Oregon GNSS Users Group

Workshop June 14th, 2019

AGENDA

8:30-9:00	Coffee & pastries; networking.
9:00-9:45	Welcome & business meeting. Whats new from NGS and GNSS Market watch by Casey Varnum.
9:45-10:45	Remote Sensing Power Hour. GNSS theory in remote sensing and applied uses. Presented by Chris Glantz and Jon Rawlings of Oregon Department of Transportation.
10:45-11:00	Break
11:00-12:00	“Surveying For Gold” Presented by Mark Armstrong and Jim Colton.
12:00-1:00	Lunch
1:00-1:30	PPP processing with Drones, presented by Brian Weaver, PhD Candidate at University of Nottingham.
1:30-2:15	OSU Geomatics updates and new projects, presented by Jihye Park, PhD. OSU College of Engineering.
2:15-2:30	Break
2:30-3:00	ORGN Update, presented by Randy Oberg of Oregon Department Of Transportation.

News in the GNSS Community

- Updates from NOAA NGS
- 2018 GNSS User Technology Report highlights
- New products on the market
- Stating accuracy

NOAA NGS Updates

New Geoid model GEOID18 to be released this year.

Multi Year CORS Solution 2 has been completed.

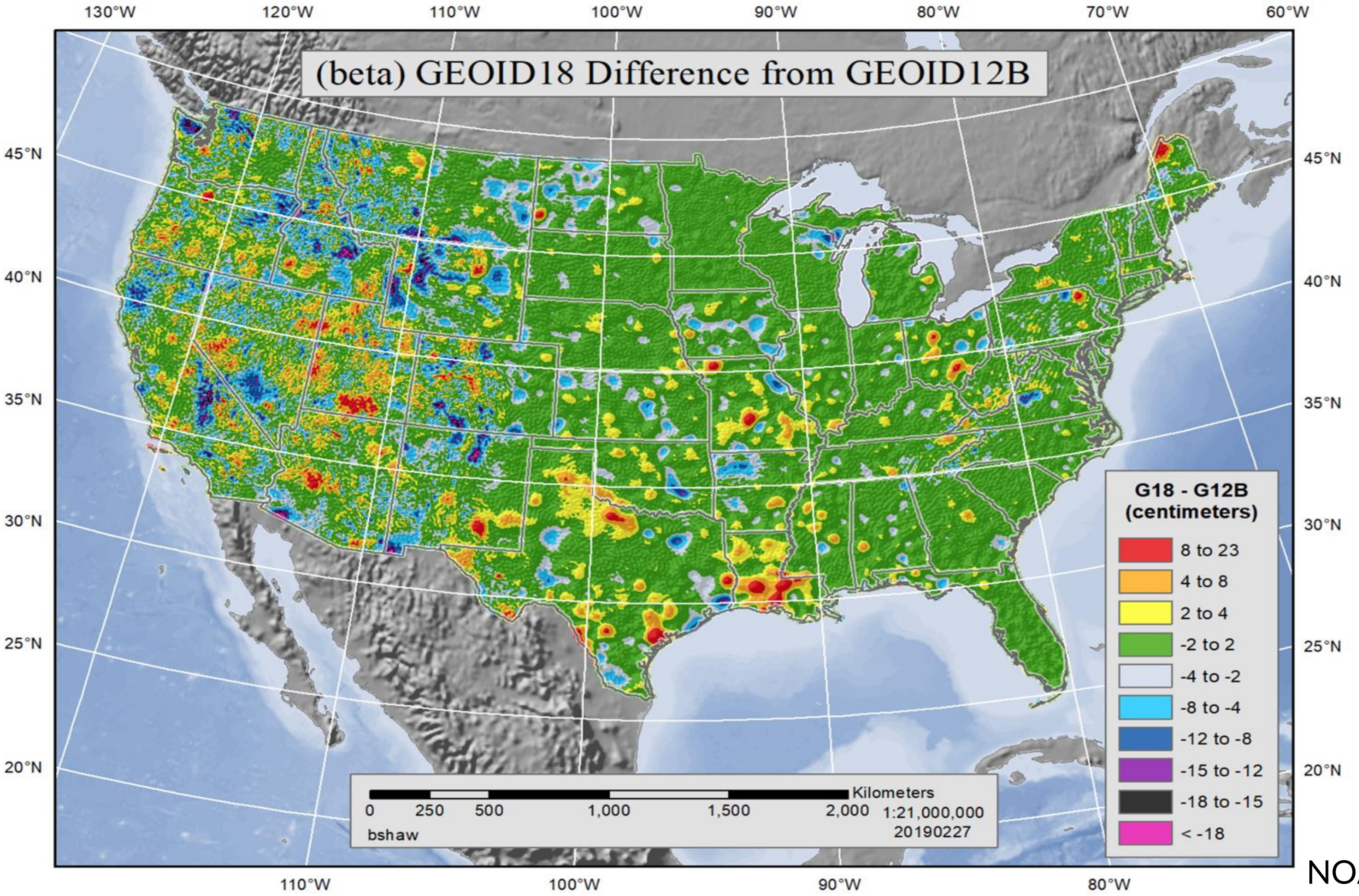
- New Coordinate and Velocities computed for CORS.
- ITRF2014 used for horizontal values.

New Geoid18

Majority of the update comes from GPS on Benchmarks!

Also includes data from:

- Better topography data and DEM techniques
- New gravity data from satellite measured gravity missions
- New airborne gravity data from NGS GRAV-D missions
- Improved Geoid modeling techniques.



(beta) GEOID18 Difference from GEOID12B
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
45°N
40°N
35°N
30°N
25°N
20°N
G18 - G12B
(centimeters)
8 to 23
4 to 8
2 to 4
-2 to 2
-4 to -2
-8 to -4
-12 to -8
-15 to -12
-18 to -15
< -18
Kilometers
0 250 500 1,000 1,500 2,000
1:21,000,000
20190227
bshaw

