



GNSS Threat Detection & Integrity Monitoring

A Research-Based Framework and Operational Implementation

Table of Contents

- 01** The Problem
- 02** The Research
- 03** The Solution
- 04** Data Analysis
- 05** Key Takeaways



The Problem

Quantifying the Impact of GNSS Interference

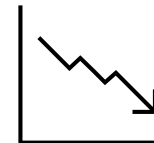
Reliance

Aviation relies heavily on GPS (80%+ of flights use it globally).



Cost of Attack

The cost of equipment for interference has reduced from ~\$500,000 - ~\$100.



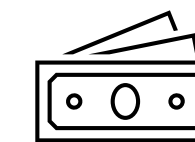
Safety Risks

- Misrouting
- Near-Misses
- Loss of Positional Awareness
- Loss of Life



Financial Risks

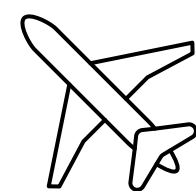
- Delays
- Diversions
- Increased Fuel Consumption & Cost



Quantifying the Impact of GNSS Interference

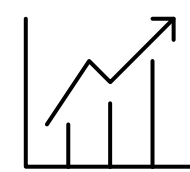
60%

Of Air Traffic over Eastern Europe is affected daily.



2,000%

Increase in GNSS RF Interference yearly.



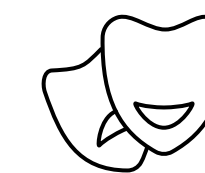
40-50 NM

Confirmed Impact Radius of GNSS Jamming.

