SBAS services
global status and plans

Outreach event on SBAS adoption in aviation
2 December 2021
EGNOS workshop 2021

prepared by SBAS IWG

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SBAS Background

- Satellite Based Augmentation System (SBAS) provides the accuracy, integrity, service continuity and availability needed to rely on Global Navigation Satellite System (GNSS) navigation for all phases of flight, from en-route through Category I equivalent approach
- SBAS technology provides the opportunity to cover very large areas of airspace and areas formerly not served by other navigation aids
- SBAS adds increased capability, flexibility, and often, more cost-effective navigation options than adding additional legacy ground-based navigation aids

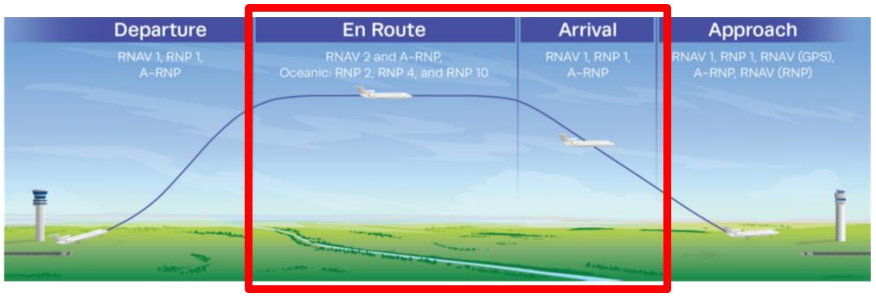
SBAS Background

- ICAO SARPs provides overarching standards and guidance for Global SBAS implementation
- Supports safe Area Navigation (RNAV) and Required Navigation Performance (RNP) operations for En-route through Category-1 Precision Approach flight operations
- Free from direct user charges worldwide
- Increasing SBAS system deployments indicate that SBAS services will be available for many years
- SBAS can provide benefits to airlines, air traffic management, and air navigation
- SBAS can be used in many non-aviation applications

SBAS IWG

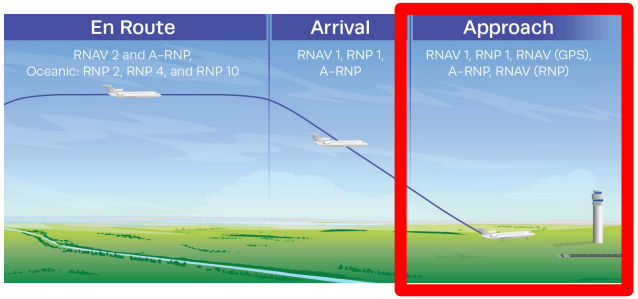
- SBAS IWG provides a forum for SBAS service providers to support:
  - common understanding and implementation of the aviation standards
  - technical interoperability to enable use of a single avionics technology designed for seamless transition between SBAS service areas
  - cooperation on SBAS development and services provision

SBAS benefits (airlines)



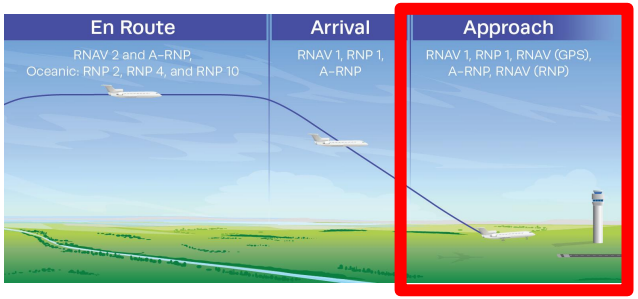
- SBAS is a primary navigation system
  - Position source to meet the most stringent navigation and Automatic Dependent Surveillance – Broadcast (ADS-B) requirements
  - Eliminates the operational requirement to ensure GPS availability using RAIM prediction tools
- SBAS supports Performance Based Navigation (PBN) capability and improves RNAV and RNP capability
- Low cost equipage solution to achieve Required Navigation Performance (RNP)

SBAS benefits (airlines)



- Enables RNP approach operations to lower minima
  - LP, LPV, and LPV-200/Category 1
    - Runways still require appropriate infrastructure
  - Lower minima for many non-ILS equipped runways
- Potential to reduced operational costs
  - Provides for best PBN capability (airport accessibility and improved safety)
  - Increased options for alternate runways
  - Lower fuel load requirements and increased dispatch reliability
  - Reduced diversion when ILS is unavailable

