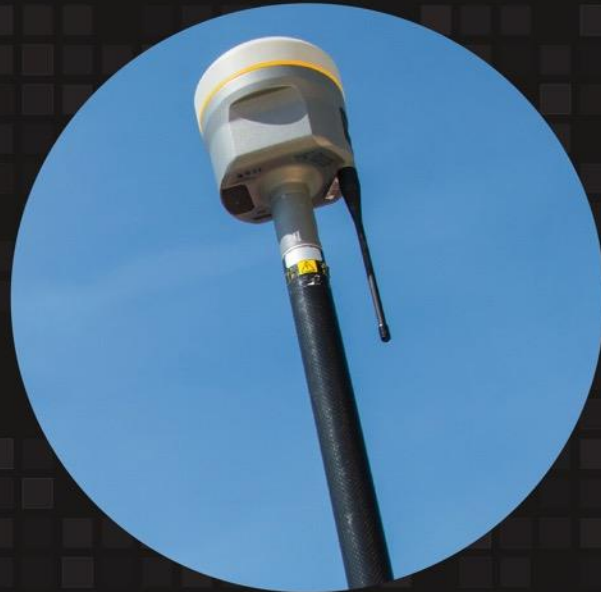


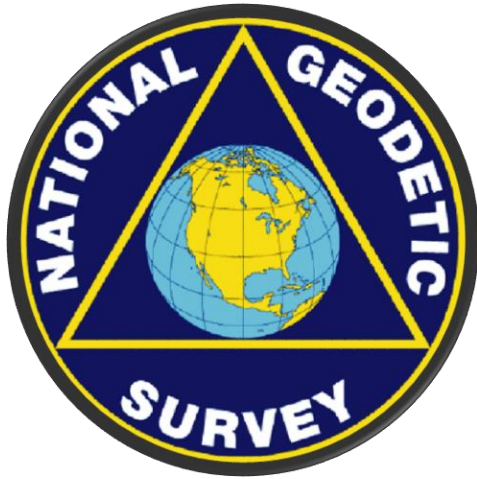
FRONTIERTM PRECISION+



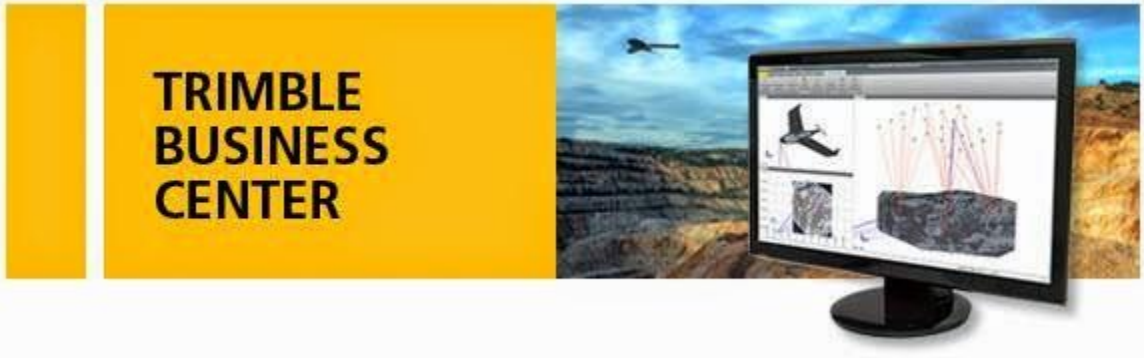
How You Measure Matters

WWW.FRONTIERPRECISION.COM

AN EMPLOYEE-OWNED COMPANY

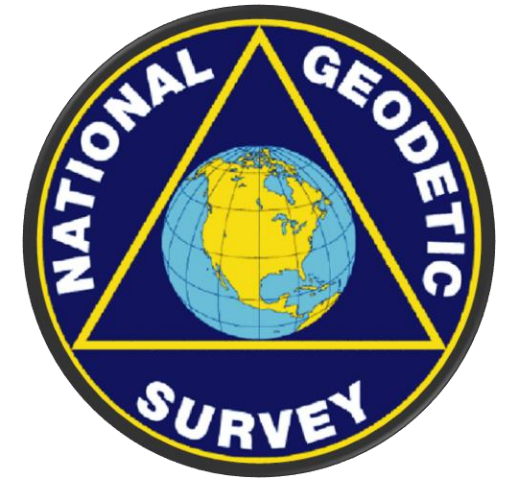


FRONTIER
PRECISION 
INC
TECHNOLOGY FOR
INFORMATION AND MEASUREMENT



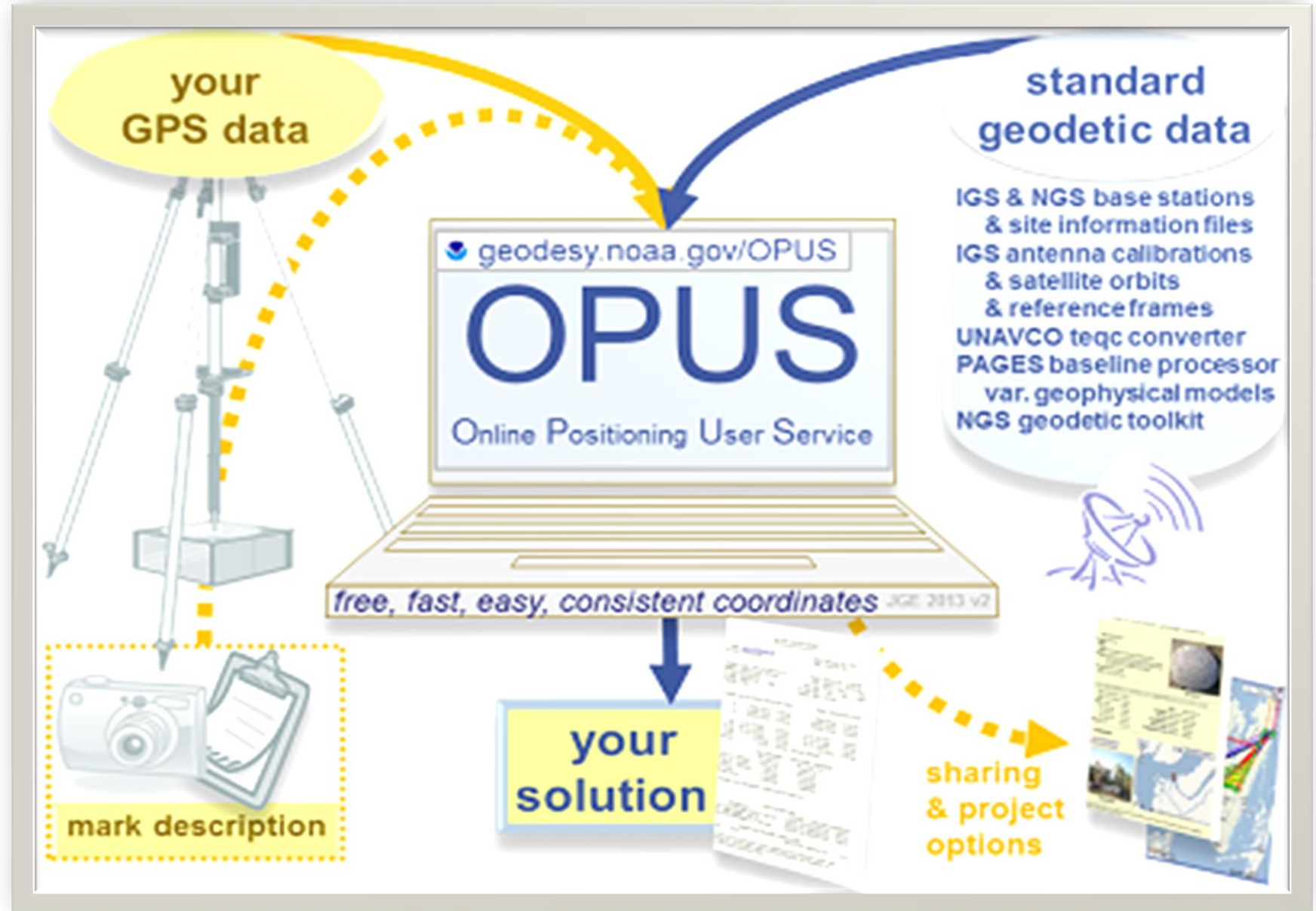
“UNDERSTANDING AND INCORPORATING NGS OPUS SOLUTIONS AND RTXPP”

SESSION OBJECTIVES



- What is OPUS?
- How to use Trimble's RINEX Converter
- Review TBC Processing Services
- Compare the basics of OPUS-S vs OPUS-RS
- OPUS – S Report explained
- OPUR – RS Report explained
- OPUS - DB Published Solutions Review
- Trimble RTXPP Solutions
- Trimble Business Center OPUS Workflow Summarized

Online Positioning User Service



WWW.NGS.NOAA.GOV/CORS - CORS MAP

CORS Map
National Geodetic Survey

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education

Search

CHOOSE MAP
 Sampling Rate Map
 Show/Hide | Help | Legend

Zoom to CORS:
 Site ID: Go

Cursor Lat/Lon :
 46.23007 , -104.00000

Three Nearest Sites :
 P054 54.68 km
 P055 111.71 km
 NDDI 120.68 km

Enter a location Go

Place X

Map | Satellite

250 km radius

** To filter sites click on icons **

GPS	GNSS	All
		1 sec rate
		5 sec rate
		15 sec rate
		30 sec rate
		All Active
		All Non-Operational
		Decommissioned

[Download CORS KMZ](#)

Map data ©2020 Google, INEGI | Terms of Use



NGS Coordinate Conversion and Transformation Tool (NCAT)

National Geodetic Survey

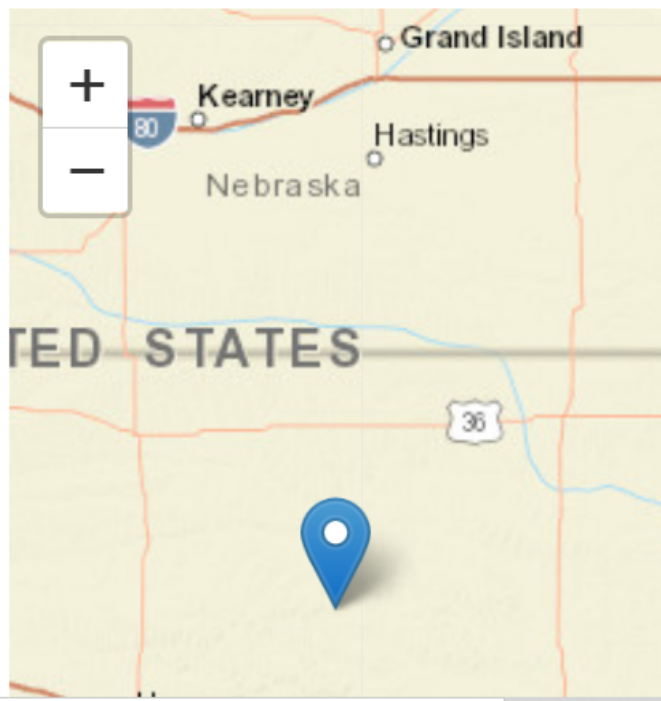
- Single Point Conversion
- Multipoint Conversion
- Web services
- Downloads
- About Conversion Tool

Convert/Transform from:

- Horizontal
- Horizontal+height
- XYZ

Select the type of horizontal coordinate:

- Geodetic lat-long
- SPC
- UTM
- USNG



Enter lat-lon in decimal degrees

Lat 39.2240867222

Lon -98.5421515000

or degrees-minutes-seconds

Lat 39-13-26.7122

Lon 098-32-31.745

or drag map marker to a location of interest



NGS Geodetic Tool Kit

On-line interactive computation of geodetic values. These utilities require Internet Explorer version 6.0+ and Netscape version 6.0+.

