

Certification of eLORAN for Aviation



Dr Mark Brammer
UK NPNT0
Positioning Programme



ELORAN FOR AVIATION

What eLORAN isn't

Historical certification of
LORAN/eLORAN for aviation

International Standards

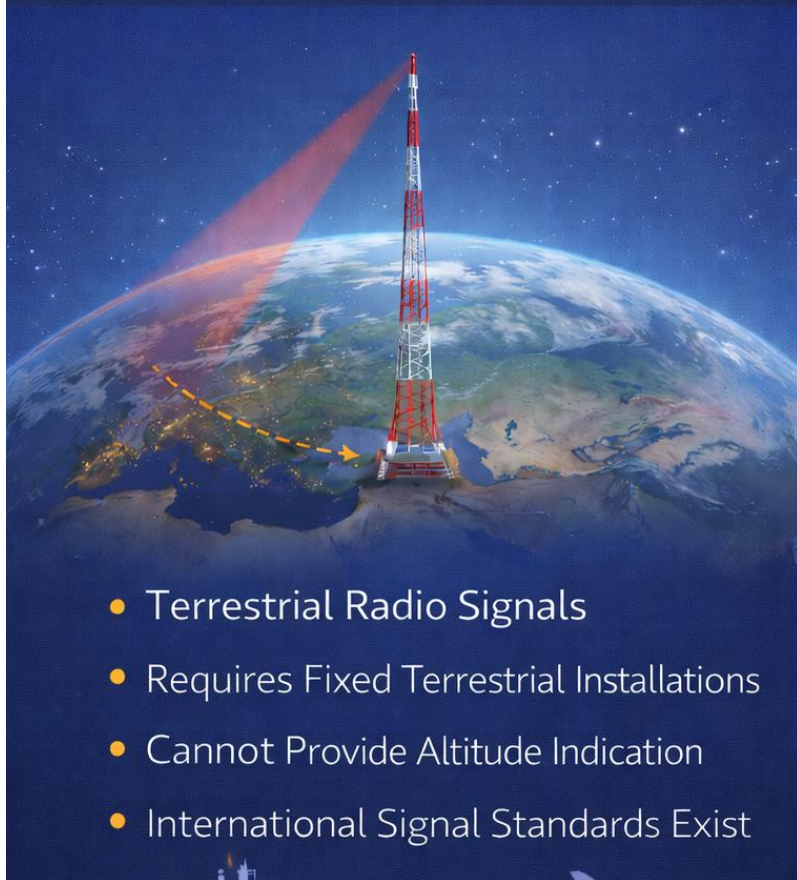
Way forward



+

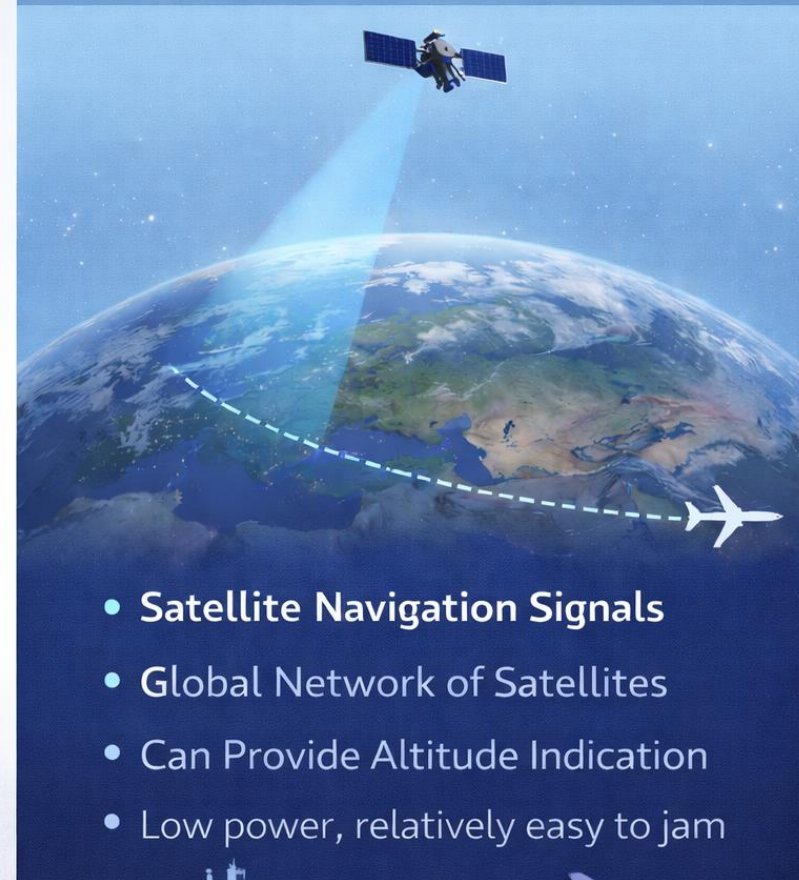
• ELORAN VS GNSS

eLORAN PNT Service



- Terrestrial Radio Signals
- Requires Fixed Terrestrial Installations
- Cannot Provide Altitude Indication
- International Signal Standards Exist

GNSS PNT Service



- Satellite Navigation Signals
- Global Network of Satellites
- Can Provide Altitude Indication
- Low power, relatively easy to jam