SBAS benefits (airlines)



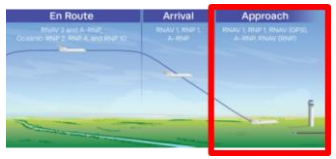
- Enabler for RNP Authorization Required (AR) operations
- SBAS provides geometric guidance, and is not impacted by barometric pressure, temperature fluctuations or barometric mis-setting

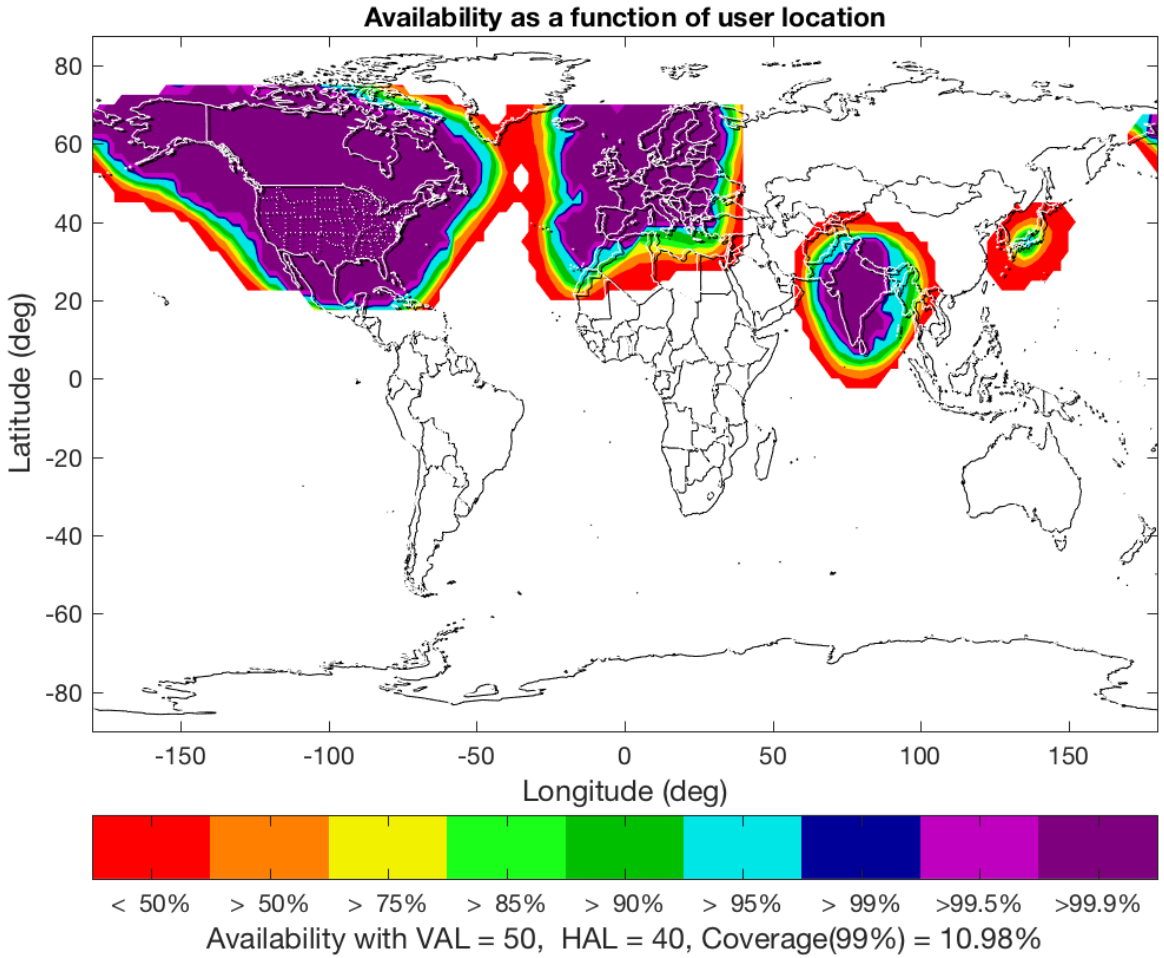
SBAS Benefits (ANSPs)

- SBAS is a regional navigation service
- SBAS service does not require the installation or maintenance of ground-based navigation aids or landing systems
  - 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 or advanced procedures
  - Approaches to runways unable to site or install an Instrument Landing System (ILS)
  - RNP to xLS transitions
  - Noise and environmental efficient approach paths

