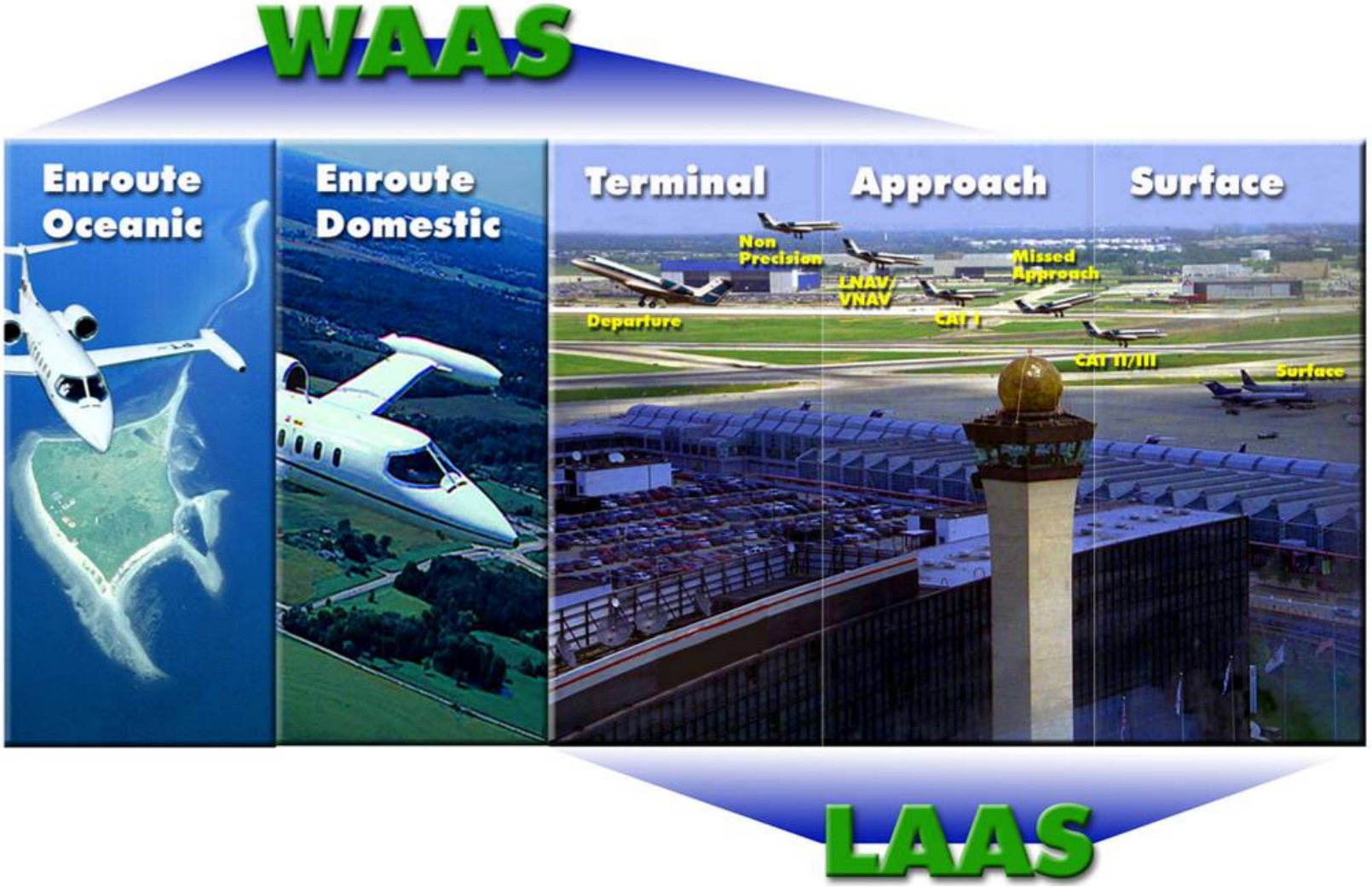
GNSS Program Status

Presented To: Satellite Navigation Summit
Munich, Germany

Date: March 10, 2010

By: Leo Eldredge, Manager
GNSS Group, FAA

FAA Satellite Navigation Program

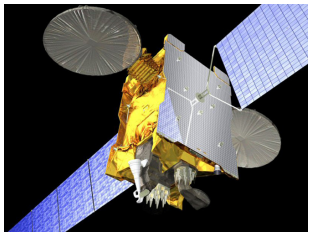


Wide Area Augmentation System - 2003

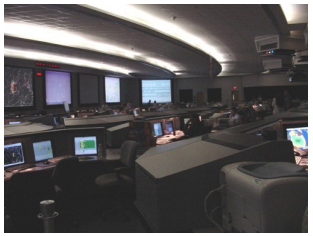
