Using GNSS in 2021 and Beyond

Using GNSS in 2021 and Beyond

In this session we will….

- Latest GNSS Advancements
- Solar Activity
- Latest GNSS Receiver Advancements
- Impacts on Surveying
- Review other correction sources

GPS / GNSS Advancements

Agenda

- GNSS Satellite Update
  - GPS
  - Ligado
  - Glonass
  - Galileo
  - BeiDou
- GNSS Receiver Technology
- MN CORS and RTX

GNSS

GNSS…

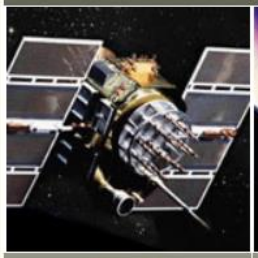
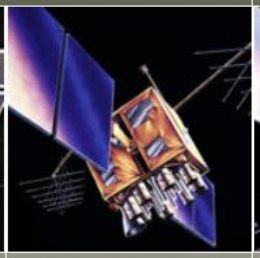
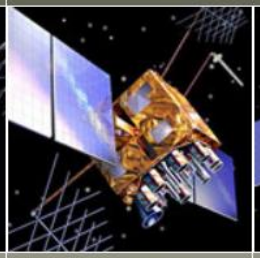
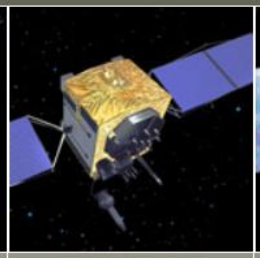
- Refers to Global Navigation Satellite System, using multiple satellite positioning systems to provide satellite-based positions.
  - GPS – US DOD System
  - Glonass – Russian System
  - Galileo – European Union System
  - Others – BeiDou

GNSS

GPS

- US Department of Defense Satellite System
  - 31 Current Operational Satellites
    - GPS III SV01 (“Vespucci”) satellite Dec 23rd, 2018.
    - 4th launched November 5th, 2020
  - Codeless/Semi-Codeless Signals
    - L1 c/a code receivers – Plan to update
    - https://www.gps.gov/technical/codeless/
  - GPS III continued
    - First GPS III tracked January 13th, 2020 (SVN 74)
    - GPS III is planned to be a 10-satellite constellation

GPS

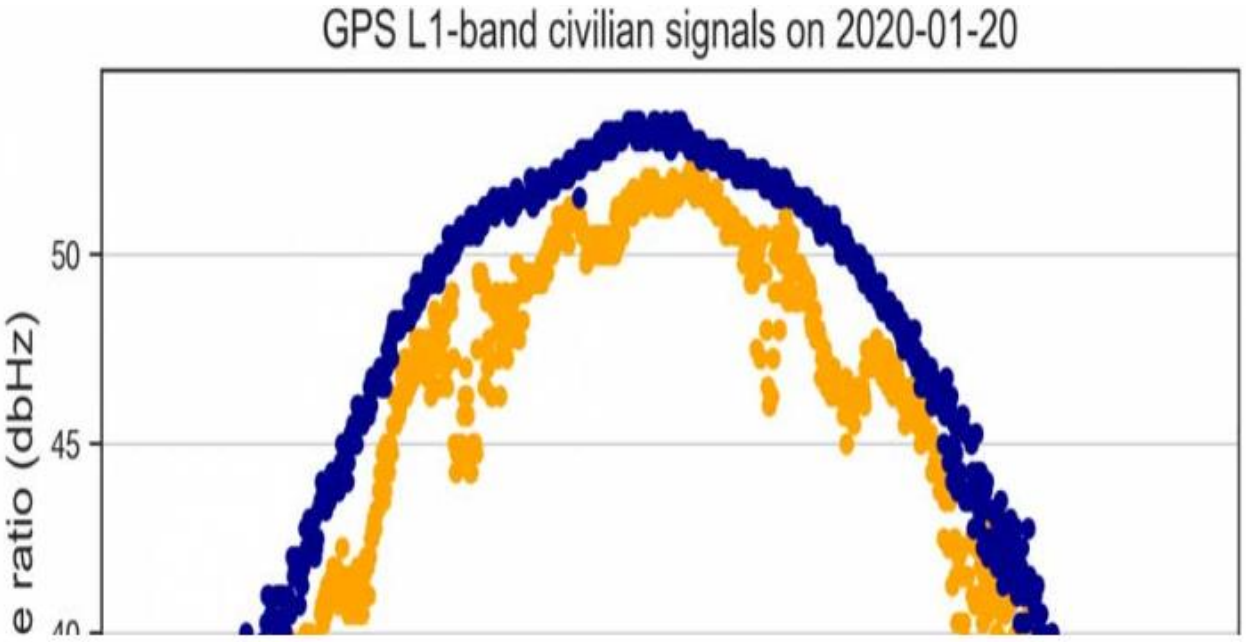
LEGACY SATELLITES		MODERNIZED SATELLITES		
				