NOAA-NGS

Geoid 18 Continued

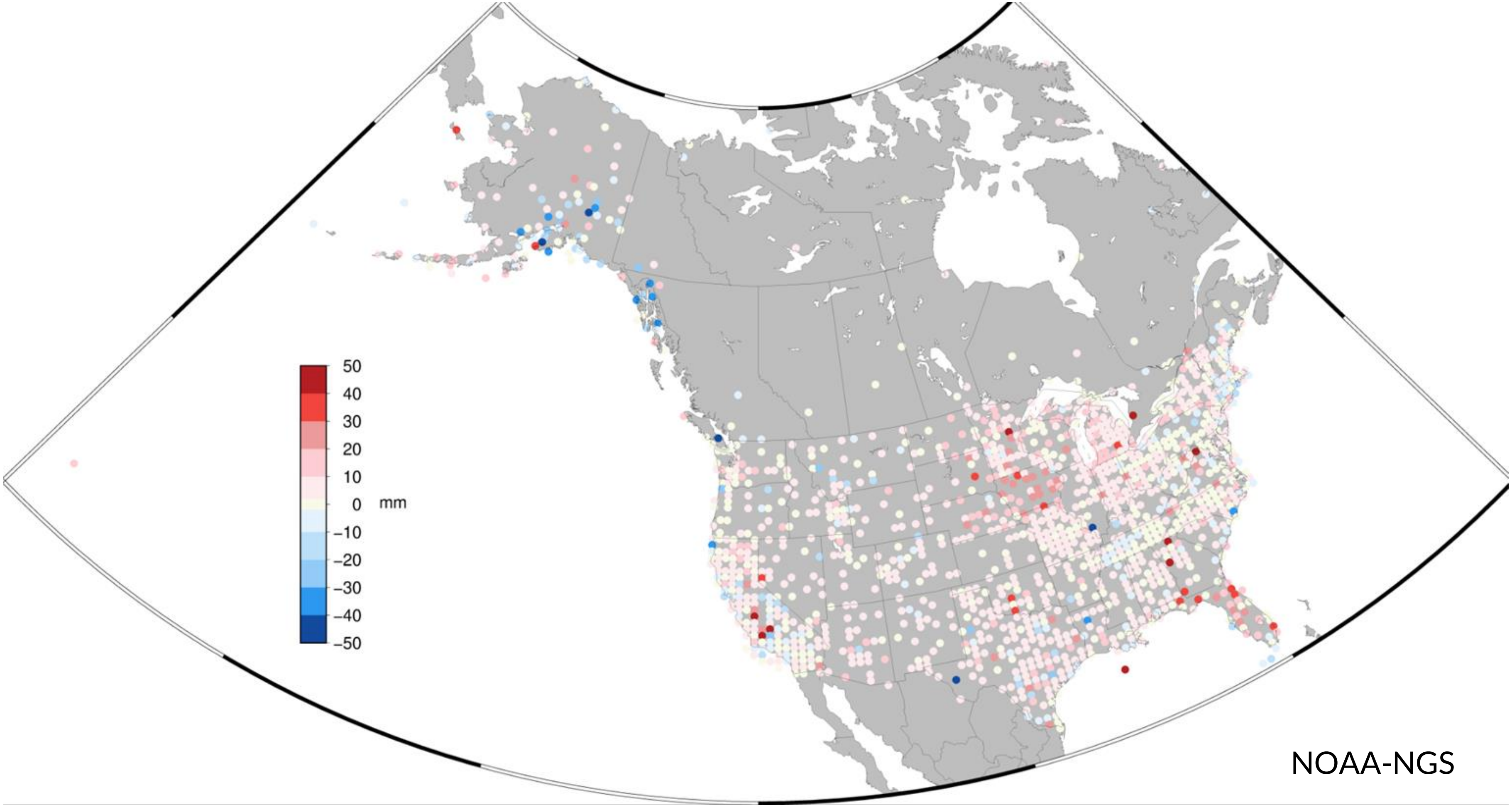
- Last hybrid model to be released before NAPDG(2022)
- Intended to be used with NAD83 2011 Reference Frame.
- Beta version released in March 2019, currently under public review.
- Will likely be released as “official” soon.
- Alaska opted out of new Geoid Model.

ITRF2014 for CORS Positions and Velocity

Multi Year CORS Solution (MYCS2)

- Need for update coordinates and velocities based on:
    - Earthquakes in SE Alaska (2013.005), Napa Valley Earthquake (2014:236), Other Earthquakes in Alaska, British Columbia, Chile, NZ, South Pacific.
    - Hundreds of new CORS
    - MYCS2 positions are ITRF2014 Epoch 2010.00
    - Average difference new reference frames is 5mm for NAD83(2011) epoch 2010.00

Vertical Position Difference: MYCS1 - MYCS2



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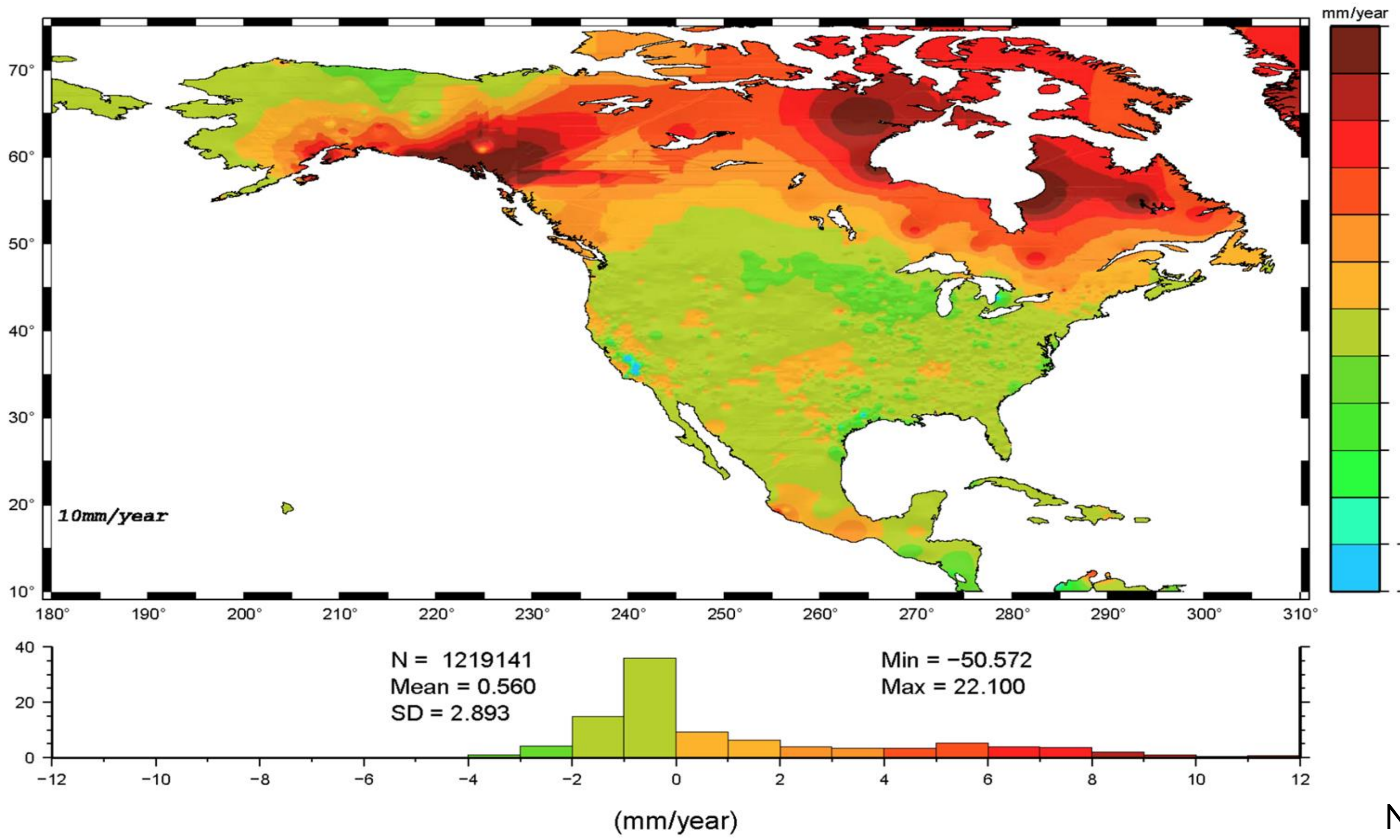
MYCS2 Vertical Velocity