38 Reference Stations

3 Master Stations

4 Ground Earth Stations

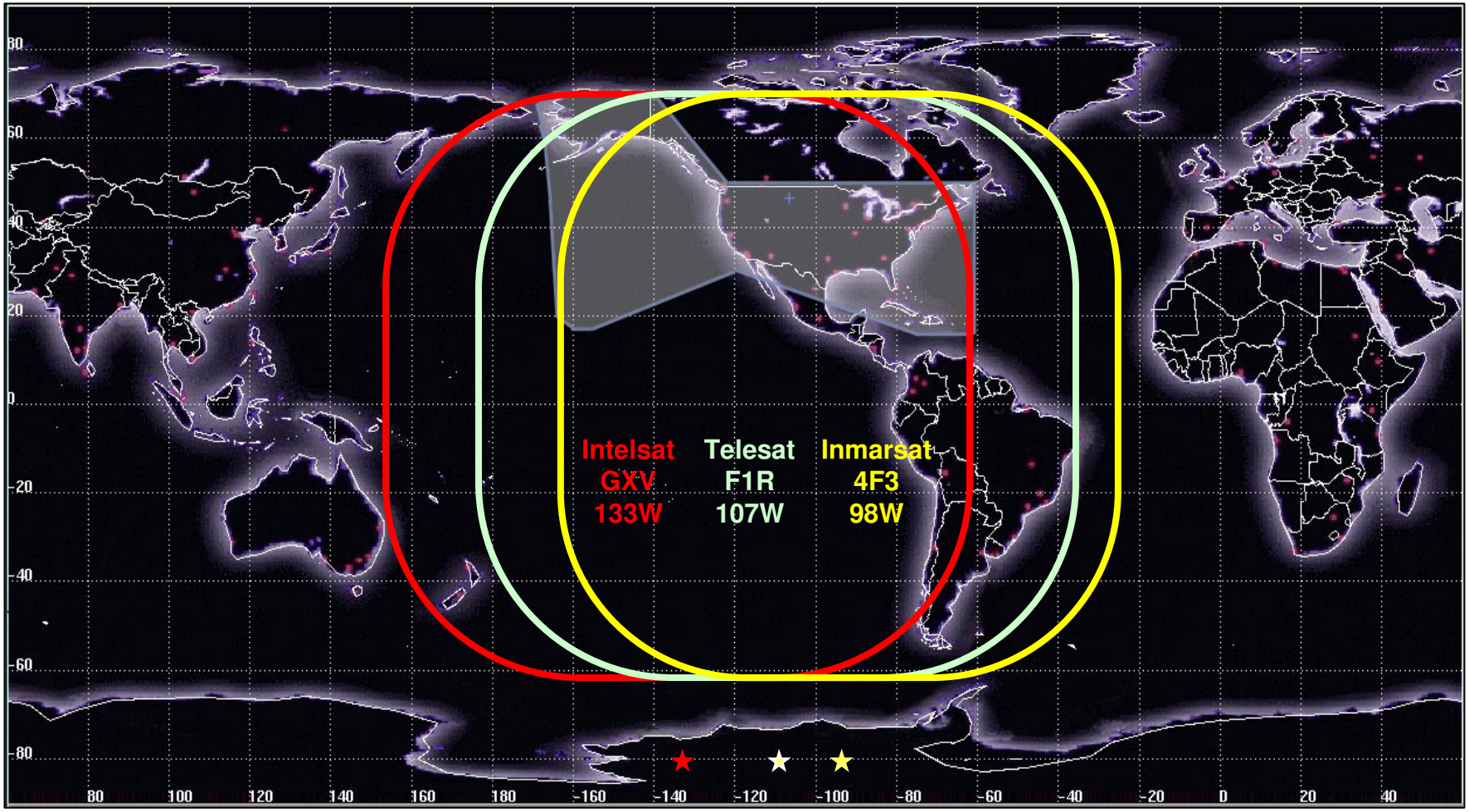


2 Geostationary Satellite Links

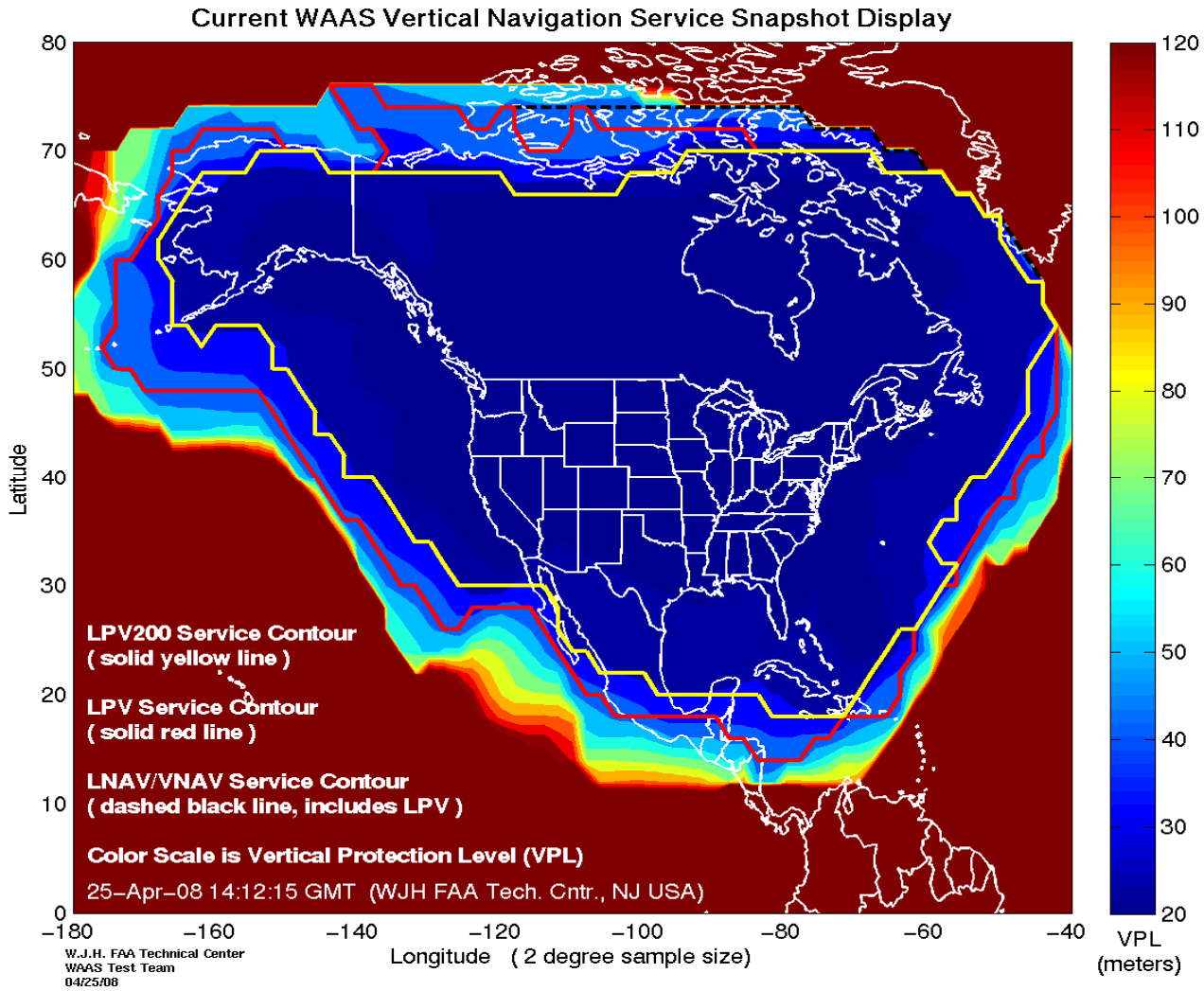


2 Operational Control Centers

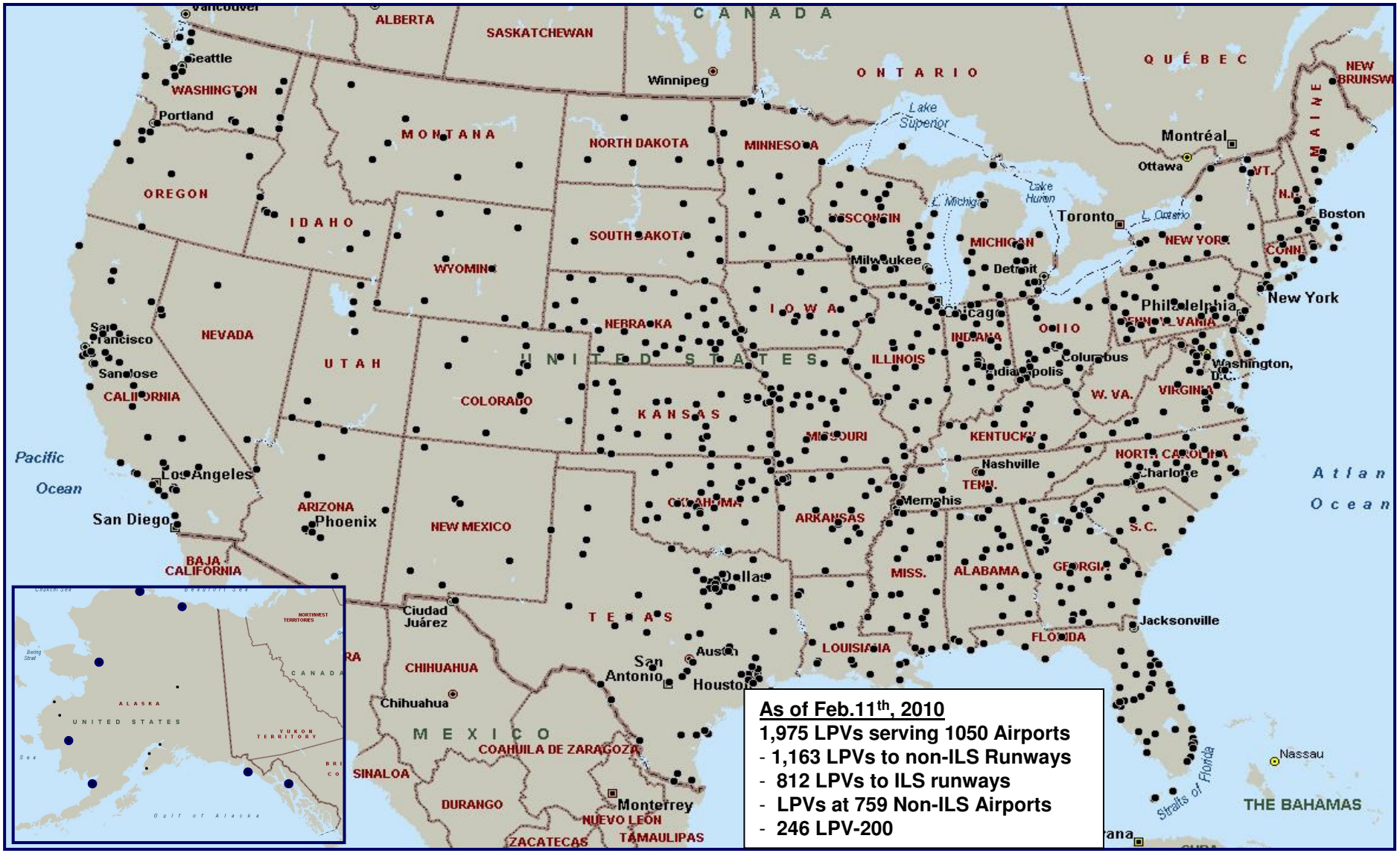
Three GEO Satellite Coverage



WAAS LPV Coverage



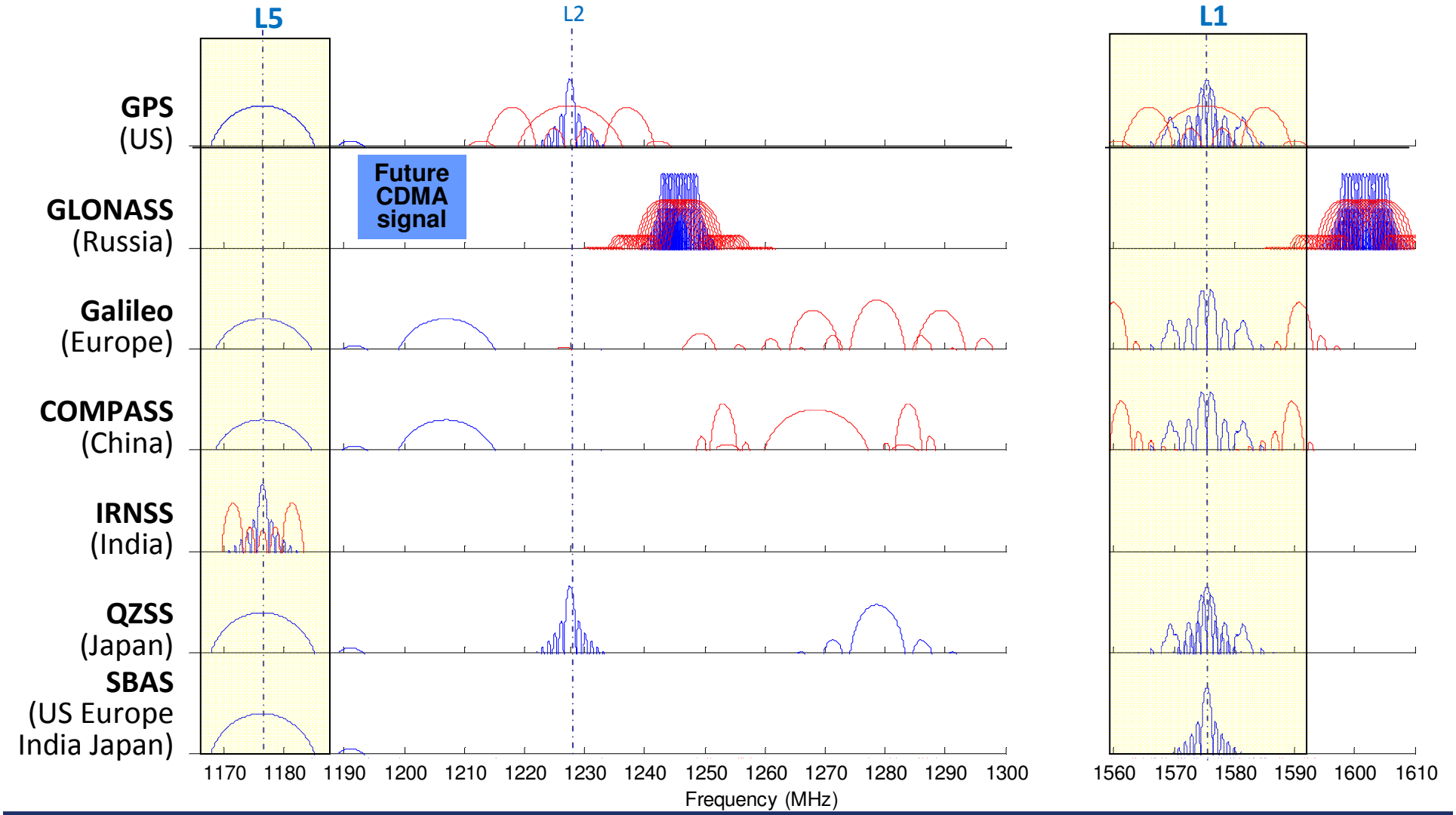