Read the articles about the **NGS Geodetic Toolkit** that were published in Professional Surveyor Magazine

To learn more about a particular online program, click on its link for a description:

- **DEFLEC99**
- **DEFLEC09**
- **DEFLEC12A**
- **DYNAMIC_HT**
- **GEOID12A**
- **GEOID12**
- **GEOID09**
- **GEOID06**
- **GEOID03**
- **GEOID99**
- **G99SSS**
- **USGG2012**
- **USGG2009**
- **USGG2003**
- **HTDP**
- **IGLD85**
- **Inverse/Forward/Invers3D/Forwr3D**
- **Leveling Online Computations User Service (LOCUS)**
- **LVL_DH**
- **Magnetic Declination**
- **NGS Coordinate Conversion and Transformation Tool (NCAT)**
- **NAVD 88 Modelled Gravity**
- **Online Adjustment User Services**
- **Online Adjustment Utilities User Services**
- **OPUS**
- **Surface Gravity Prediction**
- **Tidal and Orthometric Elevations**

*** This software has been superseded and replaced by **NGS Coordinate Conversion and Transformation Tool (NCAT)** and

New Datums

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[2010 Summit](#)

New Datums: Replacing NAVD 88 and NAD 83

To improve the National Spatial Reference System (NSRS), NGS will replace all three North American Datum of 1983 (NAD 83) frames and all vertical datums, including the North American Vertical Datum of 1988 (NAVD 88), with four new terrestrial reference frames and a geopotential datum.

The new reference frames will rely primarily on Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS), as well as on a gravimetric geoid model resulting from our Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project.

These new reference frames will be easier to access and to maintain than the current NSRS, which relies on physical survey marks that deteriorate over time.

[Delayed Release Message](#)

[Background](#) [What to Expect](#) [Get Prepared](#)

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- Tools & Software**
- PC Products
- Geodetic Tool Kit
- Web Services
- User-Contributed Software
- Other Products & Programs

HTDP – Horizontal Time-Dependent Positioning

HTDP is a utility that allows users to transform positional coordinates across time and between spatial reference frames.

***** HTDP should NOT be used to transform between NAD 83 realizations (2011, NSRS2007, HARN, etc.). It will not give correct results. To transform between NAD 83 realizations, use the [NGS Coordinate Conversion and Transformation Tool \(NCAT\)](#) instead. *****

Interactive Computations (using HTDP version 3.3.0):

- Estimate horizontal displacements between two dates.**
- Estimate horizontal velocities.**
- Transform observations to a specified reference frame and/or date. (Note)**
- Transform positions between reference frames and/or dates. (Note)**
- Transform velocities between reference frames.**

More Info:

- View **User Guide [pdf]** and/or **Revision Log [pdf]**
- Download a **zipped archive** of the HTDP PC executable, User Guide, Revision Log, sample data files, and Fortran-90 source code
- Relevant publications**

Maps of Horizontal Velocities:

OPUS WEBSITE: CONVERT TO RINEX UTILITY

https://www.trimble.com/support_trl.aspx?Nav=Collection-40773&pt=Trimble%20RINEX

File/Open, then File/Convert

0 File Settings	
Input file information	C:\Users\John\Downloads\5830F01157202004091800A.T04
Input file type	t01File
RINEX file extension	YYO, YYN, YYM
RINEX file name w/o extension	5830F01157202004091800A
RINEX file path	C:\Users\John\Downloads
RINEX file version	RINEX Version 304
RINEX MET/AUX file generation rule	Create if present in input
1 RINEX Header Settings - Required	
Agency	Trimble
Observer name	GNSS Observer
Program run by	convert ToRINEX OPR
2 RINEX Header Settings	
Marker approximate X, meters	-1459642.7132
Marker approximate Y, meters	-5014050.2045
Marker approximate Z, meters	3653191.2343
Marker name	101
Marker number	101
Marker type (v3.02 only)	GEODETIC
3 Antenna Settings	
Antenna header name	TRMR10-2 NONE
Antenna measurement point	Measure to ARP
Antenna offset, meters	2.1964
Antenna serial number	30F01157
Antenna type	R10-2
4 Receiver Settings	
Receiver header name	TRIMBLE R10-2
Receiver serial number	5830F01157
Receiver type	R10-2
Receiver version	5.45
5 Conversion Control Settings	
Antenna is initially moving	False
Log clock offsets	False
Log continuous clock (fix for millisecond time steps)	False
Log Doppler observations	False
Log only GPS observations	False
Log SNR observations	False
Suppress kinematic records	False
Suppress marker number records	False
Truncate marker names	False
Misc	
outFilePathIsGlobal	False

Scanning 5830F01157202004091800A.T04... Complete!

OPUS WEBSITE: CONVERT TOX TO RINEX

Receiver INdependent EXchange

```
satellite system identifier
G : GPS
R : GLONASS
S : SBAS payload
E : Galileo
C : Compass
```

File for OPUS

- 5830F01157202004091800A.20c
- 5830F01157202004091800A.20g
- 5830F01157202004091800A.20h
- 5830F01157202004091800A.20l
- 5830F01157202004091800A.20i
- 5830F01157202004091800A.20n
- 5830F01157202004091800A.20o**

```
file type:
O: Observation file
N: GPS navigation message file
M: Meteorological data file
G: GLONASS navigation message file
L: Galileo navigation message file
P: Mixed GNSS navigation message file
H: SBAS Payload navigation message file
B: SBAS broadcast data file
   (separate documentation)
C: Clock file (separate documentation)
S: Summary file (used e.g., by IGS, not a st
two-digit year
```

```
5830F01157202004091800A.20o - Notepad
File Edit Format View Help
| 3.04 OBSERVATION DATA Mixed(MIXED) RINEX VERSION / TYPE
cnvtToRINEX 3.13.0 convertToRINEX OPR 15-Apr-20 16:14 UTC PGM / RUN BY / DATE
-----
101 MARKER NAME
101 MARKER NUMBER
GEODETTIC MARKER TYPE
GNSS Observer Trimble OBSERVER / AGENCY
5830F01157 TRIMBLE R10-2 5.45 REC # / TYPE / VERS
30F01157 TRMR10-2 NONE ANT # / TYPE
-1459642.7132 -5014050.2045 3653191.2343 APPROX POSITION XYZ
2.1964 0.0000 0.0000 ANTENNA: DELTA H/E/N
C 8 C1X C2I C5X C6I L1X L2I L5X L6I SYS / # / OBS TYPES
R 4 C1C C2C L1C L2C SYS / # / OBS TYPES
G 8 C1C C2W C2X C5X L1C L2W L2X L5X SYS / # / OBS TYPES
E 4 C1X C8X L1X L8X SYS / # / OBS TYPES
S 2 C1C L1C SYS / # / OBS TYPES
5.000 INTERVAL
2020 4 9 20 42 40.000000 GPS TIME OF FIRST OBS
2020 4 9 20 59 55.000000 GPS TIME OF LAST OBS
0 RCV CLOCK OFFS APPL
7 R14 -7 R15 0 R16 -1 R17 4 R18 -3 R19 3 R24 2 GLONASS SLOT / FRQ #
R L2C -0.25000 SYS / PHASE SHIFT
G L2X -0.25000 SYS / PHASE SHIFT
18 LEAP SECONDS
32 # OF SATELLITES
C23 176 176 176 176 176 176 176 175 PRN / # OF OBS
C27 188 189 182 185 188 188 182 181 PRN / # OF OBS
C28 191 191 186 184 191 191 186 181 PRN / # OF OBS
C37 183 183 182 179 183 180 182 177 PRN / # OF OBS
C43 192 192 192 191 192 192 192 187 PRN / # OF OBS
```

OPUS WEBSITE: NGS.NOAA.GOV/OPUS

OPUS: Online Positioning User Service
 National Geodetic Survey

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education

Upload your data file.
 Solve your GPS position & tie it to the National Spatial Reference System.
 What is OPUS? FAQs

Choose File 78152252.19o
 * data file of dual-frequency GPS observations. sample

TRMR10-2 NONE
 GPS: L1/L2/L5
 antenna - choosing wrong may degrade your accuracy.

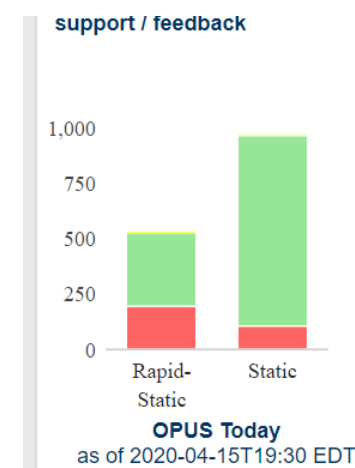
2 meters above your mark.
 antenna height of your antenna's reference point.

bob@frontierprecision.com
 * email address - your solution will be sent here. Privacy Act Statement

Options to customize your solution.

Upload to Rapid-Static for data 15 min. - 2 hrs. | Upload to Static for data 2 hrs. - 48 hrs.

* required fields
 We may use your data for internal evaluations of OPUS use, accuracy, or related research.



XML for "Drag and Drop"

Options to customize your solution.

formats **standard + XML (DRAFT)** formats explained

base stations
 Use: [] Exclude: []
 Identify any CORS you wish to explicitly include or exclude from your solution by typing in 4-char site IDs separated with line break
 -- sample
 -- find site IDs

state plane **let OPUS choose** your SPCS zone

project identifier [] enter the id provided by your project manager

my profile [] customize OPUS defaults for future solutions

share my solution **No, don't share** sharing explained

Upload to Rapid-Static for data 15 min. - 2 hrs. | Upload to Static for data 2 hrs. - 48 hrs.

* required fields
 We may use your data for internal evaluations of OPUS use, accuracy, or related research.

TRIMBLE ACCESS/TBC PROCESSING SERVICES

gnss-processor.trimbleaccess.com/gnssprocessor

Trimble

GNSS Processor Job Converter TAIM Offline Download

1 Select a file to process 2 Review Antenna Settings 3 Processing options 4 Email address 5 Submit file to Processor

Please select a Processor *

OPUS - Online Positioning User Service - National Geodetic Survey

Back Next

TBC/Survey Tab

Corridors	Point Clouds	Construction Data	Photogrammetry
Internet Download	Processing Services	Clear Processing	Loop Closure
	Send to RTX-PP	Time-Based View	Occupation
	Process Baselines	Session Editor	Vector
	GNSS		

TRIMBLE RTX POST PROCESSING SERVICE

WWW.TRIMBLERTX.COM

The screenshot shows the homepage of the Trimble CenterPoint RTX Post-Processing Service. At the top left is the Trimble logo. The navigation menu includes "CenterPoint RTX Post-Processing", "Post-Processing", "Register", "Support", and "Contact Us". A large banner features a world map and the text "Now Supporting Galileo" and "Process your data with GPS, GLONASS, Galileo, BeiDou, and QZSS". Below the banner, there are two columns of text. The left column welcomes users and lists benefits: "<2cm Horizontal Accuracy", "GNSS Compatibility", and "No Base Station Required". The right column encourages registration for unlimited access and provides a "Post-Processing" button.