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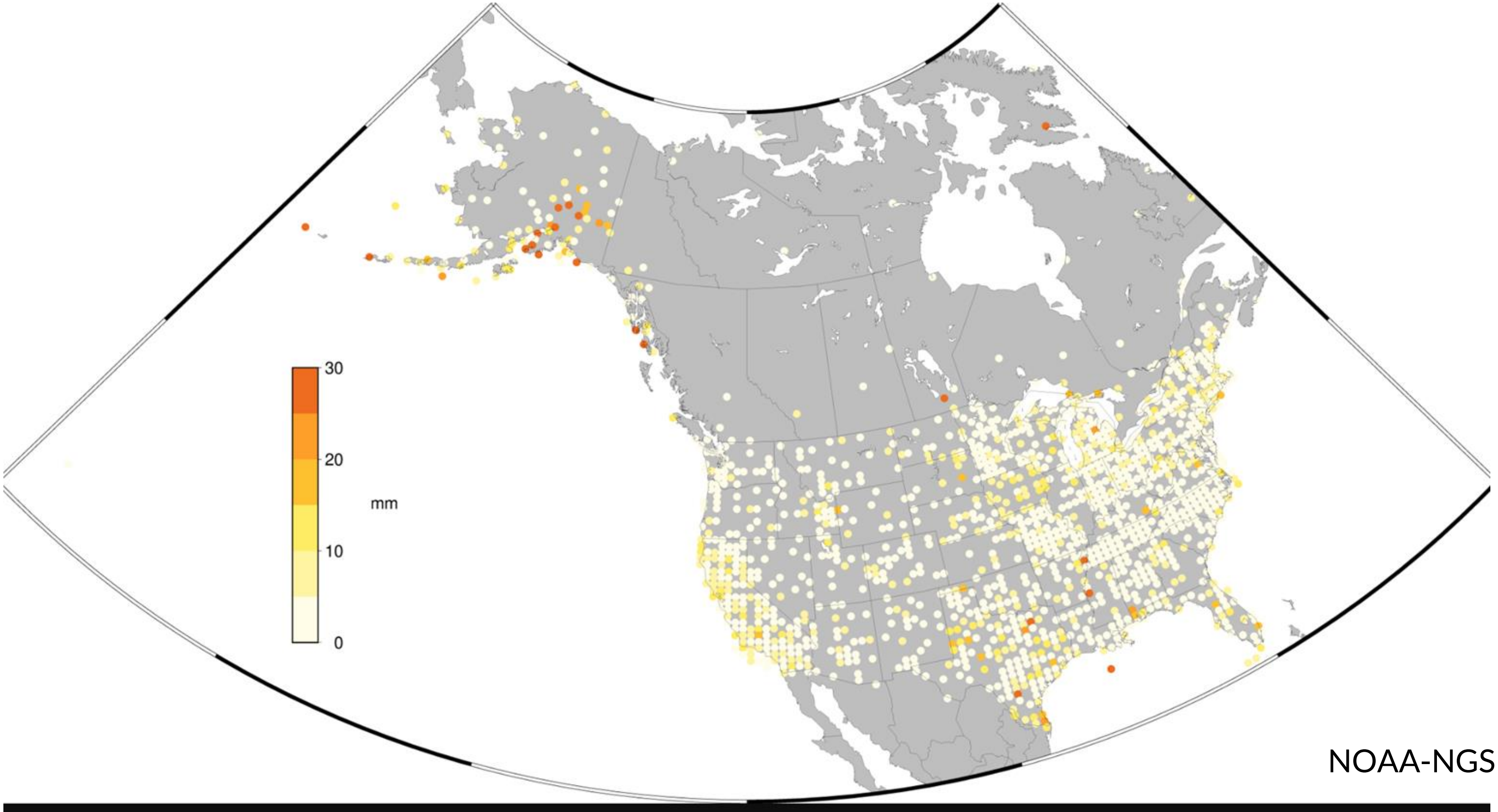
Impressive Stats!

Data included from 1996 to 2016 (1100 weeks)

3050 CORS

25TB of Data processed!