WAAS Approach Procedures Today



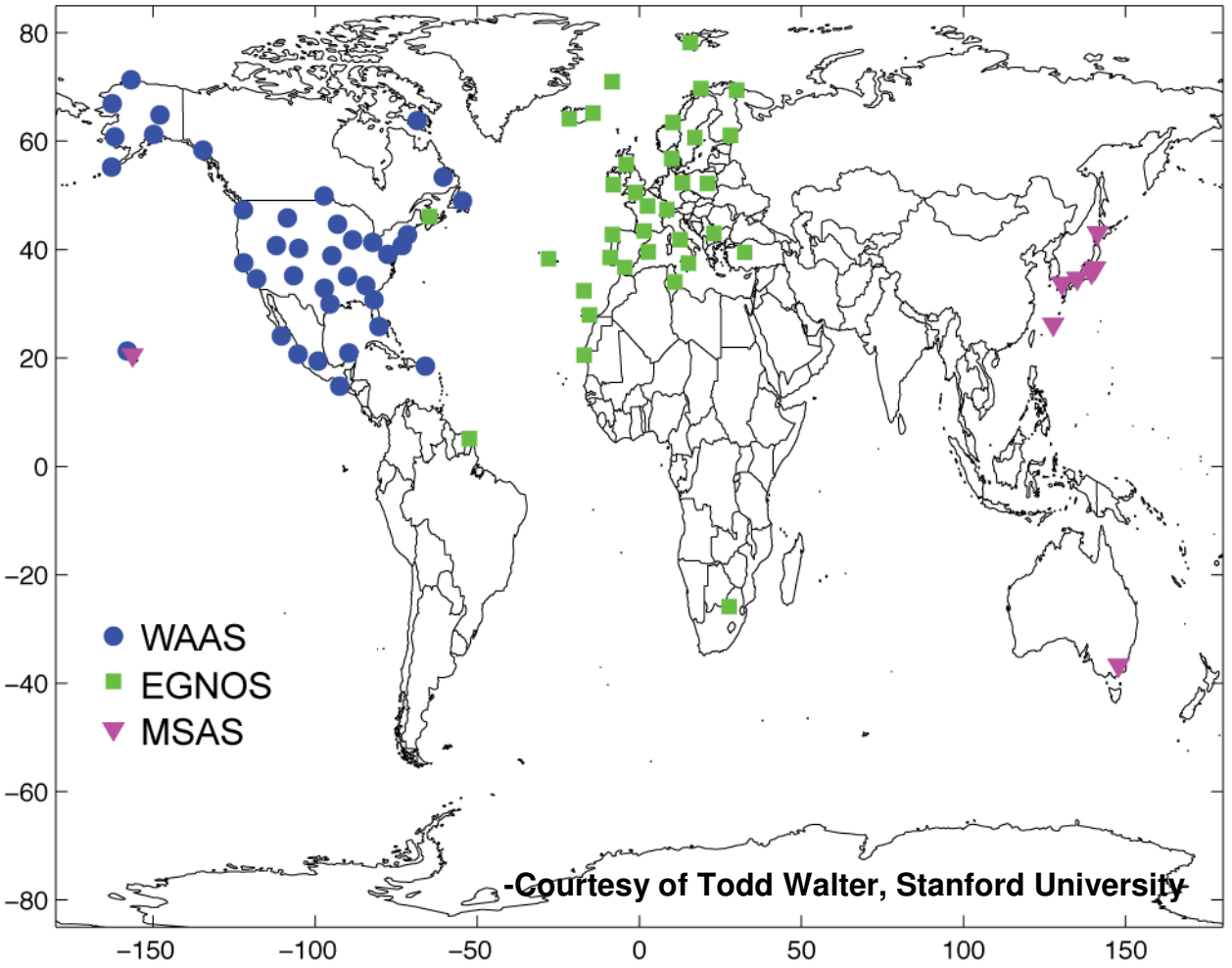
SBAS Future Considerations

- **Dual Frequency GNSS Services in protected aeronautical bands**
  - Enables direct estimation and removal ionospheric delay errors
  - Single largest source of vertical position uncertainty
- **Most significant remaining threats are satellite failure based**
