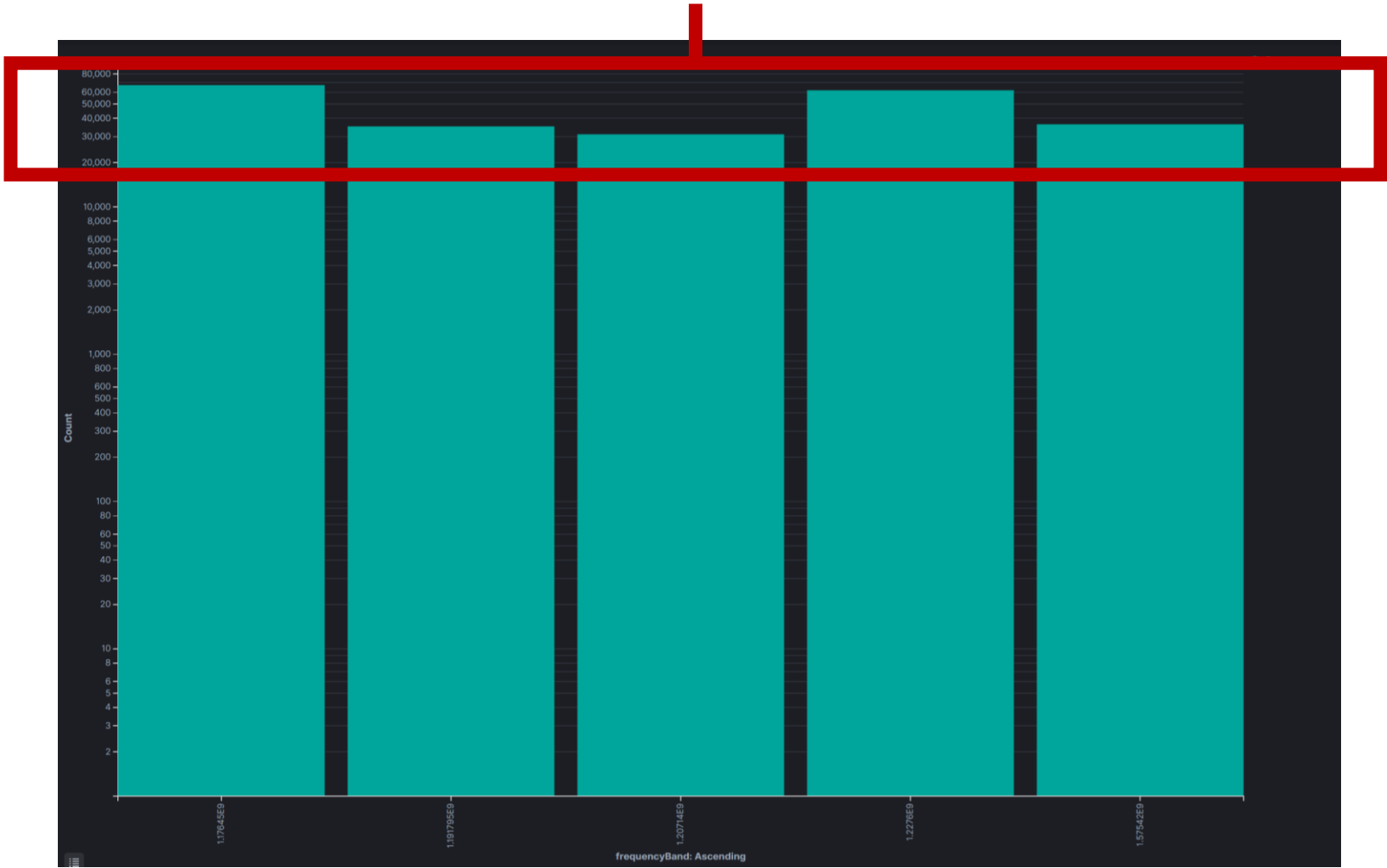
5 April

Coronavirus pandemic



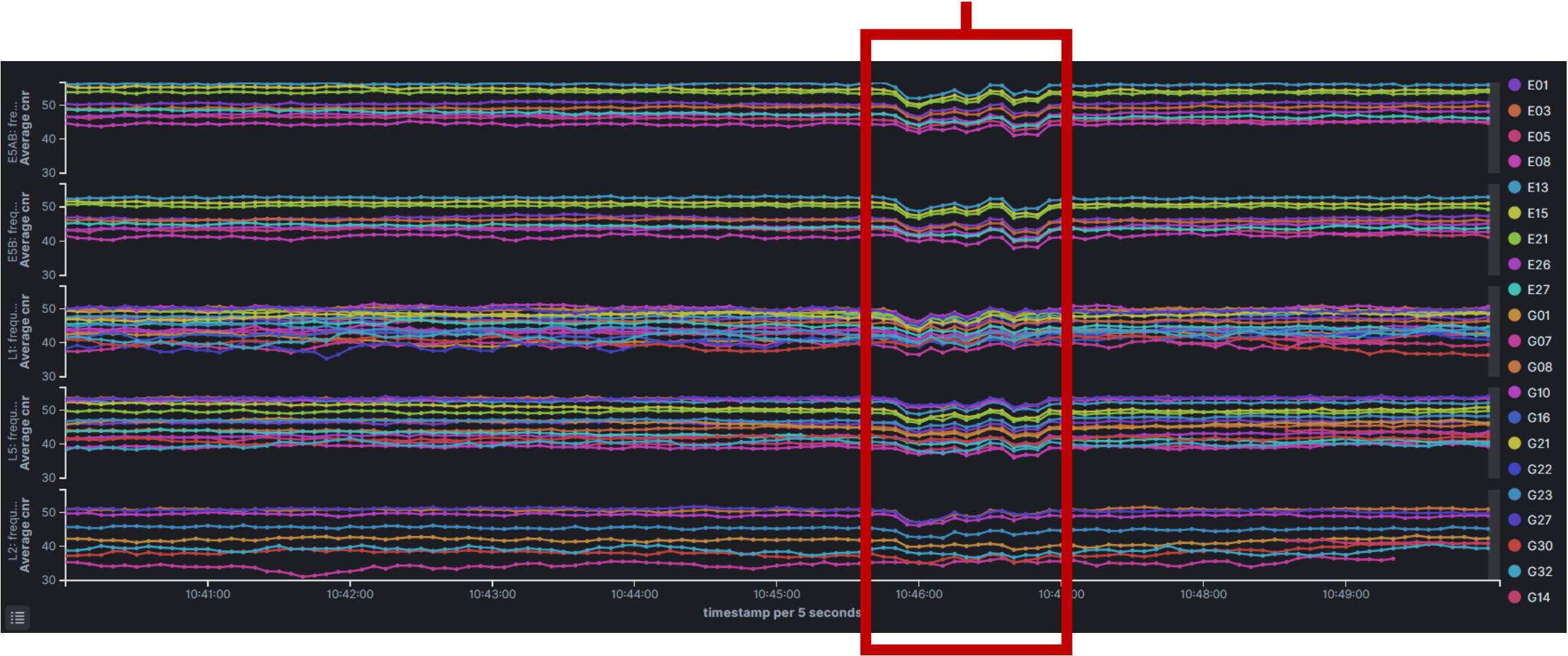
Findings: Interference is on all Bands

L1/E1, L2, L5/E5A, E5B and E5AB all experienced significant amounts of interference during the capability surge demonstration