Horizontal Position Difference: MYCS1 - MYCS2



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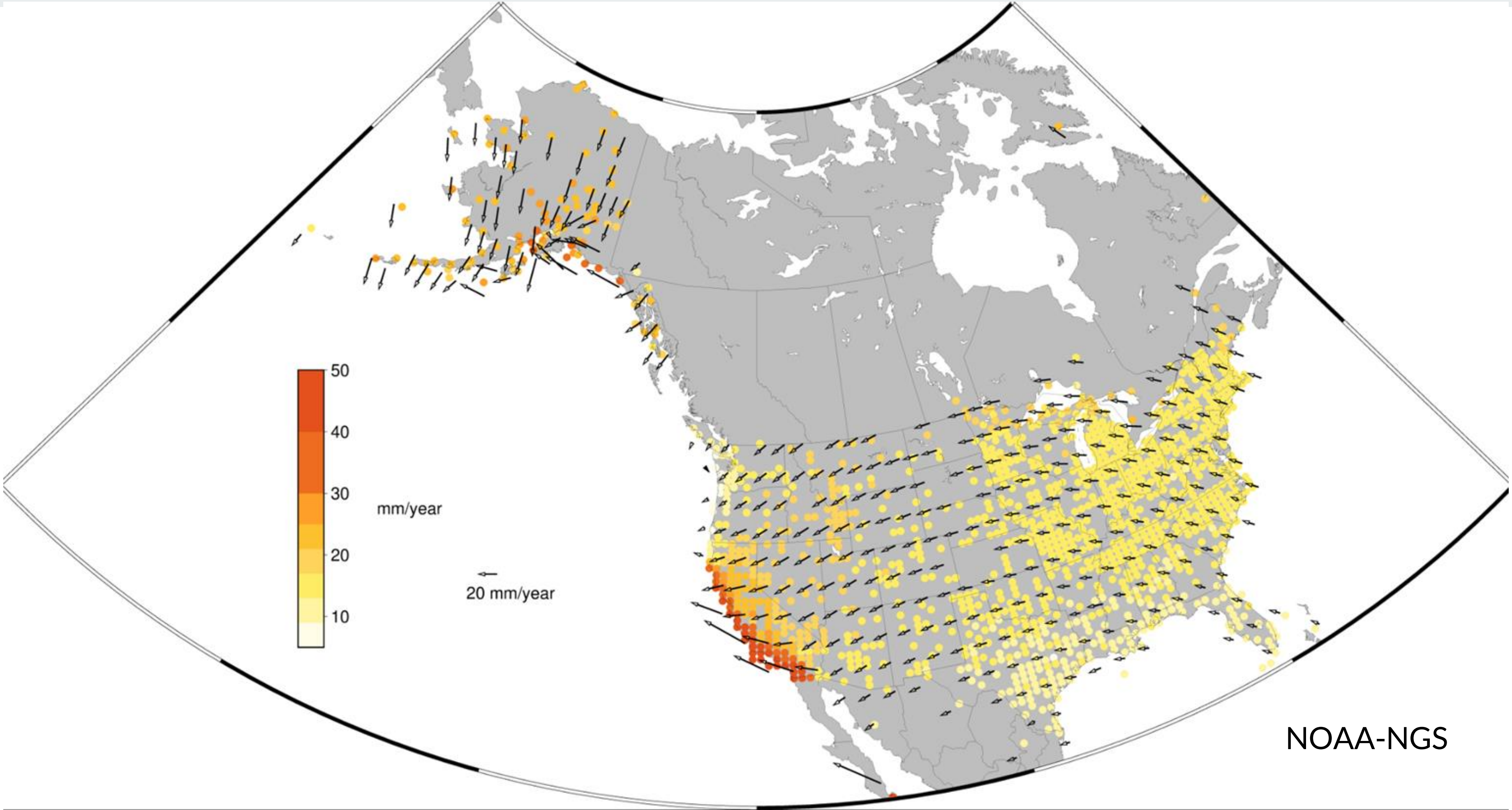
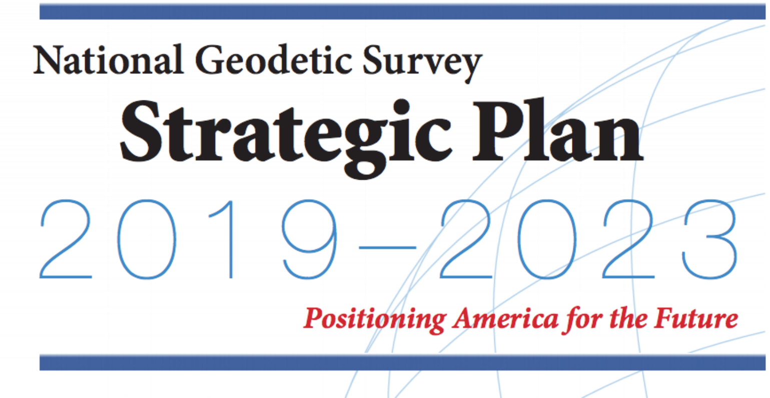
Horizontal Velocity Field - ITRF 2014



NOAA-NGS

Path to NATRAF 2022

- Ideal frames such as ITRF will be converted to NATRAF 2022 through plate motion rotation constants associated with Euler Poles.
- Since the mathematical relationship between ITRF2008 and ITRF2014 is unknown, a transformation kit for both will be available for converting to 2022.



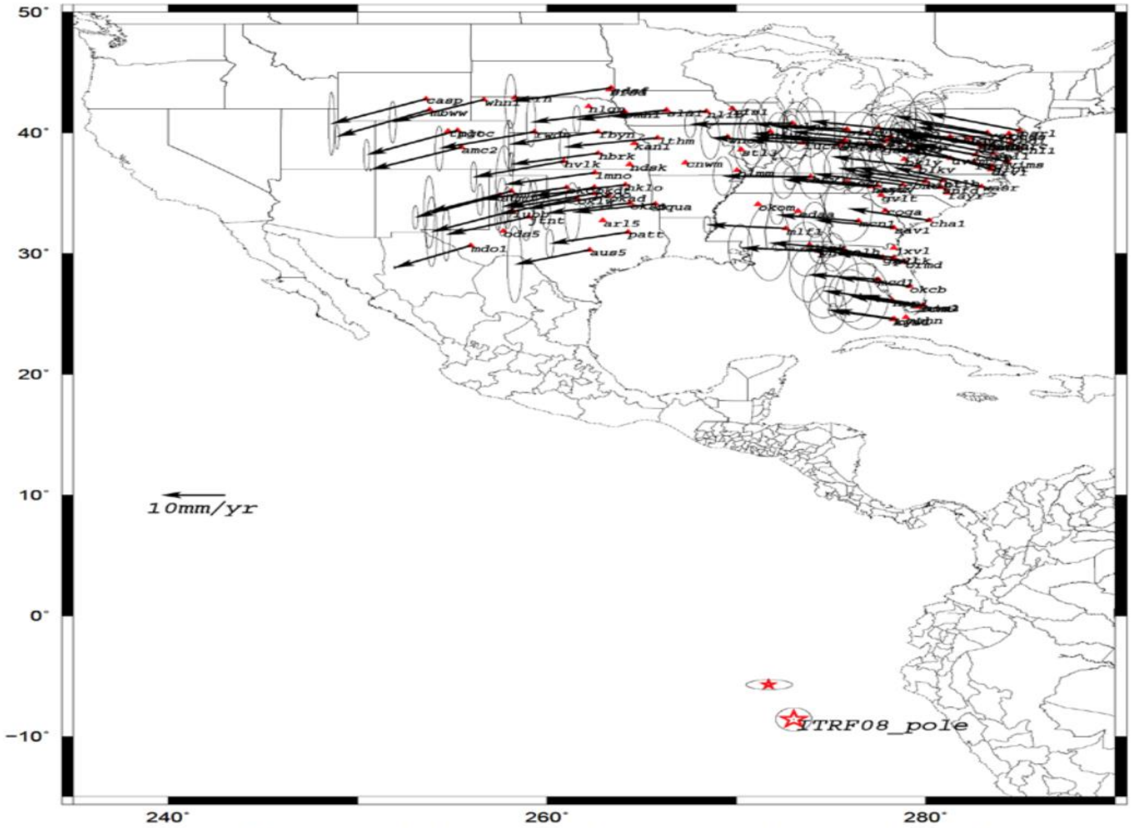


Figure 1: Vectors of horizontal velocity at 114 Continuously Operating Reference Stations (CORS) used in the "repro1" solution at NGS, as well as its associated Euler Pole solution, for the North American Plate. Also shown, for comparison, is the ITRF08 Euler Pole solution. Error ellipses are also shown to represent the uncertainty in both the magnitude and azimuth of the velocity vector.

NOAA - NGS

Transformation for Rigid Plates

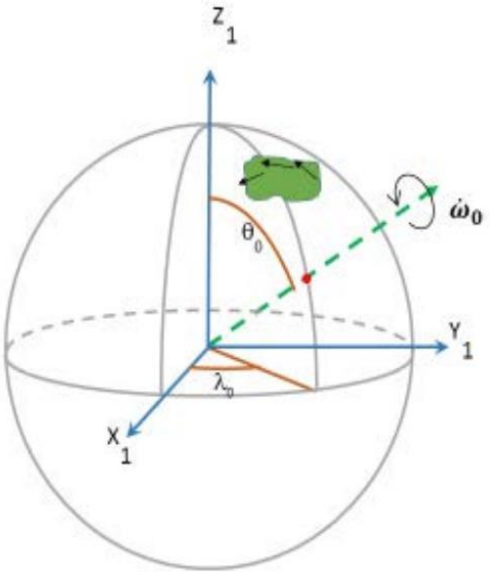


Figure 6: A rotating tectonic plate (green) and its Euler Pole (dashed green arrow and red dot).

