Trimble

Positioning Services

Worldwide Centimeter-Accurate GNSS Positioning using Trimble RTX Technology

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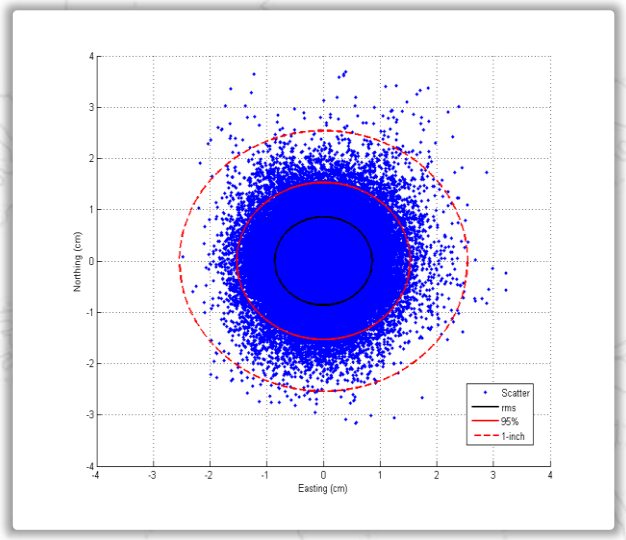
Trimble Navigation