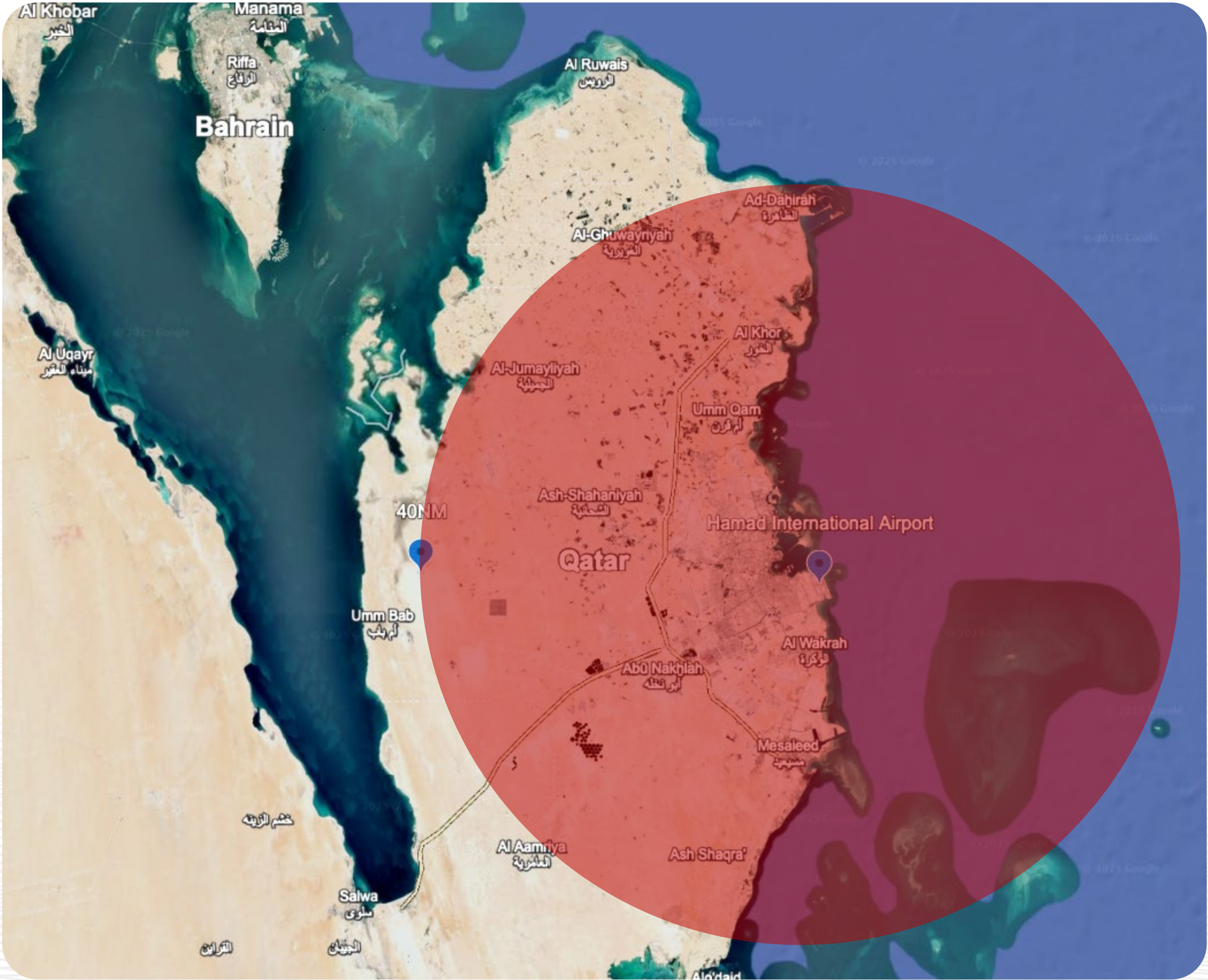


Threat Actors

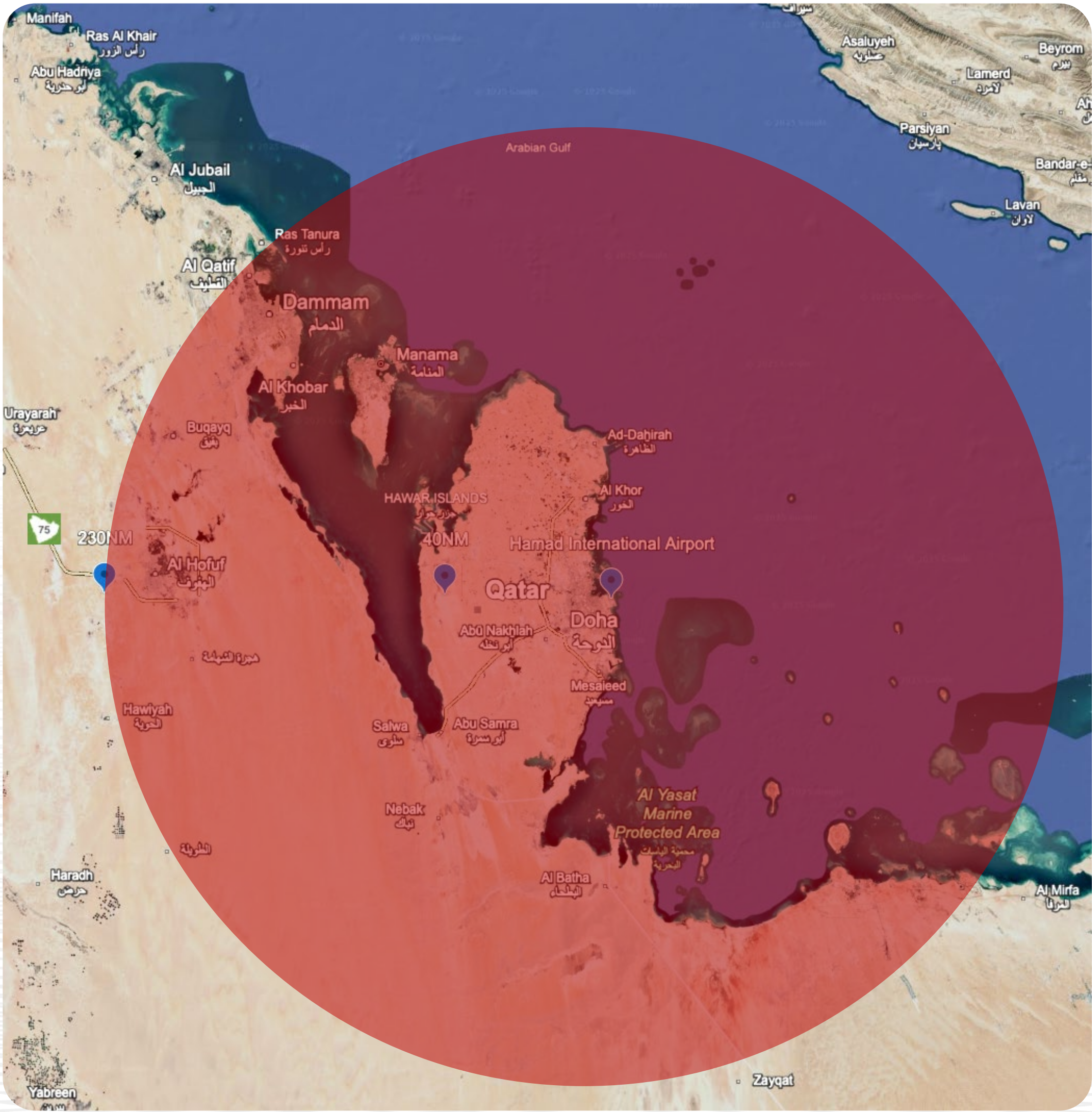
- Malicious
- Accidental
- Collateral



Potential Impact

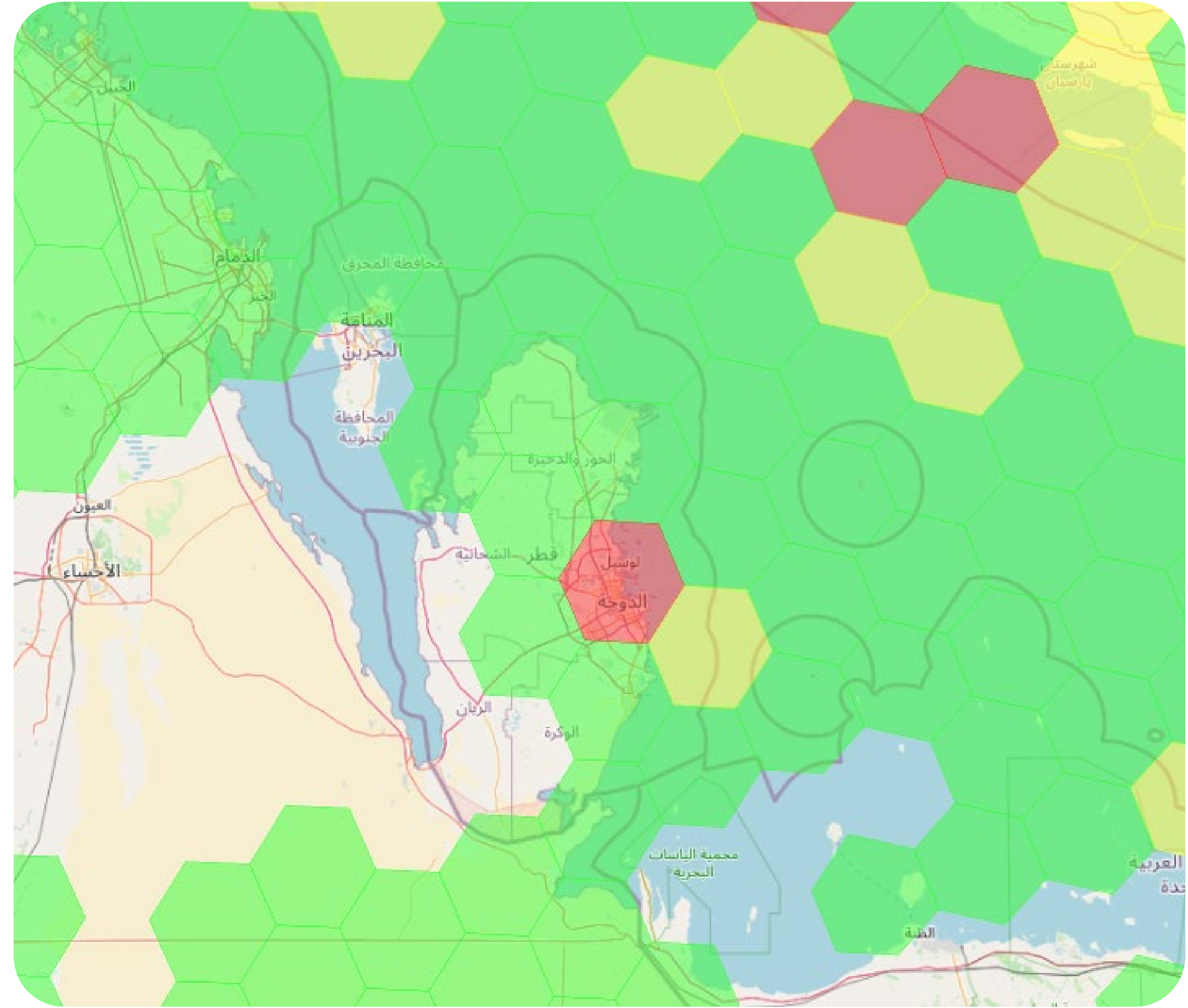


Potential Impact



Temporary Suspension of Maritime Traffic

Circular issued by Qatar Ministry of
Transport.





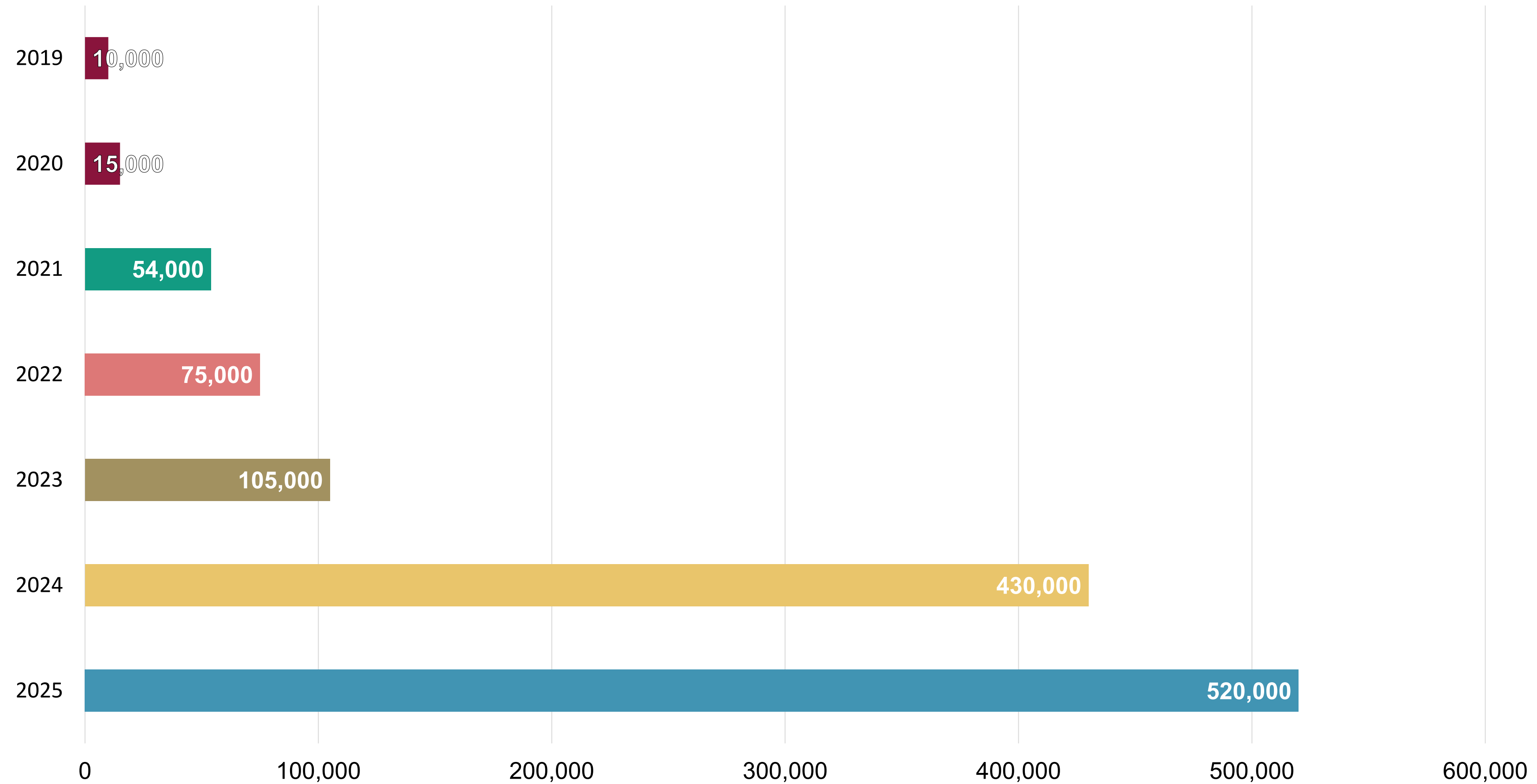
Clock & Location Shift

Frequently observed in recent months.