BLOCK IIA	**BLOCK IIR**	**BLOCK IIR-M**	**BLOCK IIF**	**GPS III/IIIF**
0 operational	8 operational	7 operational	12 operational	4 operational
▪ Coarse Acquisition (C/A) code on L1 frequency for civil users ▪ Precise P(Y) code on L1 & L2 frequencies for military users ▪ 7.5-year design lifespan ▪ Launched in 1990-1997 ▪ Last one decommissioned in 2019	▪ C/A code on L1 ▪ P(Y) code on L1 & L2 ▪ On-board clock monitoring ▪ 7.5-year design lifespan ▪ Launched in 1997-2004 *LEARN MORE ABOUT GPS IIR AT AF.MIL* ➡	▪ All legacy signals ▪ 2nd civil signal on L2 (L2C) *LEARN MORE* ➡ ▪ New military M code signals for enhanced jam resistance ▪ Flexible power levels for military signals ▪ 7.5-year design lifespan ▪ Launched in 2005-2009 *LEARN MORE ABOUT GPS IIR-M AT AF.MIL* ➡	▪ All Block IIR-M signals ▪ 3rd civil signal on L5 frequency (L5) *LEARN MORE* ➡ ▪ Advanced atomic clocks ▪ Improved accuracy, signal strength, and quality ▪ 12-year design lifespan ▪ Launched in 2010-2016 *LEARN MORE ABOUT GPS IIF AT AF.MIL* ➡	▪ All Block IIF signals ▪ 4th civil signal on L1 (L1C) *LEARN MORE* ➡ ▪ Enhanced signal reliability, accuracy, and integrity ▪ No Selective Availability *LEARN MORE* ➡ ▪ 15-year design lifespan ▪ IIIF: laser reflectors; search & rescue payload ▪ First launch in 2018

Courtesy – gps.gov

GNSS

GPS Modernization

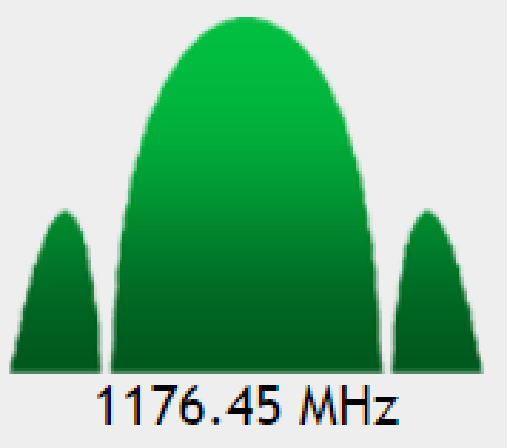
- L1C goes live -1575.42Mhz
  - Stronger signal than traditional L1
  - More accurate signal than traditional L1



GNSS

GPS Modernization

- L5 – 1176.45Mhz
  - Currently satellites broadcasting L5 = 16
  - 3rd Carrier Observable
  - Positive impact for surveying
    - Due to wide bandwidth and comparatively longer spreading codes, the L5 signal gives a higher processing gain