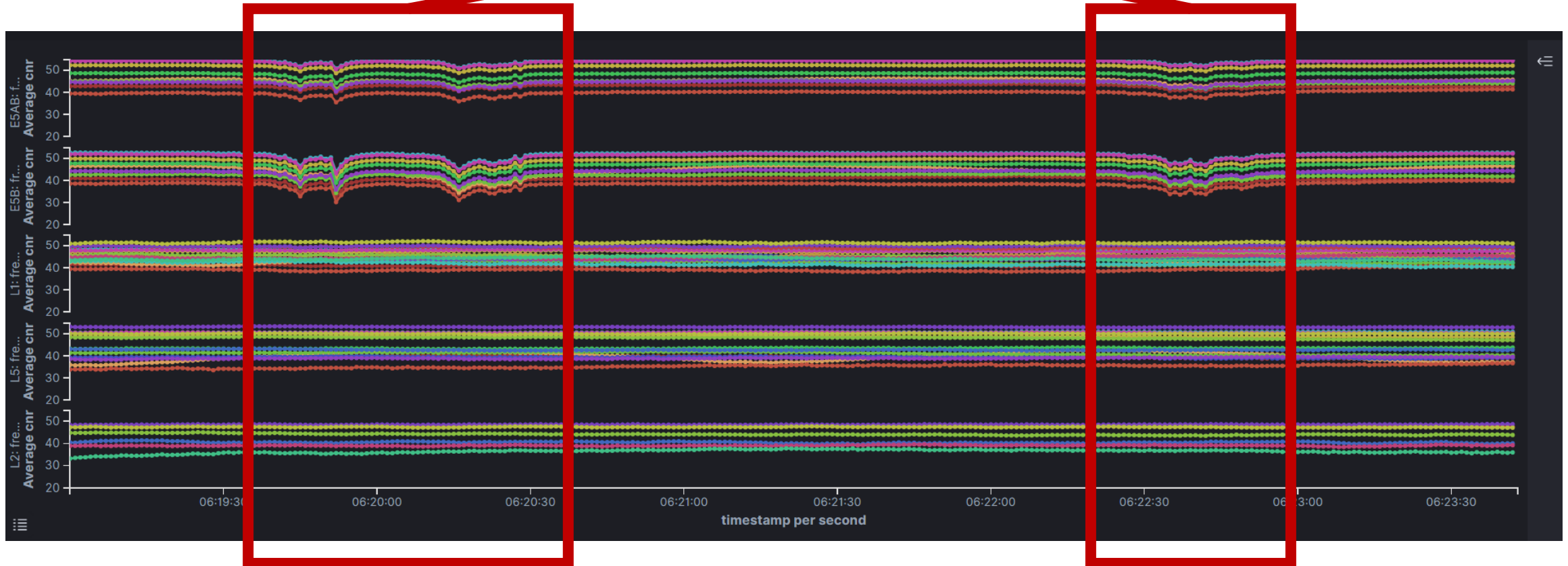
Findings: Some Interference is Multi-Frequency

