

Regional Focus



Future of Air Navigation in Africa

Part 1

Thursday 11 February 2021

13:00 – 15:30 CET



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Presentation overview

****Introduction – GNSS & Core constellation**

****GNSS elements**

ICAO GNSS Standard Menu

GNSS Evolution: DFMG GNSS

****GBAS/SBAS expected benefits**

ICAO Policy on GNSS and Documents related to GBAS/SBAS

GANP Roadmap - Navigation

Status of implementation of Assembly Resolution A37-11

****Implementation challenges, Way forward and Conclusion**



Introduction - GNSS

The ICAO definition:

“GNSS. A worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation.”
[from ICAO Annex 10, Volume I]

Core Constellation:

Multitude of **satellites** providing signals from space that include ranging signals and navigation message to GNSS receiver.



Core constellations



GPS

Glonass

Galileo

Beidou



Several types of errors :

- Satellite clock & ephemerid
- Ionosphere
- Troposphere

And lack of integrity

Need to elaborate corrections



GNSS Elements

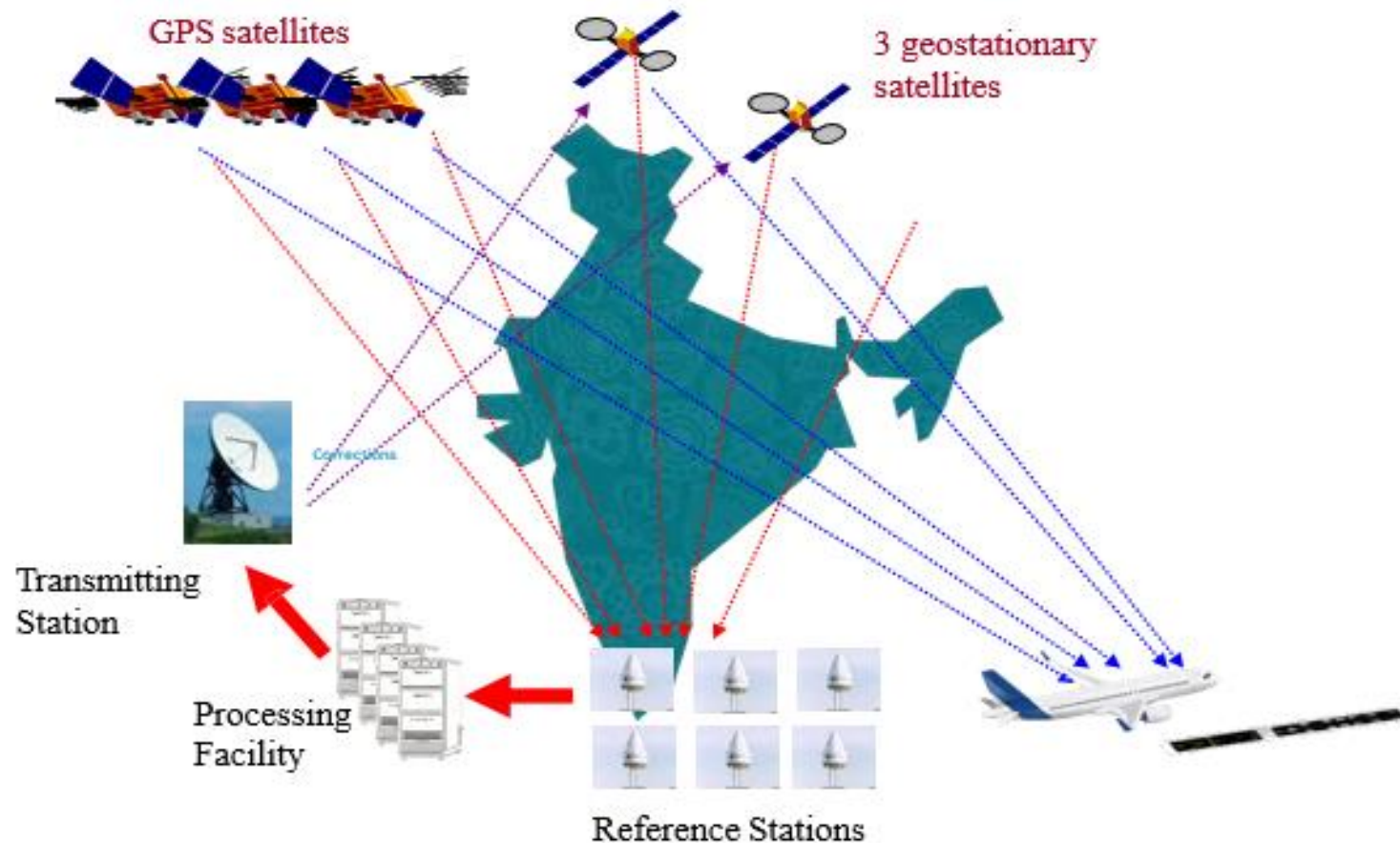


Future : Development of dual frequency multi constellation receiver. Great improvement of PBN coverage all over the globe, especially for the vertical.



GNSS Element - SBAS Architecture

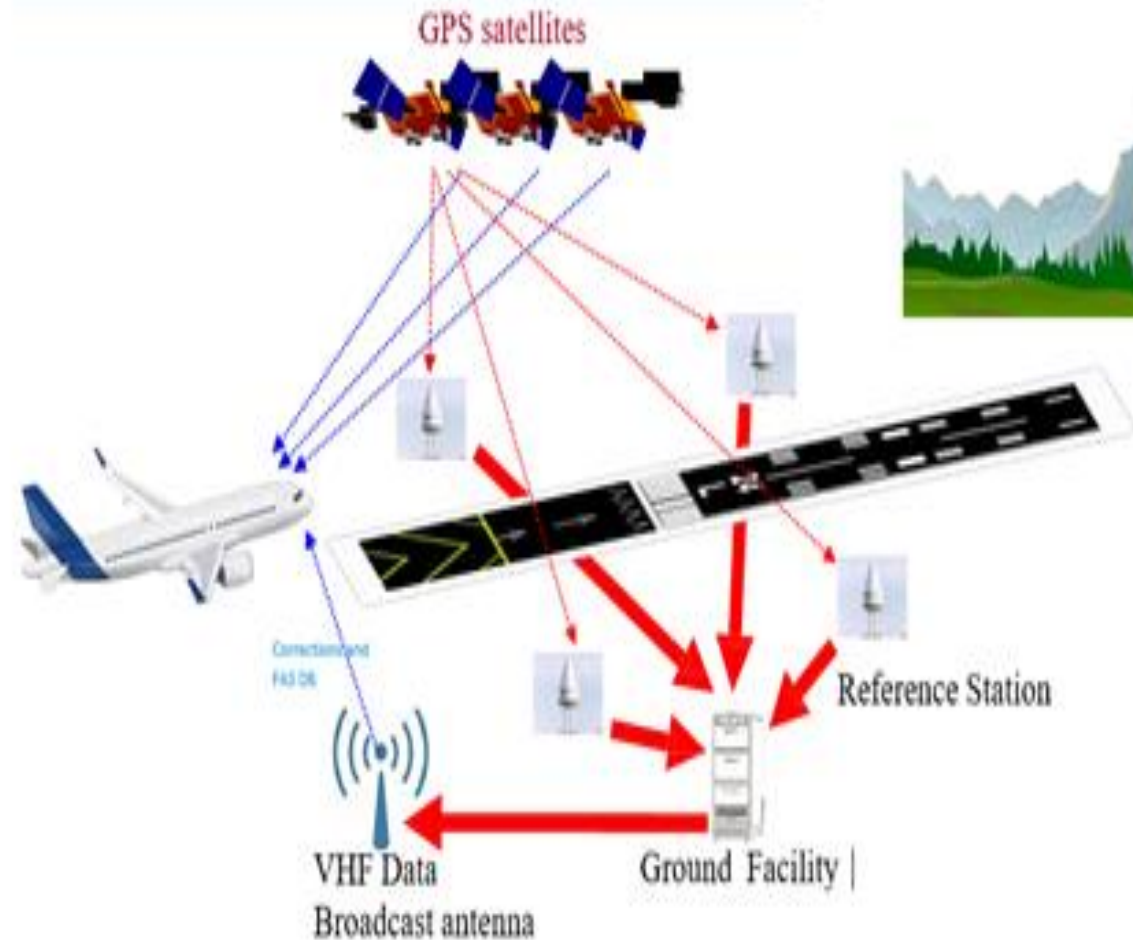
SBAS uses a wide network of ground stations and provides signals from Geostationary Earth Orbit satellites to support operations over a large geographic area from en-route down to approach.





Achieve GNSS Elements - GBAS Architecture

GBAS uses monitoring stations at the airport to process signals from core constellations (currently GPS L1) and broadcasts corrections and approach path data to support precision approach operations





The ICAO GNSS Standard Menu

System	ICAO Standard?	Infrastructure in place today?	Aircraft provisions today?	In operational use by aviation today?
GPS L1	Yes	Yes	Yes	Yes, globally
GLONASS	Yes	Yes	Russia	Russia
SBAS L1	Yes	Regional support (WAAS, EGNOS, MSAS, GAGAN, SDCM, BDSBAS, KASS, A-SBAS and SouthPAN)	Yes	Yes, regionally
GBAS Cat I	Yes	Local support (individual airports)	Yes	Yes, locally
GBAS Cat II/III	Yes	On a trial basis	Advanced development stage	No
GPS L5 GLONASS L3	2022+	Yes (Partial)	Under development	No
Galileo	2022+	Yes	Under development	No
Beidou	2022+	Yes	Under development	No
SBAS L1/L5	2022+	Under development	Under development	No

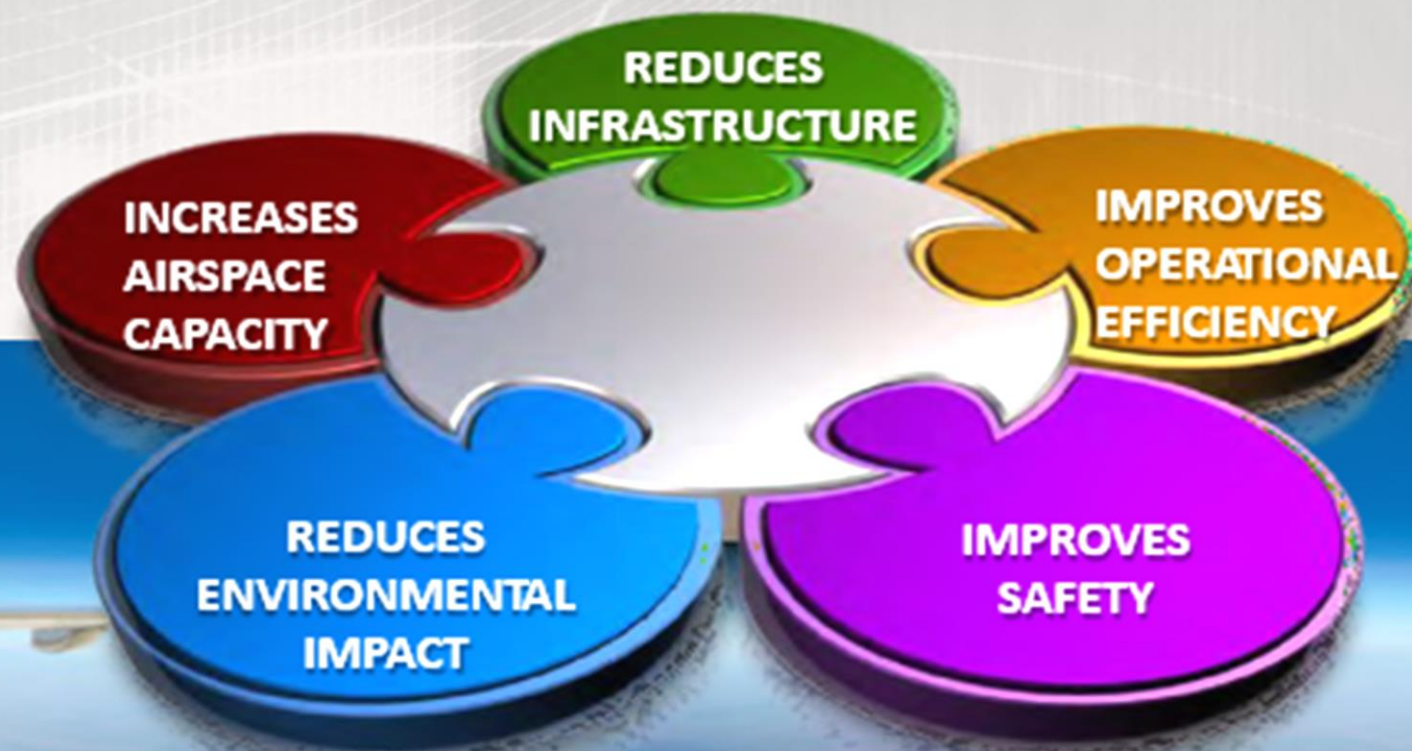


GNSS Evolution: DFMC GNSS

- *Current civil aviation use of GNSS is predominantly based on a single frequency of a single GNSS satellite constellation;*
- *The evolution of the various GNSS elements towards DFMC will take place gradually. GNSS constellations offering dual-frequency signals will be introduced into service in near future. Ground-based augmentation systems (GBAS) already support single-frequency dual-constellation GNSS and it is expected that they will evolve to support DFMC.*
- *Standardization. ICAO SARPs for DFMC GNSS core constellations and augmentation system have been developed by the NSP panel, which agreed draft DFMC SARPs in November 2020, and will be submitted to the usual ICAO SARPs approval process..*



GBAS/SBAS operations expected benefits





SBAS Benefits (ANSPs)

- ***SBAS is a regional navigation service;***
- ***SBAS service does not require the installation or maintenance of ground-based navigation aids or landing systems (apart from the SBAS infrastructure);***
 - *Opportunity to rationalize existing systems or expand where there are no current systems*
- ***SBAS guidance requires no airport critical and sensitive areas and has the potential to support new and advanced procedures;***
 - *Approach to runways unable to site or install an Instrument Landing System (ILS), RNP to xLS transition, Noise and environmental efficient approach paths*



SBAS Benefits Airlines

- ***SBAS is a primary navigation system;***
- ***SBAS supports PBN capability and improves RNAV and RNP capability;***
- ***Low cost equipage solution to achieve Required Navigation Performance (RNP);***
- ***Improve RNP capability approach operations and also enables for RNP Authorization Required (AR) operations;***
- ***Potential to reduced operational challenges; (Provides for best PBN capability (airports accessibility and improved safety, Increased options for alternate runways, Reduced diversion when ILS is unavailable, Lower minima for non ILS equipment runway, lower fuel load requirements and increased dispatch reliability***
- ***SBAS provides geometric guidance, and is not impacted by barometric pressure, temperature fluctuations or barometric mis-setting.***



Ach ICAO Documents related to GBAS/SBAS implementation

❖ **Global Strategy**

- Global Air Navigation Plan (Doc 9750)

❖ **Regional Strategy**

- AFI Regional Air Navigation Plan (Doc 7474)

❖ **System requirements and testing**

- Annex 10 Vol I - Radio Navigation Aids
- Doc 8071 Vol II - Testing of Satellite-based Radio Navigation Systems

❖ **Procedure design and validation**

- Doc 8168 Vol II - Construction of Visual and Instrument FPs
- Doc 9906 Vol V - IFP validation

❖ **Operations**

- Doc 8168 Vol I - Flight Procedures
- Doc 9613 PBN Manual
- Doc 9849 GNSS Manual
- Doc 4444 Air Traffic Management