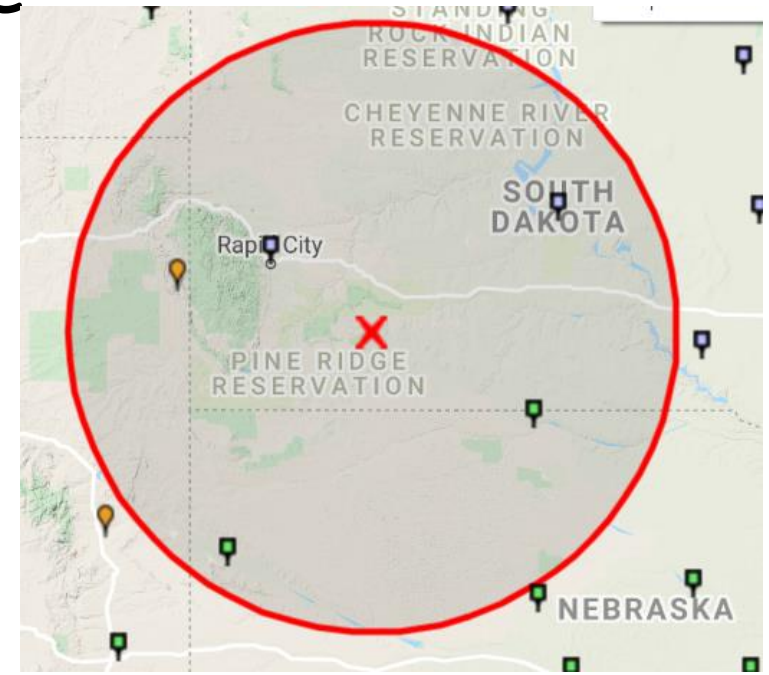
The screenshot shows the registration form on the Trimble CenterPoint RTX Post-Processing Service website. The navigation menu is the same as the homepage. The main content area includes a welcome message, a description of the service, and a registration form. The form has three main steps: 1. Select a coordinate system and tectonic plate, with dropdown menus for "Coordinate System" (set to NAD83-2011) and "Tectonic Plate" (set to North America). 2. Select a file to upload, with a "Choose File" button and "No file chosen" text. 3. Provide your email address, with an "Email:" label and an empty input field. Below the form, there are sections for "New Enhancements" and "Observation files must meet the following requirements:", which lists various technical specifications for data files.

OPUS (S) STATIC

- GPS only (NO GNSS)
- Can “Share” to OPUS – DB
 - 4 or more hours of data
- 2-48 hrs of dual frequency data (L1/L2)
- Global solutions available
- Time Dependent (3 CORS, preferably within 1000 KM)
- Utilizes PAGES Software
- Released Q1 2001

VS OPUS (RS) RAPID STATIC

- GPS only (NO GNSS)
- 15 mins to 2 hrs of dual frequency data
- Distance Dependent (3-9CORS) within 250 KM – Planning!!!
- Not available everywhere!
- Utilizes RSGPS Software
- Released Q1 2007



NGS OPUS (S) - STATIC



NGS OPUS SOLUTION REPORT

=====

All computed coordinate accuracies are listed as peak-to-peak values.
 For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: bob@frontierprecision.com DATE: December 15, 2019
 RINEX FILE: tw_c318r.19o TIME: 21:57:37 UTC

SOFTWARE: page5 1801.18 master70.pl 160321 START: 2019/11/14 17:44:00
 EPHEMERIS: igs20794.eph [precise] STOP: 2019/11/14 20:00:00
 NAV FILE: brdc3180.19n OBS USED: 6184 / 6284 : 98%
 ANT NAME: TRMR8S NONE # FIXED AMB: 37 / 40 : 93%
 ARP HEIGHT: 1.6065 OVERALL RMS: 0.010(m)

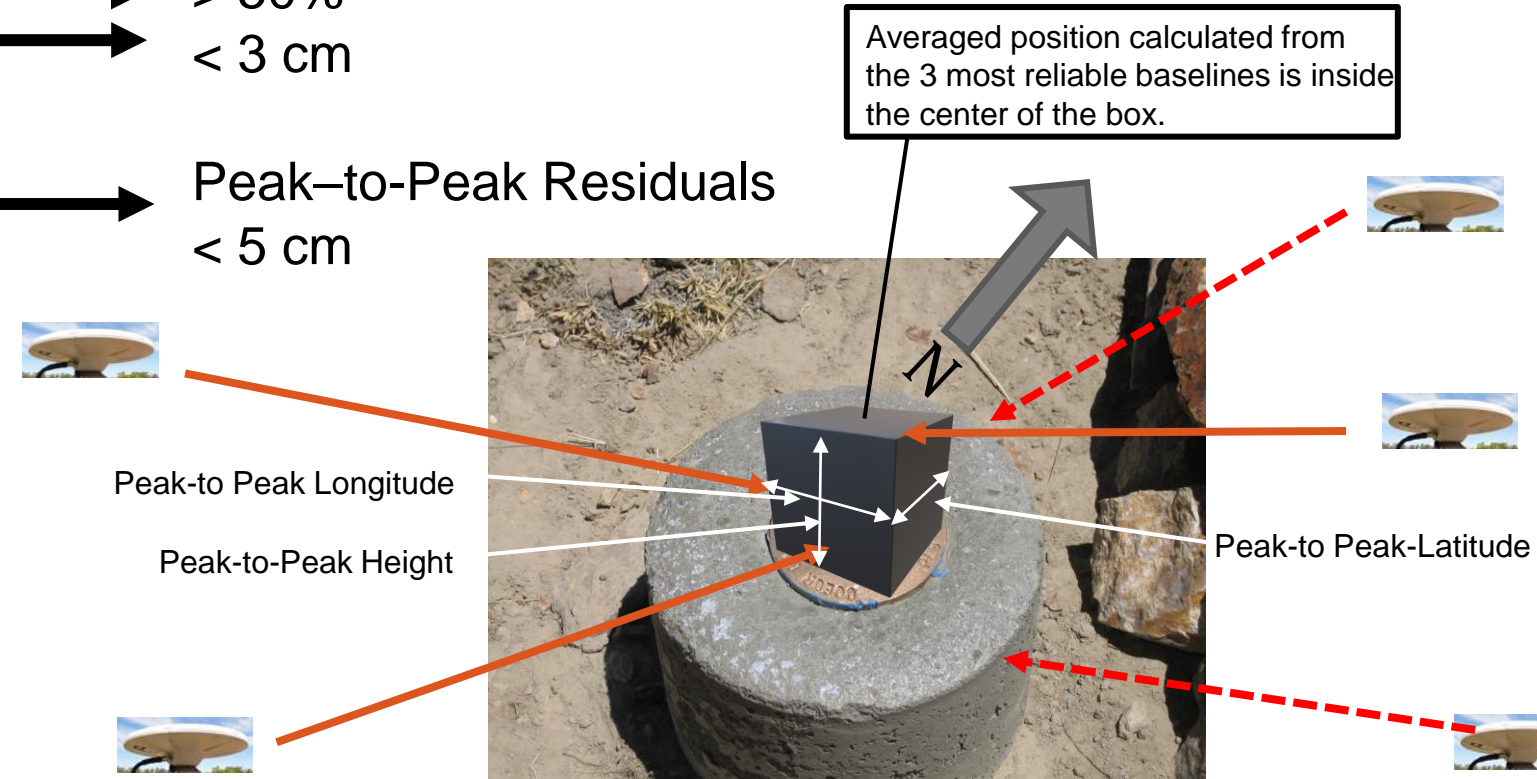
NGS Recommendations

> 90%
 > 50%
 < 3 cm

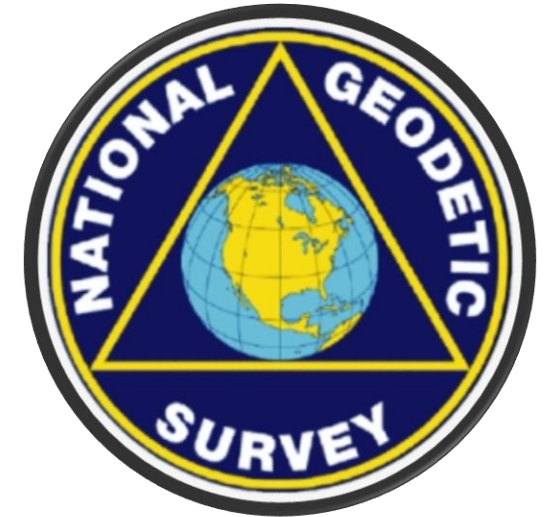
REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2014 (EPOCH:2019.8706)

Peak-to-Peak Residuals
 < 5 cm

X: -1452544.628(m)	0.002(m)	-1452545.509(m)	0.002(m)
Y: -5034883.186(m)	0.009(m)	-5034881.818(m)	0.009(m)
Z: 3627129.764(m)	0.004(m)	3627129.598(m)	0.004(m)
LAT: 34 52 12.39946	0.002(m)	34 52 12.41490	0.002(m)
E LON: 253 54 26.46241	0.003(m)	253 54 26.41417	0.003(m)
W LON: 106 5 33.53759	0.003(m)	106 5 33.58583	0.003(m)
EL HGT: 1882.114(m)	0.009(m)	1881.141(m)	0.009(m)
ORTHO HGT: 1901.961(m)	0.045(m)	[NAVD88 (Computed using GEOID18)]	



NGS OPUS (S) - STATIC



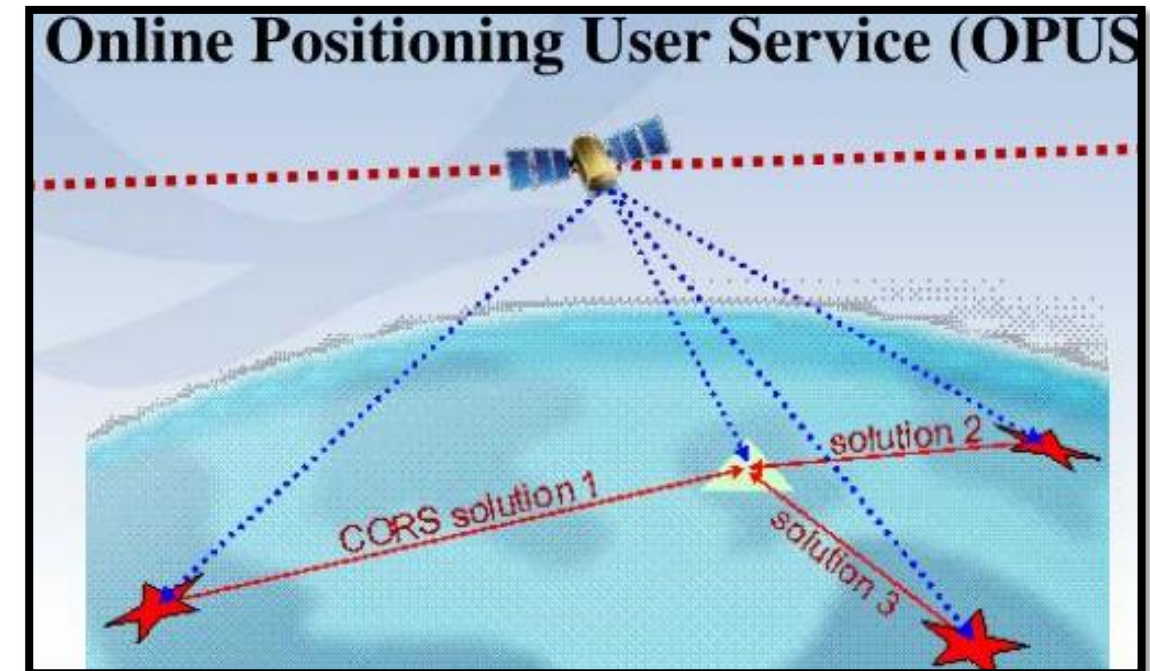
UTM COORDINATES		STATE PLANE COORDINATES	
UTM (Zone 13)		SPC (3002 NM C)	
Northing (Y) [meters]	3859183.466		429177.140
Easting (X) [meters]	400134.526		514385.484
Convergence [degrees]	-0.62473889		0.08996111
Point Scale	0.99972292		0.99990255
Combined Factor	0.99942766		<u>0.99960723</u>