ANSPs recognize the potential and are expanding SBAS offerings => SBAS as a worldwide solution

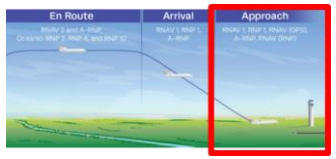
Current SBAS approach/landing services

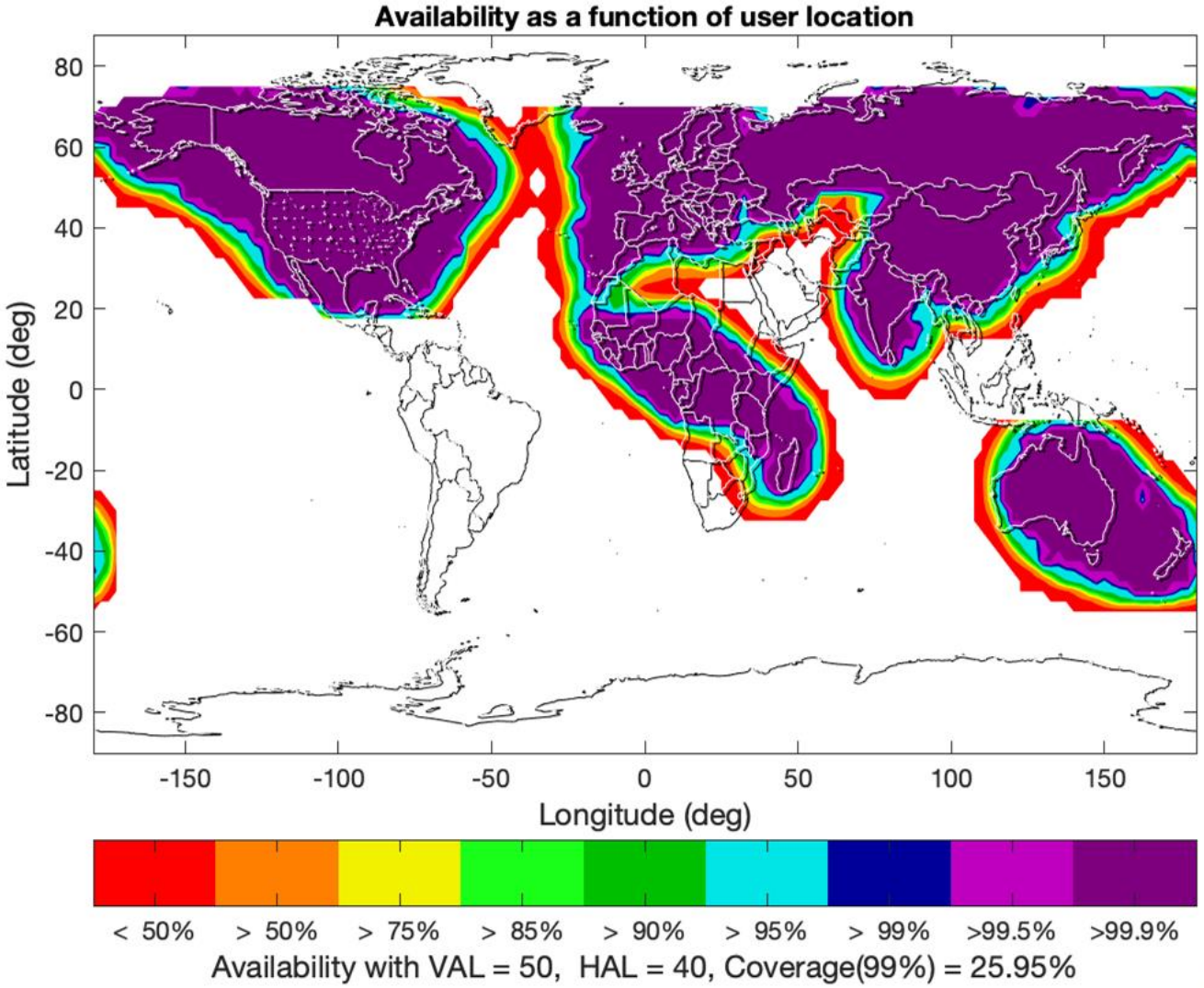




Nominal LPV Approach Service Availability with LPV-capable SBAS receivers in June 2019

