



# The NOAA Foundation CORS Network– An Ultra-Stable, Highly Reliable Backbone for the NOAA CORS Network

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## Background

Since 1994 the National Geodetic Survey has managed a collaborative network of permanently installed geodetic-grade GPS reference stations, known as **Continuously Operating Reference Stations (CORS)**. The NOAA CORS network is a multi-purpose cooperative network of GNSS observations collected from over 200 of government, academic, and private organizations. Each agency owns and operates its own stations and shares the observation data with NGS. The primary objective of the CORS network is to enable GPS users by providing precise positioning relative to the **U.S. National Spatial Reference System (NSRS)- the source of official U.S. coordinates**. Each CORS shares its data with NGS, and NGS in turn analyzes and distributes the data to the general public free of charge.

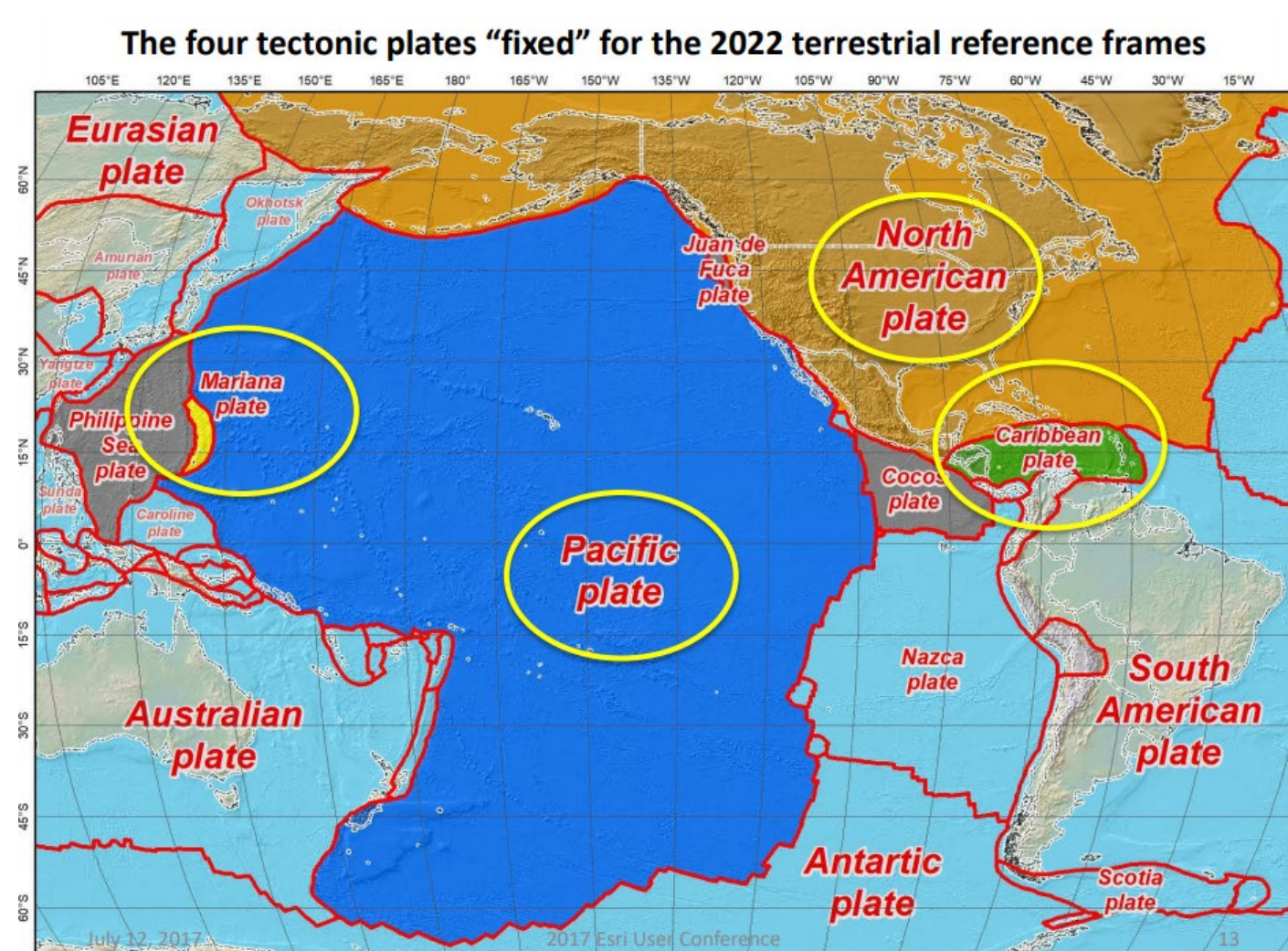
Despite the large number of partner agencies and stations, the global reference frame stations in the US are limited due to density considerations and quality issues. In order to maintain long-term consistency between the NSRS and International Terrestrial Reference Frame (ITRF), it is desirable to maintain a set of reference frame sites to the highest standard.