Ground to State Plane Grid = 0.99960723
 State Plane Grid to Ground = 1.000392924

US NATIONAL GRID DESIGNATOR: 13SDU0013459183(NAD 83)

BASE STATIONS USED					
PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)	
DH3846	P035 VAUGHNPTRL_NM2005	CORS ARP	N343604.997 W1051100.927	88452.9	
DK7586	P120 CLINESCORNNM2007	CORS ARP	N350026.823 W1053733.831	45281.1	
DG7420	P034 SANDIA_ASLSNM2004	CORS ARP	N345644.213 W1062733.318	34545.4	

NEAREST NGS PUBLISHED CONTROL POINT			
EQ0687	HIBNER	N345227.602 W1060423.582	1837.4



NGS OPUS (RS) – RAPID STATIC

NGS OPUS-RS SOLUTION REPORT

=====

All computed coordinate accuracies are listed as 1-sigma RMS values.
 For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: bob@frontierprecision.com DATE: April 15, 2020
 RINEX FILE: 5830100u.20o TIME: 19:14:43 UTC

SOFTWARE: rsgps 1.38 RS91.prl 1.99.3 START: 2020/04/09 20:43:00
 EPHEMERIS: igr21004.eph [rapid] STOP: 2020/04/09 20:59:30
 NAV FILE: brdc1000.20n OBS USED: 290 / 290 : 100%
 ANT NAME: TRMR10-2 NONE QUALITY IND. 16.39/ 3.43
 ARP HEIGHT: 2 NORMALIZED RMS: 0.327

3 “Main” “Published” Orbits

- Ultra Rapid – Real time/Near Real time
- Rapid – Available 17 hours after the end of the previous UTC day.
- Final – 13 days after the end of the “solution” week.



> 90%

Based on the W-Ratio from LAMBDA Validation Tests. Values >3

$$NRMSE = \frac{RMSE}{\sigma} \approx 1$$

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2014 (EPOCH:2020.27287)

X: -1459641.831(m) 0.028(m)	-1459642.719(m) 0.028(m)
Y: -5014048.036(m) 0.071(m)	-5014046.671(m) 0.071(m)
Z: 3653190.479(m) 0.058(m)	3653190.314(m) 0.058(m)

LAT: 35 9 20.50499 0.019(m)	35 9 20.52047 0.019(m)
E LON: 253 46 9.01016 0.018(m)	253 46 8.96142 0.018(m)
W LON: 106 13 50.98984 0.018(m)	106 13 51.03858 0.018(m)
EL HGT: 2062.635(m) 0.092(m)	2061.671(m) 0.092(m)

ORTHO HGT: 2082.120(m) 0.095(m) [NAVD88 (Computed using GEOID18)]

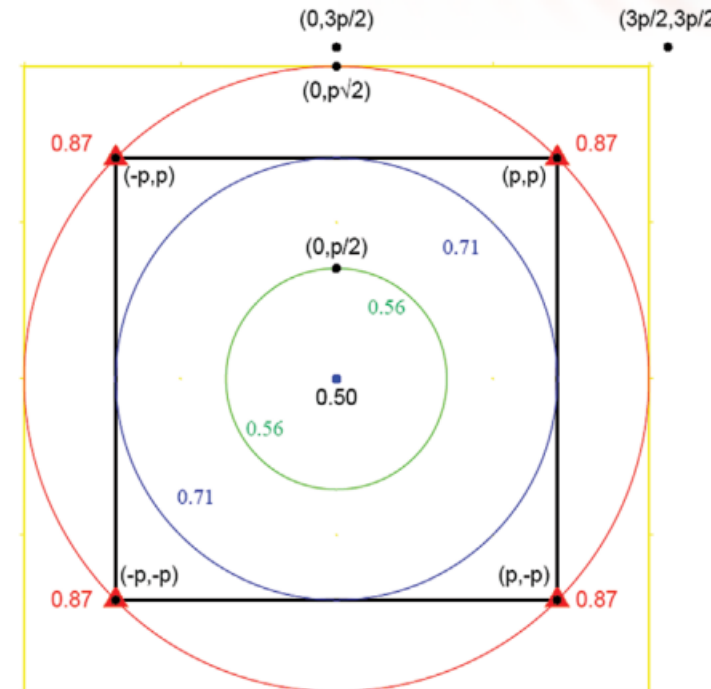
Standard Deviations

$$\sigma = \sqrt{(\alpha \cdot IDOP)^2 + (\beta \cdot RMSD)^2 + \gamma^2}$$

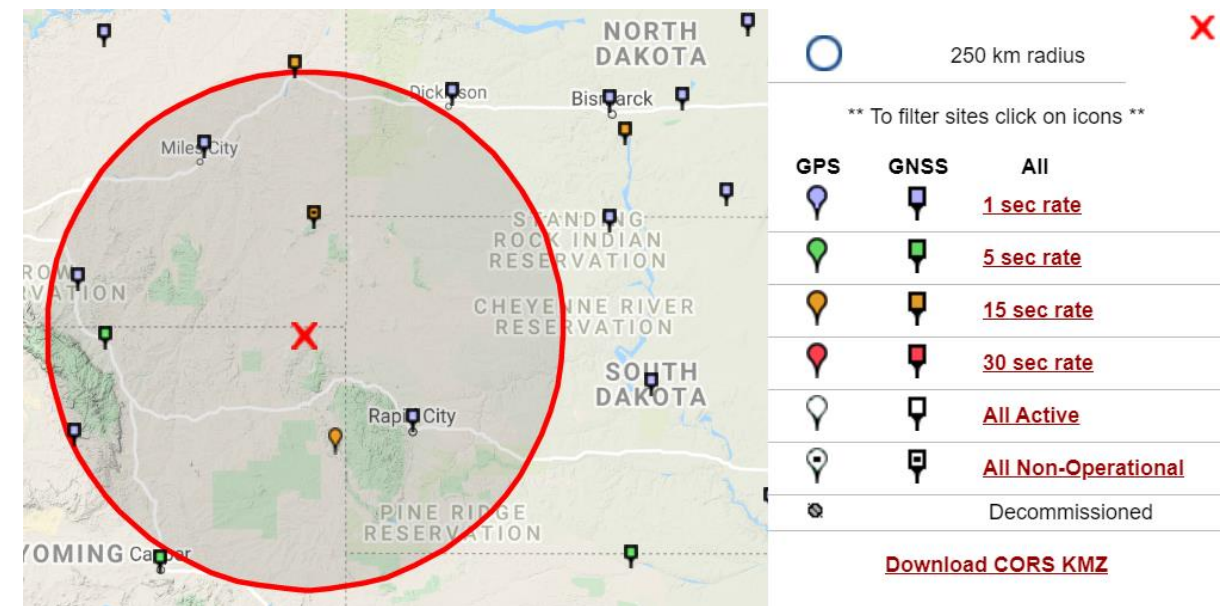
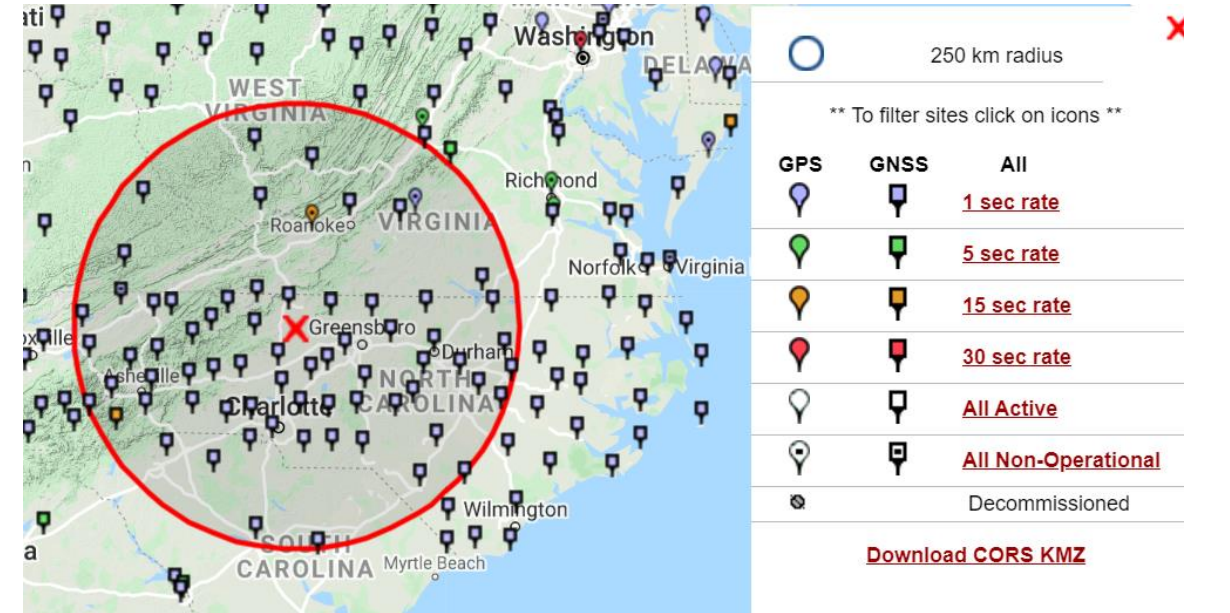
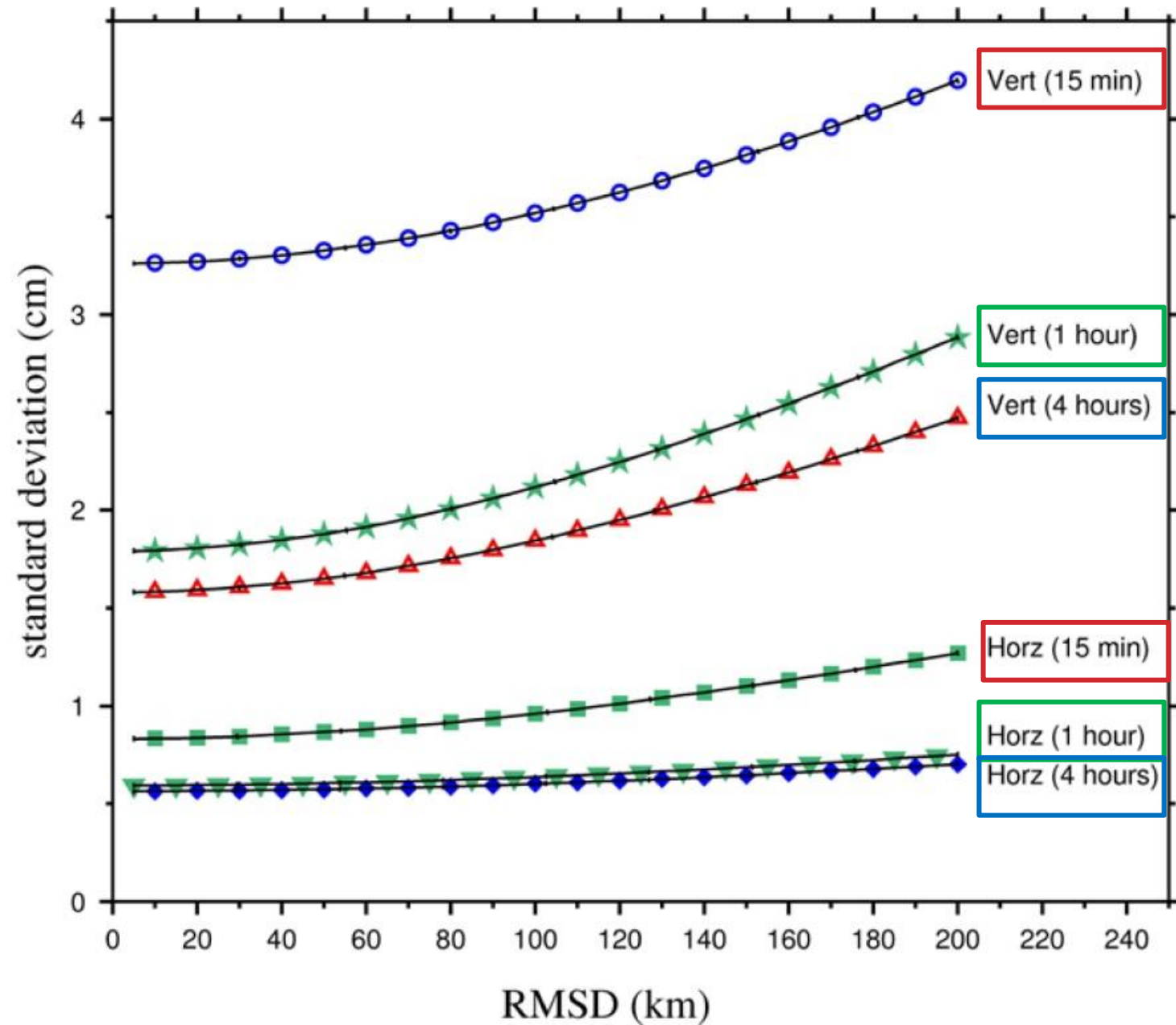
α, β, γ – Parameters Estimated from OPUS-RS Model