  - Design a new VPL equation targeting single satellite faults
- **India and Russia are developing SBAS systems**
- **Investigate potential to expand LPV to global coverage**

Current International Signal Plans



Current Reference Networks

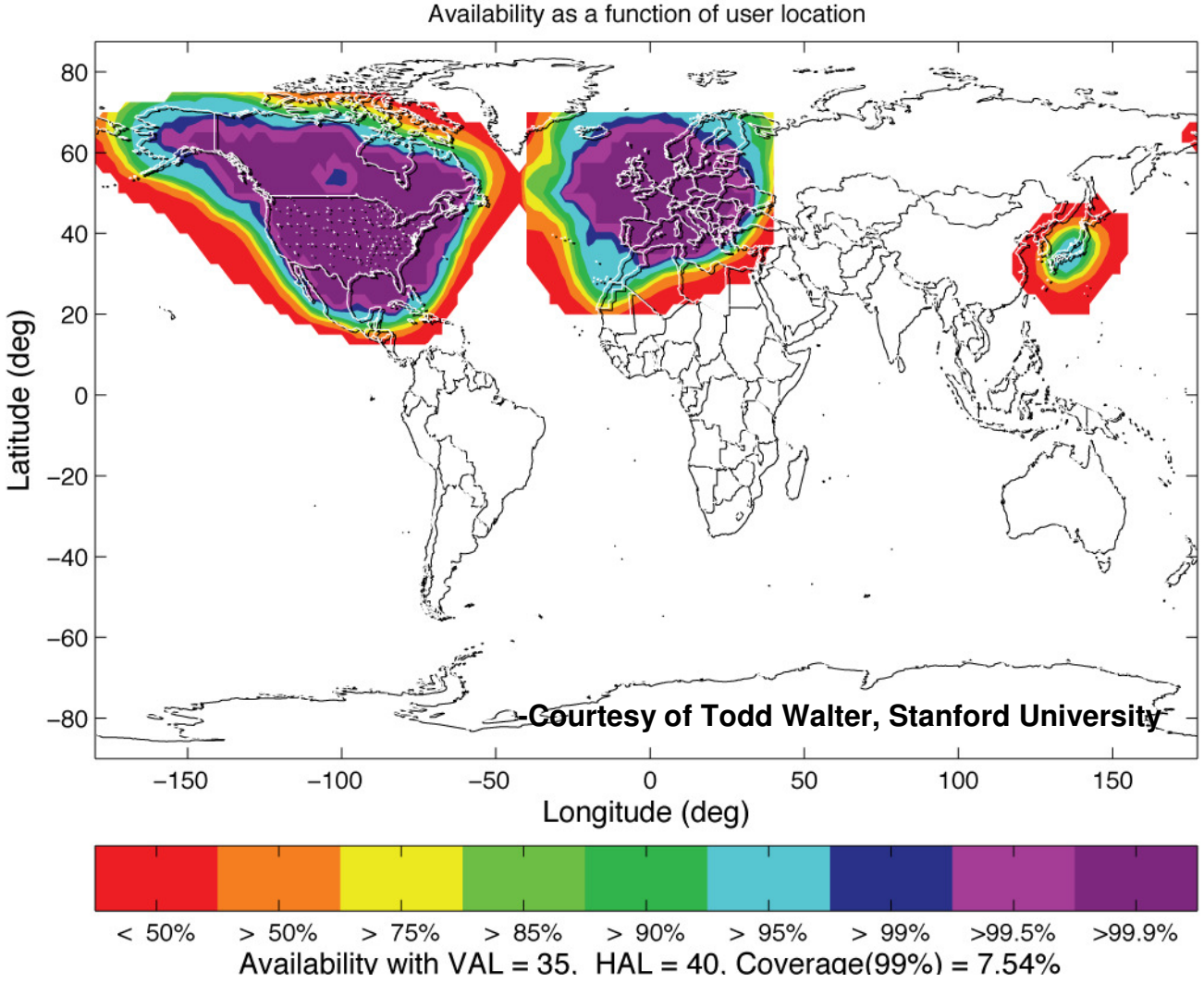


Current LPV-200 Coverage
(Single Frequency GPS)

