

# 2<sup>nd</sup> Generation SBAS Testbed

7 February, 2018





# SBAS Expectations

## ICAO ASSEMBLY RESOLUTION

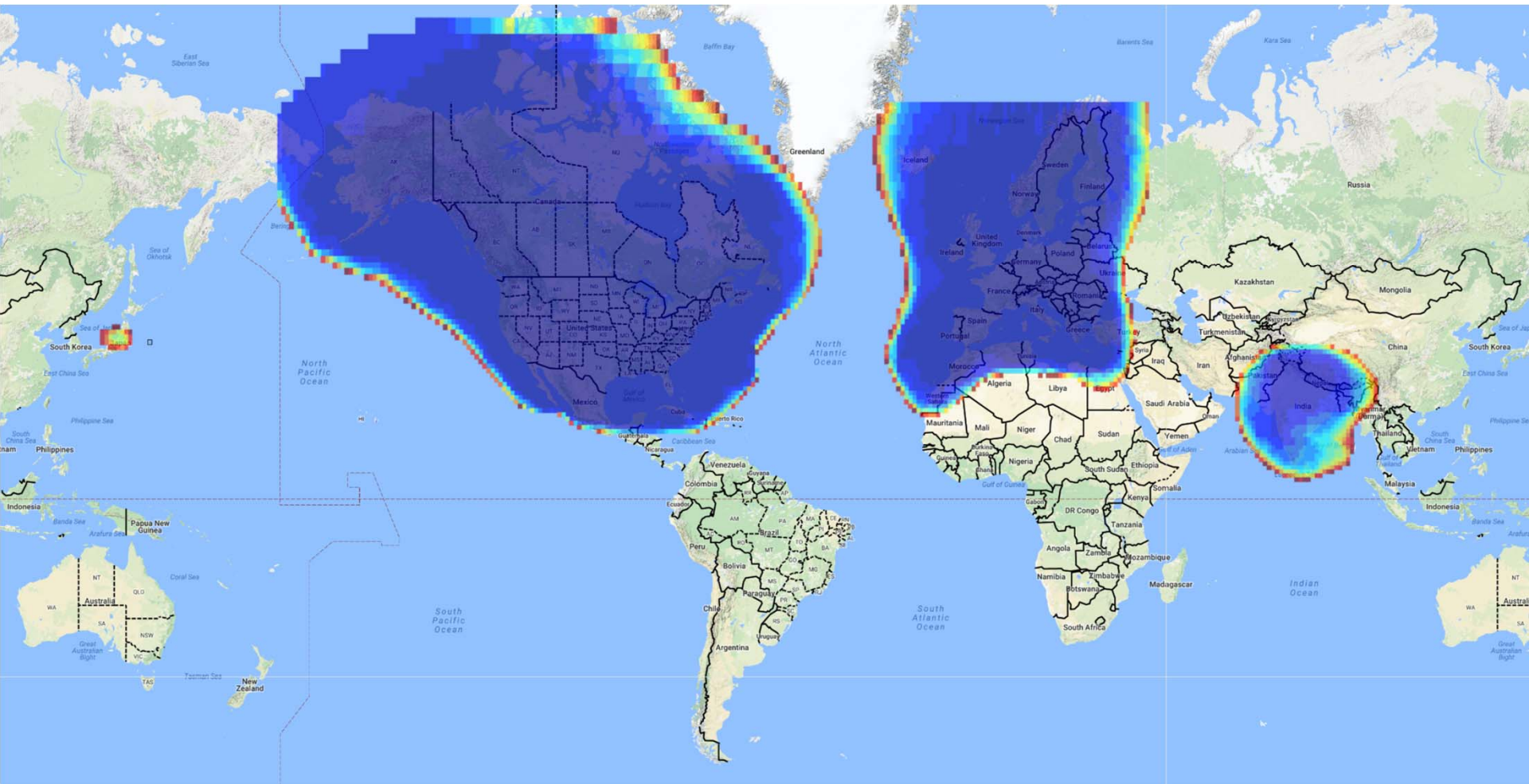
- **Resolution A36 - 23**
  - All approaches APV by 2016
    - Unachievable!!
- **Resolution 37 / 11**
  - All approaches APV by 2016
  - However, if unable then straight in approaches (with limits!)



