Global SBAS Status

Satellite Based Augmentation System (SBAS)
Interoperability Working Group (IWG)

June 2014

Agenda

- Background
- Benefits
- Interoperability
- System Status
- System Evolution
- Issues

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 can be used in many non-aviation applications

SBAS Background

- International Civil Aviation Organization (ICAO) Standards And Recommended Practices (SARPs) provides overarching standards and guidance for Global SBAS implementation
- SARPs criteria define Approach with Vertical guidance (APV) as being a stabilized descent using vertical guidance
- SBAS Interoperability Working Group (IWG) is the forum for SBAS service providers to assure common understanding and implementation of the SARPs
- IWG forum allows coordination to enable use of a single avionics technology designed to easily transition from one SBAS region to another

SBAS Benefits

- SBAS service is available for free
- SBAS supports Performance Based Navigation (PBN) capability
  - PBN improves efficiency and capacity while reducing environmental impacts
- SBAS is a low cost equipage solution to achieve Required Navigation Performance (RNP)
- SBAS clock and ephemeris corrections improve the availability of RNP for users throughout the entire GEO footprint

SBAS Benefits

- SBAS equipment provides position accuracy and integrity sufficient to meet ADS-B surveillance requirements
- SBAS is an enabler for Federal Aviation Administration (FAA) Next Generation Transportation System (NEXTGEN) and the European Commission (EC) Single European Sky Air Traffic Management Research (SESAR)

SBAS Benefits

- SBAS can support the decommissioning of ground-based Navigation Aids (NAVAIDs)
- SBAS benefits extend beyond aviation to all modes of transportation, including maritime, highways, and railroads
- SBAS benefits also extend to applications other than transportation

SBAS Benefits beyond aviation

- Proven enhancement of position accuracy wrt GPS on average in different environments
- No extra costs in new systems (consumer-grade chipsets SBAS-enabled, just requiring a suitable configuration)
- Enabling to enhance performance of present commercial applications using GPS
- Capability to implement customized solutions for the delivery of added value services further exploiting SBAS features

SBAS Benefits beyond aviation, ex. road and freights transport

More robust localization and monitoring, enabling:

- Better control and support to law enforcement and
- Enhanced management/planning
- Higher safety
- Provision of added value commercial services

SBAS Benefits – En Route/Terminal

- SBAS is a primary navigation system
- SBAS provides Area Navigation (RNAV) and RNP capability
  - Improves availability for all RNAV routes
  - Eliminates the operational requirement to ensure GPS availability using RAIM prediction tools
  - Flexibility to design more efficient airspace and instrument procedures
- Significant potential reduction in track dispersion
- Supports Trajectory Based Operations (TBO)
  - 4-D Operations (Continuous Descent Approach (CDA))
  - Significant reductions in fuel consumption

SBAS Benefits - Approach

- Supports RNP approaches down to LNAV, LNAV/VNAV, LP and LPV minima.
- Provides Category I (CAT I) equivalent vertical guidance at any qualifying runway
  - Localizer Performance with Vertical guidance (LPV)
  - SBAS service does not require the installation or maintenance of ground-based landing system navigation aids
- SBAS position and guidance do not change with barometric and temperature fluctuations and are not impacted with improper aircraft barometric altimeter settings
- SBAS guidance requires no airport “critical areas” and has the potential to improve runway throughput
- SBAS can support RNP AR operations

SBAS Interoperability - SARPs

- ICAO SARPs Annex 10 and Aviation Minimum Operational Performance Standards support the interoperability of different SBAS systems
  - Seamless transition between SBAS service areas

SBAS Interoperability Working Group (IWG)

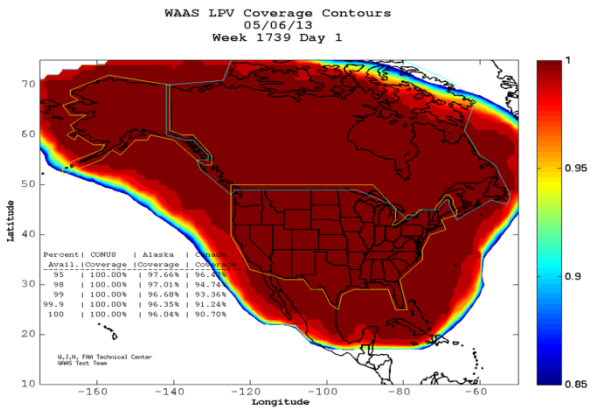
- SBAS IWG objectives established to support technical interoperability and cooperation
  - Objective 1: Harmonize SBAS modernization plans
  - Objective 2: Forum for discussion on SBAS requirements
  - Objective 3: Harmonize technical improvements based upon operational and user feedback
  - Objective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

SBAS Status:
Operational Systems

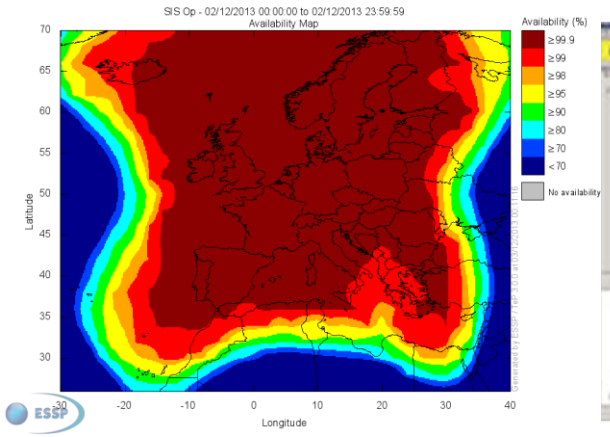
- Wide Area Augmentation System (WAAS) – United States
  - Operational since 2003
  - Supports en route, terminal and approach operations
    - CAT I-like approach capability (LPV-200)
- Multi-function Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS) - Japan
  - Operational since 2007
  - Supports en route, terminal and non-precision approach operations
- European Geostationary Navigation Overlay Service (EGNOS) – European Union
  - Open Service was declared in October 2009
  - Safety-Of-Life Service has been operational since March 2011
  - Supports En Route, Terminal and Approach operations
    - APV-1 service level supporting RNP Approaches to LPV minima

Current SBAS Performance

APV-1 Availability



WAAS



EGNOS

MSAS

(Note: Graphic shows Vertical Protection Level

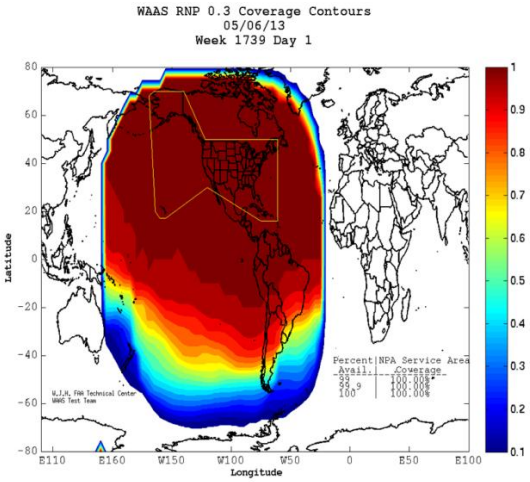
Vertically-guided operations are not yet authorized.)