WAAS

EGNOS

MSAS



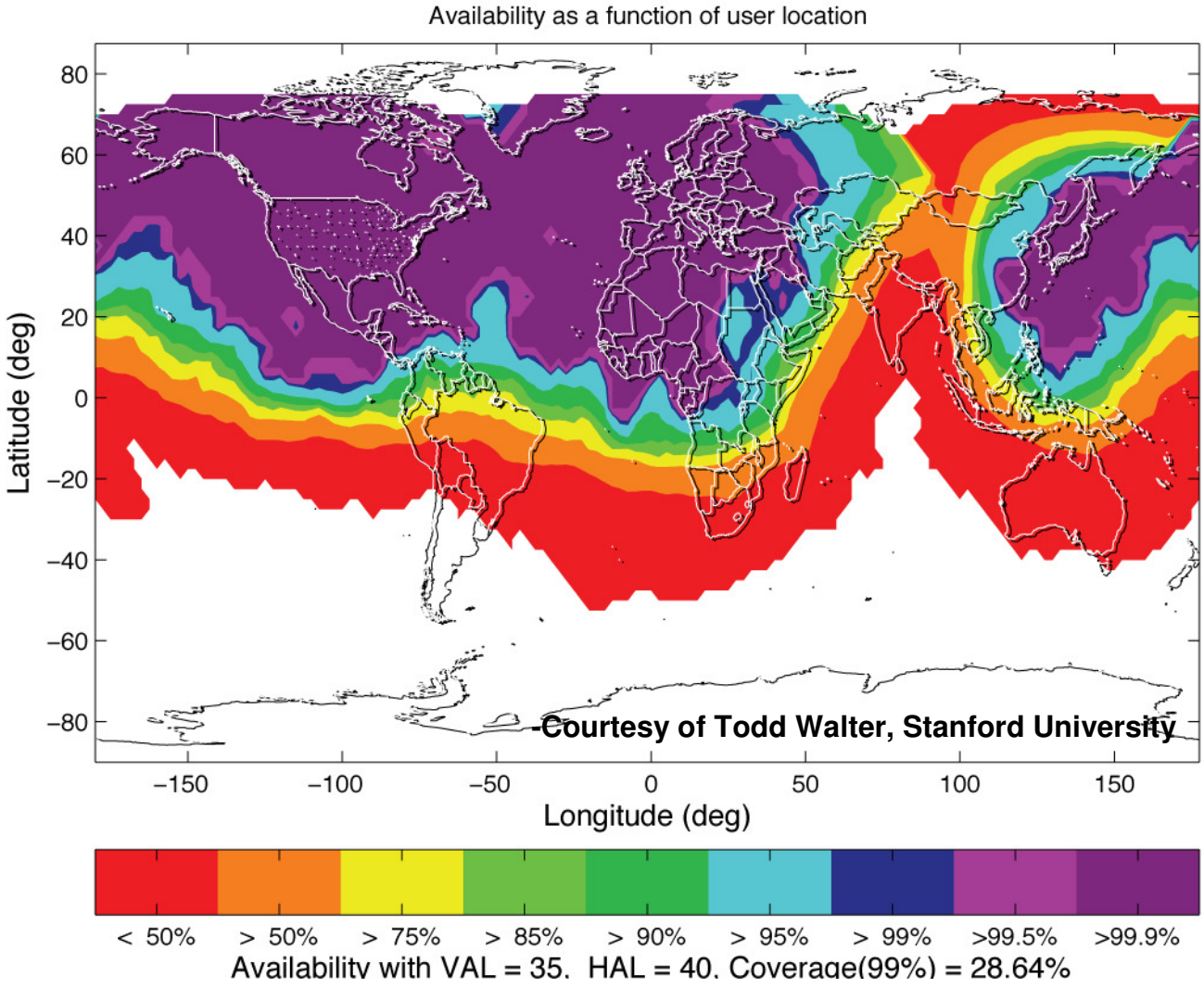
Future LPV-200 Coverage

(Dual Frequency GPS)

