



NovAtel CORRECT with Precise Point Positioning (PPP): Recent Developments

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Outline

- Introduction to TerraStar
- Challenges in Precise Point Positioning
- New TerraStar-C PRO service with improved convergence
- Instant convergence TerraStar-X service
- Global Monitoring System
- Conclusions



HEXAGON
POSITIONING INTELLIGENCE

End-to-end
solutions for
assured
positioning on
land, sea, air,
and the
Autonomous X



GPS Solutions

veripos



NovAtel



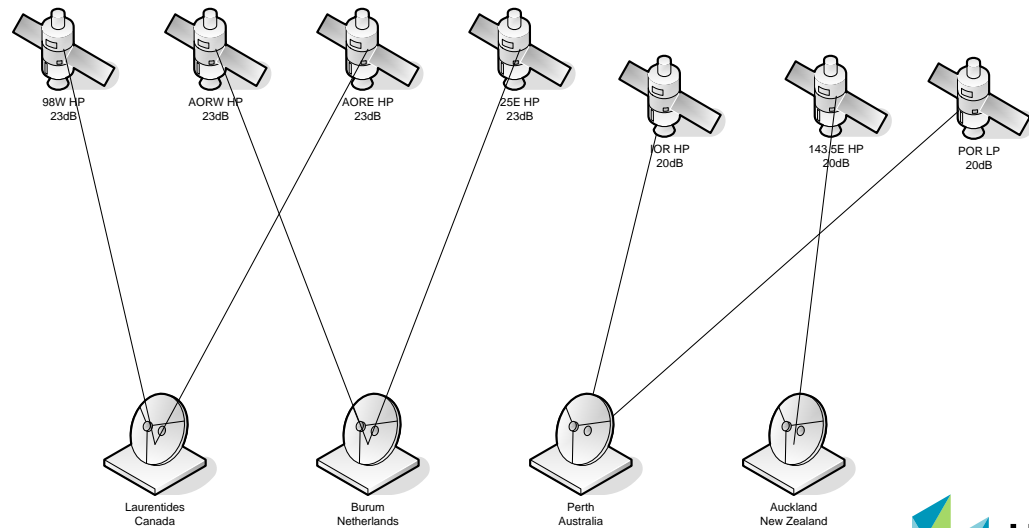
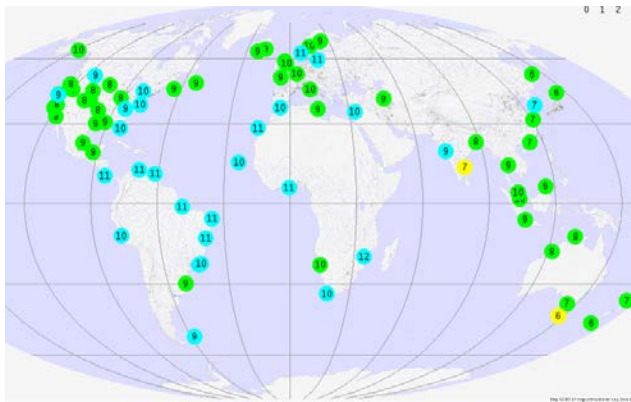
ANTCOM

ASSURED POSITIONING - ANYWHERE



Introduction to TerraStar Services

- NovAtel provides a range of positioning solutions through products and services, from metre level to cm level RTK
- TerraStar service is a global correction service for PPP solutions
 - Worldwide reference network of 80+ stations, covering all constellations
 - Redundant processing centres with failovers
 - Delivered over Lband and IP with dual beam coverage
 - High accuracy, high availability real-time service
- Used in professional applications, e.g. Precision Agriculture and Land Survey



Trends, Challenges and Opportunities for Precise Positioning

- Performance is about more than just accuracy
 - Availability in all environments
 - “Trust”
 - Integrity
 - Authentication
 - Reliability
 - TTFF(A)
- PPP and N-RTK merging
- GNSS is only part of the solution
- More satellites and signals