IDOP – Interpolative Dilution of Precision
 RMSD – Root Mean Squared Deviation

$$RMSD = \sqrt{\frac{\sum d_i^2}{n}}$$



NGS OPUS (RS) – RAPID STATIC



OPUS-DB PUBLISHING YOUR OPUS SOLUTIONS

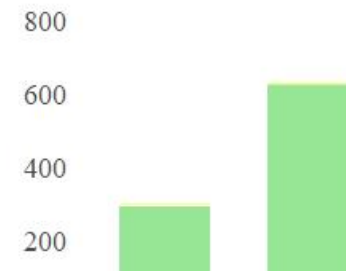
Requirements:

- 4+ hour GPS data file
 - Verify antenna type, height, and plumb, fixed height tripod recommended
- Permanent mark of public interest
 - Durable, stable setting with good satellite visibility
 - Description & photos to aid future recovery
- High-quality OPUS-S solution
 - $\geq 70\%$ observations used
 - $\geq 70\%$ ambiguities fixed
 - ≤ 3 cm RMS
 - ≤ 4 cm peak-to-peaks, lat. & lon.
 - ≤ 8 cm peak-to-peak, ellipsoid height



OPUS menu

- home / upload
- about OPUS
- projects**
- shared solutions
- planned improvements
- support / feedback

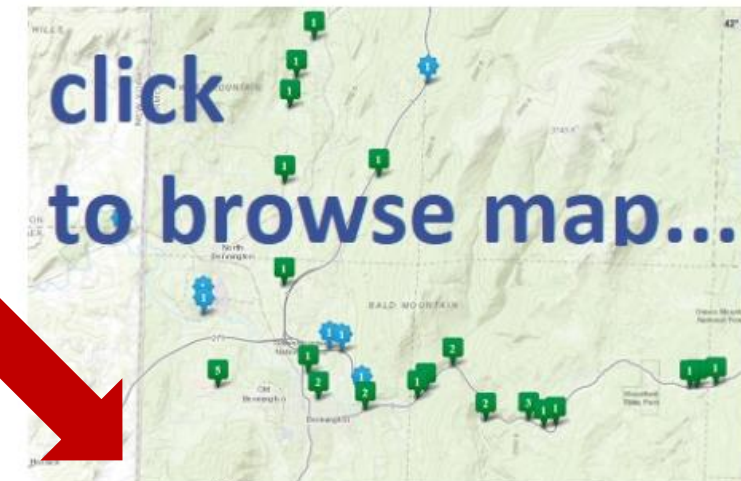


View shared solutions.

Results from survey observations on passive marks are accessible below.

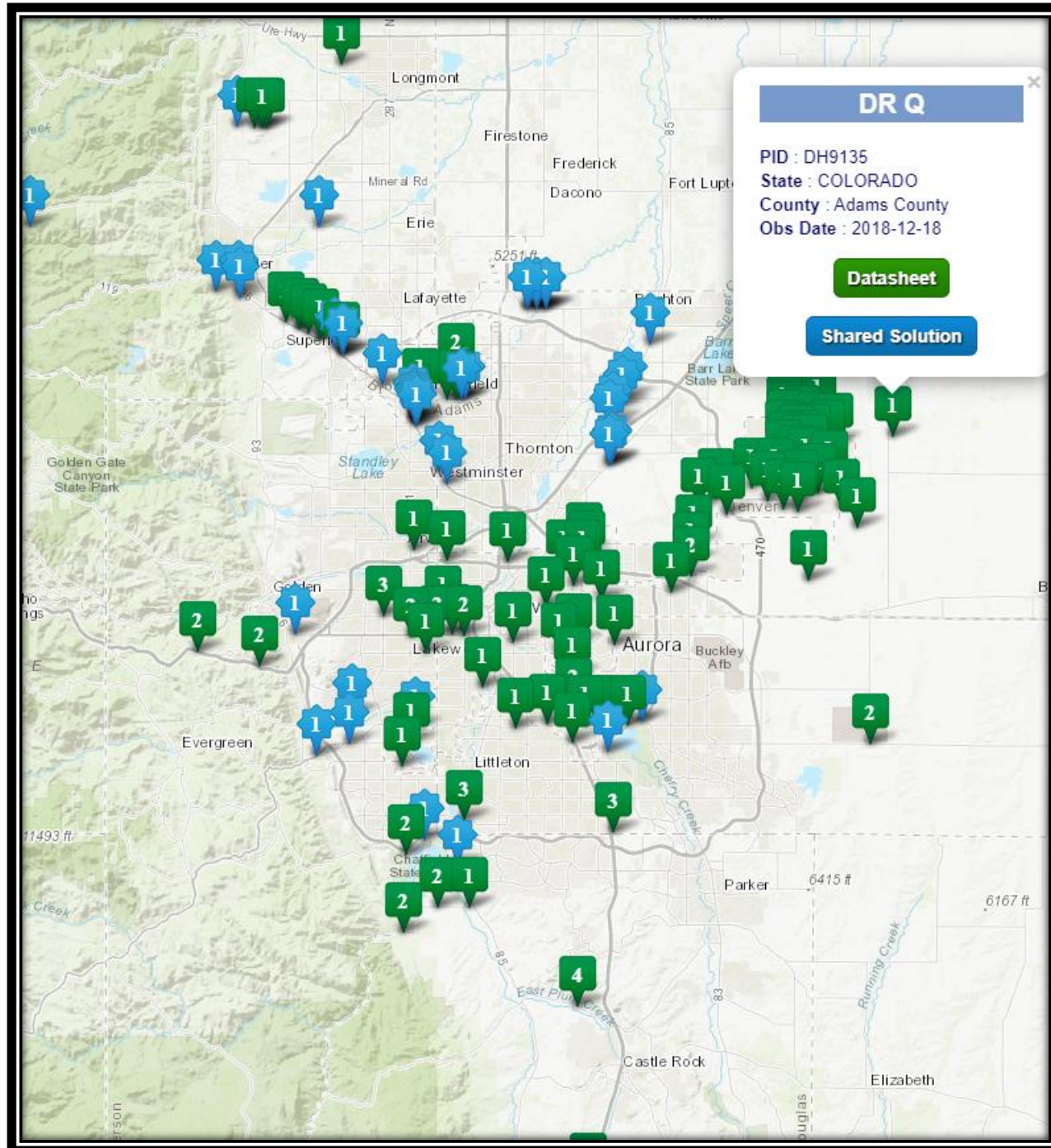
Retrieve Solutions via

Your **Search radius, County or ZIP code**
 Mark **Designation or PID**
 Observer **Date**
[browse map](#)




Add your marks -- Share Your OPUS Solutions

OPUS-DB PUBLISHING YOUR OPUS SOLUTIONS



Shared Solution


PID: DH9135
 Designation: DR-Q
 Stamping: DR-Q 822
 Stability: Monument will probably hold position well
 Setting: Stainless steel rod in sleeve (10FT+ or 3.048M+)
 Mark Condition: G
 Description:
 Observed: 2018-12-18T17:57:00Z [See Also 2005-10-21](#)
 Source: OPUS - page5 1603.24



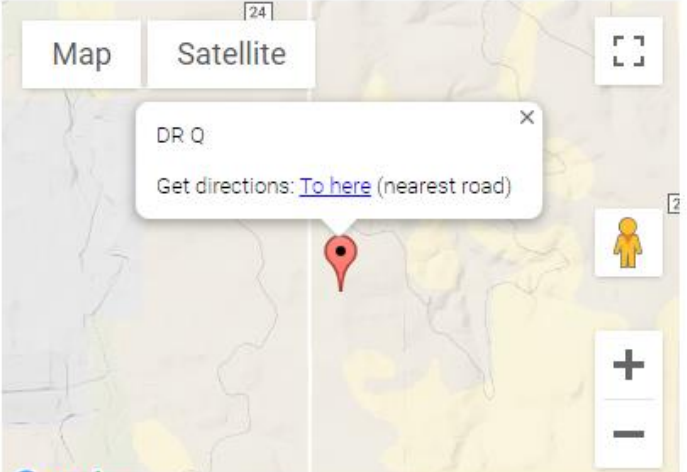
Close-up View

REF FRAME: NAD_83(2011) EPOCH: 2010.0000 SOURCE: NAVD88 (Computed using GEOID12B) UNITS: m SET PROFILE DETAILS	
LAT: 39° 53' 3.93745" ± 0.004 m LON: -104° 34' 48.53510" ± 0.007 m ELL HT: 1611.530 ± 0.008 m X: -1234046.382 ± 0.007 m Y: -4744315.120 ± 0.005 m Z: 4069180.397 ± 0.007 m ORTHO HT: 1629.797 ± 0.042 m	UTM 13 SPC 502(CO C) NORTHING: 4415014.225m 532896.148m EASTING: 535898.791m 993084.717m CONVERGENCE: 0.26922778° 0.58014167° POINT SCALE: 0.99961586 1.00002936 COMBINED FACTOR: 0.99936320 0.99977660

CONTRIBUTED BY
[thomas.breitnauer](#)
 City of Denver



Horizon View



Map Satellite

DR Q
Get directions: [To here](#) (nearest road)

Google
Map data ©2020 Terms of Use Report a map error

TRIMBLE ACCESS SURVEY STYLE SETTINGS



DO NOT USE!! →

Any of these will work but RTK & Infill seen to be the industry standard. I use 5 second logging, however
 ✗ NGS only uses 30 second data for OPUS.