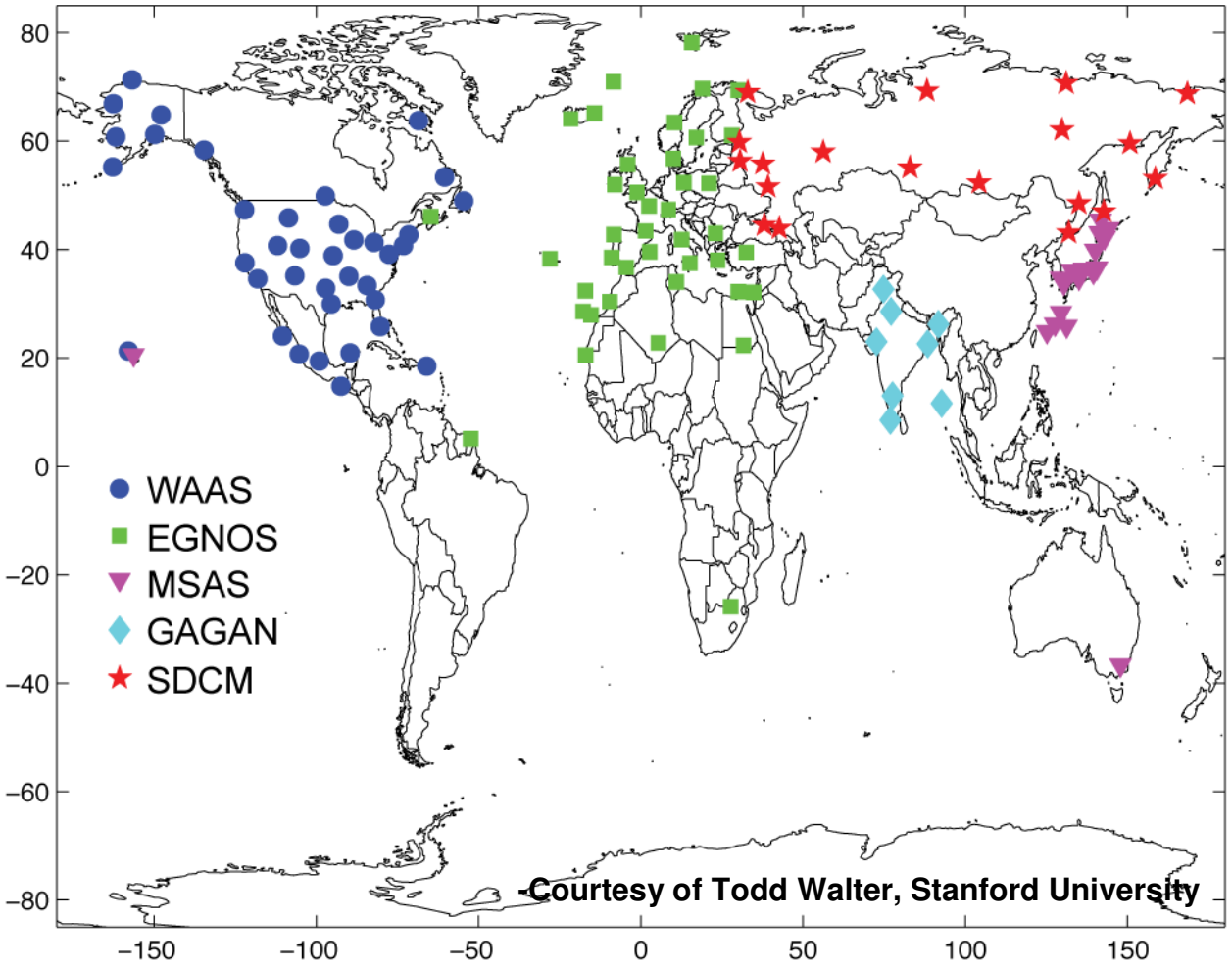
WAAS

EGNOS

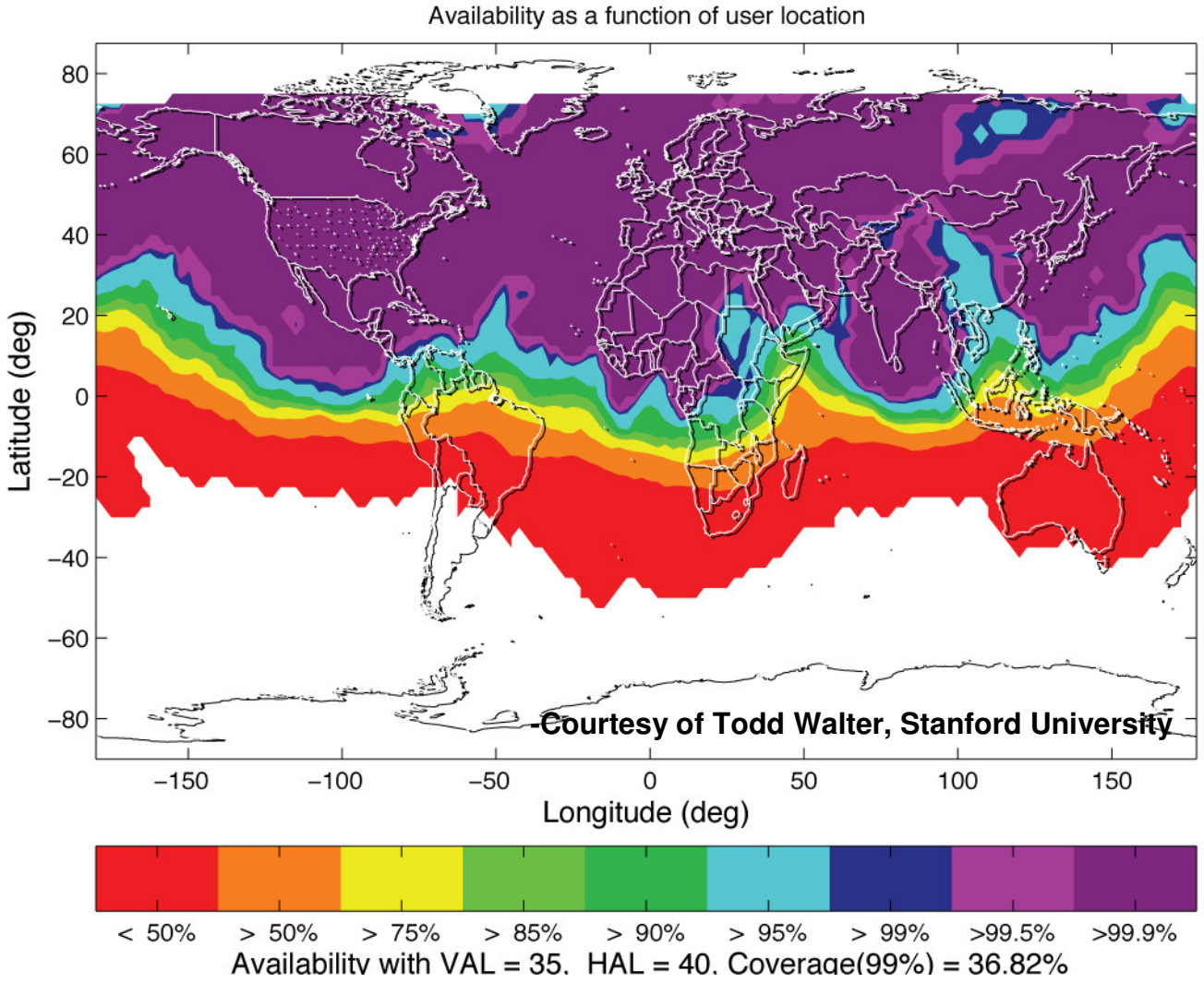
MSAS



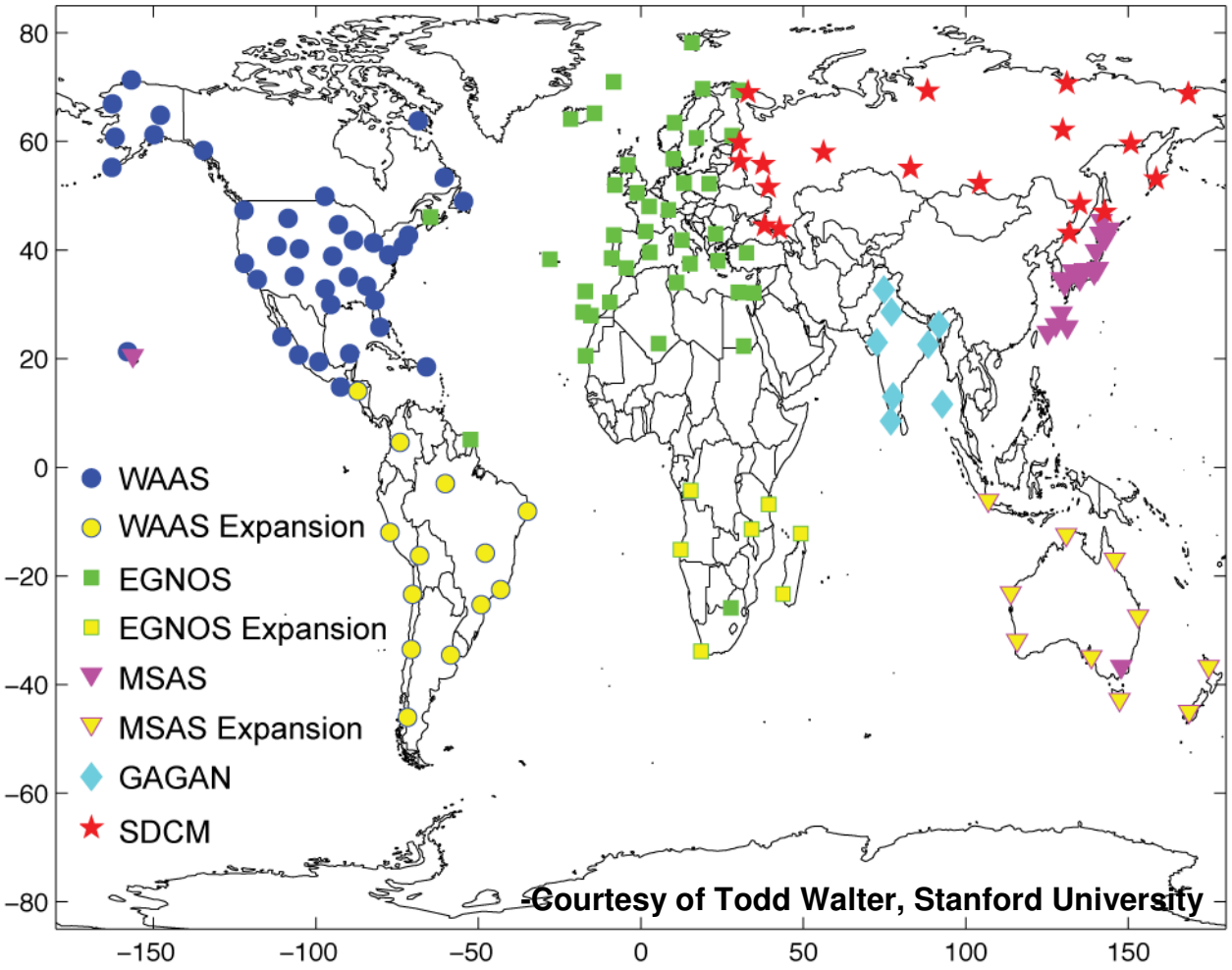
WAAS, MSAS, EGNOS, GAGAN and SDCM Reference Networks



WAAS, MSAS, EGNOS, GAGAN & SDCM
(Dual Frequency GPS)