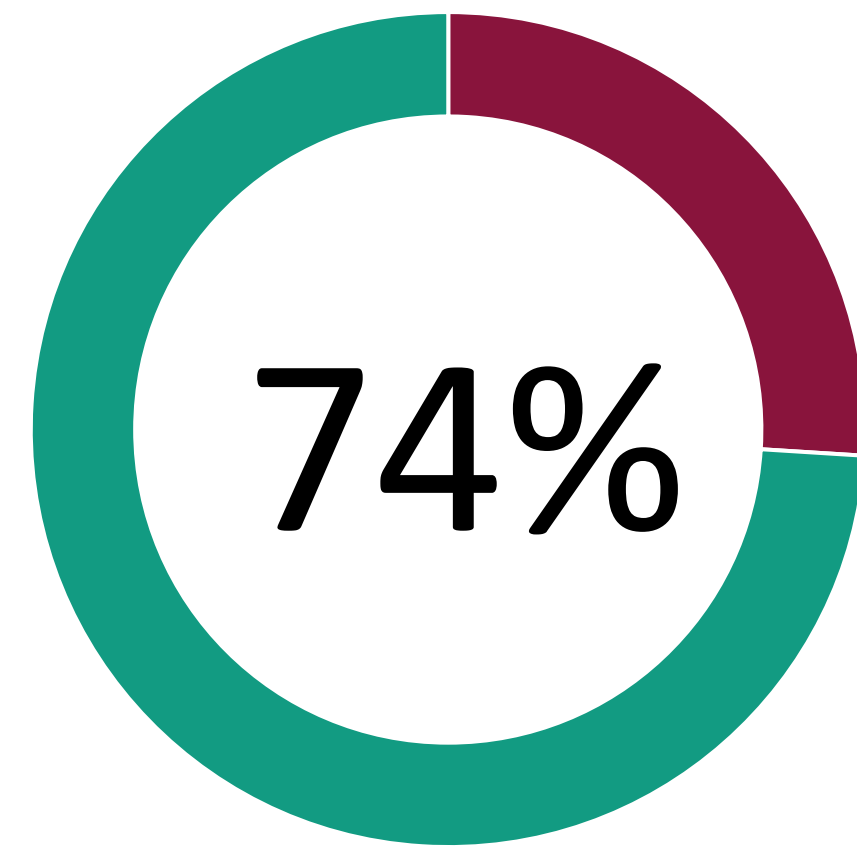
The Research

Global GNSS Interference Incidents



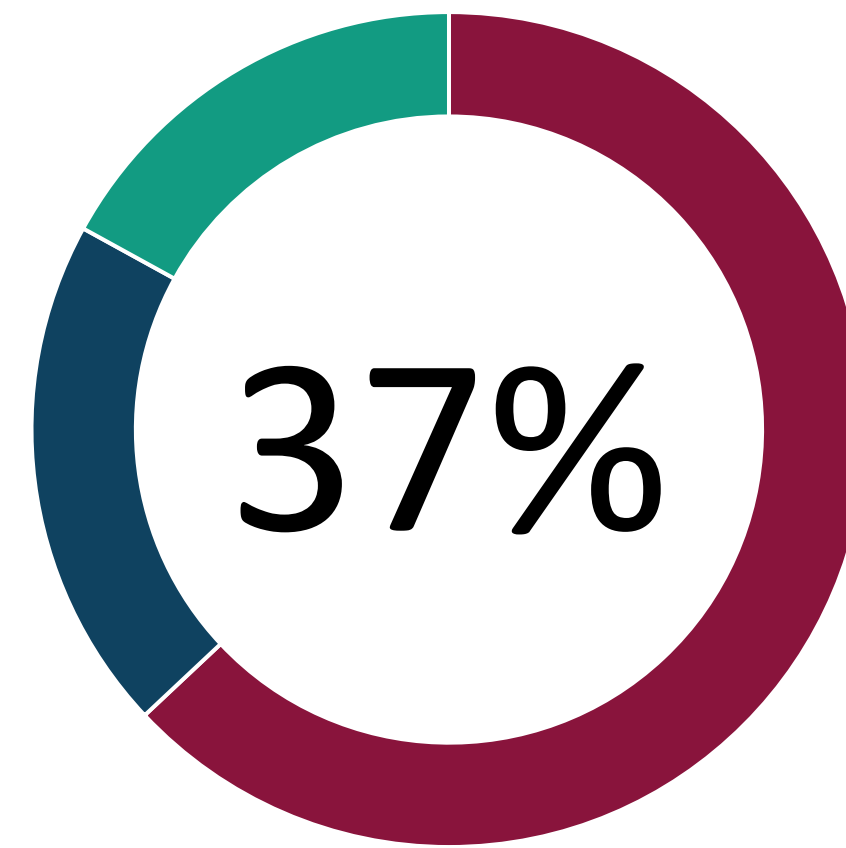
(Eurocontrol, 2021) | (Zulhusni, 2025) | (Issa, 2025) | (Romi, 2025) | (Smith, 2025)

Pilot Surveys



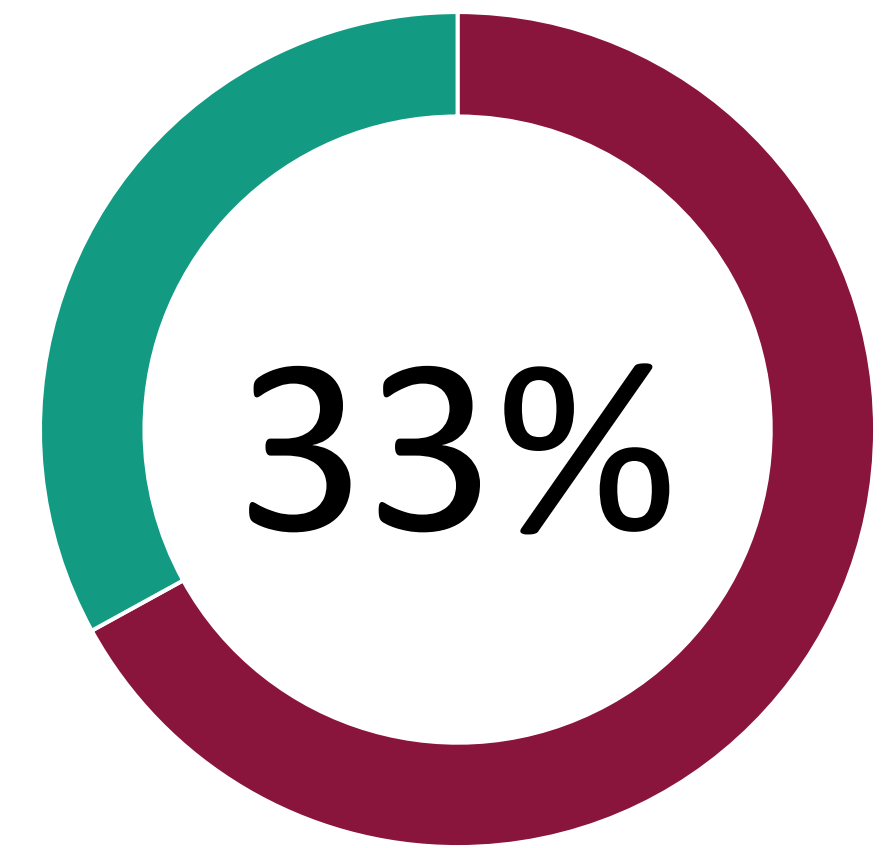
■ No ■ Yes

Have you experienced GNSS-related Issues?



■ No ■ Brief Overview ■ In-Depth

Have you received Training or Briefings?



■ No ■ Yes

Do you feel prepared to handle GNSS interference?

Air Traffic Controller Interviews



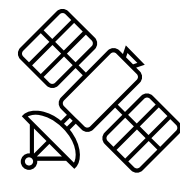
Current air traffic control systems do not incorporate GPS spoofing detection mechanisms, relying instead on manual cross-checks and pilot reports. [...] There is a strong desire for more sophisticated tools to assist in detecting and managing GNSS interference.

—

From Research to Detection Framework

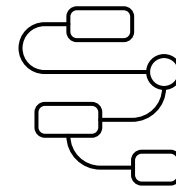
Acquisition

GNSS signals captured from fixed ground reference points.



Analysis

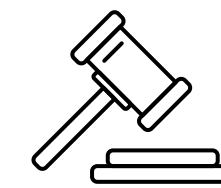
Detection and analysis algorithms evaluate each received signal for anomalies.



Classification

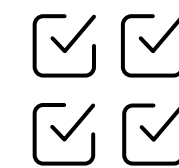
Signals categorized as:

- Normal (Authentic)
- RF Interference
- Spoofing
- Jamming



Validation

Contextual confidence checks reduce false positives and refine threat levels.