Base options

Survey type: RTK & infill (dropdown menu open showing: RTK, RTK & infill, RTK & logging, FastStatic, PP kinematic)

Broadcast format: CMRx

Measured to: Lever of R10 extension

Part number: 90912-xx

Station index: 20

Logging device: Receiver

Logging interval: 5s

Elevation mask: 10°

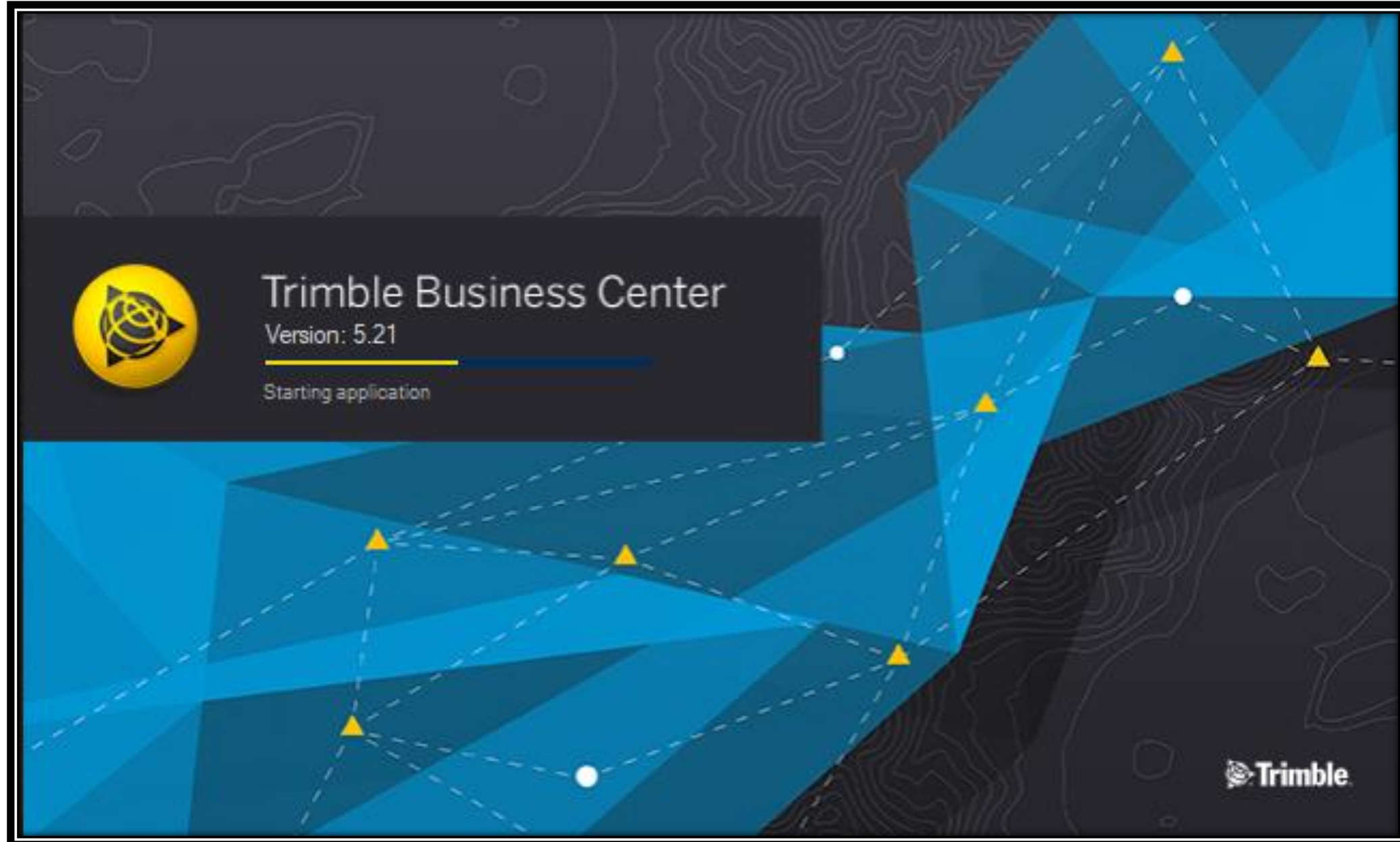
Buttons: Esc, Accept

250 km radius

** To filter sites click on icons **

GPS	GNSS	All
		<u>1 sec rate</u>
		<u>5 sec rate</u>
		<u>15 sec rate</u>
		<u>30 sec rate</u>
		<u>All Active</u>
		<u>All Non-Operational</u>
		Decommissioned

TRIMBLE BUSINESS CENTER OPUS INTERFACE



TRIMBLE BUSINESS CENTER / OPUS INTERFACE

The screenshot displays the Trimble Business Center software interface. The main window shows a plan view of a survey network with numerous points and connecting lines. A yellow warning flag is placed on point 101_BOB. The interface includes a top menu bar with options like File, Home, Survey, GIS, CAD, Drafting, Surfaces, Corridors, Point Clouds, Construction Data, Photogrammetry, Tunnels, Mobile Mapping, Data Prep, Macros, and Support. A left-hand 'View Filter Manager' panel is open, showing various filter categories such as Flag, Raw Data, and Photogrammetry. A 'Flags Pane' at the bottom lists flagged objects, with a message for point 101_BOB: 'This point has been used as starting point and it has less than survey quality. Make sure you want to use this point to flow out observations from.'

Yellow Warning Flag: Poor Quality Starting Point
(Due to Autonomous "Here Key" Position)

Flagged Objects	Message
101_BOB	This point has been used as starting point and it has less than survey quality. Make sure you want to use this point to flow out observations from.
01861070.t02	Related File: 01861070.t02 -- does not exist!

TRIMBLE BUSINESS CENTER / OPUS INTERFACE

The screenshot shows the 'Review Antenna Settings' step of the GNSS Processor interface. The following table summarizes the visible data:

Field	Value
File name	11571070.T04
Agency	Trimble
Observer	GNSS Observer
First observation (UTC)	Apr 16, 2020, 9:58:35 AM
Last observation (UTC)	Apr 16, 2020, 10:21:30 AM
Duration	0:22:55
Receiver	TRIMBLE R10-2
Serial Number	5830F01157
Point Name	101_BOB
Antenna Manufacturer	Trimble
Antenna Type	R10-2
Measurement Method	Bottom of antenna mount
Measured height (m)	1.5663

Navigation buttons: Back, Next

Windows Notification (bottom right):

```

opus
OPUS-RS aborting : 101_BOB
TR6579859366899
FILE: 101_BOB TR6579859366899
2005 NOTE: The IGS precise and IG
Outlook
    
```

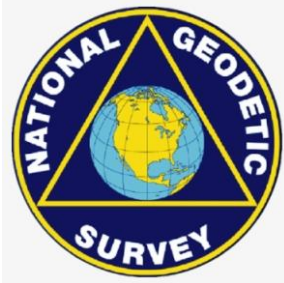
I measured a HI of 4.50' (1.372m) to the lever extension. The GNSS Processor corrected this HI to Bottom of Antenna Mount that is recognized by OPUS to 1.5663m.

OPUS-RS aborting : 101_BOB TR6579859366899

FILE: 101_BOB TR6579859366899

2005 NOTE: The IGS precise and IGS rapid orbits were not available
 2005 at processing time. The IGS ultra-rapid orbit was/will be used to
 2005 process the data.
 2005
 6029 After the single baseline analysis, fewer than 3 useable
 6029 reference stations remain. Aborting.
 6029

TRIMBLE BUSINESS CENTER / OPUS INTERFACE



NGS OPUS-RS SOLUTION REPORT

All computed coordinate accuracies are listed as 1-sigma RMS values.
 For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: Bob@frontierprecision.com DATE: April 17, 2020
 RINEX FILE: 101_107p.20o TIME: 15:26:00 UTC

SOFTWARE: rsgps 1.38 RS93.prl 1.99.3 START: 2020/04/16 15:58:35
 EPHEMERIS: igu21014.eph [ultra-rapid] STOP: 2020/04/16 16:21:30
 NAV FILE: brdc1070.20n OBS USED: 2187 / 2304 : 95%
 ANT NAME: TRMR10-2 NONE QUALITY IND. 21.17/ 29.01
 ARP HEIGHT: 1.5663 NORMALIZED RMS: 0.331

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2014 (EPOCH:2020.29146)

X: -1459662.274(m) 0.014(m) -1459663.163(m) 0.014(m)
 Y: -5014055.983(m) 0.051(m) -5014054.618(m) 0.051(m)
 Z: 3653171.482(m) 0.038(m) 3653171.317(m) 0.038(m)

LAT: 35 9 19.75190 0.005(m) 35 9 19.76738 0.005(m)
 E LON: 253 46 8.32264 0.012(m) 253 46 8.27386 0.012(m)
 W LON: 106 13 51.67736 0.012(m) 106 13 51.72614 0.012(m)
 EL HGT: 2062.607(m) 0.063(m) 2061.643(m) 0.063(m)
 ORTHO HGT: 2082.092(m) 0.068(m) [NAVD88 (Computed using GEOID18)]

UTM COORDINATES STATE PLANE COORDINATES
 UTM (Zone 13) SPC (3002 NM C)
 Northing (Y) [meters] 3890979.774 460822.655
 Easting (X) [meters] 387877.227 501729.057
 Convergence [degrees] -0.70889167 0.01092778
 Point Scale 0.99975493 0.99990004
 Combined Factor 0.99943136 0.99957642

US NATIONAL GRID DESIGNATOR: 13SCU8787790979(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DF4369	NMSF SANTA FE CORS ARP	N354025.623	W1055730.930	62621.8
DK7586	P120 CLINESCORNNM2007 CORS ARP	N350026.823	W1053733.831	57581.7
DG5392	SC01 SC01_NMTU_NM2001 CORS ARP	N340404.613	W1065759.511	138264.9
DQ3887	LANM LOS ALAMOS COUNTY CORS ARP	N355258.264	W1061814.362	80999.1
DG7423	P036 ANGELFIRE_NM2004 CORS ARP	N362512.969	W1051737.109	163989.1
DH3846	P035 VAUGHNPTL_NM2005 CORS ARP	N343604.997	W1051100.927	113823.4
DI2266	P107 GRANTS__NM2006 CORS ARP	N350755.832	W1075248.029	150333.9
DI0438	NMGR GRANTS NMDOT CORS ARP	N351259.649	W1075548.368	154946.3
DK7753	P123 TRESPIEDRANM2006 CORS ARP	N363806.598	W1055439.006	166760.3

NEAREST NGS PUBLISHED CONTROL POINT
 FO1781 SF 81 N350922.684 W1061248.413 1603.7



Post-Processing Service Based on RTX Technology

TrimbleRTX.com

Contributor: bob@frontierprecision.com
 Reference Name: 11571070.T04
 Upload Date: 04/16/2020 19:26:19 UTC

Report Time Frame:
 Start Time: 04/16/2020 15:58:35 UTC
 End Time: 04/16/2020 16:21:30 UTC
 Observation File Type(s): T04
 Observation File(s): 11571070.T04

Antenna:
 Name: TRMR10-2 NONE
 Height: 1.566 m
 Reference: Bottom of antenna mount

Receiver Name: TRIMBLE R10-2
 Coordinate Systems: NAD83-2011 & ITRF2014
 Tectonic Plate: North America
 Tectonic Plate Model: MORVEL56
 Processing Interval: 10 s

Statistics

# Total Obs	# Usable Obs	# Used Obs	Percent
276	138	138	100

Used Satellites

# Total Satellites:	21
GPS:	G07 G08 G09 G11 G16 G27 G30
GLONASS:	R01 R02 R03 R11 R12 R13 R21 R22
Galileo:	E01 E04 E13 E19 E21 E27

Processing Results

NAD83-2011 at Epoch 2010.0		
Coordinate	Value	σ
X	-1459662.249 m	0.004 m
Y	-5014055.929 m	0.010 m
Z	3653171.480 m	0.009 m
Latitude	35° 09' 19.75296" N	0.004 m
Longitude	106° 13' 51.67700" W	0.004 m
El. Height	2062.558 m	0.012 m

ITRF2014 at Epoch 2020.29		
Coordinate	Value	σ
X	-1459663.146 m	0.004 m
Y	-5014054.588 m	0.010 m
Z	3653171.281 m	0.009 m
Latitude	35° 09' 19.76706" N	0.004 m
Longitude	106° 13' 51.72584" W	0.004 m
El. Height	2061.595 m	0.012 m

Report Information

Trimble RTX Solution ID: 23027015
 Solution Type: Static
 Software Version: 8.5.0.19198
 Creation Date: 04/16/2020 19:26:28 UTC

Disclaimer

Trimble Navigation Limited does not guarantee availability, reliability, and performance of the current RTX Post-Processing service and accepts no legal liability arising from, or connected to, the use of information on this document or use of this service.



