



GPS High Accuracy Service (GPS HAS) Based on GDGPS

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Motivation and Objective

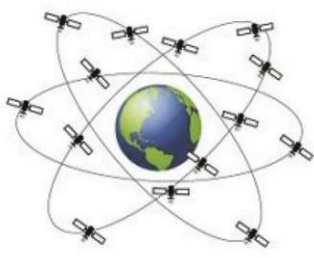
- **Motivation:** Seek a government partner to *sustain* and *distribute* GPS HAS in alignment with PNT AB and PNT Subcommittee guidelines.
- **Objective:** Highlight JPL's advanced technical contributions to improve GPS performance through the integration of High Accuracy Service (HAS) and associated applications via GDGPS.



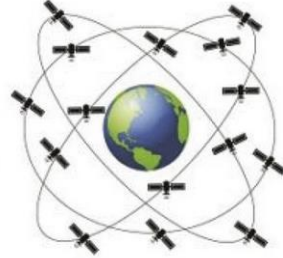
The Robust Real-Time GDGPS System



GPS



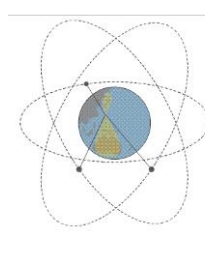
Galileo



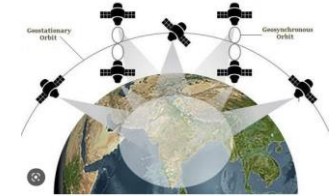
GLONASS



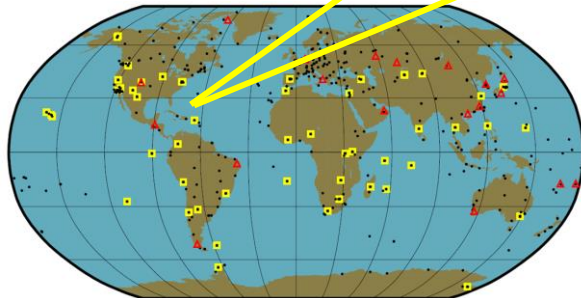
BeiDou



QZSS



NavIC



Reference Network
(Core is NASA's GGN)

