



Current Status and the future of CORS network

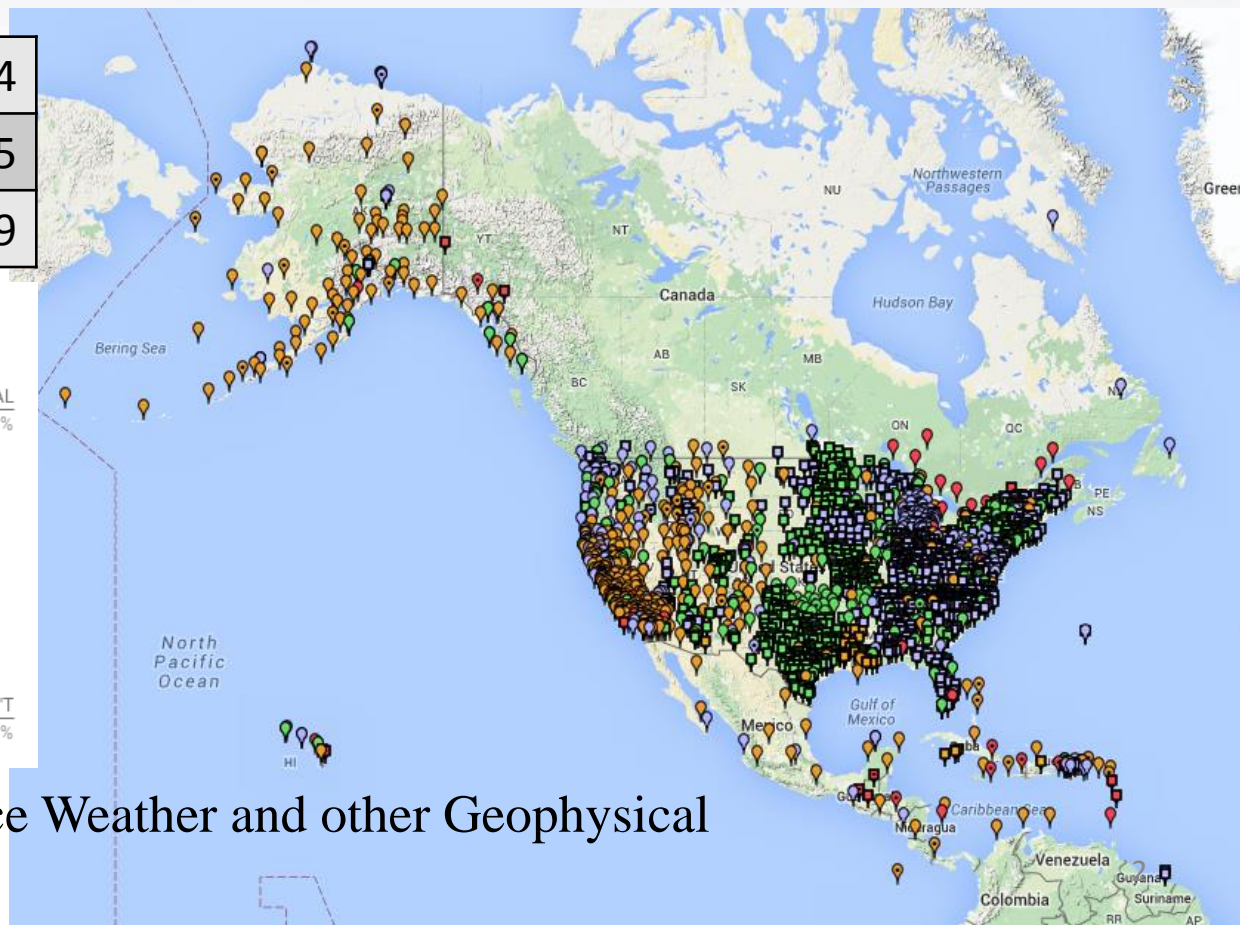
Kevin Choi

Chief, Continuously Operating Reference Stations Branch
National Geodetic Survey

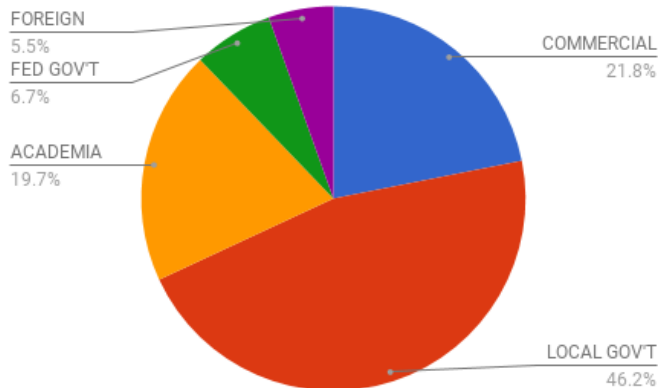
U.S. CORS Network

- ~1900 Continuously Operating Reference Stations
 - Run by various agencies and research groups
 - Provide access to the U.S. National Spatial Reference System

GPS only	524
GPS+GLO	1075
GPS+GLO+GAL	169



CORS Contribution



- Also support Space Weather and other Geophysical applications.