Four TRFs will be created for North America.

Intraframe Velocity

Intraframe velocities such as GIA (Glacial Isostatic Adjustment).

Intraframe velocities will base off predictions but will be largely data driven.

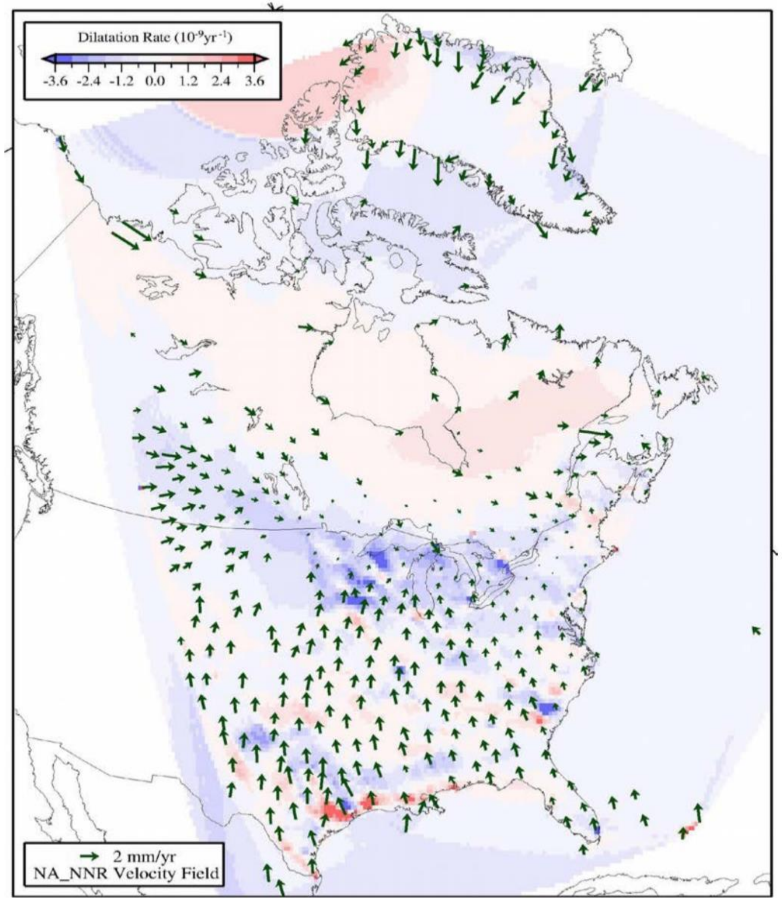


Figure 4: GIA-specific horizontal non-Eulerian velocities (Euler Pole Rotation Removed) using the MELD model (Blewitt, et al, 2016)

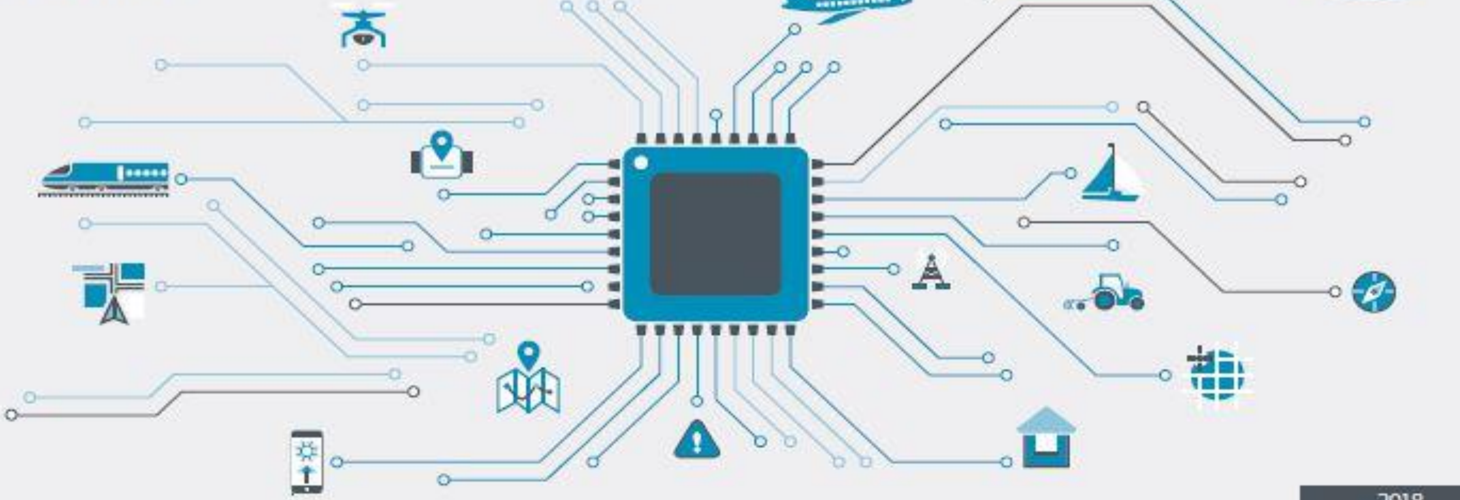
User Considerations

- Feedback on Geoid 18 and testing.
- Uploading data to NGS will be valuable for the foreseeable future.
  - RTK baselines will be accepted.
- Check coordinates of control points through OPUS. MYCS1 and MYCS2 values.
- Pay attention for various transformation tools.