GNSS

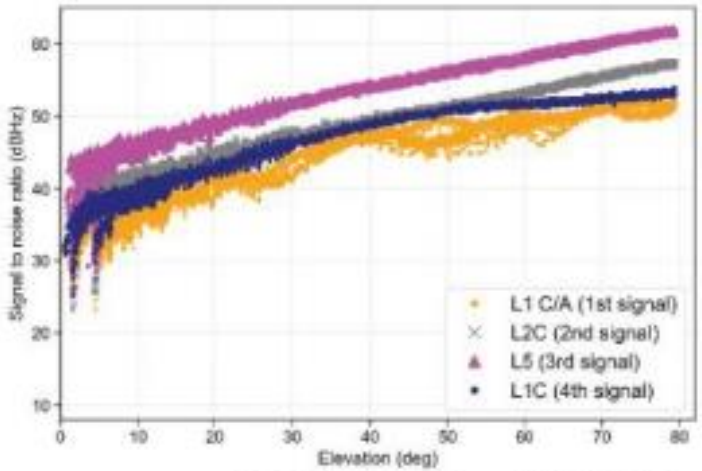
GPS

- GPS III Satellite Benefits
  - GPS III will broadcast 4 civilian signals
    - L1 C/A
    - L2C
    - L5
    - L1C
  - The new L1C signal is compatible with other GNSS constellations
    - Europe - Galileo
    - China BeiDou
    - India - IRNSS
    - Japan – QZSS
    - At some point there could be up to 50 satellites broadcasting L1C
  - Anti-jamming programming
  - GPS III, launched without Selective Availability (SA) feature

GNSS

GPS

- High Precision Benefits
  - 3rd Observable with L5
    - In the past we are only able to produce a survey-grade position with L1 and L2 (dual frequency)
    - L5 on all GNSS constellations

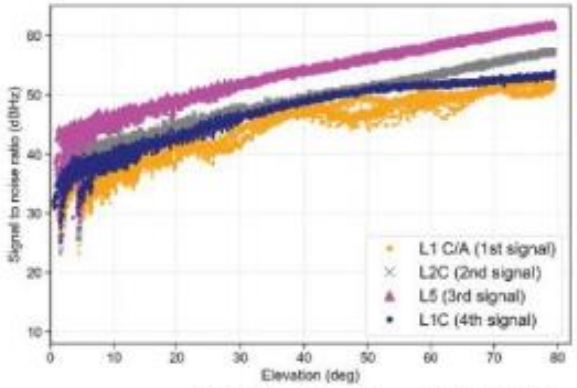


SIGNAL STRENGTH of GPS civilian signals transmitted by SVN74 — L1C/A in orange, L2C in grey, L5 in magenta, L1C in dark blue). Data recorded at Metsähovi Jan 17–22. Elevation angle varies from 0.45 to 79.37 degrees.

GNSS

GPS

- High Precision Benefits
  - Ionospheric Errors
    - Reduced with these new signals
    - Combining Signals from at least 2 frequency bands that are sufficiently apart from each other
    - Traditional L1 at 1575.42 and L2 at 1227.60
    - L1C at 1575.42 and L5 at 1176.45