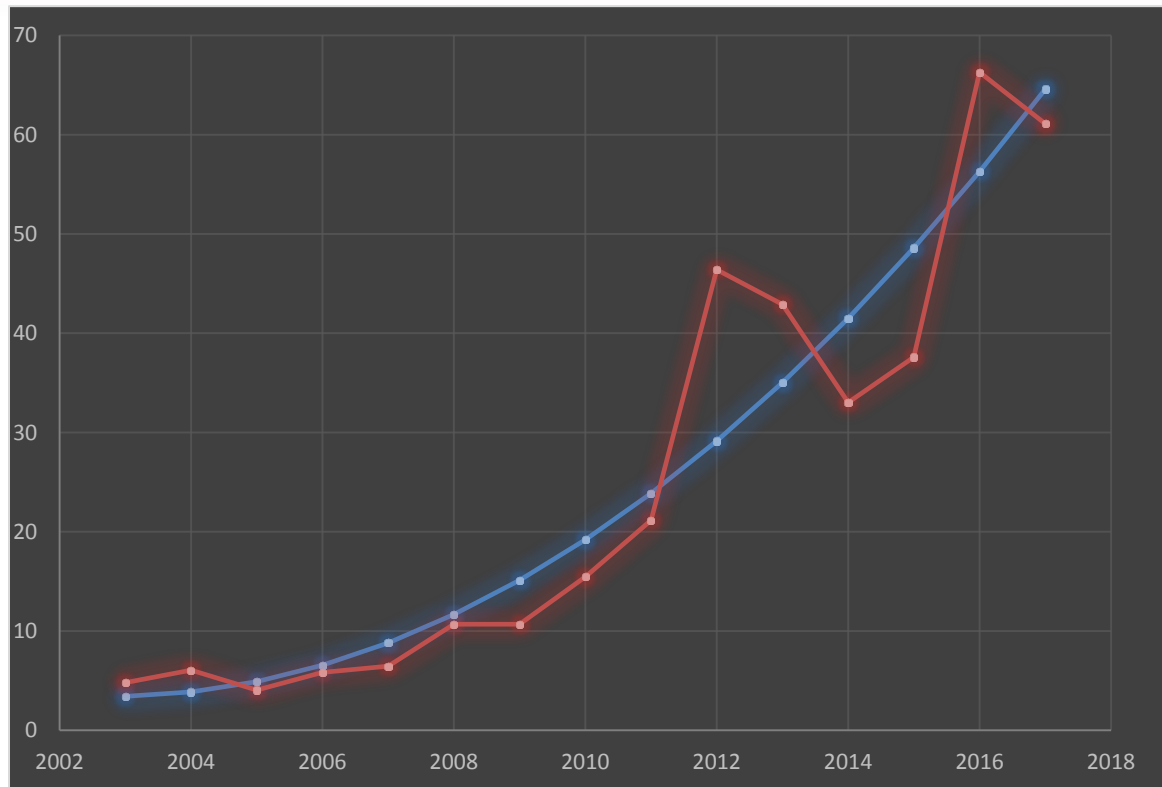
Socio-Economic Benefit

NGS Estimates of CORS Benefits, 2008 vs 2017

	2008			2017		
Service	Value per Download (2008)*	CORS Data Downloads (2008) (thousands)	Total Value (billions of dollars)	Value per Download (2017)**	CORS Data Downloads (2017) (thousands)	Total Value (billions of dollars)
OPUS-RS	\$ 500	72.2	0.04	\$ 569	155.0	0.09
OPUS-S	\$ 500	182.1	0.09	\$ 569	381.8	0.22
UFCORS	\$ 133	1,042.7	0.14	\$ 151	1,303.6	0.20
CORS FTP	\$ 30	9,391.0	0.28	\$ 34	59,262.3	2.02
	Value per Upload (2008)^	Database Uploads (thousands)	Total Value (billions of dollars)	Value per Upload (2017)	Database Uploads (thousands)	Total Value (billions of dollars)
OPUS-Share	400	0.0	0.00	455.35	2.4	1.09
TOTAL			0.55			2.53

Socio-Economic Benefit

- Growth in CORS Program Usage per Fiscal Year (Millions of Downloads)
 - Following a quadratic function



Modernizing National Positioning: New Requirements

Requirement 1:

- NGS is creating a new version of the accepted U.S. positioning framework (defining latitude, longitude, height and other mapping values).
- It is coming in 2022 and the goal is for users with precision needs to access official national positions through GNSS (CORS Network) and an online tool (OPUS).