Collective drop in C/N₀ across all
satellite signals and frequency bands



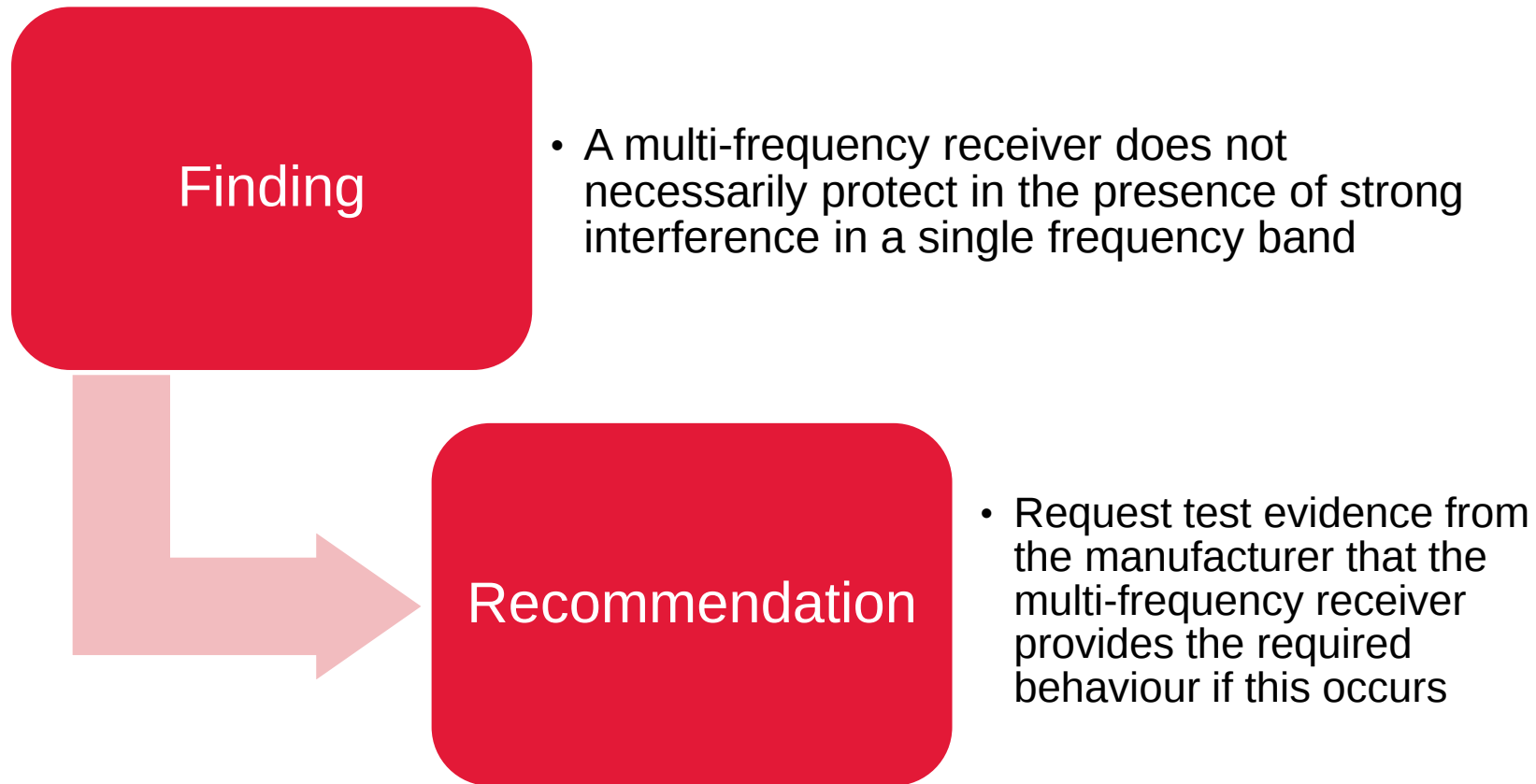
Findings: Some Interference is Galileo-Specific

Collective drop in C/N_0 across all satellite signals, in the Galileo E5B frequency band