The Solution



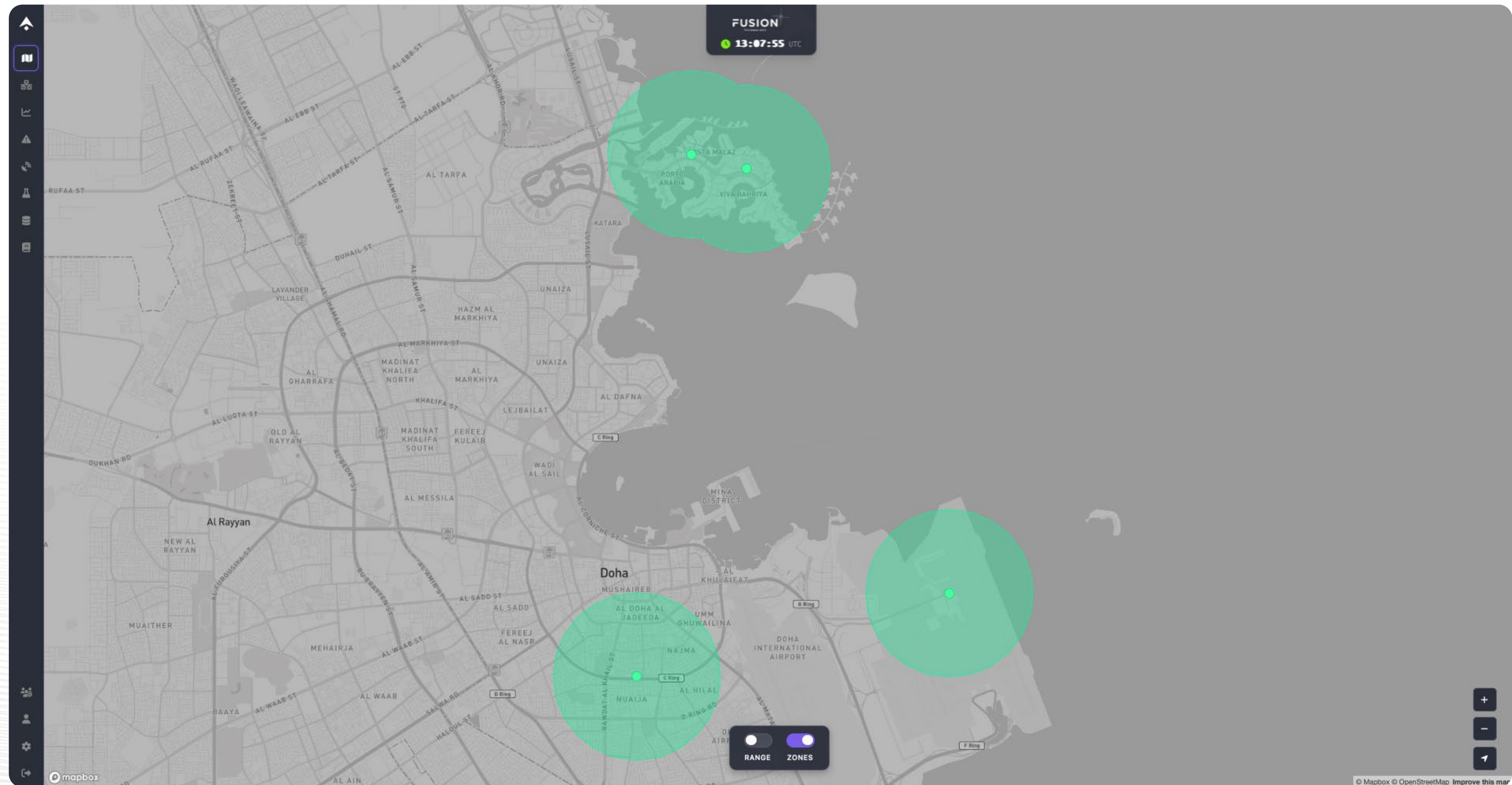
Fixed GNSS Reference Station

StratoNode

- Multi-Constellation
- Multi-Band
- 1.5m Accuracy
- Local Data Storage



StratoCentral

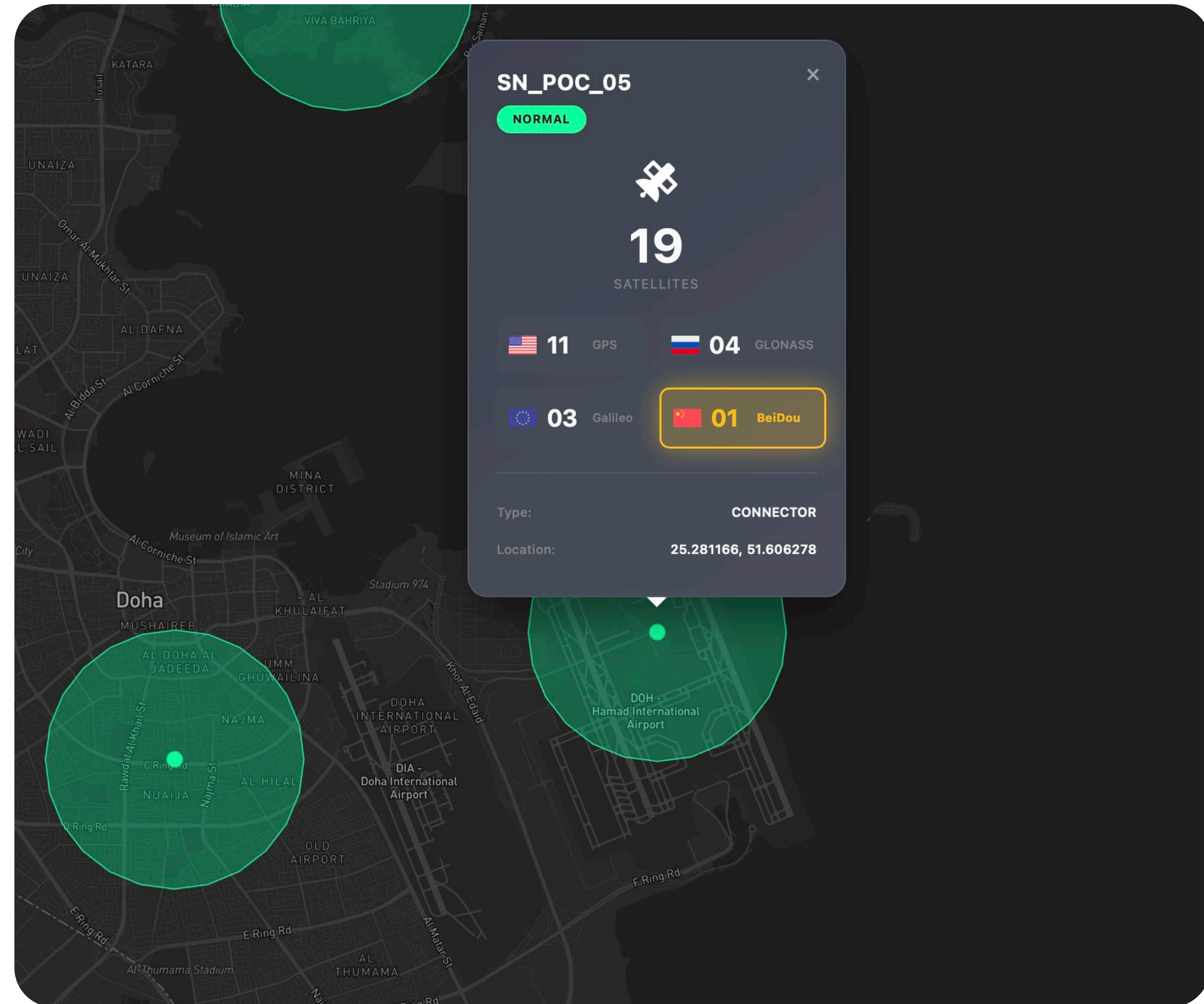


Central Analysis & Processing Platform

Use Case

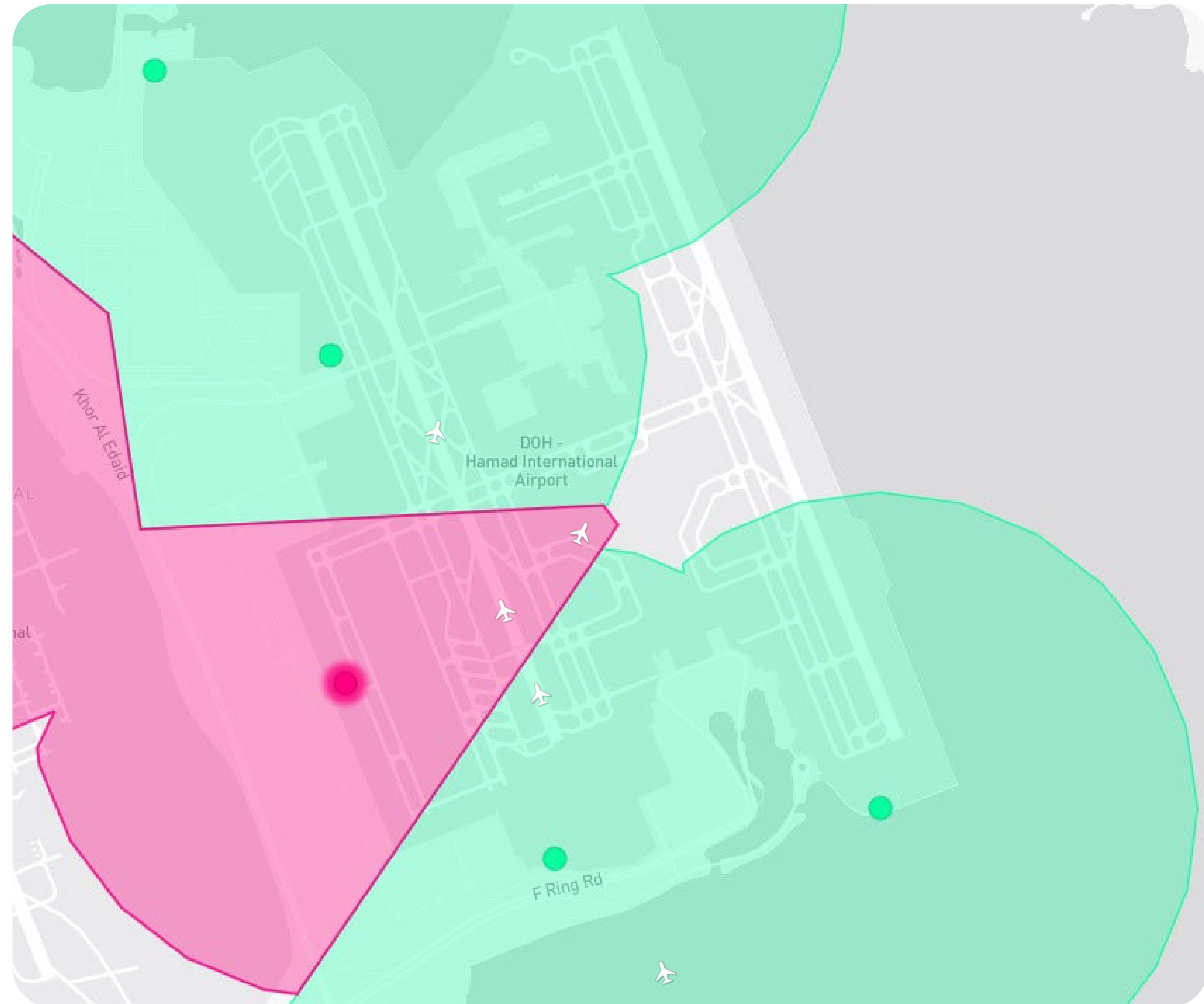
Air Traffic Control

- Early Warning of GNSS Degradation
- Supports safer RNAV/RNP-based operations
- Helps differentiate technical issues from environmental RF problems
- Reduces reliance on pilot reports or delayed information
- Stores data for incident and accident investigations



Other Use Cases

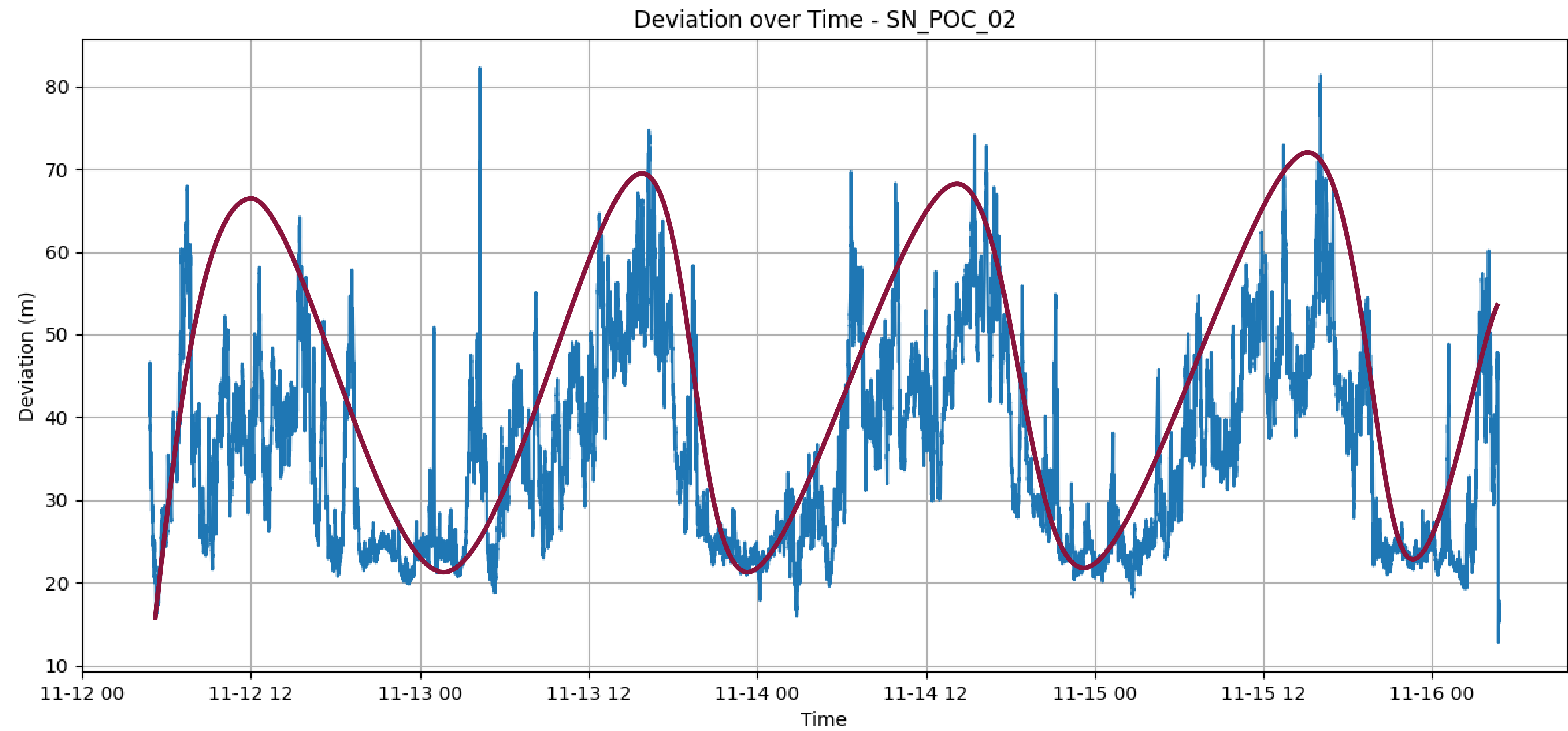
- Helps correlate flight deviations with real GNSS conditions
- Identifies RF hotspots airside, landside, and around critical infrastructure
- Support security units in detecting intentional interference
- Provides long-term data for risk, planning, and infrastructure decisions



