

Reference Frame in Practice

Manila, Philippines 21-22 June 2013



Trimble's Role in Geodetic Infrastructure

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Worldwide DGPS/DGNSS Sales Manager

Trimble Infrastructure Division

22nd June 2013

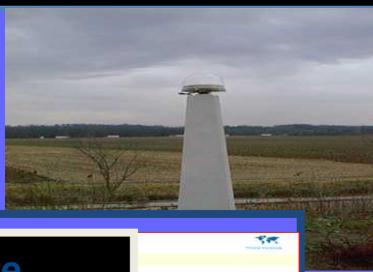
Sponsors :



Trimble's Role in Geodetic Infrastructure

- Provide Future Proof CORS receiver
- Provide Modern & Proven Network CORS app.
- Provide Turnkey Solution
- Provide Innovative Positioning

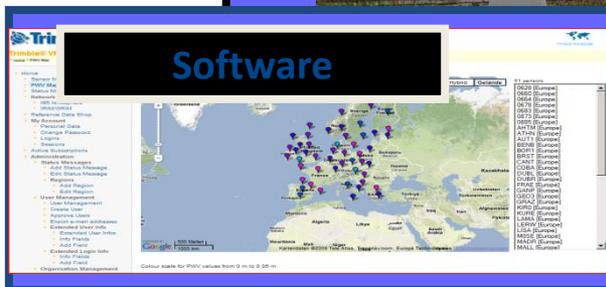
Monumentation



Hardware



Software



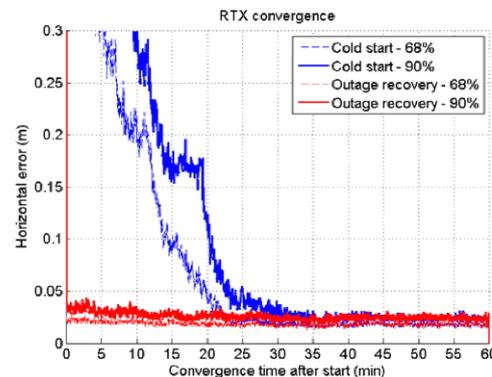
Communications

People



The Multi-Role GNSS Infrastructure Geodetic Receiver

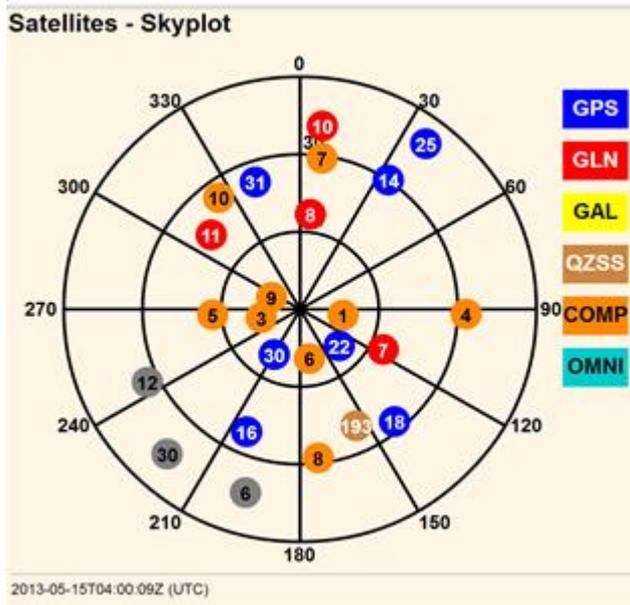
- Continuously Operating Reference Station (CORS)
- Mobile Base
- Campaign Receiver
- Scientific Reference Station
- Position Anywhere, Anytime (RTX)



Trimble NetR9 GNSS Reference Receiver

Overview

- Enhanced Trimble® R-Track™ technology with Dual Maxwell 6 chipsets
 - 440 channels for unmatched tracking in the industry
- Currently tracks GPS, GLONASS, Galileo, Beidou, QZSS, Onmistar,
 - Chipsets have capacity to handle future signal structures



Receiver Status - Position

Receiver Status Activity Position Vector Google Map Google Earth Identity Receiver Options Satellites Data Logging Receiver Configuration I/O Configuration Bluetooth OmniSTAR Network Configuration Security Firmware Programmatic Interface Help	Position: Lat: 3° 9'29.63187"N Lon: 101° 42' 43.68063" E Hgt: 453.874 [m] Type: RTX Datum: ITRF2008 (current)	Satellites Used:9 GPS(6): 14, 16, 18, 22, 31, 32 GLONASS(2): 7, 11 QZSS(1): 193	Velocity: East: -0.04 [m/s] North: -0.02 [m/s] Up: -0.02 [m/s]
Position Solution Detail: Position Dimension: 3D Position Type: Phase Diff Motion Info: Static Augmentation: GPS+GLN+QZSS RTK Solution: Normal RTK Init: RTX RTK Mode: Low Latency RTK Network Mode: Global Age of Corrections: 12.2 [Sec.] SBAS PRN: N/A Height Mode: Normal	Satellites Tracked:21 GPS (7): 14, 16, 18, 22, 30, 31, 32 GLONASS (3): 7, 8, 11 COMPASS (9): 1, 3, 4, 5, 6, 7, 8, 9, 10 QZSS (1): 193 OmniSTAR (1): RTXSA	Error Estimates(1σ): East: 0.012 [m] North: 0.009 [m] Up: 0.034 [m] Semi Major Axis: 0.013 [m] Semi Minor Axis: 0.008 [m] Orientation: 65.259°	Dilutions of Precision: PDOP : 2.5 HDOP : 1.1 VDOP : 2.2 TDOP : 2.3
	Receiver Clock: GPS Week: 1740 GPS Seconds: 273808 Offset: 0.00000 [msec] Drift: -0.00002 [ppm]	Multi-System Clock Offsets: Master Clock System: GPS GLONASS Offset: 404.8 [ns] GLONASS Drift: 0.001 [ns/s]	

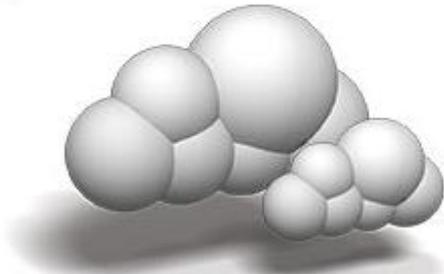
2013-05-15T04:03:12Z (UTC)

FEATURE	NetR9 TI-3	NetR9 TI-2	NetR9 TI-1
Channels	440	440	440
Data tracking/storage rate	1 Hz	20 Hz	50 Hz
On-board storage size	0 GB	4 GB	8 GB
GPS L1/L2 signal processing	✓	✓	✓
GPS L2C signal processing	×	✓	✓
GPS L5 signal processing	×	✓	✓
GLONASS signal processing	×	✓	✓
Galileo signal processing	×	×	✓
Compass signal processing	×	×	✓
QZSS signal processing	×	×	✓
CMR/CMR+ Input	×	×	✓
CMR/CMR+ Output	×	✓	✓
CMRx Input	×	✓	✓
CMRx Output	×	✓	✓
RTCM Input	×	✓	✓
RTCM Output	×	✓	✓
Advanced RTCM Output	×	✓	✓
Event Marker	×	✓	✓
NMEA	×	✓	✓
Bluetooth	×	✓	✓
External USB Support	×	✓	✓
RTK	×	✓	✓
Integrated USB support	×	✓	✓
Programmatic Interface	×	×	✓
Position Monitoring	✓	✓	✓
RTX Engine	X	X	X

How Trimble Can Assist In Developing Geodetic Infrastructure In The Region

- Provide Turnkey solution; Design, Built, & Operate solution.
- Cloud computing platform, and IT & Comm. consulting.

 Windows Azure™



Best Practics in GNSS CORS Implementation

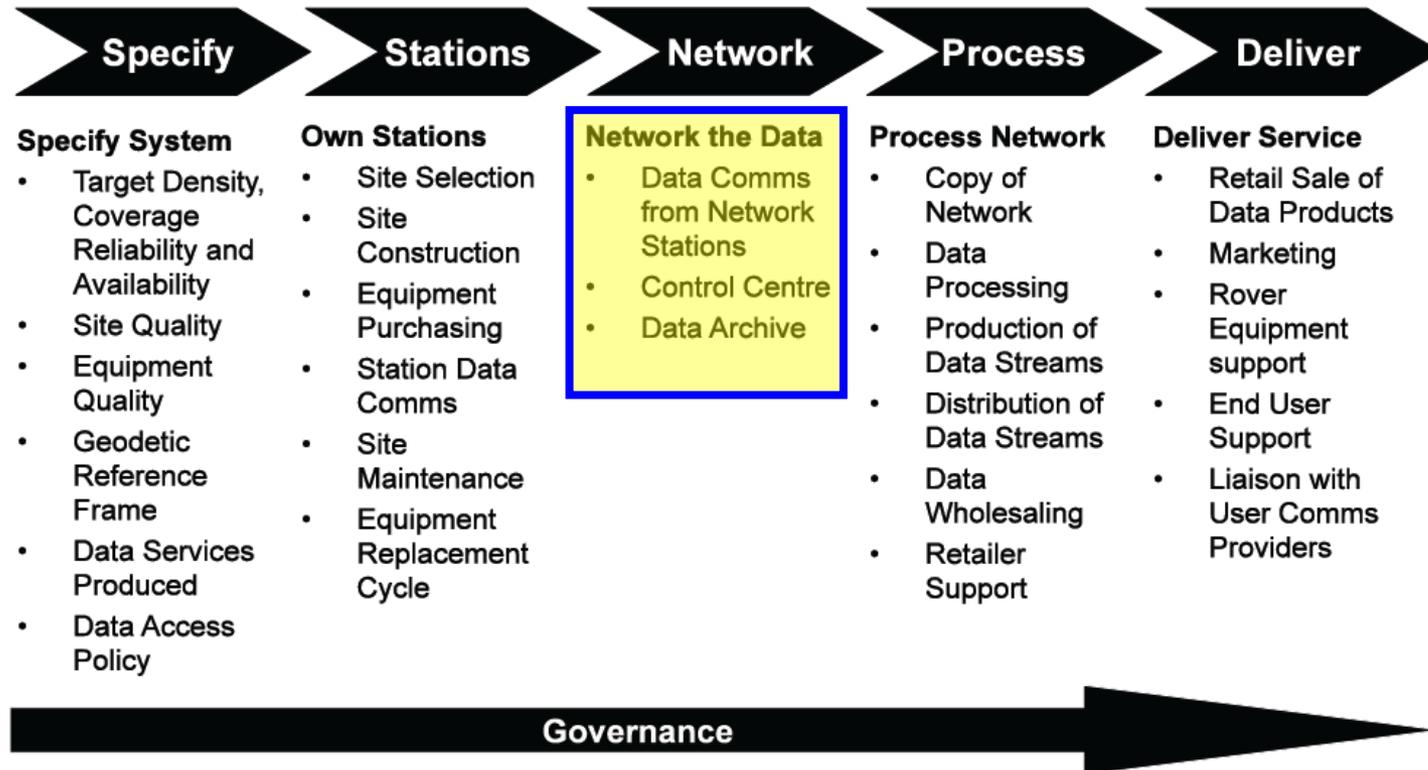
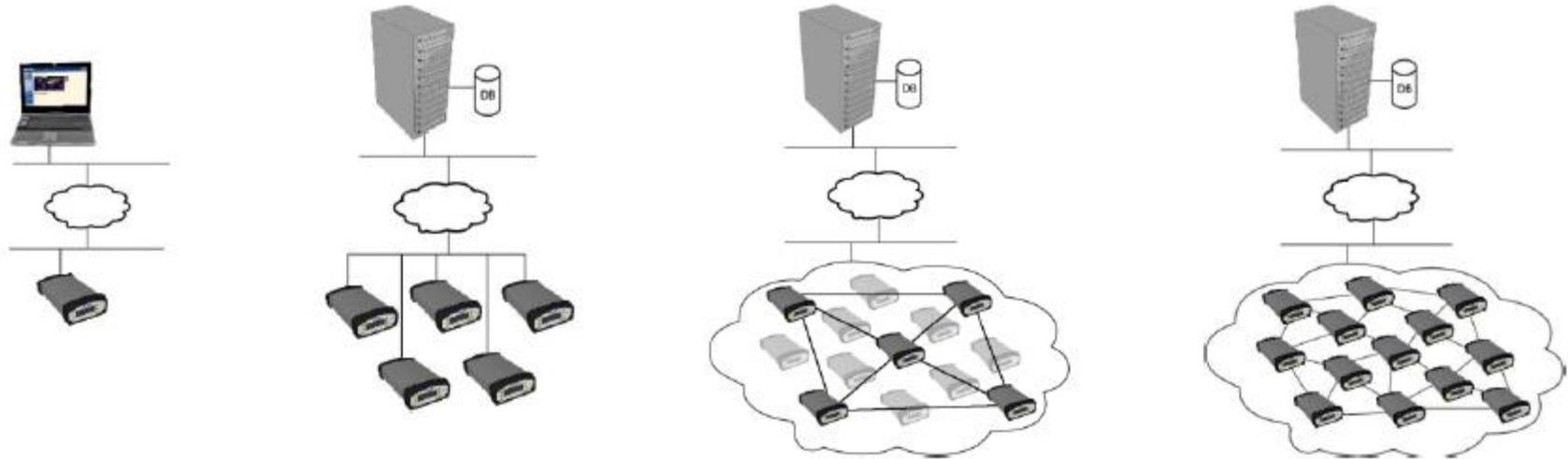


Figure 1: A Model for Describing Organisational Roles in Precise Positioning Services (Source: Higgins (2008))