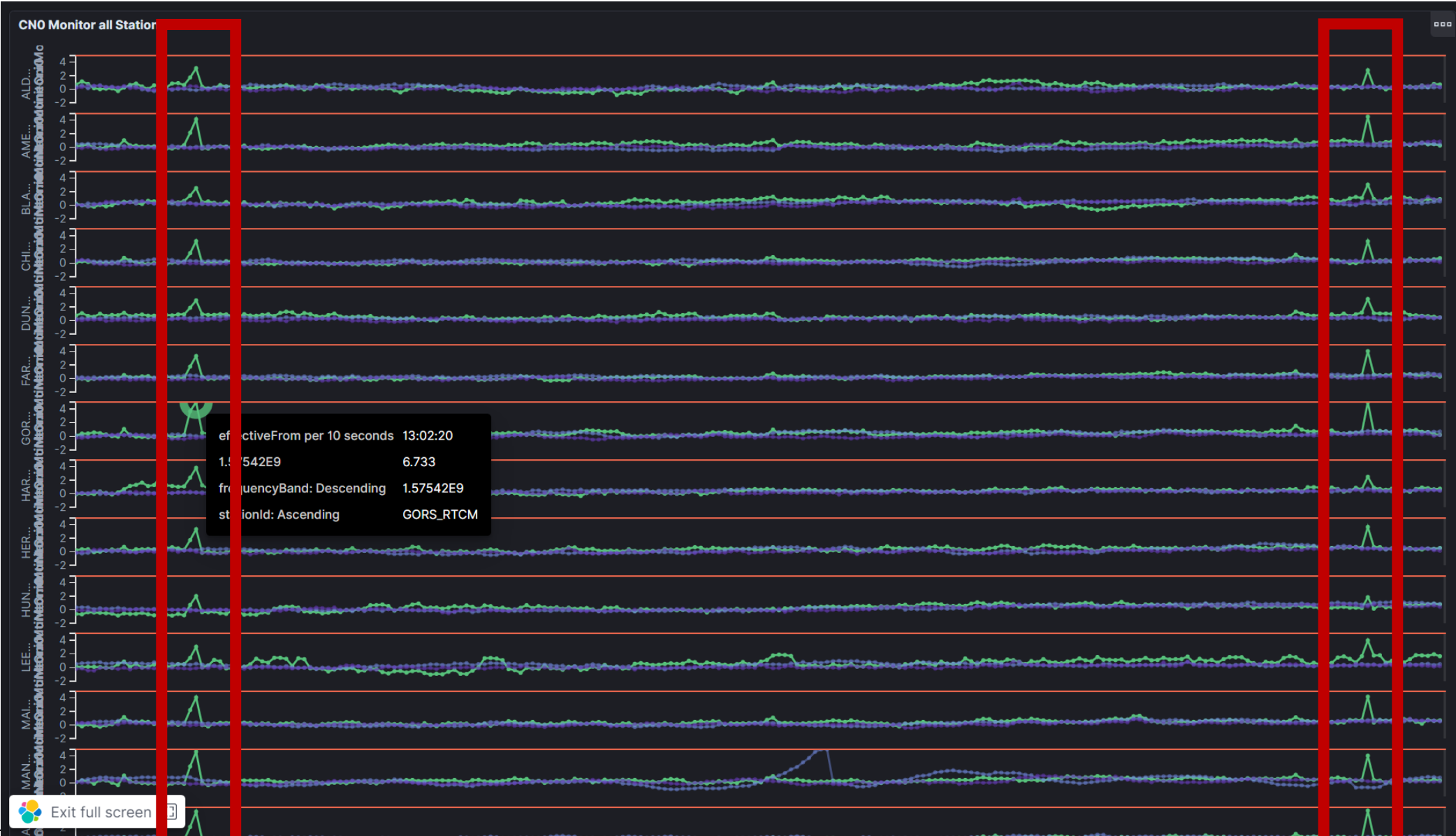


Findings:

Strong L1 Interference Can Deny Some Receivers Across All Frequencies



Findings: Some Interference Comes from Space



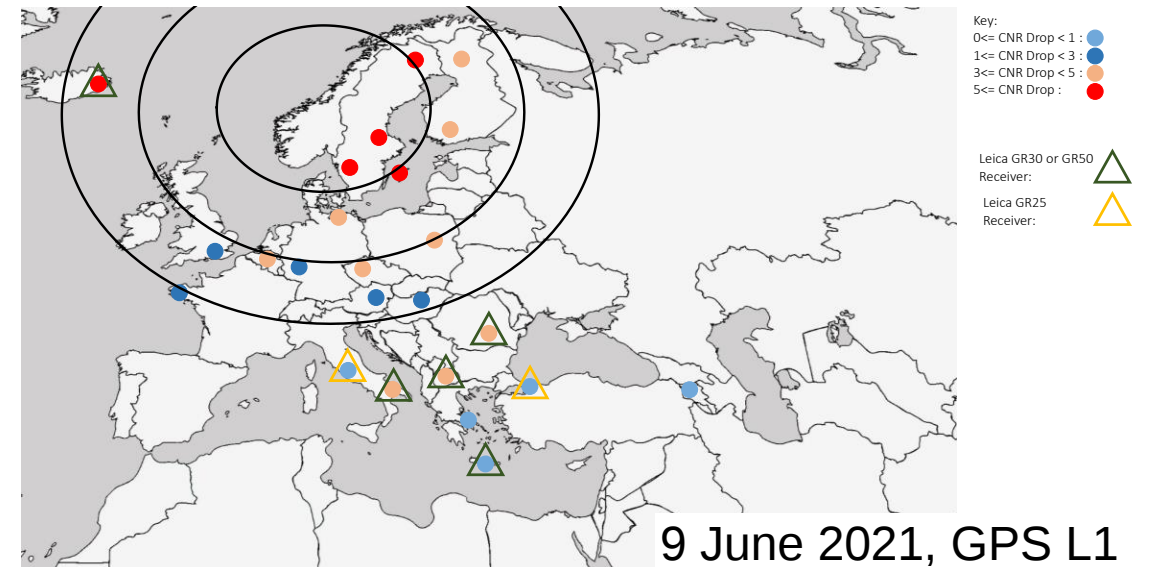
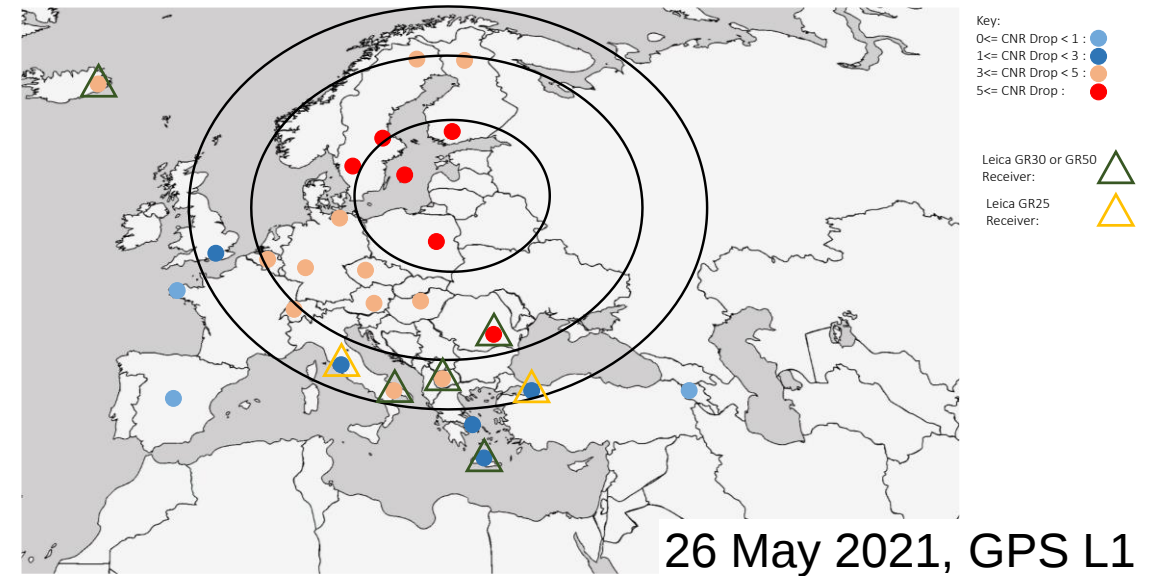
Exploring geographic extent and impact beyond the UK

Investigation of impacts of space-based interference to GNSS receivers beyond the UK

- Extent and severity of impact

Using publicly-available C/N0 data

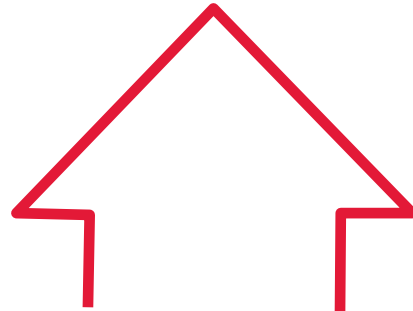
- Manual process currently
- Can be automated for rapid insights