Sources and additional detail:

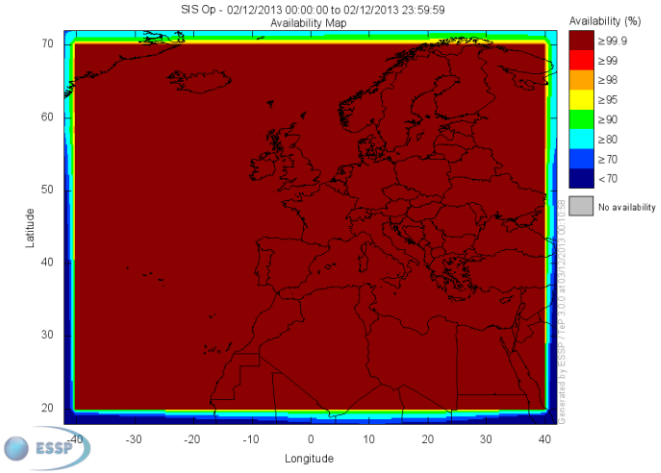
- WAAS LPV Coverage (http://www.nstb.tc.faa.gov/24Hr_WaasLPV.htm)
- EGNOS LPV Coverage (http://egnos-user-support.essp-sas.eu/egnos_ops/node/975)
- MSAS (http://www.nec.com/en/global/solutions/cns-atm/navigation/msv.html)

Current SBAS Performance

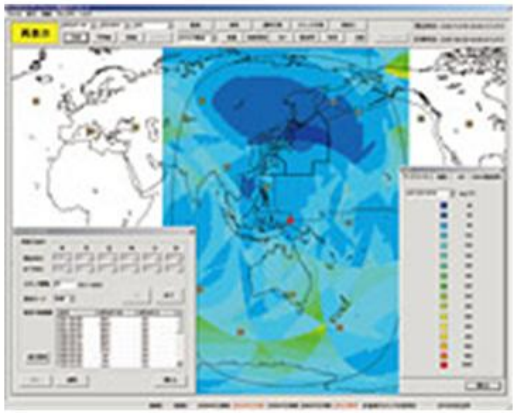
Non-Precision Approach Availability (such as RNP 0.3)



WAAS



EGNOS



MSAS

(Horizontal Protection Level Display)

Sources and additional detail:

- WAAS (http://www.nstb.tc.faa.gov/24Hr_WaasRNP3.htm)
- EGNOS (http://egnos-user-support.essp-sas.eu/egnos_ops/service_performances/global/NPA_availability)
- MSAS (http://www.nec.com/en/global/solutions/cns-atm/navigation/msv.html)

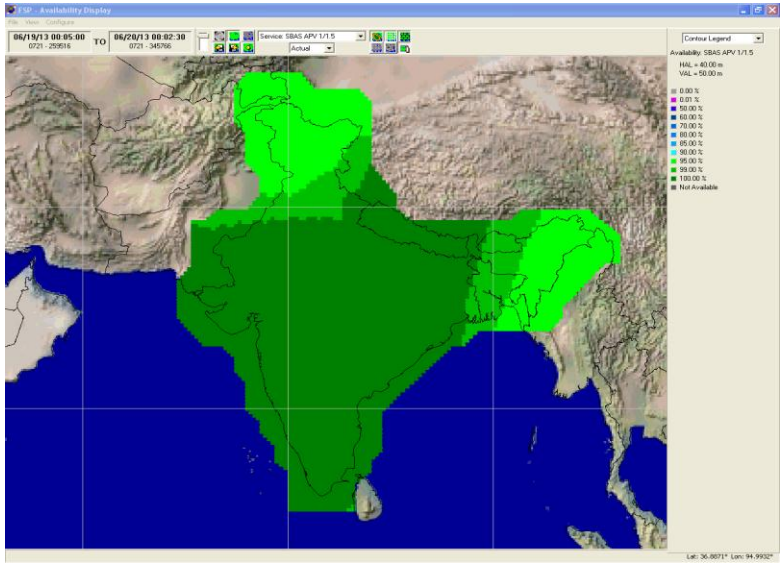
SBAS Status:
Developing Systems

- Global Positioning System (GPS) Aided Geostationary Earth Orbit (GEO) Augmented Navigation (GAGAN) - India
  - In development with plans for horizontal and vertical guidance
  - Completed Final System Acceptance Testing in 2012
  - Completed HMI, SAR documentation needed for Certification
  - Target Certification in 2013
- System of Differential Correction and Monitoring (SDCM) - Russia
  - In development with plans for horizontal and vertical guidance
  - L1 SBAS coverage over Russian territory by 2016
  - L1/L5 SBAS service and L1/L3 GLONASS precise point positioning service in 2018
  - SDCM certification for APV-2

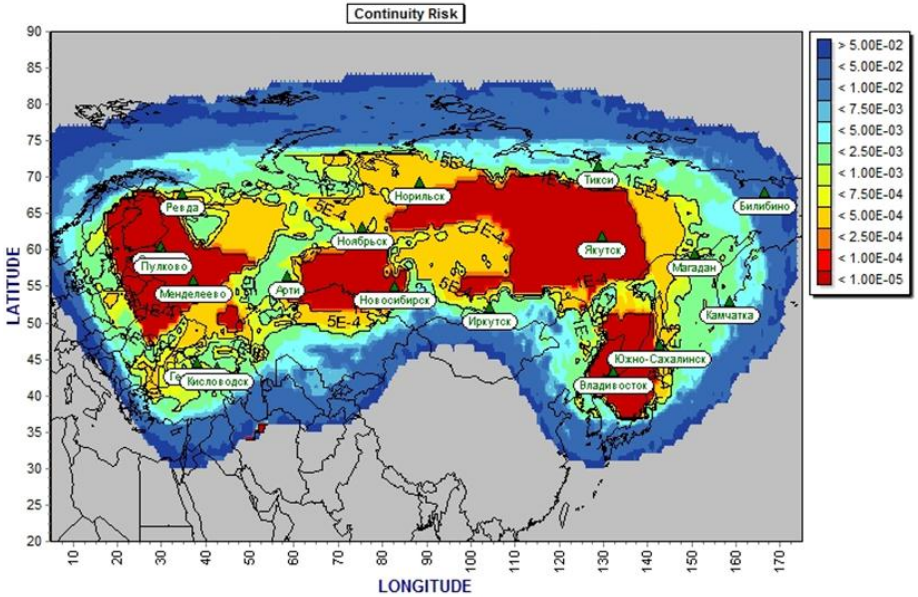
SBAS under development

Anticipated Precision Approach Availability

GAGAN



SDCM



Sources and additional detail:

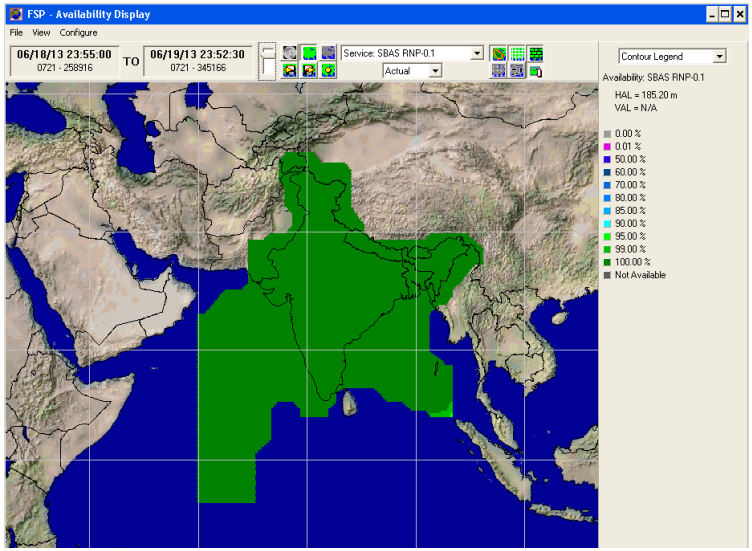
GAGAN (http://www.aai.aero/public_notices/aaisite_test/faq_gagan.jsp)