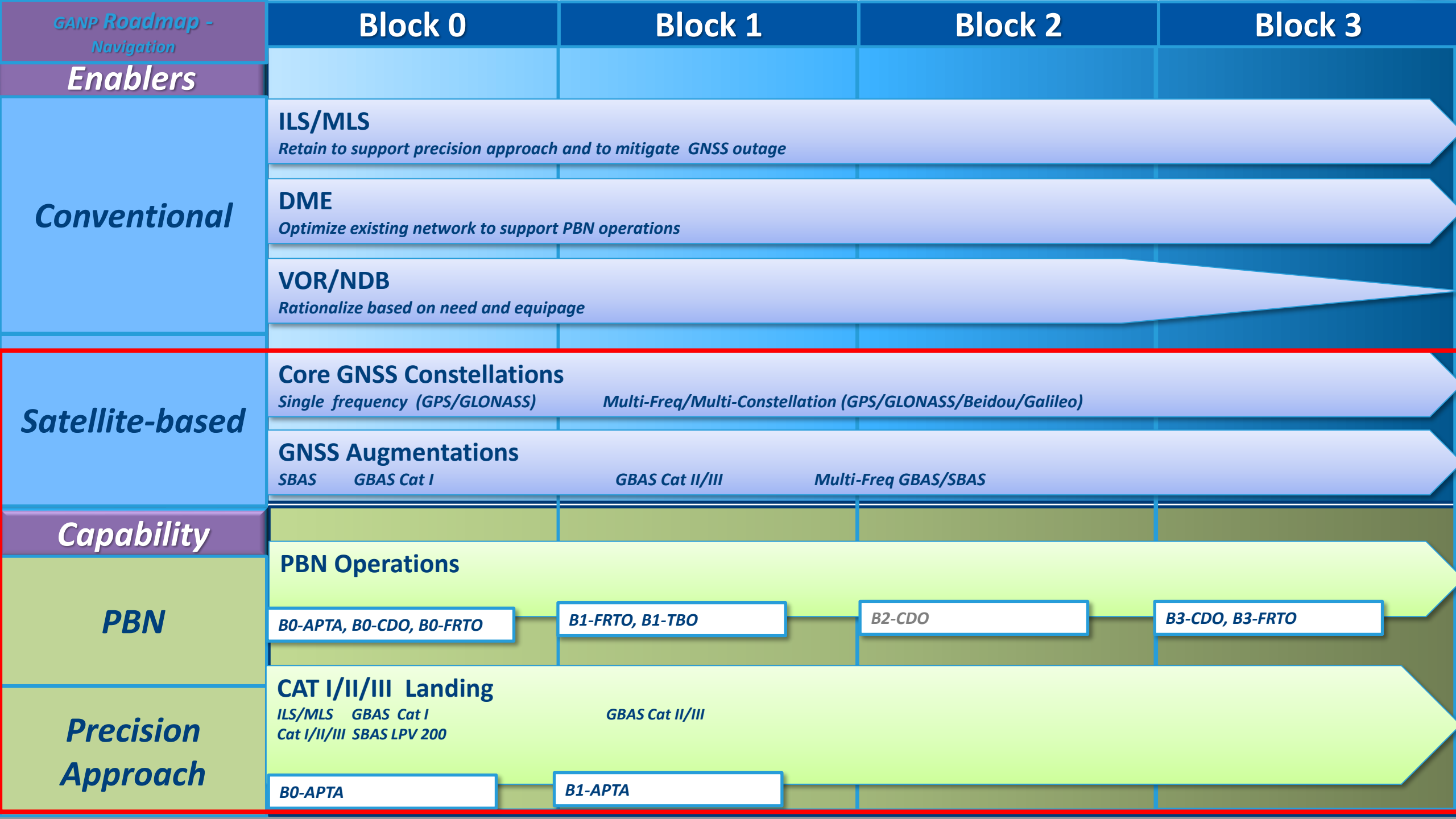
ICAO Policy on GNSS

ICAO Policy:

- Full menu of GNSS Standards to be implemented in support of PBN.
- GNSS is the keystone of PBN (refer to Assembly resolution A37-12)
- GNSS evolution: 13th Air Navigation Conference Recommendations provide guidance for States on the introduction of DFMC GNSS (ICAO policy on introduction of DFMC GNSS)

That States:

- a) when defining their air navigation strategic plans, take advantage of the improved robustness and performance offered by dual-frequency, multi constellation (DFMC) global navigation satellite system (GNSS) to deliver incremental operational benefits and encourage related industry developments;*
- b) avoid, in principle, prohibiting the use of available GNSS elements if they perform according to ICAO Standards and Recommended Practices (SARPs) and can meet all safety and regulatory requirements for the intended operations;*
- c) avoid mandating equipage or use of any particular GNSS core constellation or augmentation system unless clear operational benefits are offered in return and appropriate consultations have been made with the relevant airspace users;*
- d) ensure implementation of ICAO provisions for publication of information related to the use of GNSS elements in aeronautical information publications (AIP);*
- e) take timely action to meet the long-term goal whereby every State accepts for lateral navigation use all GNSS elements that are compliant with SARPs, thus creating a positive environment for DFMC GNSS.*



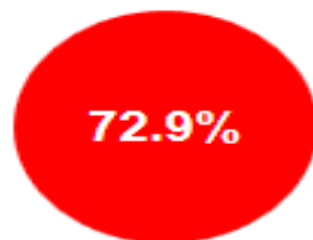


ICAO

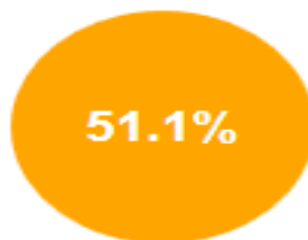
UNITING AVIATION

Assembly Resolution A37-11 on PBN Implementation – LNAV & VNAV

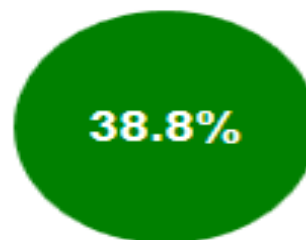
Percentage of States in World meeting the Resolution Targets for Applicable Years



2010

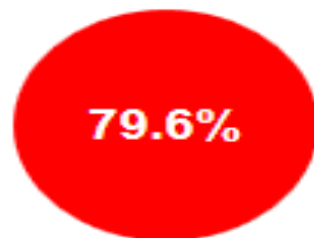


2014

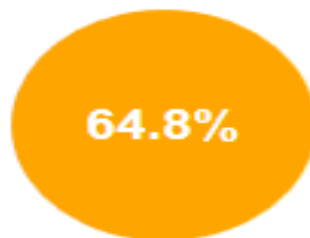


2016

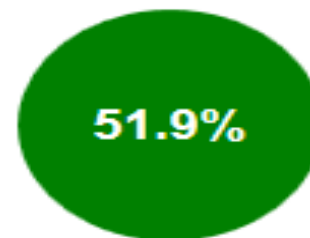
Percentage of States in Africa meeting the Resolution Targets for Applicable Years



2010



2014

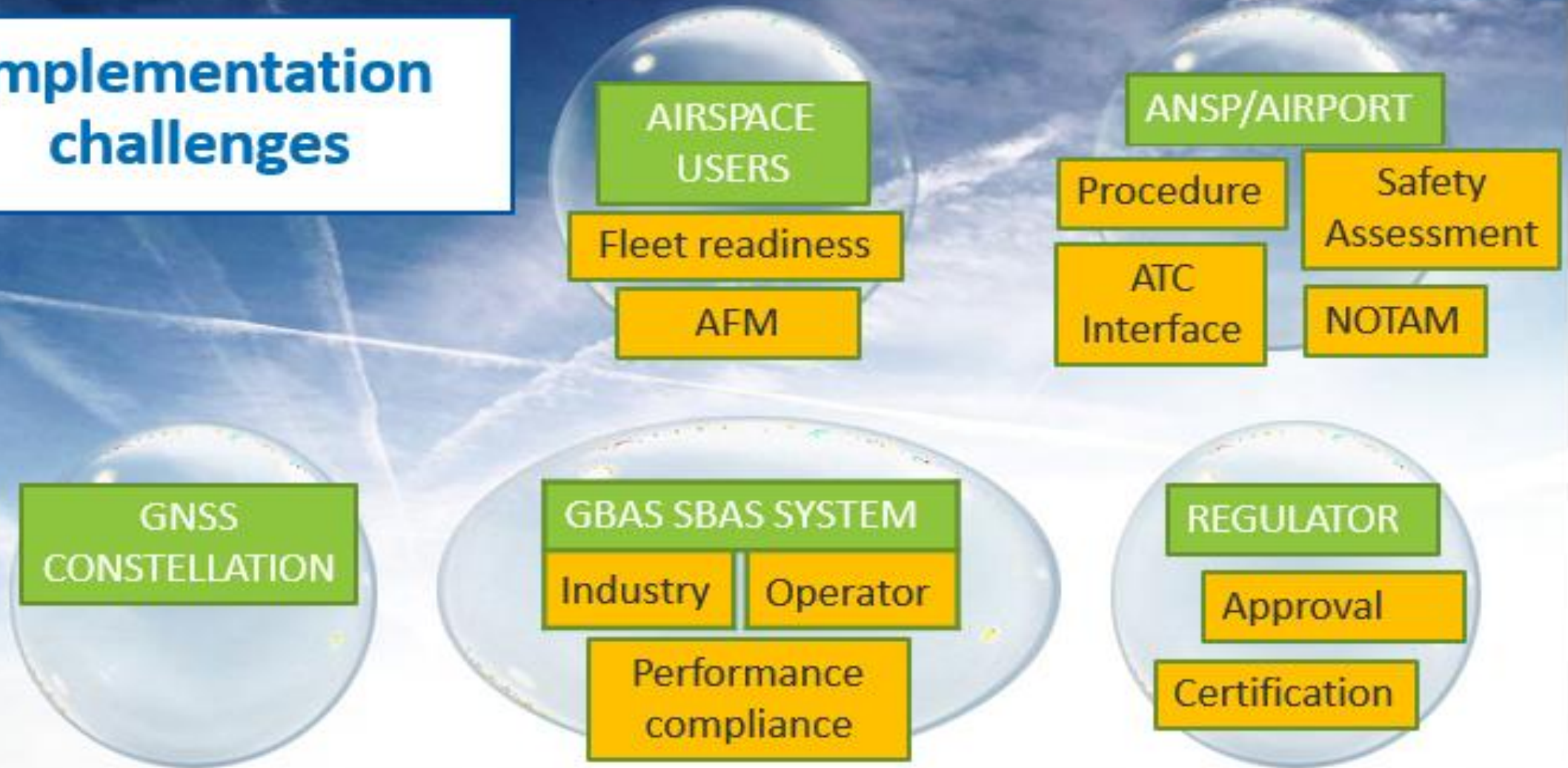


2016

Regional PBN Implementation



Implementation challenges





Way Forward

- *Embrace early benefits from Basic GNSS (ABAS) for purposes of augmenting PBN implementation (PBN RNP APCH operations; [LNAV, APV Baro-VNAV]);*
- *Recognize the regional SBAS infrastructure available and the local GBAS developments taking place around the world;*
- *Be responsive to operator needs and fleet capabilities;*
- *Coordinate regional implementation through ICAO regional structure;*
- *Address the open issues on the basis of specific cost/benefit considerations in line with the APIRG conclusions and AUC/AFCAC ongoing study on the subject matter;*
- *Monitor developments of DFCM GNSS for >2030 fruition.*



Conclusion

- *GNSS progress is commendable and ICAO has followed development since the inception of its deployment for civil aviation. ICAO will continue to monitor evolution towards advanced and robust navigation performance;*
- *For GBAS/SBAS implementation, regulator/operator interface and consensus including approvals is critical on the process to be recognized as a CNS provider (satellite navigation system provider) if needed;*
- *APV SBAS could improve access to airports with no ground navigation aids support and allow the reduction of ILSCAT I systems.*
- *The cost - benefit analysis study under auspices of AUC should be expedited to guide and facilitate stakeholders' decision-making on the next steps.*
- *ALL STAKEHOLDERS MUST BE INVOLVED THROUGHOUT ALL PROCESSES.*



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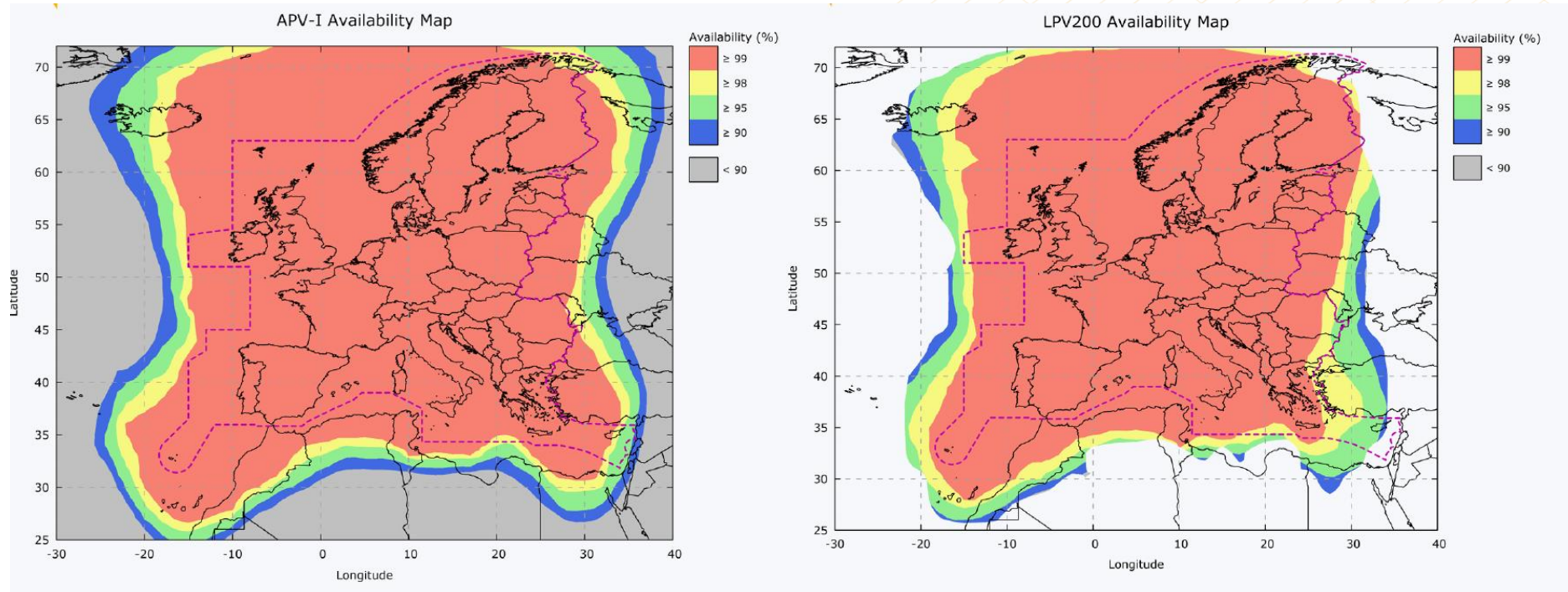