HISTORIC AVIATION PLANS

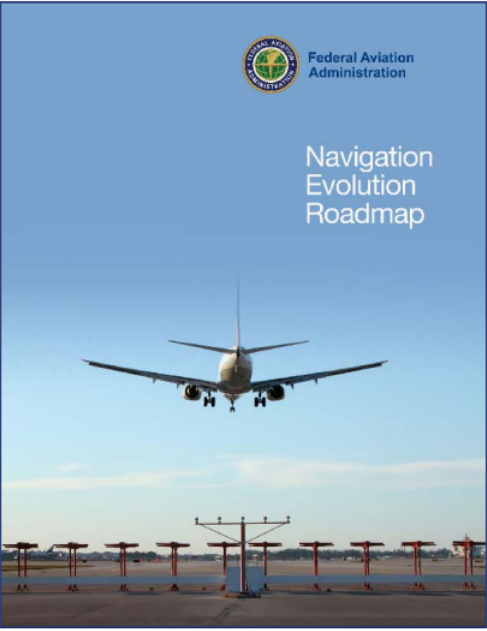

Federal Aviation
Administration

Navigation Evolution Roadmap

ION 2009 International Technical Meeting,
January 26-28, 2009, Anaheim, CA



Federal Aviation
Administration



Navigation
Evolution
Roadmap

539

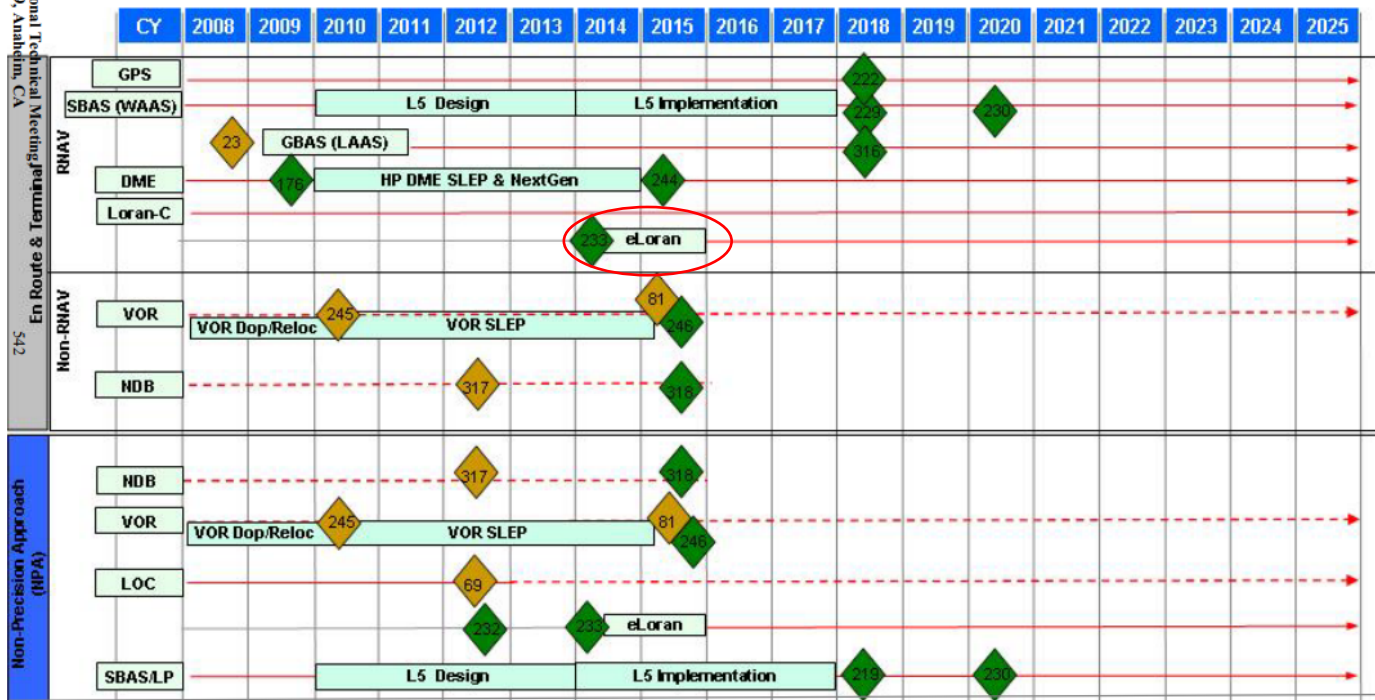
- **Provides a high-level framework for transition to performance-based navigation from navigation services primarily based on terrestrial-based systems**
- **Collaborative effort with aviation community**
- **Companion business plan**



ELORAN FOR NORTH AMERICA

NAS Enterprise Architecture (NASEA) Navigation Roadmap (1)

ION 2009 International Technical Meeting, Anaheim, CA
January 26-28, 2009



Federal Aviation Administration



• KEY STANDARDS REFERENCES

- ICAO Annex 10 Vol I & Vol V
- FAA AC 20-138D & AC 90-114B
- RTCA DO-229E (GNSS), DO-245A (Loran)
- European Radio Navigation Plan (ERNP)