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

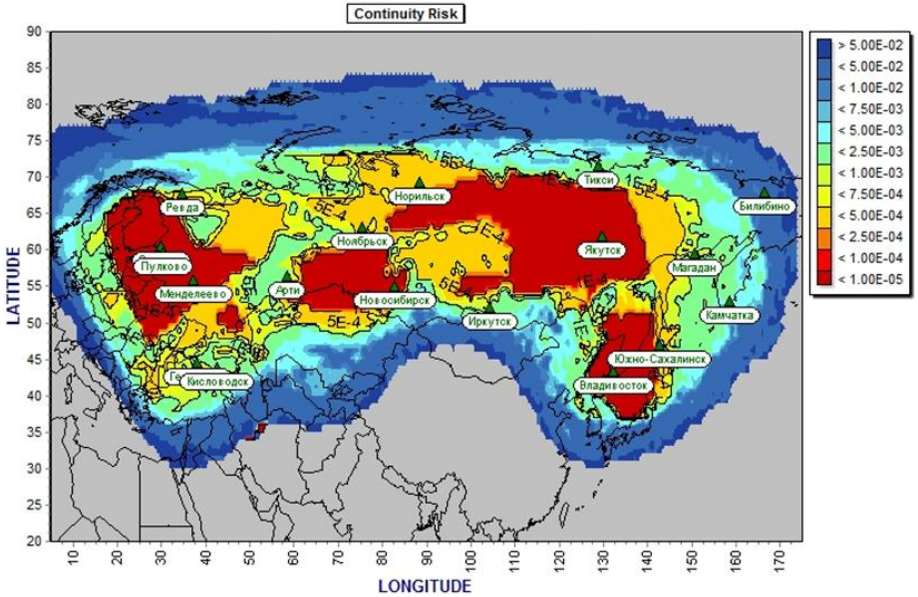
SBAS under development

Non-Precision Approach Availability

GAGAN



SDCM



Sources and additional detail:

GAGAN (http://www.aai.aero/public_notices/aaisite_test/faq_gagan.jsp)

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

SBAS Evolution
Dual Frequency

- GNSS Dual Frequency Operations
  - 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
- SBAS Service Provider Objectives
  - Avionics manufacturers support multi-constellation/multi-frequency avionics as flight-certified navigation solutions
  - Provide continued support to legacy L1-only users
  - Provide an improved level of service for SBAS operations (lower DH)
  - Support cooperative development of future SBAS standards consistent with ICAO Block upgrades

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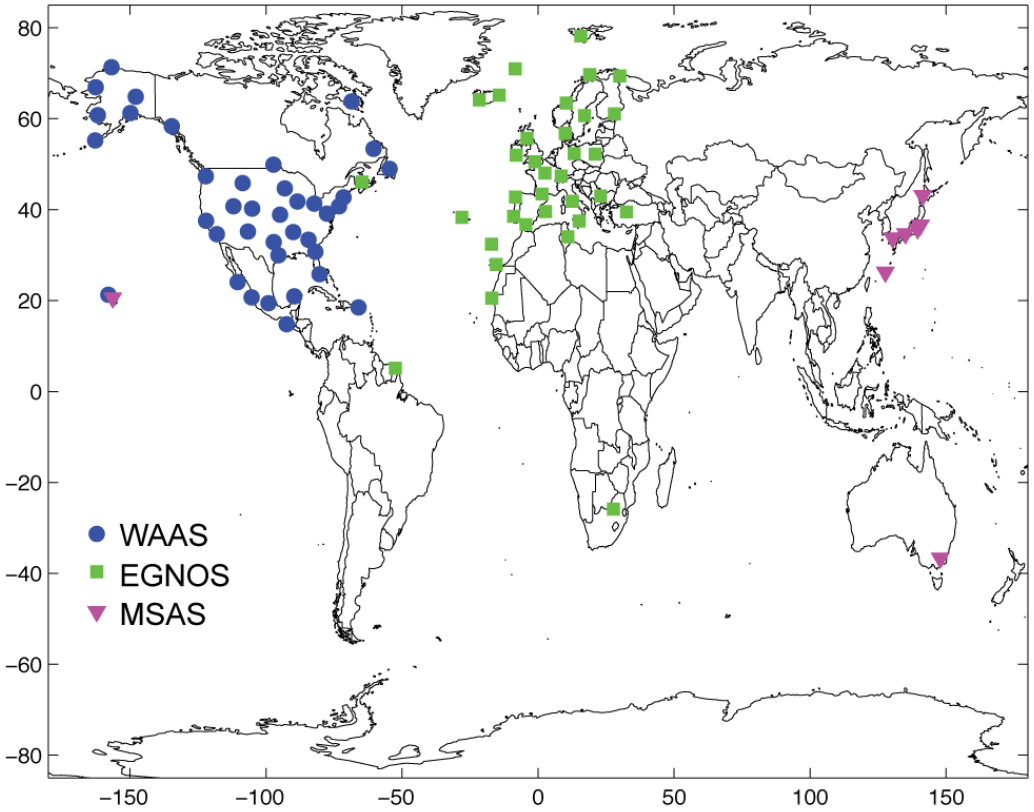
The slides that follow show a progression of scenarios in which combined SBAS coverage can provide LPV-200 service. These scenarios are based on a generalized set of assumptions across all systems and may not represent exact individual SBAS service levels.

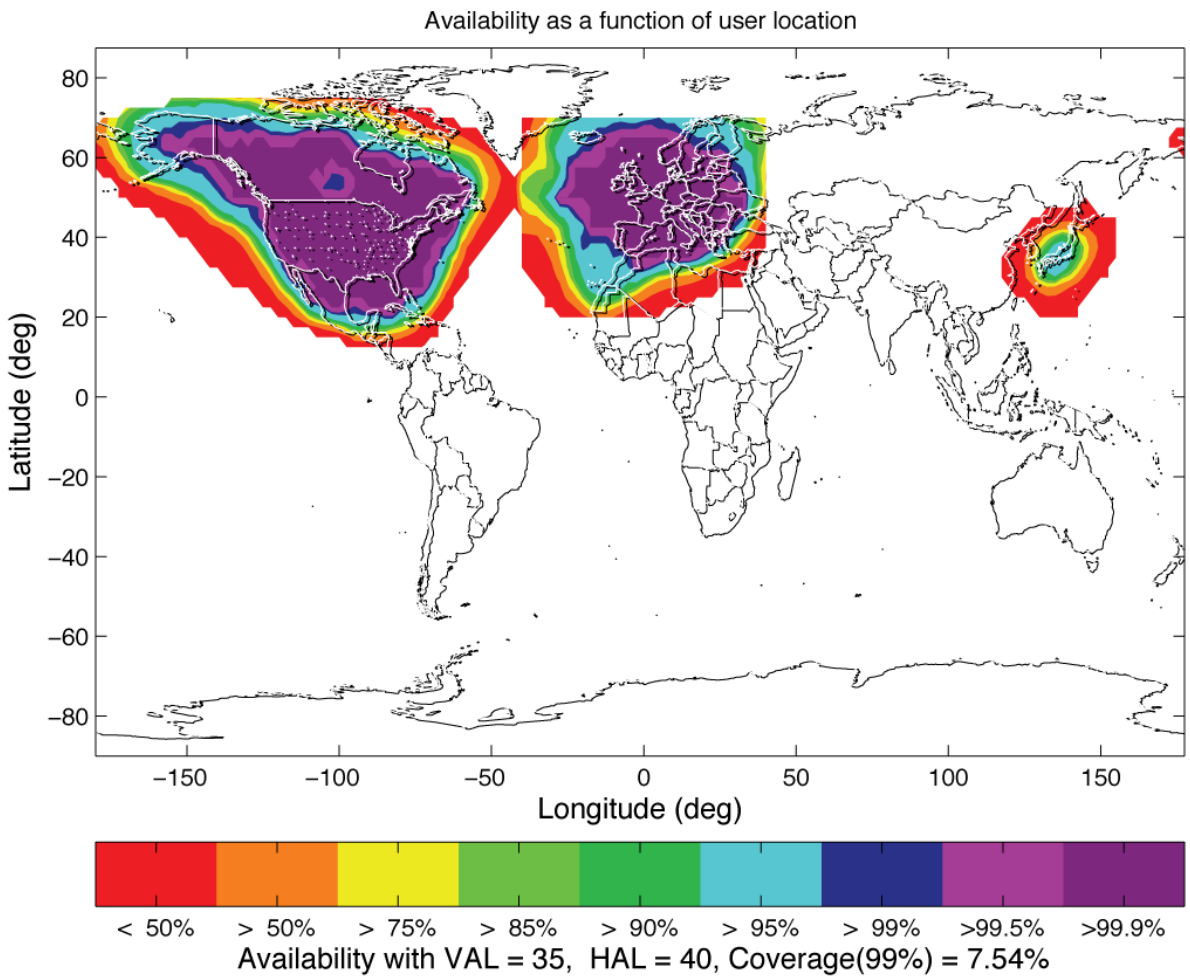
SBAS Evolution
Multiple Constellation

- GNSS Multiple-Constellation Operations
  - Evaluate use of multiple constellations by SBAS
    - Improve broadcast messages to support
    - Define avionics requirements
  - Assess modifications to equipment MOPS
    - Requires inclusion of GNSS constellations in ICAO Annex 10
      - Galileo, Beidou
    - Cost and complexity to implement versus benefit