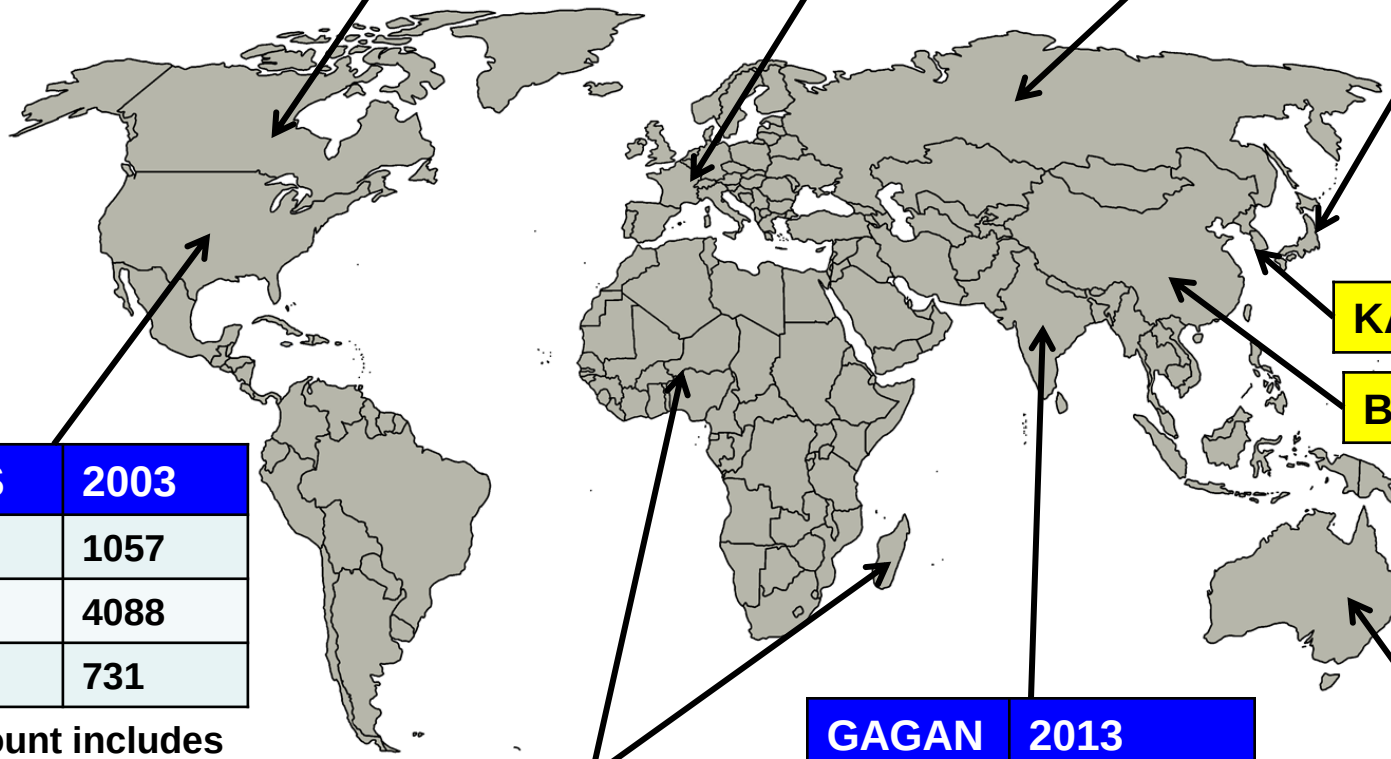
Planned SBAS services





Modeled Approach Service Availability with LPV-capable SBAS receivers in 2-4 years