- This means having a set of high-reliability CORS with even coverage across the U.S. and its territories, so that all citizens are enabled.

Requirement 2:

- Two recommendations from the National Research Council “Precise Geodetic Infrastructure” (2010) report, say that the United States should:
 - “...deploy additional stations... with a goal of reaching a [U.S.] global geodetic network of at least 24 fundamental stations.”
 - “make the long-term commitment to maintain the [international positioning framework] to ensure its continuity and stability.”

Requirement 3:

- At the same time, the United Nations has an effort to support an internationally-consistent positioning framework. Creating this requires world-wide, ultra-high-quality GNSS sites that last for decades.

NSRS Modernization: Key Elements

- Drawn from Blueprint Part 1 (forthcoming)
- Will be tied to most recent ITRF (2020?)
 - Epoch date TBD
 - North America, Pacific, Caribbean, and Mariana
- At epoch date, all frames identical to ITRF
- Then each local frame rotates on own angular rates from the Euler pole rotation
- Velocity models describe motion in frame
- Access via OPUS tool

NSRS Modernization: Four New Frames

Current:

NAD 83(2011)

NAD 83(PA11)

NAD 83(MA11)

The New:

The North American Terrestrial Reference Frame of 2022
(NATRF2022)

The Caribbean Terrestrial Reference Frame of 2022
(CATRF2022)