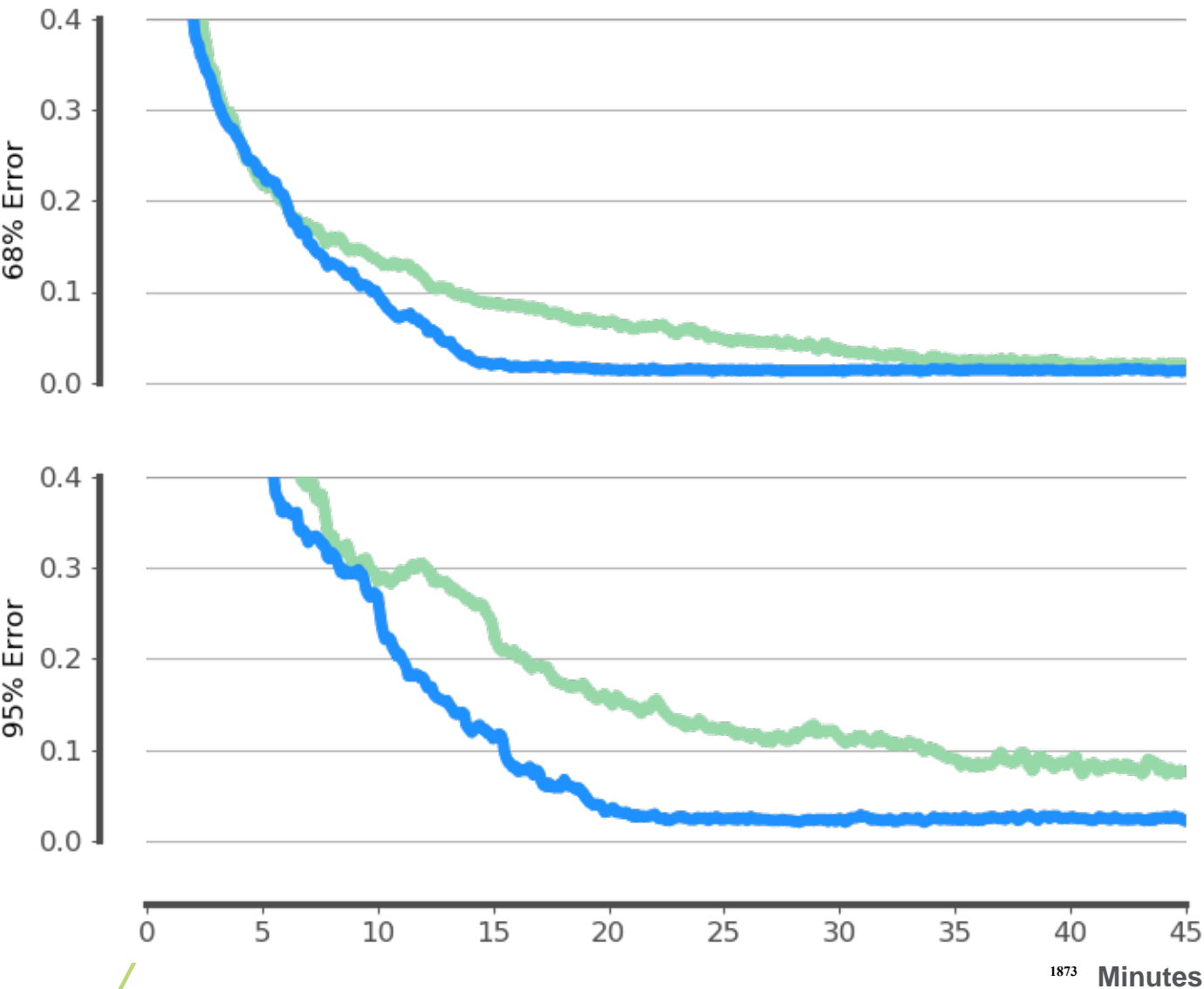
New TerraStar-C PRO service

- Significantly improved convergence compared to existing TerraStar-C service
 - Convergence to 5 cm (95%) horizontal position error typically less than 20 min
- Multi-constellation support
 - GPS, GLONASS, BeiDou, Galileo and QZSS
 - Improvements in convergence
 - Increased redundancy in challenging kinematic environments