Current Reference Networks

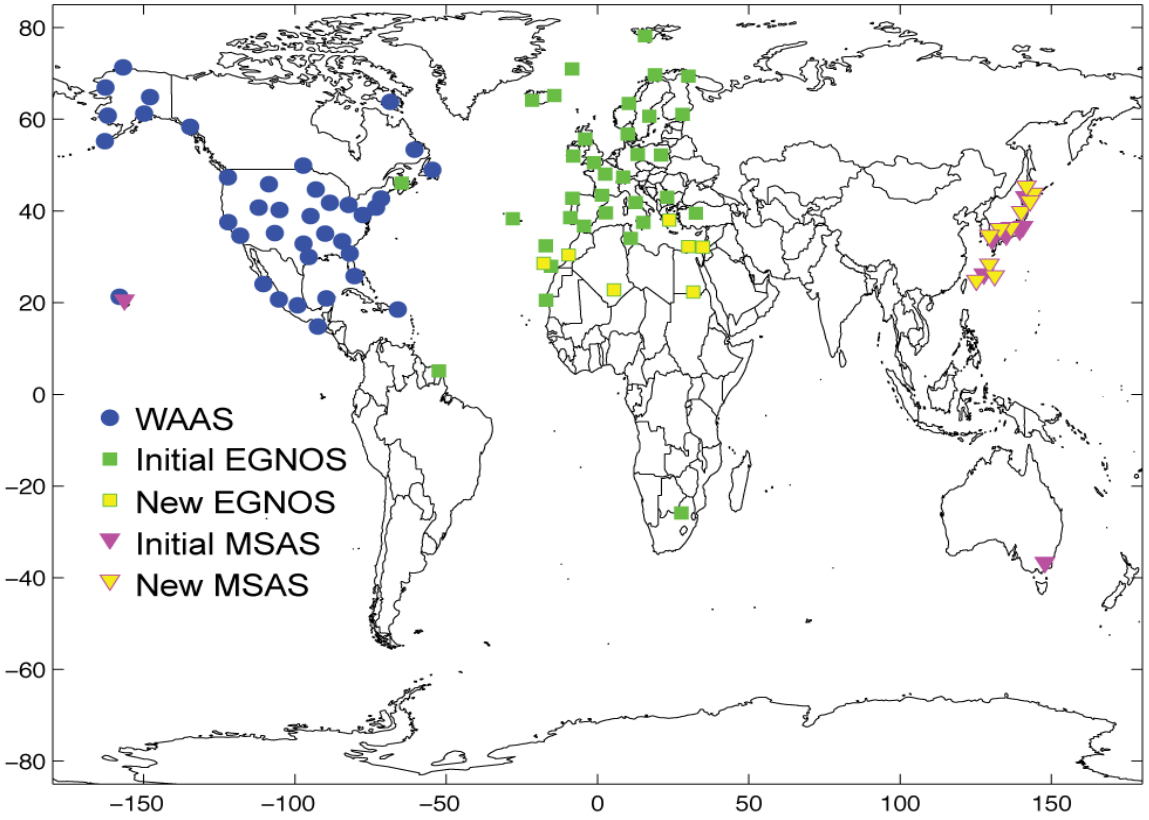


Current Potential Coverage

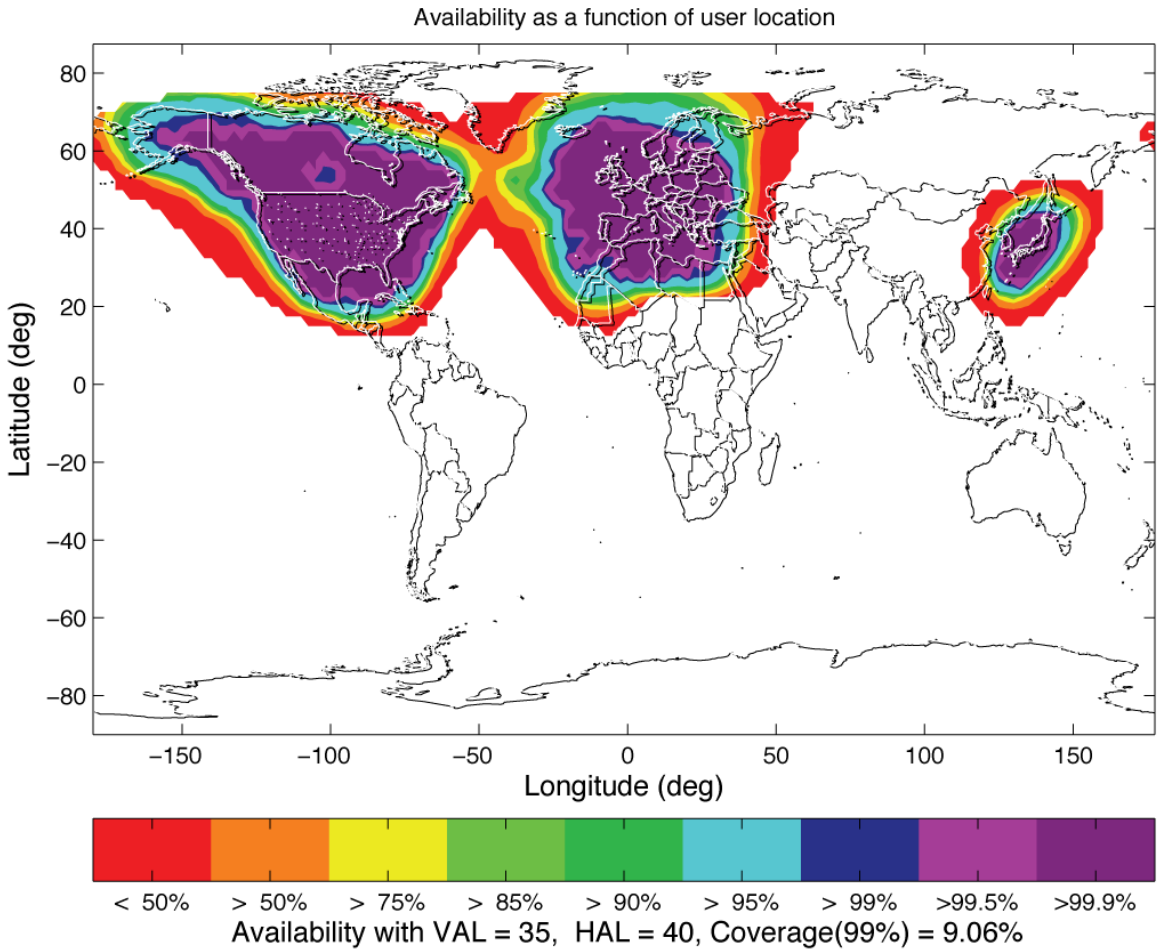


Assessment of potential LPV-200 Service Availability given use of MT-28 and kriging algorithms for ionosphere delay and GIVEs