## Motivation 1: Modernizing the U.S. NSRS

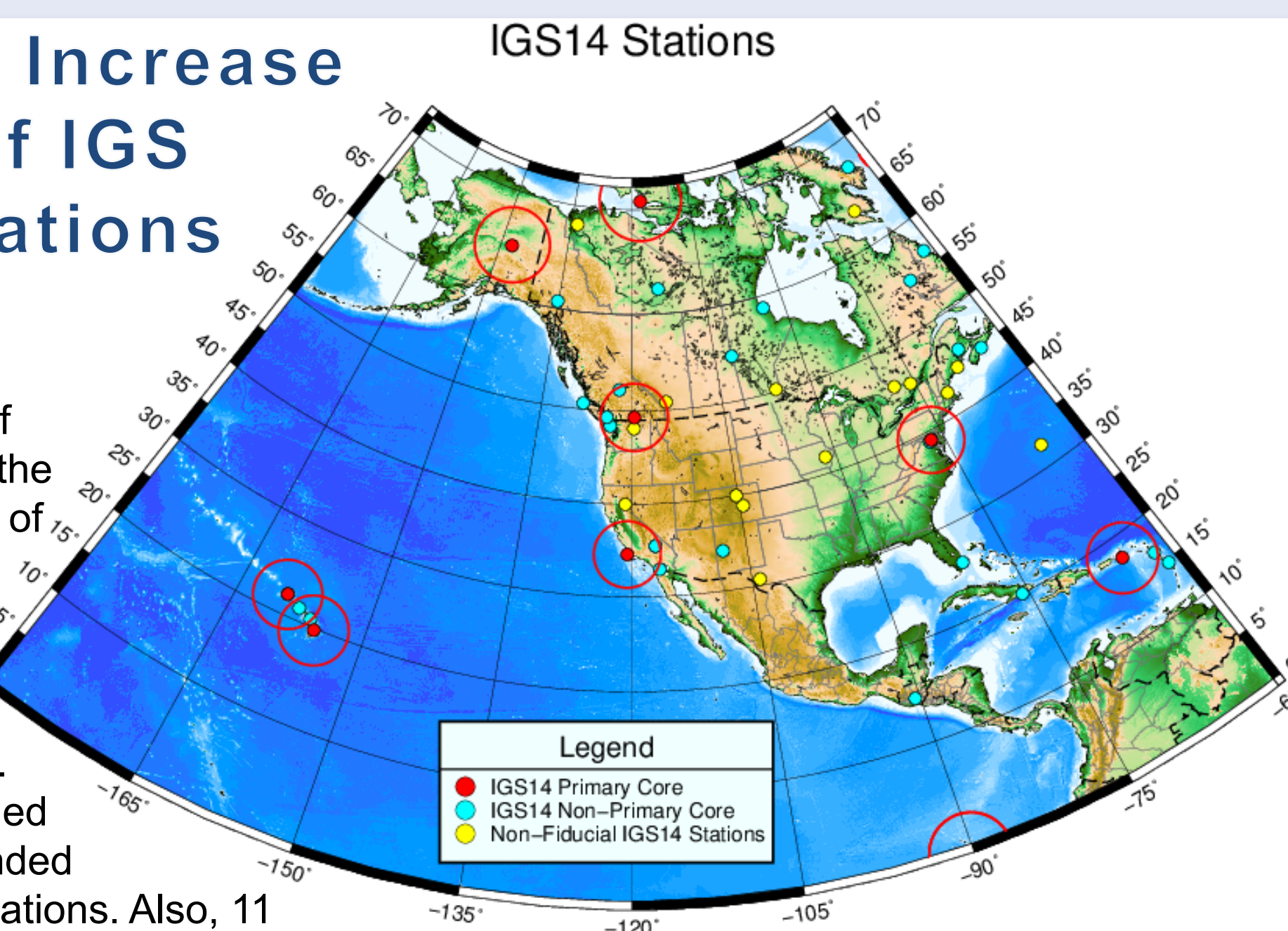
- By 2022, the National Spatial Reference System (NSRS) will be modernized with the CORS network becoming its critical component for definition and access.
- To ensure equal, high-quality access everywhere in the nation (including its holdings) **NGS will establish a backbone for the NOAA CORS Network– called the NOAA Foundation CORS Network**.