Published SBAS Procedures



Operational
Planned Year

CWAAS	2007
LPV	656

EGNOS	2011
Cat-I	304
LPV	740*

SDCM	

MSAS	2007
NPA only	
LPV	2023

KASS	2023

BDSBAS	2024

WAAS	2003
Cat-I	1057
LPV*	4088
LP	731

*LPV count includes Category 1 approaches

A-SBAS	2025

GAGAN	2013
LPV	65 Pending publication

SouthPAN	2027

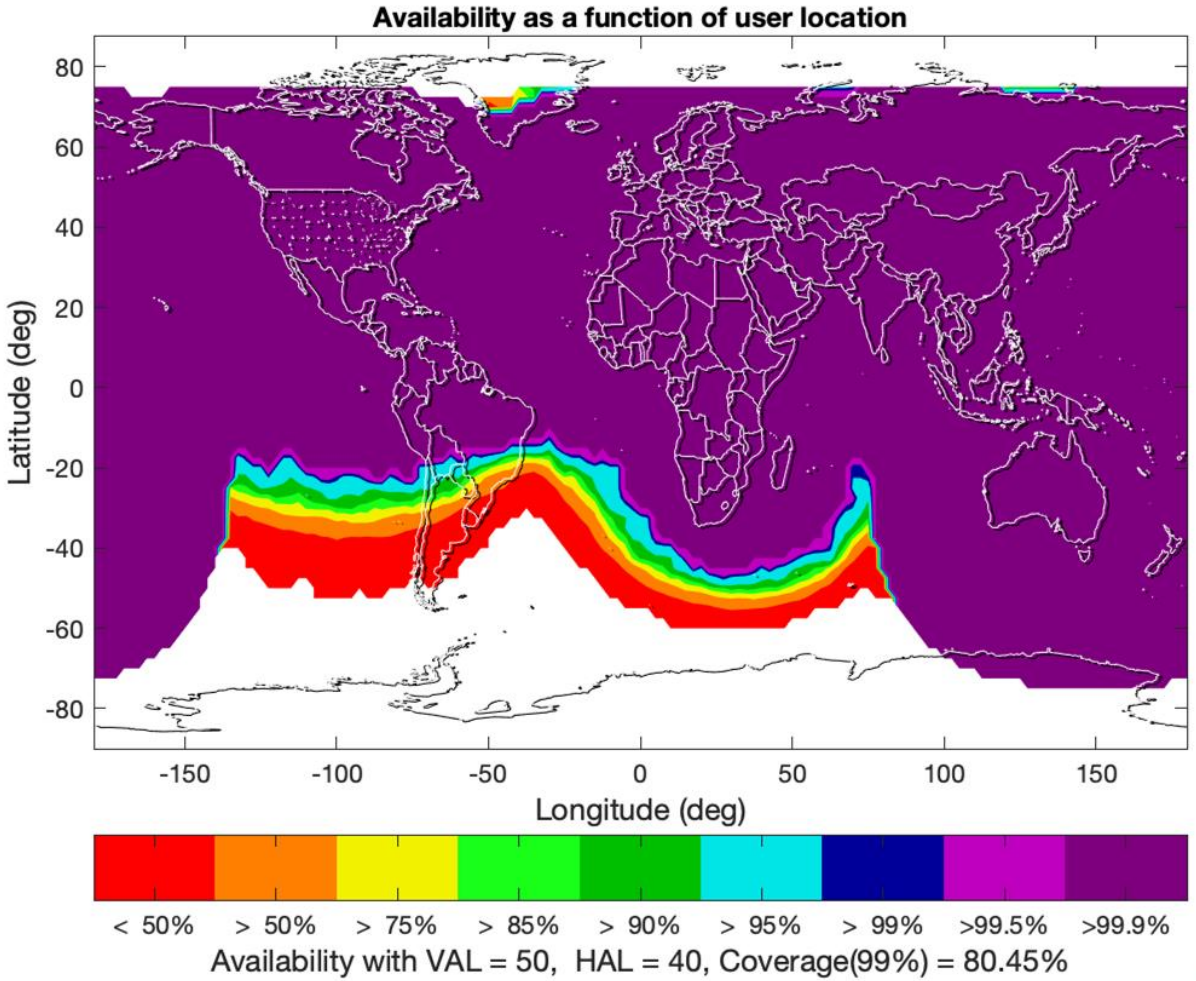
Localizer Performance (LP) with vertical guidance (LPV)

SBAS evolution
Dual Frequency Multiple Constellation

- GNSS Dual Frequency Operations
  - Standards to enable augmentation of multiple constellations by SBAS
    - DFMC SARPs amendment approved by ICAO NSP in Nov 2020
      - Will be effective in Nov 2023
    - Joint EUROCAE/RTCA MOPS to be available from 2022
  - Increases SBAS availability and performance by direct avionics correction of ionospheric signal delay
    - Specifically during ionospheric storms and in equatorial regions
  - Improves robustness against unintentional interference
  - Provide continued support to legacy L1-only users
  - Progressive services provision from 2026
  - Projecting readiness of approved certified DFMC user equipment around 2027