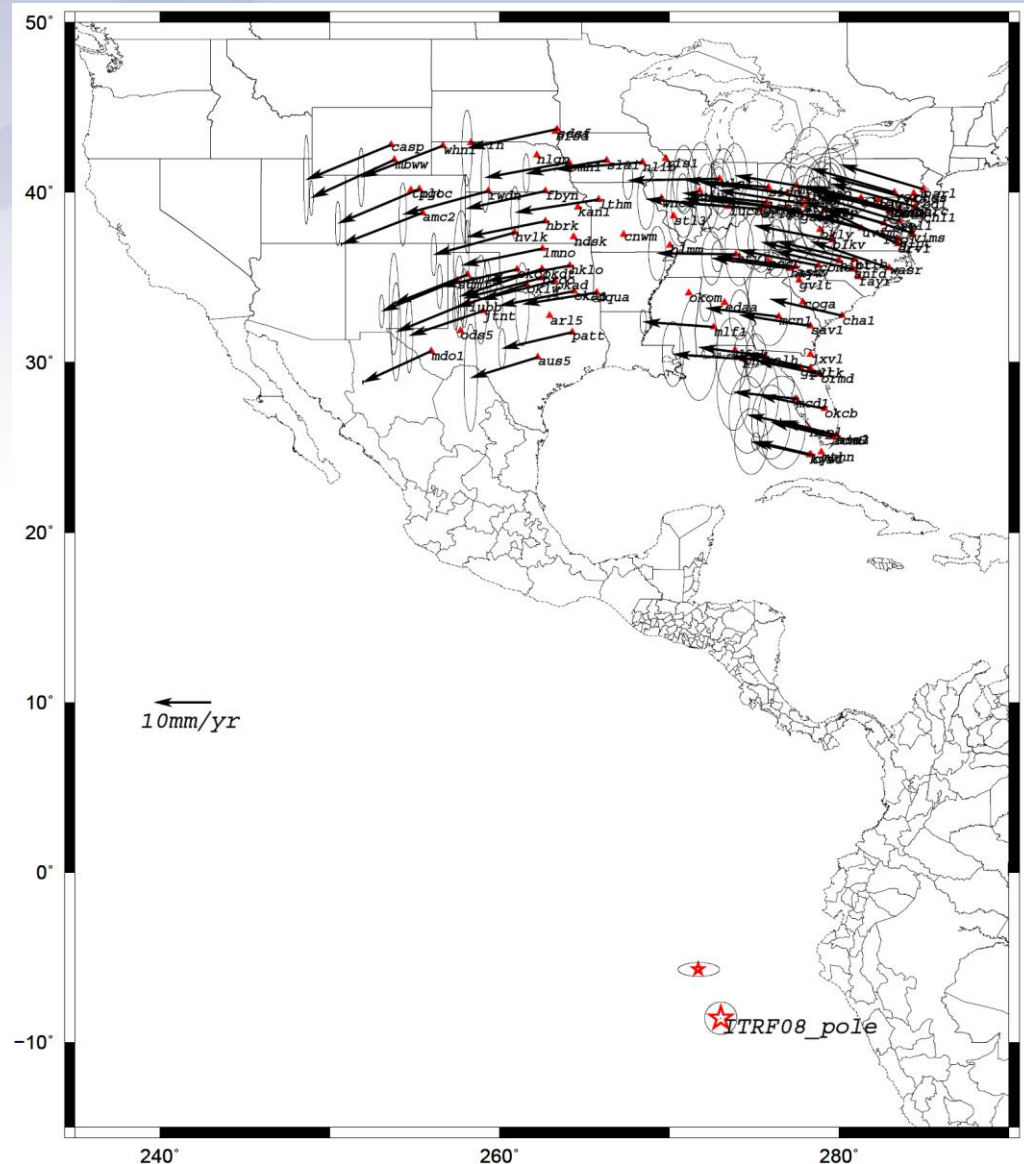
The Pacific Terrestrial Reference Frame of 2022
(PATRF2022)

The Mariana Terrestrial Reference Frame of 2022
(MATRF2022)

Each frame will get 3 parameters

- Euler Pole Latitude
- Euler Pole Longitude
- Rotation rate (rad/yr)

Used to compute time-dependent TRF2022 coordinates from time-dependent ITRF coordinates.



