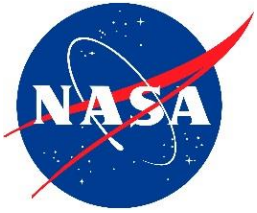


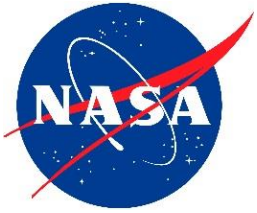
# Global Differential GPS (GDGPS) System Future

Christine Bonniksen  
NASA Management Office  
NASA Headquarters



# Presentation Purpose

- Provide Purpose and Status of NASA initiated GDGPS Working Group
- Solicit input from PNT Advisory Board to support data analysis and inform GDGPS Working Group Recommendations



# Outline

- GDGPS Overview
- GDGPS Working Group
- Summary and Advice Questions



# GDGPS Overview



# Global Differential GPS (GDGPS) System

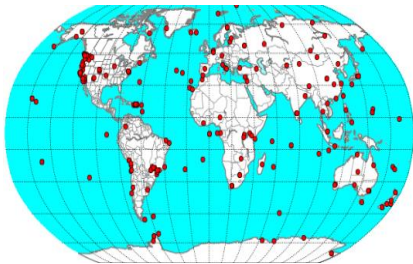
- Designed to improve upon the positioning and timing accuracy provided by operational GPS
- Provides real-time corrections to the GPS broadcast navigation message, enabling global sub-10-centimeter accurate positions
- Estimates the precise orbits and clock states of the GPS satellites
- Create global differential corrections within seconds
- Monitors system stability
- Does the same for most current GNSS systems



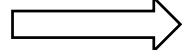
# The Global Differential GPS (GDGPS) System

Provides real-time GNSS products – continuously – since 2000  
Multi-GNSS constellations: GPS, GLONASS, BeiDou, Galileo, QZSS  
~5 cm real-time positioning globally

Real-Time Tracking Network  
(Core is NASA's network)



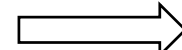
Measurements



Reliable Redundant Data Centers



Products, Services



GNSS Monitoring



Precision Industrial Positioning



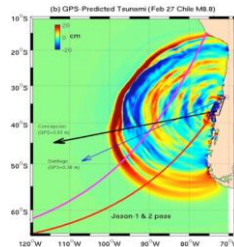
Personal Geolocation



Repeat pass positioning support for UAVSAR airborne radar



Time-critical environmental monitoring services (Earthquake monitoring, tsunami prediction, etc.)



Provides near real-time infrastructure for Sentinel-6 weather products, including radio-occultation



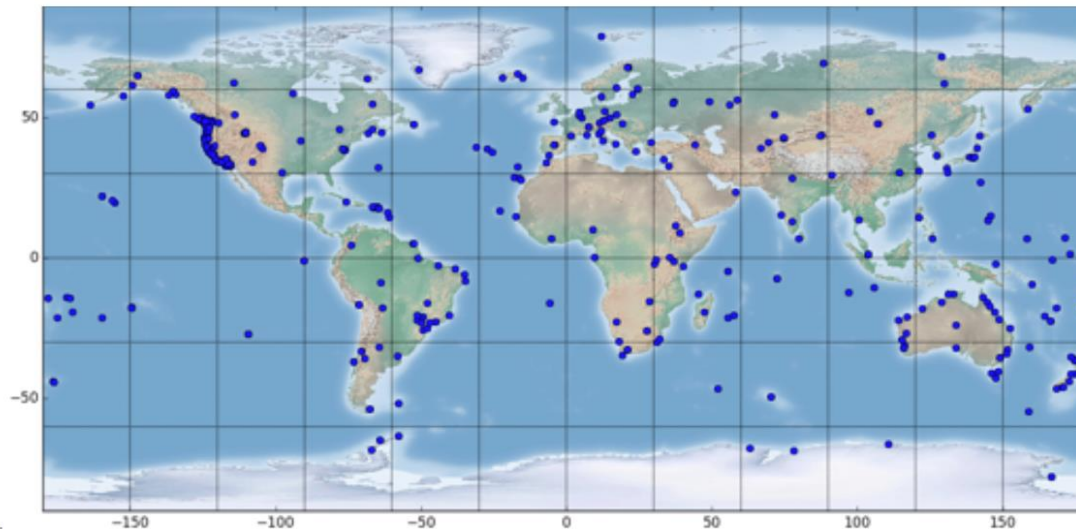
Prototype system and testbed for next generation GPS Control Segment (OCX)