Post-Processing Service Based on RTX Technology

TrimbleRTX.com

Contributor: bob@frontierprecision.com
 Reference Name: 11571070.T04
 Upload Date: 04/16/2020 19:26:19 UTC

Report Time Frame:
 Start Time: 04/16/2020 15:58:35 UTC
 End Time: 04/16/2020 16:21:30 UTC
 Observation File Type(s): T04
 Observation File(s): 11571070.T04
 Antenna:
 Name: TRMR10-2 NONE
 Height: 1.566 m
 Reference: Bottom of antenna mount
 Receiver Name: TRIMBLE R10-2
 Coordinate Systems: NAD83-2011 & ITRF2014
 Tectonic Plate: North America
 Tectonic Plate Model: MORVEL56
 Processing Interval: 10 s

Statistics

# Total Obs	# Usable Obs	# Used Obs	Percent
276	138	138	100

$$P_{i,k}^j = |r_i(t_i) - r^j(t_i - \tau_i^j)| + c \cdot \Delta t_i - c \cdot \Delta t^j + T_i^j + I_{P,i,k}^j + b_{P,i,k} - b_{P,k}^j + m_{P,i,k}^j + \epsilon_{P,i,k}^j$$

$$\Phi_{i,k}^j = |r_i(t_i) - r^j(t_i - \tau_i^j)| + c \cdot \Delta t_i - c \cdot \Delta t^j + T_i^j + I_{\Phi,i,k}^j + b_{\Phi,i,k} - b_{\Phi,k}^j + \lambda_k \cdot N_{i,k}^j + m_{\Phi,i,k}^j + \epsilon_{\Phi,i,k}^j$$

Used Satellites

# Total Satellites:	21
GPS:	G07 G08 G09 G11 G16 G27 G30
GLONASS:	R01 R02 R03 R11 R12 R13 R21 R22
Galileo:	E01 E04 E13 E19 E21 E27

Processing Results

NAD83-2011 at Epoch 2010.0		
Coordinate	Value	σ
X	-1459662.249 m	0.004 m
Y	-5014055.929 m	0.010 m
Z	3653171.480 m	0.009 m
Latitude	35° 09' 19.75296" N	0.004 m
Longitude	106° 13' 51.67700" W	0.004 m
El. Height	2062.558 m	0.012 m

ITRF2014 at Epoch 2020.29		
Coordinate	Value	σ
X	-1459663.146 m	0.004 m
Y	-5014054.588 m	0.010 m
Z	3653171.281 m	0.009 m
Latitude	35° 09' 19.76706" N	0.004 m
Longitude	106° 13' 51.72584" W	0.004 m
El. Height	2061.595 m	0.012 m

Report Information

Trimble RTX Solution ID: 23027015
 Solution Type: Static
 Software Version: 8.5.0.19198
 Creation Date: 04/16/2020

Disclaimer

Trimble Navigation Limited does not guarantee availability, reliability or accuracy of information arising from, or connected to, the use of information.

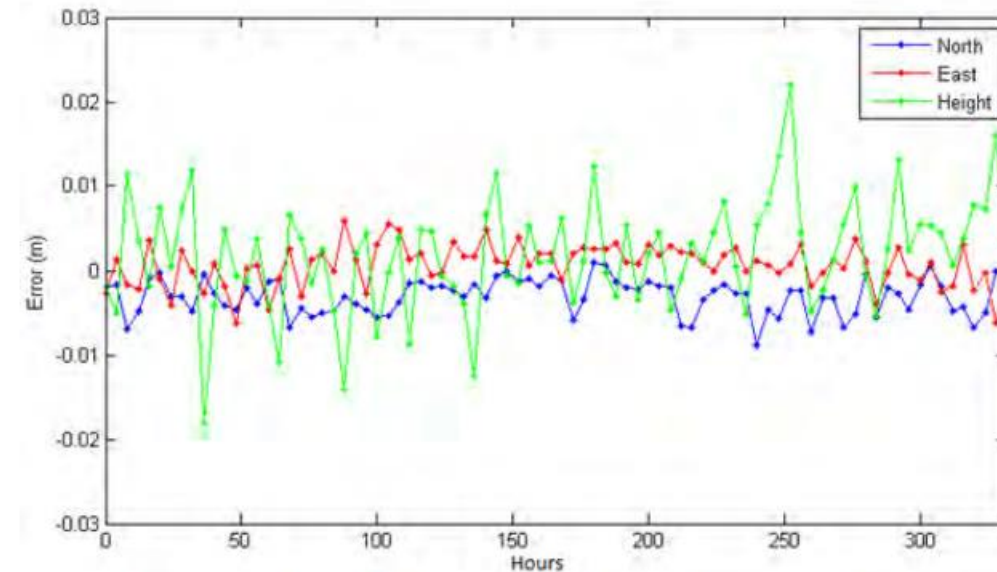


Figure 13 Position errors for 4 hour periods

Trimble RTX – PP White Paper

Introducing Ambiguity Resolution in Web-hosted Global Multi-GNSS Precise Positioning with Trimble RTX-PP

Ken Doucet, Michael Herwig, Adrian Kipka, Philip Kreikenbohm, Herbert Landau, Rodrigo Leandro, Matthias Moessmer, Christian Pagels

Trimble TerraSat GmbH, Germany

ABSTRACT

In the middle of 2011 Trimble introduced the CenterPoint RTX real-time positioning service providing centimeter accurate positions for real-time applications. This service relies on the generation of precise orbit and clock information for GPS and GLONASS satellites in real-time. Support for the first Japanese QZSS satellite was recently added to the system. While existing PPP systems are available via web access today, the RTX-PP is unique with respect to the support of QZSS signals, the ability to resolve carrier phase ambiguities and the associated convergence performance.

The CenterPoint RTX service is providing real-time precise GNSS positioning for specific markets such as Precision Agriculture, Survey and Machine Control. The delivery of corrections for the receivers in the field occurs either via satellite link or internet connection.

This paper introduces the new Trimble RTX Post-Processing (RTX-PP) service which is running in the cloud providing absolute position estimates in the well-defined reference frame ITRF2008 using GPS, GLONASS and QZSS observations. The service is available as a web service as well as through a variety of Trimble office software products.

The achievable horizontal and vertical accuracy level of RTX-PP can be better than one centimeter with one day of measurement data. Since the convergence time of the solution is well below one hour, however, the delivered horizontal positioning accuracy is typically better than 2 centimeters after only one hour.

The paper presents the technology behind RTX-PP and discusses the different applications the service addresses. These include but are not limited to the establishment of precise reference frames with a well-defined datum; especially in areas without sufficient infrastructure,

monitoring of the positions of GNSS reference stations for quality assurance purposes and tectonic motion and monitoring of deformation and subsidence.

Time series of position estimates will be presented to demonstrate the achievable accuracy in a variety of scenarios, including static and kinematic cases.

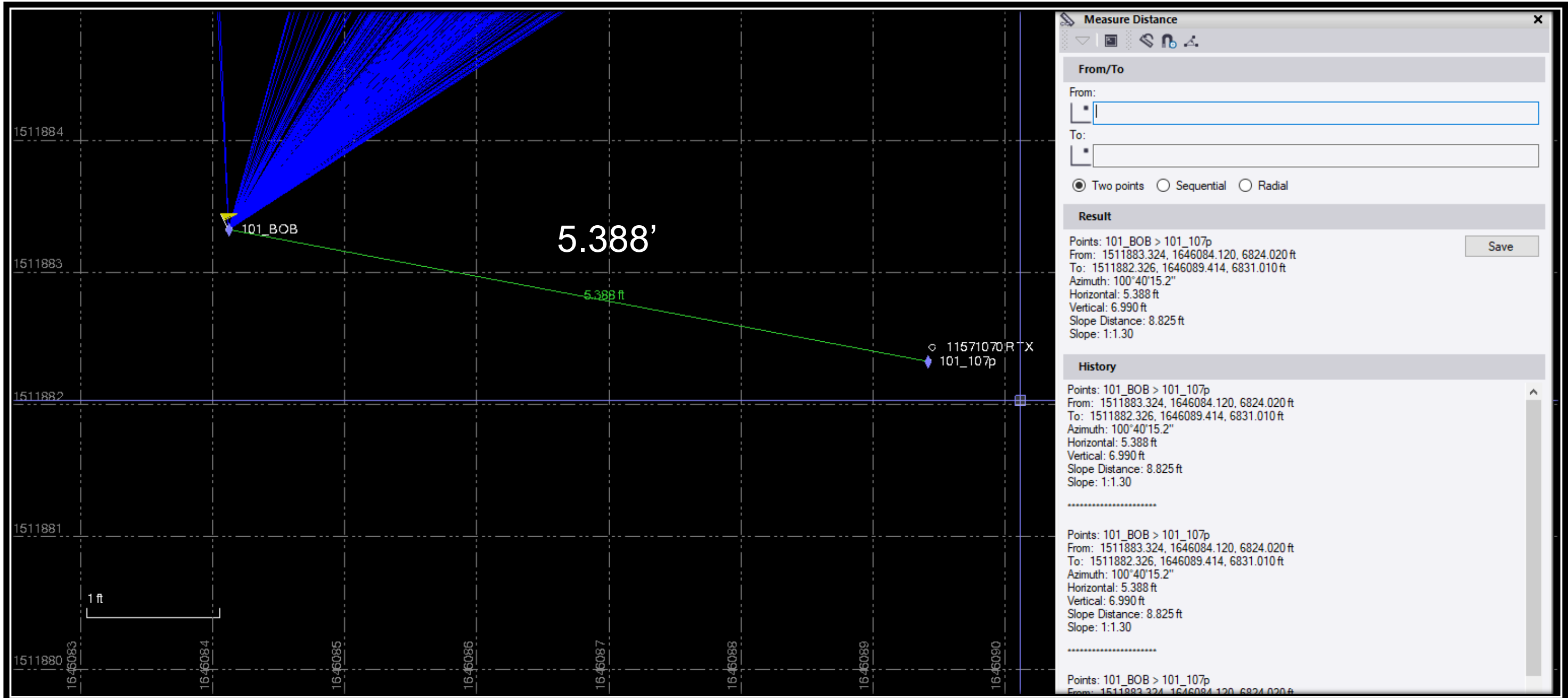
INTRODUCTION

For several years now Precise Point Positioning (PPP) solutions have been available via the Internet for GNSS users. These include the JPL APPS service based on Gipsy technology (Zumberge et al. 1997), the CSRS service of the Natural Resources of Canada (NRCAN9, (Mireault et al. 2008), the University of Brunswick service GAPS (Leandro et al. 2007), and the magicGNSS by GMV, Spain (Piriz et al. 2008). An overview and details on these services can be found in Wanninger et al. (2011).