EDITOR'S SPECIAL
AUTOMATION

GNSS USER TECHNOLOGY REPORT

ISSUE 2

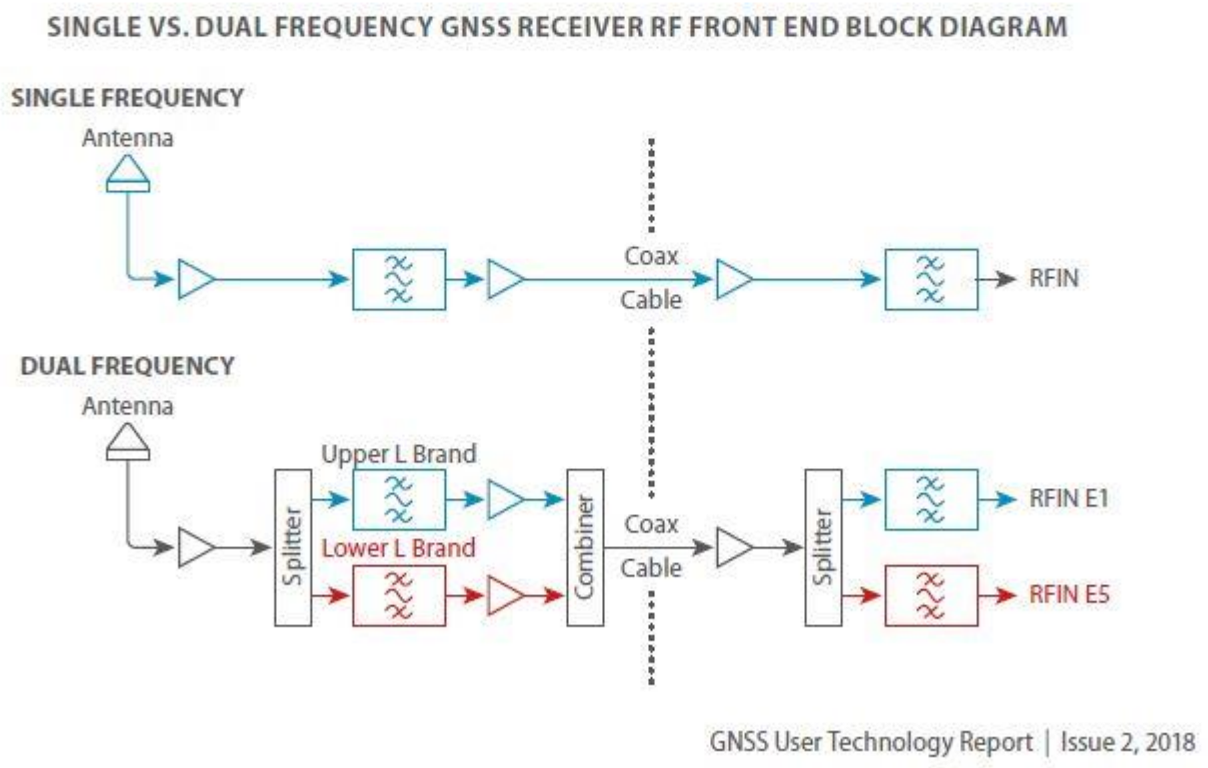


2018

European
Global Navigation
Satellite Systems
Agency

“All components of GNSS receivers are subject to intensive development.”

- GNSS User Technology Report, 2018



- Antenna capabilities drive receiver performance.

Broadcom L1/E1 + L5/E5

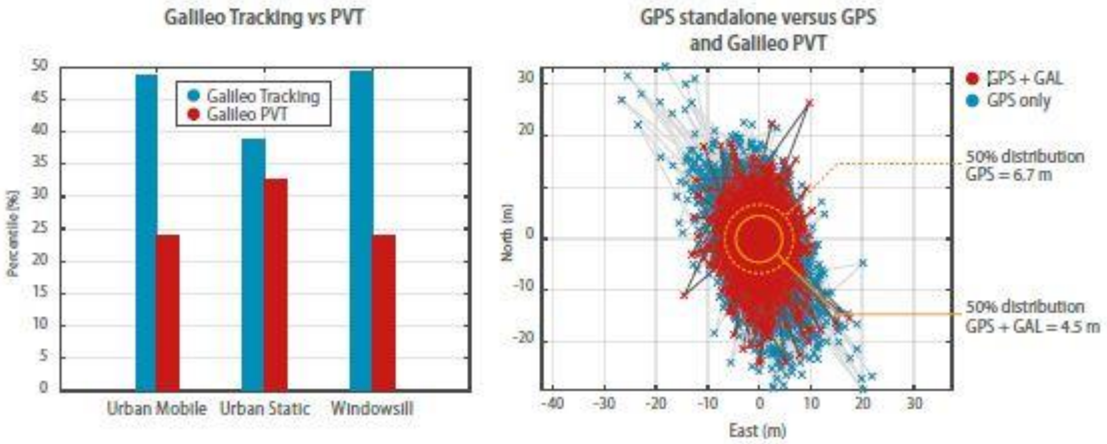
Released in May 2018.

30 cm accuracy stated.

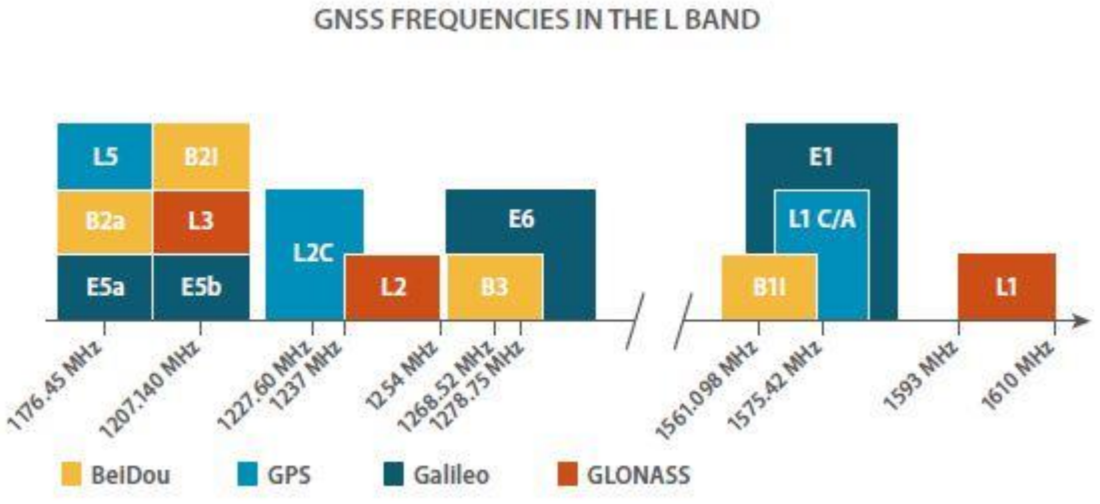
Galileo signals are critical to success.

Possibly will be a consumer differentiating factor in cell phone selection (Maybe).

Galileo in smartphones



Improves up to 4.5 meters of accuracy.



GNSS User Technology Report | Issue 2, 2018

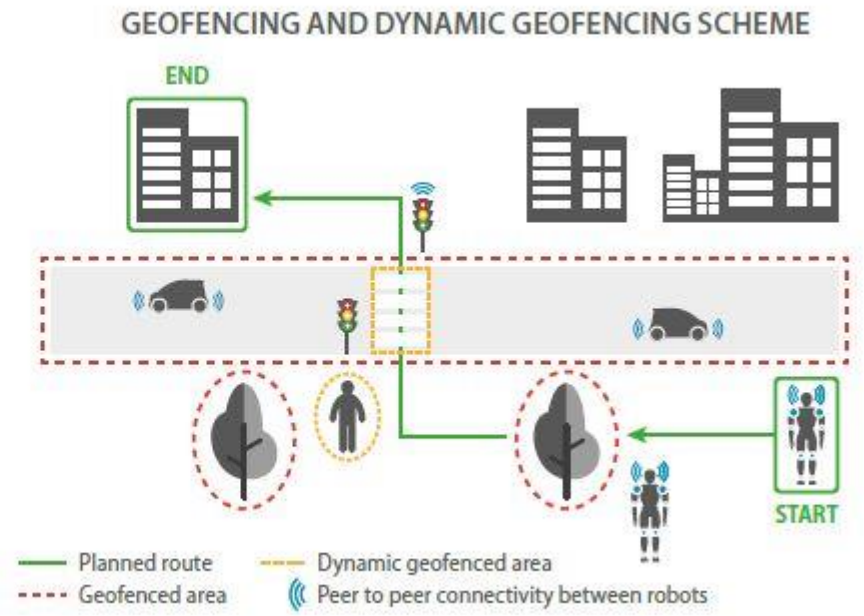
Check what frequencies your equipment is compatible with.