Mr. Pieter De-Smet

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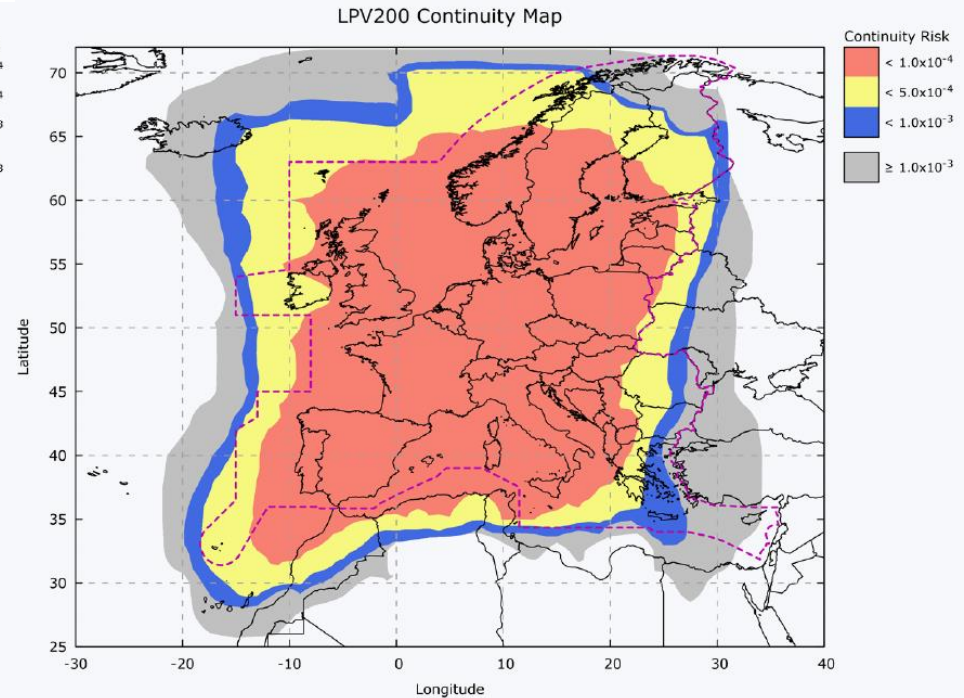
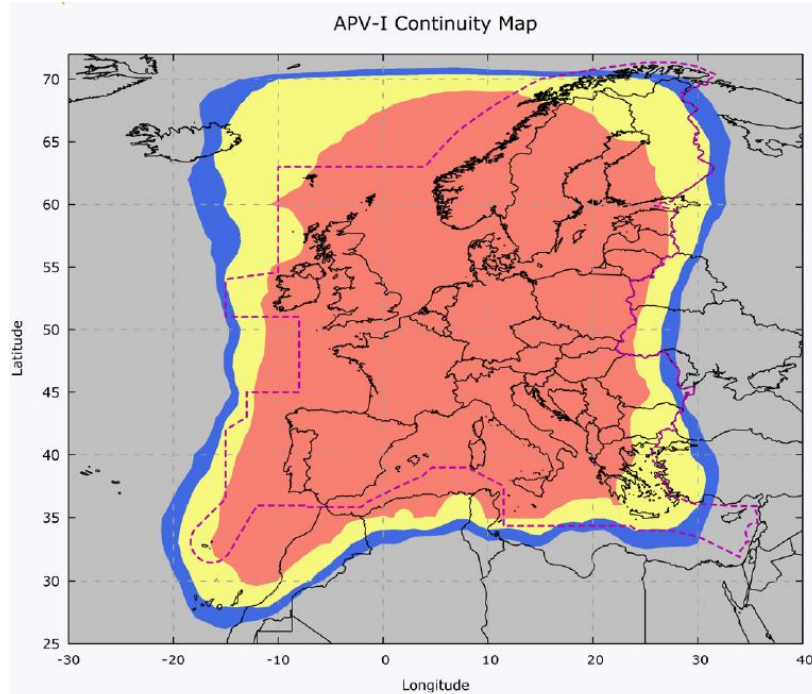
CURRENT EGNOS SAFETY OF LIFE (SOL) IN THE EUROPEAN UNION AND NORTH AFRICA

EGNOS APV-I and LPV-200 services are delivered partially in North Africa



CURRENT EGNOS SAFETY OF LIFE (SOL) IN THE EUROPEAN UNION AND NORTH AFRICA

EGNOS does not meet today ICAO continuity requirements
(same case in Europe where ICAO continuity requirements are not met
and EGNOS is widely used)



CURRENT EGNOS SAFETY OF LIFE (SOL) IN THE EUROPEAN UNION AND NORTH AFRICA

The actual EGNOS performance is achieved thanks to the current EGNOS stations network (NB: 5 stations in North Africa)

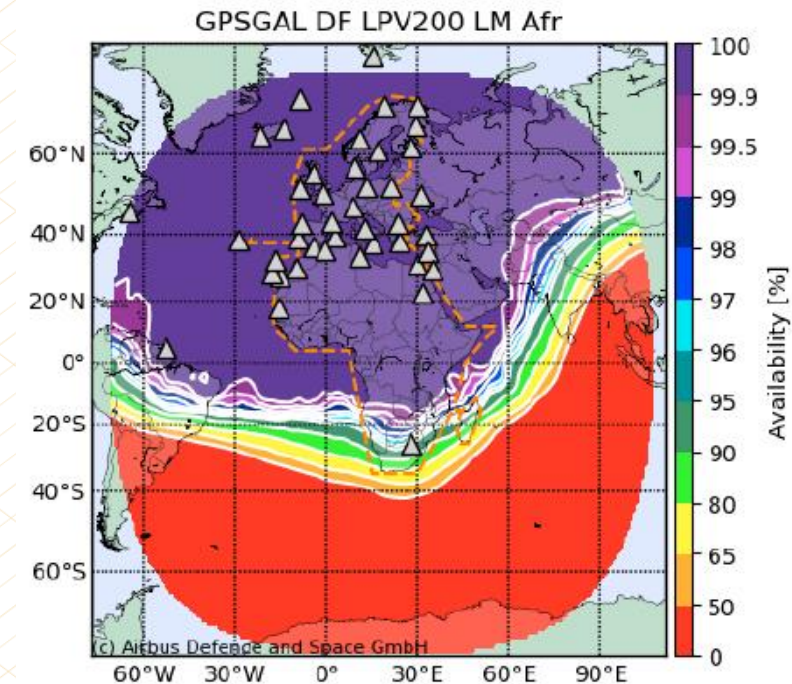
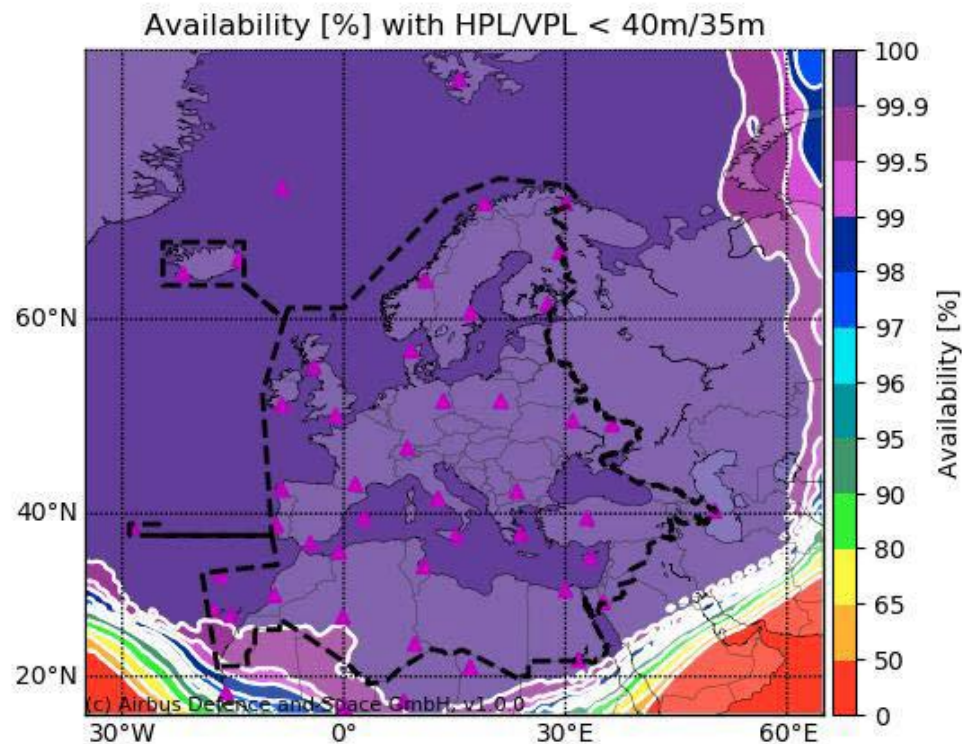
There will be an additional station in Oran around 2025 (which will mainly increase robustness)



FUTURE EGNOS SAFETY OF LIFE (SOL) IN THE EUROPEAN UNION AND AFRICA

A new generation of EGNOS (EGNOS V3) will:

- Deploy around 2027 three additional stations to extend services
- Provide full LPV-200 service to North Africa (*) including ICAO continuity compliance around 2027 both for Single Frequency (GPS L1) and dual frequency users (GPS + Galileo)



INTERNATIONAL AGREEMENTS TO USE EGNOS



- If a non-EU country wants to use EGNOS for Safety of Life applications like aviation, it has to conclude an international agreement with the EU;
- In the context of the extension of EGNOS, the EU is in contact with a number of countries in North Africa (and in the Middle East and Eastern Europe) who have expressed an interest to negotiate such an international agreement.



Ms Deborah Lawrence

Manager, FAA Navigation
Programmes

FAA

FAA GNSS Program Overview

To: Civil Aviation Navigation Services Organization (CANSO)

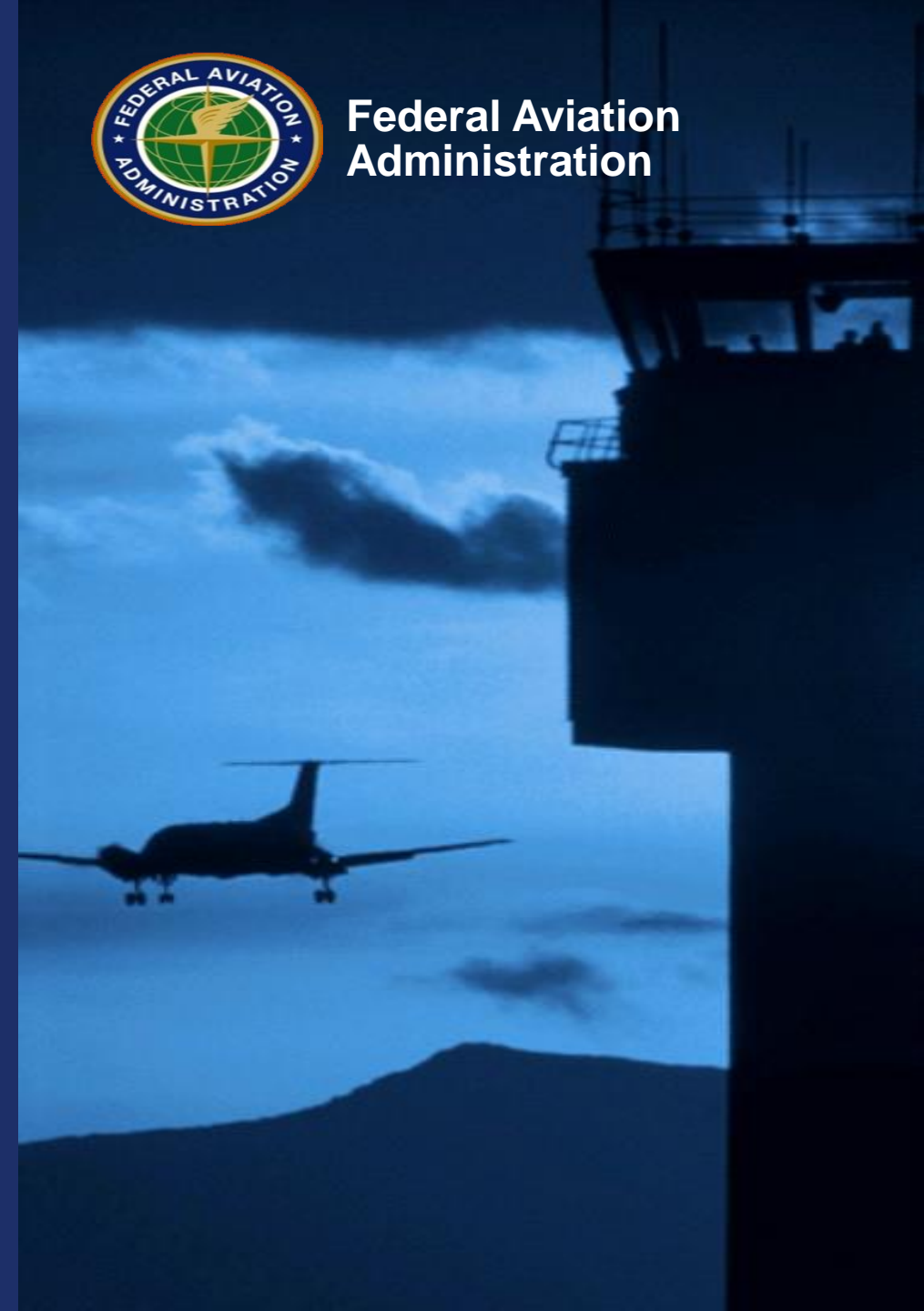
Regional Focus: Future of Air Navigation in Africa

By: Deborah Lawrence, Manager,
FAA Navigation Programs

Date: February 11, 2021



Federal Aviation
Administration



Overview

- **FAA's implementation of GNSS relying on GPS and augmentations (ABAS, GBAS, SBAS)**
- **Benefits and challenges for operational implementation**
- **FAA's Navigation Strategy to provide a resilient navigation infrastructure**
- **Considerations for African operational needs and requirements**

Global Positioning System (GPS)

Space Segment

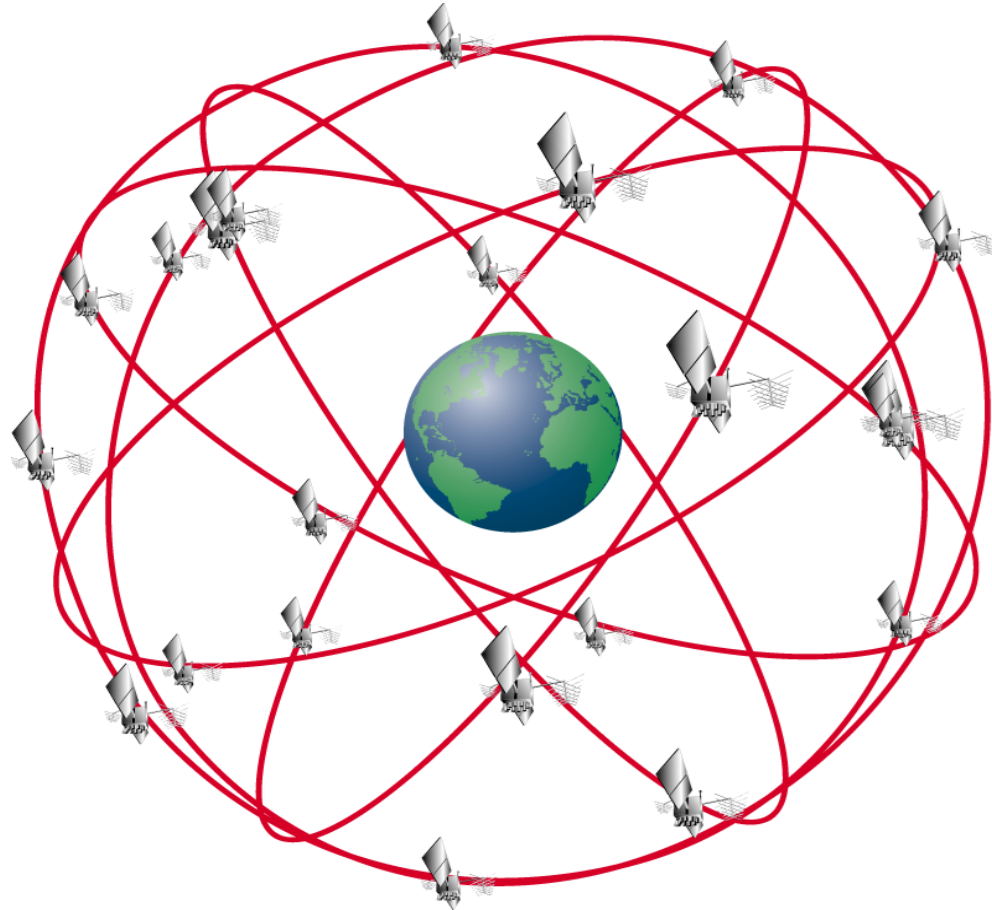
- 24 Orbit Slots
- 6 Orbital Planes
- 4 Satellites Per Plane (Nominal)
- 55 Degrees Inclination
- Orbit at 10,800 Miles
- Orbits Once Every 12 Hours

Control Segment

- 5 GPS Monitor Sites
- 13 NGA Monitor Sites
- 2 Operational Control Centers

User Segment

- Military & Civil Receivers
- Precise Positioning Service (PPS)
- Standard Positioning Service (SPS)



Augmentations to GPS

- **Aircraft Based Augmentation System (ABAS)**
 - Commonly called Receiver Autonomous Integrity Monitoring (RAIM) to alert aircraft when not to use GPS satellite(s)
- **Satellite Based Augmentation System (SBAS)**
 - Wide Area Augmentation System (WAAS) is the FAA's implementation of SBAS
 - Provides Localizer Precision Vertical (LPV) service equivalent to Instrument Landing System (ILS) Category-I service over all of US, and significant portions of Canada and Mexico
- **Ground Based Augmentation System (GBAS)**
 - FAA's Local Area Augmentation System (LAAS) program, later changed to the GBAS program
 - Intended to provide precision approach service equivalent to ILS CAT-I and Category-II/III service