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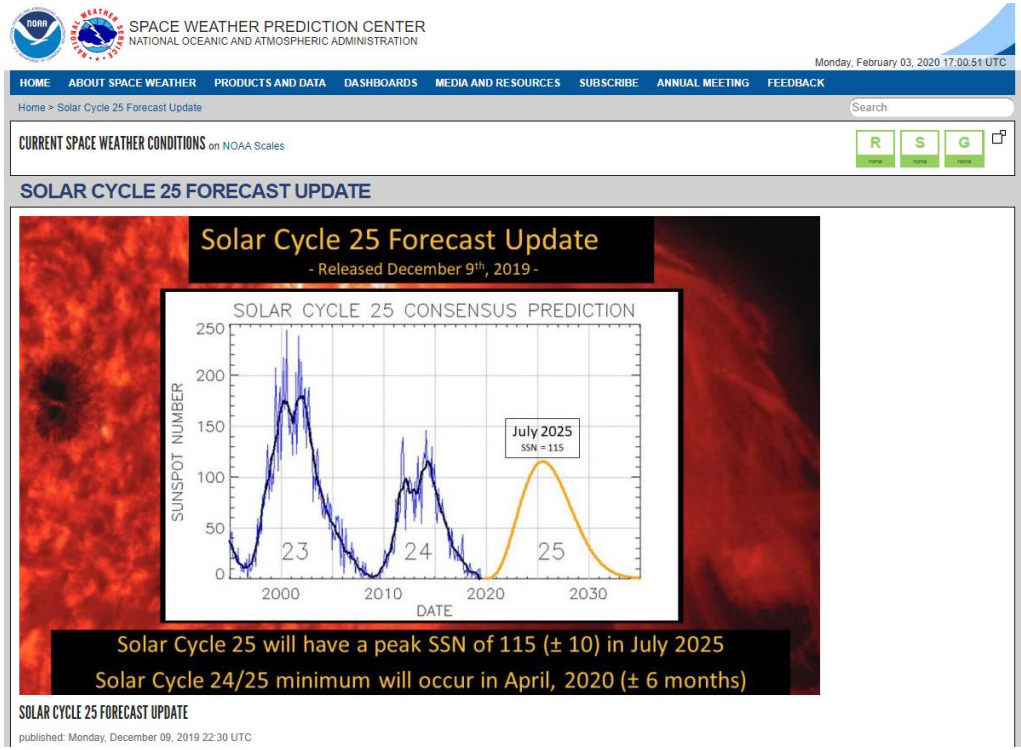
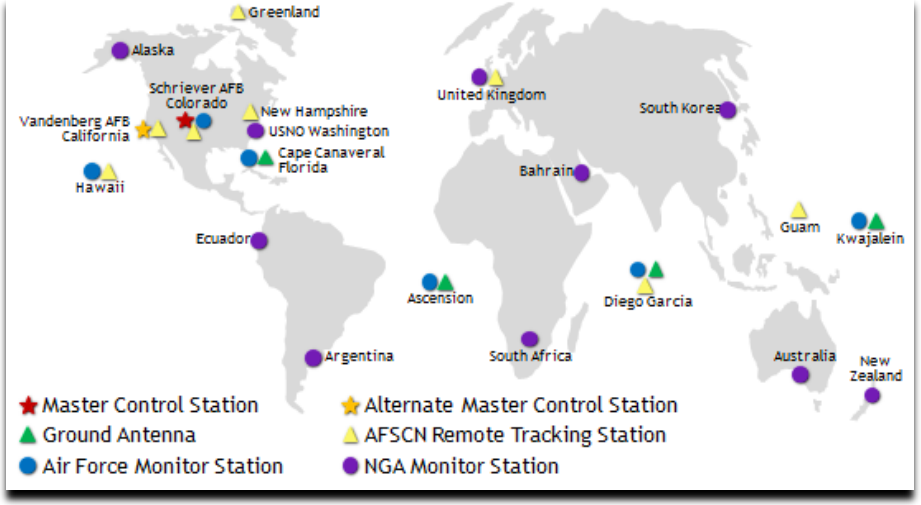
Ionospheric Errors

Solar Activity

- Currently in “Solar Minimum”
- “Solar Maximum” predicted for 2025
- 1ppm with local base / .5ppm with network RTK



GNSS



GPS Modernization

- Control Segment
  - Legacy Accuracy Improvement Initiative
    - Completed in 2008
    - Expanded monitor stations from 6 to 16
    - GPS Intrusion Protection Reinforcement – Nov ‘15
  - Operational Control System (OCX)
    - Improved Support, Monitor, and Control
    - 2016 – First Phase – long delayed to this point