E6 will be broadcast for free through Galileo. ~20 cm accuracy real time PPP.

GNSS Augmentation in Different Environments

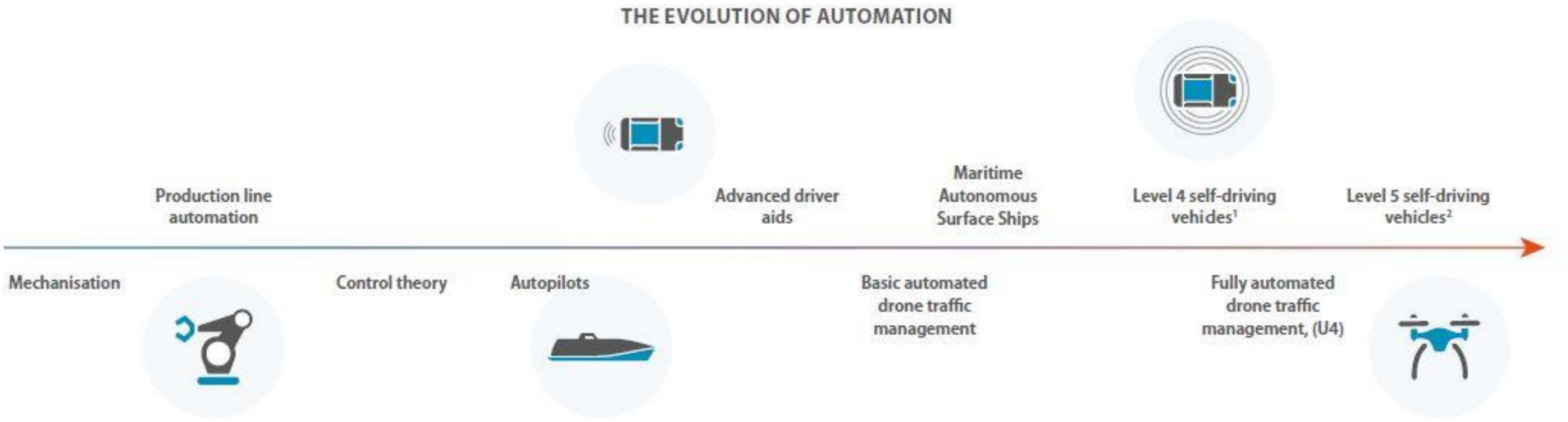
GNSS User Technology Report | Issue 2, 2018

Geofencing Robots

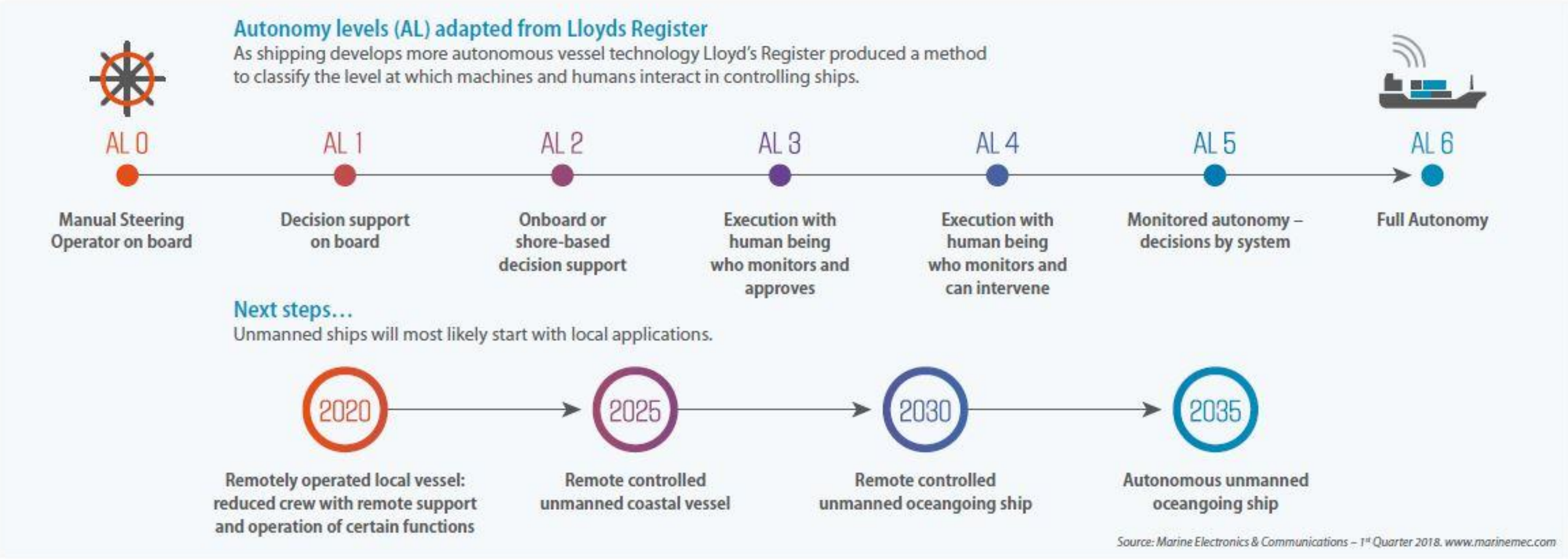


Improve GNSS accuracy is a fundamental building block of autonomous navigation.

Timescale - Automated Navigation



Timeline for Shipping Automation



New Products on the Market

Self Driving Cars is likely the largest factor for cheap GNSS.

Survey and mapping industry will benefit from these cost reductions.

Tiers of accuracy options widely available.

GPS on Chickens!

Your chicken was healthy, but was it happy?