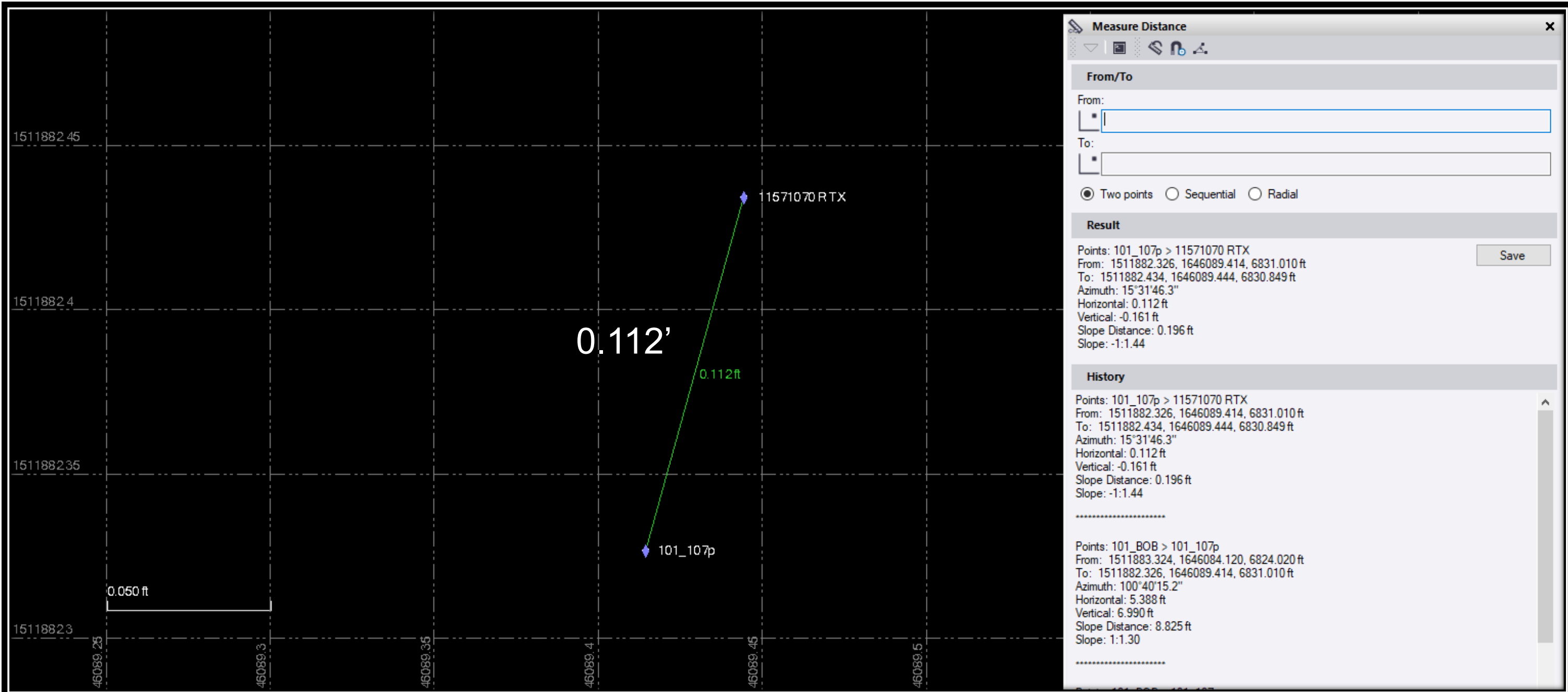
The Trimble RTX-PP service introduces a number of unique features such as the processing of GPS, GLONASS and QZSS satellites and resolution of carrier phase integer ambiguities. It is based on a Trimble owned orbit and clock solution for the satellites which is derived from a global tracking network of more than 100 reference stations equipped with Trimble NetR5, NetR8 and NetR9 receivers. The global distribution of the network is shown in Figure 1.

The reference station receivers stream 1 Hz observation data to processing centers in the US and in Europe. At the processing centers the observations are used by multiple redundant servers to compute precise orbit and clock estimates which are then transmitted to users worldwide. In addition the servers store the parameter estimates in a compressed data format with 1Hz clock updates. This data is used as input for the RTX Post-Processing service.

TRIMBLE BUSINESS CENTER / OPUS INTERFACE



TRIMBLE BUSINESS CENTER / OPUS INTERFACE



TRIMBLE BUSINESS CENTER / OPUS INTERFACE

The screenshot shows the Trimble Business Center / Opus interface. The main window displays a grid with a point labeled '101_BOB' and a vector labeled 'RTK Vector : 101_BOB-17 (V2)'. A 'Merge Points' dialog box is open on the right, showing filter settings and a table of selected points.

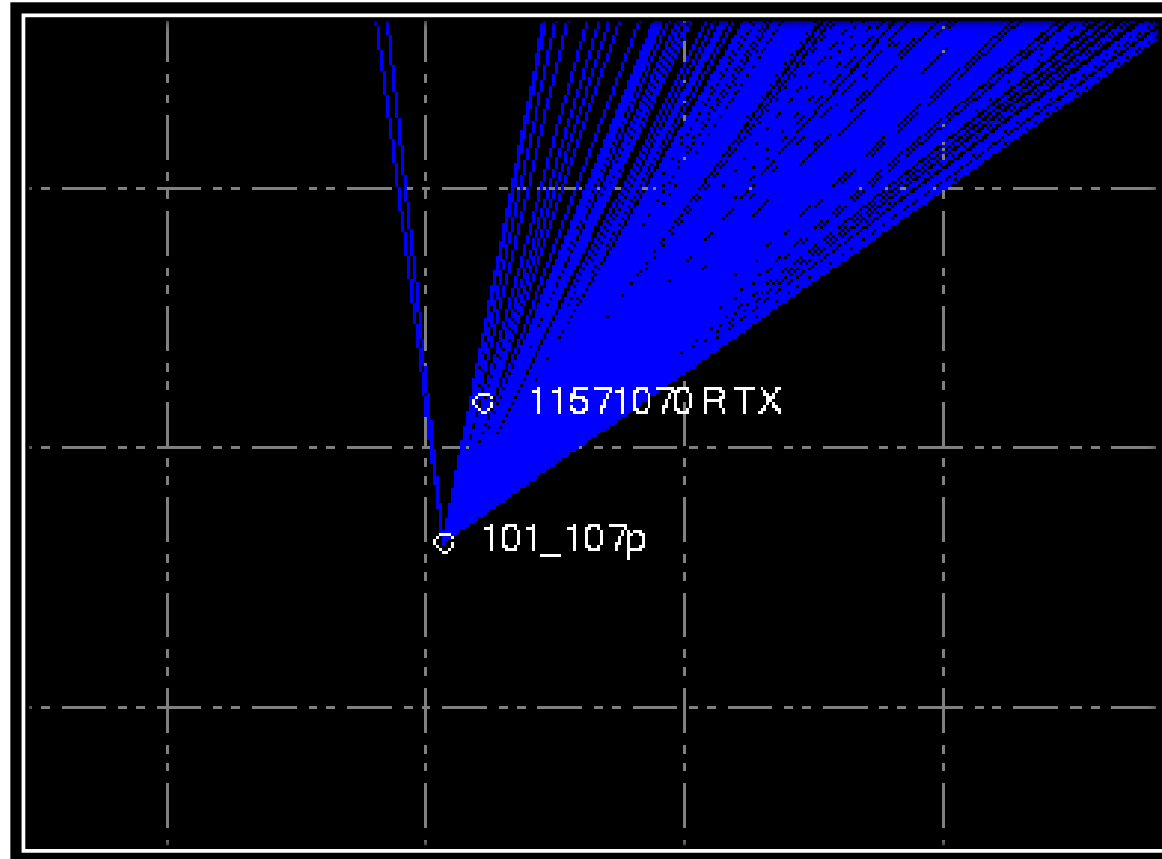
Merge Points Dialog:

- Data:** Selected: 2
- Filter Points by ID:** Identical, Ignored
- Filter Points by Distance:** Within the following distance: 0.003
- Selected Points:**

Point ID	Count
101_107p	2

Horizontal Quali	Vertical Quali	Point ID	Final Po	Include	Distance
		101_107p	<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	0.000 ft
		101_BOB	<input type="radio"/>	<input checked="" type="checkbox"/>	5.388 ft

TRIMBLE BUSINESS CENTER / OPUS INTERFACE



Project Explorer

- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 101_107p
 - Office entered (Local)
 - Global (OPUS WEBINAR...)
 - 101_107p-16 (V1)
 - 101_107p-17 (V2)
 - 101_107p-18 (V3)
 - 101_107p-19 (V4)
 - 101_107p-20 (V5)
 - 101_107p-21 (V6)
 - 101_107p-22 (V7)
 - 101_107p-23 (V8)

Properties

Office entered (Local)
101_107p

Office entered (Local) (1)

Point Information

Point ID: 101_107p

Local Coordinate

Latitude: N35°09'19.75190"

Longitude: W106°13'51.67736"

Height: 6767.070

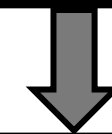
Status: Enabled

Plan View [My Filter]

15118825

11571070 RTX

101_107p



Project Explorer

- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 101_107p
 - Office entered (Local)
 - Global (OPUS WEBINAR...)
 - 101_107p-16 (V1)
 - 101_107p-17 (V2)
 - 101_107p-18 (V3)
 - 101_107p-19 (V4)
 - 101_107p-20 (V5)
 - 101_107p-21 (V6)
 - 101_107p-22 (V7)
 - 101_107p-23 (V8)
 - 101_107p-24 (V9)
 - 101_107p-25 (V10)
 - 101_107p-26 (V11)

Properties

Point
101_107p

Point (1)

Point Information

Point ID: 101_BOB

Selection sets:

Feature code: CP

Description 1:

Description 2:

Layer: Points

Include in surface: Yes

Label Visibility

Show label: By view filter

Show feature code: By view filter

Show elevation: By view filter

Plan View [My Filter]

15118825

11571070 RTX

101_107p

1511882

After "Merge Points" RECOMPUTE!

THE 3-D GLOBAL SPATIAL DATA MODEL

Principles and Applications

SECOND EDITION



EARL F. BURKHOLDER



GSDM - Global Spatial Data Model

by

Earl Burkholder

My Book –
I'm Back at It!!



The Evolution of the
Ellipsoid of Revolution

“A History of the
Measurement of the Size
and Shape of the Earth”

Robert L. Green

A high-angle view of Earth from space, showing a vast expanse of blue oceans and white clouds. In the upper right corner, a portion of a satellite or space station is visible, featuring gold-colored thermal insulation and various instruments. The text is centered over the image.

THANK YOU

**FOR YOUR TIME
AND
ATTENTION!!**

**Bob Green
Bob@FrontierPrecision.com
303-728-4984**