Four Frames/Plates in 2022

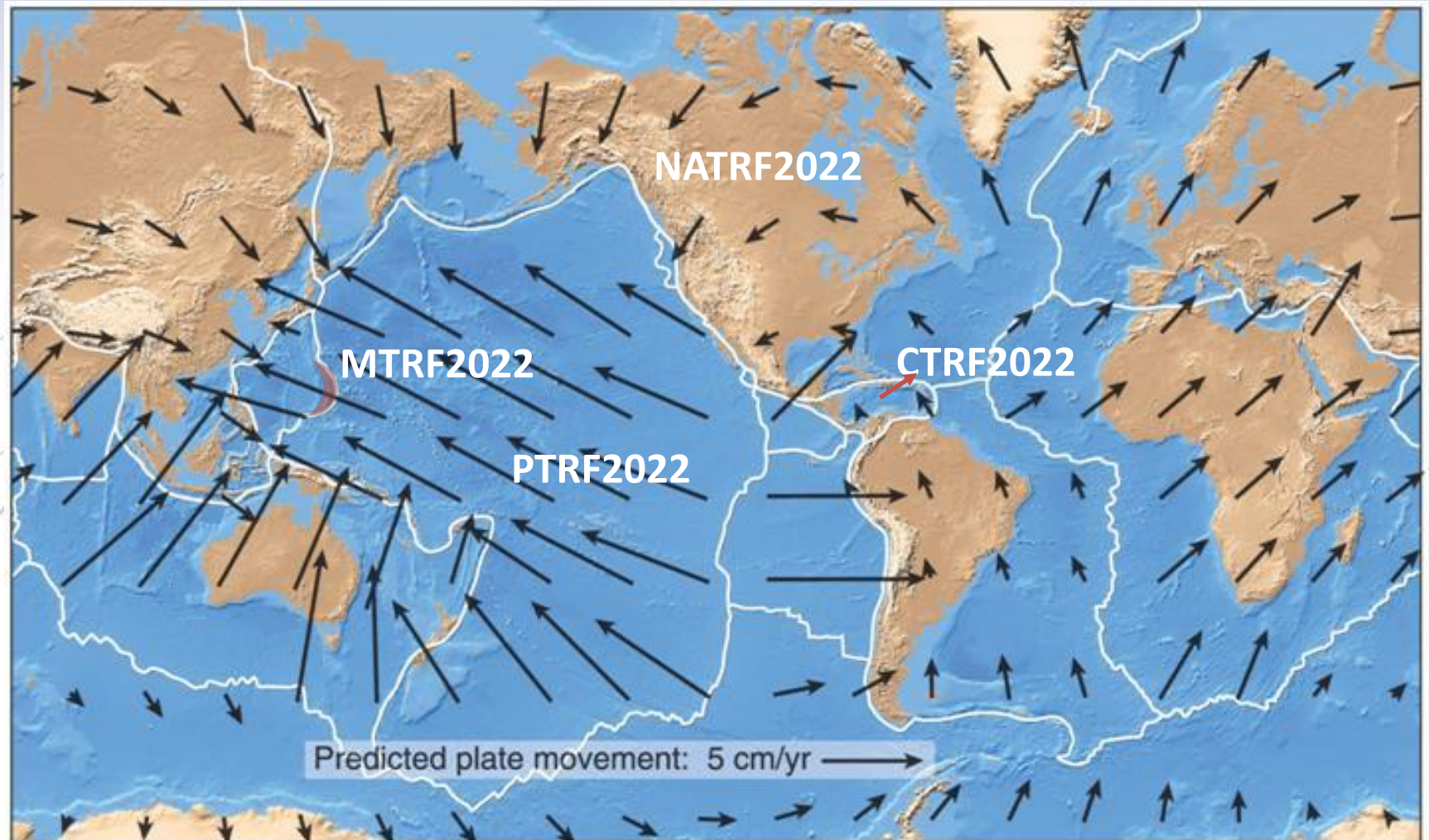
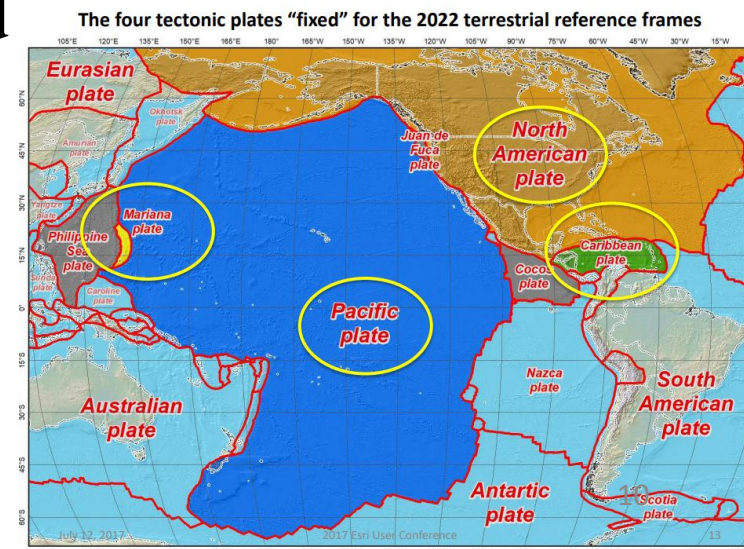