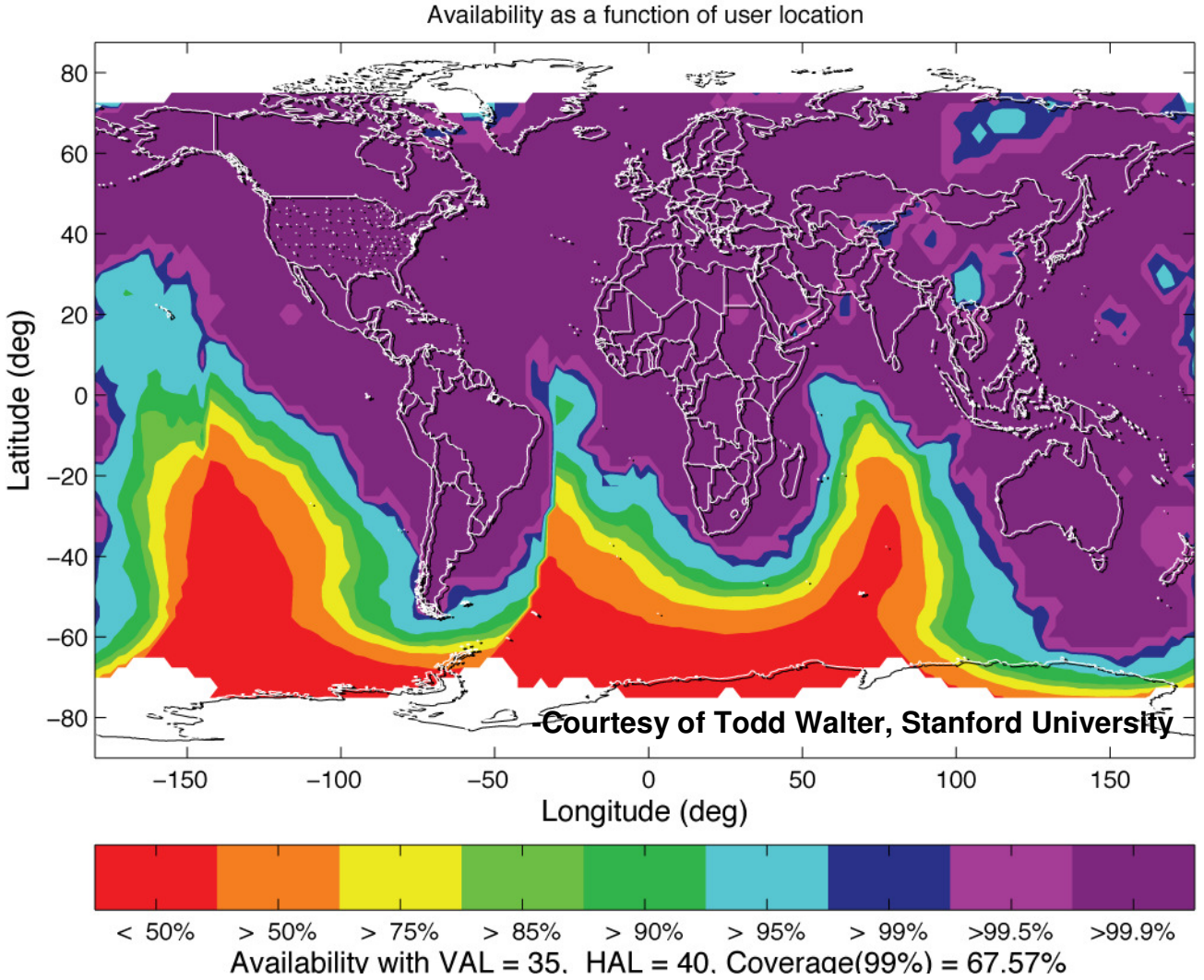
Expanded Networks



-Courtesy of Todd Walter, Stanford University

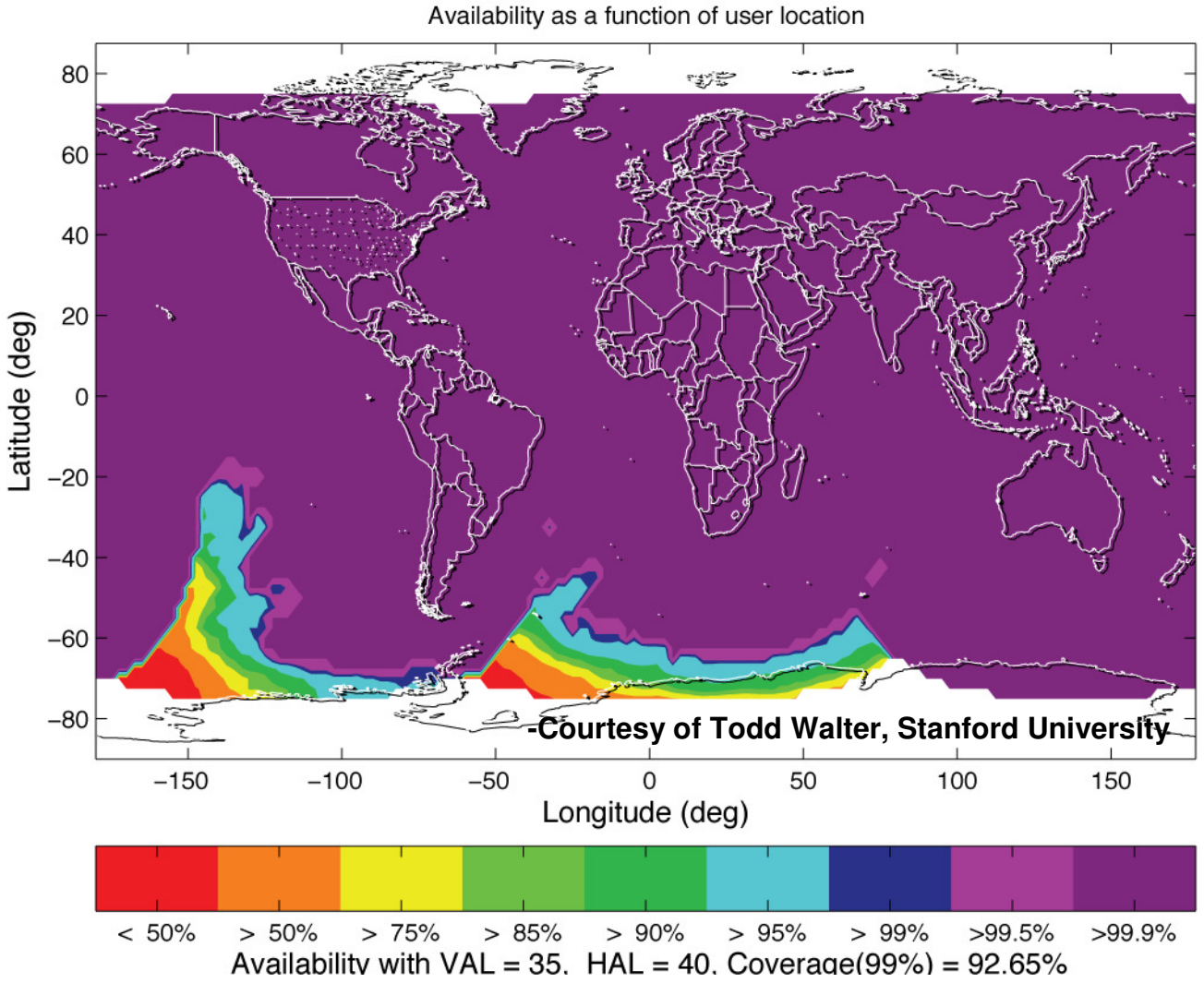
WAAS, MSAS, EGNOS, GAGAN & SDCM

(Dual Frequency GPS + Expanded Networks)



WAAS, MSAS, EGNOS, GAGAN & SDCM

(Dual Frequency GPS + Expanded Networks + Two GNSS Constellations)