TerraStar-C PRO improvements

- The TerraStar-C PRO service is supported by NovAtel OEM7 receivers starting from 7.05.00 software release
- Improved PPP filter architecture with advanced functional and stochastic models
 - Capable of processing all available signals and constellations
 - Future-ready for three/four/five frequency PPP
 - Future-ready for using external ionosphere information such as regional ionosphere model
- Enhanced ambiguity resolution
 - Significantly faster resolution
 - Increased robustness
 - Better availability
- Increased number of stations in the global network, particularly in North America
- Improvements to orbit, clock, and bias corrections

TerraStar-C PRO improvement in Penzberg, Germany



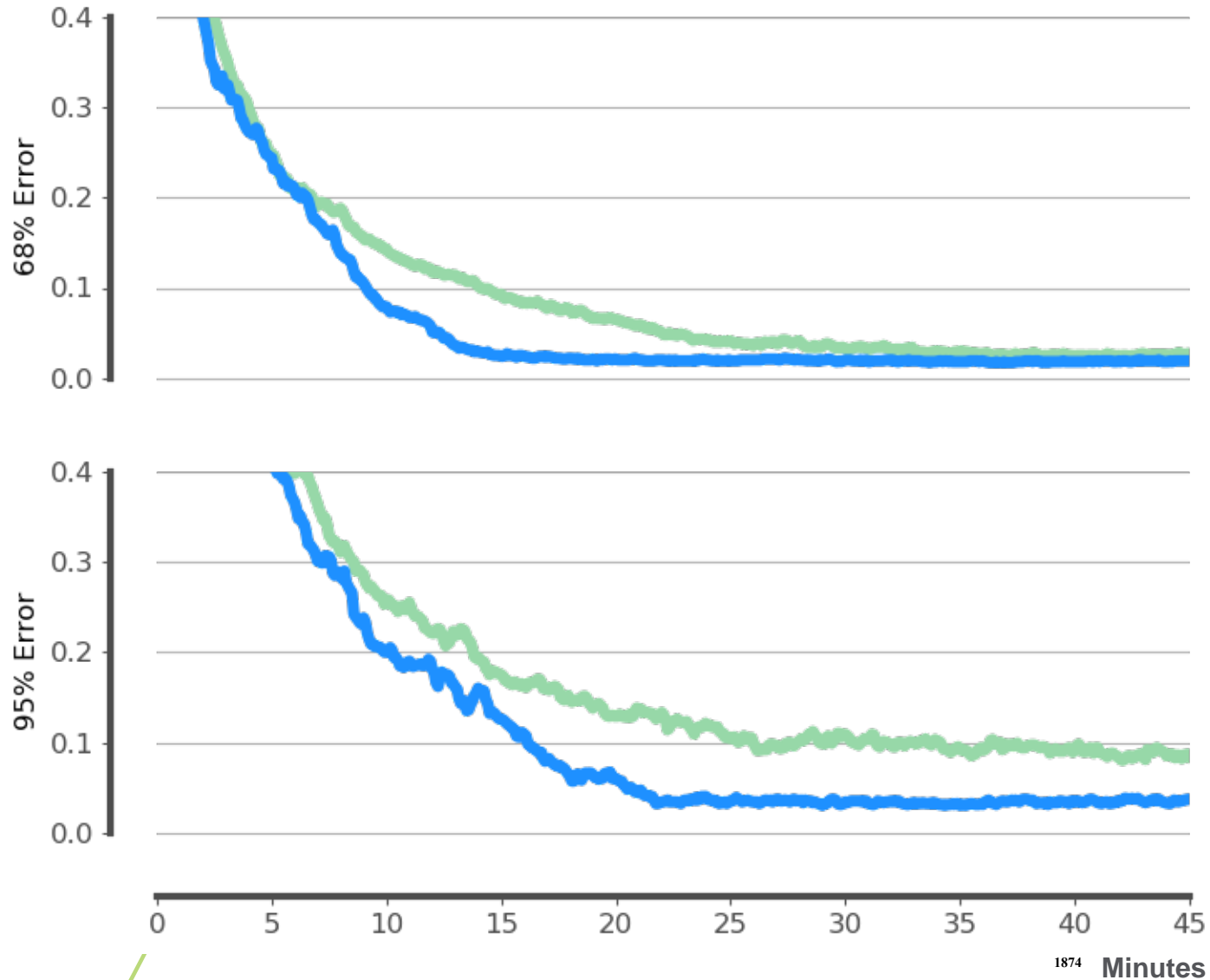
10 cm convergence times

	TSC PRO Time	Improvement
68%	10.0 minutes	24%
95%	15.5 minutes	54%

5 cm convergence times

	TSC PRO Time	Improvement
68%	12.6 minutes	49%
95%	19.0 minutes	68%

TerraStar-C PRO improvement in Aberdeen, UK



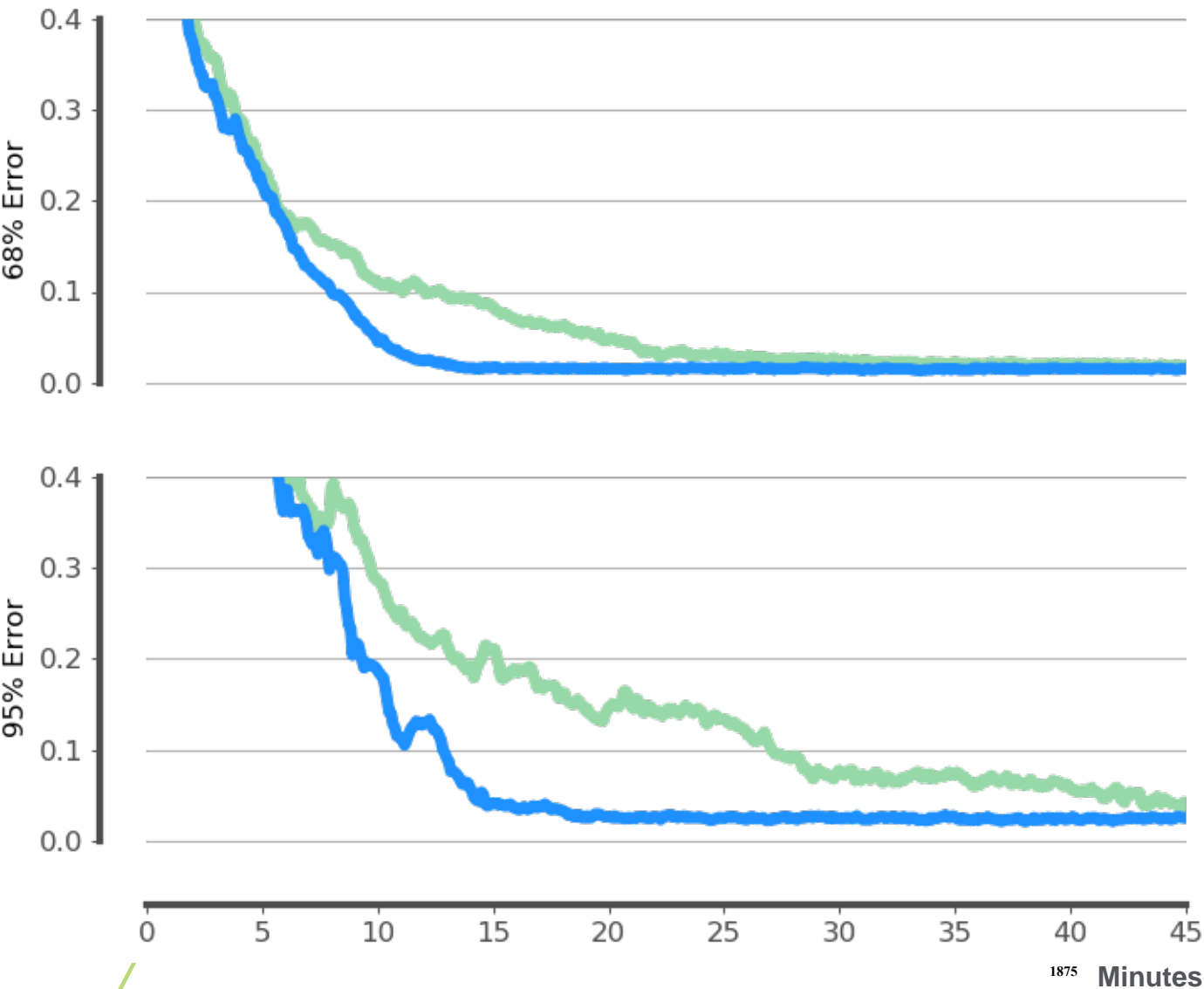
10 cm convergence times

	TSC PRO Time	Improvement
68%	9.2 minutes	35%
95%	16.1 minutes	56%

5 cm convergence times

	TSC PRO Time	Improvement
68%	12.3 minutes	44%
95%	20.6 minutes	65%

TerraStar-C PRO improvement in Indiana, USA



10 cm convergence times

	TSC PRO Time	Improvement
68%	8.0 minutes	38%
95%	12.8 minutes	53%