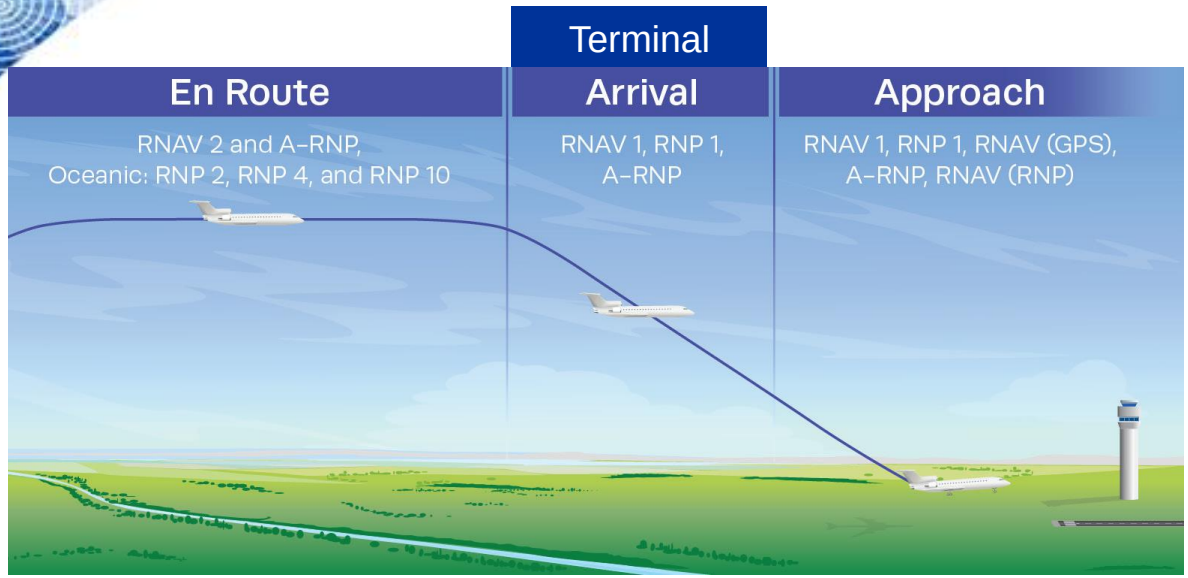
The slide that follows shows a progression of scenarios in which combined SBAS coverage can provide LPV service. These scenarios are based on a generalized set of assumptions across all systems and may not represent program plans of individual SBAS providers.

SBAS evolution
Dual Frequency / Dual Constellation



This slide shows the combined SBAS LPV service is all SBAS provide a dual-frequency multiple constellation service. This scenario is based on a generalized set of assumptions across all systems and may not represent program plans of individual SBAS providers.

SBAS Equipment Considerations



Class 1 – Oceanic to Approach (LNAV)

Class 2 – Oceanic to Approach (LNAV/VNAV)

Class 3 - Oceanic to Approach (LNAV/VNAV, LP, LPV)

Class Beta-1/2/3 (Sensor) TSO-145

Class Gamma-1/2/3 (Sensor + Display) TSO-146

Class Delta 4 (Approach Sensor) TSO-146

Lateral Navigation (LNAV) / Vertical Navigation (VNAV)

SBAS Equipment Considerations

- SBAS receivers are designed to select the designated system for RNP approach operations to LPV minima
  - Uses information from the Final Approach Segment Data Block

- Expanding SBAS Satellite Tracking
  - Legacy DO-229D compliant equipment can only use SBAS satellites from the legacy list of SBAS satellite codes.
  - **New receivers shall be DO-229E compliant to track all future SBAS satellite codes**

Conclusion

- SBAS offers significant benefits to aviation
  - Enhances PBN operations for all phases of flight, from en-route through Category I equivalent approach
  - Position source to meet the most stringent ADS-B requirements
  - Vertically guided approaches up to Category I minima
- Expanding availability of safe SBAS approaches worldwide
  - Four operational systems with plans for continued improvement and additional procedures
    - Europe (EGNOS), US (WAAS), India (GAGAN), Japan (MSAS)
  - New systems in procurement
    - China (BDSBAS), Korea (KASS), Africa (A-SBAS), Russia (SDCM), Australia/NZ (SouthPAN)

Benefits will be available to Aircraft operators that begin to integrate SBAS in their navigation strategy **now**