Ian Mallett

# SBAS Precision Approach Coverage

May 1, 2016



Courtesy of FAA Tech Center

# Obstacles to 1<sup>st</sup> Generation SBAS



- **Technology**
  - Reduced availability in equatorial region
  - Airline equipage lagged due to lack of world-wide coverage
- **Cost**
  - **WAAS life cycle: US\$3 Billion** (including life-cycle satellites)
    - Annual program costs: \$80-100M (not including communication links)
  - **EGNOS cost the EC €1.1B**
    - Total annual operating costs: €110M (2011 data from ESA)
  - **GAGAN cost India more than US\$110M** (partial ground segment only)
- **Politics**
  - Reluctance to base navigation on US military-controlled constellation
  - Regional tensions prevent collaboration on widely disbursed system
  - Refusal of SBAS operator to accept liability for foreign use

# A Better Option—Fully Exploit Dual Frequencies, Multiple Constellations



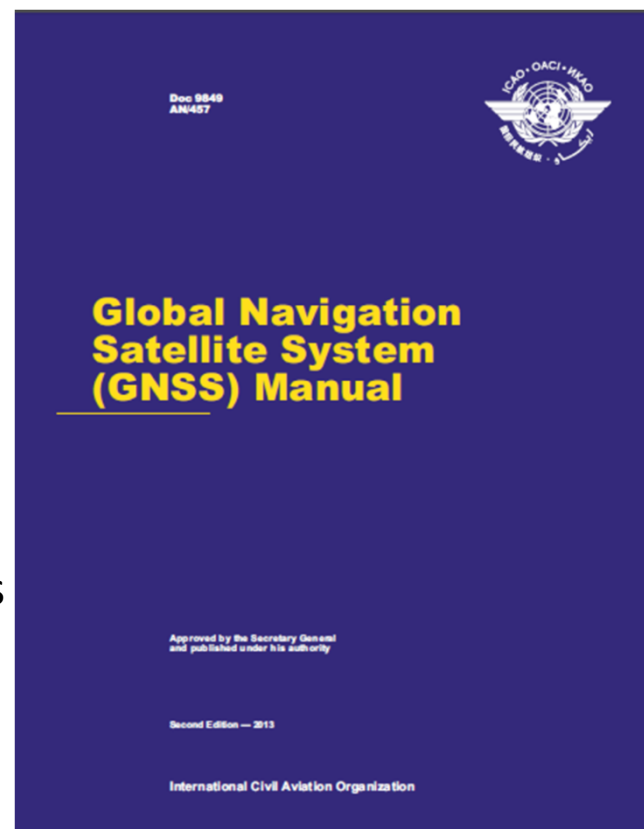
**GPS III**

- **L5/E5a frequency introduced on GPS IIF, Galileo, and GPS III**
  - 2<sup>nd</sup> frequency in protected band
  - User receiver makes ionospheric corrections
  - Simplifies SBAS architecture
    - <40 reference stations worldwide
    - Integrated global system
  - Solves equatorial challenge
- **Multiple Constellations**
  - More ranging signals in view
  - Redundancy of GNSS provider
  - Creates opportunity for new model for service delivery



# Collaborative Approach to GNSS

- Full benefits of GNSS are best realized through collaboration
- Both public and private sector have key roles to play, which reinforce each other for the benefit of all
  - Public sector provides open GNSS signal-in-space
  - Private sector addresses issues with sovereignty
    - Indemnity against liability through insurance
    - Shared ownership through operating company
- International Civil Aviation Authority (ICAO) leadership in standards
  - ICAO Doc. 9849: GNSS Manual
  - ICAO Doc. 9082: Charges for Air Navigation Services