ICAO Annex 10 Vol I & Vol V

Core Performance Requirements

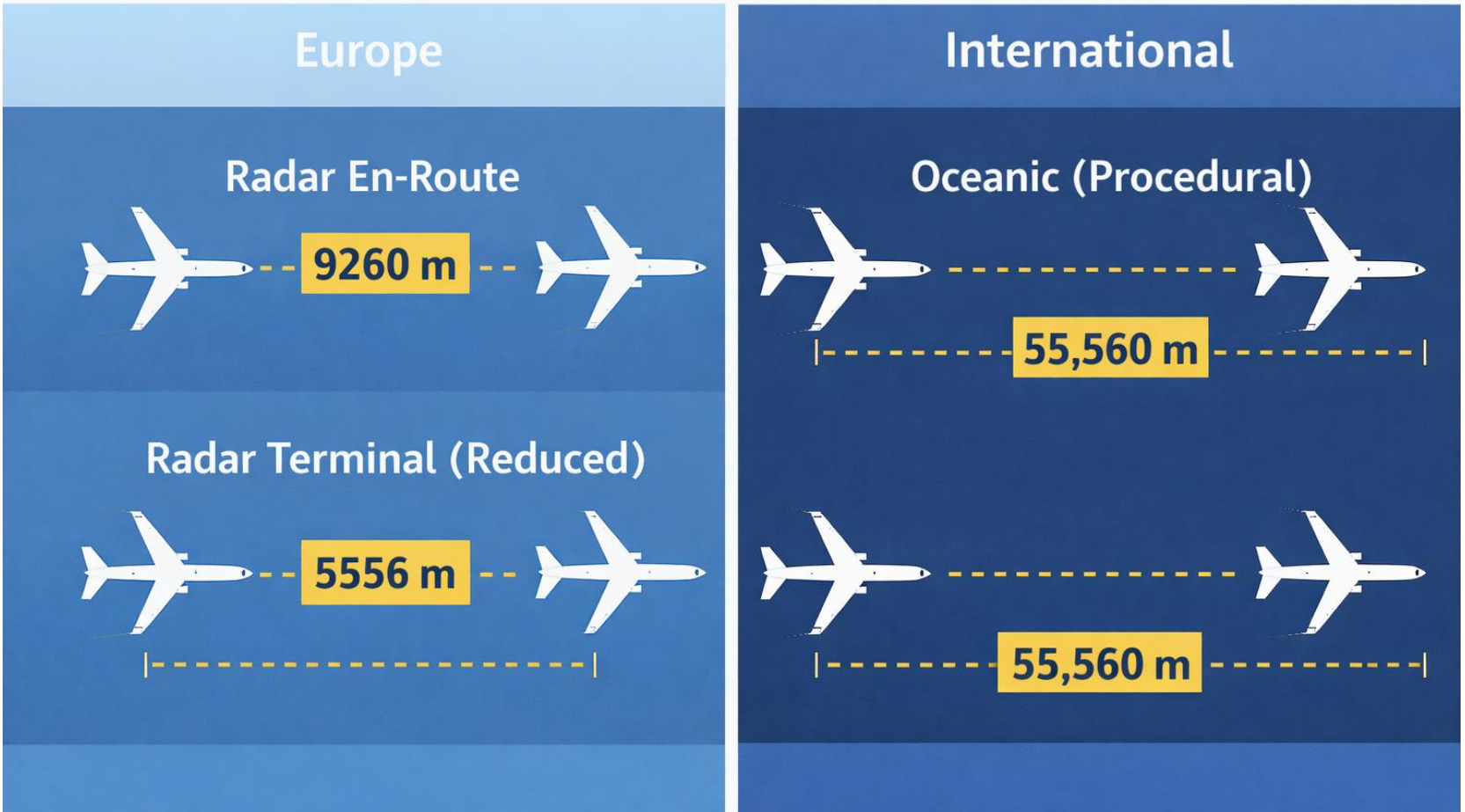
These four parameters form the backbone of aviation PNT certification:

- **Integrity** – ability to provide timely warnings when navigation information is unreliable.
- **Continuity** – probability that the service will remain uninterrupted for defined flight operations (e.g., $\leq 1 \times 10^{-5}$ per 15 min for NPA).
- **Accuracy** – required horizontal and vertical accuracy consistent with approach minima and en-route needs.
- **Availability** – proportion of time the navigation service must meet required performance (typically ≥ 0.999 depending on operation).



FUNDAMENTAL INTERNATIONAL STANDARDS

Horizontal Separation Distances for Aviation



Types of Navigation Equipment Required on Civilian Aviation



+

•

TRACEABILITY MATRIX - 2

Availability (Vol I)	≥ 0.999 (context dependent)	Service availability modelling (ERNP guidance)	Network planning; Tx reliability; robust maintenance	Availability model + observed service stats
Timing/Synchronization (Vol I)	UTC traceability; low timing error for surveillance/A DS-B ops	DO-245A timing performance; FAA AC guidance	Holdover stability; disciplined references; monitoring	Timing error stats; calibration certificates
Interference/Robustness (Vol I)	Resilience to RF interference & jamming/spoofing	System safety assessments; DO-245A robustness notes	High-power LF signal; independent path from GNSS	EMI tests; threat scenarios; incident logs