Real Time GNSS Network - Scalable Approach



Single BASE/CORS
Trimble NetR9

BASE/CORS Array
Trimble Dynamic Control App

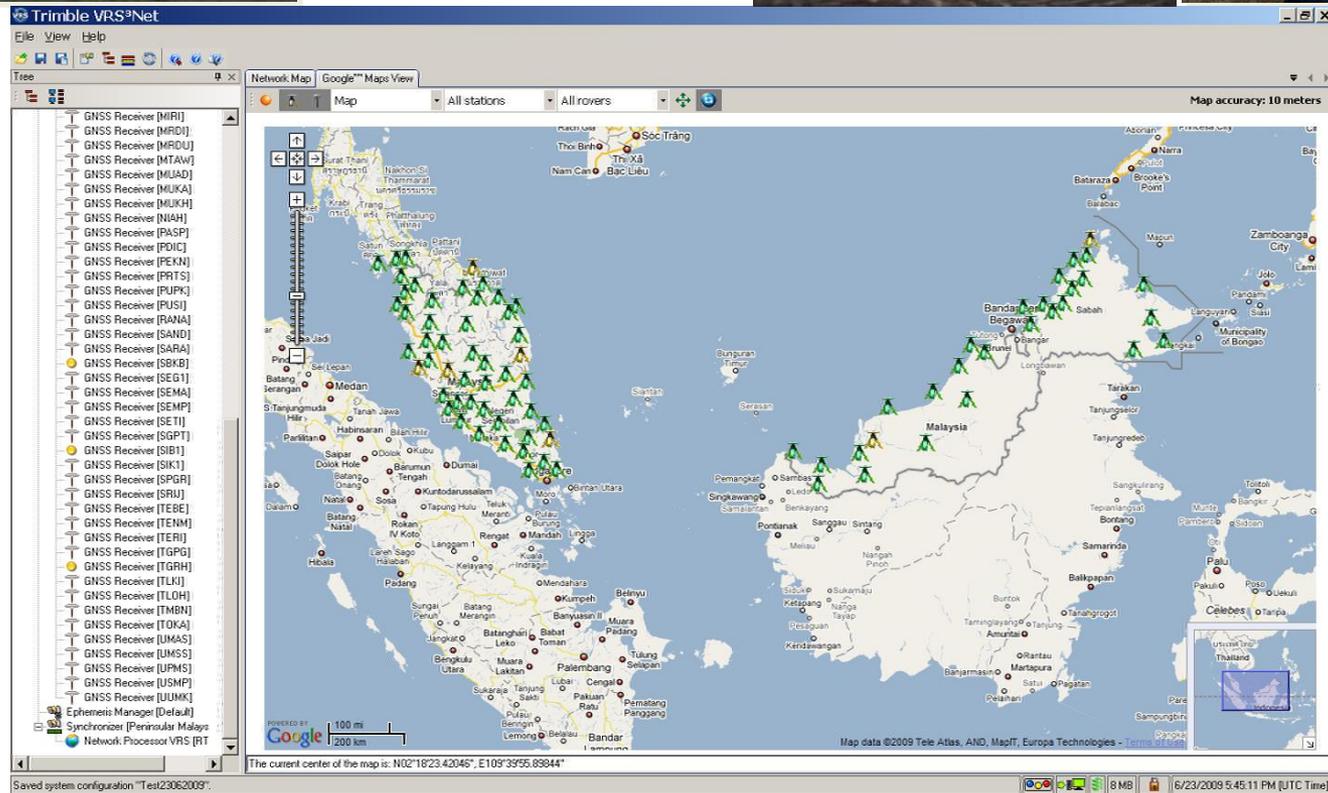
SparseVRS Network
Trimble SparseVRS

VRS Network
Trimble VRS³Net App

TIC	TED	TSM	TDC	sVRS	VRS	TIM	
ATMO							
TRI	RTX	RTX-PP	TNC	ISCOPE	TAC	TDS	
TTG							

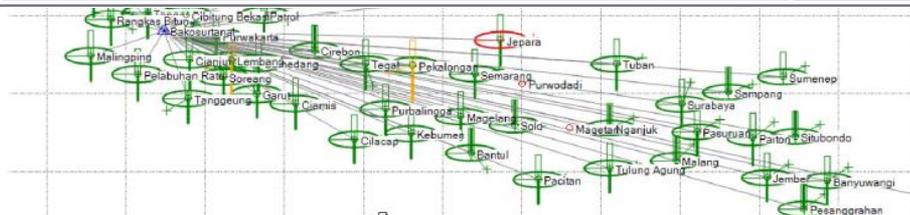
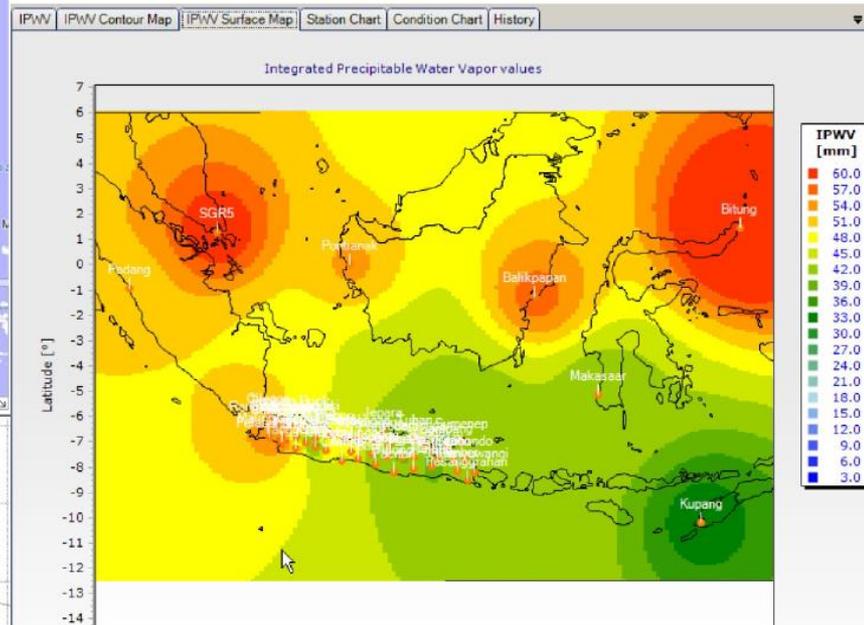
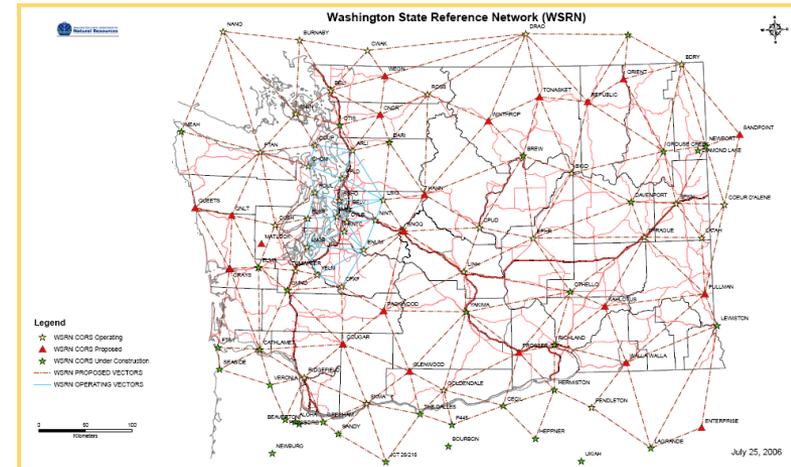
Software Platform

Foundation for Geodetic Framework



Multiple use of GNSS Networks

- GNSS network as reference frame
- Positioning with cm-accuracy
- Monitoring
- Meteorology



Trimble VRS — Cadastral, engineering, etc..

GPS, GLO, QZSS, Beidou



1 CONNECT

Just power up your receiver and connect to the system.

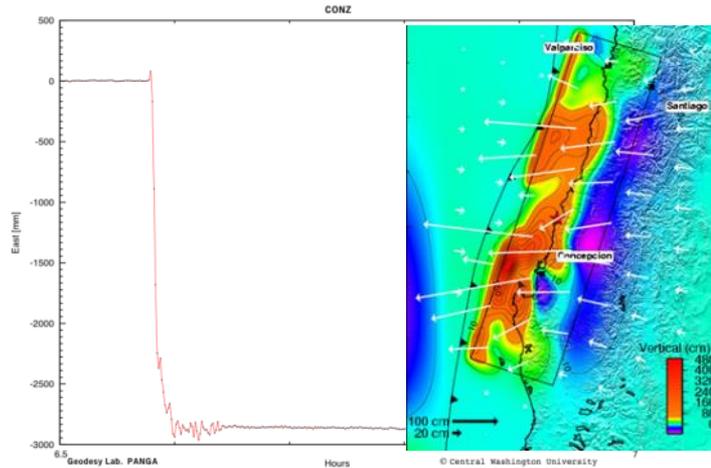
2 CORRECT

Trimble VRS Now delivers centimetre-accurate corrections tailored for your geographic location.

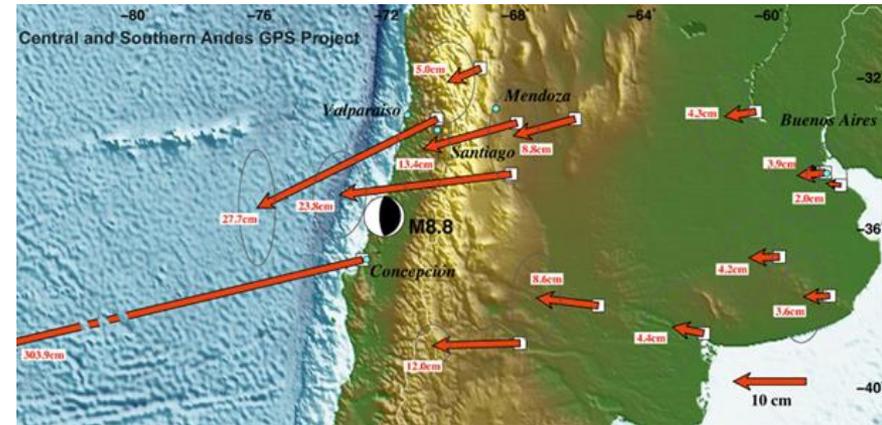
3 MEASURE

Complete your project without the delay of a field base station setup.

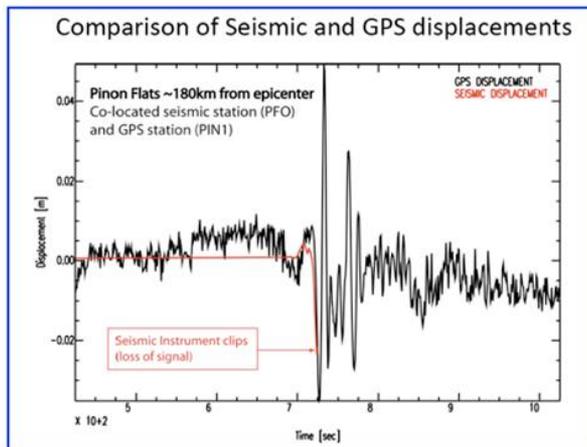
GNSS – Better Seismic Monitoring Earthquakes