BACKUP

SBAS IWG objectives

- SBAS IWG specific objectives
  - Objective 1: Harmonize SBAS modernization plans
  - Objective 2: Forum for discussion on SBAS requirements
  - Objective 3: Harmonize technical improvements based upon operational and user feedback
  - Objective 4: Research and Development (R&D) cooperation on key SBAS technologies
  - Objective 5: Support joint SBAS promotion

SBAS IWG participants

- Current and future SBAS services providers:

Identifier	SBAS System (Provider)
0	WAAS (US)
1	EGNOS (Europe)
2	MSAS (Japan)
3	GAGAN (India)
4	SDCM (Russia)
5	BDSBAS (China)
6	KASS (Korea)
7	A-SBAS (Africa)
8	SouthPAN (Australia/NZ)

Assigned ICAO Service Provider Identifiers (see ICAO Annex 10)

SBAS Status:
Systems Under Development

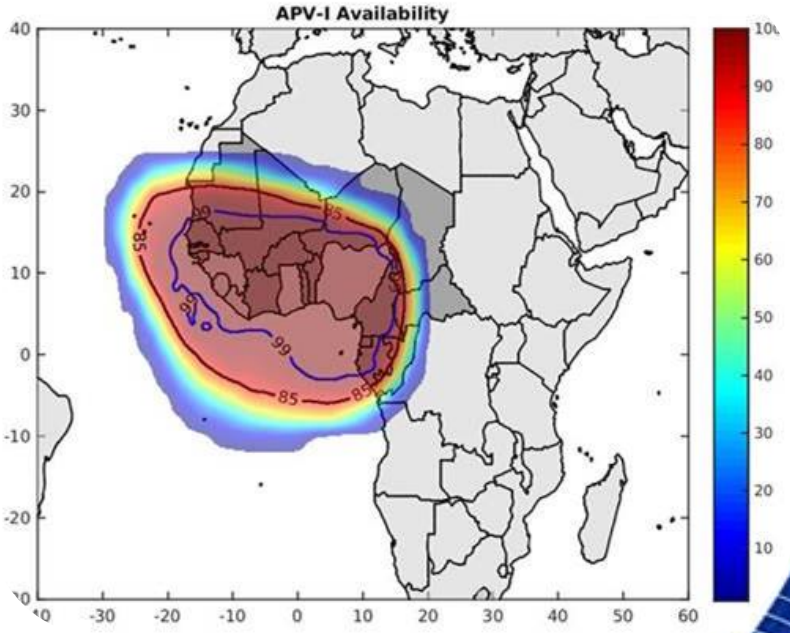
- BDSBAS - China
  - In development with the plan to support en-route, terminal and approach
  - All 3 GEOs with orbital slots 80° E, 110.5° E, and 140° E have been successfully launched and completed in-orbit tests
  - 27 monitoring stations, 2 data processing centers, 1 operation control center and 3 uplink stations have been deployed
  - On-air testing with the BDSBAS SF and DFMC services started June 2020
  - Certification for BDSBAS SF service expected in 3-4 years

SBAS Status:
Systems Under Development

- Korean Augmentation Satellite System (KASS) - Korea
  - In development with plans for supporting en-route, terminal and approach operations in Korea
  - Program kick-off in October 2014, Preliminary Design Review in April 2017
  - Malaysian Measat-3D will be the first KASS satellite, with a launch date in early 2022
  - SBAS services provision objectives
    - Full APV services by 2023

SBAS Status:
Systems Under Development

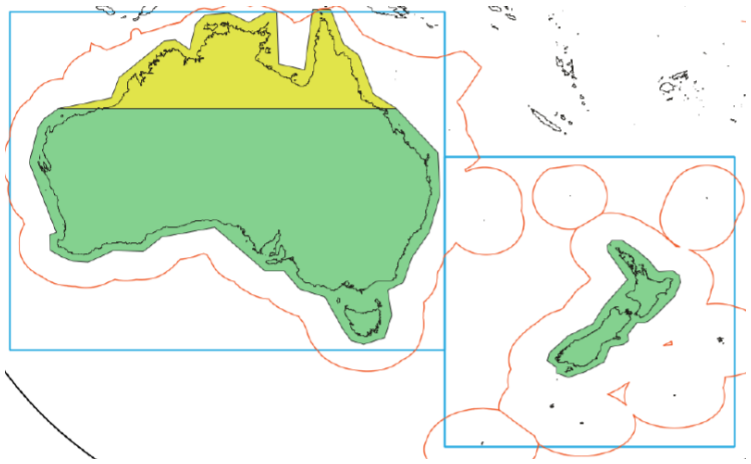
- A-SBAS - Agency for Air Navigation Safety in Africa and Madagascar (ASECNA)
  - 18 Member States in Africa & Indian Ocean
  - In development with plans for supporting en-route down to Cat-1 operations in the ASECNA area of responsibility (18 Member States, 6 Flight Information Regions, 16 million km^2) with a potential progressive coverage to the continent:
    - Early open/pre-operational SBAS services (L1) available since September 2020
    - Operational SBAS services (L1) from 2025
    - Operational SBAS services (DFMC) beyond the horizon 2028/2030