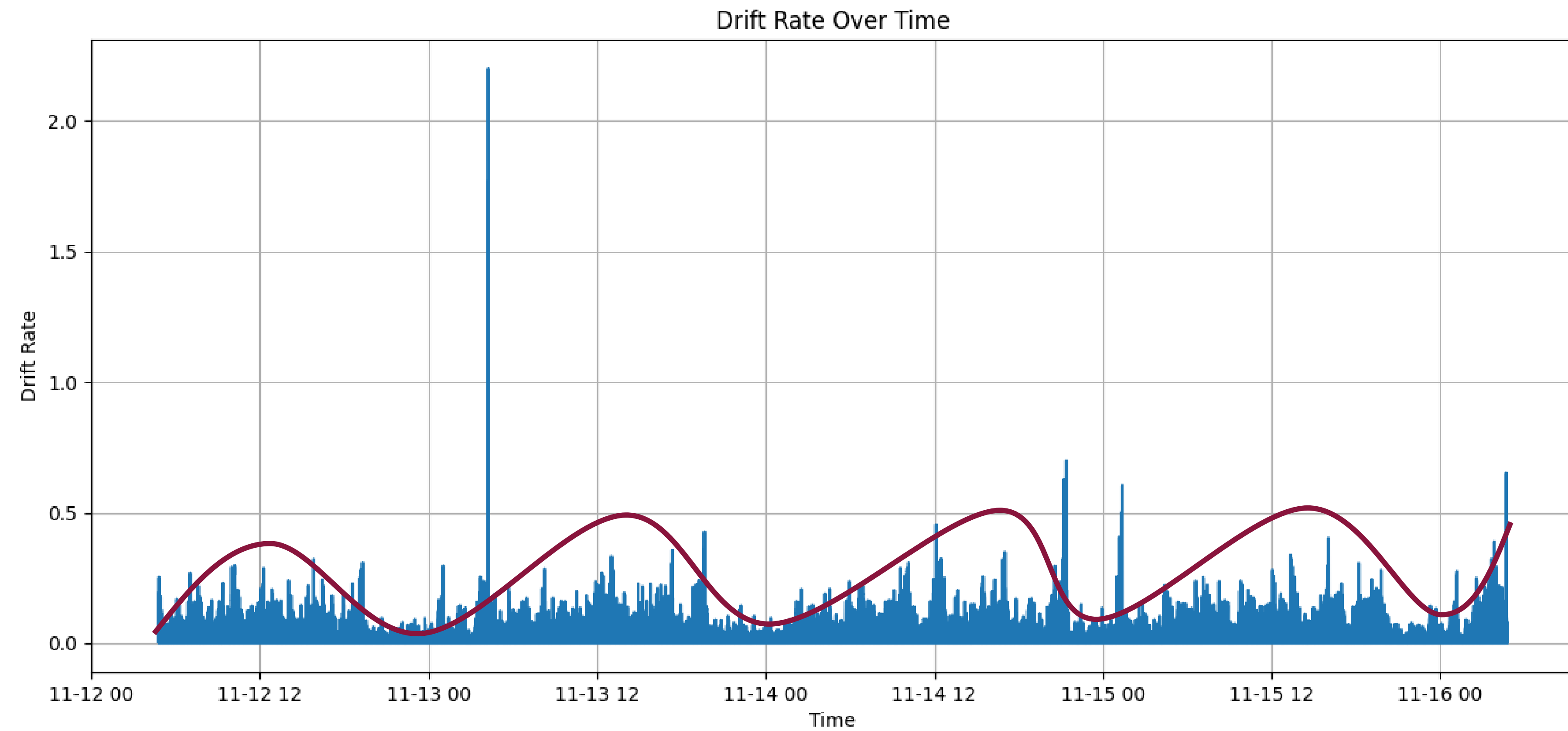


Data Analysis

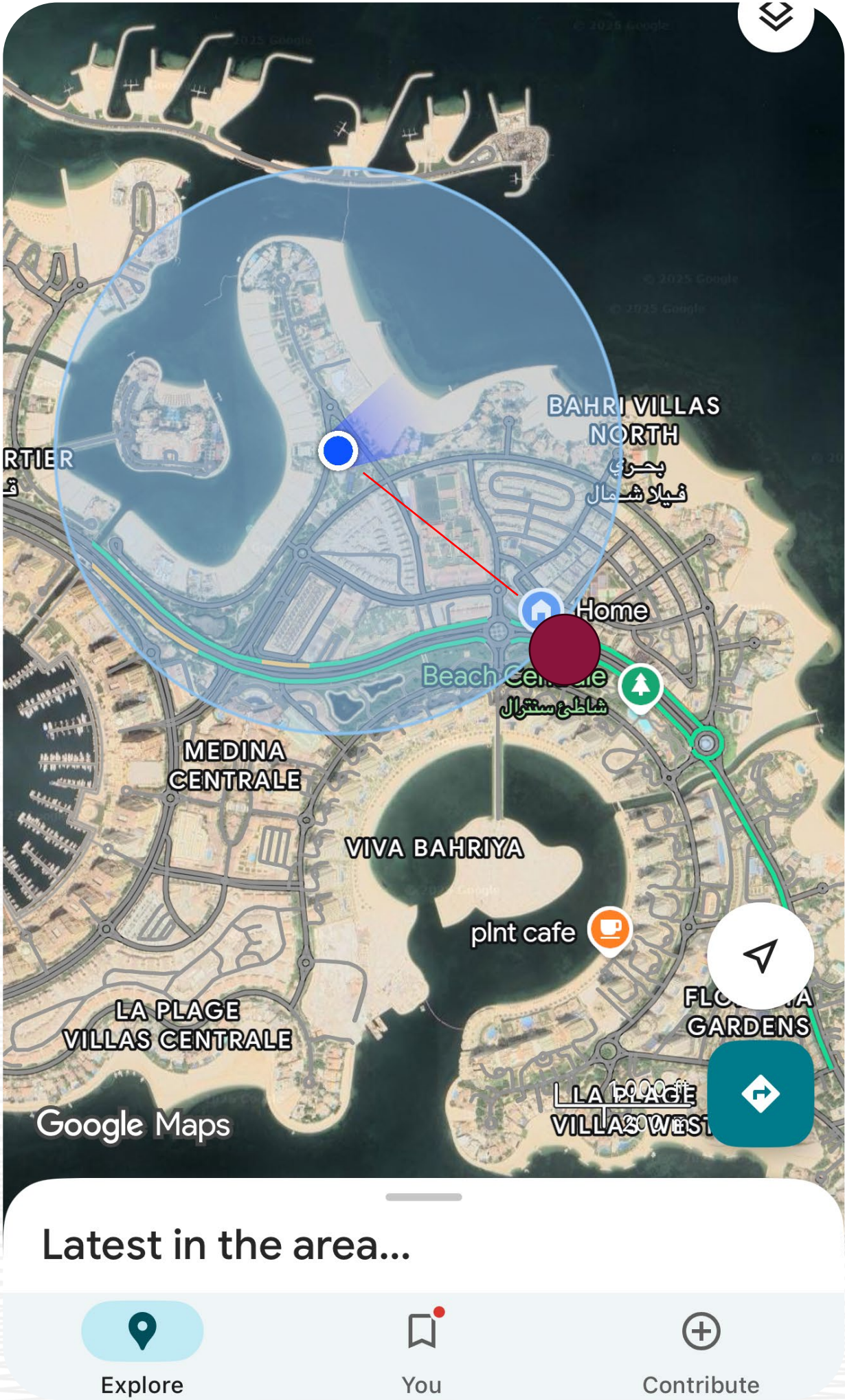
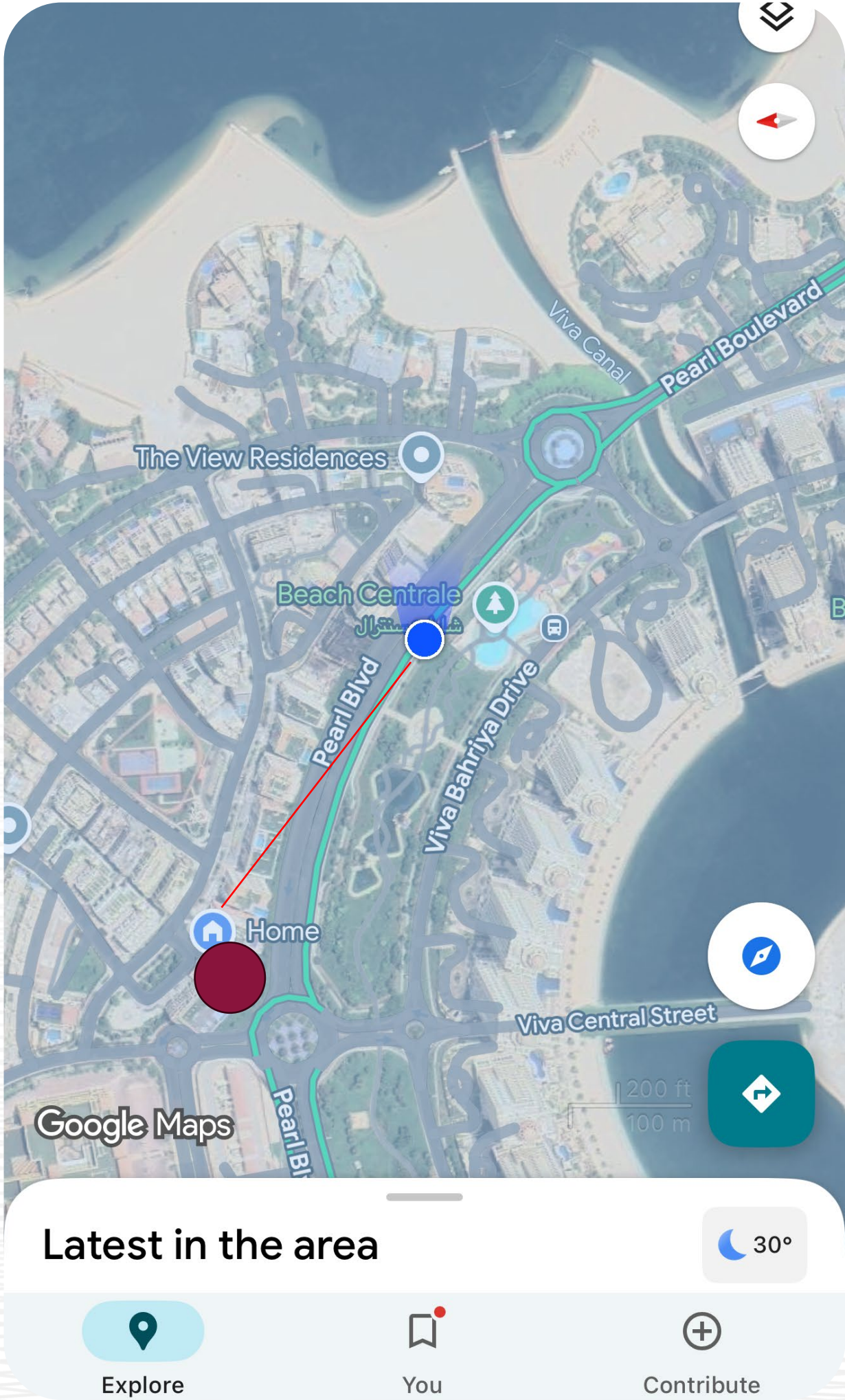