Source - Unavco
Example of GNSS Derived Displacement - Chilean Quake

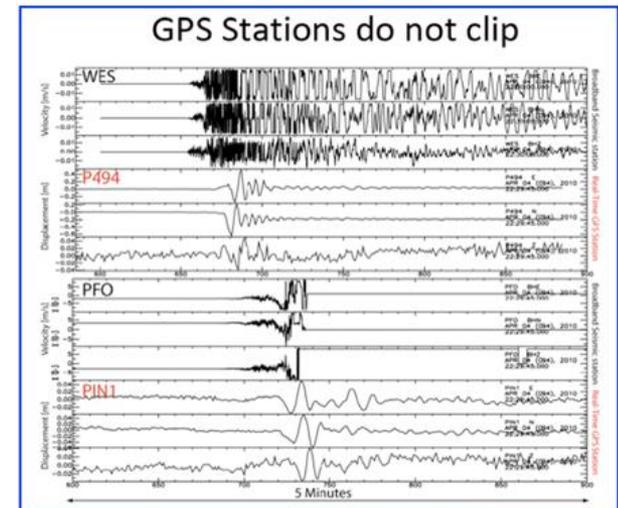


Source - Unavco



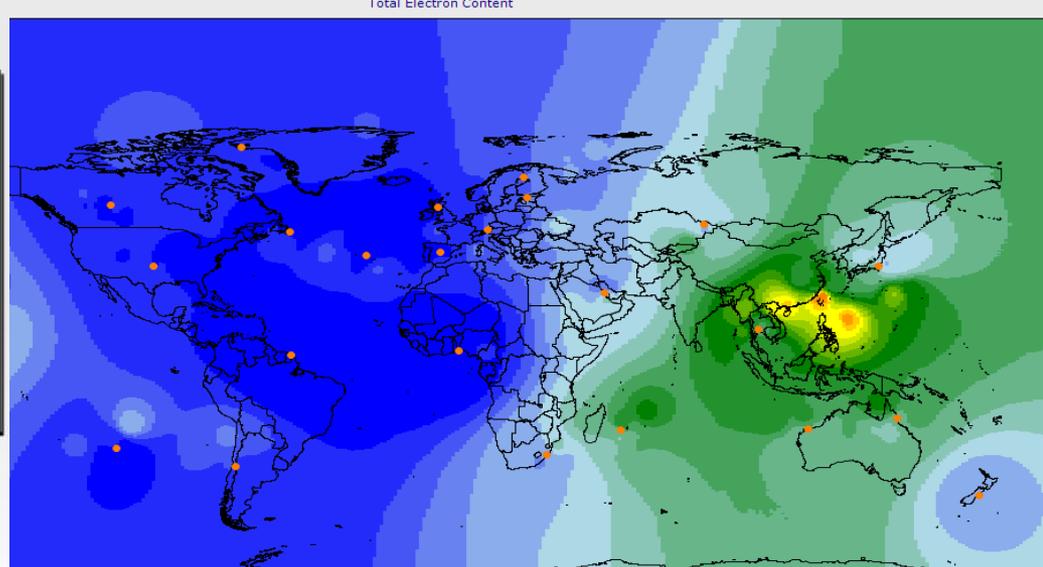
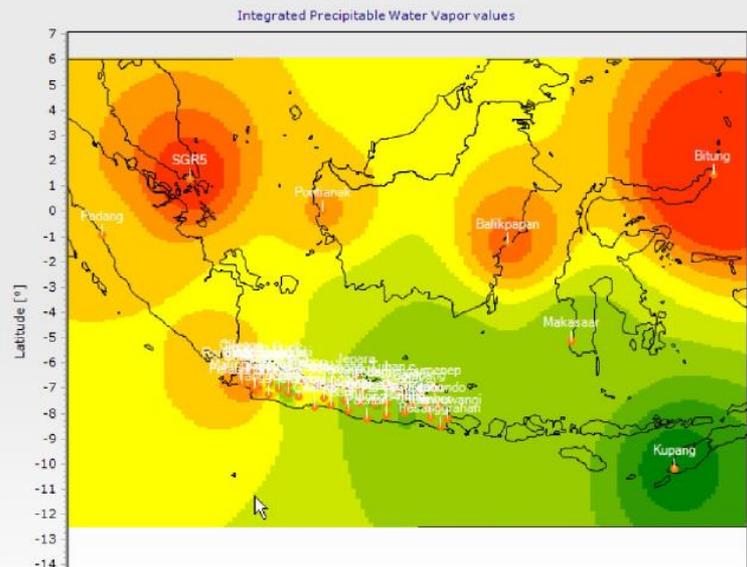
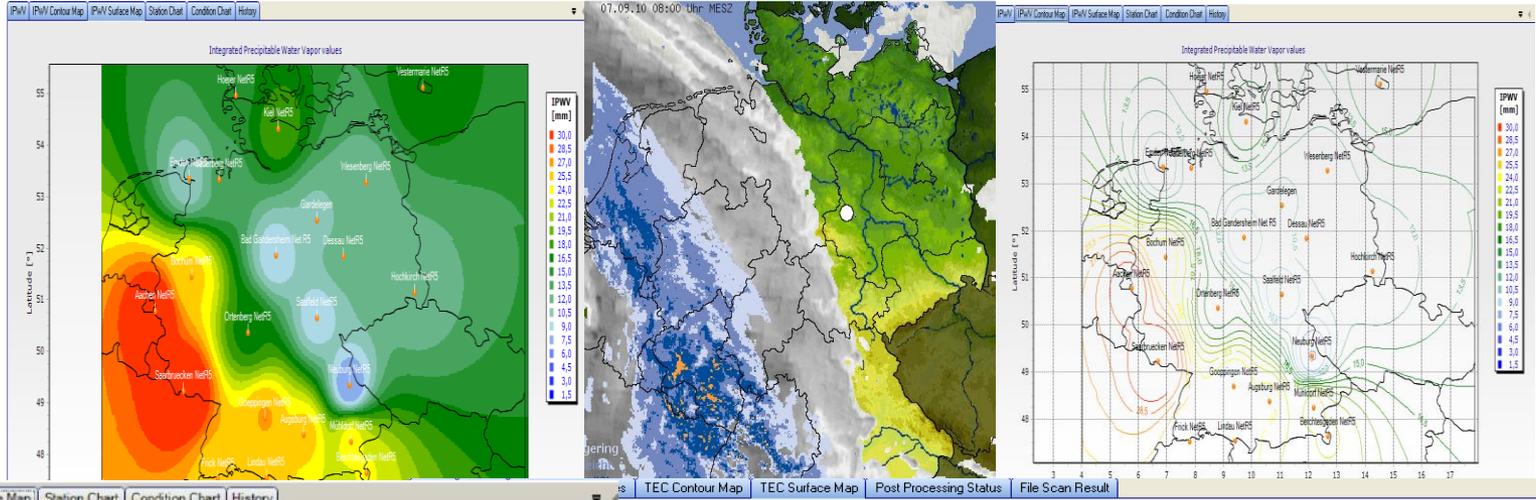
Source - Unavco

Example Seismic System Drop-Out and Clipping



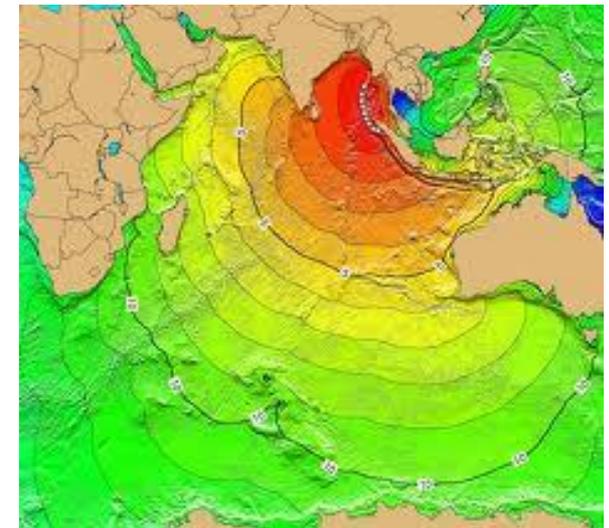
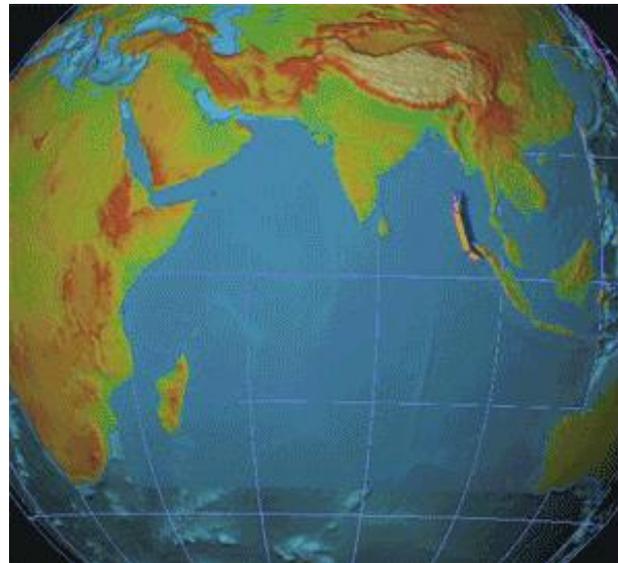
Source - Unavco

GNSS - Water Vapor/TEC/Iono



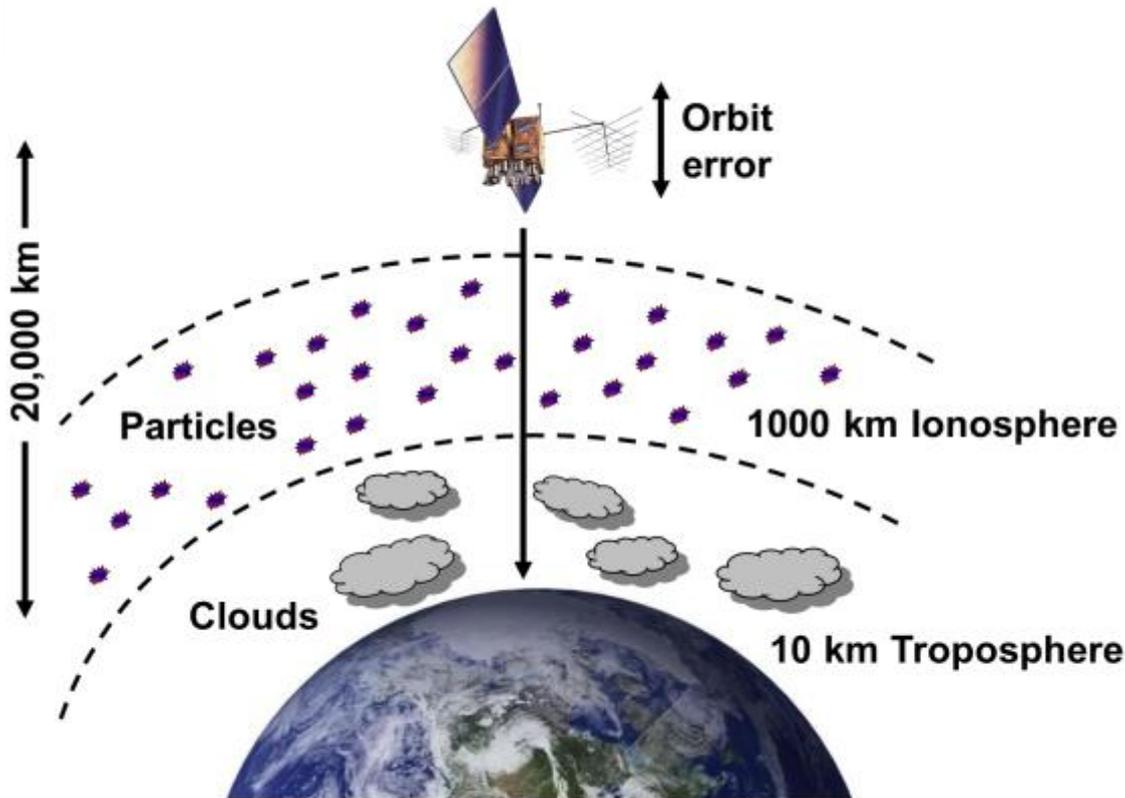
Trimble's Role in Geodetic Infrastructure

- *What technical advice or applications Trimble can supply to users to manage data in a modern and ever changing geospatial environment, especially with respect numerous geodetic datums / reference systems?*



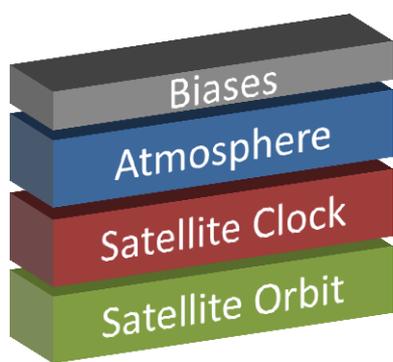
Trimble RTX Technology

(global)

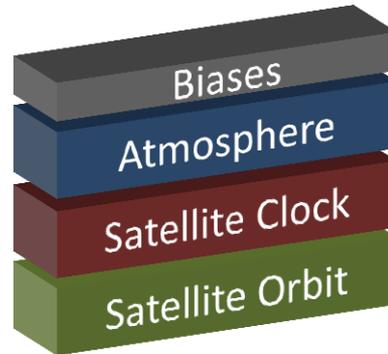


- Absolute positioning
- ITRF2008
- Modeling errors instead of mitigating them by differencing
 - Satellite orbit
 - Satellite clock
 - Atmospheric effects
- **GPS&GLONASS&QZSS**

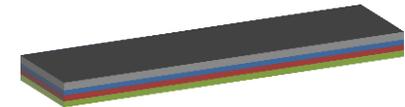
CenterPoint RTX basics



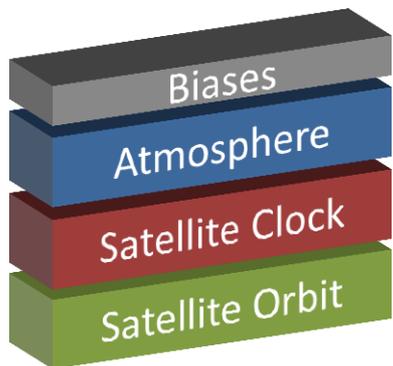
GNSS errors for the rover



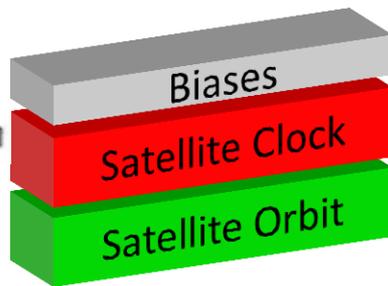
GNSS errors for the reference station / VRS