+

TRACEABILITY MATRIX - 1

Requirement (ICAO Annex 10)	Performance Objective	Evidence/Standard	eLORAN Mechanism	Verification / Data
Integrity (Vol I & Vol V)	$P(\text{HMI}) \leq 1 \times 10^{-7}$ per approach	RTCA DO-229E (GNSS integrity) + DO-245A (Loran integrity)	Tx health, timing stability; ASF-based differential; eLORAN integrity alarms	eLORAN health logs; integrity monitor results; flight/ground trials
Continuity (Vol I)	Continuity risk $\leq 1 \times 10^{-5}$ per 15 min (typical NPA)	DO-229E continuity methods; DO-245A service continuity	Multiple transmitters; network redundancy; rapid fault detection	Outage records; MTBF/MTTR metrics; scenario testing
Accuracy (Vol I)	Horizontal accuracy consistent with NPA minima	DO-245A accuracy modelling; ASF corrections; site surveys	Differential eLORAN; local ASF models; receiver processing	RMS/95% error from trials; conformance test reports



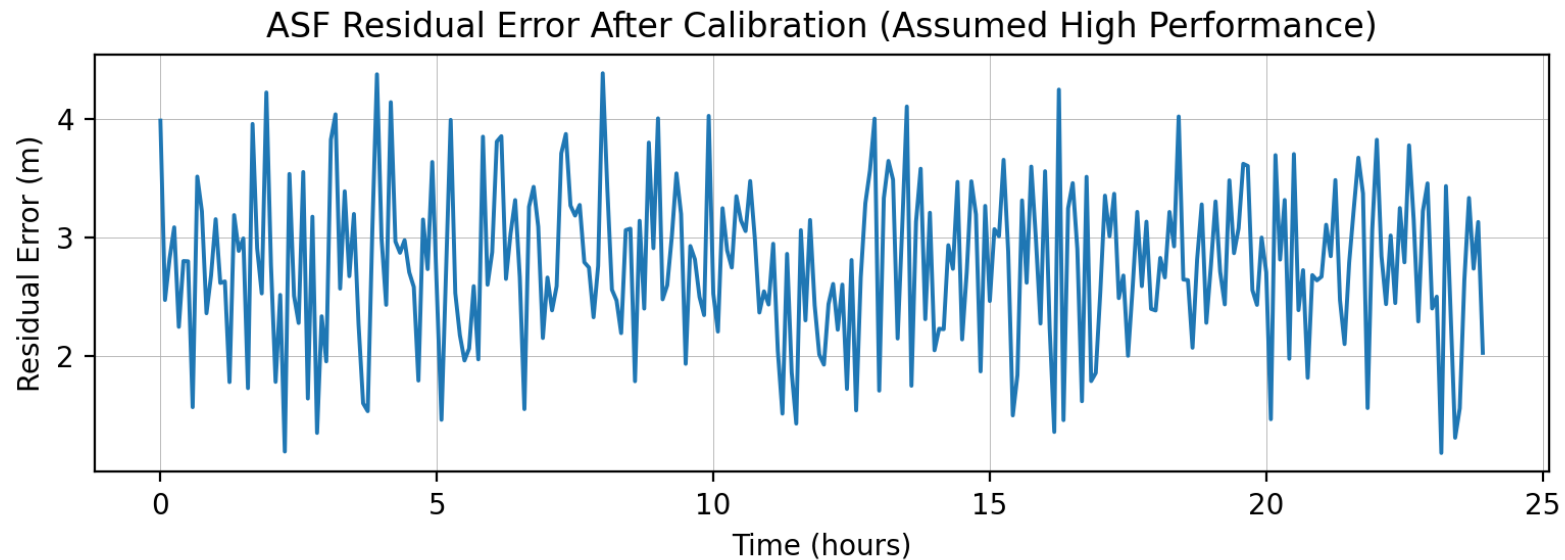
INTEGRITY RISK ALLOCATION

Allocation Concepts:

- Total system integrity risk 1×10^{-7} per approach
- eLORAN integrity via ASF monitoring, timing stability, Tx health
- Integration with GNSS through RAIM/eRAIM-like architectures



ASF MONITORING PERFORMANCE (ASSUMED)

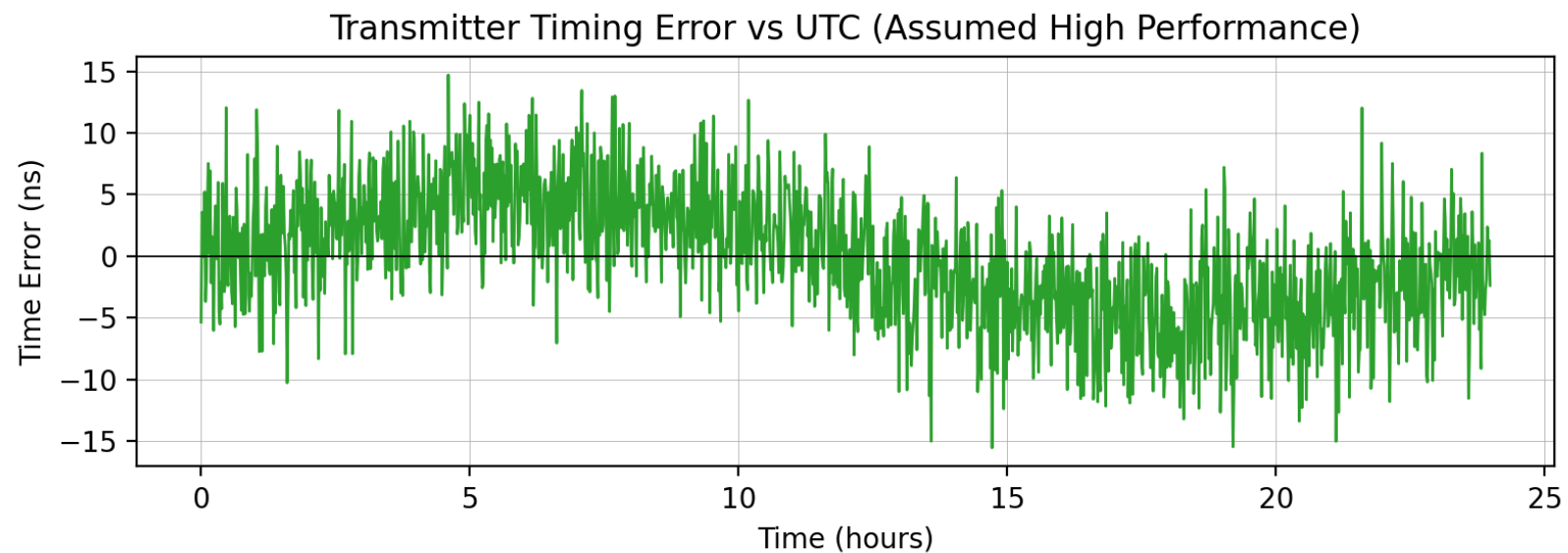


Synthetic data used (high-performance ASF scenario).

