Status of ARAIM

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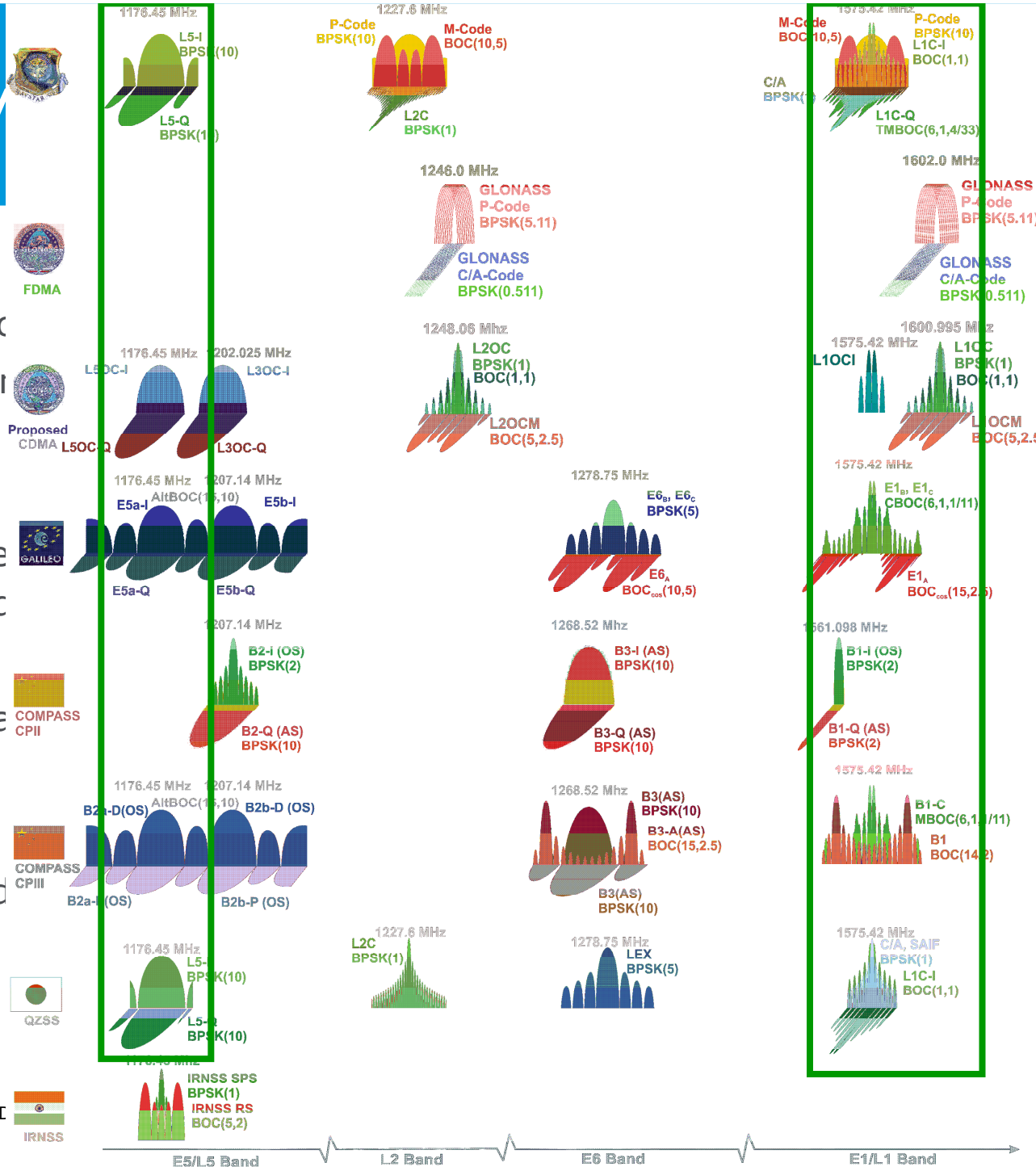
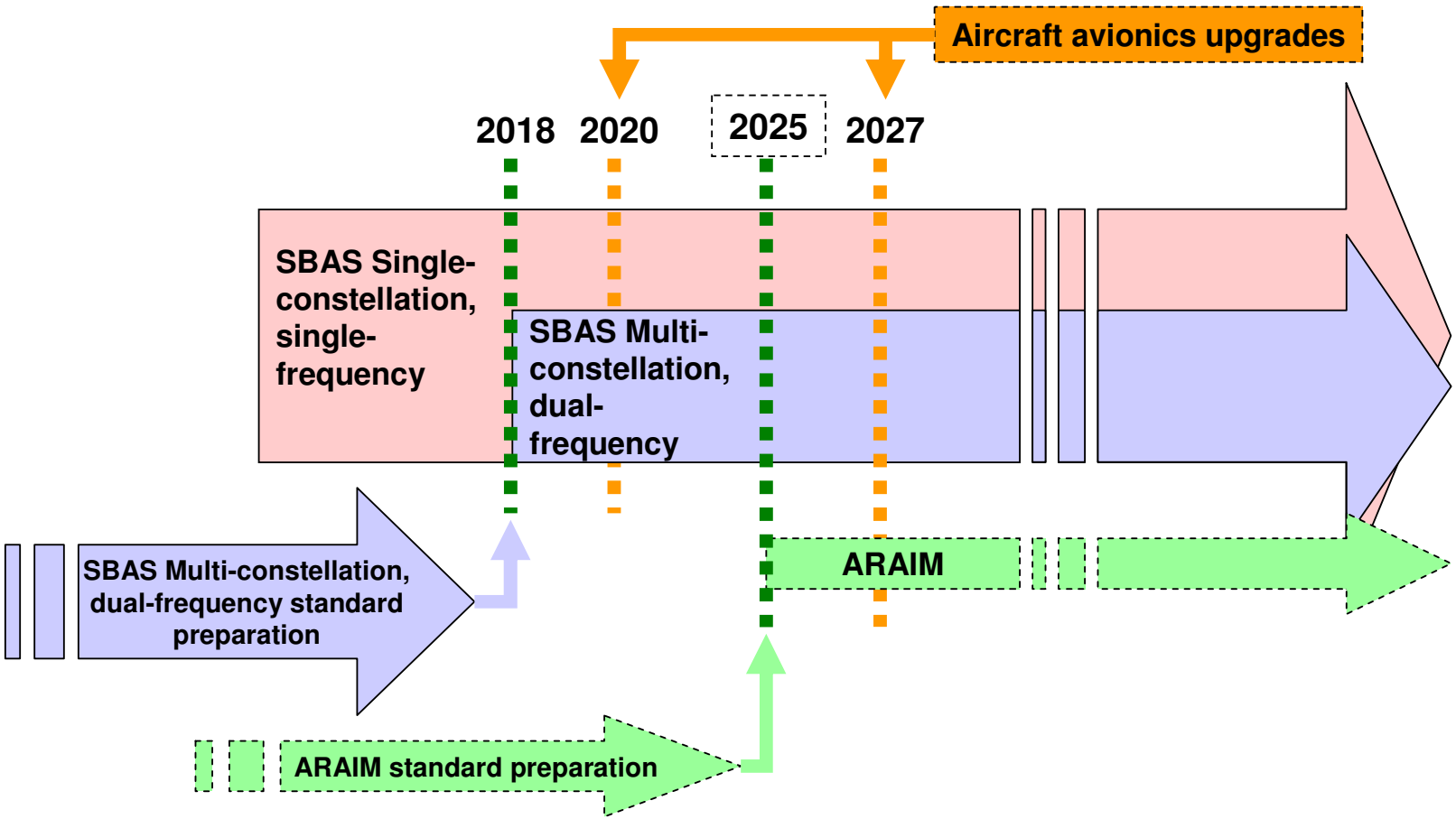
ARAIM