Residual errors in differential GNSS



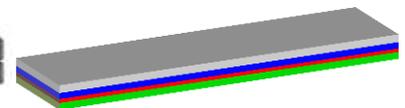
GNSS errors for the rover



GNSS errors modeled in RTX stream



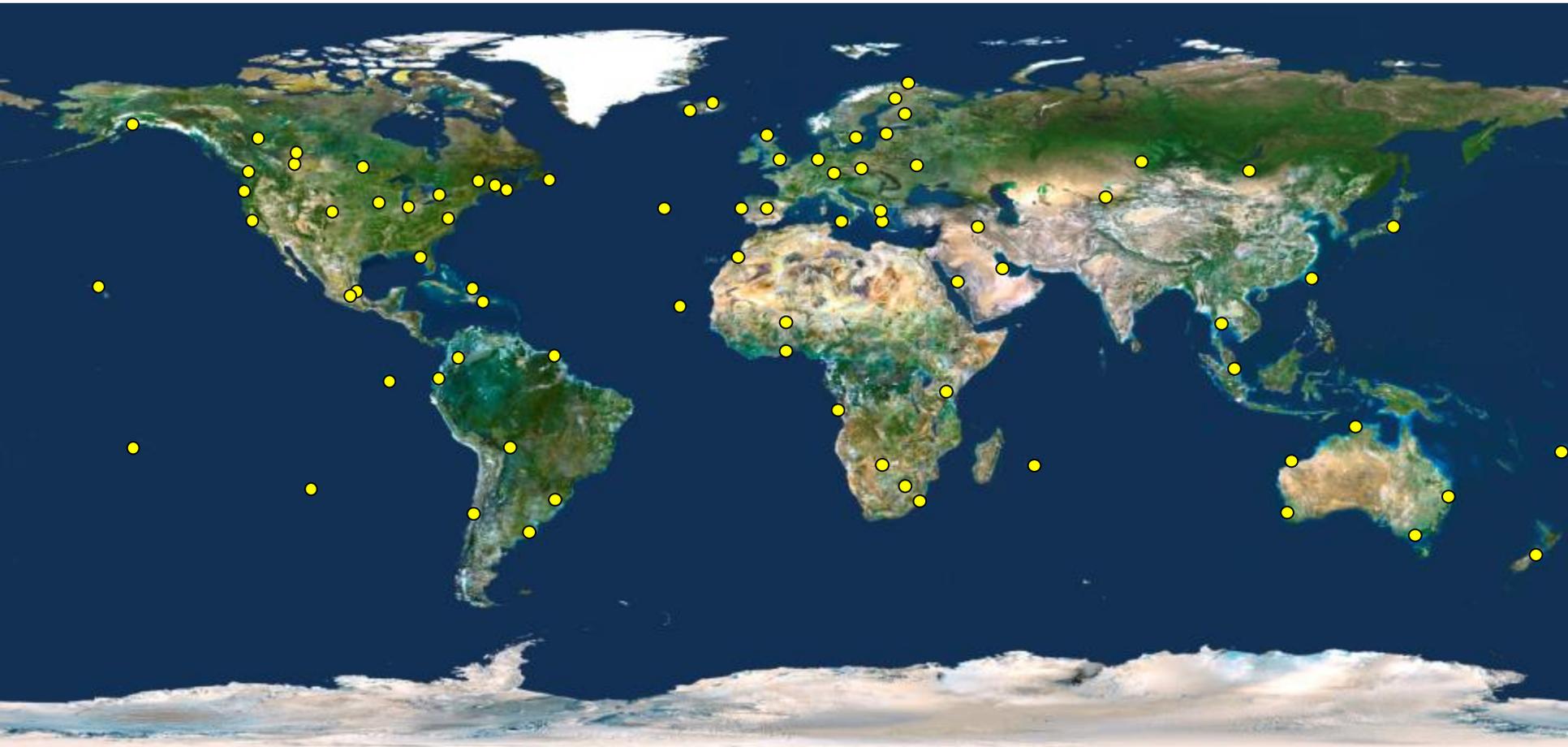
GNSS algorithms used in RTX



Residual errors in Trimble RTX

Global Tracking Network

- Tracking network
 - >100 stations in 53 countries
 - Trimble NetR5/NetR9
- Control centers
 - Munich, Germany
 - Ashburn, USA



● Tracking Stations
(~100)

Trimble CenterPoint RTX™ Service



www.trimblertx.com

Satellite & Internet coverage worldwide



CenterPoint RTX Post Processing

Home

Post Processing

Support

Contact Us

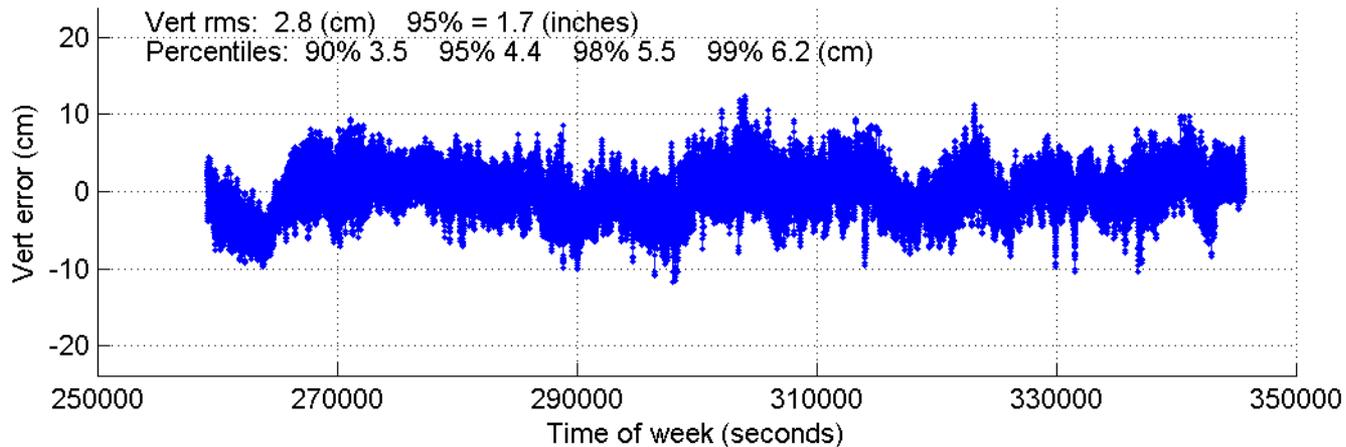
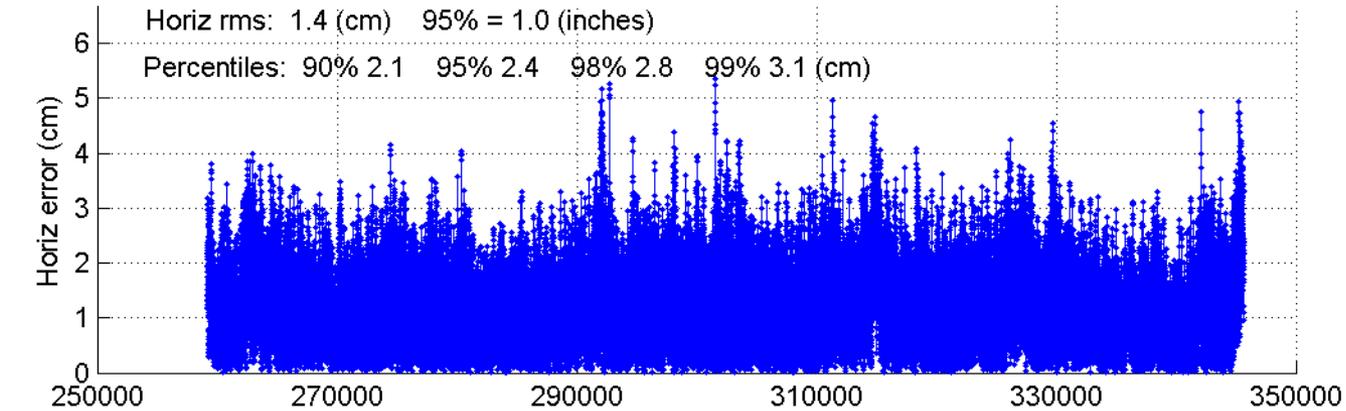
WELCOME TO THE TRIMBLE CENTERPOINT RTX POST PROCESSING SERVICE

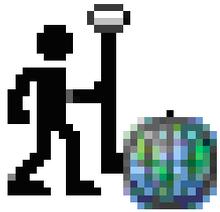


JAVAD TRE_G3TH DELTA	216 channels GPS L1/L2/L2C/L5, GLO L1/L2, GAL E1/E5A
JPS LEGACY	GPS/GLONASS dual- or single-frequency receiver, requires external antenna
JPS ODYSSEY	GPS/GLONASS dual- or single-frequency receiver, with internal (Legant) flat groundplane antenna
JPS REGENCY	GPS/GLONASS dual- or single-frequency receiver, with internal (Regant) choking antenna
LEICA GR10	120 channel GPS L1/L2/L5, GLONASS, Galileo, Compass receiver
LEICA GRX1200+GNSS	120 channel GPS L1/L2/L5, GLONASS, Galileo, Compass receiver
LEICA GRX1200GGPRO	14 GPS, 12 GLONASS L1/L2, CORS receiver (RTK out standard)
LEICA GRX1200PRO	12 channel L1/L2 receiver (RTK out standard)
RNG FASA+	L1/L2+L2C/L5 GLONASS L1/L2 GALILEO Maxwell-6 ASIC, eth + SBAS, 440 channel
TPS E_GGD	Same as JPS E_GGD: "Legacy E" 160mm Eurocard-based GPS/GLONASS dual frequency receiver
TPS GB-1000	Dual-frequency GPS/GLONASS
TPS HIPER_GD	P/N 01-830401-01 Integrated antenna+receiver
TPS NETG3	GPS/GLONASS/Galileo 72 channel receiver
TPS NET-G3A	GPS/GLONASS/Galileo 144 channel receiver - Topcon E2G3 GNSS board

Trimble RTX Positioning Results

Real-time Results - 24 hours, 2D RMS: 1.4 cm





RTX - Real Time Engine



Trimble Pivot Platform

File View Help

Tree

- Trimble Pivot Platform [Default]
 - Device Manager [Germany]
 - Ephemeris Download [Default]
 - Ephemeris Manager [Test]
 - Ionosphere Activity [Default]
 - Synchronizer [All]
 - RTX Engine [RTX3 Moderate]
 - Integrity Monitor [Moderate]
 - RTX Engine [RTX3 Static]
 - Integrity Monitor [Static]
 - RTX Engine [RTX3 Sudden]
 - Integrity Monitor [Sudden]
 - RTX Engine [RTX3]
 - Integrity Monitor [Unfiltered]

Processing Status | Filtered Results | Chart

Last processing time: 22/10/2012 06:19:17 [GPS Time]; 7 stations; 7 stations are being processed;

	Station Code	Status	Orbit	# Sat	Δ North [m]	Δ East [m]	Δ Height [m]	Δ 3D [m]
●	0304	Position OK	Realtime	14	0.007	-0.013	-0.017	0.023
●	0315	Position OK	Realtime	14	0.014	-0.005	-0.011	0.019
●	BGOK	Position OK	Realtime	15	-0.001	-0.013	0.034	0.036
●	0313	Position OK	Realtime	14	0.014	-0.015	-0.006	0.021
●	LAUN	Position OK	Realtime	16	0.000	0.011	-0.003	0.012
●	Sing	Position OK	Realtime	17	-0.006	-0.001	-0.014	0.015
●	HONO	Position OK	Realtime	17	-0.003	-0.007	-0.037	0.038

Loading of system configuration "Default" finished.

Login: admin 3125 MB 22/10/2012 08:19:01 [Local Time]