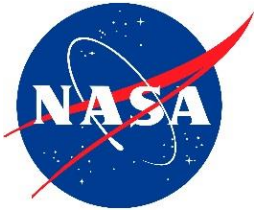




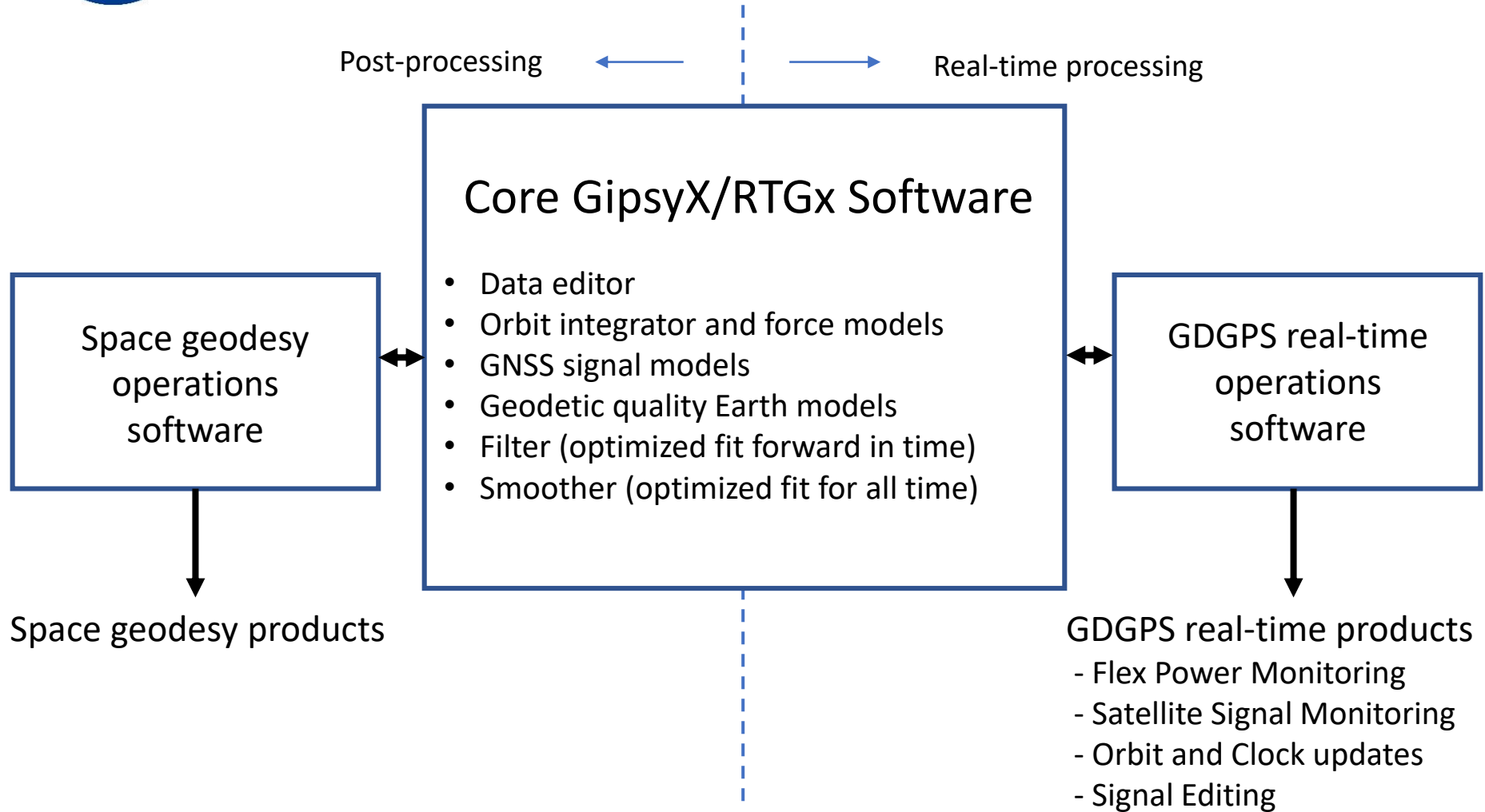
# Global Tracking Resources Based on NASA's Global GNSS Network