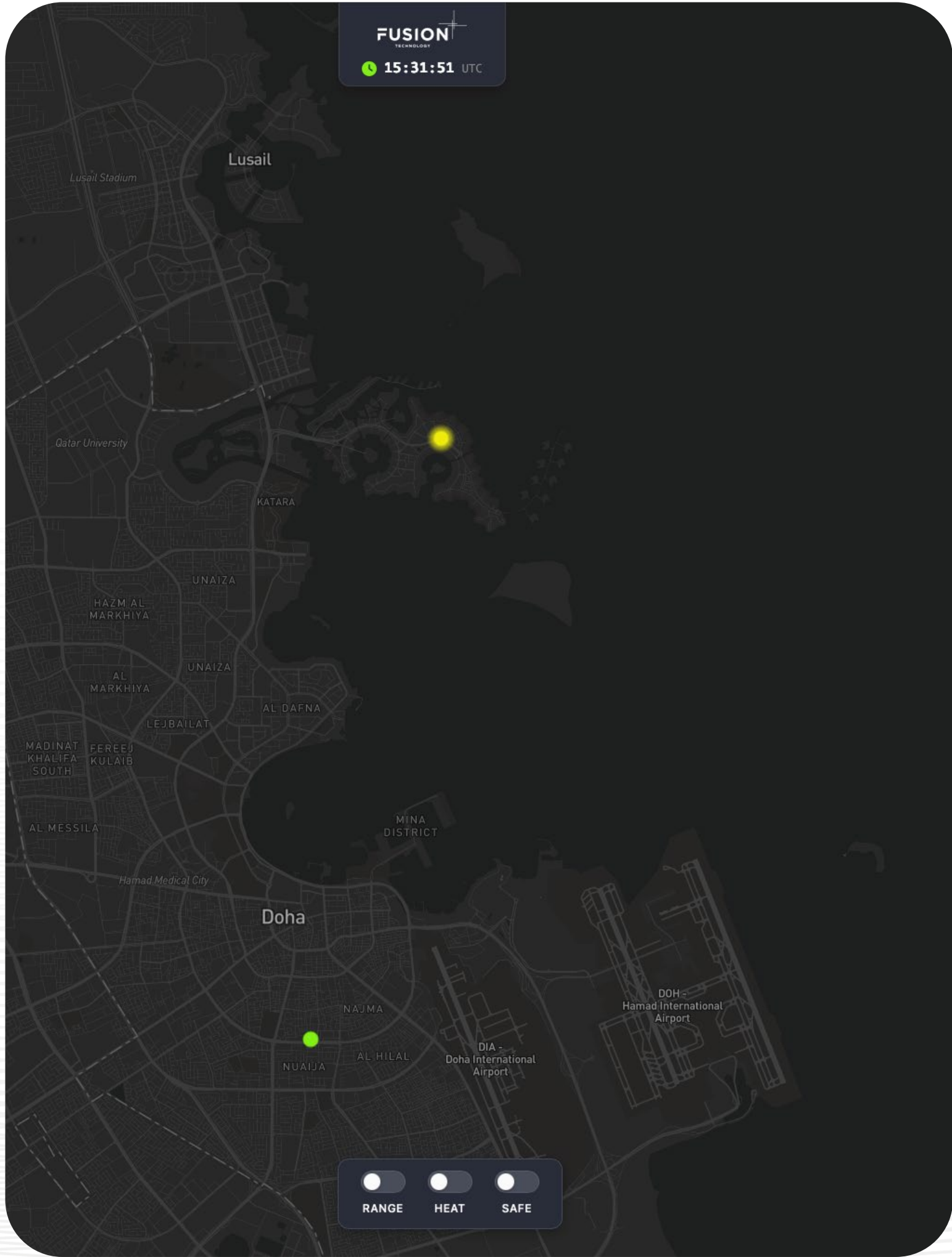
Multi-Path Effects



Drift Rate Over Time

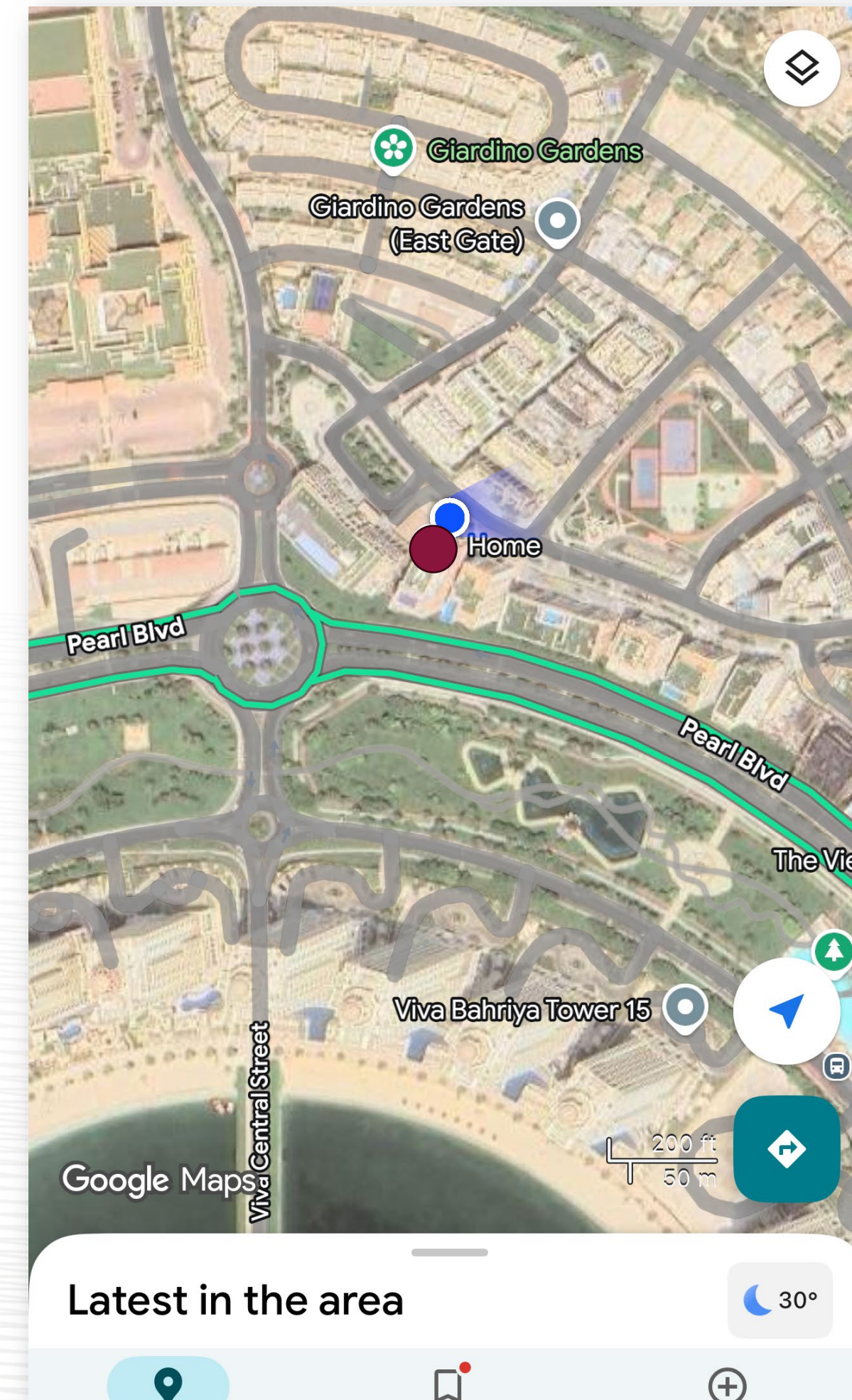
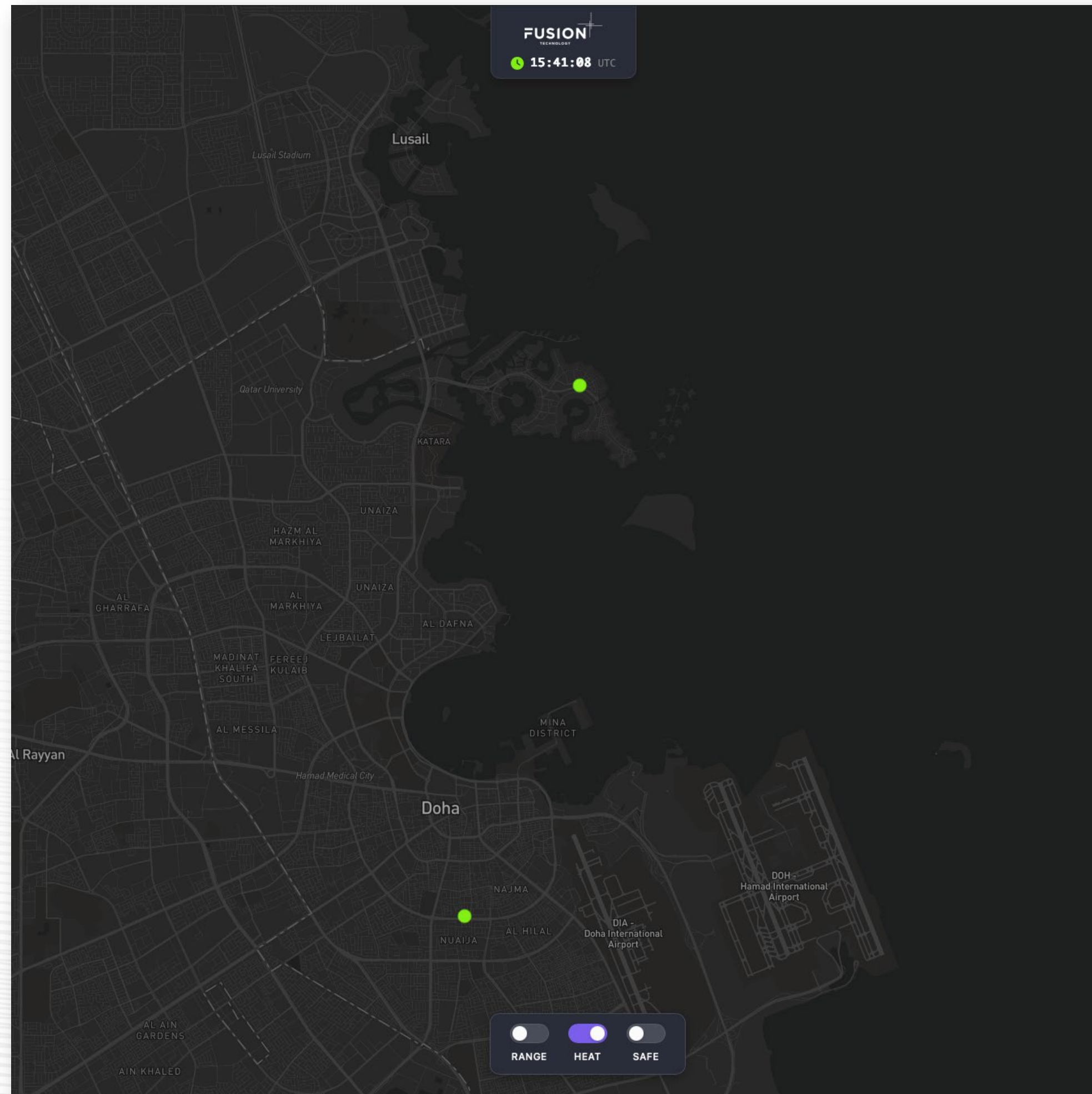