5 cm convergence times

	TSC PRO Time	Improvement
68%	10.0 minutes	49%
95%	14.5 minutes	66%

TerraStar-X

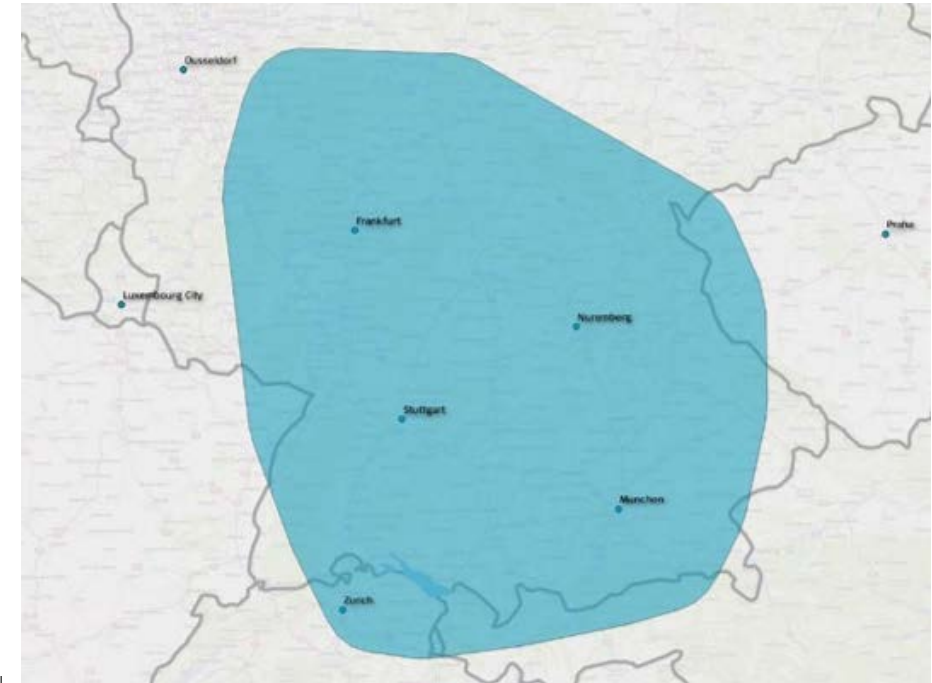
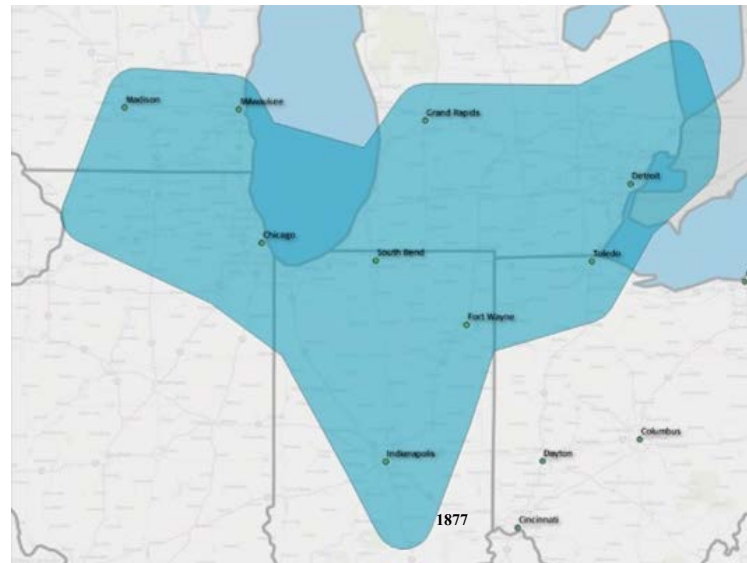
- Future TerraStar service with convergence to centimeters in minutes
- Uses regional ionosphere models
 - Data from reference networks are used to estimate ionosphere in real-time
 - Ionosphere corrections are broadcast with other TerraStar corrections in the same feed
- Benefits over RTK:
 - Users don't need to maintain reference stations
 - Solution consistency with global TerraStar solution
 - Easy setup for end-users
 - TCP/IP or L-band delivery possible
- Currently in development and test phase