# Global SBAS Advantages



- **Superior Performance**

- World-wide monitoring gives better integrity compared to regional systems
- Very high availability with minimum assets
- Same architecture supports:
  - Civil aviation
  - Intelligent Transportation Systems
  - Precise Maritime Navigation
  - Unmanned Aerial Vehicles
  - Positive Train Control

- **Lower Cost**

- At least 40% efficiency gain over regional SBAS expansion
- Fee-for-service business model spreads costs among large customer base

- **Shared sovereignty**

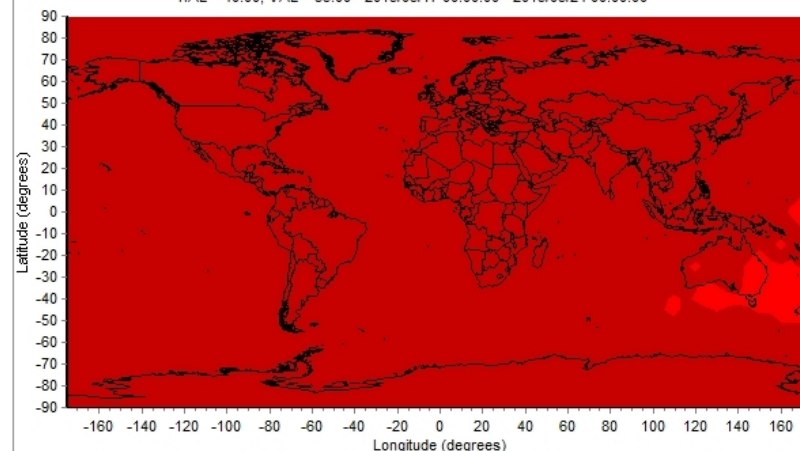
- Eliminate dependency on one GNSS constellation
- Spread key operating assets across major stakeholders

Technical approach has been validated in laboratory;  
Now demonstrating capability with signal-in-space



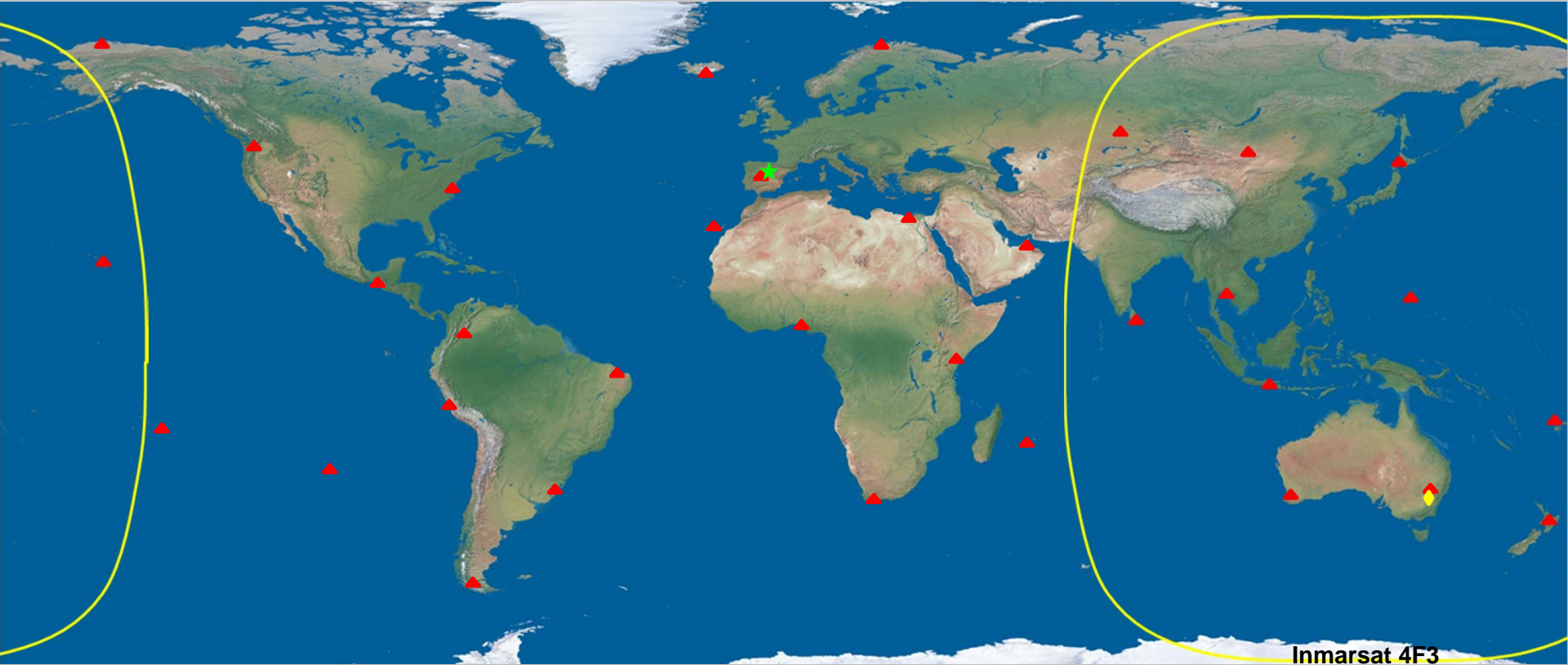
Cumulative Availability (GPS-GLO-SBAS)