WAAS Architecture



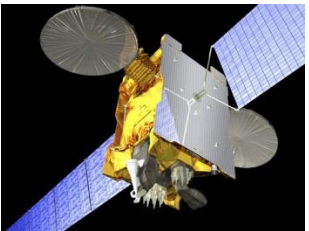
38 Reference Stations



3 Master Stations



4 Ground Earth Stations






3 Geostationary Satellite Links



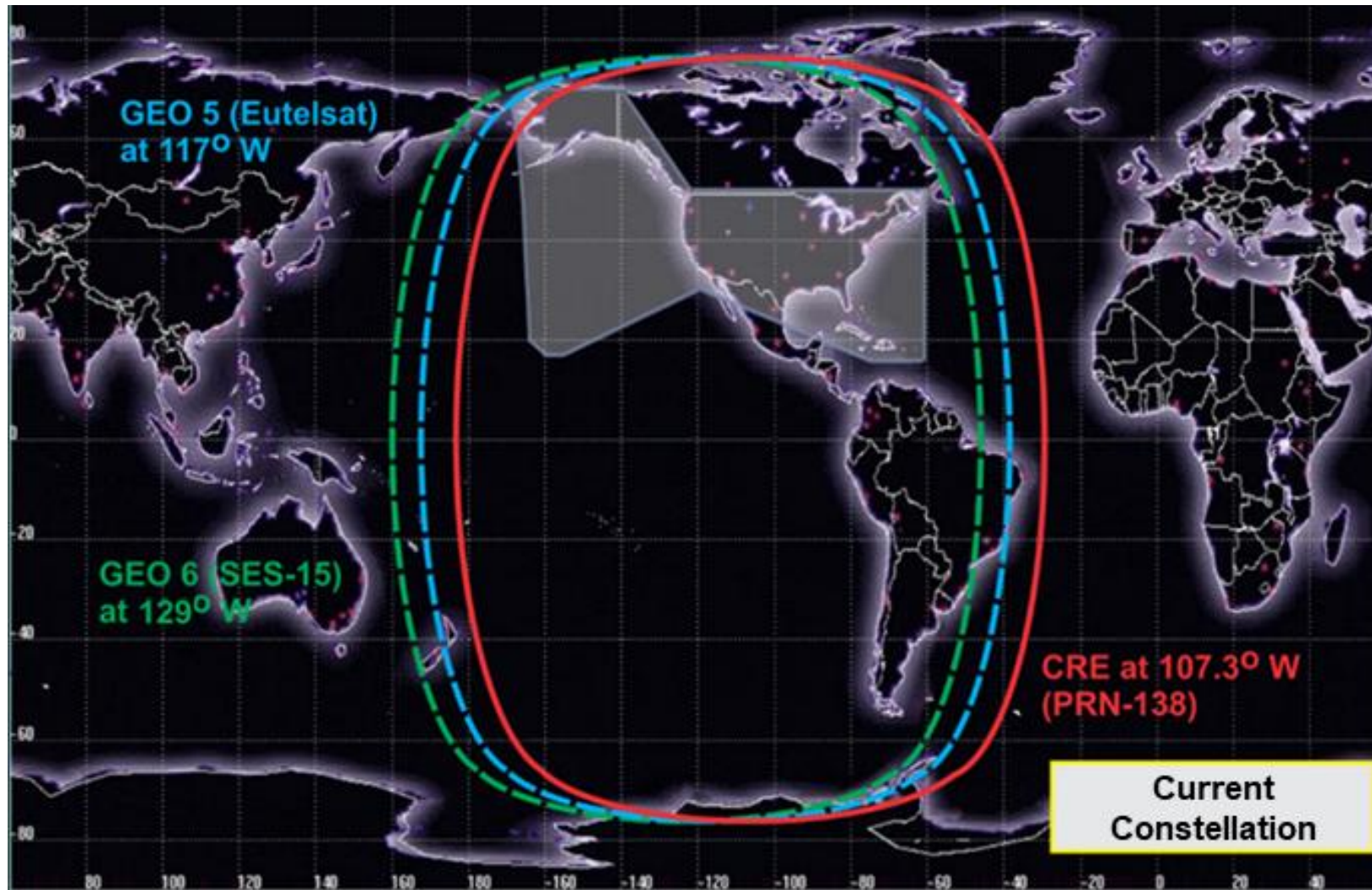
2 Operational Control Centers

WAAS GEOs

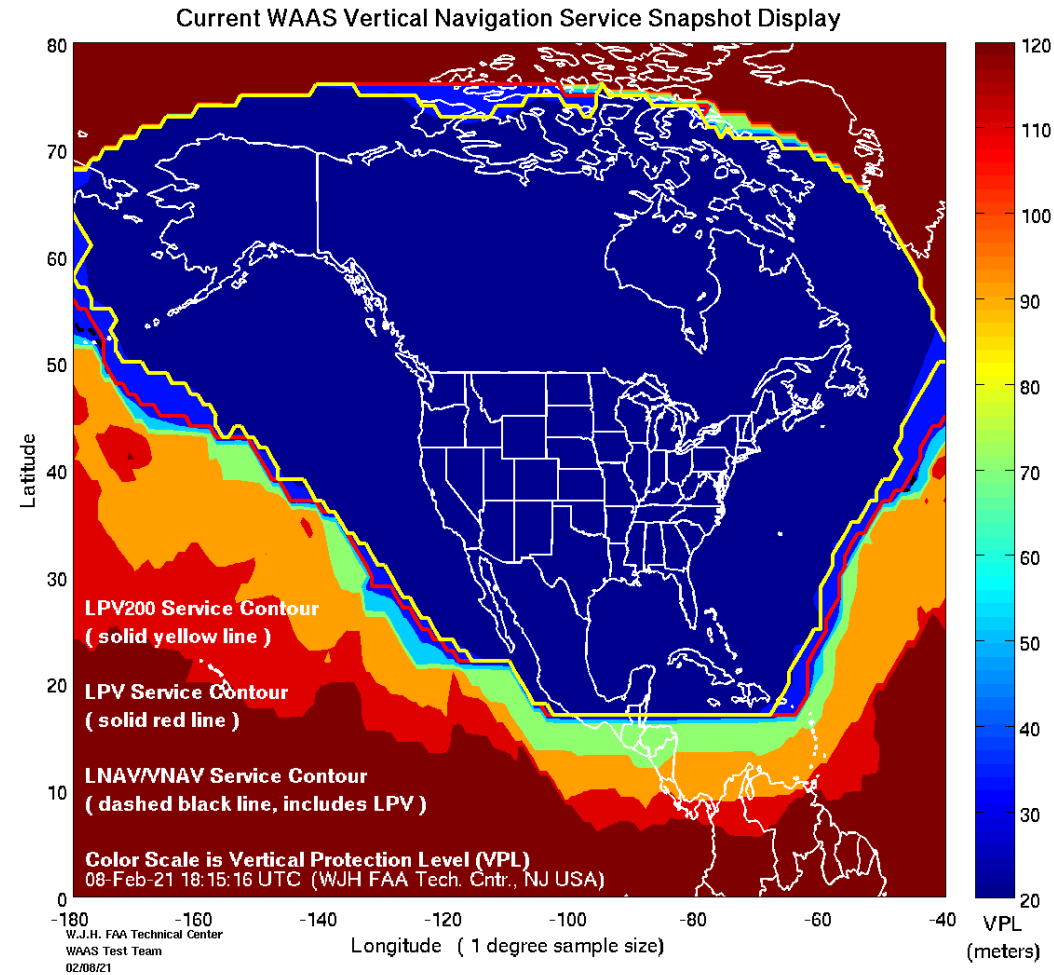
Current Operational WAAS GEOs		
		
Telesat Anik F1R Launched: 9/2005 Operating: 107.3°W	Eutelsat Satmex-9 Launched: 6/2016 Operating: 117 °W	SES SES-15 Launched: 5/2017 Operating: 129 °W <i>Operational: 6/2019</i>

- **Anik F1R (CRE)**
 - On contract thru July 2020 with options thru July 2022
- **Eutelsat 117 WB [ex SatMex 9] (GEO 5)**
 - Completed WAAS integration on March 27, 2018
- **SES-15 (GEO 6)**
 - Completed WAAS integration on June 15, 2019

WAAS GEOs



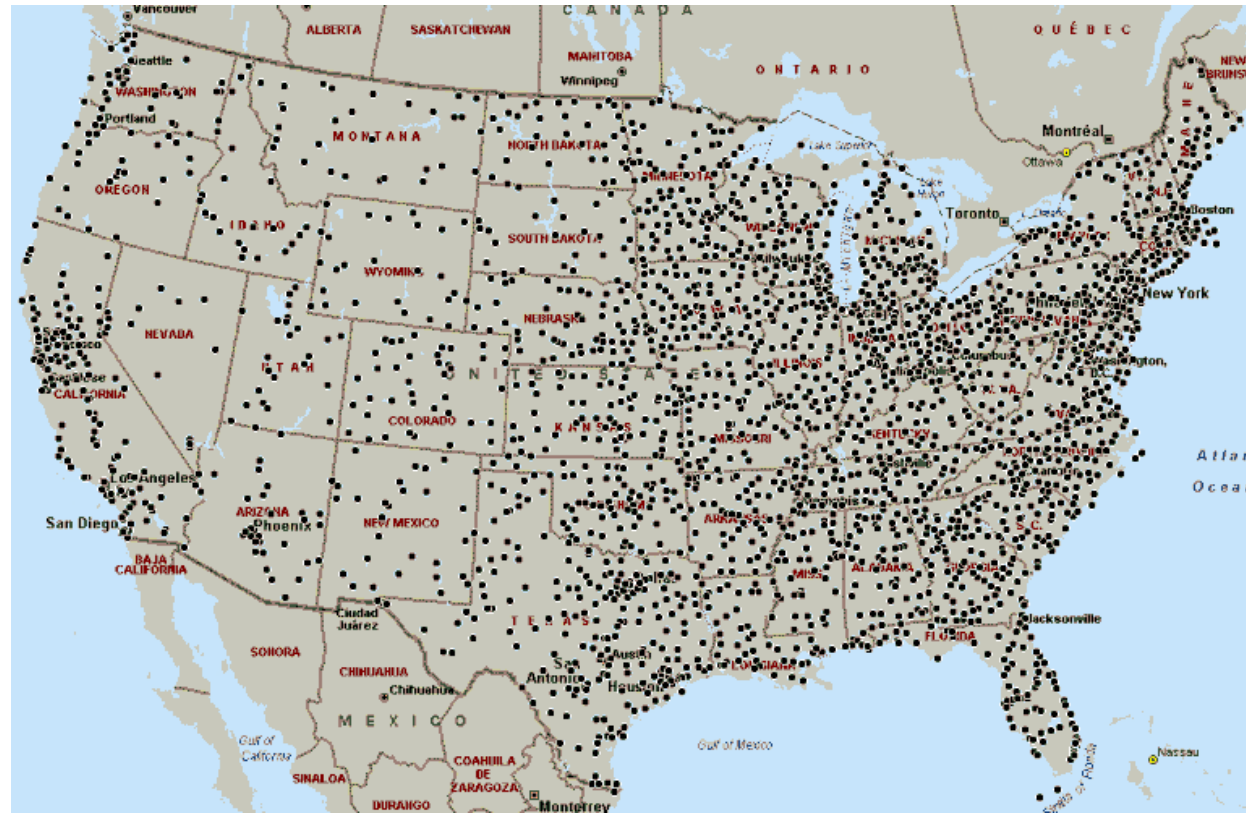
Localizer Precision Vertical (LPV) Coverage



Airports with WAAS LPV/LP Instrument Approaches



- Most of the airports throughout the National Airspace System contain WAAS Procedures



Procedures as of 12/2020:

ILS Category-1 = 1,198

WAAS LPV = 4,801

Access Benefit = 3,603

WAAS Avionics Equipage

- **Over 139,128 aircraft operating in the US NAS are equipped with WAAS**
- **Equipage has increased for all classes of aircraft since 2006**
- **WAAS is the only GNSS service that enables all capabilities for:**
 - Performance Based Navigation (PBN)
 - Automatic Dependent Surveillance Broadcast (ADS-B)



SBAS Benefits and Challenges

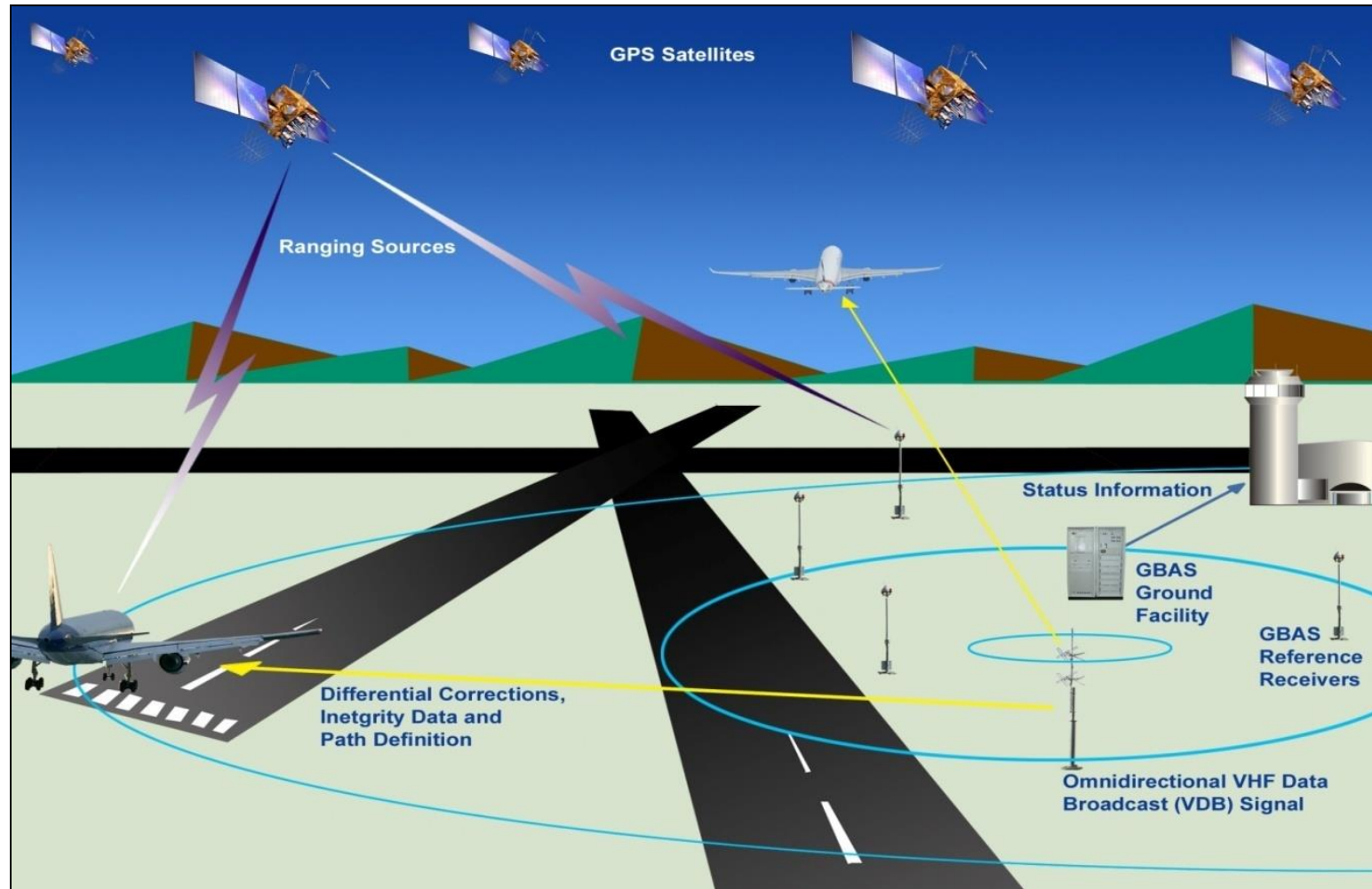
- **Benefits**

- Enables implementation RNP vertically guided approach service to reduce controlled flight into terrain (CFIT) hazard and improve operational efficiency
- Provides coverage over large geographical areas without the need to install navigation equipment at each service delivery location
- Meets all accuracy and integrity requirements for PBN and ADS-B