Case Study 01



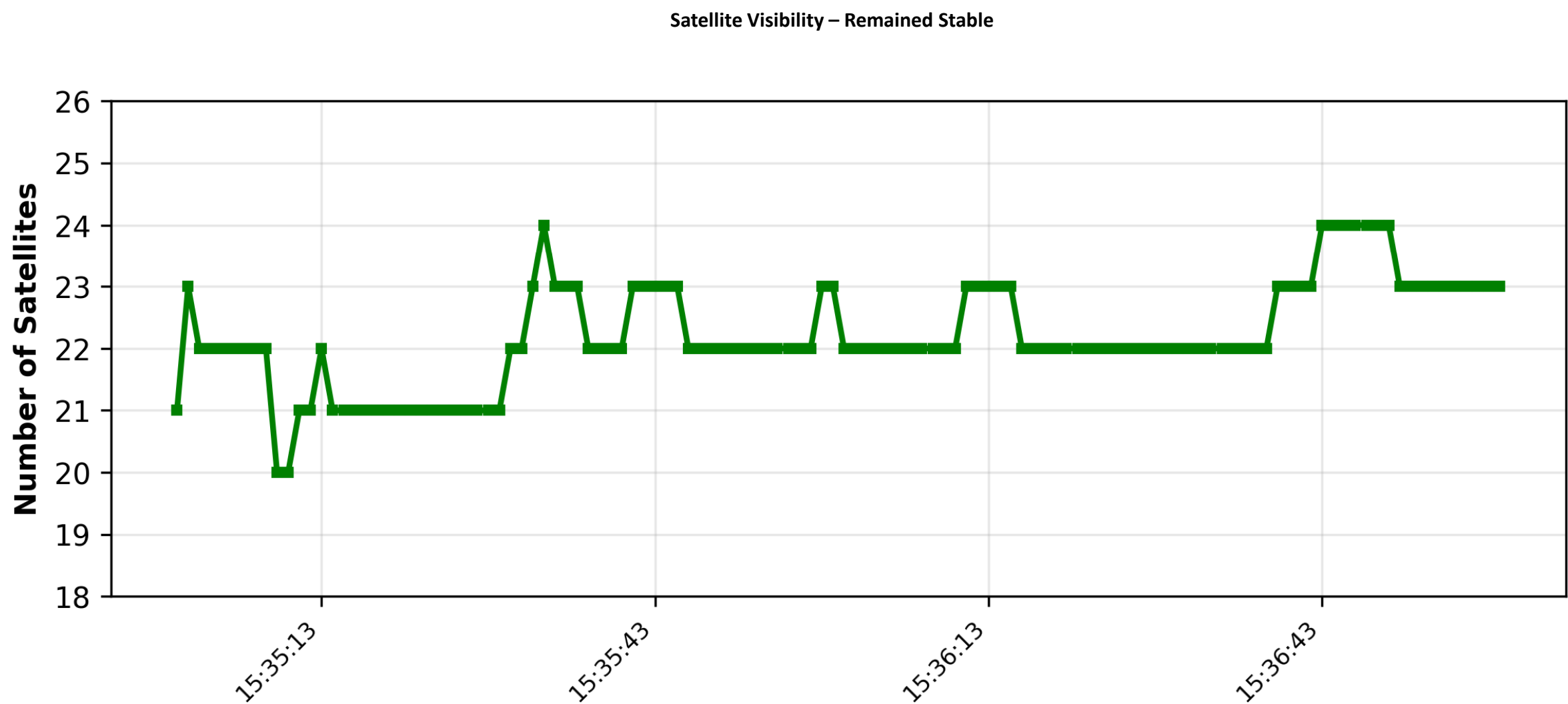
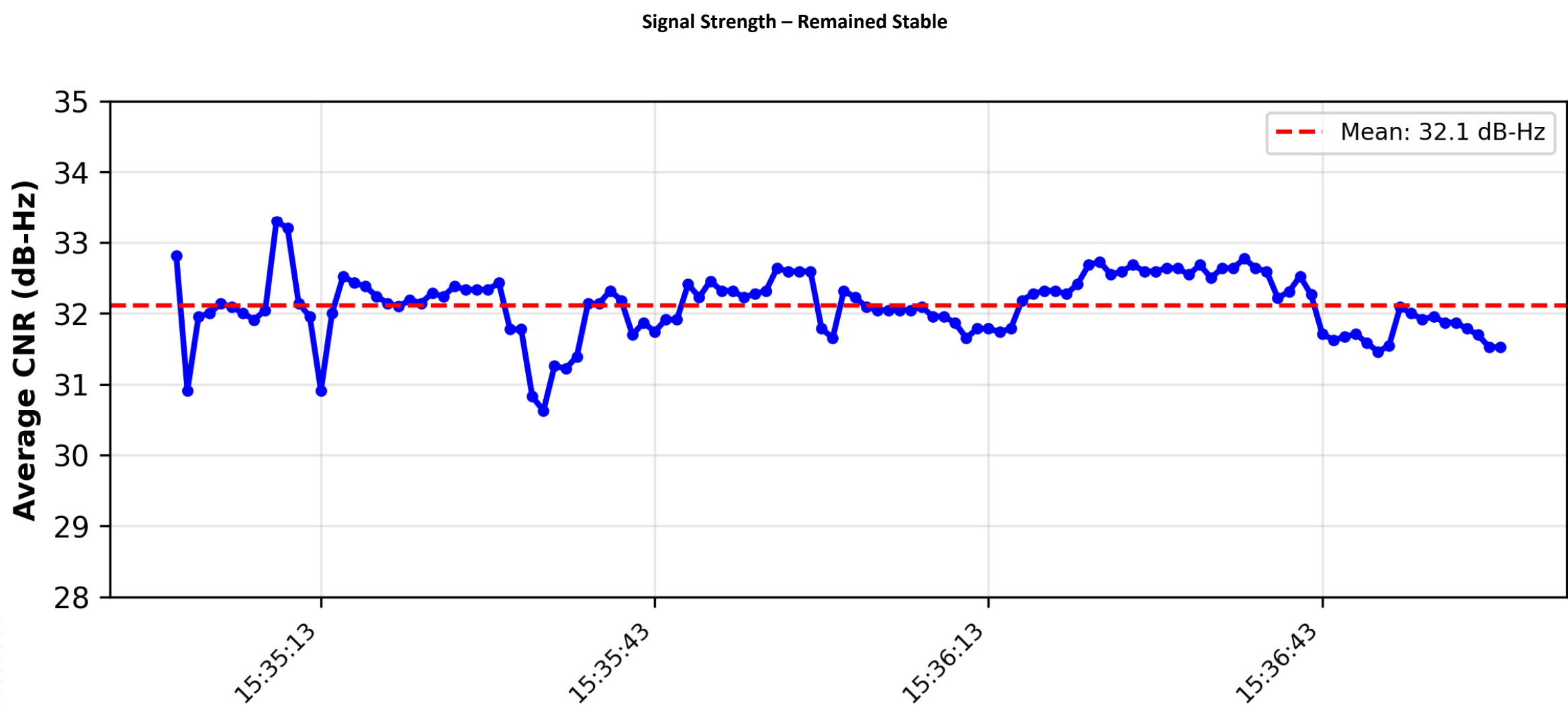
Observed GNSS Instability on Commercial GPS Receivers