HAL = 40.00, VAL = 35.00 - 2015/05/17 00:00:00 - 2015/05/24 00:00:00





# Global SBAS Testbed, Phase 1:



## Collaborative Agreement

- Government and industry cooperation
- Use existing assets to extent feasible
- Anticipates operational system topology
- Demonstrate capability and benefits
- February 2017 through January 2019

- **Australia and New Zealand**

- CORS sites used as reference stations
- Communication links
- Inmarsat 4F1 navigation payload

- **GMV: magicSBAS™ processors**

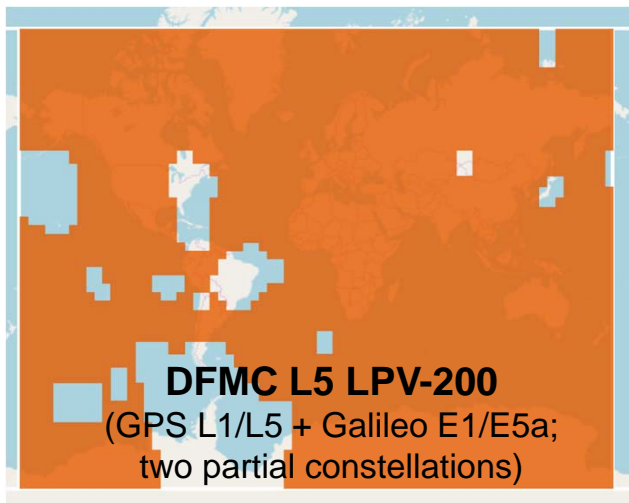
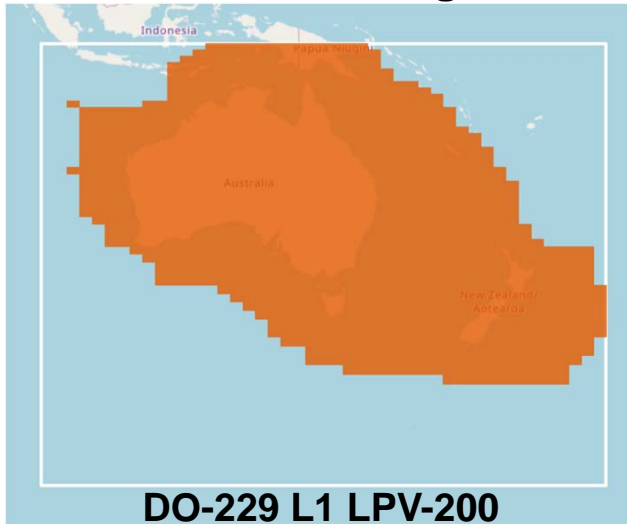
- **Lockheed Martin: Uralla uplink station** <sub>8</sub>