- **Challenges**

- Investment in infrastructure for the wide area network of monitoring stations, processing facilities, and geostationary satellites can be challenging for some ANSPs
- Stringent requirements for safety, integrity, and offline monitoring requires continuous analysis to validate threat model assumptions
- Vulnerable to outages caused by RFI and ionosphere storms

Ground Based Augmentation System (GBAS)



U.S. GBAS Implementation

- **GBAS is implemented as a Non-Federal System:**
 - Non-Federal sponsors (e.g., airports) fund system purchase, installation, commissioning, and maintenance
 - Deployment is driven by user interest and sponsor investment
 - FAA retains regulatory authority of GBAS
 - System Design Approval, commissioning, and periodic inspections
 - Currently Approved GLS Operations
 - All published GLS approaches are straight-ins overlaid on ILS
 - GLS/LPV visibility minimums reduced to RVR 1800 June 2017
 - Autoland is currently not authorized
 - The FAA does not have a plan to consider airline requests for approval of GAST-C GBAS to CAT II minima
- **FAA acquisition of GBAS is not planned due to unfavorable cost/benefit analysis in the U.S.**

GBAS Approvals & Sites

- **FAA approved the Honeywell SLS-4000 GBAS for CAT-I operations**
 - Latest modification to the SLS-4000 was approved November 2019
- **Public Operational Sites:**
 - PANYNJ Newark Int'l Airport (EWR) – over 3500 procedures flown
 - HAS George Bush Intercontinental Airport (IAH) – over 2500 procedures flown
- **Private sites – Boeing:**
 - Grant County Int'l Airport (MWH)
 - Charleston Int'l Airport (CHS) – Not commissioned
- **Potential SLS-4000 additions over the next one to three years:**
 - San Francisco Int'l Airport (SFO)
 - John F. Kennedy Int'l Airport (JFK)
 - LaGuardia Int'l Airport (LGA)

Benefits of GBAS

- **One GBAS can serve all runway ends at an airport with multiple approaches to enable different glideslopes and/or displaced thresholds**
- **No need for ILS critical areas that require aircraft to hold short while another aircraft is flying a GLS approach**
- **Vertical guidance is unaffected by snow and system is more robust than ILS during snow storms**
- **Eliminates “false glideslopes” associated with ILS**
- **GLS enables a shorter final approach segment and a smoother transition from an RNP approach segment compared to ILS**

GBAS Challenges

- **GBAS (like all GPS-based systems) is susceptible to outages due to Radio Frequency Interference**
 - Improvements to the Honeywell SLS-4000 improved robustness to interference in 2012
 - Retention of ILS is necessary to avoid loss of service during GPS outage events
- **Prevalence of ILS**
 - In the U.S. all airports where GBAS would be installed already have ILS so upgrading to GBAS is not cost-effective
- **Aircraft Equipage Rates**
 - Mixed equipage of the fleet complicates usability of new procedures from an Air Traffic perspective, and ability to take advantage of other GBAS benefits elimination of ILS critical areas

Other Considerations

- **Consideration of Regional Ionospheric Models**
 - The FAA approval of the Honeywell SLS-4000 GBAS is predicated on the CONUS Ionospheric Threat Model. Other regions will need to develop their own threat model, and if it is not bounded by the CONUS model, work with the vendor to determine appropriate mitigations to maintain a working safety case.
- **Complexity of Certification**
 - Different GBAS vendors may have varying strategies to perform required GPS and environmental monitoring to provide the required levels of accuracy and integrity.
 - Subject matter experts in ionospheric behavior and GPS failure modes will be required by any entity wishing to conduct approval activities for GBAS.

CAT III/GAST-D GBAS

- **Standards for GAST-D GBAS were approved by ICAO November 2016 and promulgated November 2018**
 - GAST-D is the GBAS Approach Service Type that will enable CAT III using single-frequency GPS
- **GBAS CAT III MOPS (DO-253D) were completed by RTCA SC-159 WG4 in July 2017**
- **GBAS GAST-D applicant has approached the FAA requesting non-federal System Design Approval**
 - The applicant has agreed to participate in the validation of an updated FAA non-Federal intake & approval process
 - Process validation has been impacted by COVID-19
 - No timeline for determination of whether or not to move forward with a full System Design Approval effort is currently available

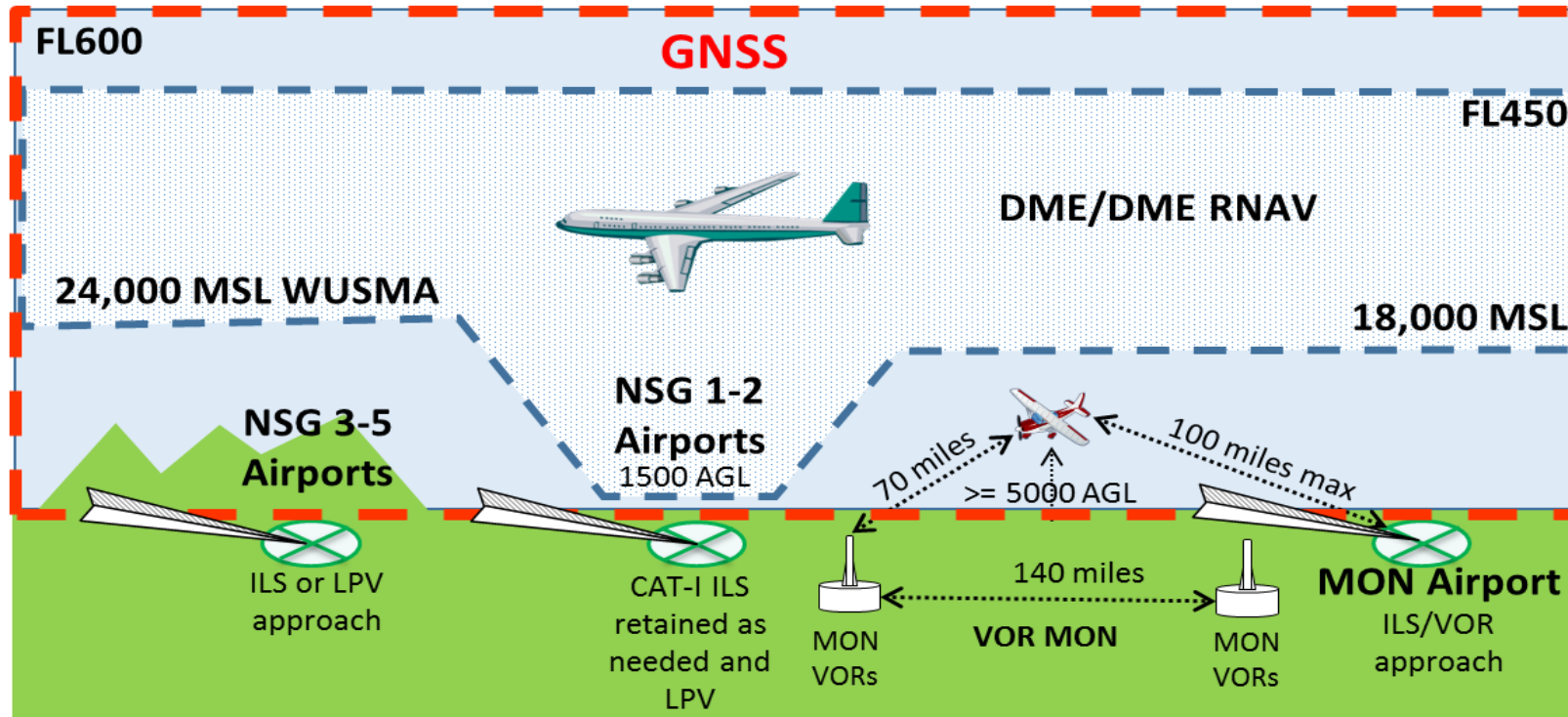
GAST E/F GBAS

- **Efforts in requirements development for dual-frequency/multi-constellation GBAS are underway at ICAO and RTCA**
- **The FAA has no current prototyping or development funding for these systems**
- **The FAA will continue to participate in ICAO Navigation Systems Panel (NSP) GBAS Working Group (GWG) and RTCA SC-159 WG 4**
 - Participants currently from Aircraft Certification, Flight Standards, and NextGen

FAA Navigation Strategy



Resilient Navigation Infrastructure



- GNSS is the primary enabler for all PBN (RNAV and RNP) and ADS-B
- DME/DME navigation provides an alternate RNAV service for air carrier aircraft during GNSS outages. FAA adding 123 DMEs to improve DME RNAV coverage
- VOR MON provides a conventional backup for aircraft without DME RNAV
- FAA discontinuing approximately 308 of 957 VORs to establish the MON
- CAT-I ILSs support safe recovery in the event of a GNSS outage

Considerations for Africa

- **ABAS**

- Virtually all GNSS receivers come with RAIM, but only suitable for lateral navigation and air carriers require an independent non-GNSS navigation system

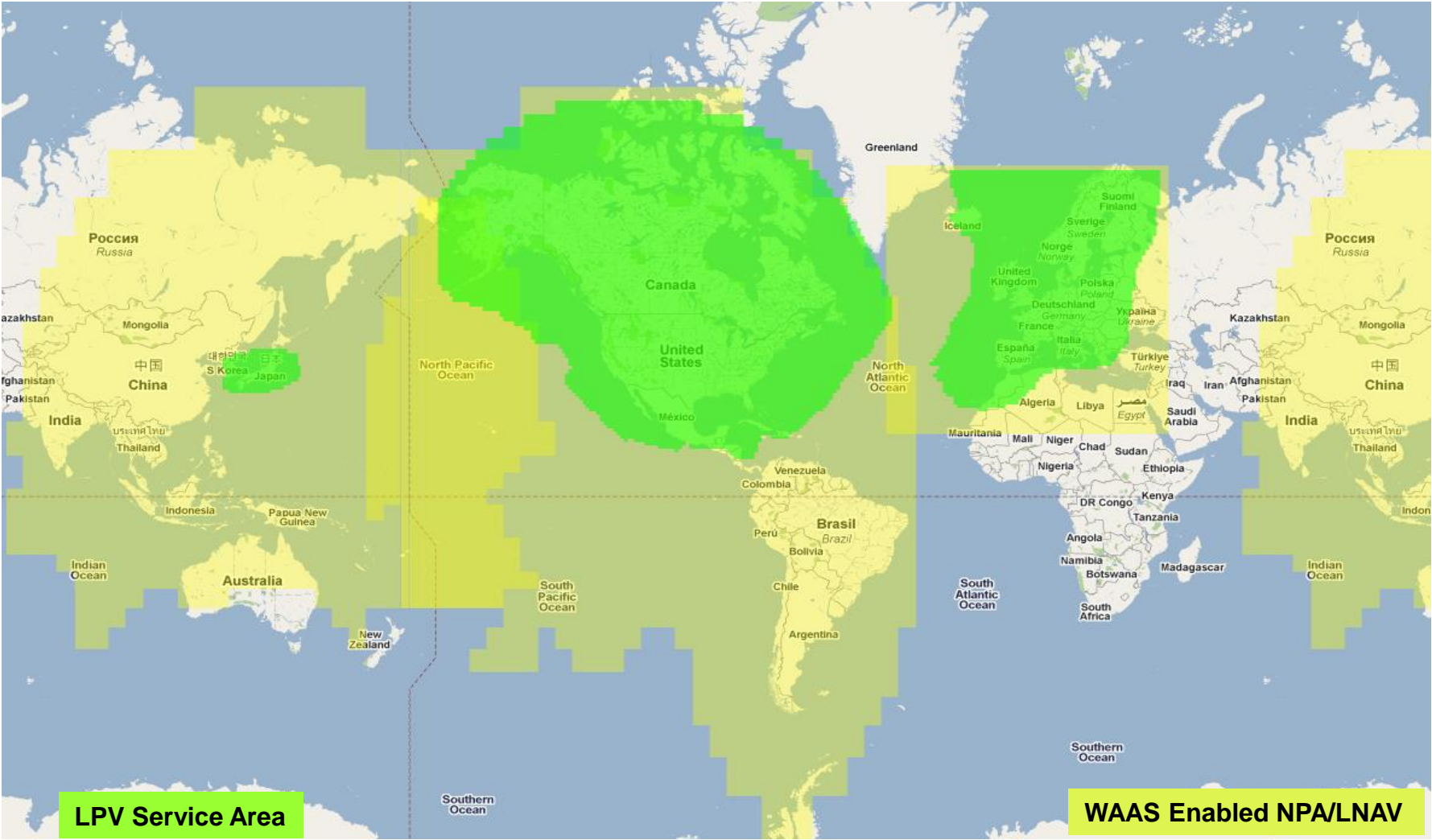
- **SBAS**

- Well suited for large geographical areas like Africa to provide PBN for all airspace and vertically guided approach service.
- Implementing the wide area monitoring network and securing geostationary satellite coverage may be challenging for the multi-state region

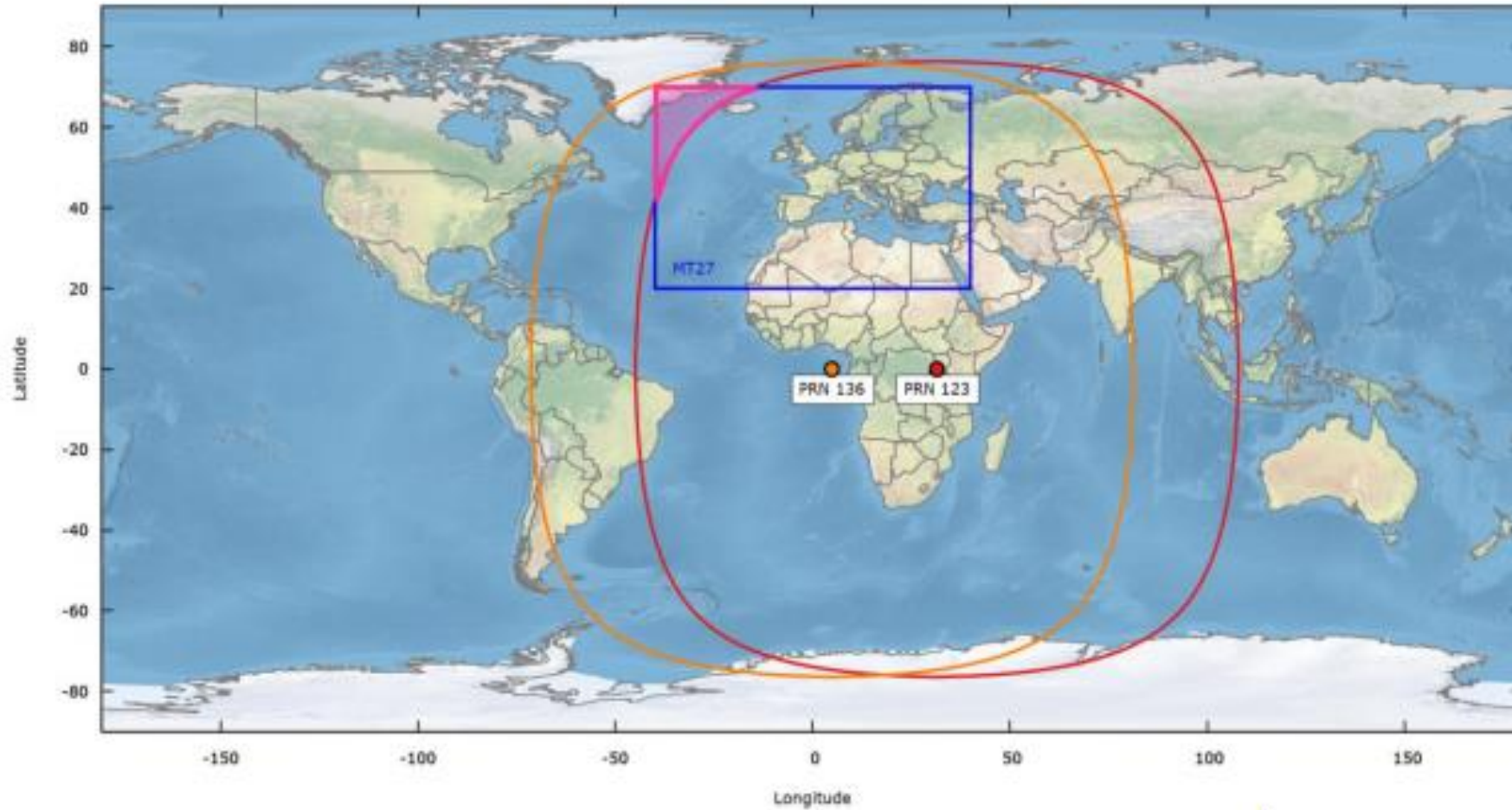
- **GBAS**

- Implemented and controlled on an airport basis
- May provide suitable service in combination with ABAS depending on RFI risk and specific operational needs