GipsyX / RTGx
GDGPS Software

GDGPS

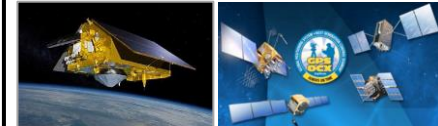


Multiple Redundant
Operation Centers

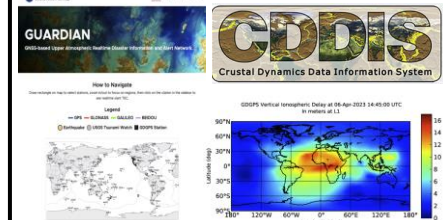
Products,
Services

Users

Precise Positioning and
GNSS Signal Monitoring






Time-Critical Environmental
Monitoring and Science
Products



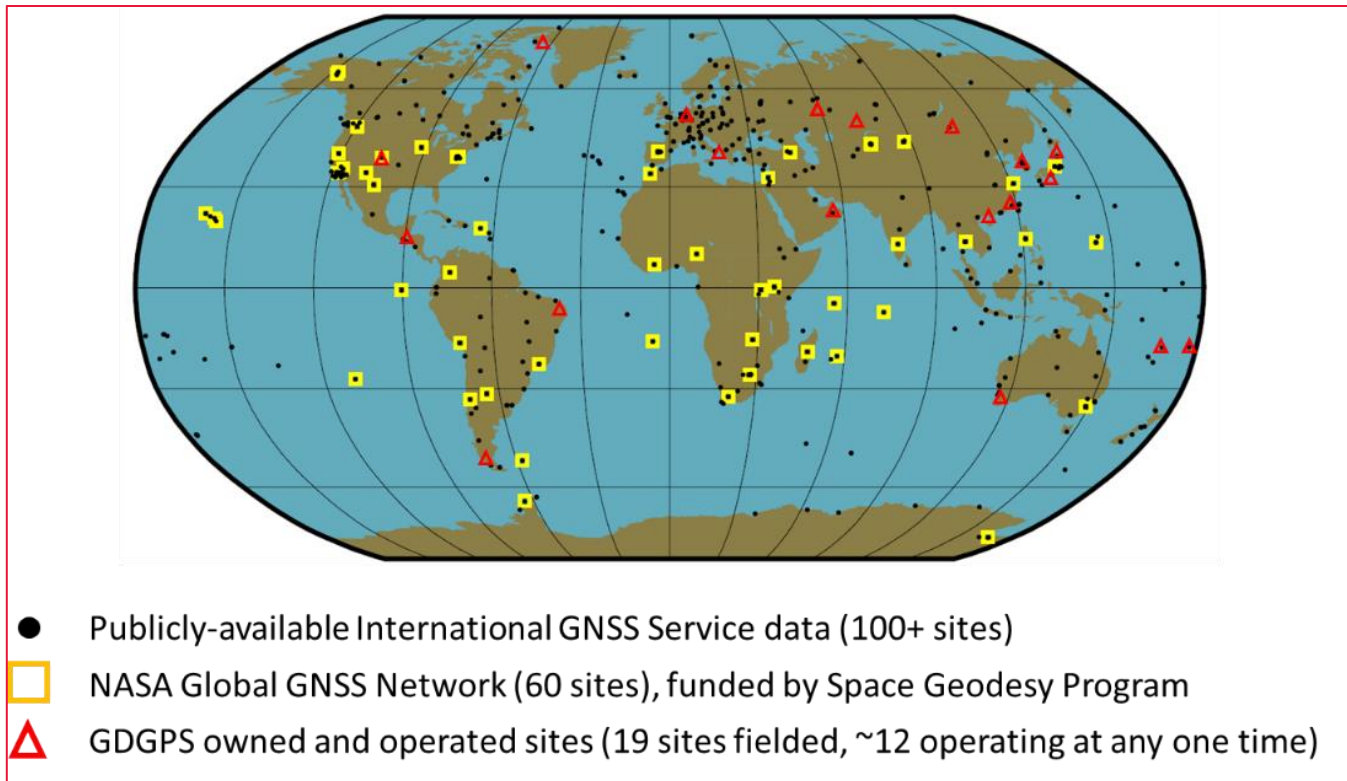
GDGPS enables 5-10 cm real-time accuracy, and provides other unique products



