Operational Performance of the EGNOS AOC System for Civil Aviation

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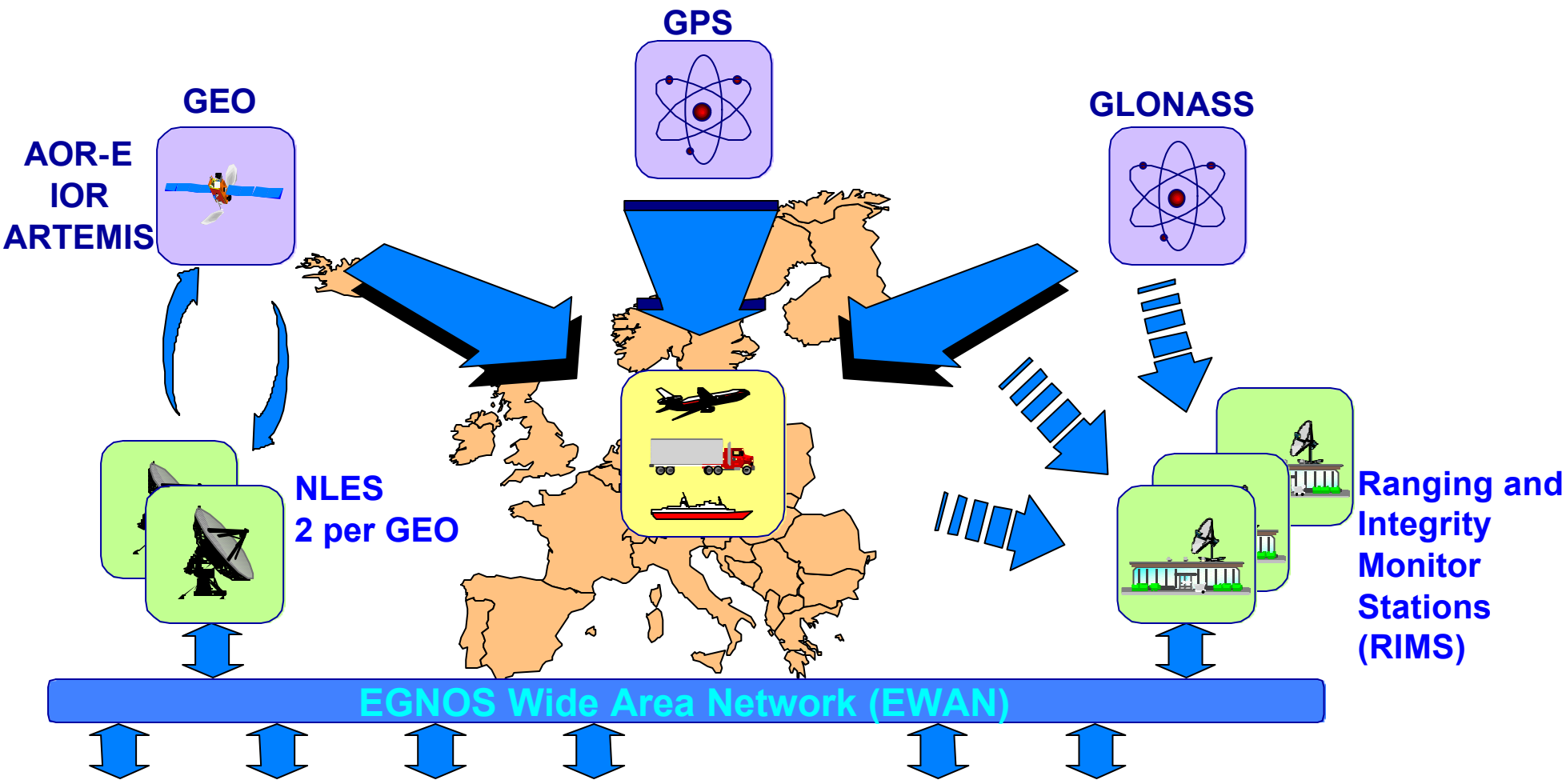
The EGNOS AOC System