Combined SBAS Snapshot



EGNOS Footprint



Summary

- **GNSS Implementation has several alternatives for ANSPs to consider**
- **Operational needs influence the strategy**
- **GNSS vulnerabilities can be addressed through repurposing conventional navigation systems**

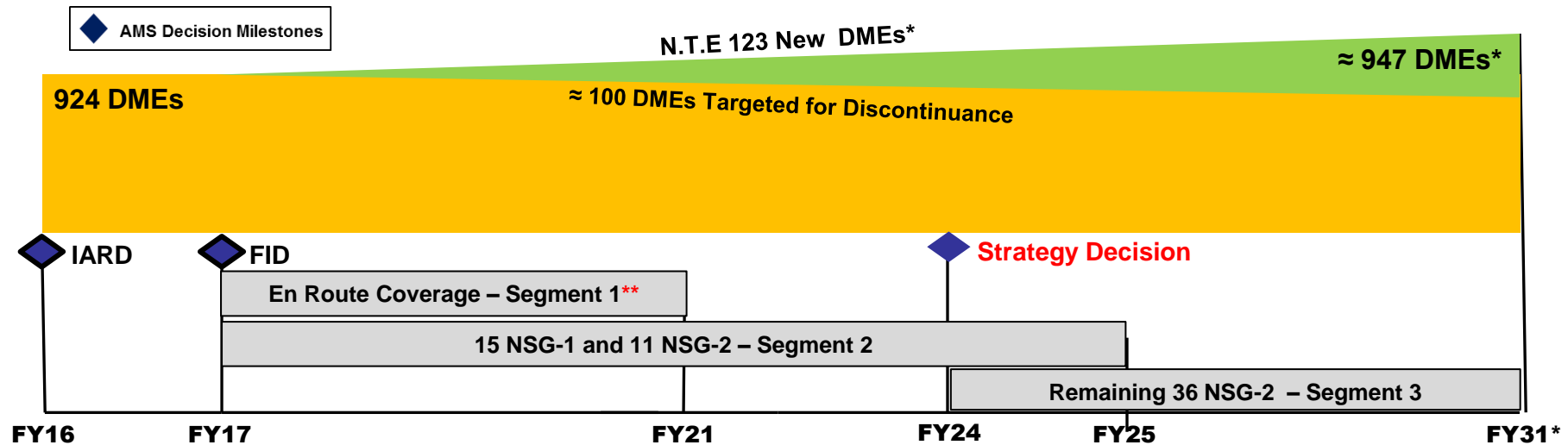
FAA Resilient Navigation Strategy

- **Provide resilient navigation services to enable transition of the NAS to PBN operations**
 - GPS and WAAS enable all PBN and ADS-B operational capabilities
 - DME/VOR/TACAN continue to provide resiliency for the foreseeable future
 - DME infrastructure supports RNAV operations in the event of GNSS service disruptions
 - VOR MON Program will provide a backup for aircraft that lose RNAV during a GNSS outage
- **Rationalize infrastructure to improve efficiency**
 - Discontinue VORs to establish the MON
 - Enhance the DME network to improve RNAV coverage
 - Rationalization of ILS again placed on hold for the near future
- **Innovate navigation services to enable new capabilities**
 - Multi-Constellation GNSS to enable Advanced RAIM
 - LED technology, etc.

WAAS Implementation

- **WAAS is implementing Dual Frequency SBAS using GPS L1/L5 signals consistent with GPS Modernization**
- **Development work for Dual Frequency requires upgrades to existing infrastructure**
 - Integration of new processors and operating system to handle additional processing load
 - Replacement of GPS receivers for reference stations and geostationary uplink sites
 - Upgrade of terrestrial communications circuits and transition to IP communication circuits as part of larger FAA infrastructure upgrades
- **WAAS will continued sustainment of the current L1 single frequency service for the foreseeable future**

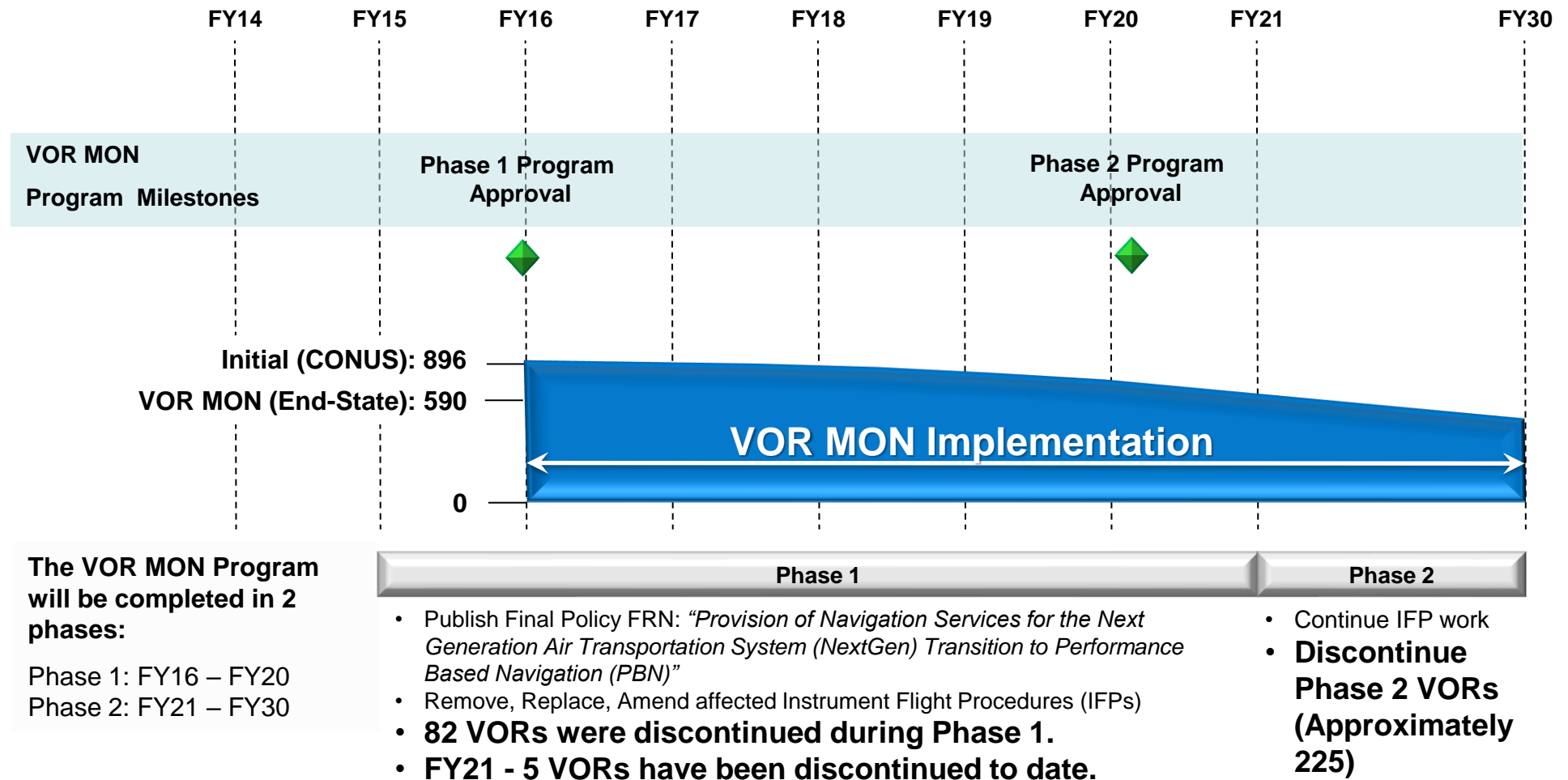
NextGen DME Program



- **Navigation Service Group (NSG) Airports grouped into clusters to maximize benefits**
- **Clusters grouped into discrete segments**
 - **Segment 1:** En Route Coverage. ****Segment 1 Completion date to be delayed**
 - **Segment 2:** Terminal Coverage for 15 Navigation Service Group (NSG)-1 and 11 NSG-2 Airports
 - **Segment 3:** Terminal Coverage for 36 NSG-2 Airports

** After program revised scope, April 2018*

VOR MON Program



TACAN Minimum Operating Network (MON)

- **Development of the TACAN MON Concept**
 - There are 513 existing Military- and FAA-owned TACANs in CONUS
 - The concept rationalizes military operational needs and service volume expansion for the retained facilities to identify candidates for divestment
 - The concept identified 122 candidates for divestment
- **Implementation of the TACAN MON**
 - Unneeded TACANs will be divested as service volume changes are made to the remaining MON facilities

ILS Rationalization

- **ILS Rationalization Strategy was approved in 2016**
 - ILSs at small airports where the majority of users were equipped with WAAS LPV avionics were identified as candidates
- **Further activities were placed on hold in 2017 due to concerns from users**
- **Program remains on hold**



Ms Amornrat Jirattigalachote

Strategic Planning Manager

AEROTHAI

Navigation Strategy



- Asia/Pacific Seamless ANS Plan
- Navigation Strategy for the Asia/Pacific Region



- ASEAN ANS Master Plan

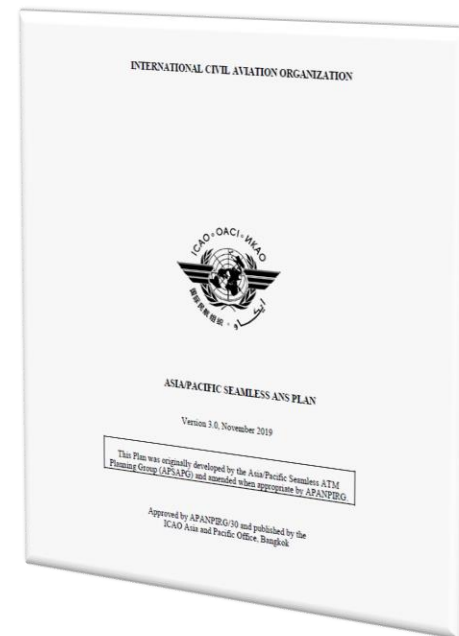


- AEROTHAI Corporate Plan



- Asia/Pacific Seamless ANS Plan
- Navigation Strategy for the Asia/Pacific Region

- Performance Improvement Plan
 - Phased implementation
 - Phase I: 12 November 2015
 - Phase II: 7 November 2019
 - Phase III: 3 November 2022
 - Phase IV: 27 November 2025



Terminal Operation	<ul style="list-style-type: none">• RNAV1/RNP1 SID/STAR• SBAS/GBAS precision approach• ILS/MLS approach• Approach with vertical guidance• Non-exclusive/exclusive PBN airspace
En-route Operation	<ul style="list-style-type: none">• RNAV2 or RNP2 routes• Non-exclusive/exclusive PBN airspace• Free route airspace



• ASEAN ANS Master Plan

• Development Program

– Priority

- Required ASEAN-Wide Harmonized Implementation
- First-Priority Implementation
- Capability Enhancement Implementation

– Phased Implementation

- Phase I: 1 January 2018 – 31 December 2020 (target: 31 December 2018)
- Phase II: 1 January 2018 – 31 December 2022 (target: 31 December 2020)
- Phase III: 1 January 2022 – 31 December 2025 (target: 31 December 2024)

Terminal Operation	<ul style="list-style-type: none">• GBAS precision approach• ILS approach• Straight-in RNP APCH with LNAV/VNAV• Non-exclusive/exclusive PBN airspace
En-route Operation	<ul style="list-style-type: none">• RNAV2 or RNP2 (other acceptable – RNAV5) routes• Free route airspace





• AEROTHAI Corporate Plan

• 5Y Rolling Plan

- Current edition: 2021 – 2025
- Annual review



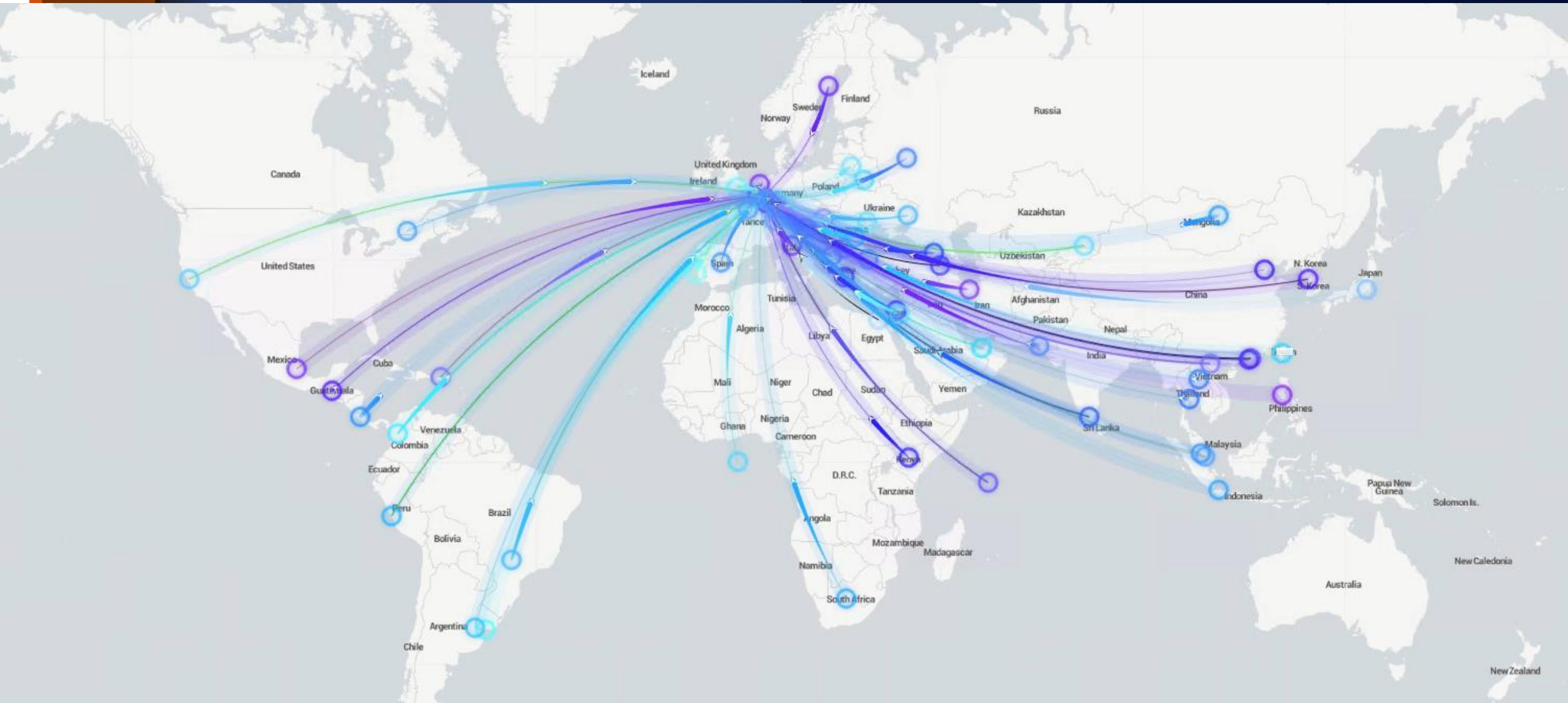
Terminal Operation	<ul style="list-style-type: none">• GBAS precision approach – VTBS, VTSP<ul style="list-style-type: none">– Ionospheric threat model– Demonstration at VTBS: 2020 – 2022• Non-exclusive/exclusive PBN airspace
En-route Operation	<ul style="list-style-type: none">• RNAV5 or RNAV2 or RNP2 routes• Non-exclusive/exclusive PBN airspace• Free route airspace
Terminal/ En-route Operation	<ul style="list-style-type: none">• DME/DME network; backup for PBN airspace