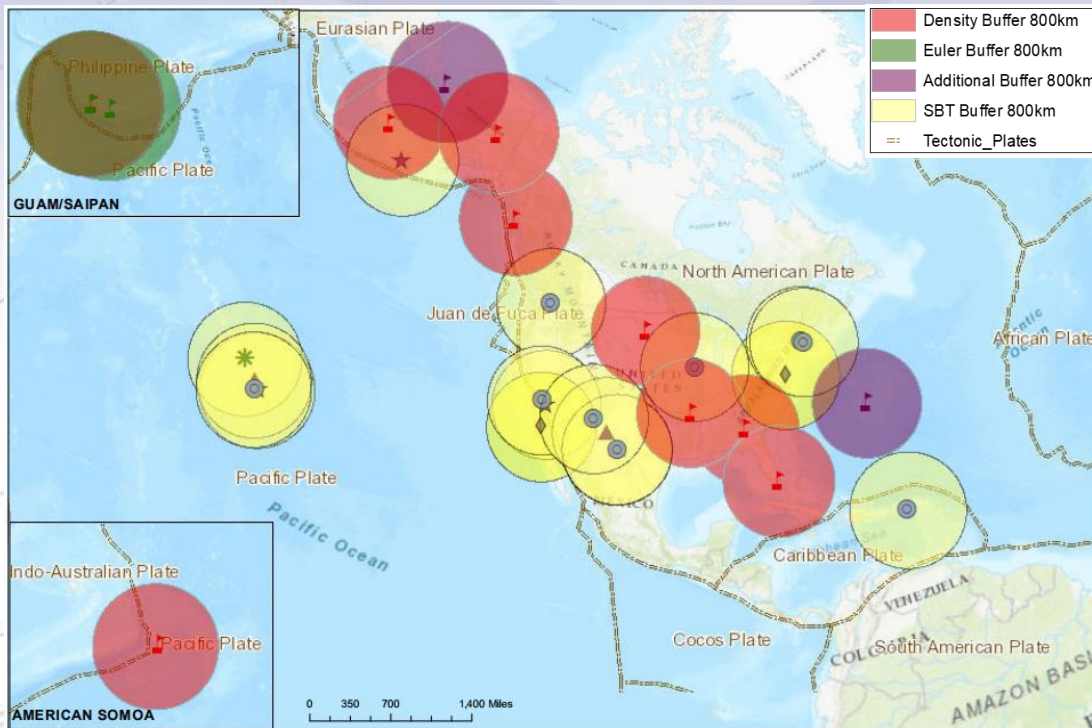
Image from UNAVCO

Foundation CORS Project

- Establish a backbone for the NGS CORS Program using an ultra-stable sub-network
- By 2022, the National Spatial Reference System (NSRS) will be modernized with CORS becoming a more foundational component.
- NGS will continue to support the ITRF and GGOS activities through International GNSS Service (IGS) reference sites.
- The NSRS will continue to be defined in relation to the ITRF (GGRF).
- Four Tectonic Plates to monitor
 - NATRF2022 - North America
 - PATRF2022 - Pacific
 - CATRF2022 - Caribbean
 - MATRF2022 - Mariana



Foundation CORS- The Backbone of the NSRS



A set of federally-operated, ultra-high-quality, high-reliability stations with the longevity to guarantee citizens access to official NSRS positions and support international positioning consistency efforts.



Federal Partners	Site ID	Location	
National Science Foundation (NSF)	AB09	Wales, AK	
	P777	Dennard, AR	
	P804	Georgia	
Existing Sites	AB51	Petersburg, AK	
	ATQK	Atkasuk, AK	
	P043	Wyoming	
	CRO1	Saint Croix, VI*	
	BREW	Brewster, WA*	
National Aeronautics and Space Administration (NASA)	FAIR	Fairbanks, AK	
	GODE	Greenbelt, MD*	
	GOL2	Goldstone, CA*	
	MDO1	McDonald Observatory, Texas*	
	MONP	Mount Laguna, CA*	
	NLIB	North Liberty, IA*	
	PIE1	Pie Town, NM*	
Existing Sites	GUAM	GUAM	
	KOKB	Kauai, HI*	
	MKEA	Mauna Kea, HI*	
NASA or Pacific GPS Facility	HAL1 or MAUI	Haleakala, HI*	
	ASPA	American Samoa	
NOAA- National Geodetic Survey (NGS)	CNMR	Saipan, TQ	
	GUUG	GUAM*	
	BRSG	Bermuda	
	FLF1	Richmond, FL*	
	WES2	Westford, MA*	
	TMG2	Boulder, CO	
	Existing and New Sites	NEW	Apache Point, NM*
		NEW	Fort Davis, TX*
		NEW	Fort Irwin, CA*
		NEW	Hancock, NH*
NEW		Los Alamos, NM*	
NEW		Kitt Peak, AZ*	
NEW		Owens Valley, CA*	
NEW		Cold Bay, AK*	
TBD	TBD	Existing location in Caribbean	
	TBD	Existing location in Caribbean	

26 in North America, 4 in the Pacific, 3 in the Caribbean, and 3 in the Marianas.