- 80+ global tracking sites deployed, controlled, operated and maintained by JPL for NASA
  - JPL installs and maintains receiver hardware (UNAVCO subcontract)
  - JPL software edits and streams data every second
  - Monitoring multiple GNSS: GPS, GLONASS, Galileo, BeiDou and QZSS
- Hundreds of additional sites contributed by US and foreign agencies leveraged to increase redundancy and diversity

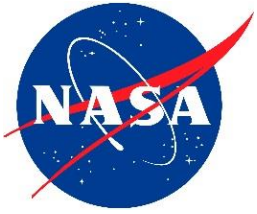




# Global Differential GPS (GDGPS) System Core Software





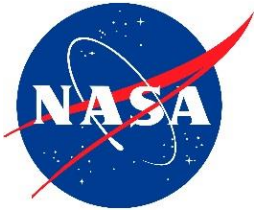


# Global Differential GPS (GDGPS) System Working Group



# Global Differential GPS (GDGPS) System Working Group Establishment

- NASA and JPL were evaluating the future of GDGPS due to the changing commercial markets, emerging dependencies on the GDGPS products and software, and an increasing user base that was not contributing to maintaining the baseline capability
- NASA determined that reviewing individual tasks would not provide the necessary knowledge to identify the NASA and national needs of the this capability
- The GDGPS working group was established in May 2020
- Membership:
  - NASA HQ/SCAN
  - NASA HQ/Earth Science Division
  - NASA HQ/NASA Management Office
  - Jet Propulsion Laboratory



# Global Differential GPS (GDGPS) System Working Group Purpose

- Establish Capability Baseline necessary for current and future NASA and National needs
- Identify Future Operating Construct
  - Funding source(s) and structure
  - Government/FFRDC or Commercial
- Identify any necessary inter-agency cooperation and methods for codifying the cooperation



# Global Differential GPS (GDGPS) System Issues

- End users do not recognize GDGPS dependencies due to no direct interface
- Funding to maintain capability
  - Currently provided by users directly requesting unique products
  - Not all users of the GDGPS products provide funding to support basic capabilities

# Evaluation of Commercial Precise Point Positioning (PPP) Services (work in progress)

Parent Company	Provider	Service/s	Users	Coverage <sup>1</sup>	Ref. Network	GDGPS Dependency
Hexagon AB (Sweden)	Veripos (UK)	Standard	Maritime	Global	GDGPS	Ref. Data
		Ultra	Maritime	Global	VERIPOS <sup>2</sup>	Ind. Backup
		Apex	Maritime	Global	VERIPOS <sup>2</sup>	Ind. Backup
	TerraStar (UK)	TerraStar-X	Agriculture	Regional <sup>3</sup>	TERRASTAR <sup>4</sup>	-
		TerraStar-C PRO	Land, UAS	Global	TERRASTAR <sup>4</sup>	-
		TerraStar-C	Land, UAS	Global	TERRASTAR <sup>4</sup>	-
TerraStar-L		Land, UAS	Global	TERRASTAR <sup>4</sup>	-	
Deere & Co (USA)	NavCom (Canada)	StarFire Subscription Service: Land Only	Land	Global	Starfire Network <sup>5</sup>	-
		StarFire Subscription Service: All Area	Maritime	Global	Starfire Network <sup>5</sup>	-
		StarFire Over IP	All	Internet	Starfire Network <sup>5</sup>	-
Trimble (USA)	-	Trimble-RTX	Land	Global	Trimble <sup>6</sup>	-
		VRS Services	Land	Selected Areas <sup>7</sup>	Trimble <sup>6</sup>	-
		xFill Premium	Land	Global	Trimble <sup>6</sup>	-
Fugro <sup>8</sup> (Netherlands)	Fugro-Marinestar	Marinestar Positioning Services	Maritime	Global (<70°N)	Fugro Network	Ind. Backup
		Marinestar Arctic Services <sup>9</sup>	Maritime	Arctic (>70°N)	Fugro Network	Ind. Backup
UniStrong (China) <sup>10</sup>	Hemisphere GNSS (USA)	Atlas Basic	All	Global	~200 stations <sup>11</sup>	Divested <sup>12</sup>
		Atlas H10	All	Global	~200 stations <sup>11</sup>	Divested <sup>12</sup>
		Atlas H30	All	Global	~200 stations <sup>11</sup>	Divested <sup>12</sup>
Swift Navigation (USA)	-	Skylark Cloud Corrections Service	Land, UAS	Regional <sup>13</sup>	Skylark Network <sup>11</sup>	-
TopCon (Japan)	-	TopNET	Land, UAS	Selected Countries	TopCon GNSS Network <sup>11</sup>	-
DLR & Telespazio (Europe) <sup>14</sup>	Spaceopal (Germany)	NAVCAST <sup>15</sup>	All	Internet	~100 IGS stations	-