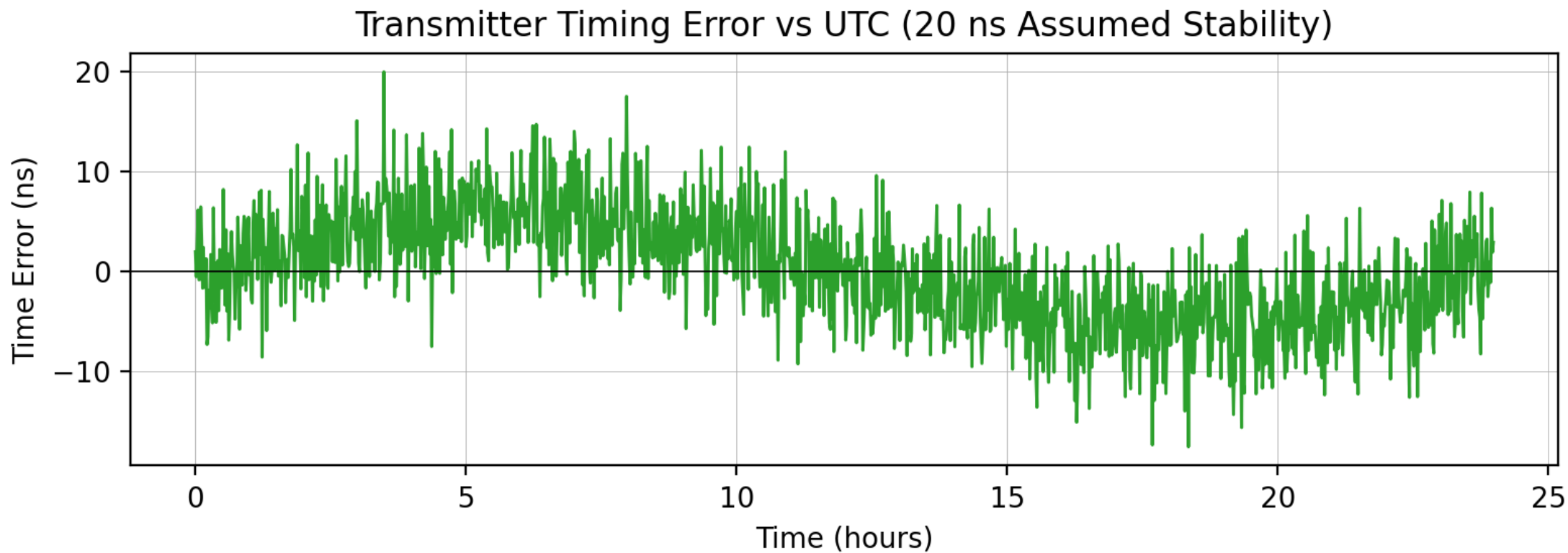


Transmitter Stability (Assumed)

Key Assumptions & KPIs: |Time error| 95th percentile \approx 10 ns | Max |error| \approx 16 ns | Disciplined references with holdover

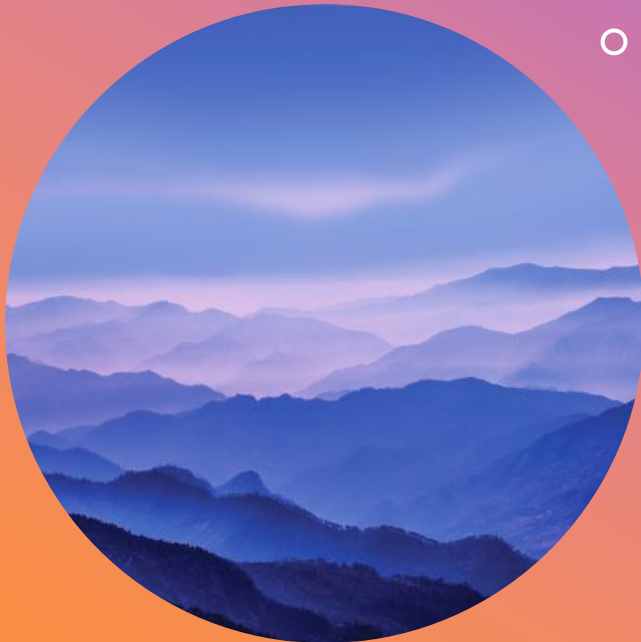


TRANSMITTER STABILITY (20NS ASSUMED)



UK development of fused GNSS/eLORAN for Unmanned Air Vehicles





THANK YOU

Mark Brammer

Mark.brammer@dsit.gov.uk

UK National PNT Office