TerraStar-X testbed locations



California

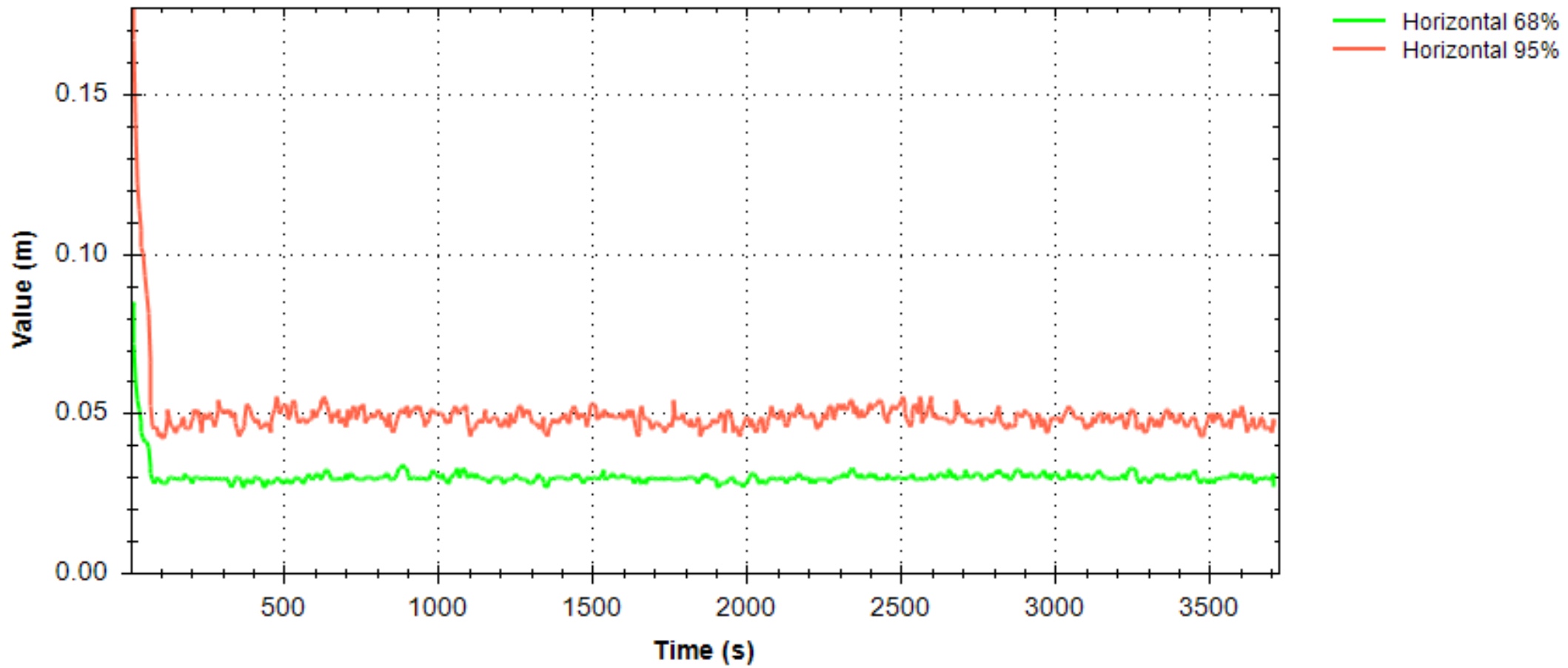
Michigan



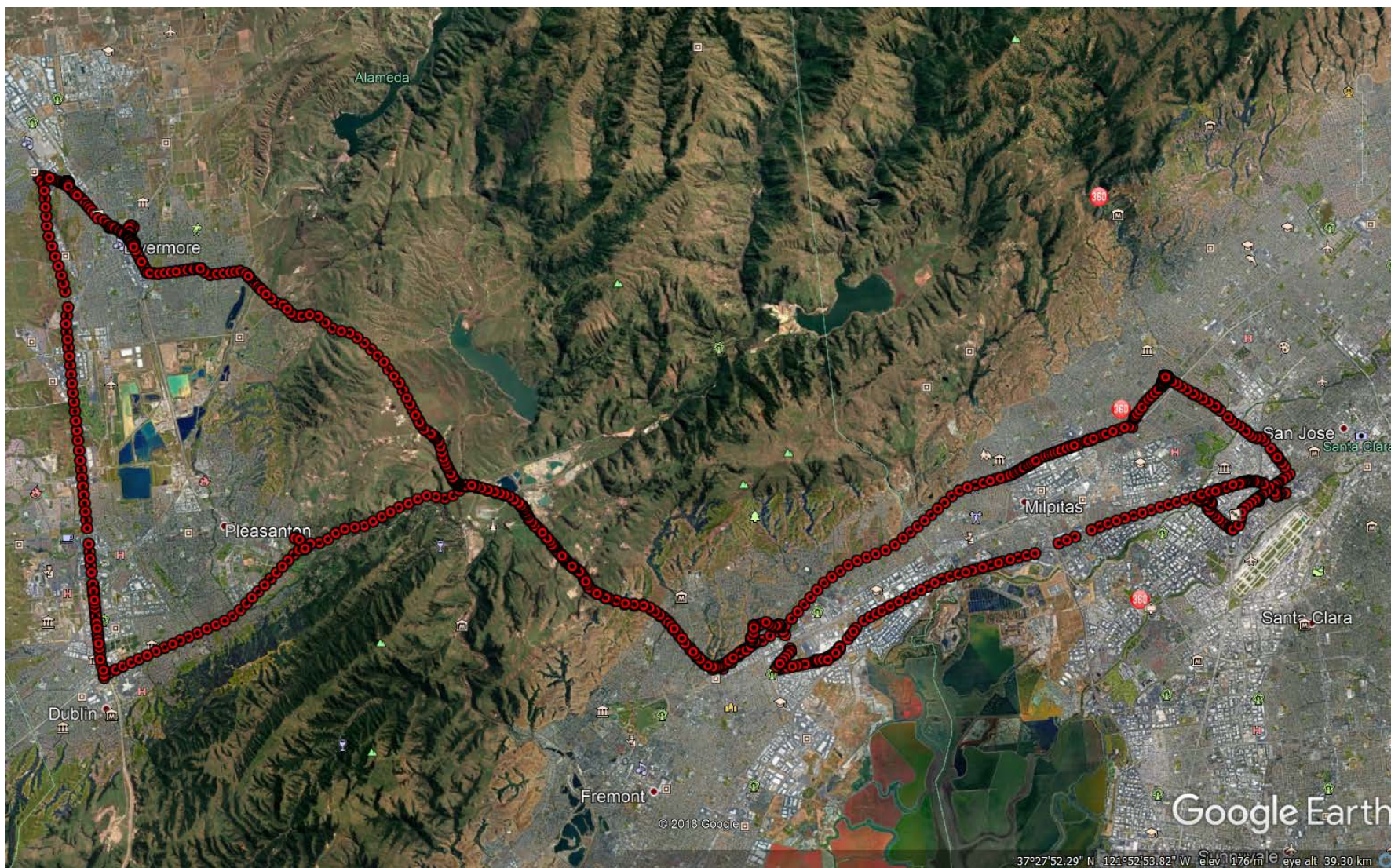
Germany

TerraStar-X convergence in Calgary

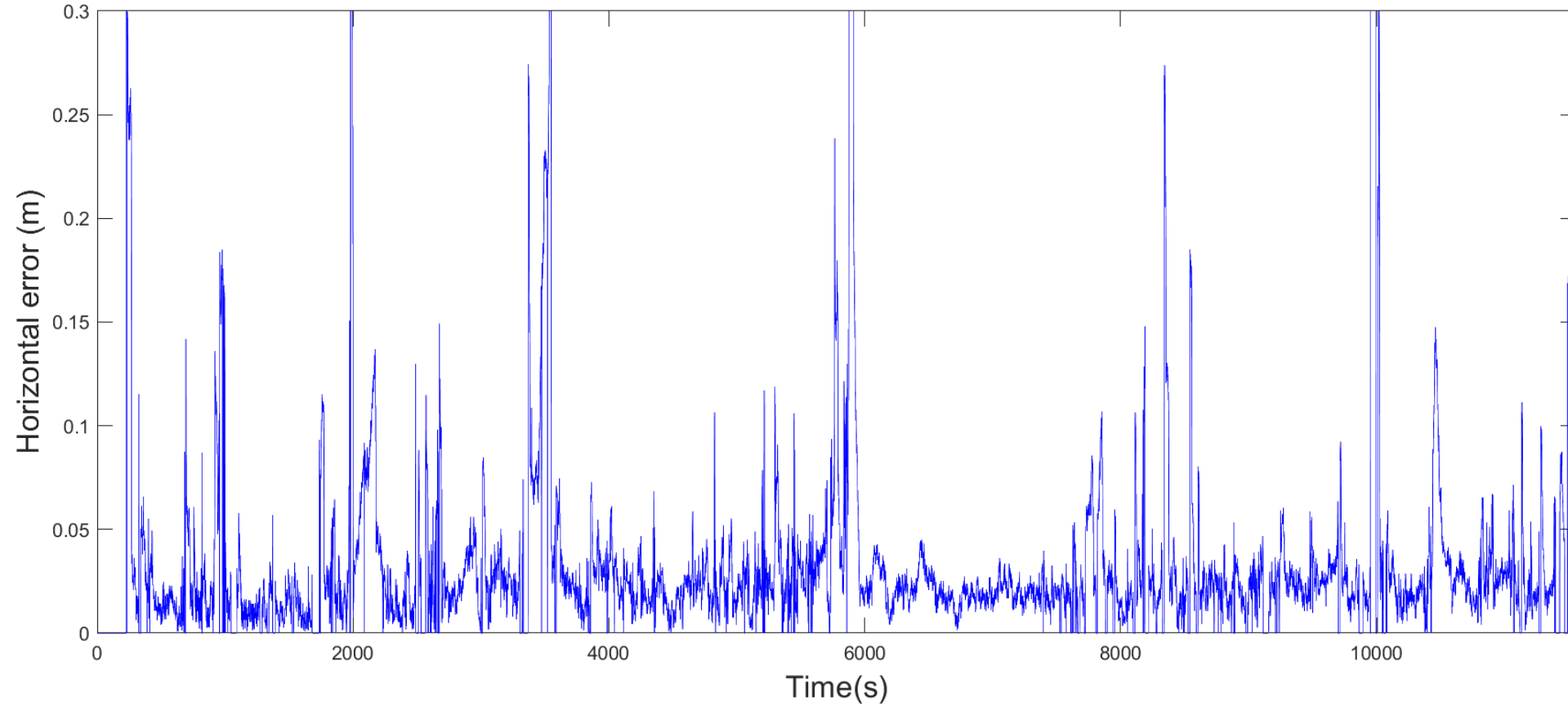
PPPPOS Convergence Statistics



TerraStar-X test route in San Francisco Bay Area



TerraStar-X kinematic performance in San Francisco Bay Area



Global Monitoring System (GMS)

- Automated system to monitor and analyze performance of current and future TerraStar services
- Uses data from global reference stations networks
- Long-term assessment of complete fielded solutions (corrections + positioning engines), including characterisation
- Regression testing (confirming changes as part of a new service will not degrade fielded solutions)
- Supporting system diagnostics

Conclusions

- Improved performance of new TerraStar-C PRO service level demonstrated
 - Already available for customers in NovAtel 7.05.00 firmware release
 - Significantly faster convergence
 - Improved reliability
 - Better accuracy
- Nearly immediate convergence with prototype TerraStar-X
 - Based on using local ionosphere model
 - Currently available in demonstration testbeds in certain areas
 - Plan to have it available for customers in 2019