Network of GDGPS-Processed GNSS Receivers

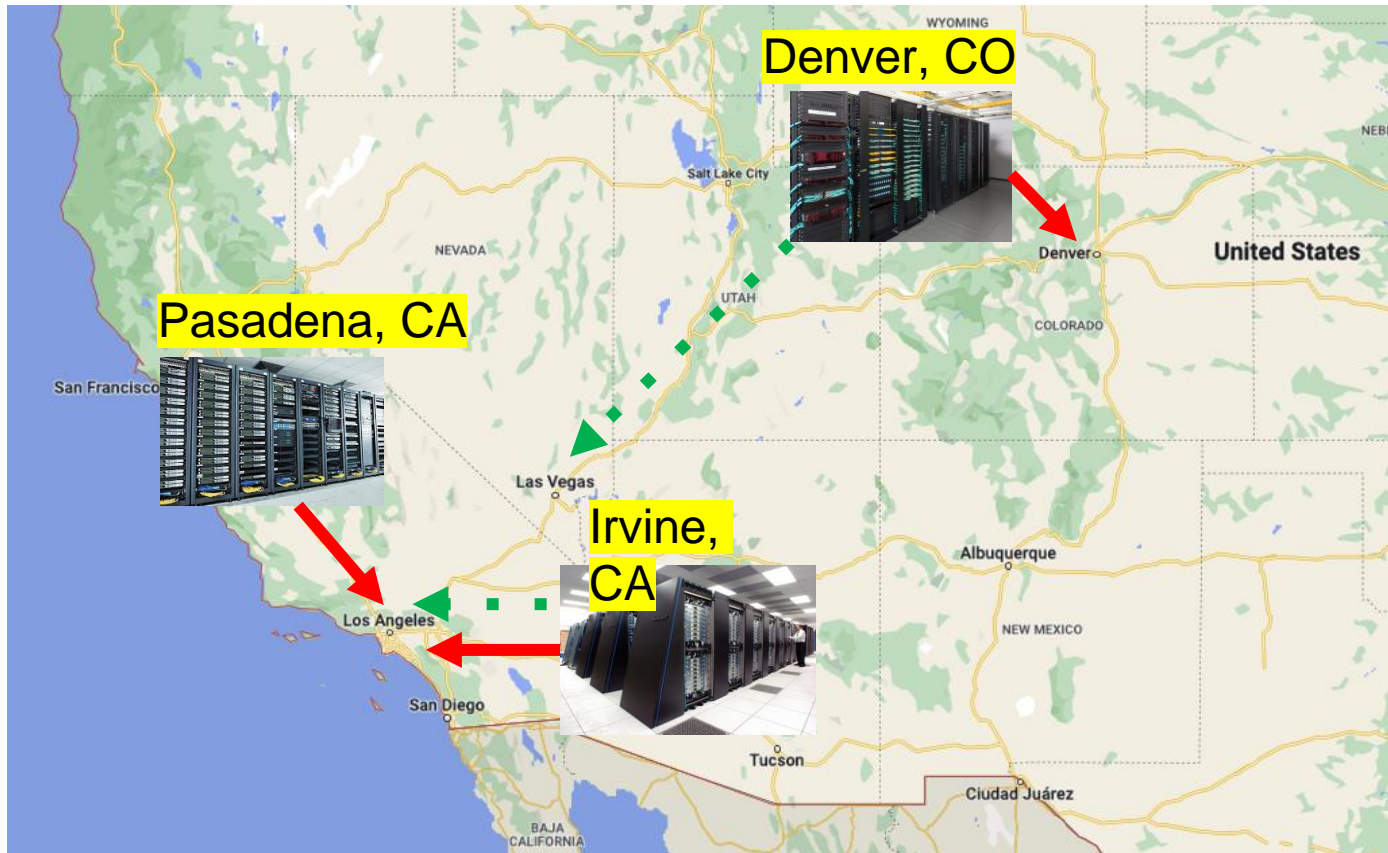
- GDGPS uses and supports NASA-owned JPL-operated GNSS receivers (GGN) 
- Network augmented by a smaller set of GDGPS-operated sites 
- Publicly available IGS streaming data supplements the global network 