A-SBAS pre-operational APV-1 service

SBAS Status:
Systems Under Development

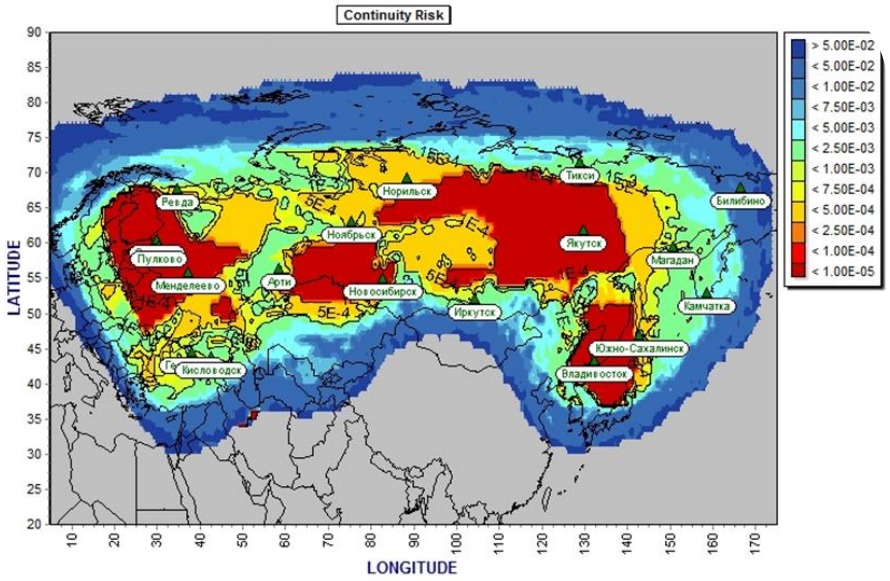
- Southern Positioning Augmentation Network (SouthPAN) - Australia and New Zealand
  - In development for en-route, Terminal, and RNP approach to 200-ft minima
  - Testbed program commenced in February 2017 with L1 GPS, L1/L5 GPS + E1/E5a GAL, L1 GPS PPP, and L5 GPS + GAL PPP services
  - Whole-of-industry approach to a National Positioning Infrastructure Capability led by Geoscience Australia and Land Information New Zealand, with support from the Civil Aviation Safety Authority, Airservices Australia, NZ Civil Aviation Authority, Airways NZ, and other industry organisations
  - Acquisition program commenced July 2018, full services planned for 2027
  - Satellite transponder secured (I4F1) to aid integration and testing activities
  - More information is available on http://www.ga.gov.au/scientific-topics/positioning-navigation/positioning-for-the-future/satellite-based-augmentation-system



*Predicted **NPA** & **LPV-200** Service Areas*

SBAS Status:
Systems Under Development

- System of Differential Correction and Monitoring (SDCM) - Russia
  - In development with plans for horizontal and vertical guidance (APV-1)
    - Completed system test, undergoing system certification through 2020
    - Initial service will be L1 SBAS coverage over Russian territory
  - L1/L5 SBAS service and L1/L3 GLONASS precise point positioning service planned



APV-1 Continuity Risk

SDCM (IWG-25 Brief - SDCM 25-27 Jun 2013 ENG)

SBAS Status:
Potential future systems

- EGNOS in Africa Programme - Africa & Indian Ocean region
  - Initiative for SBAS/EGNOS development and services provision in Africa, beyond ASECNA area of responsibility
  - Coordinated and supported by the pan-African instrument “EGNOS-Africa Joint Programme Office” through Africa-EU Strategic Partnership

Modular approach foreseen

Indicative only- approach

DFMC services foreseen

- OS GPS, GPS+GALILEO by 2025
- SoL NPA GPS, GPS+GALILEO by 2026
- SoL NPA+APV1+LPV200 GPS, GPS+GALILEO by 2028