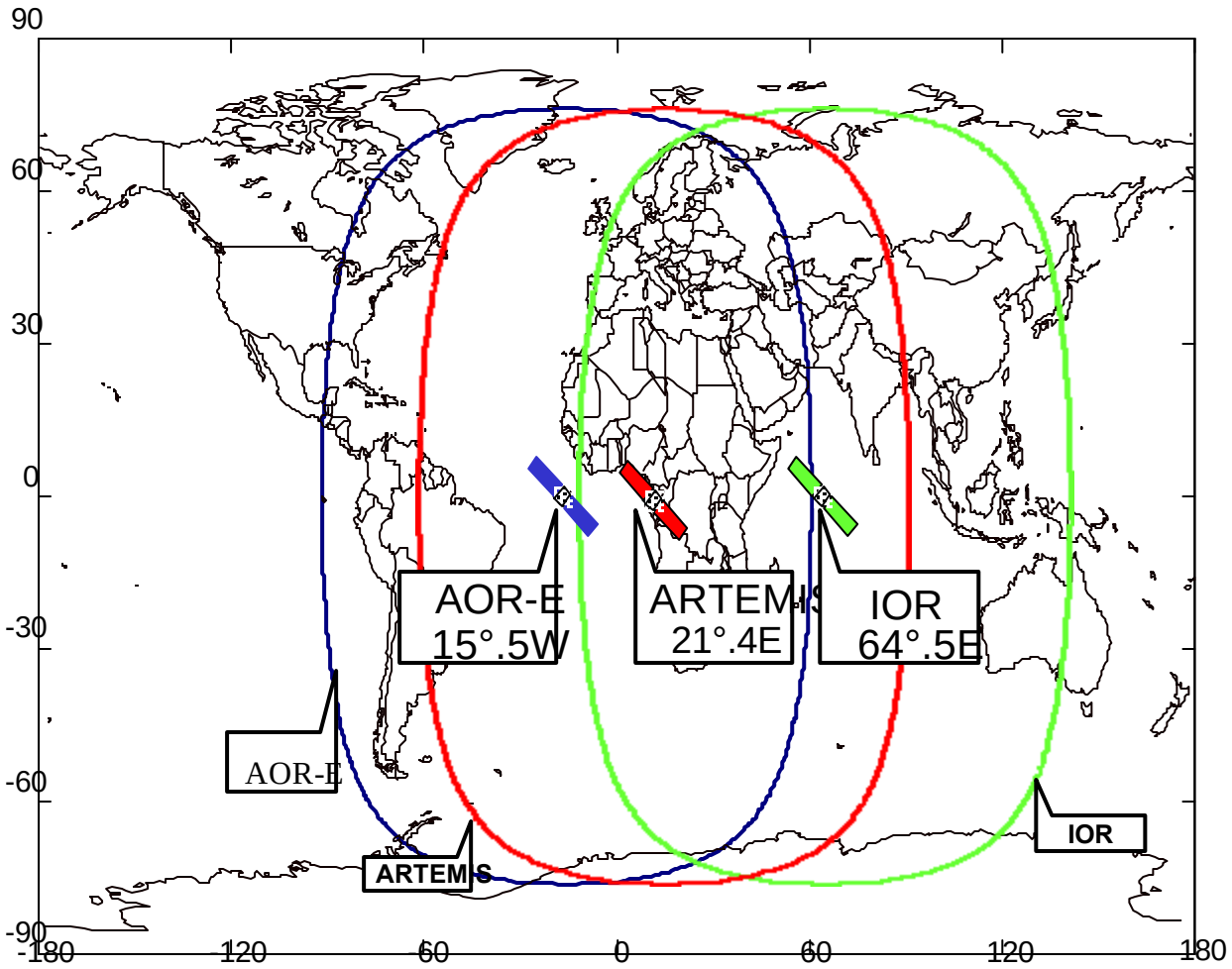
(AOC = Advanced Operational Capability)