ZhongAn Technology partnered with Opentrust Technology to create “GoGo Chicken”

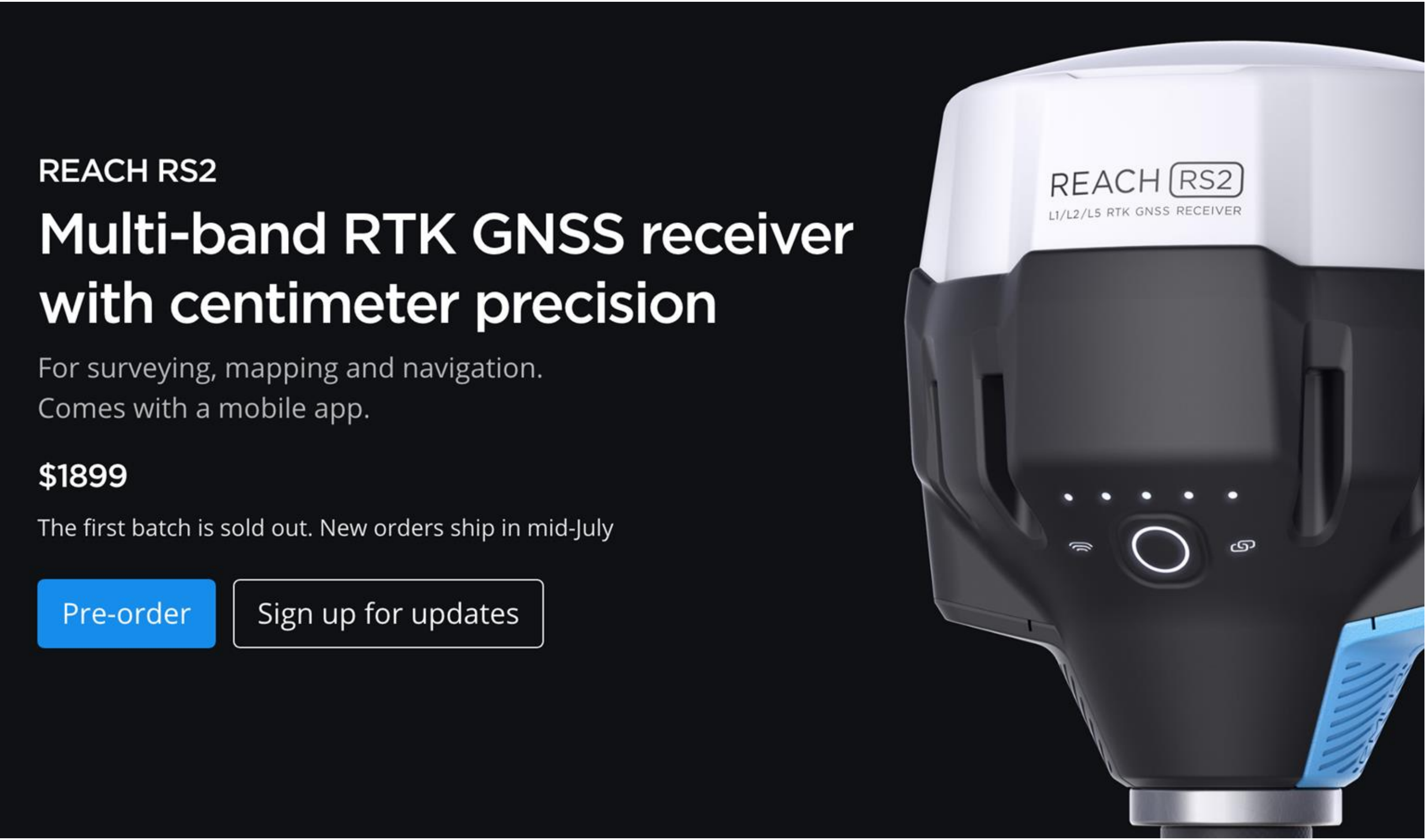
100,000 trackers in place. Planned to be in 2,500 farms in China by 2020.

Photo: ZhongAn Technology

High Precision GNSS Receivers

GNSS

Signals:	GPS/QZSS L1, GLONASS G1, BeiDou B1, Galileo E1, SBAS
Tracking channels:	72
IMU:	9DOF
Update rate:	14 Hz / 5 Hz



Check XYHt for review of this product.

BYOD - Cell phone or tablet.

IMU, GNSS and INS Systems

GNSS improvements complement INS precisions.

- ITAR Free IMUs are becoming more popular and produced in large scale.
- Can be sold Internationally without rigorous oversight.

MEMS (Micro Electric Mechanical Systems) are gaining popularity mostly associated with cost.

SWIFTNAV Duro Inertial

Performance During GNSS-RTK Outages		Position Accuracy 2-Sigma (m) RMS		Velocity Accuracy (m/s) RMS	
Outages	Prior Position Mode	Horizontal	Vertical	Horizontal	Vertical
1 second	RTK	0.02	0.06	0.035	0.020
5 seconds	RTK	0.05	0.09	0.040	0.030
10 seconds	RTK	0.17	0.16	0.055	0.045

The accuracy of position and velocity solutions provided during GNSS outages is dependent on the accuracy of solutions prior to the GNSS outage. The table above represents solution performance during GNSS outages directly preceded by RTK fix GNSS solutions.

www.swiftnav.com

Consider when Buying

Constellations supported?

What frequencies are supported?

Software/Firmware capabilities and frequency of updates.

Accuracy statements of products.

Expressions of Accuracy

“Accuracy”

- The Federal Geographic Data Committee (FGDC) defines accuracy as 2 sigma (95%) confidence interval.
- Same as the American Society for Photogrammetry and Remote Sensing (ASPRS).

RMSE

- Uses 68% confidence interval.
- Often used as an accuracy statement

ASPRS - Vertical Accuracy Reporting for Lidar Data

NMAS Equivalent Contour Interval	NSSDA $RMSE_{(z)}$	NSSDA $Accuracy_{(z)}$	Required Accuracy for Reference Data for "Tested to Meet"
0.5	0.15 ft or 4.60 cm	0.30 ft or 9.10 cm	0.10 ft
1	0.30 ft or 9.25 cm	0.60 ft or 18.2 cm	0.20 ft
2	0.61 ft or 18.5 cm	1.19 ft or 36.3 cm	0.40 ft
4	1.22 ft or 37.0 cm	2.38 ft or 72.6 cm	0.79 ft
5	1.52 ft or 46.3 cm	2.98 ft or 90.8 cm	0.99 ft
10	3.04 ft or 92.7 cm	5.96 ft or 181.6 cm	1.98 ft

Table 1 Comparison of NMAS/NSSDA Vertical Accuracy

USGS - Base Lidar Specification V1.3

Table 4. Absolute vertical accuracy for light detection and ranging data and digital elevation models.

[QL, quality level, $RMSE_z$, root mean square error in the *z* direction; NVA, nonvegetated vertical accuracy; VVA, vegetated vertical accuracy; m, meter; ≤, less than or equal to]

Quality level	$RMSE_z$ (nonvegetated) (m)	NVA at the 95-percent confidence level (m)	VVA at the 95th percentile (m)
QL0	≤0.050	≤0.098	≤0.15
QL1	≤0.100	≤0.196	≤0.30
QL2	≤0.100	≤0.196	≤0.30
QL3	≤0.200	≤0.392	≤0.60

NSPS Recommendations

National Society of Professional Surveyors recommends to use 95% confidence interval with point clouds.

- Widespread usage.
- Higher point density - Especially airborne.
- Consistency with reporting.
- Acceptance of point clouds as survey grade data.

Thank you!

Contact info:

Casey Varnum

Varnum.Casey@gmail.com

503-784-2964