Current Status and the Future of the CORS Network

Francine Coloma
Continuously Operating Reference Stations Branch
NOAA National Geodetic Survey
To understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources.
The **National Spatial Reference System (NSRS)** constitutes the official system of the civilian government for enabling a user to determine geodetic latitude, longitude, and height, plus orthometric height, geopotential, acceleration of gravity, and deflection of the vertical at any point within the United States and its territories.

Contains information about its orientation and scale relative to international reference frames, as well as the precise orbits of all satellites used in defining or accessing the NSRS.

The NSRS is crucial for meeting our nation’s economic, social and environmental needs.
NSRS = Geodetic control

Without a geodetic control “base map” layer, GIS applications will not work properly!
Continuously Operating Reference Stations (CORS)

- NGS operates a network of ~1900 stations that provide GPS or GNSS data consisting of carrier phase and code range measurements in support of three dimensional positioning.

- **Contributions by more than 200 organizations** (various government, academic, and private organizations)
NGS’ Mission

To define, maintain and provide access to the National Spatial Reference System (NSRS) to meet our Nation’s economic, social, and environmental needs.

Web site: https://www.ngs.noaa.gov/CORS/

Email: ngs.cors@noaa.gov
Continuously Operating Reference Stations (CORS)

CORS Cumulative Network Status
1888 active
(852 decommissioned)

- Operational, 1722, 63%
- Non-Operational, 155, 6%
- Preliminary, 11, 0%
- Decommissioned, 852, 31%
Continuously Operating Reference Stations (CORS)

CORS by Signal Type
(snapshot of 2019-239)

- GPS_GLO_GAL: 21%
- GPS: 23%
- GPS_GLO: 56%
Since 2004, at-sampling CORS RINEX data (where available) is directly available online.

NGS only keeps 30 days of at-sampling data, then decimates to 30-second sampling rate online.

Data is free, but you must register CORS online repository at NOAA’s CLASS.
Guiding Principles for Continuously Operating Reference Stations (CORS)

• By 2022, the National Spatial Reference System (NSRS) will be modernized, with CORS becoming a more foundational component.

• The International Earth Rotation and Reference Systems Service (IERS) International Terrestrial Reference System (ITRF) will continue to be the worldwide standard reference system.

• NGS will continue to support the ITRF through International GNSS Service (IGS) reference sites with the “Foundation CORS” network

• The NSRS will continue to be defined in relation to the ITRF.
Notable Events

• Ongoing **discontinuance of the USCG DGPS Service** to culminate in year 2020
• **GPS Rollover**, second epoch ended on 2019 April 06
  – GPS Time was defined in the legacy GPS navigation message (ICD-200), and used 10-bit to count GPS Week Numbers: a finite period of 1024 weeks (19.7 year epoch)
  – Modernized GPS Navigation has 13-bit week number, and mitigates the former ambiguity
• **Ridgecrest Earthquake Sequence in 2019 July 4 – 6**
  – Mw 7.1 (2019 July 16 03:19 UTC)
• **Completion of Multi-Year CORS Solution 2 (MYCS2)**
  – An undertaking of several years’ work
  – New CORS coordinates and velocities available in NAD83 and ITRF
• **Foundation CORS process underway**
Multi-Year CORS Solution 2 (MYCS2) Released

As of Last Week (Sept 13th): You now have access to more accurate NOAA CORS Network station coordinates and velocities in both the national (NAD83) and international (ITRF) reference frames

What:

New robust coordinates and velocities in ITRF2014 and NAD83(2011) epoch 2010.00 (a within-realization update) for all NCN stations installed before 2014.

Modeled coordinates and velocities available for stations installed between 2014 and present.

New GPS orbits to match with ITRF2014.

Updated OPUS online positioning software uses the new coordinates and velocities, and new GEOID18.

How:

Two years of detailed quality control on all data collected by the NCN over 22 years (1995-2017).

A full network adjustment of 3050 stations, 1100 weeks of data for all NCN stations installed before 2014 (active and decomm.), IGS, and NGA stations.

~240 new CORS (<3 yrs old) have approximate coordinates and velocities “modeled” with OPUS-Net and HTDP (lower accuracy than the network solution).
Multi-Year CORS Solution 2 (MYCS2) Released

New Coordinates (MYCS2): In ITRF2014 epoch 2010.00 and NAD 83(2011,MA11,PA11) epoch 2010.00
These coordinates were computed using absolute antenna calibrations and should only be used when processing data with absolute antenna calibrations.

Position and Velocity
Data Sheet for Position at ARP
Data Sheet for Position at ARP and, if available, MON (monument)

Old Coordinates (MYCS1): In IGS08 epoch 2010.00 and NAD 83(2011,MA11,PA11) epoch 2010.00
No longer supported as of September 1, 2019
These coordinates were computed using absolute antenna calibrations and should only be used when processing data with absolute antenna calibrations.