- Classic
- Evolvi
  - Proposed
  - CDMA
- Evolve proced
- Rebala
- Consid

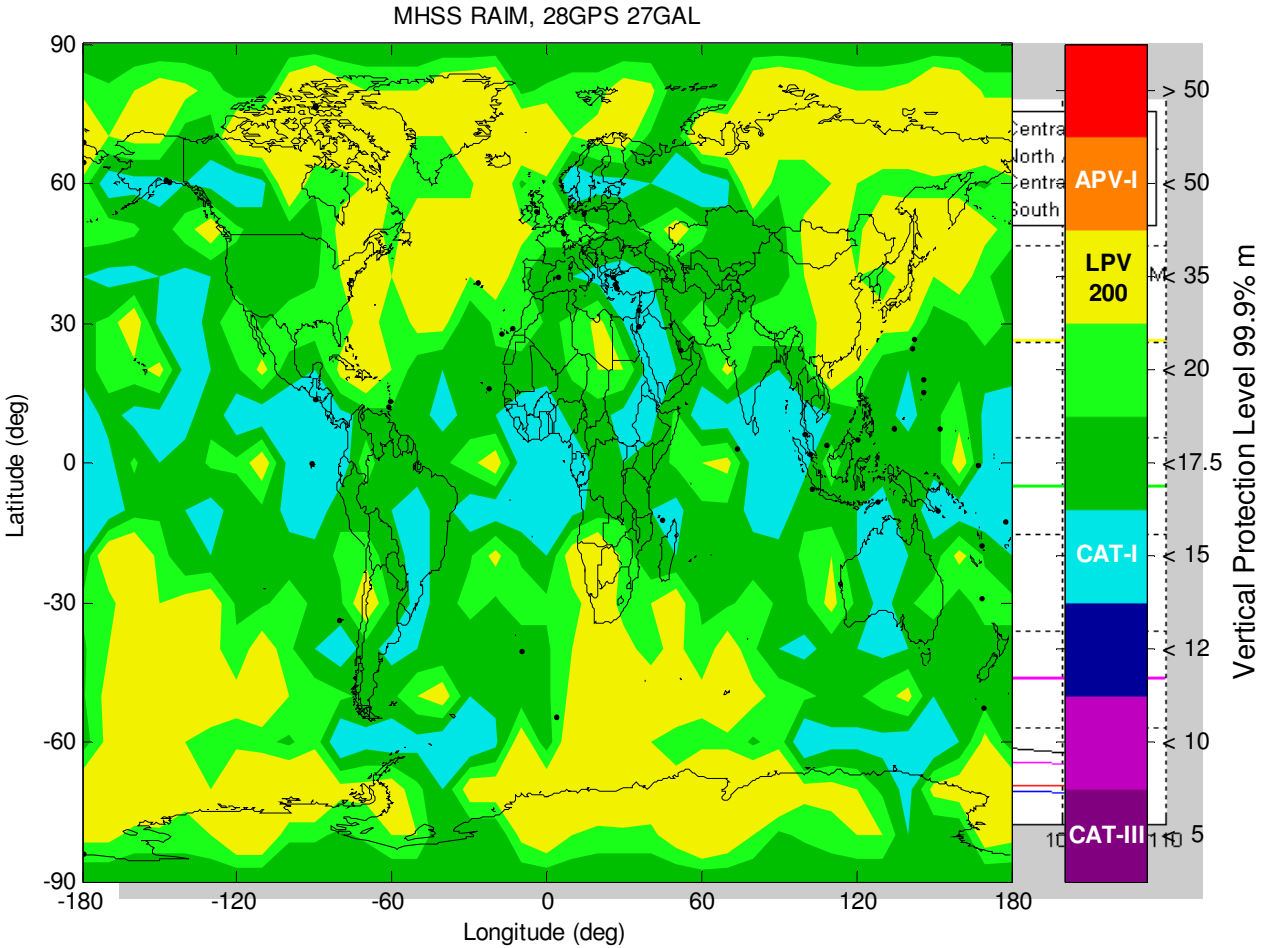


ARAIM Context



ARAIM Expected Performance

- Several studies identify the potential of ARAIM for PA procedures



SISE/URE:	0.25m
URA:	0.5m
Nom. Bias:	0.1m
Max. Bias:	0.75m
P_{const}:	1e-7
P_{sat}:	1e-5

List of Threats

Nominal errors

- Nominal Clock and ephemeris errors
- Nominal signal deformation errors
- Antenna bias
- Tropospheric errors
- Code noise and multipath

Narrow failure errors

- Clock and ephemeris estimation errors
- Signal deformations
- Code-carrier incoherency

Wide failure errors

- Induced by inadequate manned operations
  - Update of operational G/S
  - Commanding of S/C
- Induced by G/S facilities
  - Nav message generation and uplink
  - S/C and constellation control
- Externally induced
  - EoP and EoPP
    - Type A (Earth motion changed since update)
    - Type B (EoPPs in OD process bad and not detected in GNSS ground segment)