Current Plans for Expanded Reference Networks

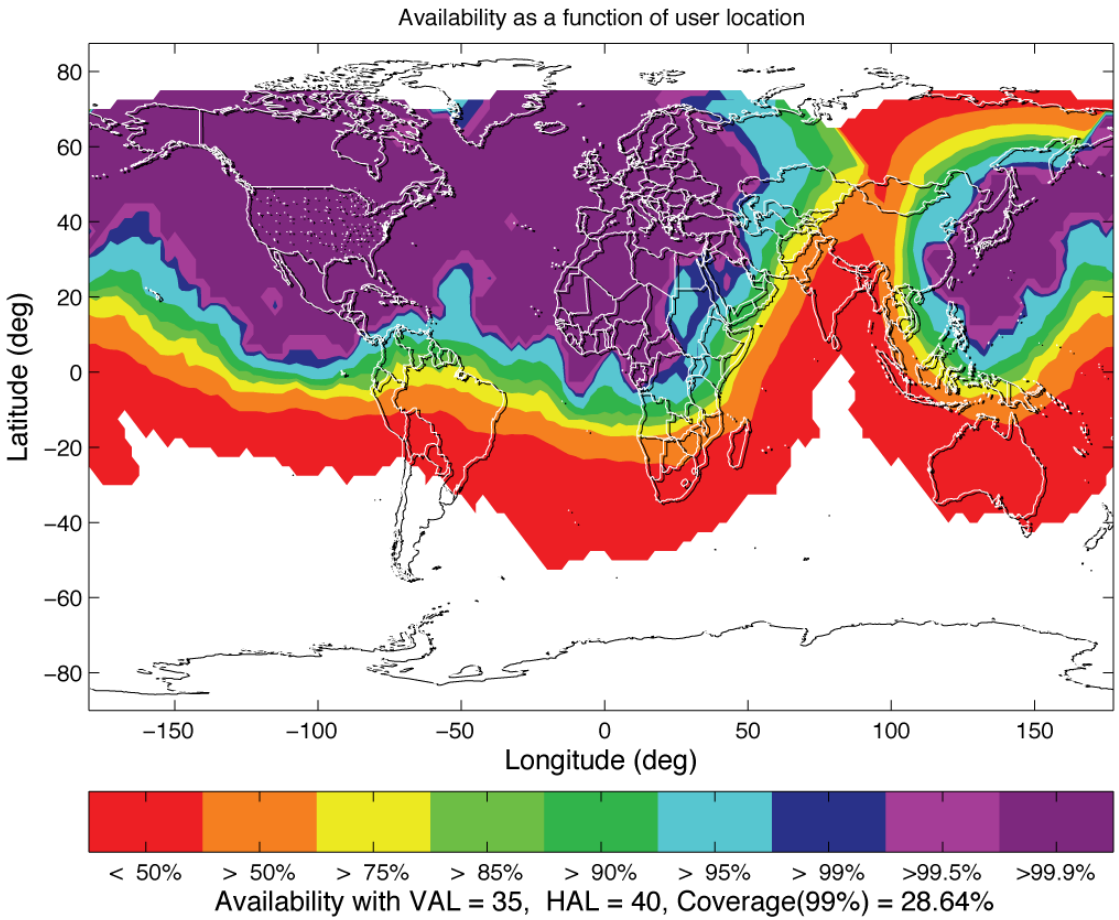


Improved Single Frequency Coverage



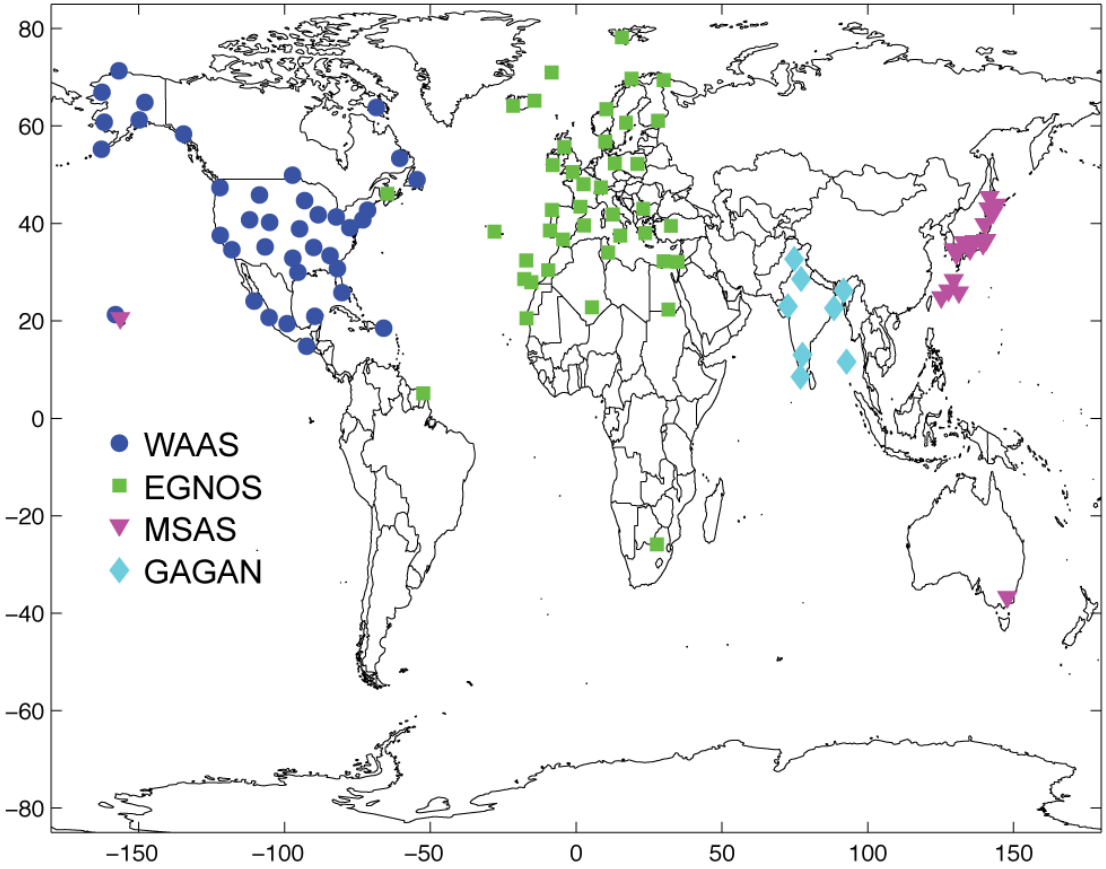
Potential LPV-200 Service Availability with Expanded Networks

Dual Frequency Coverage (WAAS, EGNOS, MSAS)