Cancel

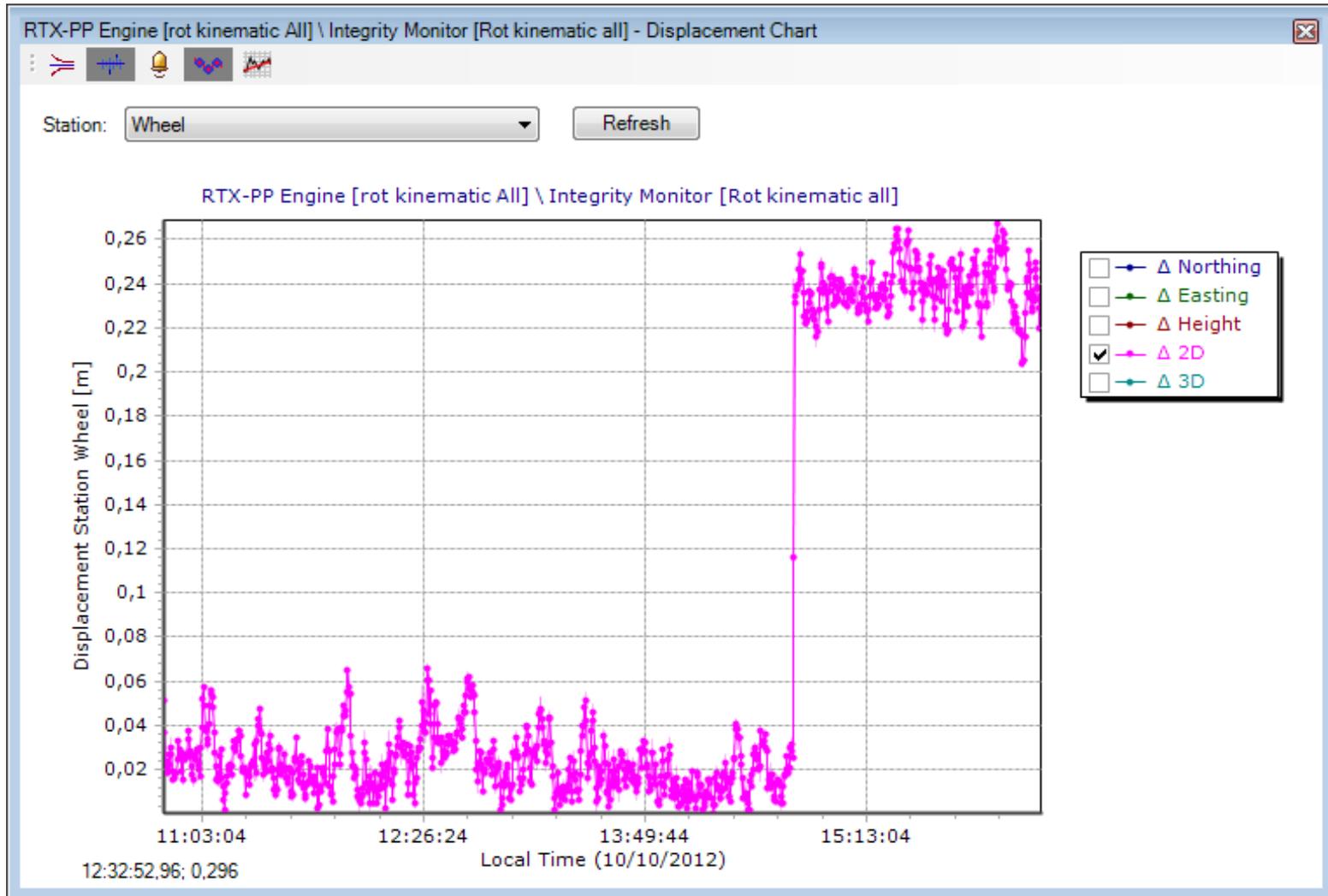


Motion detection



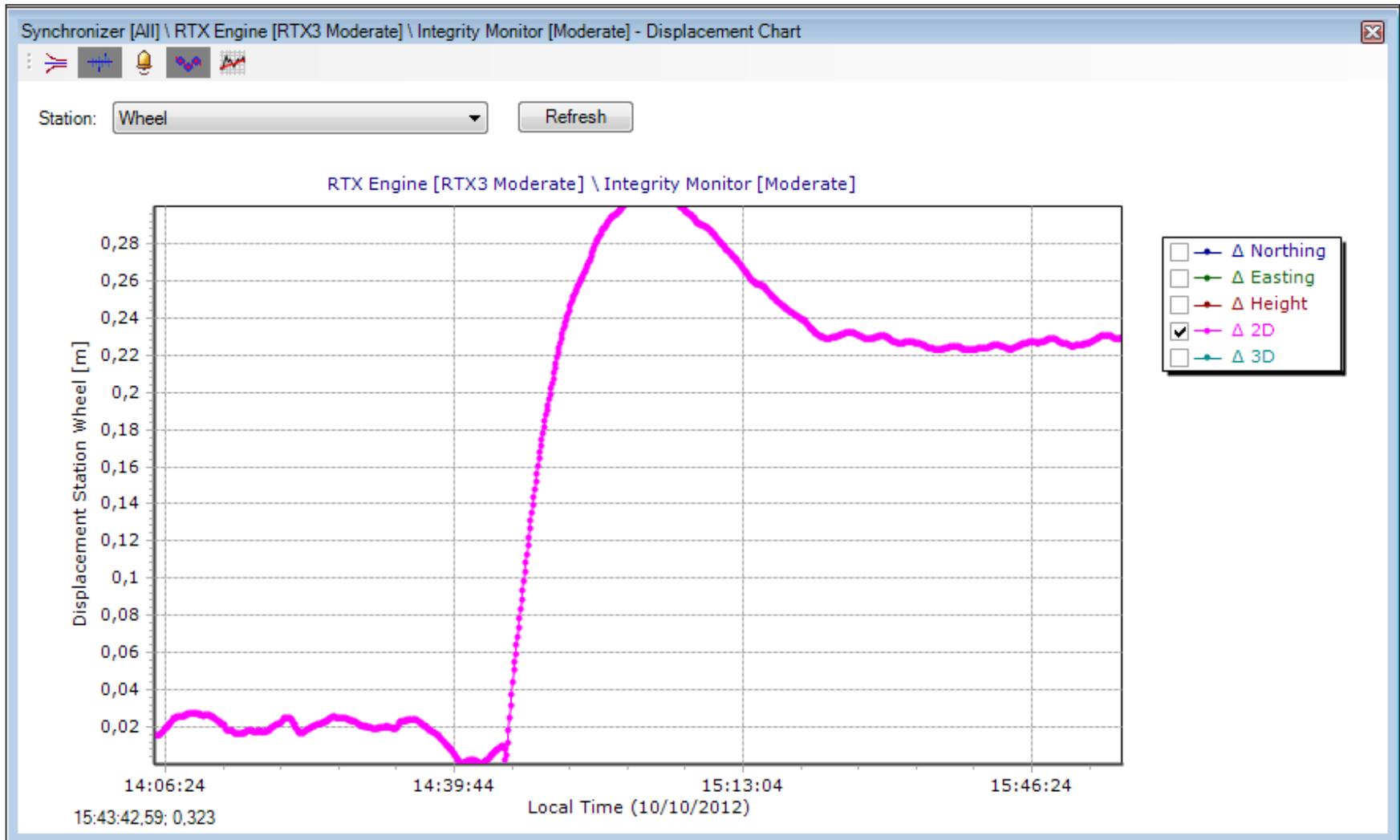


Motion detection

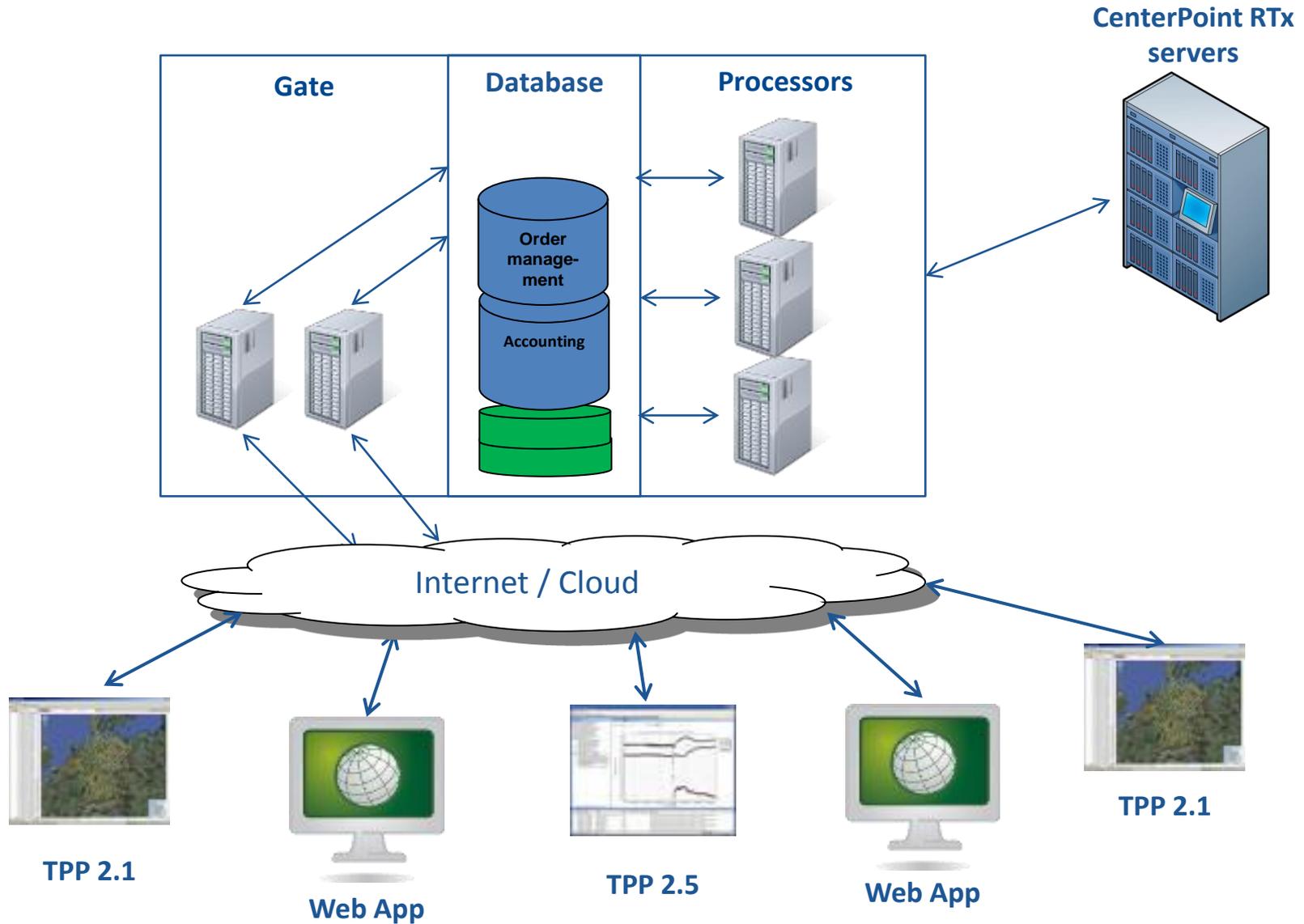




Motion detection



RTX-PP service



RTX-PP Engine

60 minute expected static accuracy (1σ)

Horizontal 10 mm Vertical 25 mm

24 hour expected static accuracy (1σ)

Horizontal 6 mm Vertical 8 mm

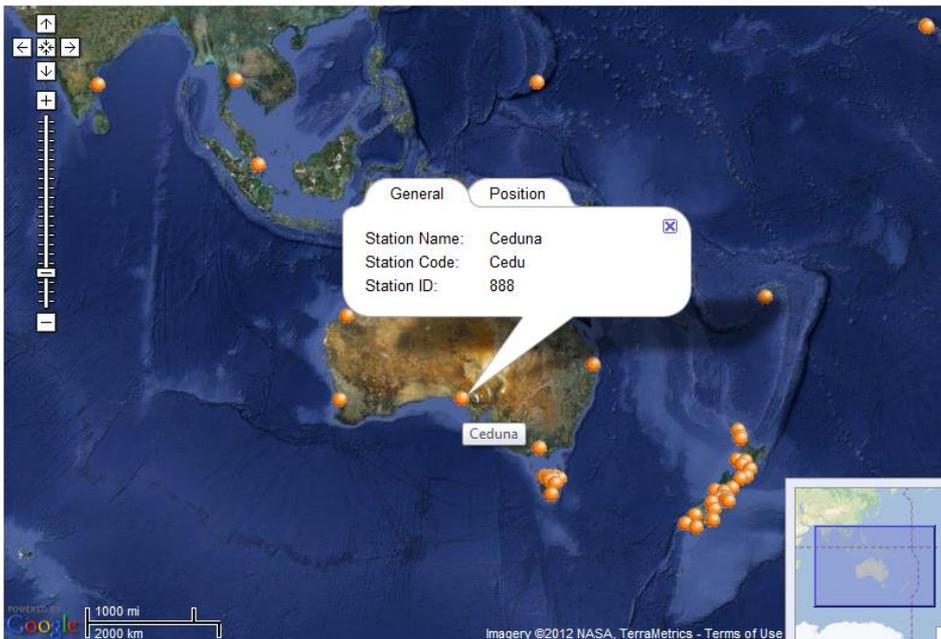


Tectonic Plate Monitoring

Station: Ceduna

Reference: ITRF 2005
(Year 2000)

Observations:
01.01.2012 – 25.10.2012



Station Data (1)	
Station name	Ceduna
Station code	CEDU
Last modification time [UTC Time]	10.09.2012 13:27:07
Position	
Tectonic plate	None
X	-3753472.3680
Y	3912741.0080
Z	-3347960.7180
Velocity X [m/year]	-0.041700
Velocity Y [m/year]	0.000700
Velocity Z [m/year]	0.051100
Reference time	01.01.2000 00:00
Observer	
Agency	Geoscience Australia
Observer	Jens Boehme
Antenna Information	
Antenna calibration	Type calibrated
Manufacturer	ROGUE
Name	AOAD/M_T NONE
Serial number	194_AUST
Antenna height [m]	0.006
Receiver Information	
Manufacturer	TRIMBLE
Name	TRIMBLE NETR8

Tectonic Plate Monitoring

Known position / velocity

IGS

Position (m)

x: -3753472.3680

y: 3912741.0080

z: -3347960.7180

Velocity (m/year)

x: -0.0417

y: 0.0007

z: 0.0511

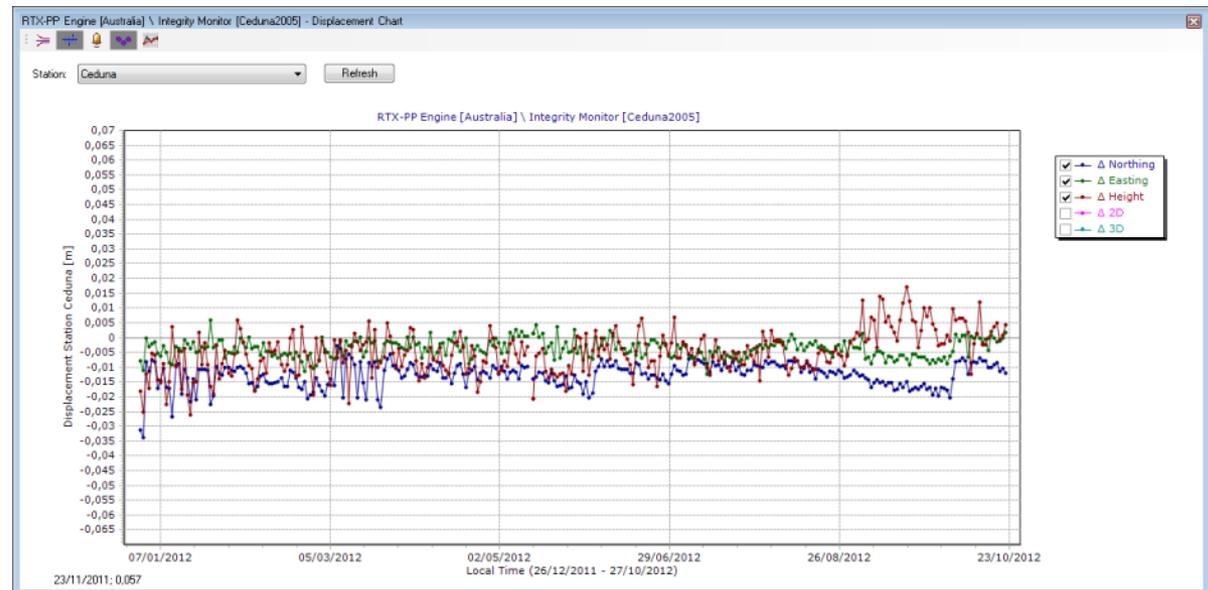
Pivot RTX-PP

Position (m)