EGNOS Augments GPS and GLONASS Performance for multi-modal Users
For Civil Aviation Users it will support operations in all phases of flight down to CAT-1 Precision Approach
Performance is expressed in terms of Required Navigation Performance (RN) parameters specified by ICAO in terms of:

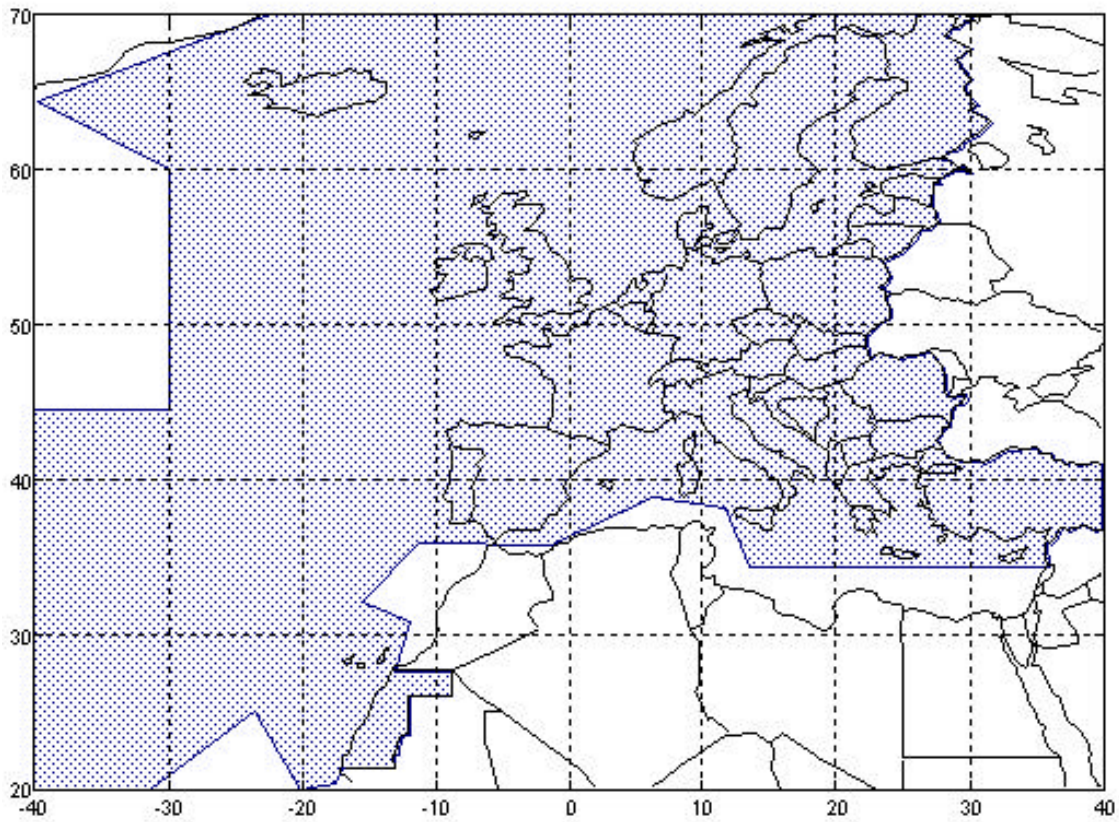
Accuracy, Integrity, Availability, Continuity