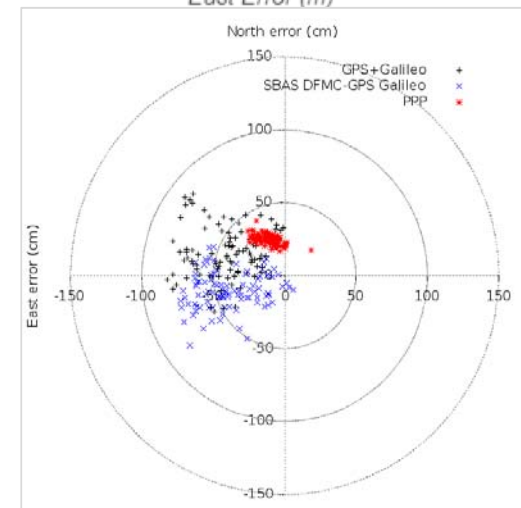
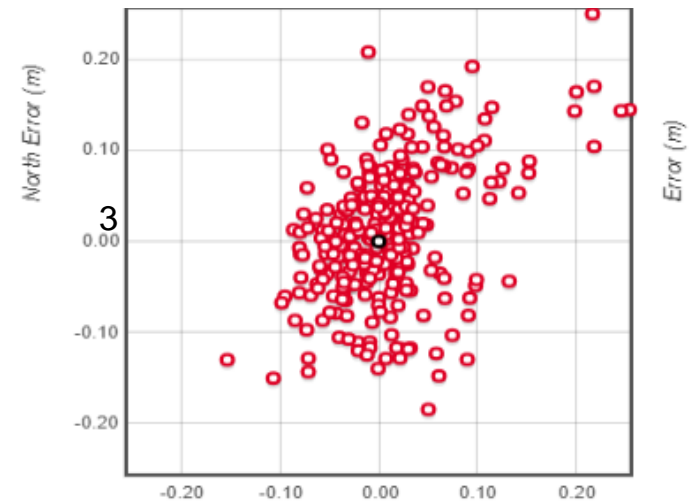
# Testbed now broadcasting 3 signals



## 2 ICAO SBAS Signals



## + Precise Point Positioning on L1 & L5





# Demonstrations

Testbed to analyze economic benefits in ten Industries



## Civil Aviation (including UAVs)

- Reduce flight delays and cancellations
- Increase safety, capacity, and efficiency
- Reduce navaid infrastructure cost