The available global tracking network undergoes continual review and upgrading





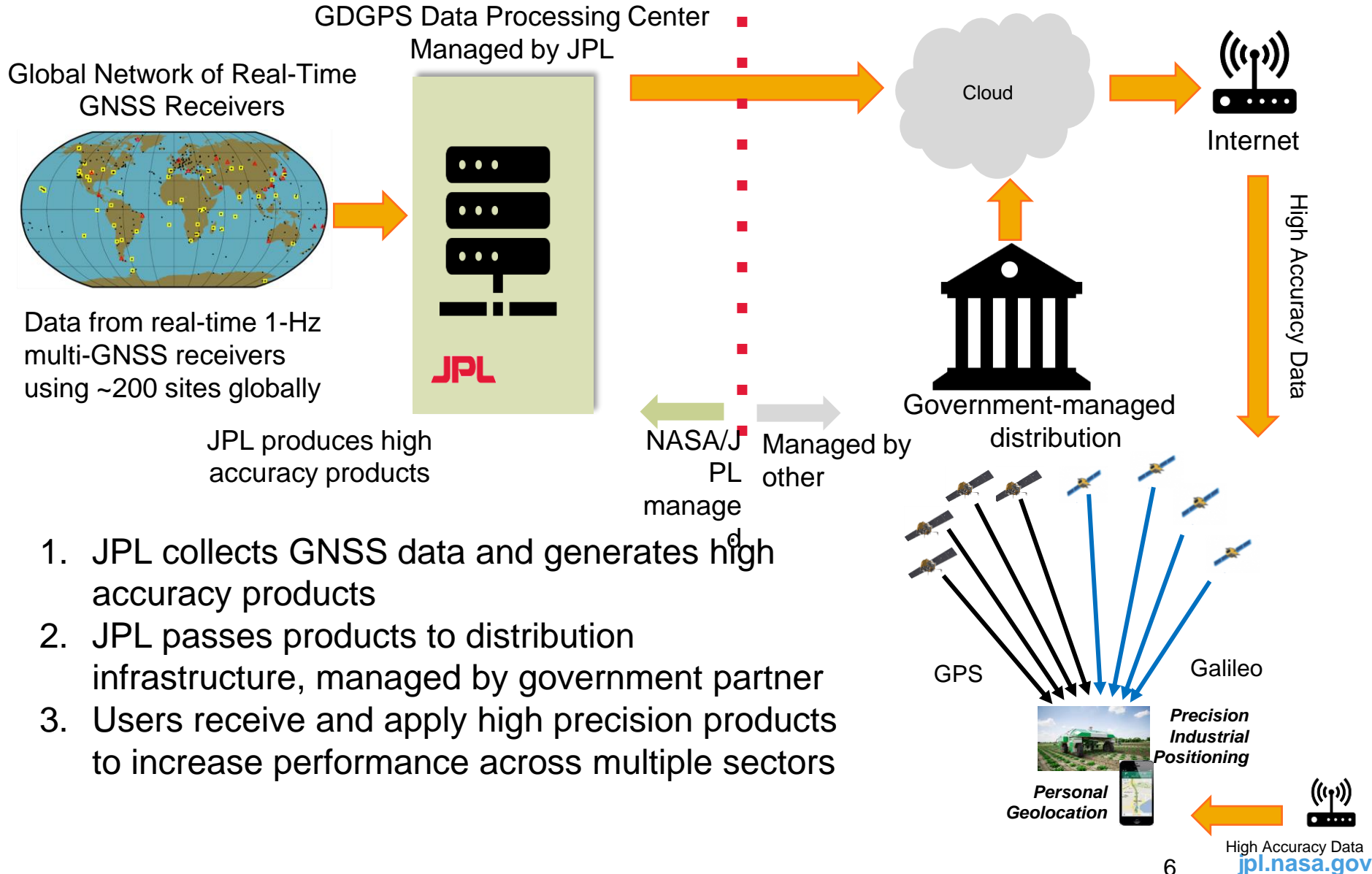
Transitioning GOCs to JPL Data Centers



- Operational data processing is carried out in multiple independent GDGPS Operations Centers (GOCs) with separate ISPs
- We are currently **in transition** to two **JPL Data Centers** located in Pasadena and Las Vegas to comply with **NASA data security requirements (FISMA)**



GDGPS Contribution to a High Accuracy Service (HAS)



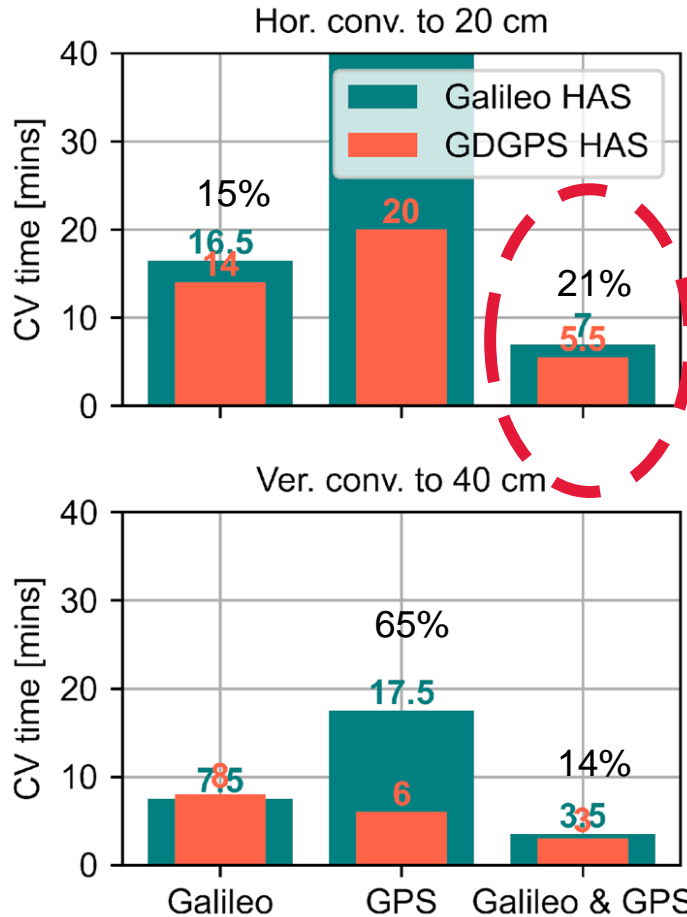
1. JPL collects GNSS data and generates high accuracy products
2. JPL passes products to distribution infrastructure, managed by government partner
3. Users receive and apply high precision products to increase performance across multiple sectors