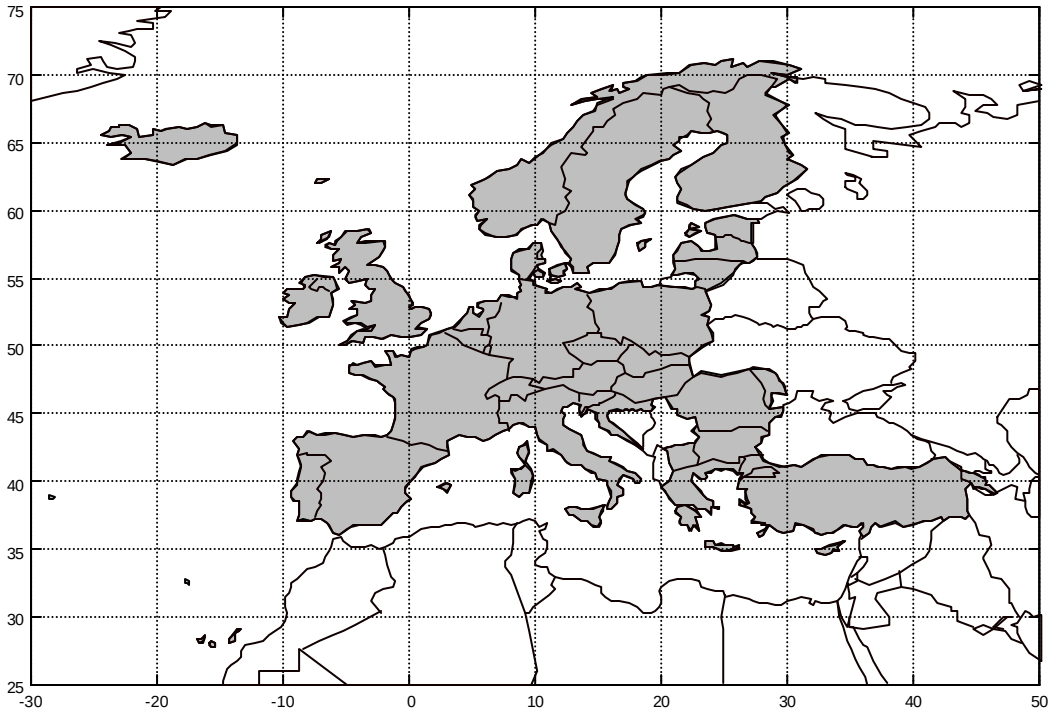
Coverage Zones



EGNOS BROADCAST AREA
INMARSAT AOR-E
INMARSAT IOR
ARTEMIS

EGNOS ECAC Service Area
All performances to be met for En-route down to NPA





ECAC Land Mass Area
Precision Approach Services

Expected Performance

EGNOS AOC Operational Performances with at least 2 GEOs Visible

Phase of Flight	EN ROUTE	TMA/NPA	NPV 1	Precision Approach	
RNP TYPE	RNP 12.6 to RNP 1	RNP 0.3	RNP 0.3/125	RNP 0.03/50 to	RNP 0.02/40
Space Segment	GPS + EGNOS			GPS + EGNOS	GPS+ GLONASS+ EGNOS
Accuracy (95%)	100m (H)		100m (H) 20m (V)	7.7m (H) 7.7m (V)	5m (H) 5m (V)
Integrity Risk	10^{-7}/hr		$2.\ 10^{-7}$/hr		
Protected Alarm Limit	1 n.mile	556m	556m (H) 50m (V)	20m (H) 20m (V)	13m (H) 13m (V)
Time to Alert	10s		6s		
Continuity Risk Loss of Integrity Function	10^{-7}/hr [1]	10^{-5}/hr [1]	8.10^{-5}/Appr [1]		
Availability	0.99999 [1]	0.9999 [1]	0.9999 (H)[1] 0.99 (V)	0.99	TBD[2]

[1] Assuming GIC/RAIM combination with GPS

[2] GLONASS constellation not stable

- Performance within the ECAC Area (even with only 1 Geo visible)
- Performance within the ECAC Area (with 2 GEOs visible)
- Performance within the ECAC Land Mass Area

OPERATIONAL ASSUMPTIONS

- **EGNOS used as Primary Means of Navigation**
- **GPS with RAIM approved to support Basic-RNAV**
- **En-Route to NPA Operations - RAIM/FDE Can be used as back-up if EGNOS Signal is unavailable.**
- **Alternate Destination Airports have Landing capability independent from EGNOS (e.g. ILS)**