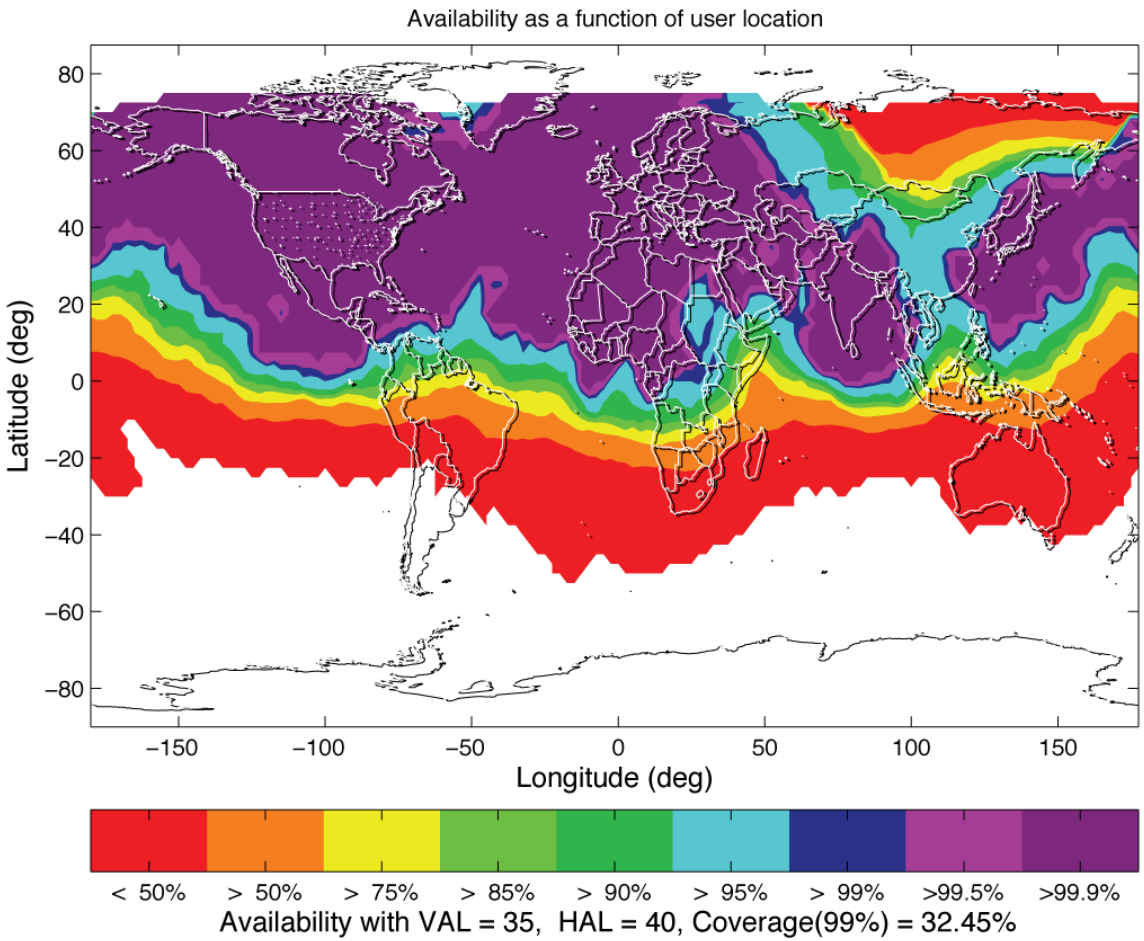


Potential Dual-Frequency
LPV-200 Service Availability

Reference Networks with GAGAN

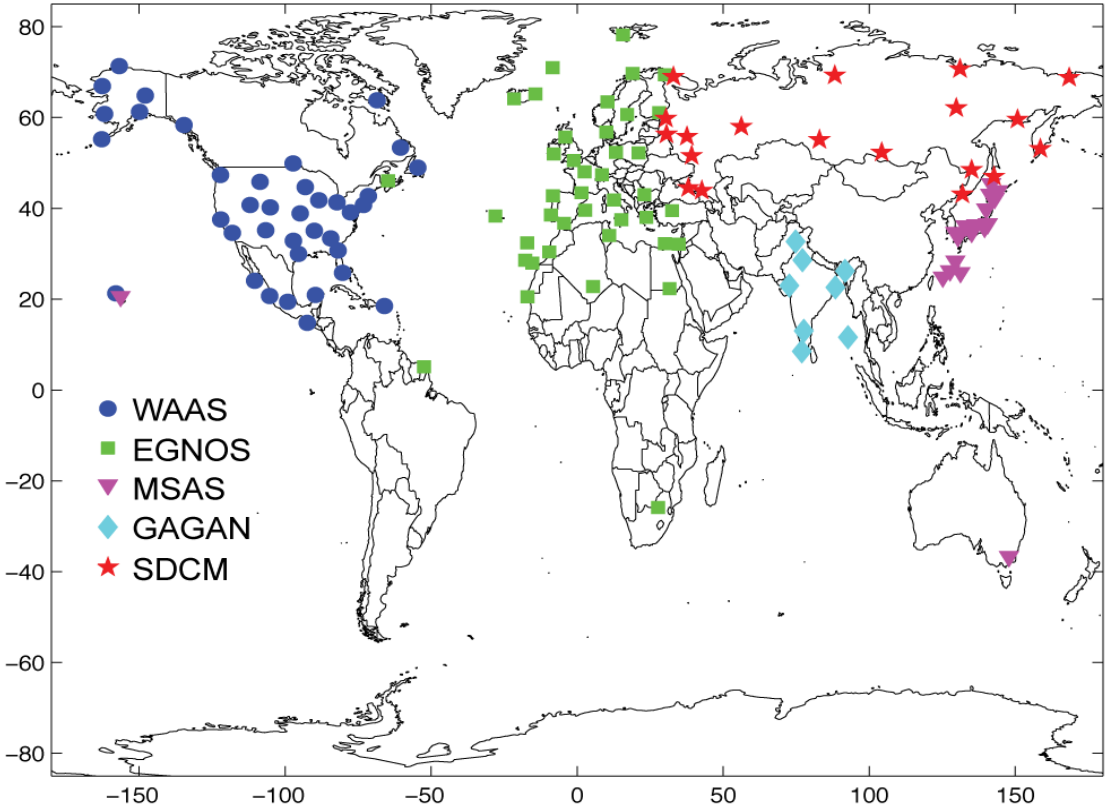


Dual Frequency Coverage (with GAGAN)