GNSS

Ligado

- Formally Lightsquared
  - Wireless 5G IoT Networks including Satellite based
  - Potential Interference with GPS Users
    - Adjacent band interference
    - Potential SATCOM Interference
  - April 20, 2020 FCC approval
  - Transmission Power higher than GPS on an Adjacent band
  - Jan 19, 2021 letter to FCC – Stay order on Ligado Decision

GNSS

Ligado

- GPS Advisory Council Formed Response
  - Deere and Co, Garmin, Trimble
  - Other Members
    - Lockhead, BAE, Collins Aerospace
  - Stance
    - FCC regulators appreciate difference between navigation and communication
    - 1bd metric to be used
    - FCC rules on marketing/sale of jammers
  - NTIA's technical memo to FCC
    - Demonstrates impact Ligado will have on day-to-day GPS operations
  - FCC denied Motion January 19, 2021

GNSS

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  - Others – QZSS, BeiDou

GNSS

Glonass

- Russian Aerospace Defense Forces
  - 23 Current Operational Satellites
    - 2 In Maintenance
    - 2 in Testing Phase
    - 1 Spare
  - October 2011 returned to full constellation
    - 24 SV’s
  - Complementary to GPS
  - Glonass-M Satellites
  - July 2013 – Proton Rocket Crash
    - 3 Glonass SV’s destroyed
  - Ephemeris Issues throughout 2016

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GNSS

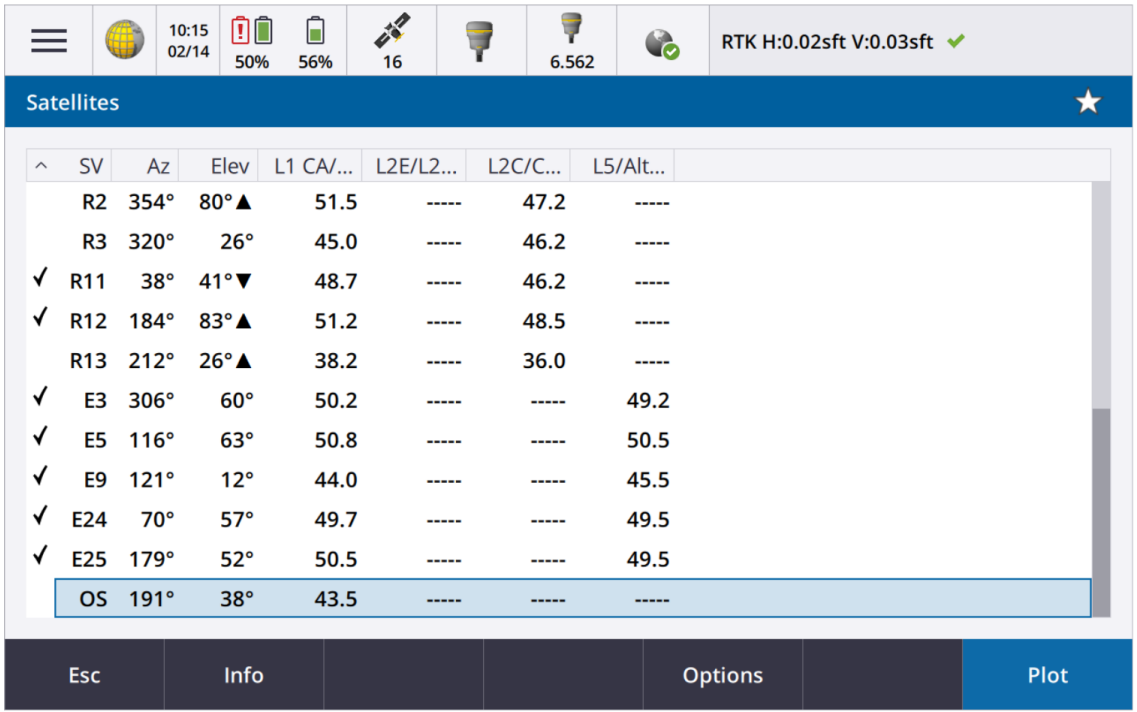
Galileo

- European Union and European Space Agency
  - Civilian Control
  - Planned Global Coverage
  - First Service offerings – 2016
    - Multiple Signal Services
  - First 2 Operational SV's launched 2011
  - 2014 – Faulty Launch
    - 2 SV's in wrong Orbit
    - Year Long "Einstein Test" to correct
  - 24 current usable SV's
  - L1 and L5 frequencies