Case Study 01

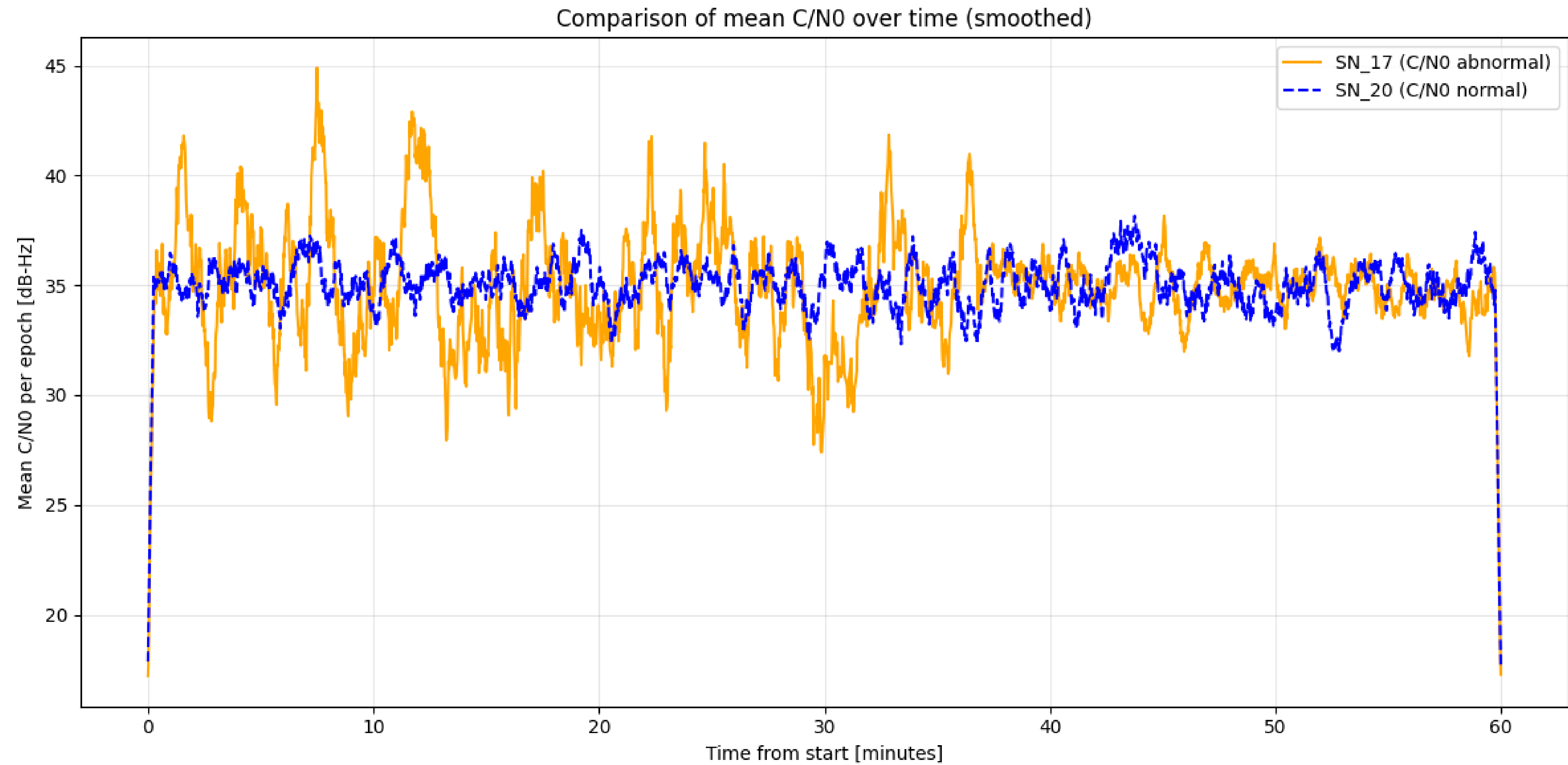


Observed GNSS Instability on Commercial GPS Receivers

Case Study 01



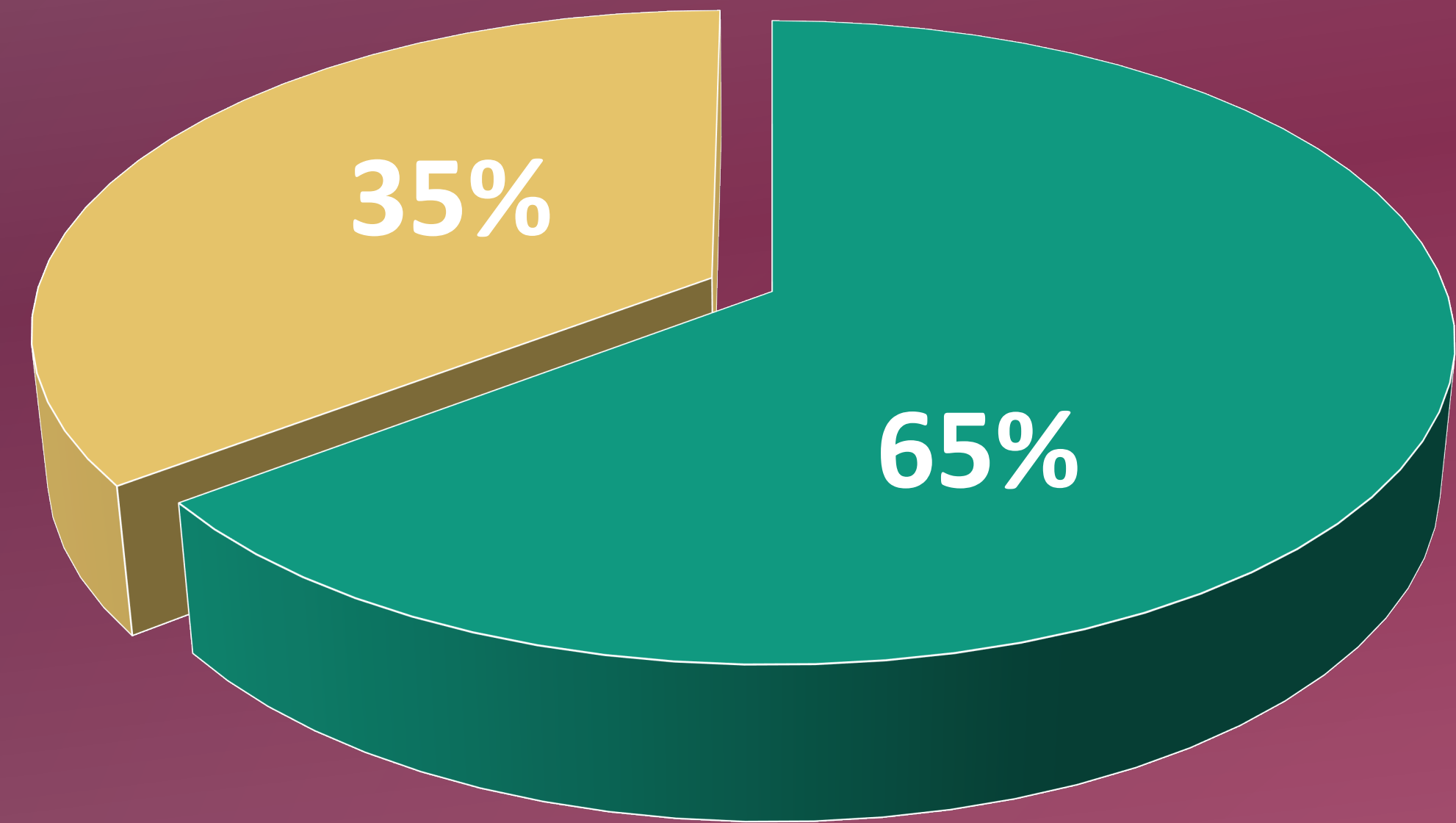
Case Study 02



Data Analysis

Detected Anomalies

Total detected anomalies across the ground station network during the monitoring period.

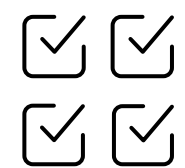


■ Environmental Interference ■ RF Interference

Next Steps & Collaboration

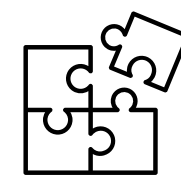
Validation

Of detection framework
with ICAO member
states and partners.



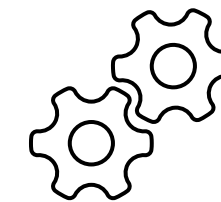
Integration

Of additional data
sources such as ADS-B.



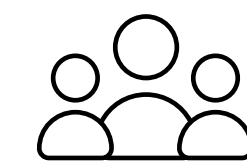
Development

Of enhanced GNSS
interference
classification models.



Proposal

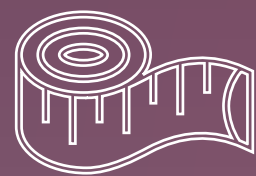
For regional GNSS
integrity monitoring
network.



Key Takeaways

01

Measurable Threat



02

Detection
Methodologies

03

Real-Time Awareness

04

Collaboration &
Standardization



Any Questions?



الهيئة العامة للطيران المدني
Civil Aviation Authority

دولة قطر • State of Qatar