To each threat a dynamic level can be associated

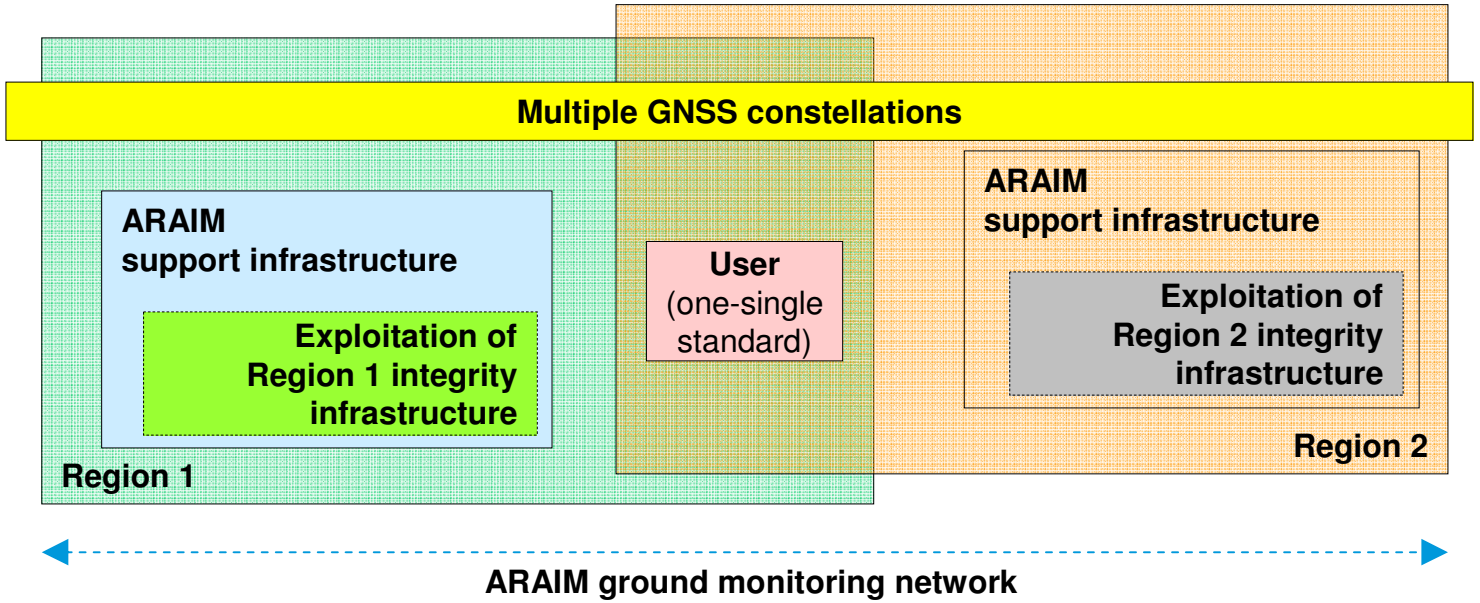
Threat Mitigation

- Threat mitigation needs to involve 3 levels
  - GNSS ground segment
  - Independent ARAIM ground segment
  - User receiver
- Combination of 3 levels needs to eliminate the integrity threats to extent compliant with required integrity risk
- Allocation of threats to mitigation levels according to threat dynamics
  - All high dynamic threats to be mitigated at user level
  - Low dynamic threats to be mitigate at user **and** ground segment level

  → Ground segment needs not to react to threats within the TTA of 6 s

Independent ARAIM Ground Monitoring

- GNSS ground segments may not be designed according to civil aviation safety requirements
- Independent ARAIM ground monitoring network allows for high level of trust
- Independent ARAIM ground monitoring network to be designed according the appropriate Design Assurance Level (DAL), DAL-B for LPV-200



Integrity Support Message Data

- ARAIM ground monitoring network to provide relevant ARAIM algorithm input to user → Integrity Support Message (ISM)
  - Signal in Space Accuracy (SISA)/User Range Accuracy (URA)
  - Signal in Space Error (SISE)/User Range Error (URE)
  - Nominal and maximal biases
  - Probability of a single satellite fault (P_{sat})
  - Probability of a constellation wide fault (P_{const})
- Significant reduction of latency requirement of ISM compared to SBAS
- ISM requirements highly interrelated with ARAIM algorithm performance, constellation performance and threat allocation; theoretical analyses and assessments still ongoing

Integrity Support Message Dissemination

- Modifications at avionics level required to support ARAIM in the future to be kept to minimum extent possible
- Reuse of already available data links
  - L-Band RNSS allocation
    - GNSS
    - SBAS L5
  - VHF Aeronautical Mobile Route Services (AMRS) Allocation
  - ISM dissemination at gate dispatch

Conclusions

- ARAIM identified as promising concept to enable approaches with vertical guidance
- Thorough implementation required
- List of threats identified, threat models to be developed
- ARAIM ground monitoring network
    - Needs not to react to threats within the TTA of 6 s
- Overall ARAIM system needs to be compliant to appropriate Design Assurance Level
- Integrity Support Message (ISM) to provide ARAIM user algorithm with required input