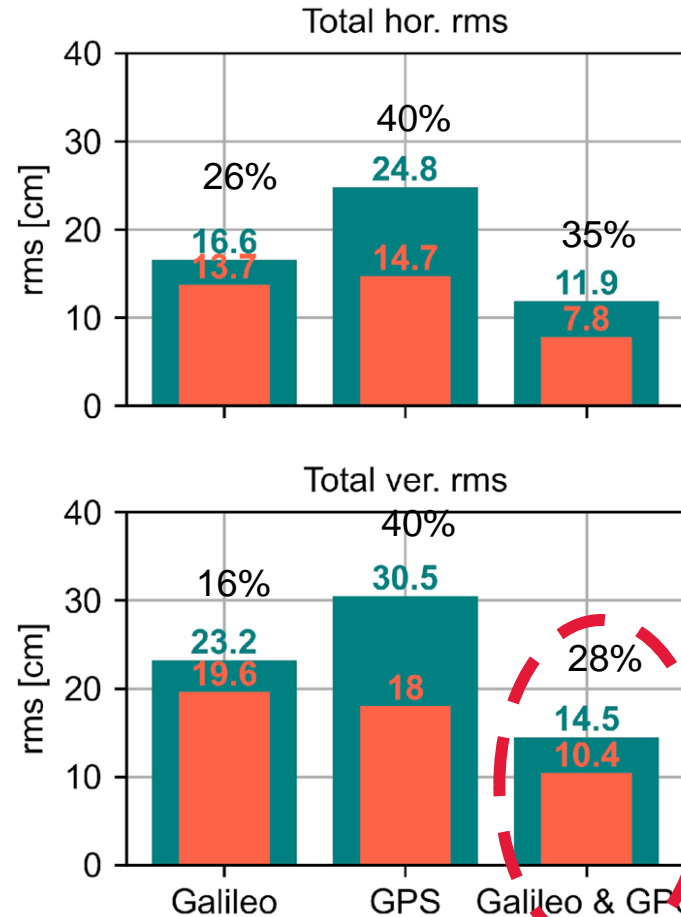
Galileo and GDGPS HAS Horizontal and PPP Vertical Error Comparisons

- Real-time PPP solutions computed using York University's PPP engine (GNSS Lab at York University, Canada)