- The Foundation CORS network will be made of 36 ultra-stable, highly reliable, federally-controlled stations.
- The NSRS will continue to be defined in relation to the ITRF, with plate rotation models.
- Four Reference Frames for Four Plates
  - NATRF2022 - North America
  - PATRF2022 - Pacific
  - CATRF2022 - Caribbean
  - MATRF2022 - Mariana

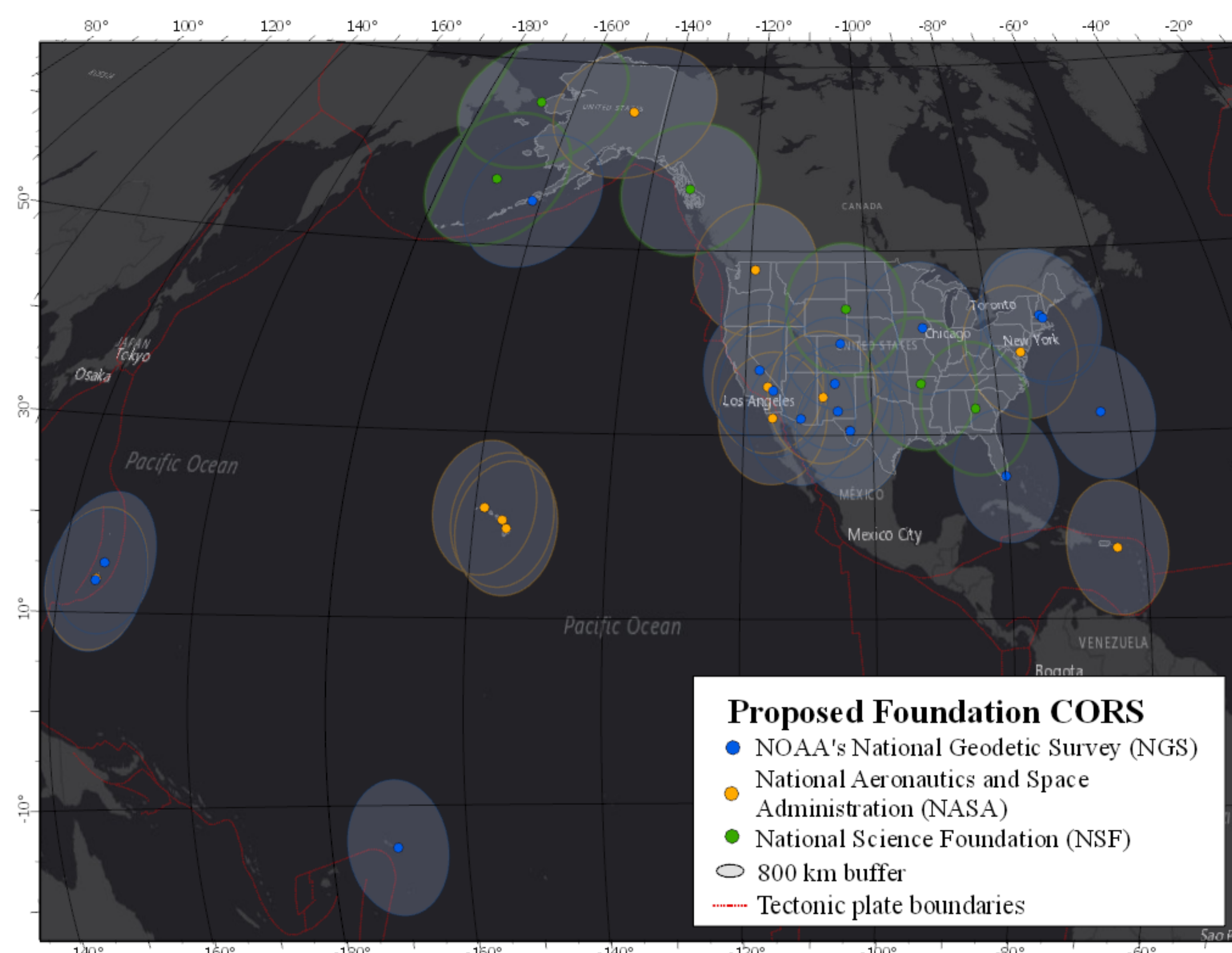


## Motivation 2: Increase the number of IGS Reference Stations in the U.S.

There were a low number of IGS14 stations available in the U.S. Increasing the number of IGS reference stations supports the NSRS and ITRF and also supports the Global Geodetic Observing System (GGOS). Therefore, the 16 NGS-owned Foundation CORS are intended to become IGS reference stations. Also, 11 of those 16 are at existing ITRF sites where they will be co-located with other geodetic reference frame observing techniques (VLBI, SLR, DORIS). These Foundation CORS will strengthen both the IGS and ITRF in the U.S. and its territories.