## Maritime

- Increase efficiency
- Improved safety
- Reduce navaid infrastructure costs



## Positive Train Control

- Increase capacity
- Improve safety
- Reduce labor & infrastructure costs



## Intelligent Transportation

- Increase capacity
- Improve safety
- Reduce costs

## Medical

- Electronic seeing eye
- Allow personal mobility for seeing impaired



## Precision Agriculture

- Increase crop yield
- Reduce pesticide and fertilizer cost



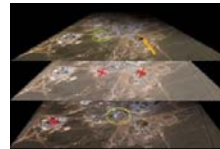
## Construction

- Reduce costs
- Increase precision and efficiency



## Mining

- Reduce labor costs
- Increased efficiency



## Spatial

- Increase precision and efficiency
- Reduce costs



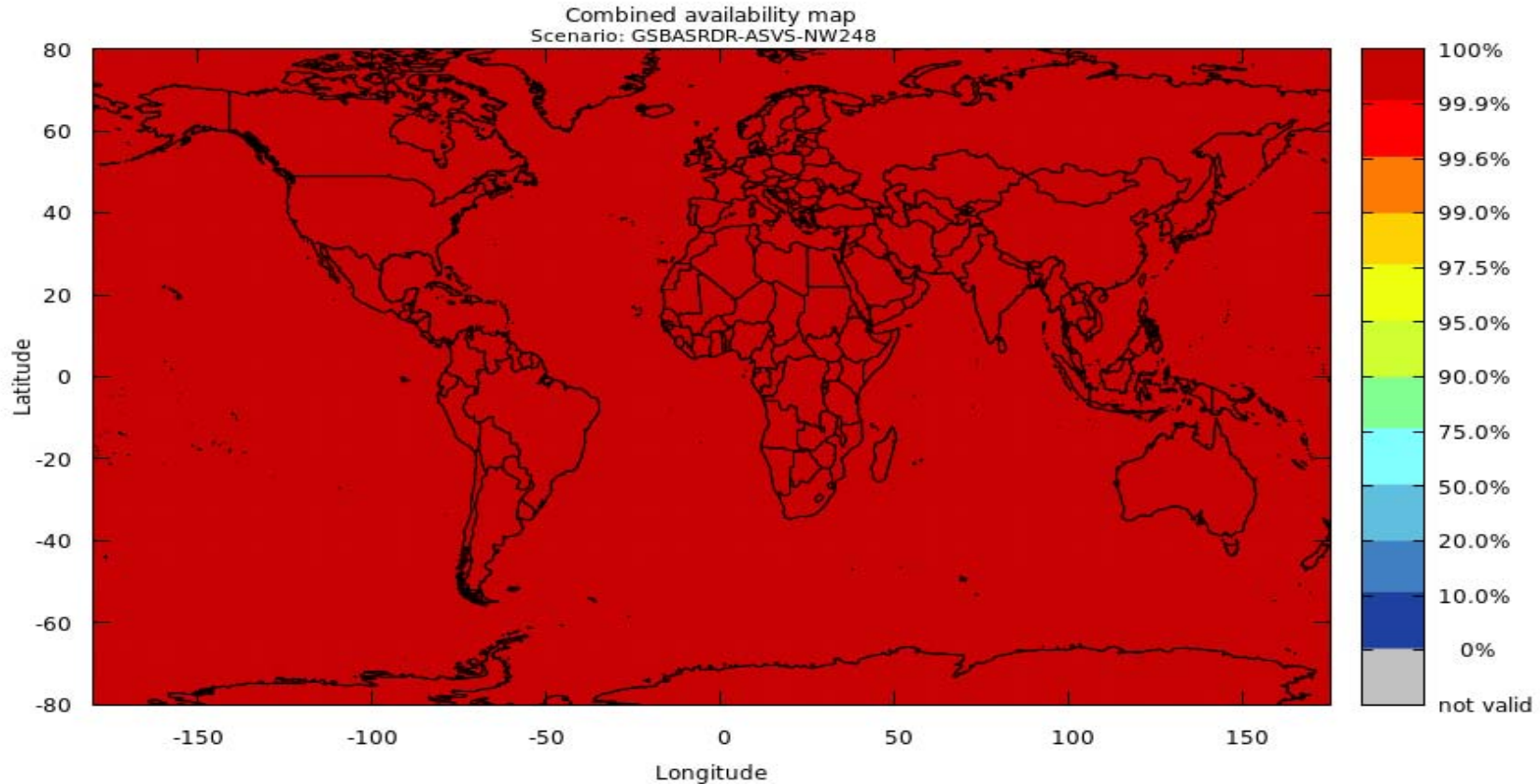
## Utilities

- Enable smart grids
- Protect integrity of timing signals



# LPV-200 Availability

## 35 meter Vertical Alert Limit

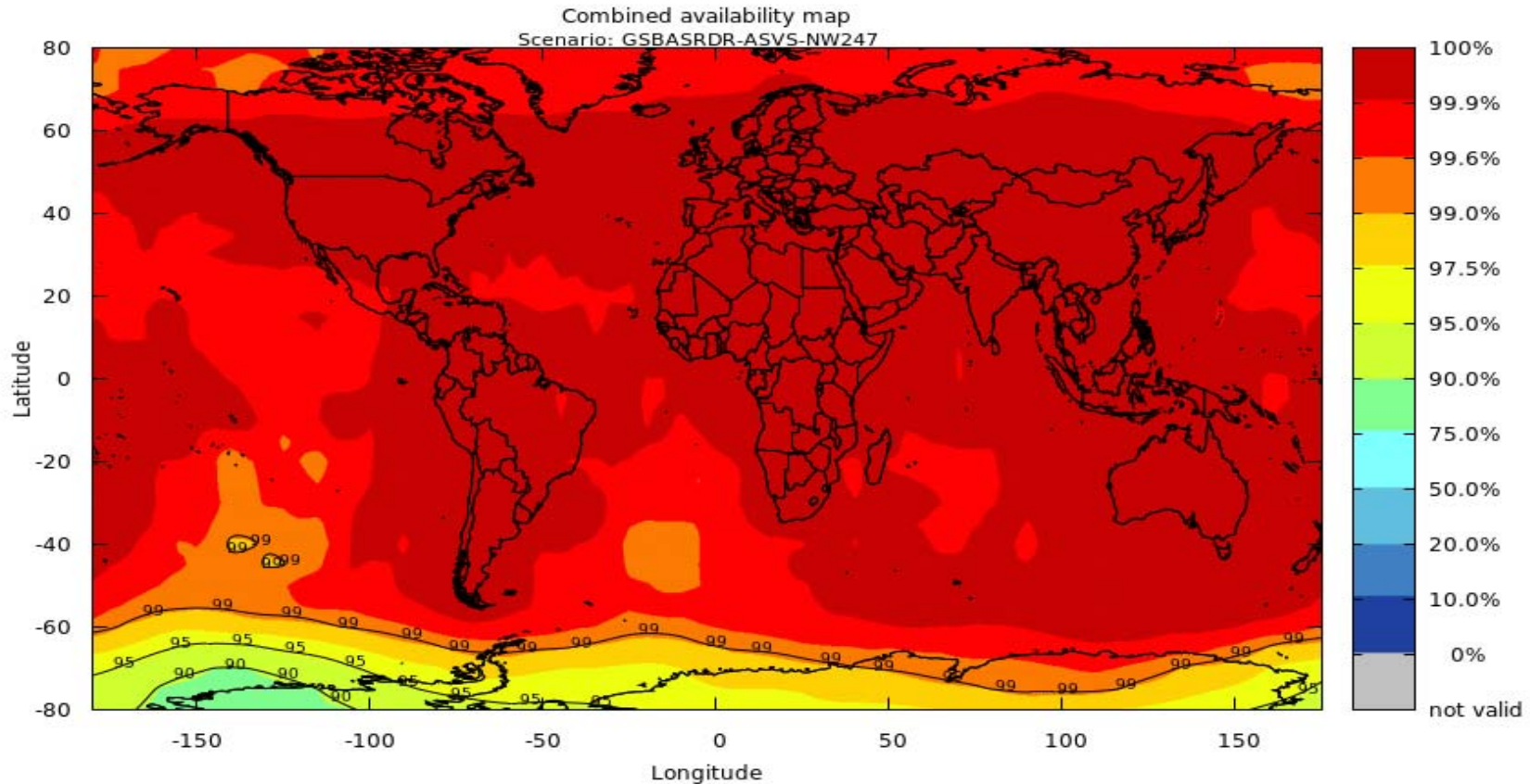


Projected availability based on 24 GPS and 24 Galileo satellites broadcasting L1/E1 and L5/E5a, monitored by a global network of 26 reference stations.



# CAT-I Availability

## 10 meter Vertical Alert Limit



Projected availability based on 24 GPS and 24 Galileo satellites broadcasting L1/E1 and L5/E5a, monitored by a global network of 39 reference stations