GNSS

Galileo

- **Near full constellation**
  - Enhance RTK positioning
  - March 3rd, 2020 – Available from MN CORS
  - “E” is the Galileo SV Indicator



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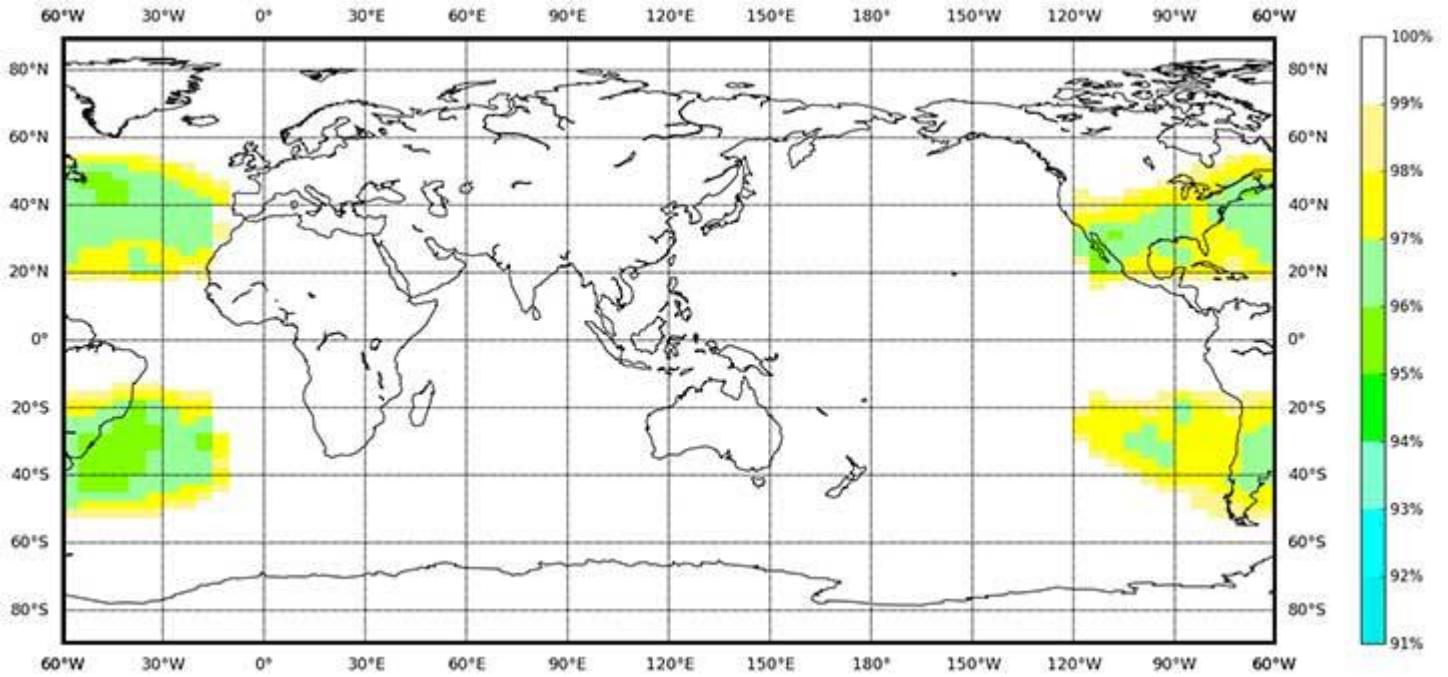
  - Glonass – Russian System
  - Galileo – European Union System
  - BeiDou – Chinese Positioning System

GNSS

- **BeiDou – Chinese Satellite Nav Sys**
  - Three Step Strategy
    - Regional Coverage System – Phase 1
      - Country of China
  - Global Coverage (BeiDou-2) – Phase 2
    - Globa Global SV's
  - 12 new Ground Stations in 2019
  - Global Accuracy
    - 3.6m Horizontal / 6.6 Vertical

GNSS

- **BeiDou – Chinese Satellite Nav Sys**
  - **Global Coverage**



GNSS Modernization

How does this impact the Surveyor?