## NOAA Foundation CORS Network Target Sites



U.S. Federal Partners	GNSS Site ID	Location	Other Geodetic Equipment	Existing IGS or ITRF Site
National Science Foundation (NSF)	AB09	Wales, AK		
	P777	Dennard, AR		
	P804	The Rock, GA		
	AB51	Petersburg, AK		
	ATQK	Atkasuk, AK		
	P043	New Castle, WY		
	CN11	Pedro Cay, Jamaica		
	SAN0	San Andres Island, Colombia		
	CRO1	Saint Croix, VI	VLBI	ITRF
	BREW	Brewster, WA	VLBI	ITRF
National Aeronautics and Space Administration (NASA)	FAIR	Fairbanks, AK		IGS
	TBD	Greenbelt, MD	DORIS, SLR, VLBI	IGS/ITRF
	TBD	Goldstone, CA	VLBI	IGS/ITRF
	MDO1	McDonald Observatory, TX	SLR	ITRF
	MONP	Mount Laguna, CA	DORIS, SLR	IGS/ITRF
	PIE1	Pie Town, NM	VLBI	IGS/ITRF
	GUAM	Dededo, Guam		IGS
	KOKB	Kauai, HI	DORIS, VLBI	IGS/ITRF
	MKEA	Mauna Kea, HI	VLBI	IGS/ITRF
	HAL1	Haleakala, HI	SLR	IGS/ITRF
NOAA- National Geodetic Survey (NGS)	ASPA	Pago Pago, American Samoa		IGS
	CNMR	Saipan, Northern Mariana Islands		IGS
	GUUG	Mangilao, Guam	DORIS	IGS/ITRF
	BRSG	St. George, Bermuda		
	FLF1	Richmond, FL	DORIS	ITRF/Proposed IGS
	WES2	Westford, MA	VLBI	IGS/ITRF
	TMG2	Boulder, CO	Absolute Gravity	Proposed IGS
	NEW	Apache Point, NM	SLR	ITRF
	NEW	Fort Davis, TX	VLBI	ITRF
	NEW	Fort Irwin, CA	DORIS	ITRF
Existing and New Sites	NEW	Hancock, NH	VLBI	ITRF
	NEW	Los Alamos, NM	VLBI	ITRF
	NEW	Kitt Peak, AZ	VLBI	ITRF
	NEW	Owens Valley, CA	VLBI	ITRF
	NEW	Cold Bay, AK	DORIS	ITRF
	NEW	North Liberty, IA*	VLBI	ITRF
	NEW			
	NEW			

## NFCN Project Highlights

The Proposed NOAA Foundation CORS Network (NFCN) Provides:

- A geographic distribution no greater than 800 km apart to provide 1.5 cm accuracy ellipsoidal height results through NGS' OPUS anywhere in the U.S.
- Support for the ITRF by co-locating at existing space-based geodetic sites.
- Favorable geometry to monitor tectonic plate (Euler Pole) rotation.
- High quality stations that fill gaps in coverage.

# Sites	Proposed Stations by Contributor
8	Current NGS Stations
8	New NGS Stations to Build
12	NASA Stations
8	NSF Stations
36	Total Target Foundation CORS

All Foundation CORS were submitted by NGS and accepted by the IGN as stations to be included in the global reprocessing (Repro3) supporting ITRF2020.



The Foundation CORS built at NGS' Table Mountain Geophysical Observatory (Boulder, CO). ID: TMG2

## Project Goals

- Stations are high-quality, stable, and chosen for longevity. They are deep or shallow drilled braced monuments where possible, especially for new stations NGS will build.
- Target operational time:
  - Network availability > 90 % at all times.
  - Individual Station down time < 14 days, where possible
- All NGS-owned Foundation CORS are submitted to the IGS for inclusion in their network. And as many partner Foundation CORS as possible.
- Stations provide definitional support for the international frame and plate rotation model with densified ITRF stations.
- There are at least 3 permanent marks at every site.
- IERS-style site surveys are repeated on a 5-year cycle, even for GNSS-only sites.
- GNSS equipment is multi-constellational and measures all existing systems' signals.
- RINEX3 files are available.
- Prepared formal agreements with NASA and NSF for project support.

## Project Phases

### 1. Incorporate partner stations

Existing NASA, NSF, and Caribbean partner stations brought into the Foundation CORS network.

### 2. Upgrade existing NGS CORS

Upgrades include fully-GNSS equipment, RINEX3, and submission to IGS Network to meet Foundation CORS requirements

### 3. Construct ~8 new stations

These NGS-owned stations will be co-located at sites with other existing space geodetic techniques and are expected to be installed by the end of 2023 at a rate of 2 per year.

### Possible Stretch Goals Under Consideration:

- Co-location with terrestrial gravity measurements in support of the International Height Reference System and NGS' proposed Geoid Monitoring Service.
- Station participation in the IGS Real-Time Service (Many of NASA's Foundation CORS already participate).
- Installation of InSAR reflectors to provide geodetic control for NISAR (U.S. – India satellite) and other InSAR satellites.
- Inclusion of meteorological systems