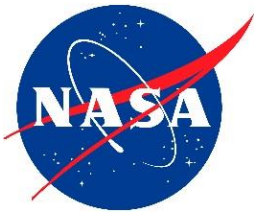


# Uniqueness of Global Differential GPS (GDGPS) System Domestic Providers of Similar Positioning Services

Green indicates not provided commercially

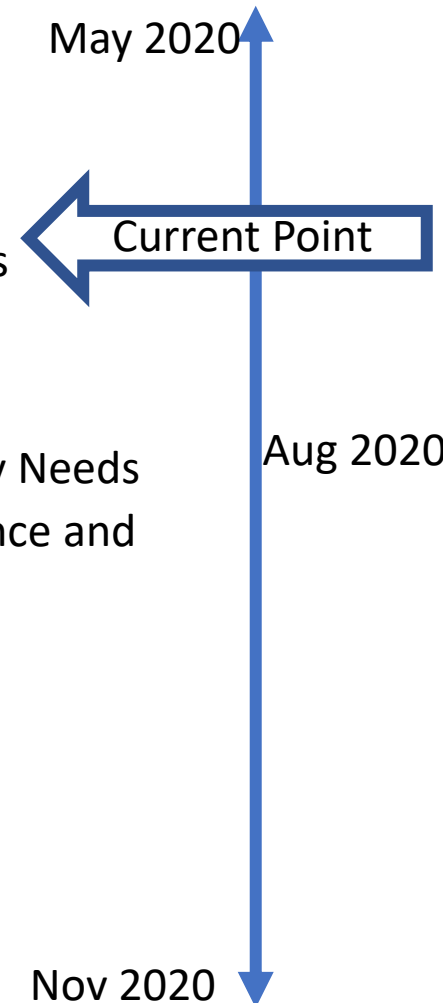
Attribute	JPL	General Provider Capabilities
<b>Constellation:</b>		
GPS	Yes	Yes
GLONASS	Yes	Yes
BeiDou	Yes	No
Galileo	Yes	No
QZSS	Yes	No
Independent of user receiver or software	Yes	No
Global feed (uniformly valid; use anywhere)	Yes	No
No geographical limits	Yes	Yes
<b>Access available:</b>		
Internet	Yes	Yes
Secure Land Line	Yes	No
Secure VPN	Yes	No
GPS III models	Yes	No
Attitude Quaternions	Yes	No
RTCM SSR Standard	Yes	No
Licensable Technology	Yes	No

Table 1. Comparison of high accuracy (sub 10 cm) GNSS differential corrections available over Internet



# Global Differential GPS (GDGPS) System Working Group Actions

- Data Collection
  - Operational Construct Options
  - Current Status of Commercial Market Place
  - Common Understanding of GDGPS Capability and Current Uses
- Analysis
  - Determine NASA Baseline Capability Needs
  - Identify any differences between NASA and National Capability Needs
  - Identify Operational Construct for Future Capability Maintenance and Upgrades





# Summary and Advice Questions

- GDGPS is becoming a part of National Infrastructure – should it be?
- What is the Current Government user set?
- Are there Future uses that should be taken into consideration?
- Are there Operating constructs that shouldn't be missed in the evaluation (funding and oversight)?
- Any additional advice or guidance?