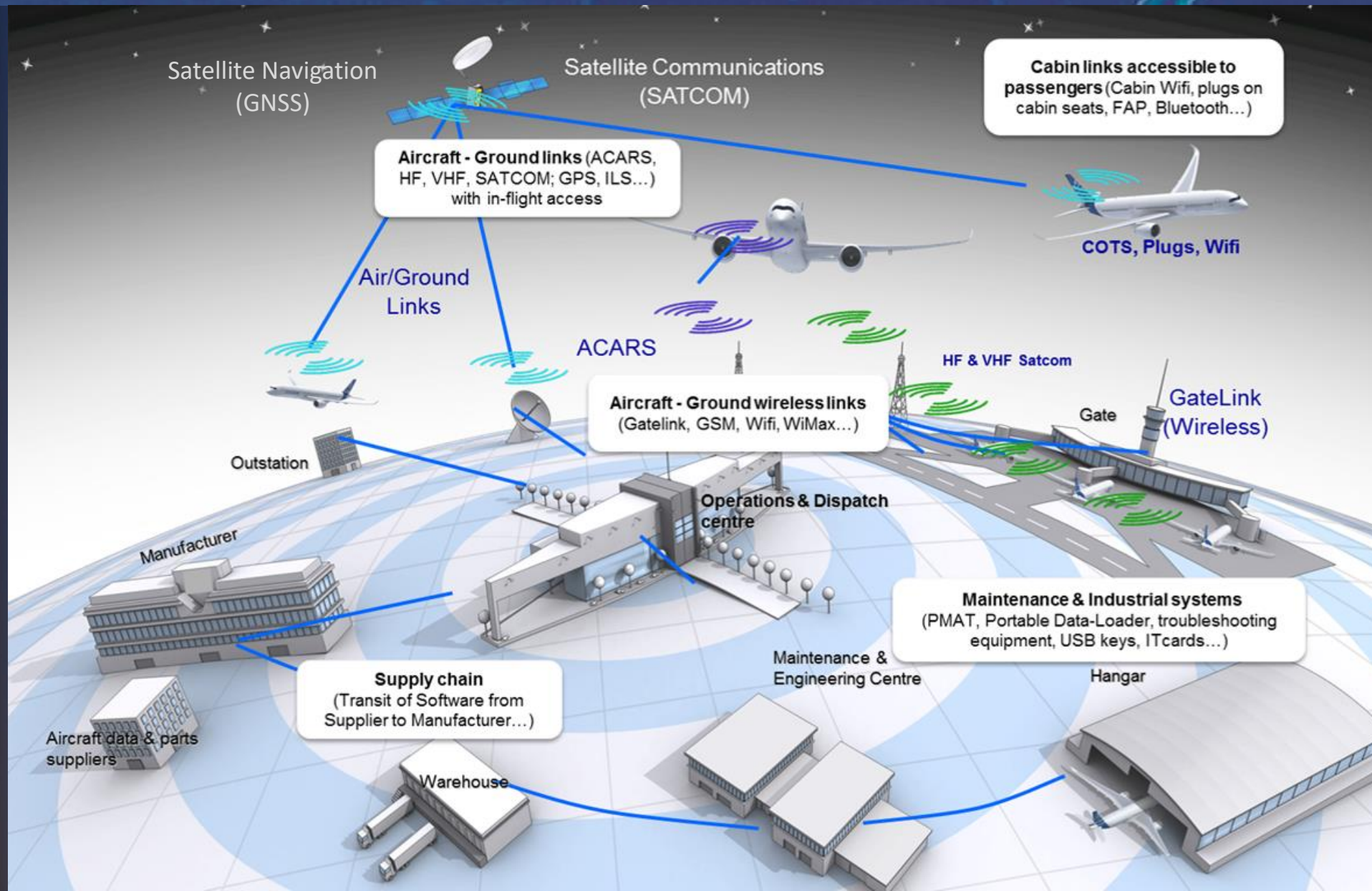
Mr. Patrick Mana

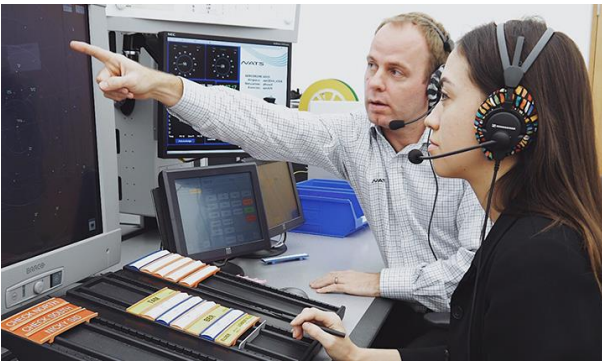
Cyber Security Project Manager

EUROCONTROL

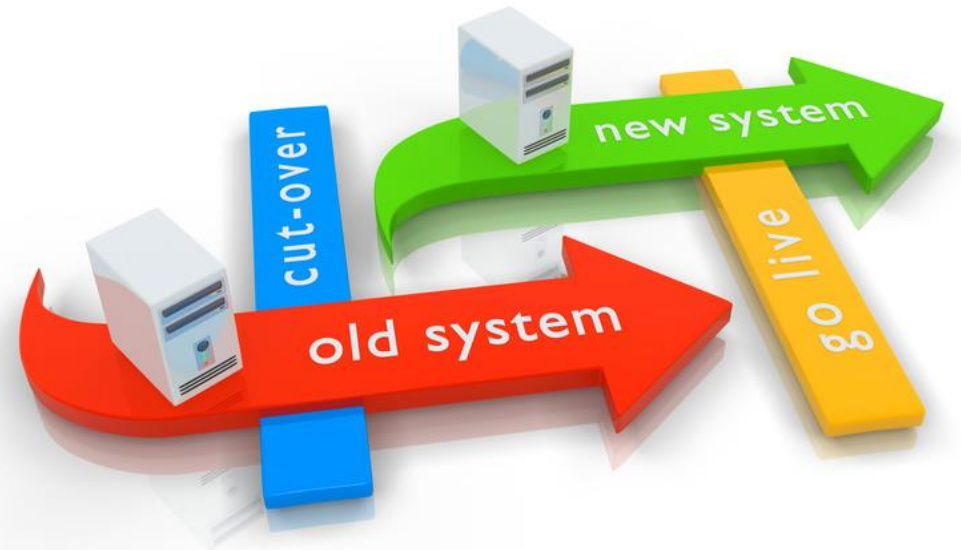


Complexity of Securing the Aviation Ecosystem





Aviation =
Mix of legacy and new
... forever



EATM-CERTEuropean Air Traffic Management
Computer Emergency Response Team

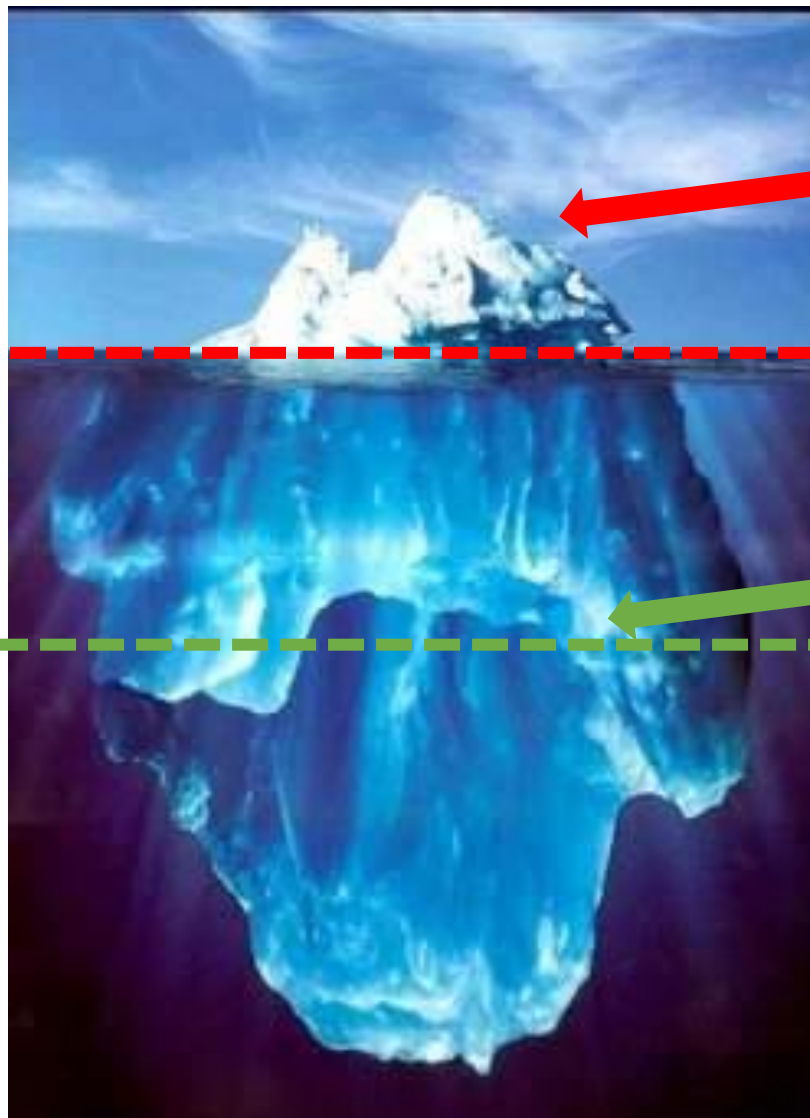
2020 Report on cyber in aviation



SUPPORTING EUROPEAN AVIATION



Context and limitations



2020 dataset

2021 dataset

No detection means (e.g. SOC)
Company sharing culture or policy
Misuse of TLP
De-identification

Lack of maturity
National regulation
Legal framework to share
Trust

State-sponsored / Geo-political



Cyber-crime ...

it's an industry

Motivation and Cost to Compromise Cybercrime

Malware Products

Account Stealer	\$ 32 - \$ 324
Bank Trojan	\$ 1,273 - \$ 3,956
Basic Malware Kit	\$ 323 \$ 97 /month \$ 258 /year
Advanced Malware Kit	\$ 450 /week \$ 1,800 /month
Custom Kit	\$ 323 - \$ 8,075
Malware vs AV checks	\$ 20
Zero-day money back guarantee	+10%

Command & Control Rental

Bulletproof VPN	\$ 25 /month
Bulletproof hosting	\$ 50 /month
Bulletproof domains/fast flux	\$ 50 /month
Custom C&C	\$ 1000 -

DDOS Services

DDOS kit rental	1 month	\$ 81
	6 months	\$ 161
	1 year	\$ 258
DDOS service / day	1 GB	\$ 16
	10 GB	\$ 161
	DNS server	\$ 323

Compromised Hosts

Asia	1000	\$ 20
NA/EU	1000	\$ 200 - \$ 270
Mix	1000	\$ 35
Handpicked		\$...

Stolen Data Products

Credit Card US	\$ 4 - 8
Credit Card EU / Asia	\$ 12 - 18
Credit Card + stripe data	\$ 19- 28
US Fullz (ID, SSN, address, ...)	\$ 25
EU Fullz (ID, SSN, address, ...)	\$ 30 - 40
Bank Account + credentials (\$70k+)	\$ 20 - 300

Professional Services

Doxing / Targeting	1 person	\$ 25 - 1000
Fake bank site		\$ 81 - 1000
File Cracking	zip, xls, ..	\$ 45
Hacking	Personal email	\$ 47
	Corporate email	\$ 81 - ...
	Website	\$ 100 - \$ 300
Coordinator / remote support		\$ 50 / hour
Zero Day exploit		\$ 500 - 250,000

Cyber-crime



Contact Us

Subject: Choose an option

Name: aaroneu2

Surname:

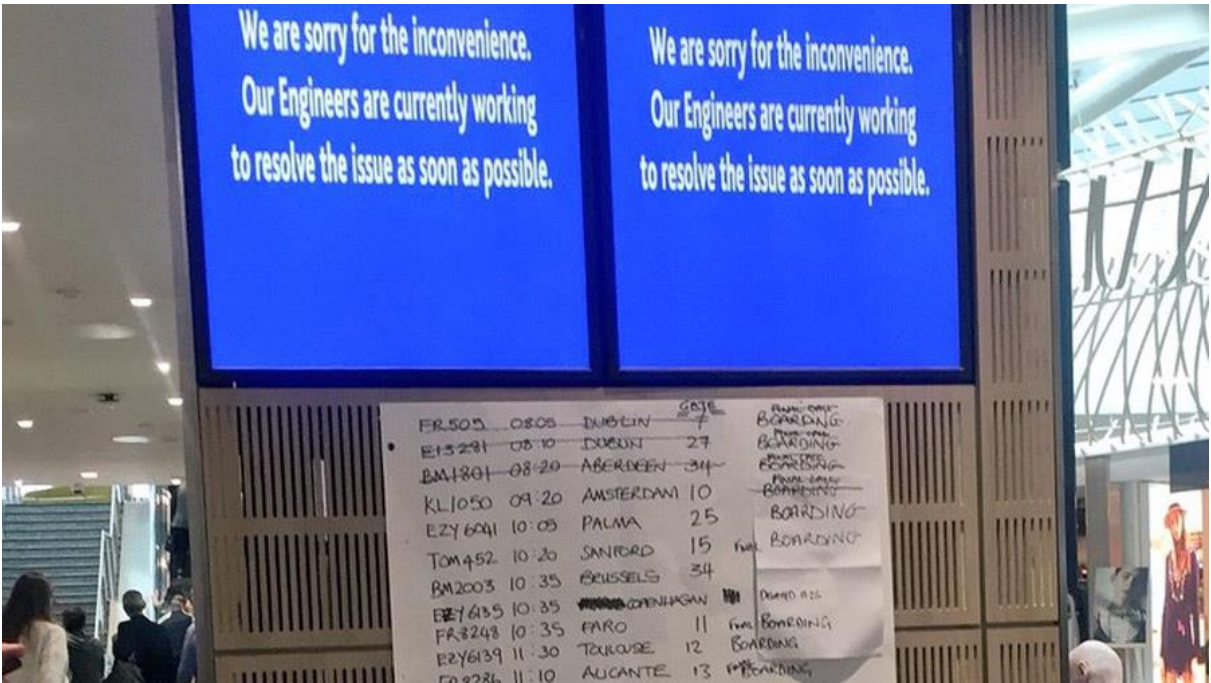
Email: benitabd1@kenta5710.kenshin69.downl

Contact Number: 87191139353

Flypass Number: 6019

Message: New super hot photo galleries, daily updated collections
<http://cupid.dating.bloglag.com/7katie>

Attachment: Choose File



Bristol but also Atlanta, Cleveland, Albany, SFO, ...