Potential EGNOS Extensions

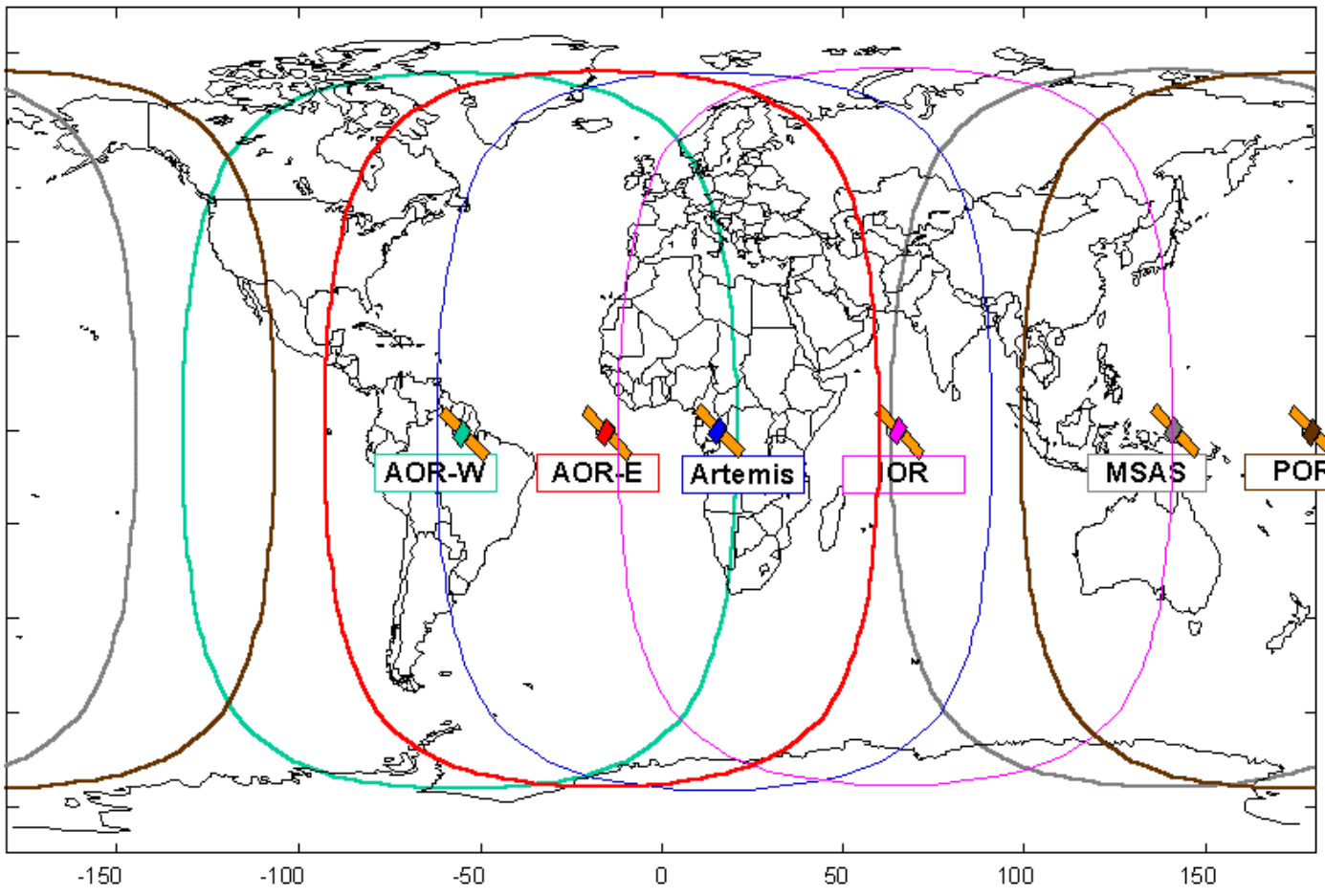
Entire GEO Footprint Area

- Extension of the provision of the SARPS NPA service over the full footprint of EGNOS GEOs could be provided by connecting a few additional reference stations (RIMS).
- NPV-I service level could be provided assuming the computation and transmission of some level of IONO corrections.
- Different possible architectural approaches have been identified for an EGNOS extension
- Further work concentrates on the NPV-I feasibility (using the ESTB) and on the selection of the most convenient architecture.