March 2011

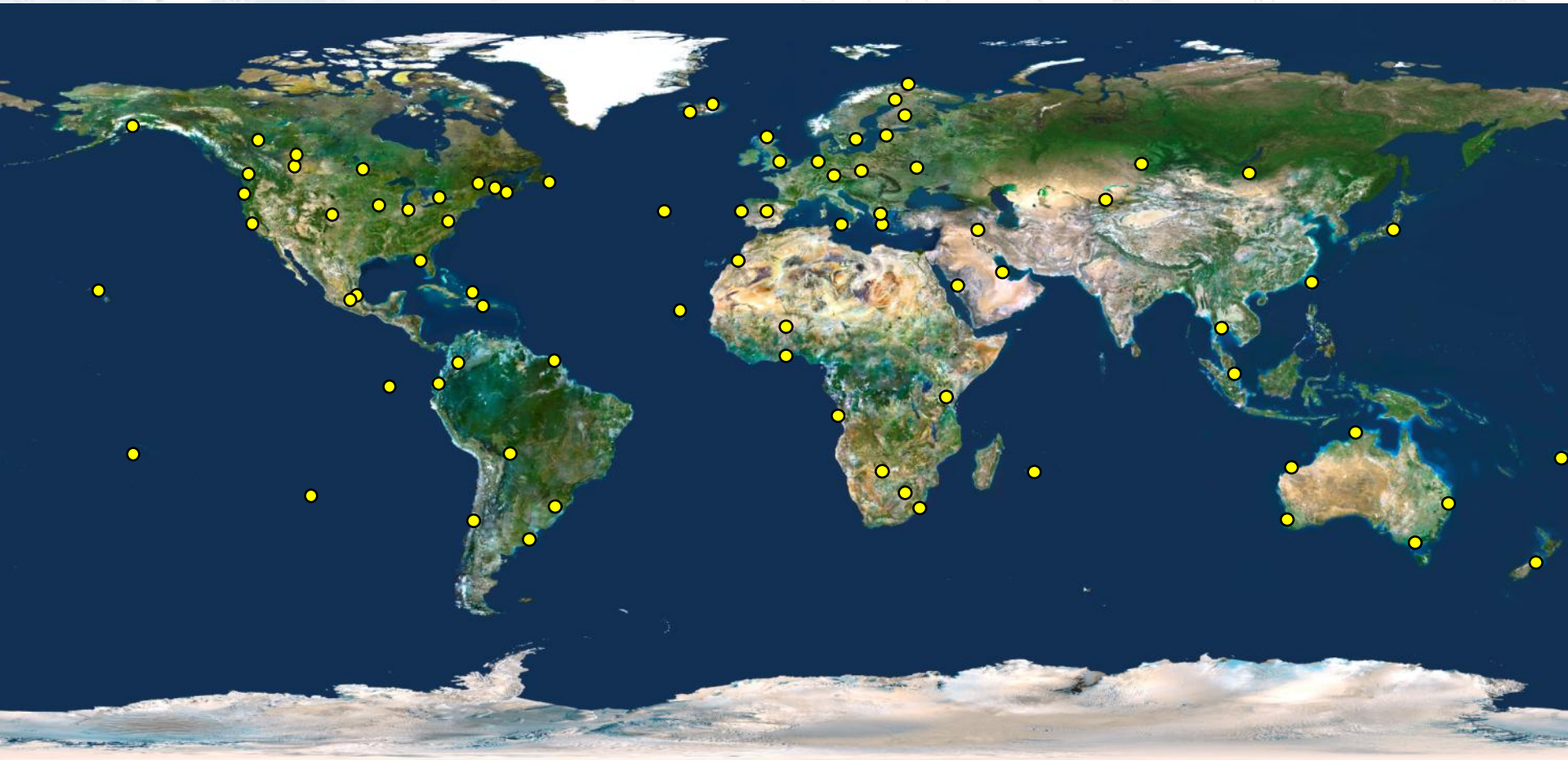
The Development Team in Munich

Introducing RTX

- Absolute Positions Worldwide
- Uses integer nature of carrier phase ambiguities
- Multi-GNSS
- Symbiosis with existing Trimble technology (e.g. 20 Hz position output)
- Precise real-time orbit, clock,…
- Regional Augmentation using ionospheric and tropospheric information