Convergence time in min



20 cm convergence is achieved in 5.5 min using GDGPS GPS+GAL HAS



10.4 cm vertical RMS achieved using GDGPS GPS+GAL HAS

Horizontal

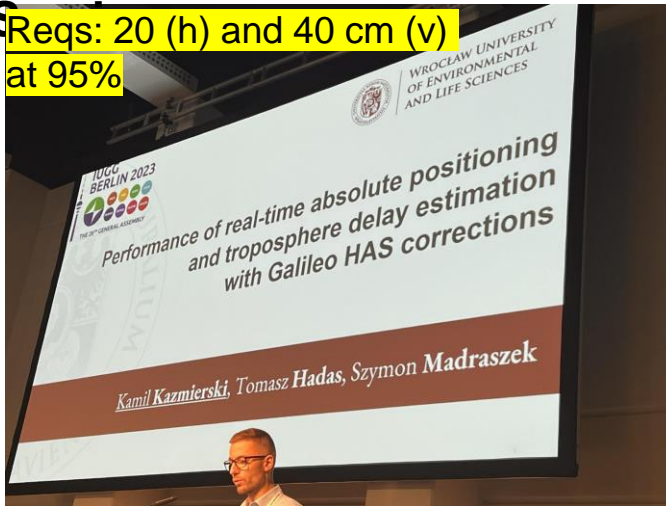
Vertical



Global Landscape: Galileo HAS and PPP-B2b Are Operational

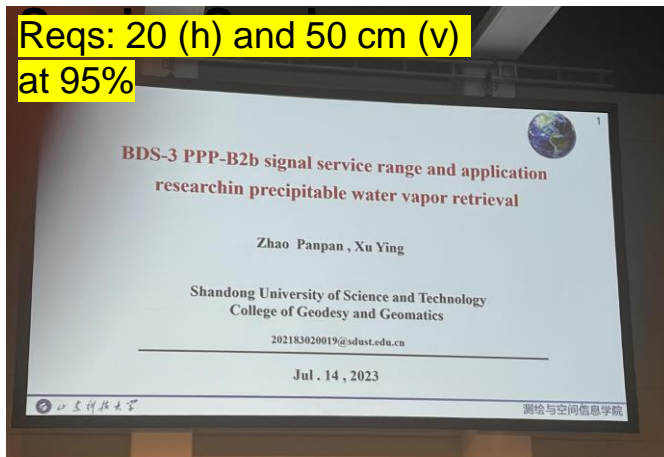
1) Galileo High Accuracy

Reqs: 20 (h) and 40 cm (v)
at 95%



2) PPP-B2b High Accuracy

Reqs: 20 (h) and 50 cm (v)
at 95%



3) German Federal Agency for Cartography and Geodesy (BKG) planning a global PPP service

- Accuracy: <10 cm in 2D, <30 cm in height
- Distribution: mobile internet; via NTRIP
- Network: global RT-GNSS of IGS
- Timeline: development stage 2024-2025; Operational phase: beginning of 2026