x: -3753472.3578

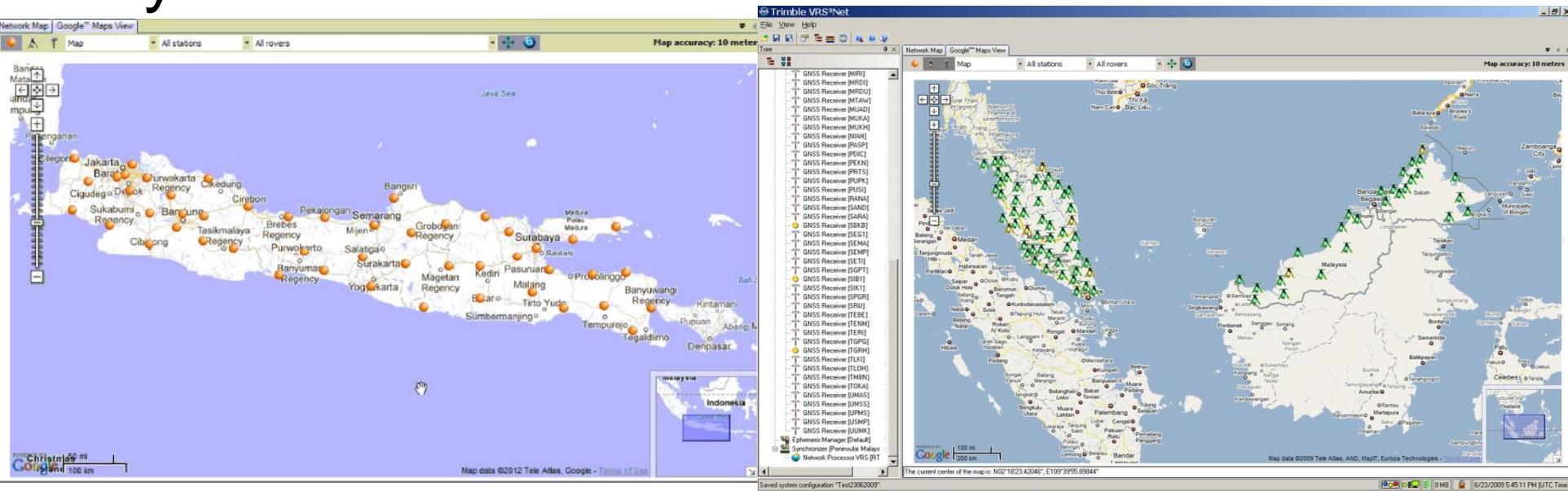
y: 3912741.0027

z: -3347960.7261

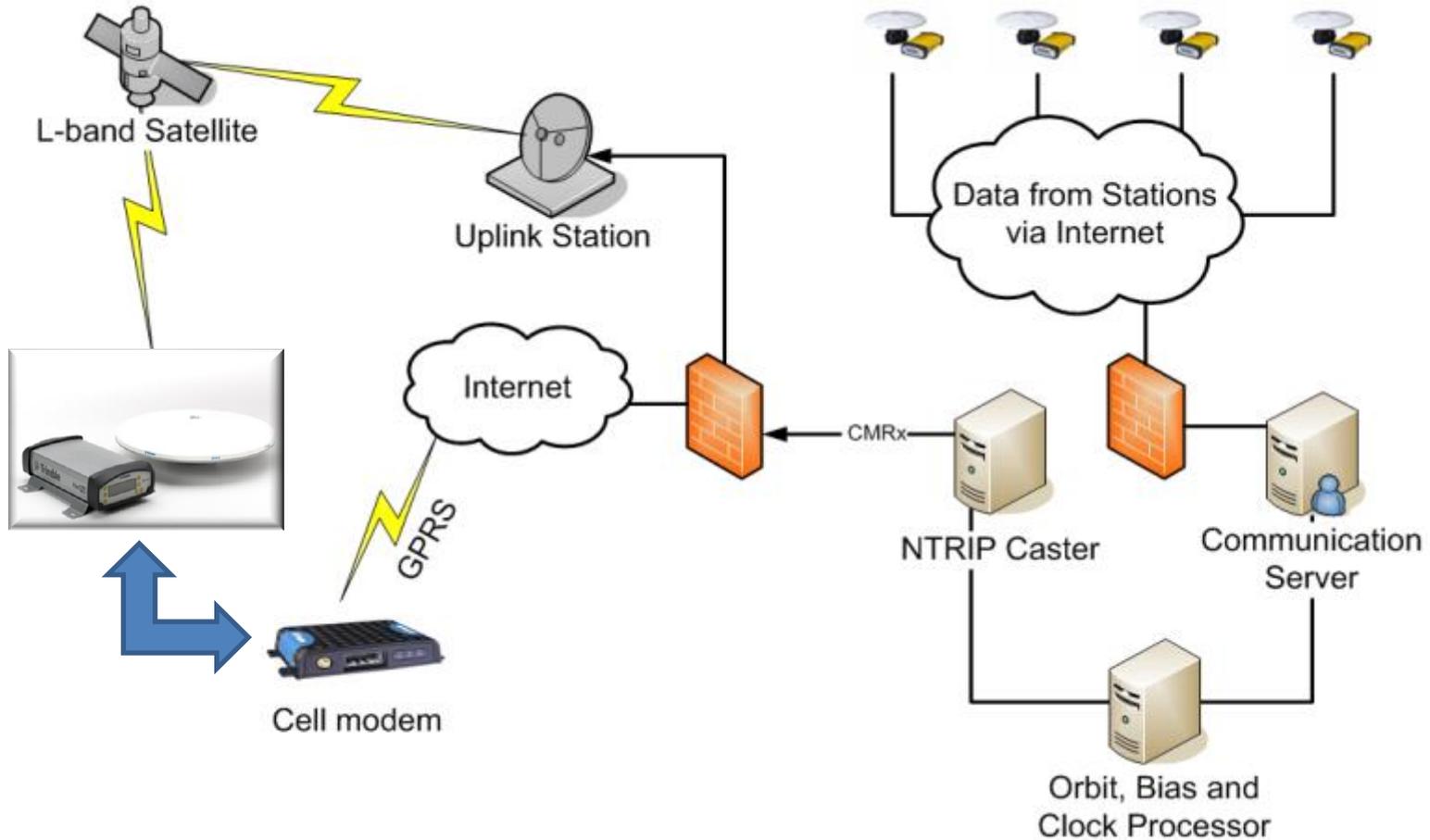


RTX Clients in Trimble Pivot

- IP driven and post processing service
- Independent from a reference station
- Static and kinematic
- **Absolute coordinate** for monitoring of your network

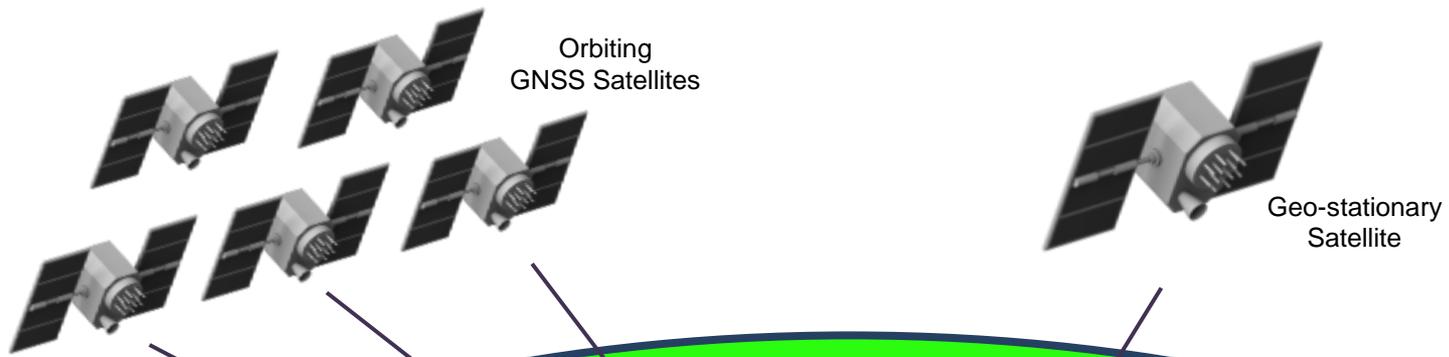


RTX Rover



Trimble CenterPoint RTX™

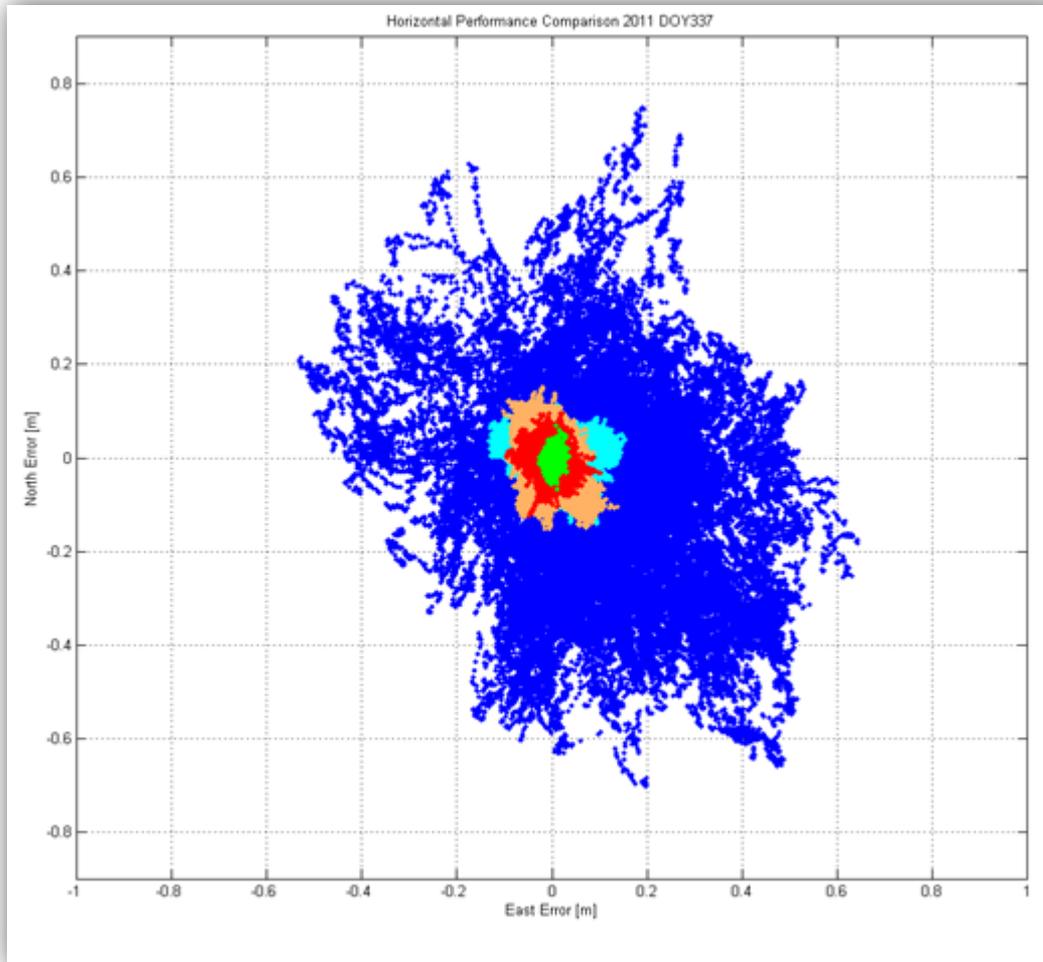
(via Satellite)



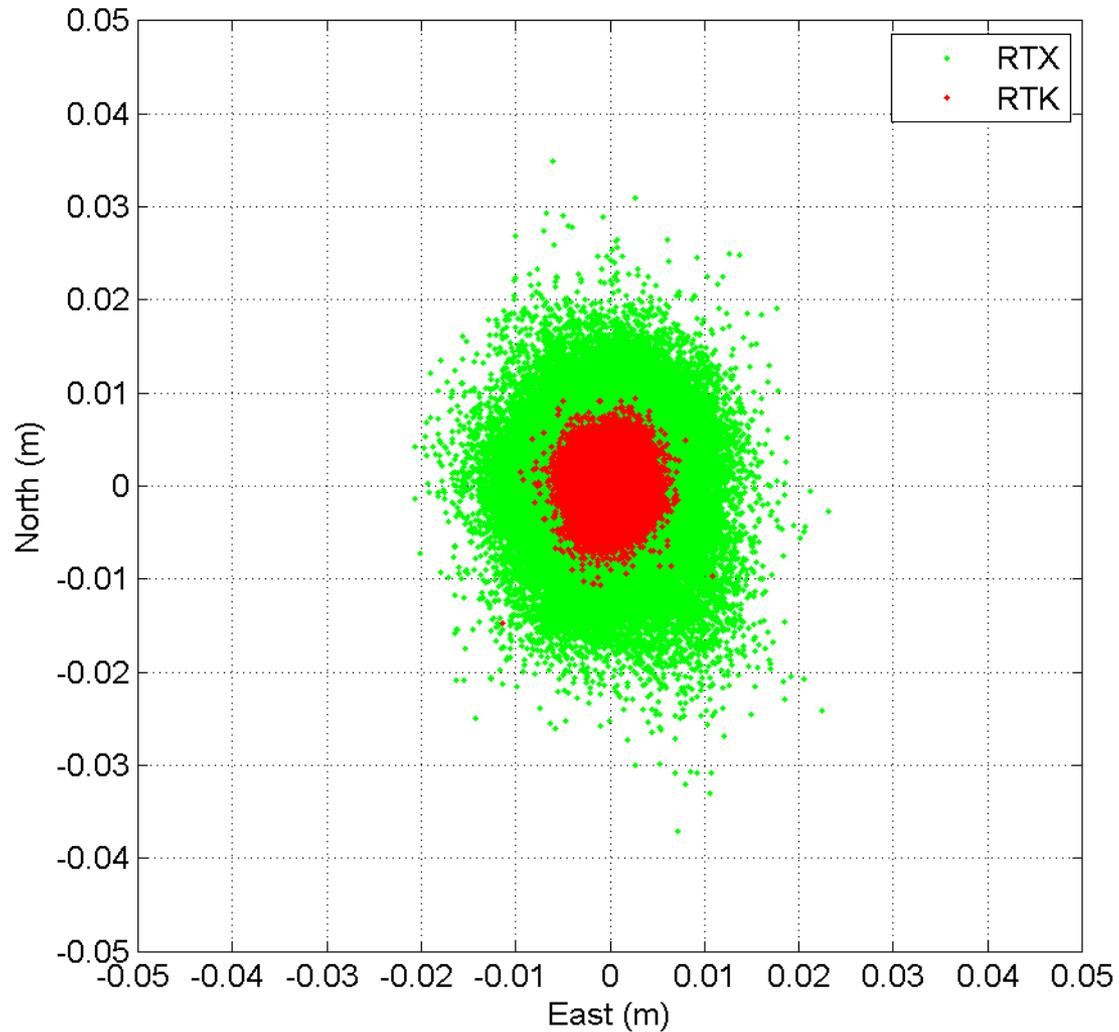
Data transmission

- Real-time global stream (orbits, clocks, etc.)
- GPS, QZSS, and GLONASS
- NTRIP/IP and L-Band delivery
- New messages based on Trimble CMRx technology
 - IODE-free
 - Negligible message inter-dependency
- **Bandwidth/Resolution/Update rate**
 - 600 bps to cover the Americas
 - 1200 bps for global coverage
 - 1 mm resolution for orbits and clocks
 - 2-4 sec update rate