Foundation CORS Project

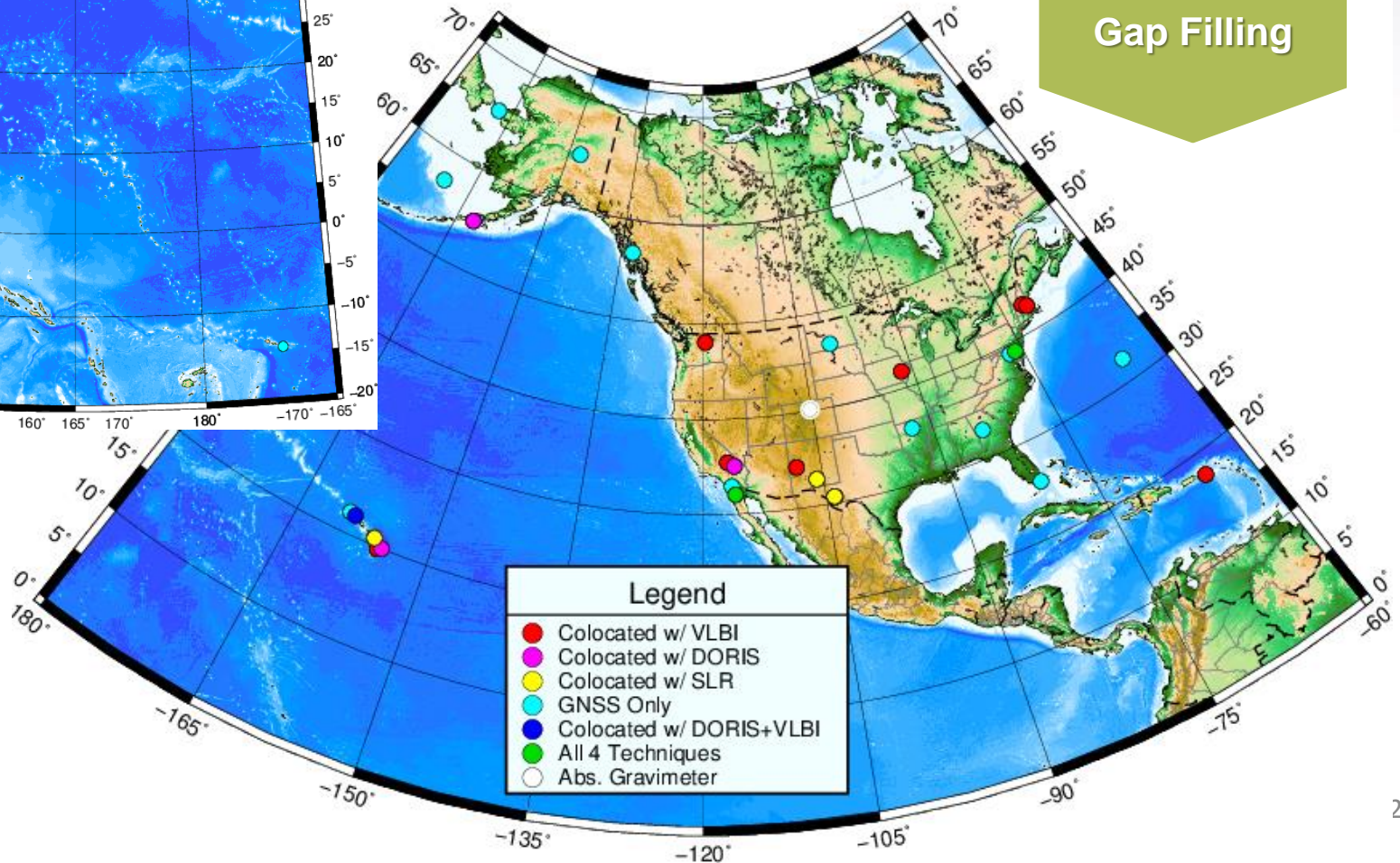
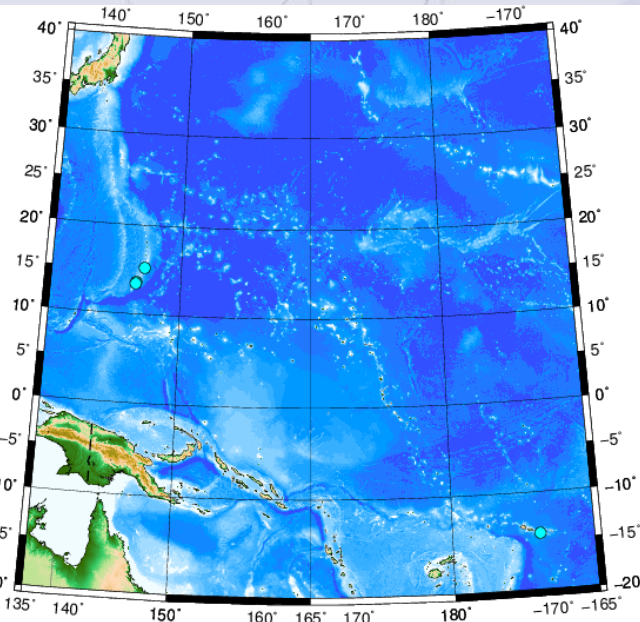
Colocation