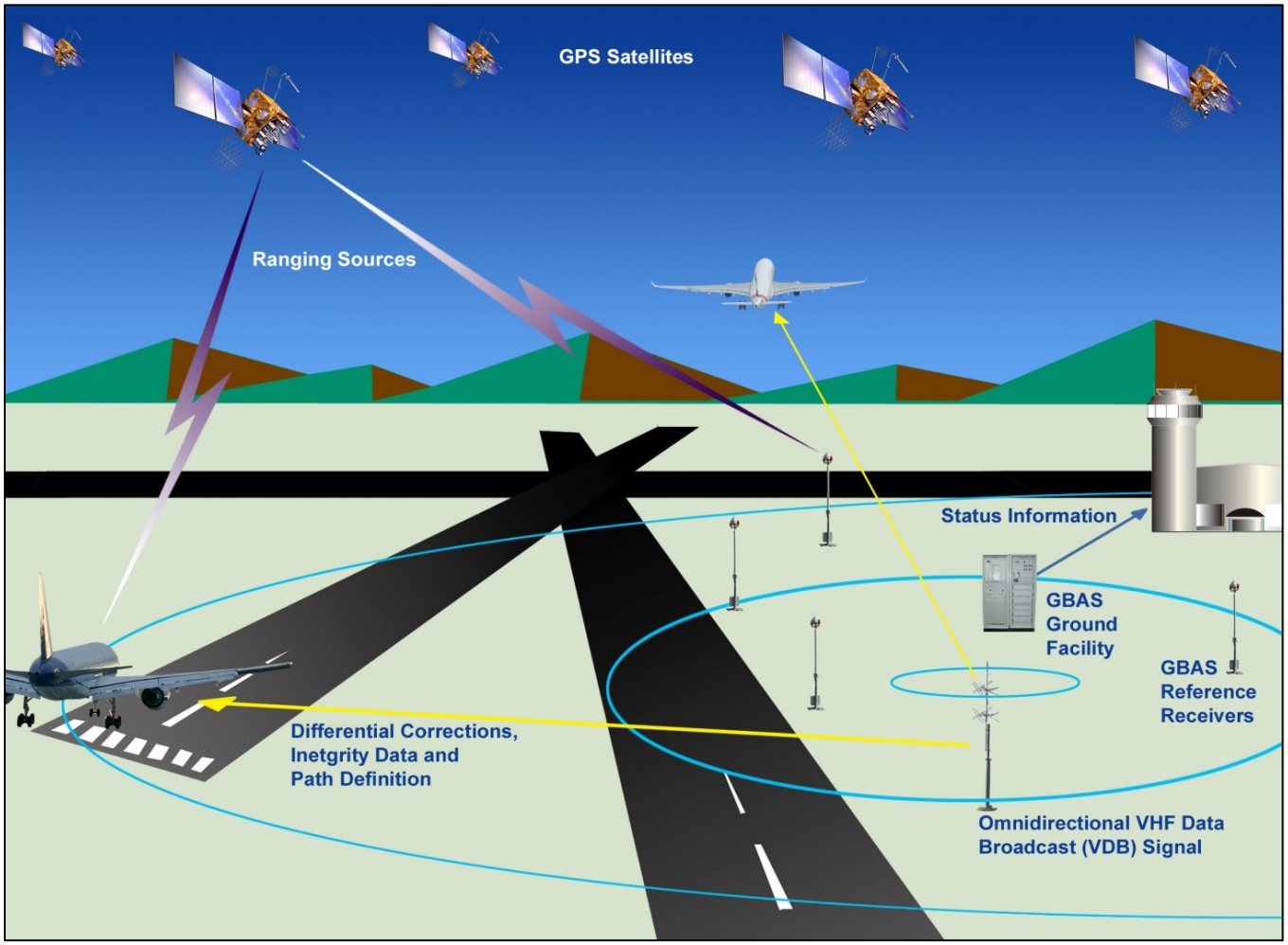


Conclusions

- **Single frequency coverage is good within the countries fielding SBAS**
- **Dual frequency extends LPV coverage outside reference networks**
- **Expanding networks into southern hemisphere could allow global coverage of land masses**
- **Multi-Constellation SBAS allows even greater coverage with fewer stations**
  - Compatible Geodesy and Time Standards are Important

Local Area Augmentation System (LAAS)

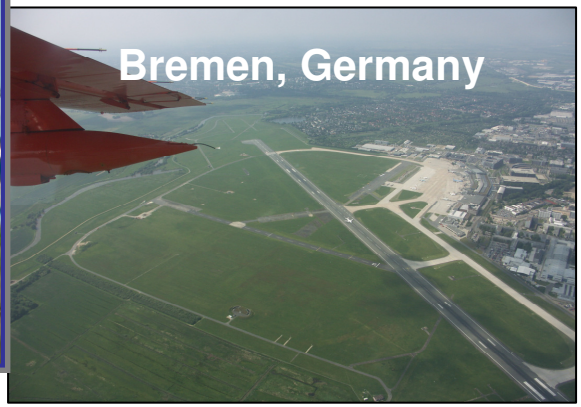
- Precision Approach For CAT- I, II, III
- Multiple Runway Coverage At An Airport
- 3D RNP Procedures (RTA), CDAs
- Navigation for Closely Spaced Parallels
- Super Density Operations



GBAS Pathway Forward

- **Cat-I System Design Approval at Memphis – Complete**
- **Cat-III Validation by - 2010**
- **Cat-III Final Investment Decision by - 2012**

LAAS/GBAS International Efforts



Questions

Universal Navigation Systems (UNS)

Completed Aircraft Approvals

- Astra 1125*
- Beech 400*,
- Boeing B-737-200, B-727-200, B-737
- Bombardier Q-series, Q-300, Q-400
- Bombardier CL-600/60
- Bombardier DHC-8-400 series 'Q-400'
- Citation 550 Bravo Series,
- Citation V 560 Series, & XL, , 525*, Fleet
- DeHaviland 'Dash-8'
- Falcon 10, 20D, 50, 50*
- Gulfstream G-II*
- KingAir 200*, 350
- LEAR 31A, 35, 35A,
- LEAR 40, 40XR, 45, 45XR, 60
- MD-87
- S-76, S-76B, S-76C++
- Sabre 65

Projected Aircraft Approvals

- ATR-42
- Beech Be-200, -300
- Boeing B-727-200 C&F, B-737
- Bell 412
- Cessna Citation II
- Cessna Citation 560XL/XLS, 650
- Cessna Citation VII, Encore
- C-9
- Northrop Grumman T-38
- Gulfstream G-II, G-III
- Falcon 20, 2000
- Hawker 125-700B
- King Air 300, RC-12, US Army
- PC-12
- Embraer NB-145

Rockwell-Collins

Completed Aircraft LPV STCs:

- Bombardier Challenger CL-604
- Bombardier CRJ-200
- Cessna Citation Jet CJ-1+, 2+, 3
- King Air-300
- Hawker 800XP
- Cessna Citation Encore+

Aircraft LPV STCs in work:

Estimate completion w/in 6 months:

- Bombardier CRJ-700/900
- Beechcraft Premier 1 & 1A
- Beechcraft King Air 200,200GT,300,350,C90GTi
- Hawker 400XP, 750, 850/XP, 900XP
- Beechjet 400A (est. 30 Sep for STC)

Estimate completion w/in 12 months:

- Dassault Falcon 20, 50/EX, 2000/EX
- Piaggio P-180
- Gulfstream G-150, G-200
- Bombardier Lear 60XR

Estimate Completion w/in 18 months:

- Bombardier Challenger CL-300, CL-605

Honeywell/CMC

Approved Avionics LPV TSOs:

- **Primus Epic FMS**

Pending Avionics LPV TSOs:

- **Primus 2000 (NZ-2000)**
- **APEX**
- **EPIC (in other airframes)**
- **KSN 770 (for GA aircaft)**

Approved *Aircraft* LPV STCs:

- Gulfstream G-450 & -550

Pending LPV STC Approvals:

- Gulfstream G-IV, G-V
- F-900B,-900EXC
- Challenger CL-601
- Hawker 800
- Citation X
- PC-12
- Viking
- Dassault EASy
- Cessna Sovereign