Static Accuracy (clear sky)

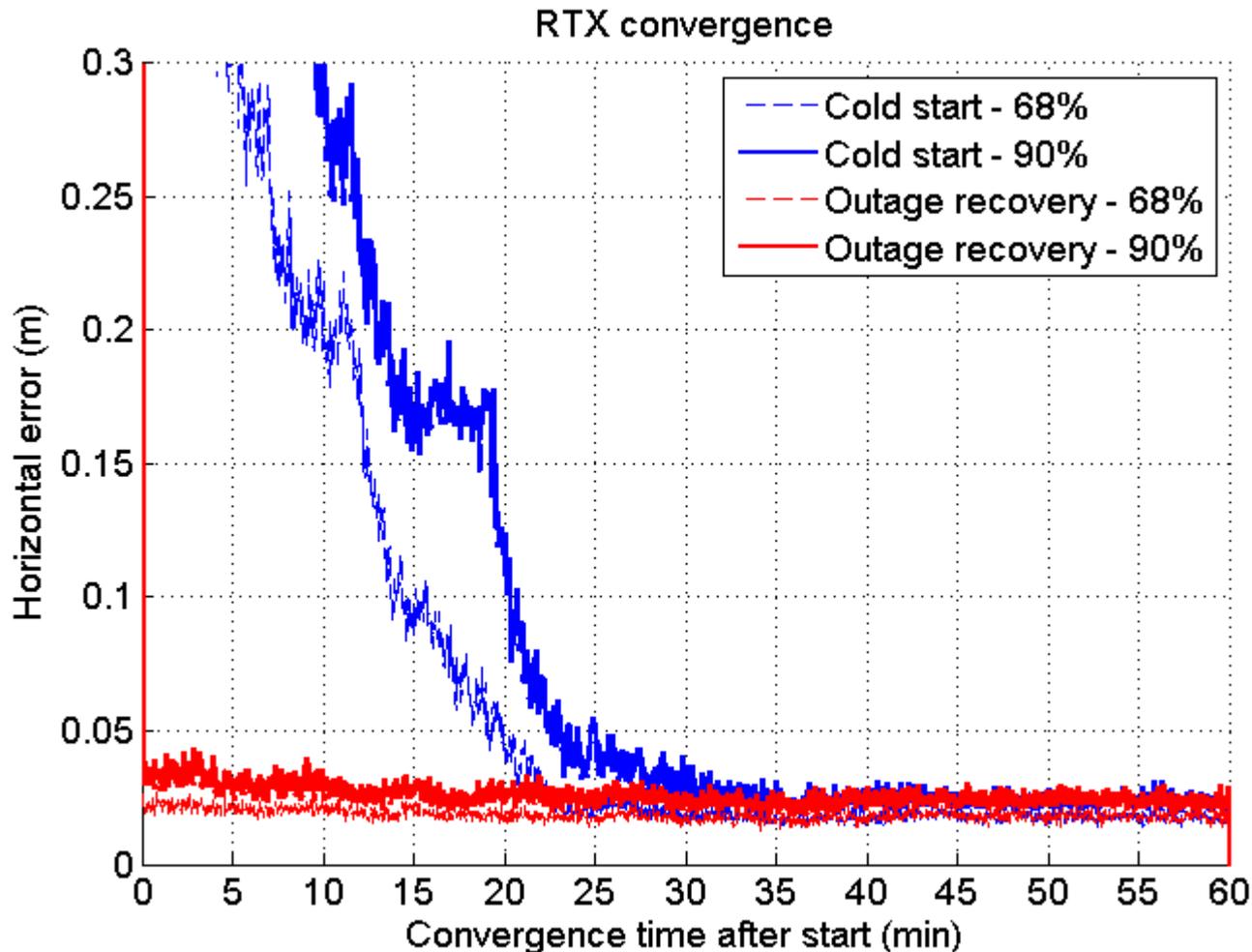


RTX vs Short baseline RTK



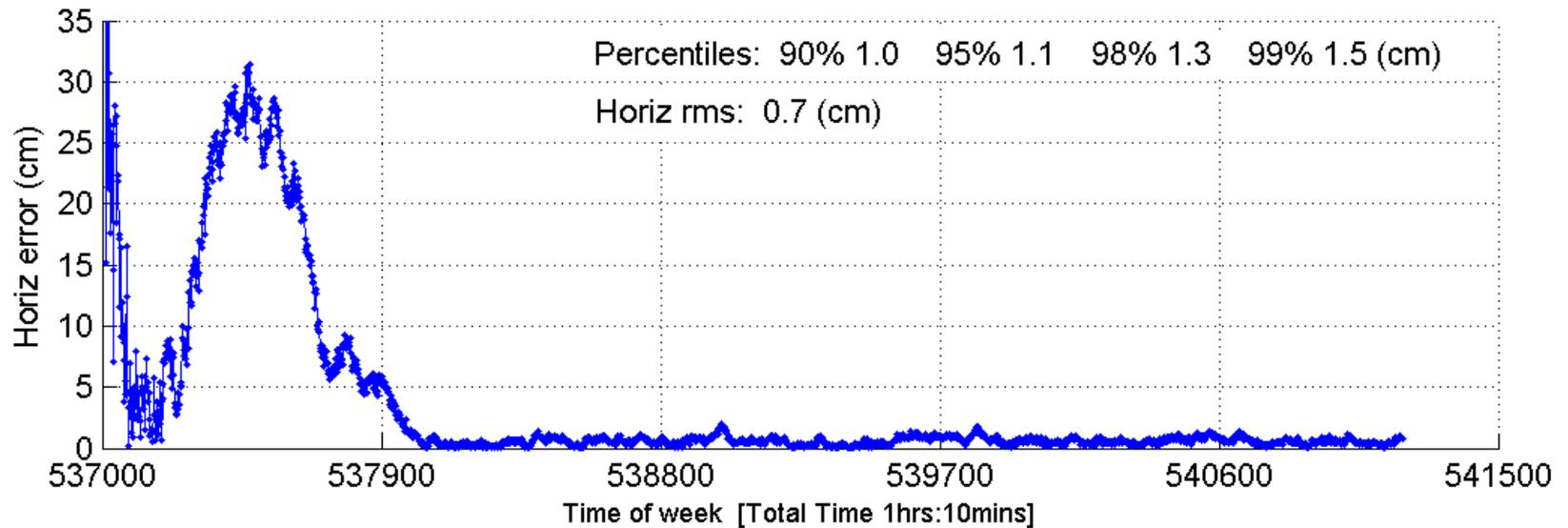
Convergence Runs

Cold Start and outage recovery, 3-min interruptions every hour



Position Convergence

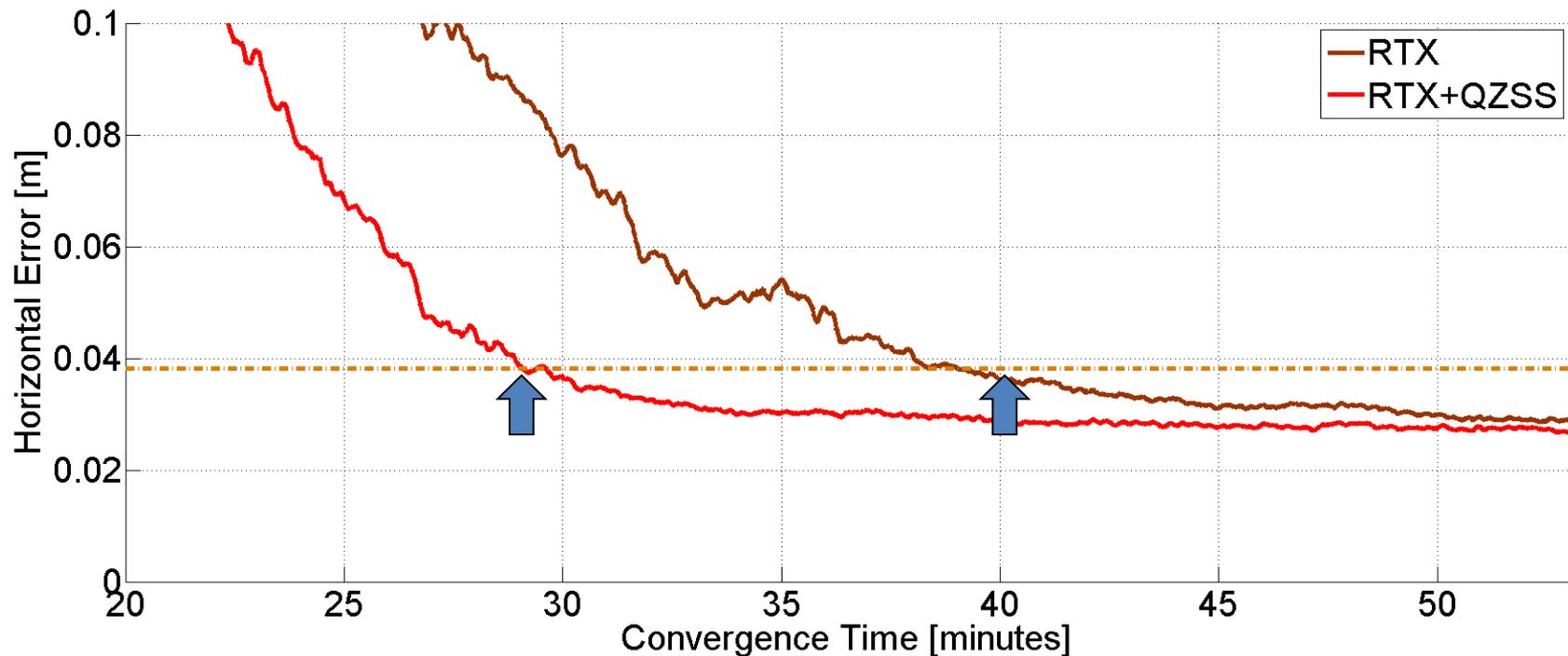
Horizontal Error over 1h 10m



- Converged to better than 5 cm over 15 minutes
- 2D RMS after convergence: 7 mm

Benefits from QZSS

Convergence Time (95%) out of 1623 Runs

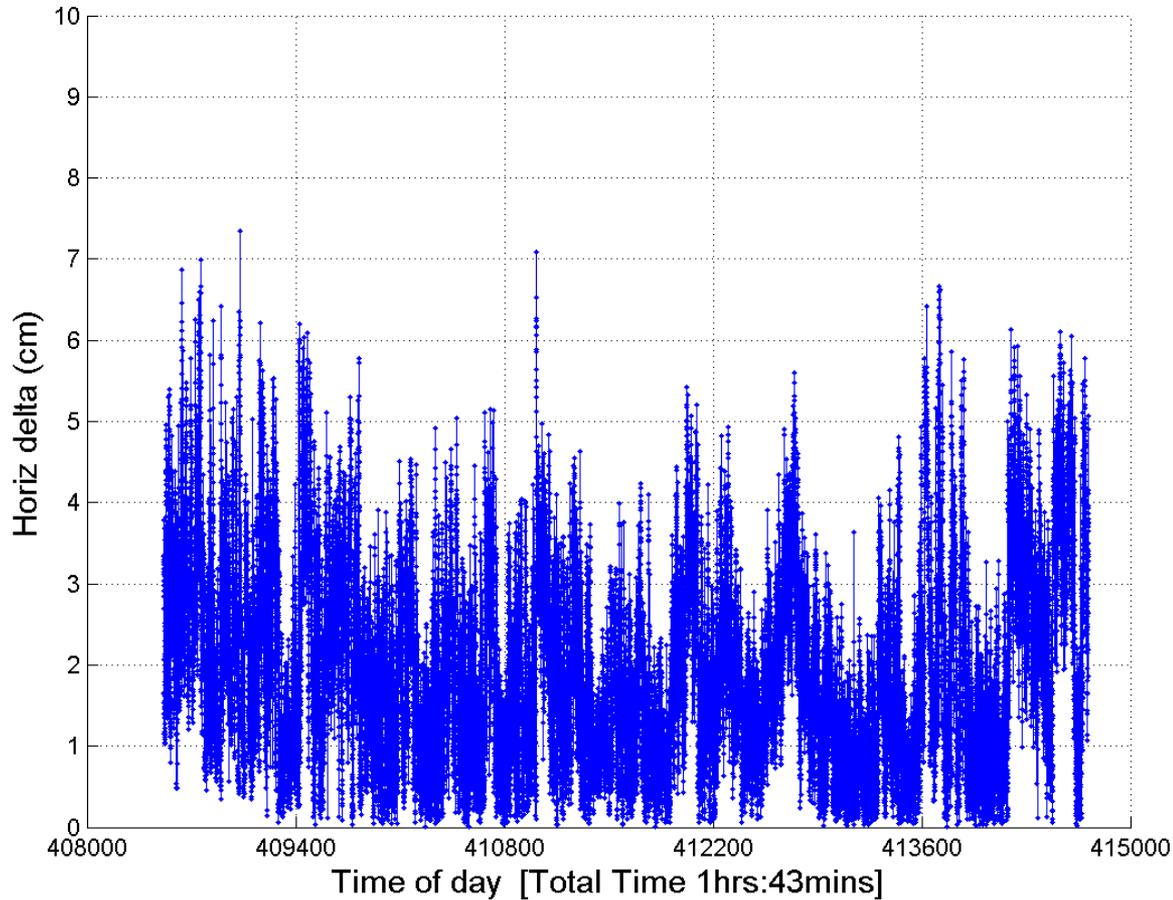


Dynamic Test



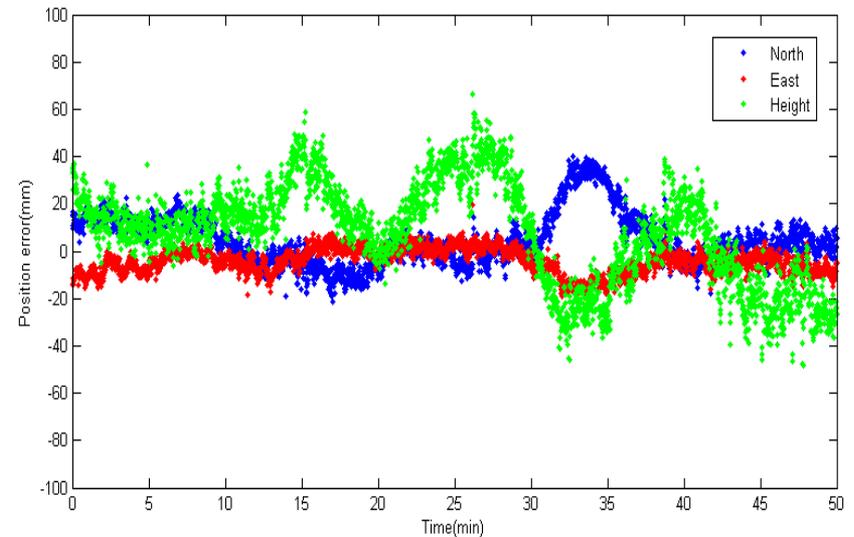
- Illinois, US
- 103 minutes

Dynamic Test Results



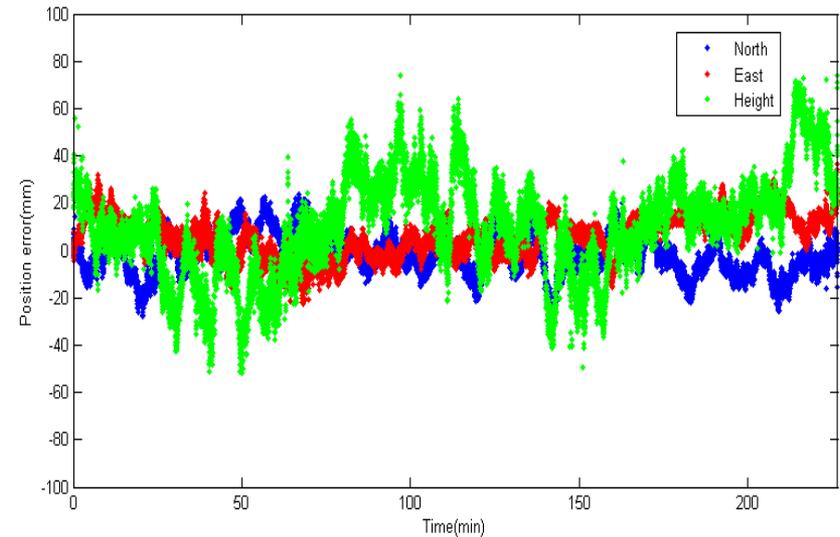
- Comparing with short range RTK
- 2D RMS = 2.3 cm
- 95% = 4.2 cm

RTX vs RTK (land application)



	North	East	Up
Mean (mm)	4.7	-4.2	7.8
σ (mm)	10.9	5.3	21.0
RMS (mm)	11.9	6.7	22.4

RTX vs RTK (airborne application)