Plate
Rotation

Geographic
Distribution

Gap Filling

Foundation CORS Plan

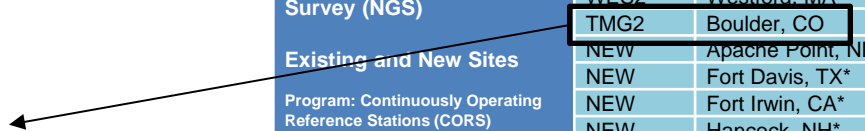


Foundation CORS Project Started FY18

# Sites	Status/Description
7	Current NGS Foundation CORS
8	New NGS Foundation CORS to build
1	Partner Foundation CORS to renovate (NASA- NLIB)
12	NASA-Operated Foundation CORS
6	NSF-Operated Foundation CORS
2	Other, non-federal partners
36	Target Foundation CORS count



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	GOL2	Goldstone, CA*	
	MDO1	McDonald Observatory, Texas*	
Existing Sites	MONP	Mount Laguna, CA*	
	NLIB	North Liberty, IA*	
	PIE1	Pie Town, NM*	
	GUAM	GUAM	
Program: Global GNSS Network (GGN), operated by Jet Propulsion Laboratory	KOKB	Kauai, HI*	
	MKEA	Mauna Kea, HI*	
	HAL1 or MAUI	Haleakala, HI*	
	NASA or Pacific GPS Facility	ASPA	American Samoa
CNMR		Saipan, TQ	
GUUG		GUAM*	
BRSG		Bermuda	
NOAA- National Geodetic Survey (NGS)	FLF1	Richmond, FL*	
	WES2	Westford, MA*	
	TMG2	Boulder, CO	
	Existing and New Sites	NEW	Apache Point, NM*
NEW		Fort Davis, TX*	
NEW		Fort Irwin, CA*	
NEW		Hancock, NH*	
NEW		Los Alamos, NM*	
NEW		Kitt Peak, AZ*	
NEW		Owens Valley, CA*	
NEW		Cold Bay, AK*	
TBD		TBD	Existing location in Caribbean
		TBD	Existing location in Caribbean



Operational Capability of L2C

- L2C is a new civilian GPS signal in L2 frequency (1227 MHz)
- Enables ionospheric correction for the civilian uses.
- GPS Block IIR-M and II-F satellites transmits L2C.
 - Currently 19 SVs transmits L2C.
- Pre-operational by USAF
- Are these ready for operation?

Known issues with L2C

- L2C is known to have satellite induced phase shifts, aka “quarter cycle problem”.
 - Geo++ and IGS raised the issue in 2009.
(http://www.geopp.com/pdf/geopp_phase_shift_l2c.pdf)
 - GPS World, 2015 by Alan Cameron (<http://gpsworld.com/to-l2c-or-not-to-l2c-that-is-the-operational-question/>)
 - Ambiguity resolution algorithm is affected.
- Many receiver vendors updated the firmware to mitigate the issue.
- Still some receivers/firmware have this issue.
 - There’s no easy tool to mitigate.
 - One group in TU-Dresden, Germany is conducting a research and monitoring.

Thank you!

(And sorry for the
signal blocking)