The Future

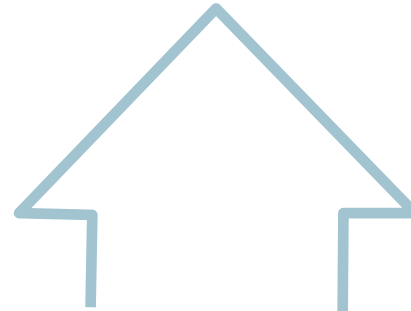
The Future

Localisation and attribution of GNSS incidents



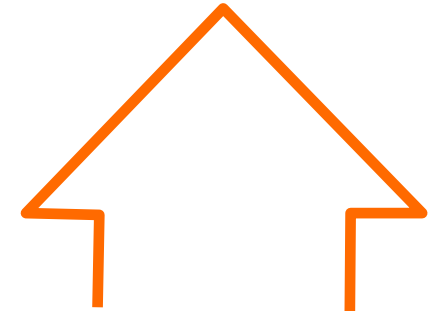
Integrate

Combine GNSS interference detection with ANPR cameras



Harness

Harness the use of opportunistic GNSS sensors already roving the roads, the waterways, the skies and in space

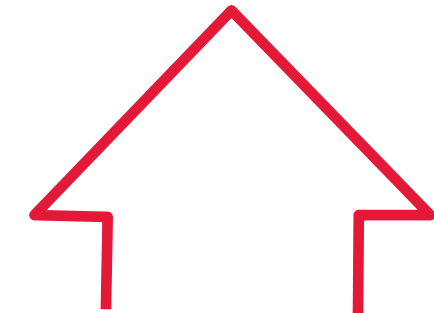


Pinpoint

Tactical capabilities for pinpointing the emitter location

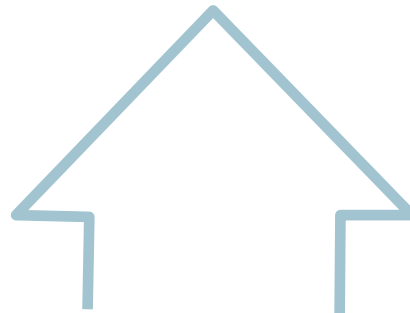
The Future

Capability enhancements



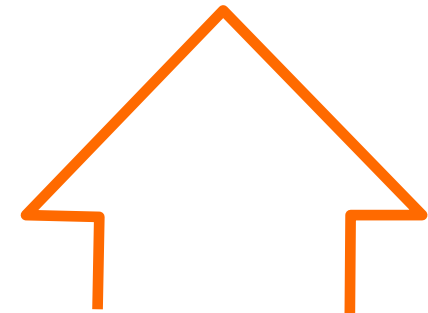
Detection

Algorithm enhancement for spoofing and interference types



Characterisation

Determination of emitter class, potentially a specific emitter



Integration

Connection and communication with domain specific systems

Conclusion

01

PGG, Sprint Review enabled good stakeholder engagement and regular feedback on desired and developed features and capability

02

Agile approach enabled GENS to adjust direction and explore areas not envisioned at the projects start; impact of interference on receivers, use of additional data feeds

03

Microservices and framework provides adaptability for the incorporation of new sensor feeds, processing algorithms, support for scalability trials and future continuous evolution

04

GENS infrastructure and processing developed supports pre-production/production deployment including the PoC Receiver Testbed for an IDM

05

GNSS Guidance Document developed for and delivered to UK Space Agency to support the informed procurement of systems utilizing GNSS

The innovation provided in the agile delivery method in terms of governance and alignment to ESA processes has been very welcome. The direction of the programme despite the agile method has been focused and efficient.

- The ESA Technical Officer

Thank You

Doug Hudson
Director Consulting Expert
Aerospace and Assured Space Systems
email: douglas.hudson@cgi.com
phone: +44 7776 165127
Web: www.cgi.com
LinkedIn: <https://www.linkedin.com/in/doug-hudson-design-authority/>

Dr John S Glover
Director Consulting Delivery
Aerospace and Assured Space Systems
email: john.glover@cgi.com
phone: +44 7595 612633
Web: www.cgi.com
LinkedIn: <https://www.linkedin.com/in/johnsigsworthglover/>