- ProPoint GNSS
  - GPS + Glonass + Galileo + BeiDou or any combination of these modernized GNSS Positioning Systems
  - Survey-grade positioning using most combinations of GNSS constellations and signals

- Accurate
- Reliable
- Productive

What about my Base Station

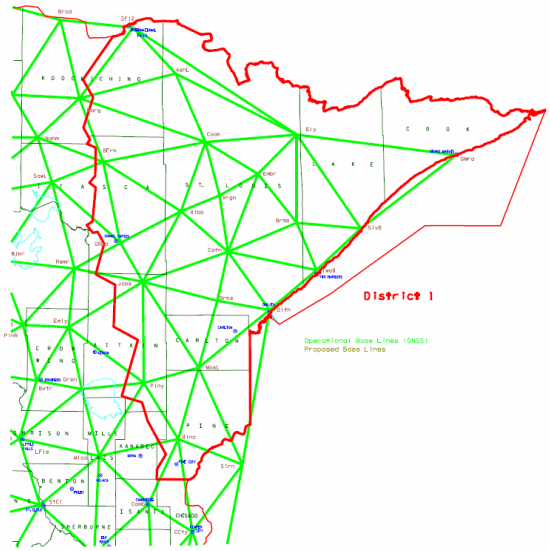
Does my Base need to track these same GNSS satellite signals to take advantage of them at the Rover?

- For Survey Grade accuracy, it depends…
  - Some new RTK engines can take advantage of existing signals and just process the data differently or faster.
  - New RTK engines and old engines will traditionally benefit from these signals
  - Some receivers do not support Galileo or Beidou
  - Check with your dealer or rep