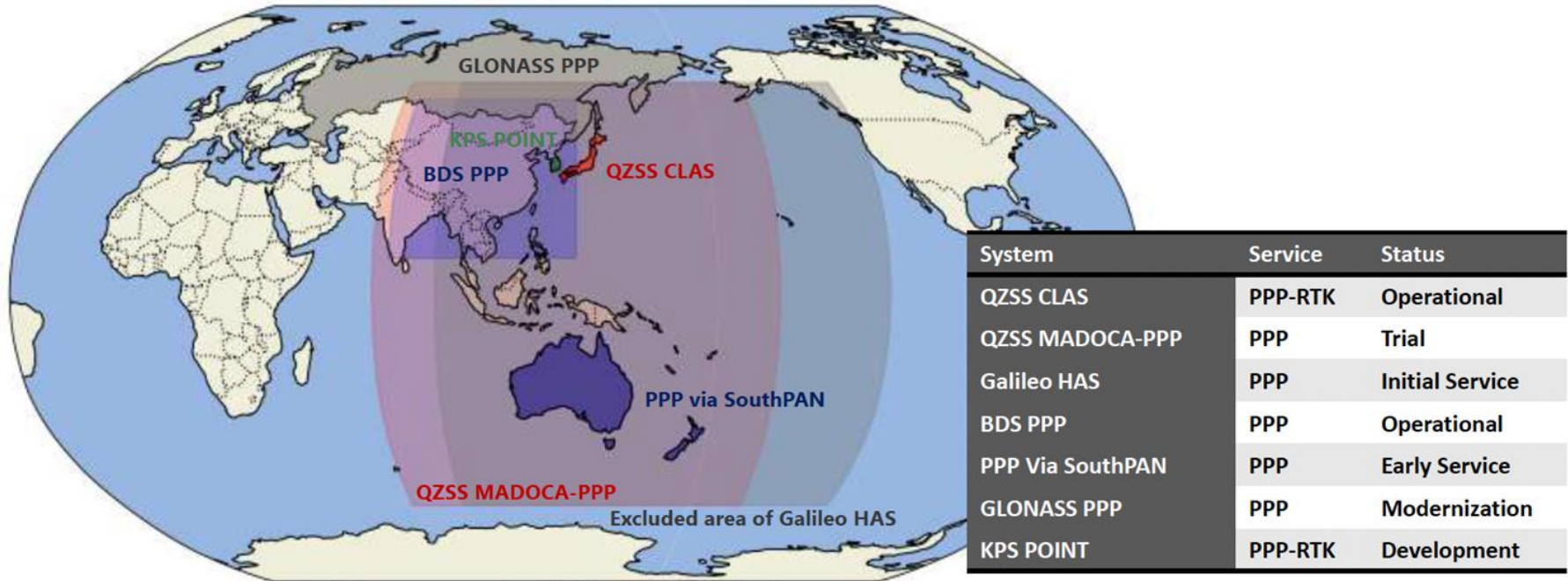
Potential users and applications

- Police, security and rescue services; traffic decongestion, lane navigation; autonomous driving, UAV, agriculture, GIS collection, etc.

Galileo and BeiDou HAS systems in service now



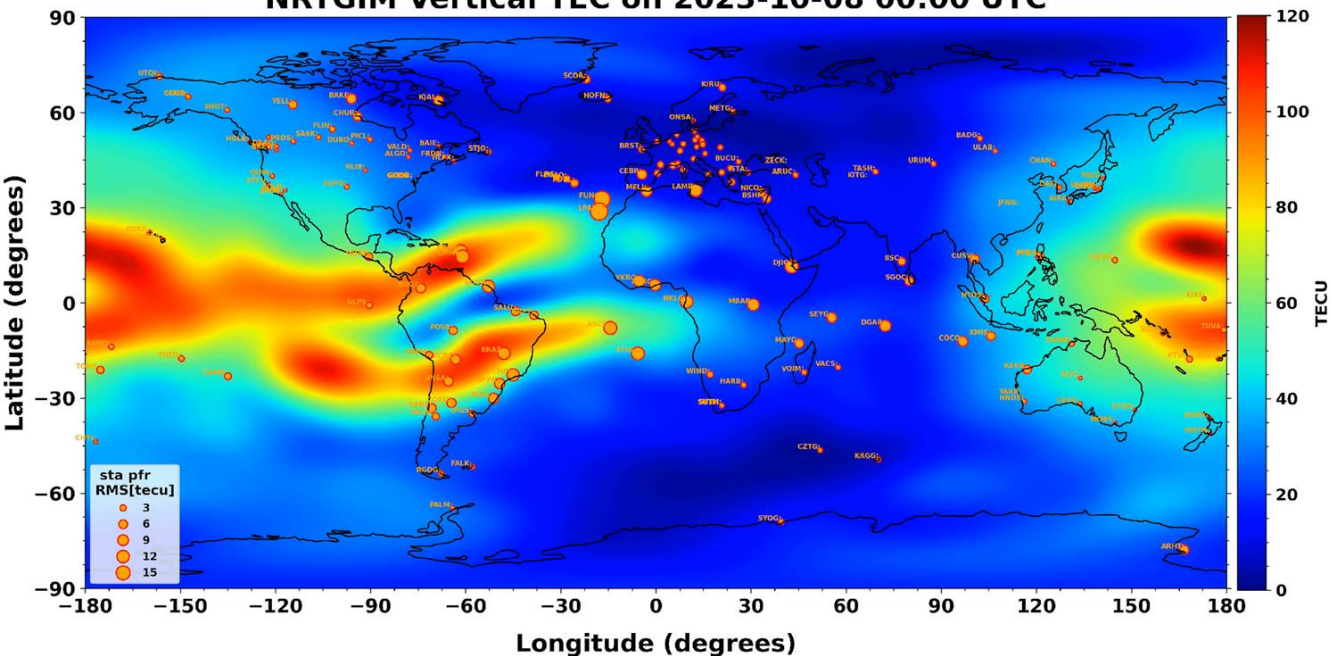
Multiple High-Accuracy Services Available Internationally