Position and Velocity
For additional information on the differences between ITRF2014, NAD 83(2011,MA11,PA11) and IGS08, NAD 83(2011,MA11,PA11) consult:
geodesy.noaa.gov/CORS/coords.shtml
The NOAA Foundation CORS Network

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

### U.S. Federal Partners

<table>
<thead>
<tr>
<th>Program: NOAA CORS Network</th>
<th>GNSS Site ID</th>
<th>Location</th>
<th>Existing IGS or ITRF Site</th>
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<tbody>
<tr>
<td></td>
<td>AB09</td>
<td>Wales, AK</td>
<td>IGS</td>
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<tr>
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### Program: Network of the Americas (NOTA)

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### Program: COCONet

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### Program: Global GNSS Network (GGN)

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### Proposed Foundation CORS

- NOAA’s National Geodetic Survey (NGS)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)
- 800 km buffer
- Tectonic plate boundaries

26 in North America, 4 in the Pacific, 3 in the Caribbean, and 3 in the Marianas.
Goals of Foundation CORS Project

Federally-owned and operated “backbone”

- Chosen for location, longevity, and high quality
- Operational Goals:
  - Non-operational time minimized for each station
  - 90% of NOAA Foundation CORS Network available at any time (no more than 4 stations non-operational)

All stations are critical to some function of the new NSRS, including:

- A geographic distribution no greater than 800 km to provide minimum 1.5 cm accuracy ellipsoidal height results through NGS’ OPUS tools anywhere in the U.S.
- 22 out of 36 stations are (currently or will be) co-located with other space geodetic stations supporting the IGS/ITRF, which the NSRS depends on
Three Ongoing Phases of Foundation CORS

Phase 1: Incorporate partner stations
Existing NASA, NSF, and Caribbean partner stations brought into the Foundation CORS network.

[NASA MOU expected approval by November 2019. Started discussions with NSF.]

Phase 2: Upgrade existing NGS CORS
Upgrades include fully-GNSS equipment and submission to IGS to meet Foundation CORS requirements

[RINEX3 development underway. 5 of 7 existing NGS Foundation CORS are fully-GNSS enabled]

Phase 3: Construct ~8 new stations
These NGS-owned stations will be co-located at sites with existing space geodetic techniques

[Planning for Fort Davis, TX and Apache Point, NM station installations in 2020]
NOAA CORS Network Quality

<table>
<thead>
<tr>
<th>% of Stations</th>
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<th>Horizontal Motion</th>
<th>Vertical Motion</th>
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</thead>
<tbody>
<tr>
<td>64%</td>
<td>1139</td>
<td>&lt;= 3 mm AND</td>
<td>&lt;= 6 mm</td>
</tr>
<tr>
<td>35%</td>
<td>623</td>
<td>&lt;= 5 mm</td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>16</td>
<td>&gt; 5 mm</td>
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Continued Modernization Efforts

**Better access** to the National Spatial Reference System (NSRS)

- Goal: achieve sustained quality of 5 mm horizontal, 10 mm vertical
  (See Blueprint Part 3)
- That’s nearly **75% BETTER** than before
- All but 16 CORS met the standard as of MYCS2 end date in 2017
- Today (2.5 yrs later), motion (e.g. Ridgecrest Earthquake, July 2019) means more stations are out of spec and need to have coords/velocities repaired.
Continued Modernization Efforts

**NOAA CORS Network Comprehensive Plan** (Expected Fall 2020)

Present new ways to:

- Redesign the CORS website with dynamic plots, new metrics, faster refresh
- Improve OPUS’ selection of CORS by providing it with better CORS data quality statistics
- Repair out-of-spec stations and provide new station coordinates more quickly
- Provide an OPUS tool to track NSRS coords/velocities for any continuous GNSS station
- Increase CORS data provider and data user communications
- Better models of motion, for both plate rotation and regional motion (IFVM)
- Automate more of the network management at NGS
Planned NDGPS discontinuance by 2020

https://www.navcen.uscg.gov/?pageName=dgpsMain
Learn more about space weather and GPS/GNSS later this session.

SWPC’s GPS Dashboard

Hurricane DORIAN (2019 Aug-Sep)

Station NCBX at Cape Hatteras Secondary School in Buxton, NC
Acknowledgements to the following:

CORS Division Chief Theresa Damiani, for her contribution of the Foundation CORS and Multiyear CORS Solution 2 (MYCS2) powerpoint slides

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Our Partners and Data Contributors for volunteering their geodetic stations, networks, time and efforts in coordination with NGS to make a robust contribution towards the NSRS. You are all deeply appreciated