Differential Correction Sources

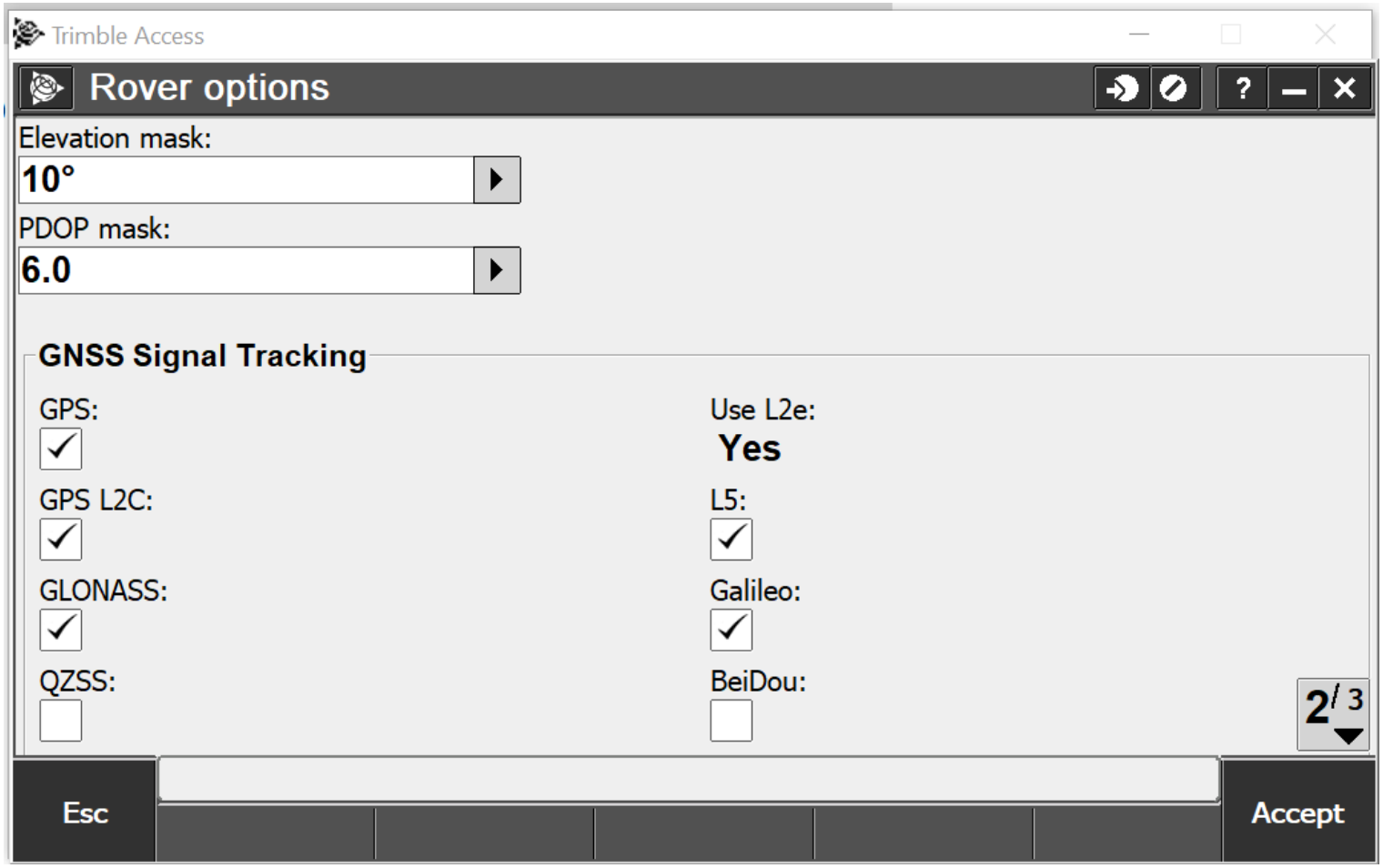
MN CORS

- Free VRS correction source in Minnesota
  - GPS + Glonass + Galileo broadcast
    - Trimble users – CMRx
    - Other Manufacturers – RTCM 3.2
    - Mncors.dot.state.mn.us
  - Potential future plans to add BeiDou



GNSS

Trimble Users - Survey Styles



Differential Correction Sources

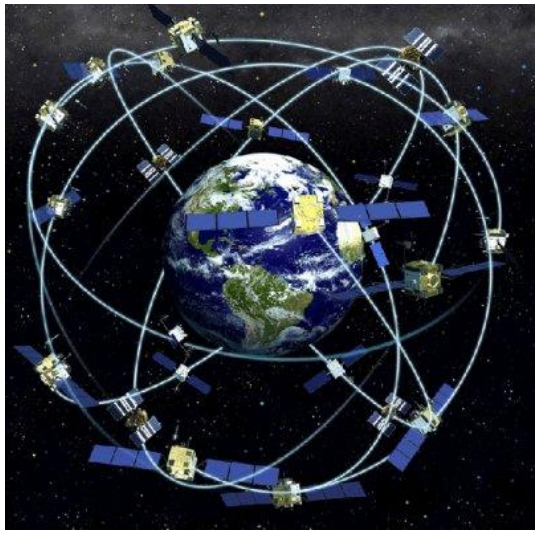
Satellite Based Correction

- RTX and RTX Fast
  - Subscription Based Service
  - Convergence Time
  - Available anywhere
  - Highly Accurate
  - Fast RTX service now available

GNSS Modernization

Summary

- Latest on GNSS Technology for Surveying
- Scalable solutions for future
- Integrated Technologies
- New Real-Time Corrections



More Information

- www.gps.gov
- www.gpsworld.com
- https://www.dot.state.mn.us/surveying/cors/
- www.spaceweather.com

Questions

srichter@frontierprecision.com