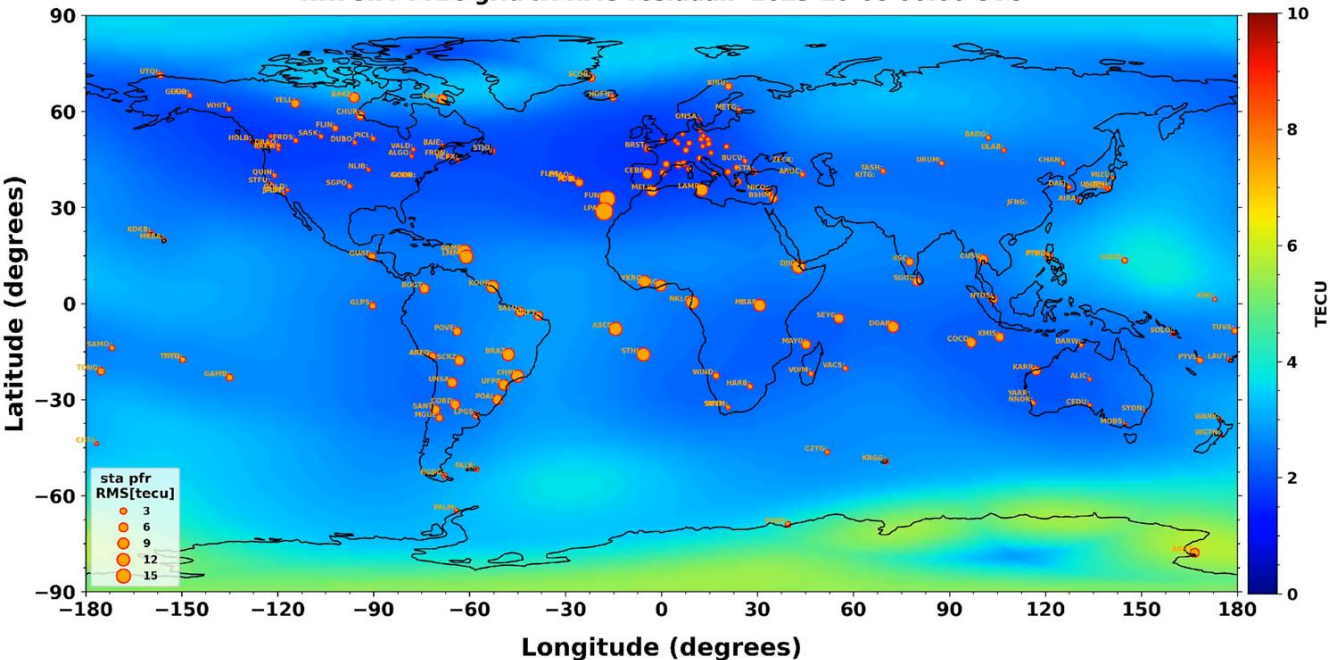
Hirokawa, et al., 2023 at ION
GNSS+ in Denver, CO

6 regional HAS and 1 global HAS service are operational or in development at this time

NRTGIM Vertical TEC on 2023-10-08 00:00 UTC



NRTGIM VTEC grid fit RMS residual: 2023-10-08 00:00 UTC



Additional GDGPS-based science products:

- High-rate near real-time ionospheric corrections to increase convergence time
- Monitoring space weather for geomagnetic disturbances



Conclusions

- GPS has been the premier satnav system to date
 - All consumer GNSS chips depend primarily on GPS
 - Competing systems coming on strong: European Galileo HAS and BeiDou PPP-B2b HAS are operational; Germany planning global PPP service
- A potential GPS HAS using GDGPS has unique and multiple advantages:
 - Global network of GDGPS-processed stations available (100+ stations)
 - Network designed for resiliency, robustness using multiple redundancies
 - GDGPS also provides global real-time monitoring capability of ionospheric disturbances
 - GDGPS is fully capable of providing GPS & Galileo HAS



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