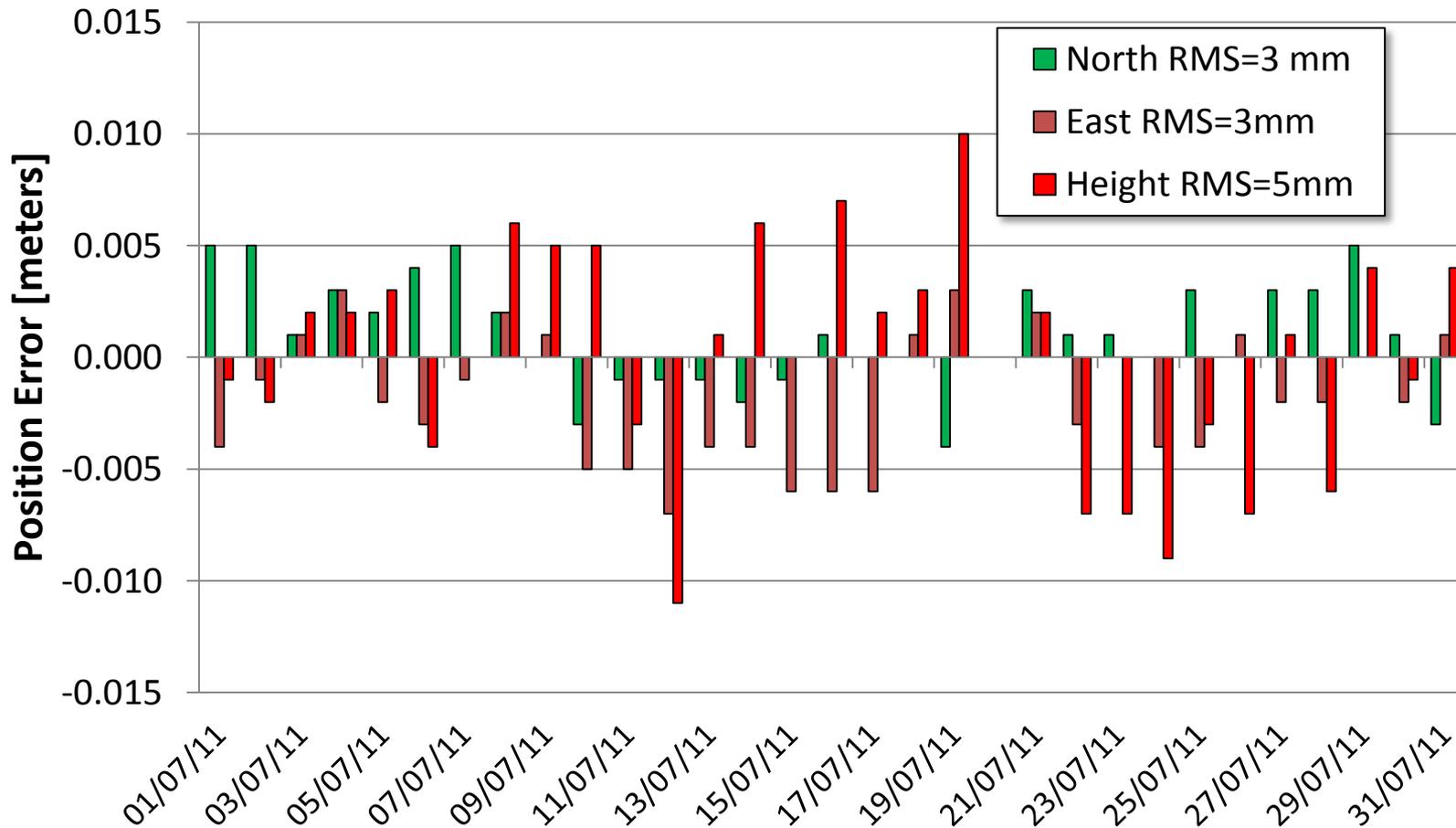


	North	East	Up
Mean (mm)	-1.5	5.7	10.1
σ (mm)	8.5	8.6	21.2
RMS (mm)	8.6	10.3	23.5

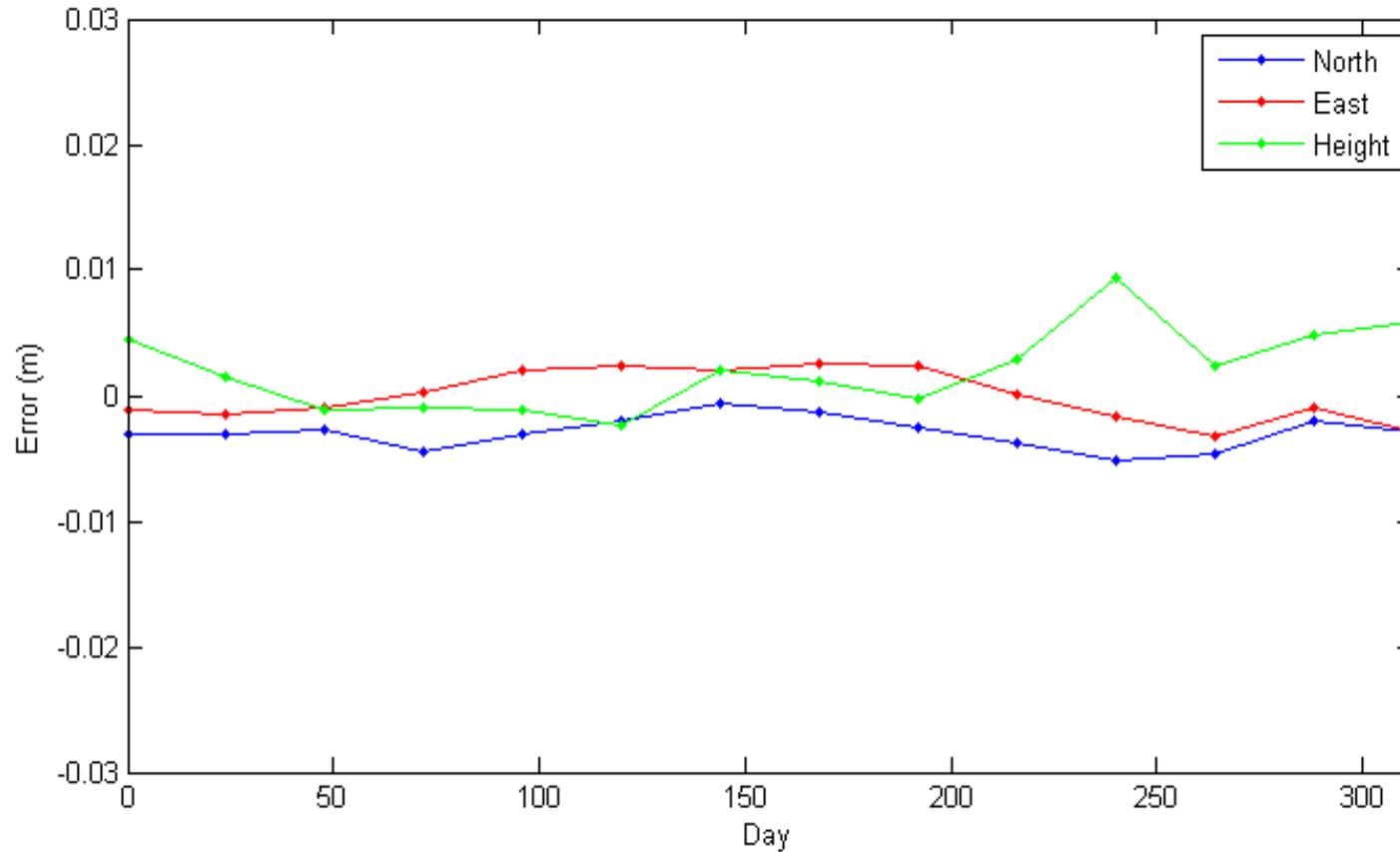
Post-Processing RTX

Daily results from 31 days in July 2011

 www.trimblertx.com



Static accuracy tests



24 Hours

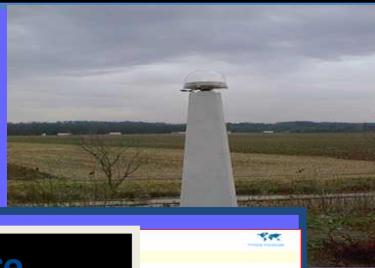
GNSS Performance Summary

Method	Horizontal [95%, cm]	Vertical [95%, cm]	Convergence [95%]
RTK < 30 km	0.8 + 1ppm	1.5 + 1 ppm	< 10 sec
VRS < 70 km	0.8 + 0.5 ppm	1.5 + 0.5 ppm	< 10 sec
Trimble RTX RT	4	7	< 30 min
Trimble RTX PP	1	2	24 hours

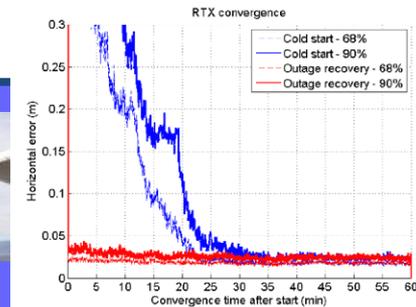
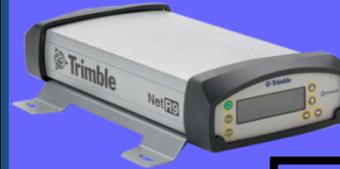
Summary

- Future Proof NetR9 CORS receiver
- Modern & Proven Trimble PIVOT App
- Turnkey Solution
- RTX – positioning anywhere, anytime.

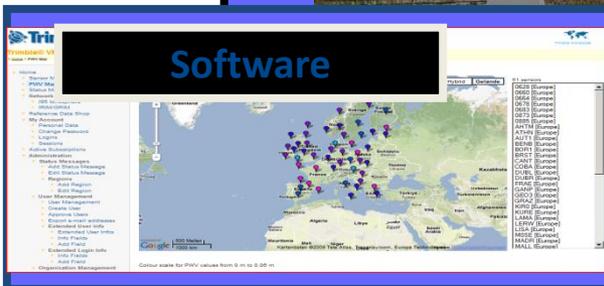
Monumentation



Hardware



Software



Communications

People