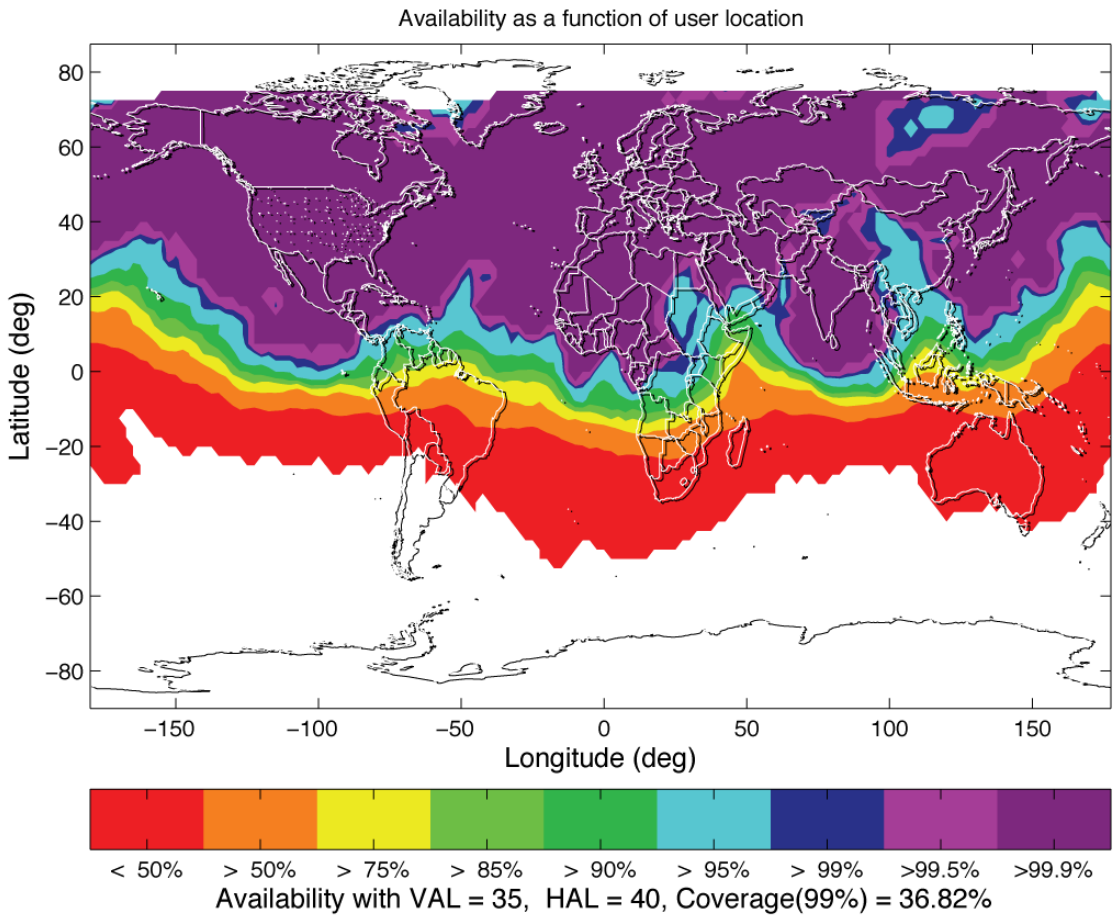


LPV-200 Service Availability

Reference Networks with GAGAN and SDCM

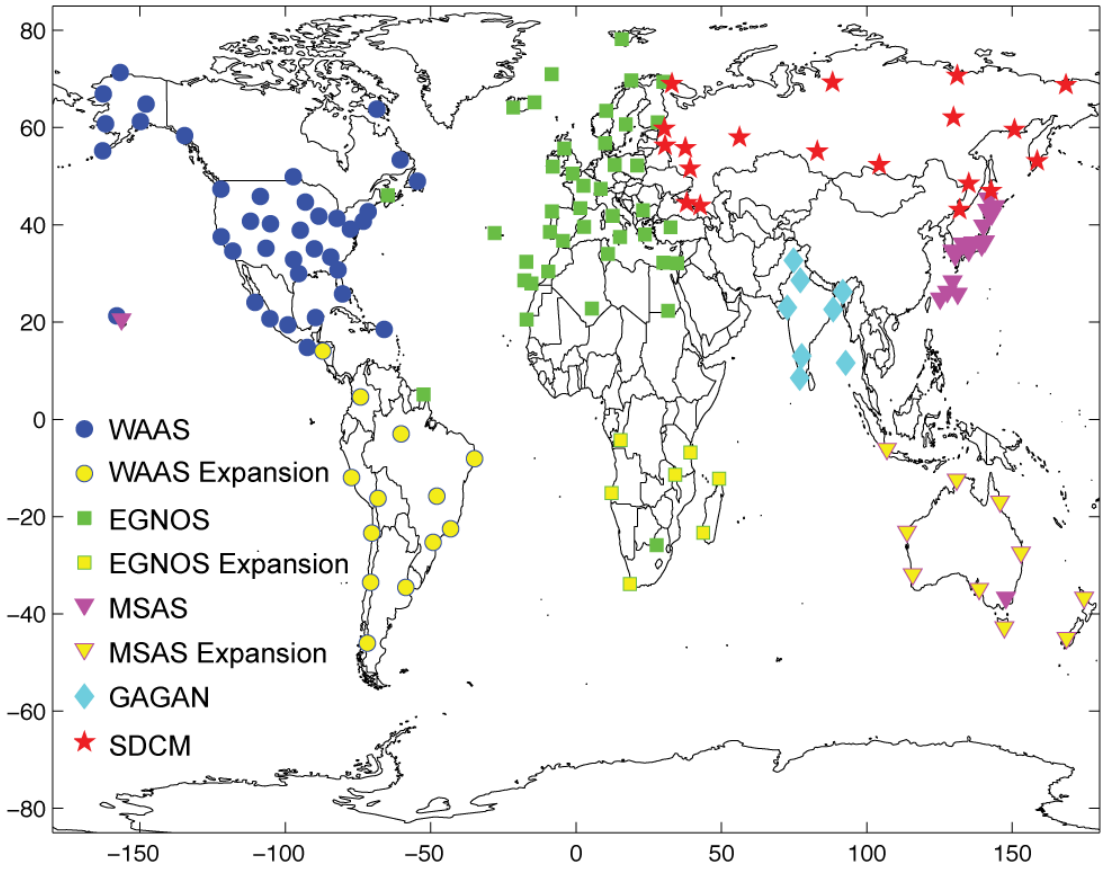


Dual Frequency Coverage (with GAGAN + SDCM)