Extension over Africa and Indian Ocean

- ICAO / APIRG Strategic Decision made in June 1999 for the introduction of SBAS in the AFI Region
- AFI Priority User Needs focus on NPV-I over Land Masses. NPV 2 (or Cat 1 if necessary) to be provided only in specific areas at a later stage either by SBAS or GBAS
- AFI SBAS Test Bed Arrangements and Objectives, supported by ESTB Extension, have been preliminarily defined
- Data collection and simulations have demonstrated the feasibility of NPV 1 in terms of signal capacity

Interoperability



EGNOS - Europe
AOR-E, IOR, ARTEMIS

WAAS - USA
AOR-W, POR

MSAS - Japan

SBAS Geostationary Broadcast Areas

What is Needed for SBAS Interoperability?

SBAS Interoperability at user level implies:

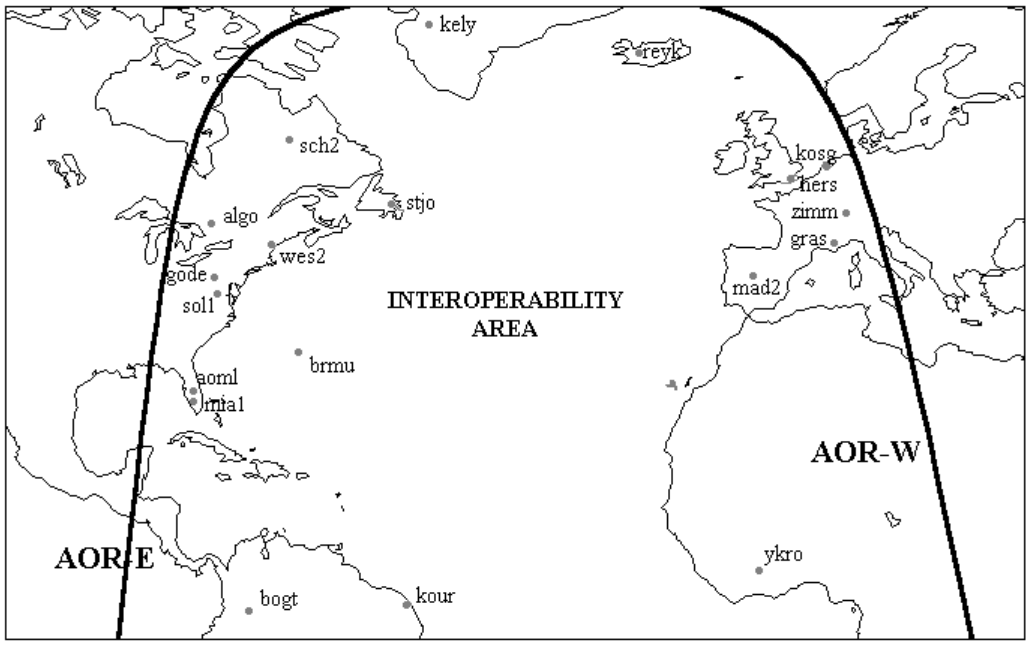
- Compliance of SBAS Signal-In-Space with ICAO GNSS SARPs
- Compliance of SBAS receiver with RTCA D0229 standards
- Harmonization of the system certification process
- Compliance of GNSS/SBAS procedures with the rules developed by ICAO Obstacle Clearance Panel (OCP)

In addition, SBAS Interoperability at system level implies:

-Provision of a minimum combined operational service in intermediate regions between SBAS Initial Service Areas

Interoperability Areas of Interest

- Identification of traffic flows in the intermediate regions between SBAS Initial Service Areas
- Quantification of the significant traffic flows
- Analysis of the ATS and Airlines operational conditions
- Identification of user priority needs