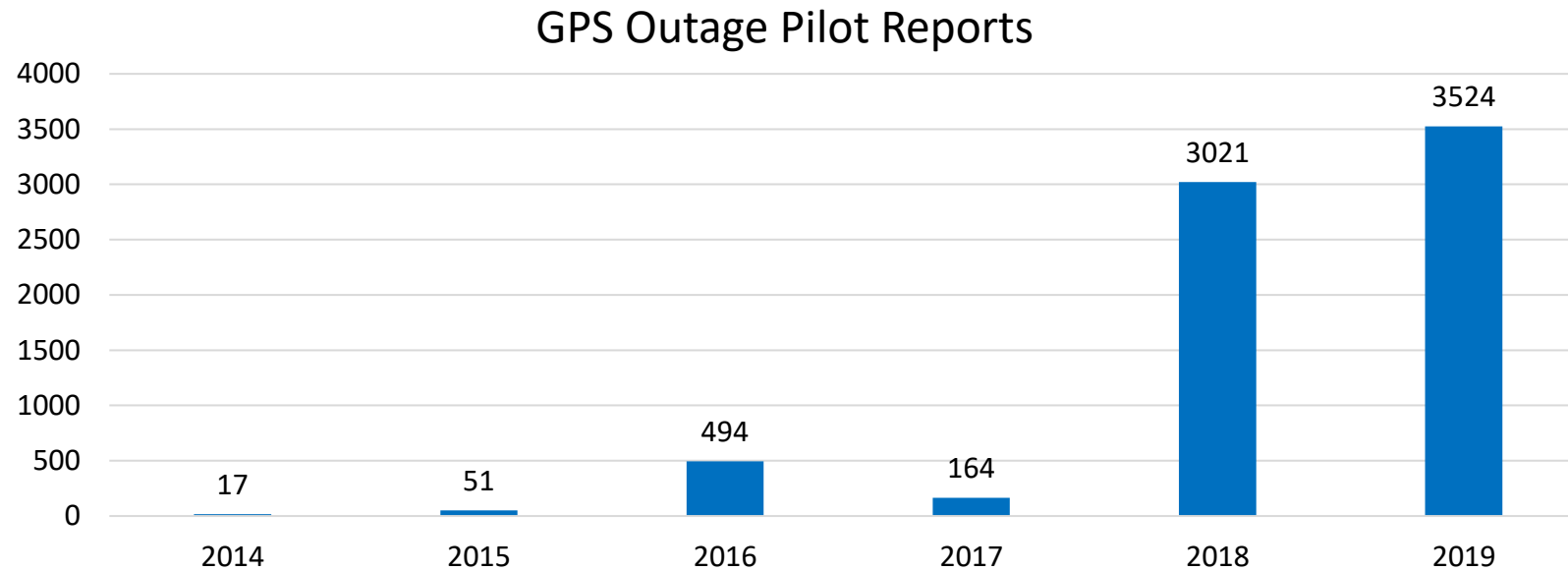


Hacktivism

- Eco-hacktivism
- Not only cyber (physical as well)

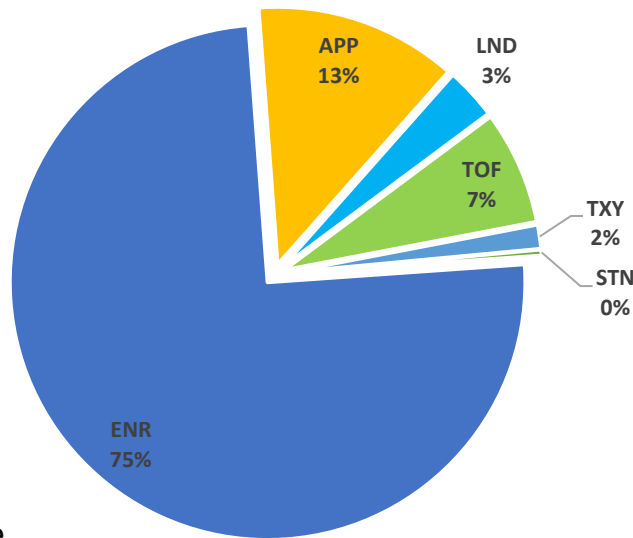


EUROCONTROL Voluntary ATM Incident Reporting (EVAIR)



- 250 Participating Aircraft Operators
 - Coverage: Europe, Middle East, Northern Africa
 - Detail reports subject to confidentiality (just culture reporting)
- RFI most probable cause in absence of rx, constellation or solar issues
- 2018/2019 trend continues: average of 10 GPS reports DAILY!
 - 2020 decrease due to reduced flights (COVID), RFI persists in many locations

Outage Statistics



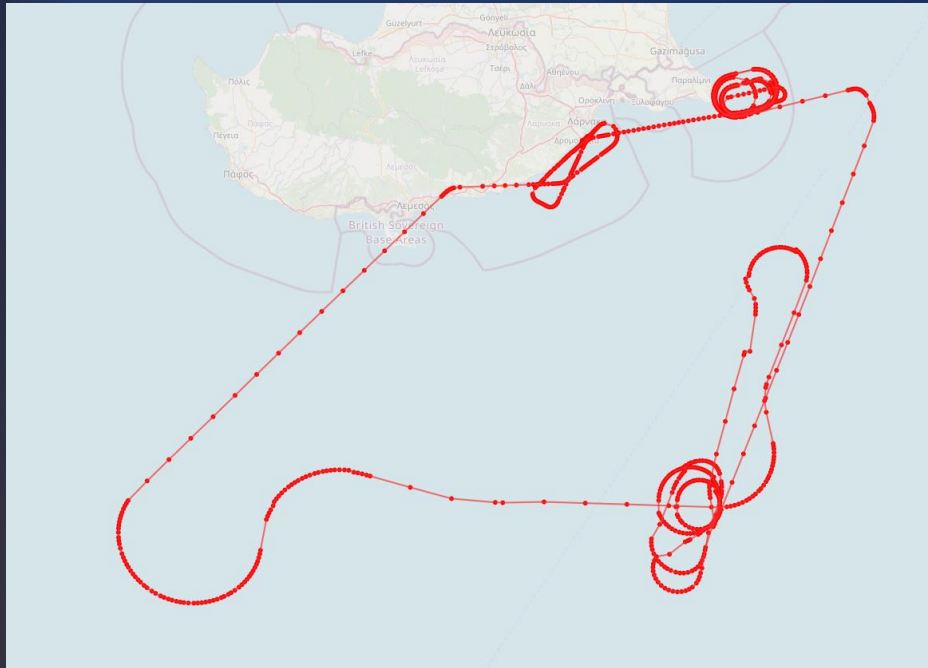
ENR = En-Route
APP = Approach
LND = Landing
TOF = Take Off
TXY = Taxi
STN = At Gate / Stand

EVAIR GPS

- 35 Flight Information Regions FIR affected
- Several measurements clearly confirm narrowband RFI on L1 at significant distances (300+ km) and altitudes (10km)
- Most affected regions:
 - Middle East / Asia Routes across the Black Sea / Caspian Sea Regions
 - Middle East / Asia Routes via Mediterranean Sea (Cyprus and Malta Airspace)
 - Middle East – Canada / USA via cross polar Routes
- Several events also in West European Terminal areas (airports)
- Significant number of events in a specific area leads to further investigation: Cyprus example (Nicosia FIR)

DLR Airbus A320 Test Flight in Cyprus Airspace (ATRA)

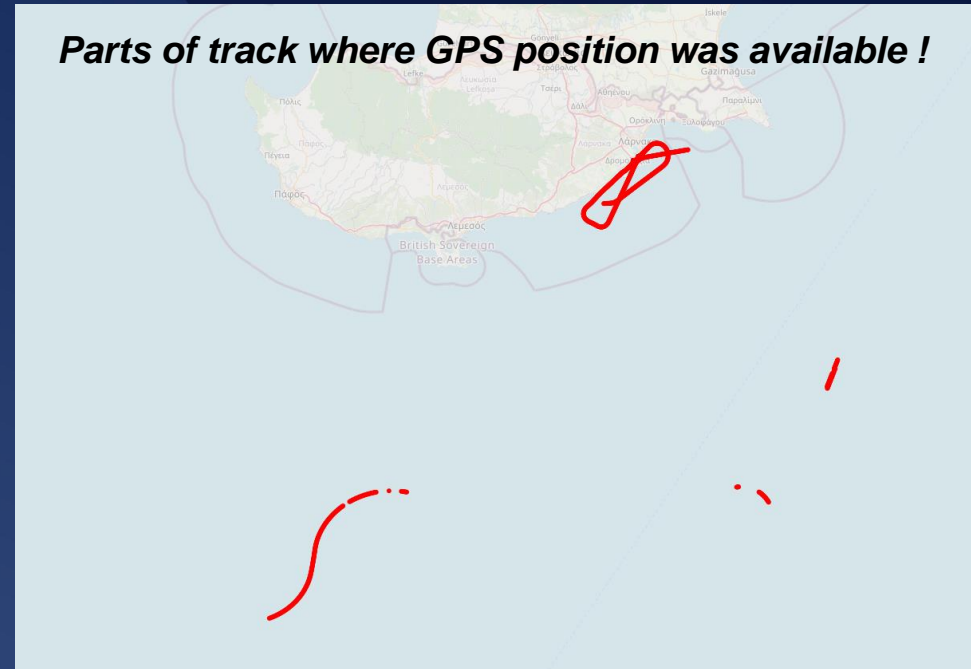
13 FEB 2020 Flight Track



- DLR: German Aerospace Research Center
- Flight conducted in an area about 250km (east-west) x 170km (north-south) between 10'000 – 30'000 ft altitude



Parts of track where GPS position was available !



- GNSS signal reception heavily affected for most part of the flight
- Multiple GPS-related alerts in cockpit (GPS 1 Fault, GPS 2 Fault, GPS Primary Lost)



Catherine Dunn, Fortune Magazine, "Mysterious GPS outages are wracking the shipping industry", 22 January 2020

GNSS RFI in Africa

Apply : ICAO DOC 9849, GNSS RFI Mitigation Plan

- Impact of outages: [GNSS Reversion Handbook](#)
- Build an equivalent to EVAIR
- Mitigation: checklists in Appendix F of ICAO Doc 9849
- Basic step = legal framework:
 - Laws forbidding the use and ownership of jammers
 - Ensure decent location privacy laws to limit people's motivation to jam
 - Check and enforce them e.g. [here](#) and [here](#)
- Civil-military coordination e.g. [UK OFCOM](#)



Mr. Benoit Roturier

Director of Air Navigation Services &
Programme Manager Satellite Navigation

DSNA

EU PBN implementing rule

- ❑ PBN implementing rule 2018/1048, towards “exclusive use of PBN” by 2030
 - ❑ The rule makes **SBAS EGNOS** the required landing system after 2030 for all **Category I operations**,
 - ❑ ANSPs allowed to keep ILS, but only for contingency situations (SBAS not available)
 - ❑ This rule represent an implicit SBAS equipment mandate for African airlines flying to Europe in order to maintain Cat I accessibility
 - ❑ Note: SBAS unequipped airlines will still have access to LNAV or LNAV/VNAV minima
 - ❑ The regulation also requires ANSPs to rationalize ground nav aids networks (ILS, VOR, NDB)
 - ❑ For France the PBN rule applies over more than 200 runway-ends
-

PBN in France

- ❑ **DSNA is a leading ANSP in Europe in term of PBN implementation**
 - ❑ Quantitatively, through the large number of implemented procedures at airports – SID, STAR, RNP APCH
 - ❑ Qualitatively, through the wide variety of actual PBN implementations and new innovations planned
 - ❑ **DSNA has successfully passed the first step of the PBN implementing rule in Europe the 3rd Dec. 2020**
 - ❑ DSNA PBN Transition Plan approved
 - ❑ High success rate of implementing LNAV, LNAV/VNAV and LPV minima as required by regulation
 - ❑ **SBAS is an important system in support of PBN implementation, and DSNA has been an active actor to include SBAS benefits in the context of the global PBN plan.**
-

Contribution of SBAS to PBN in France

DSNA assessed – already a long time ago – 3 main axis of benefits for SBAS within PBN. Also endorsed by the French regulator, and now EU PBN regulation.

- 1. Airport accessibility improvement through “Cat I everywhere, everytime”**
 - 2. Safety improvement, again 3 main axis of benefits:**
 - ☐ 3D vs 2D guidance
 - ☐ 3D Geometric vs 3D Barometric
 - ☐ In line with e.g. IFALPA Position on Implementation of the Future of Air Traffic Operations (1st Edition 20POS08 2 December 2020): *“Currently, Baro VNAV Approaches are subject to temperature and pressure errors which increase the risk. IFALPA supports GBAS/SBAS Geometric Approaches, as a replacement to Baro VNAV Approaches”*
 - ☐ 3D Geometric SBAS vs 3D Geometric ILS
 - ☐ Removal of ILS false axis, more stabilized descents
 - 3. Rationalisation of conventional landing nav aids**
 - ☐ France has removed 50 Cat I ILS (about 50%), and now VOR rationalisation program launched, thanks to PBN/SBAS
-

PBN vs. technology

SBAS has now the potential shown here:

Cat I minima « everywhere , everytime »

Technology

Minima

ABAS		400 – 600 ft DH
ABAS + BaroVNAV		350 – 400 ft DH
SBAS		250 – 300 ft DH
SBAS/GBAS Cat I		200 ft DH
GBAS Cat II/III		200 – 0 ft

**On-going
EU R&D**

Cat II/III

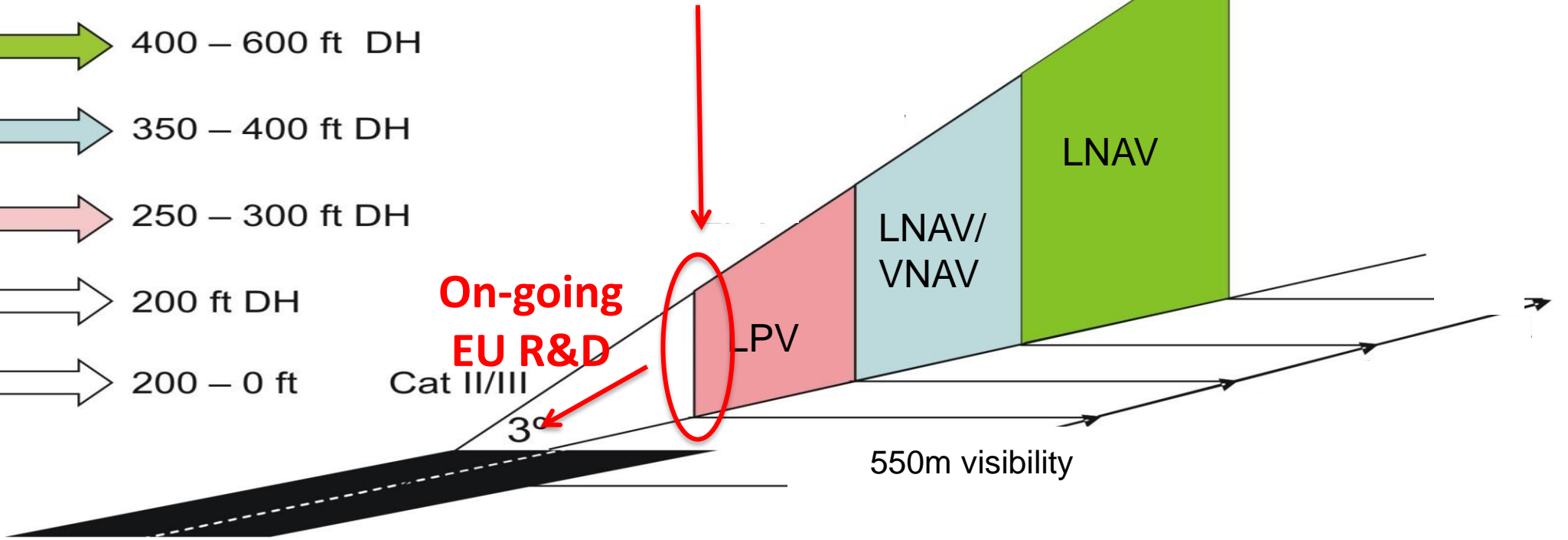
3°

LPV

LNAV/
VNAV

LNAV

550m visibility



GBAS in France

❑ GBAS Cat I

- ❑ The business case is quite limited in Europe, due to existing ILS Cat I + PBN regulation + GBAS costs
 - ❑ 2M€ per airport: much too expensive for small airports lacking ILS
- ❑ Currently no DSNA plans to implement GBAS Cat I

❑ GBAS Cat III

- ❑ DSNA main interest is for Paris CDG at the moment
 - ❑ Strategic interest is alleviate the dependency over ILS in the future for very big airports
 - ❑ Foreseen to remove 4 ILS Cat III over the 8 ILS Cat III existing today at CDG
 - ❑ But costs still very high (estimated 12 M€ for a dual GBAS Cat III configuration at CDG)
 - ❑ DSNA is joining the GBAS Alliance with IATA, Spain, Italy and German ANSPs/airports
 - ❑ Currently seeking support from European Commission, in order to find a financing solution for the future network of GBAS Cat III, in addition to ILS that we have yet to maintain in operation
 - ❑ DSNA participating to European projects evaluating the potential to support Cat II or Cat III operations through SBAS for smaller airports
 - ❑ GSA DFMC SBAS Cat II project
 - ❑ SESAR Augmented Approach to Land phase 2 - film now released: <https://youtu.be/595TxKcMSsQ>
-



Mr. Jeffrey Matshoba

Executive ATM/CNS Planning and
Standards

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European Commission



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Ms. Boni Dibate

Director Africa Affairs

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