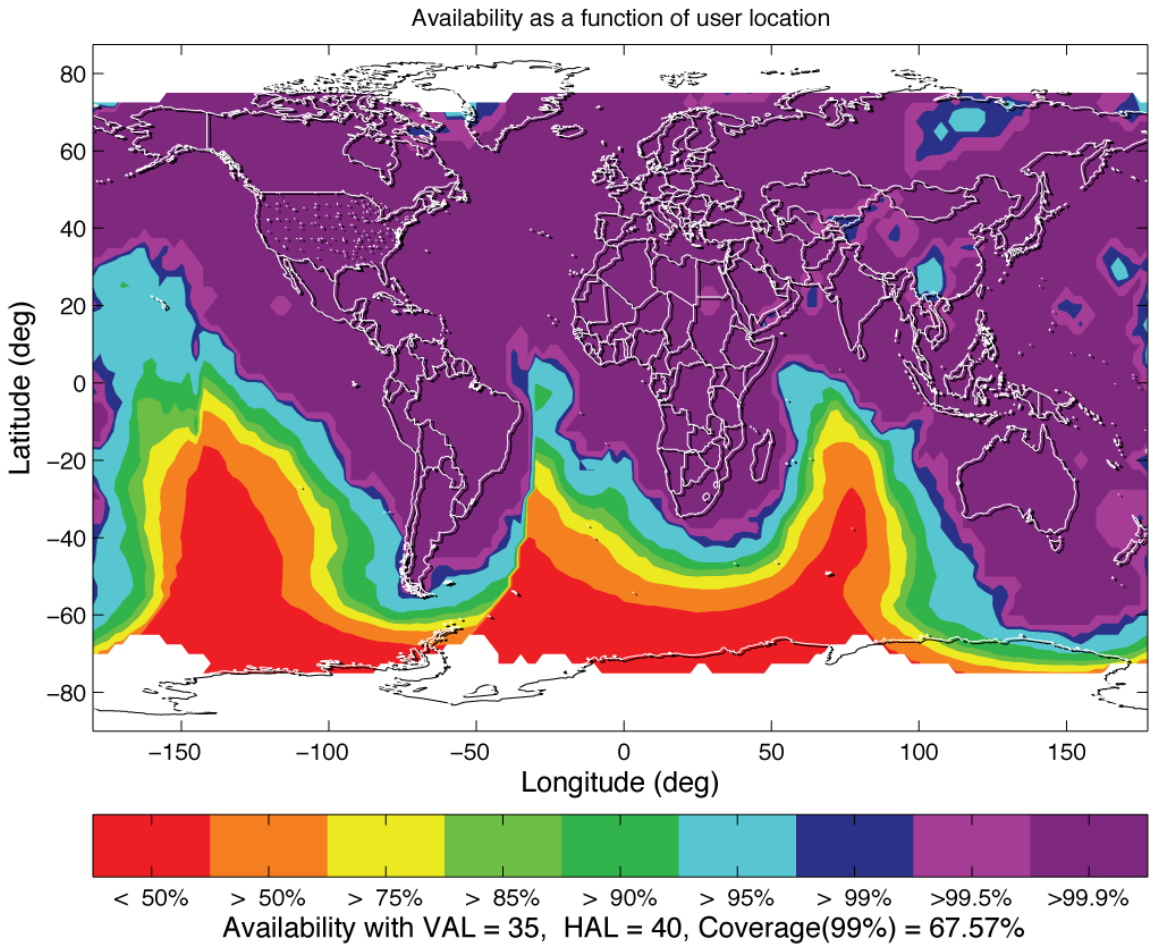


LPV-200 Service Availability

Expanded Networks

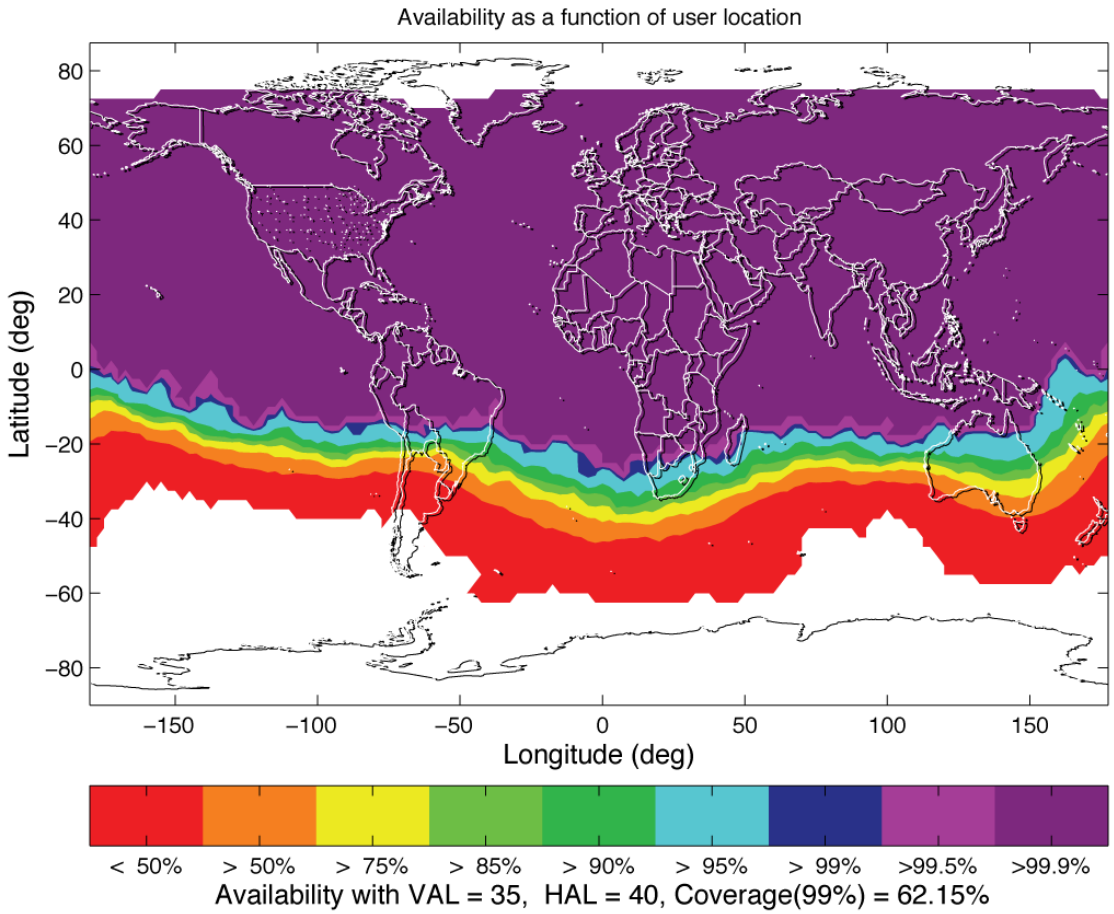


Dual Frequency, Expanded Networks



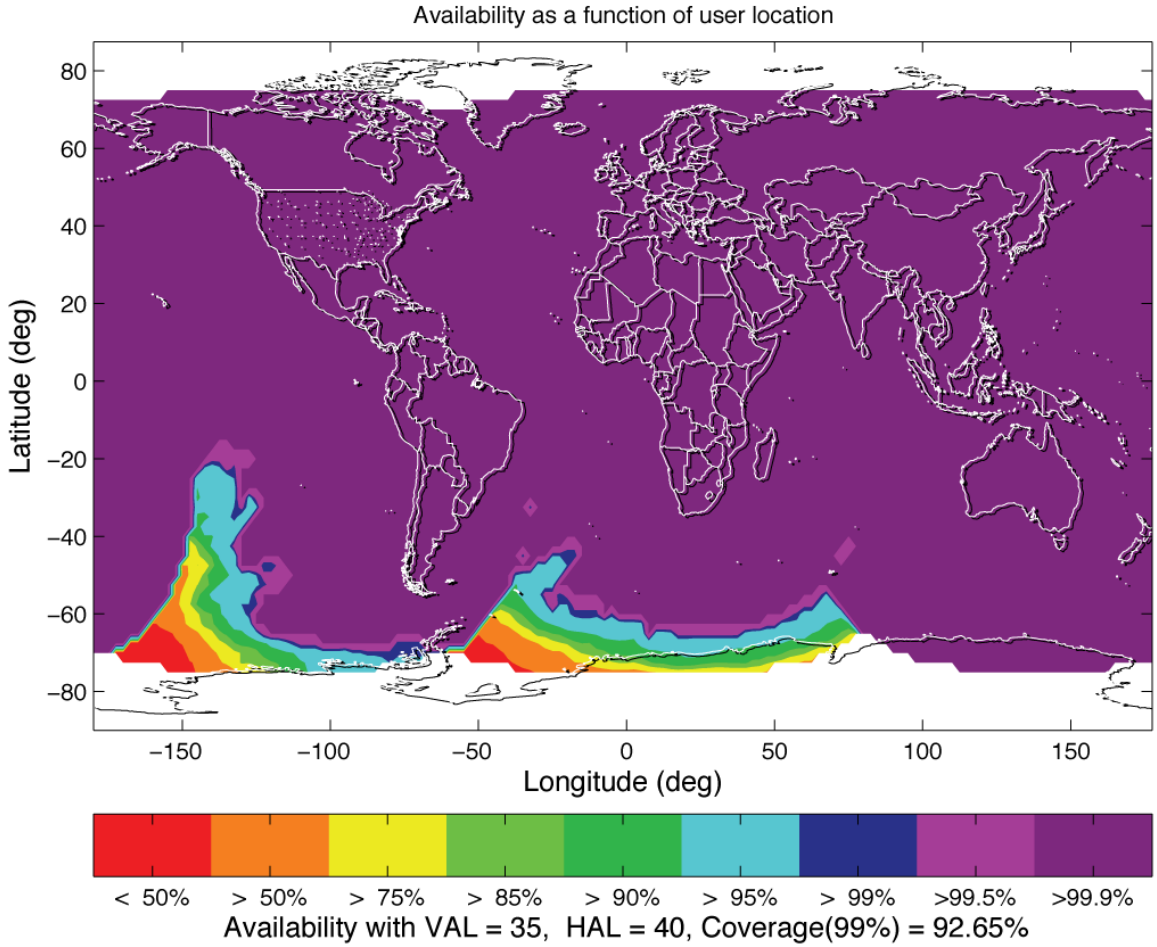
LPV-200 Service Availability

Dual Frequency + Second Constellation (Galileo)



LPV-200 Service Availability

Dual Frequency, Dual GNSS, Expanded Networks



LPV-200 Service Availability

Issues Being Addressed

- Seamless transition between SBAS service areas
  - Evaluating transitions between SBAS and RAIM, along with transitions between two SBASs, and between SBAS and GBAS
- Common interpretation of standards among SBAS developers
  - Established a work plan for development of a definition document to support a dual-frequency, multi-constellation user
- Increased Global coverage percentage with addition of GAGAN and SDCM
- Availability of worldwide LPV-200 service expected with addition of a second frequency, multiple constellations and extended reference networks
- Investigation of alternative dissemination means and increased coverage in polar regions

Conclusions

- Single Frequency SBAS offers significant benefits within covered service areas
- Dual Frequency extends precision approach coverage outside reference networks and allows LPV operation in equatorial areas and during ionospheric storms
- Expanding SBAS networks into southern hemisphere will allow global coverage of land masses
- Additional GNSS constellations improve availability away from reference stations and result in lower achievable protection levels