EGNOS/WAAS Intermediate Area

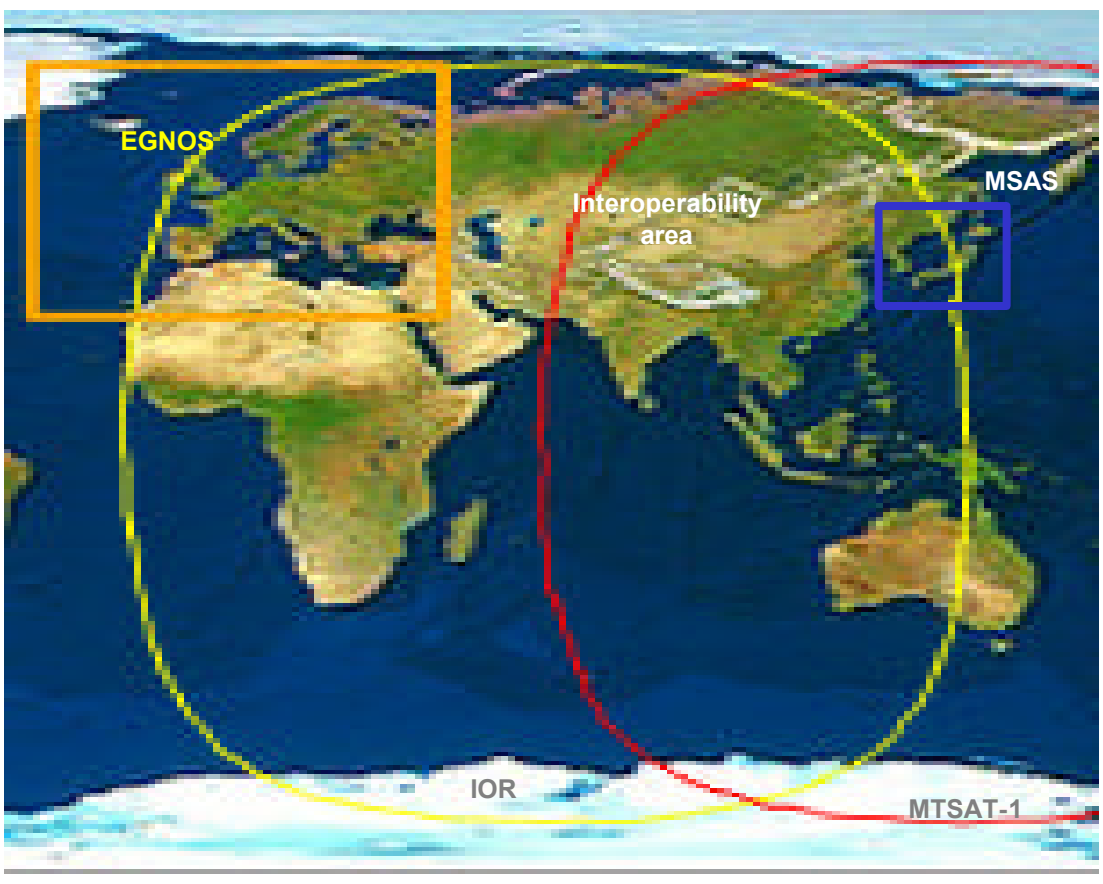
·Transatlantic NAT MNPS Airspace

·Regional Caribbean Airspace

EGNOS/MSAS Intermediate Area

•Intercontinental Europe/South and Southeast Asia Routes (Northern and Southern Himalayas Routes)

•Intercontinental Europe - North East Asia Routes (Northern Siberian routes)



Conclusions on Interoperability

Provision of NPA Service Level

- Through simple EGNOS-WAAS and EGNOS-MSAS interoperability, NPA service, compliant with SARPS requirements could be provided in the SBAS intermediate areas
- UDRE degradation factor has been analysed considering the proposed message Type 27 (Described in RTCA DO 229 B). The degradation factor used (i.e. 10) produced good results in all the simulations.

Provision of NPV- I Service Level

- For all real measurements, it can be observed that large margins exist between the actual errors and the required protection level to meet the integrity requirement.
- NSE 95% accuracy is achievable
- NPV-I protection level (VPL) outside the initial service area could be achievable assuming the introduction of limited ionospheric corrections
- Ongoing EGNOS/WAAS real time interoperability tests are concentrating on analysis of this important issue.