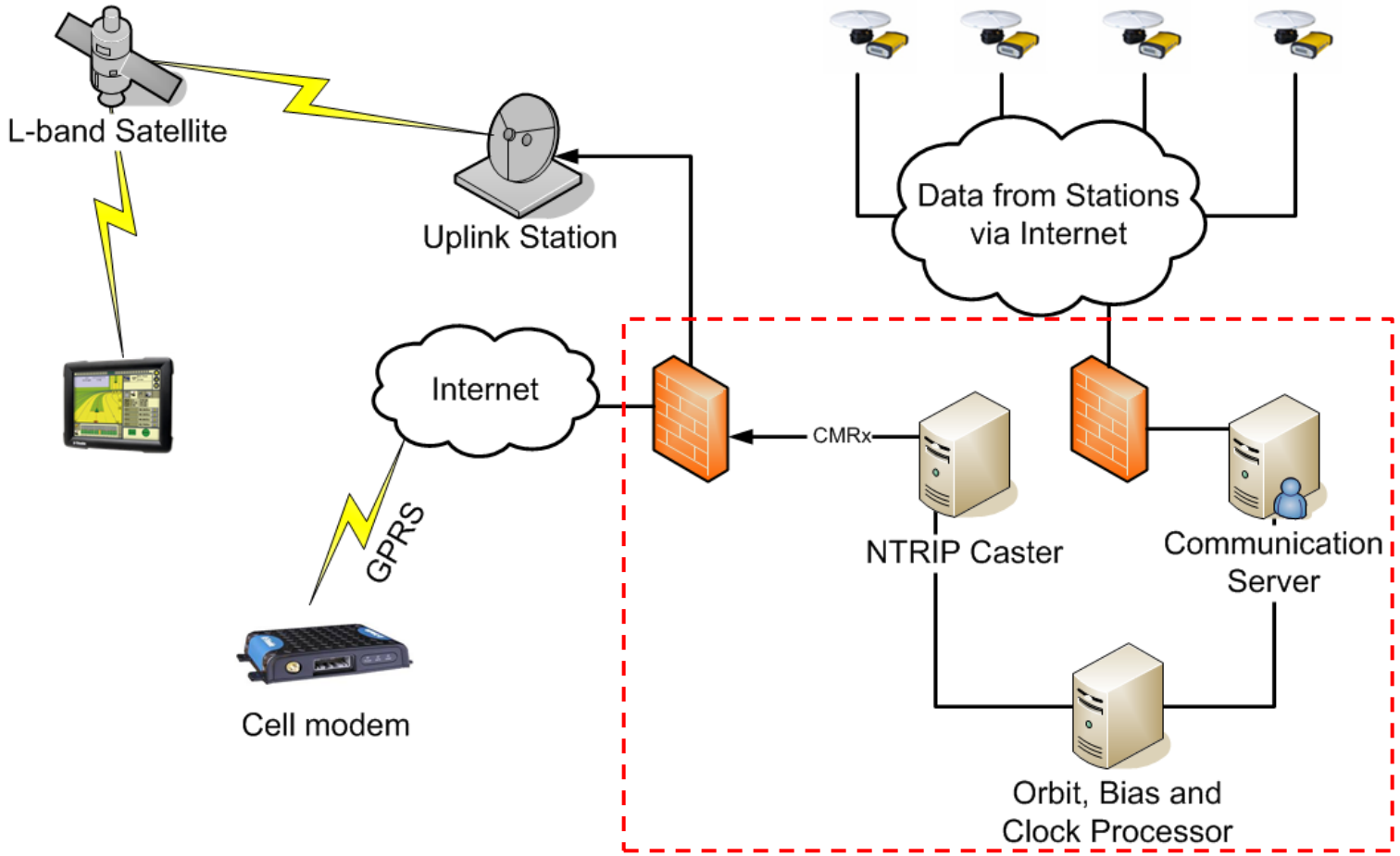


Global CenterPoint RTX Network



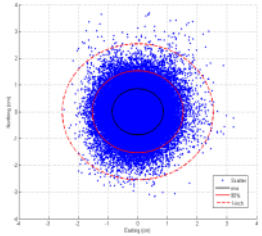
Tracking Stations (~100)

Descriptive System Setup

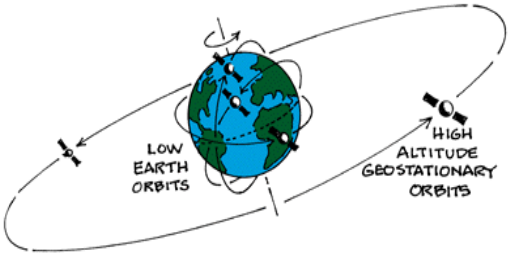


Pieces of the Puzzle

Positioning



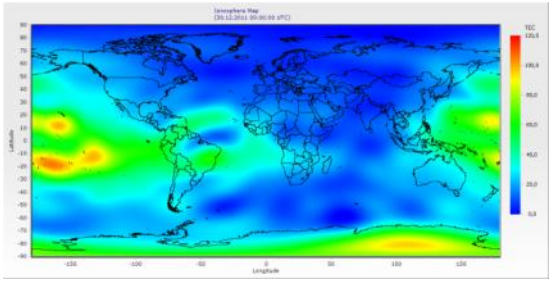
Orbit determination



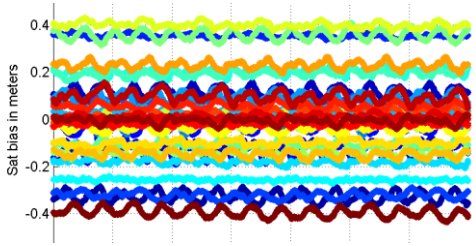
Communication

Clock estimation

Atmosphere Models

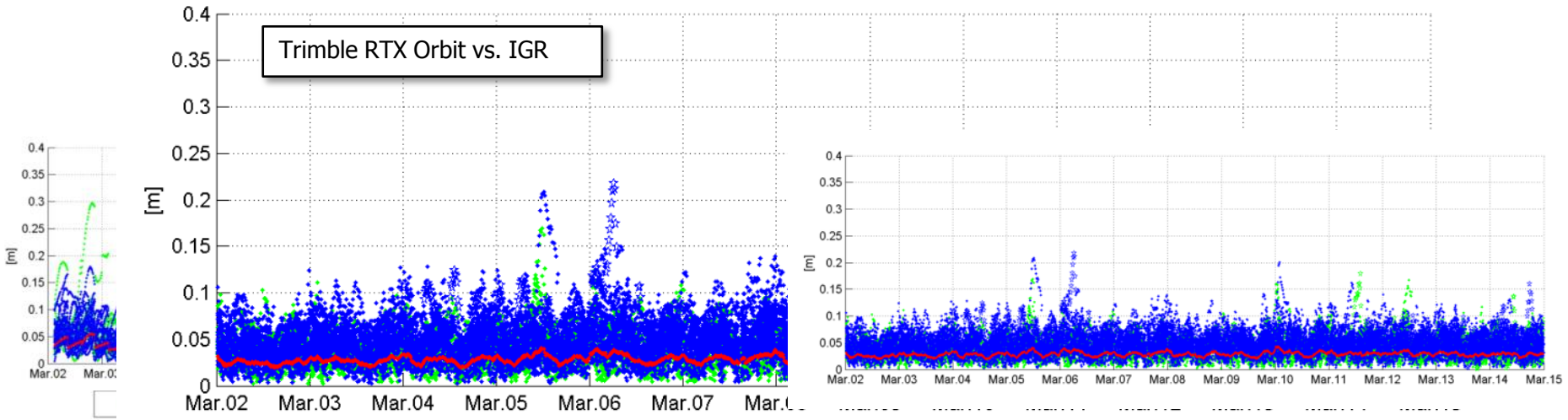


Bias estimation



Real-Time Orbit Determination

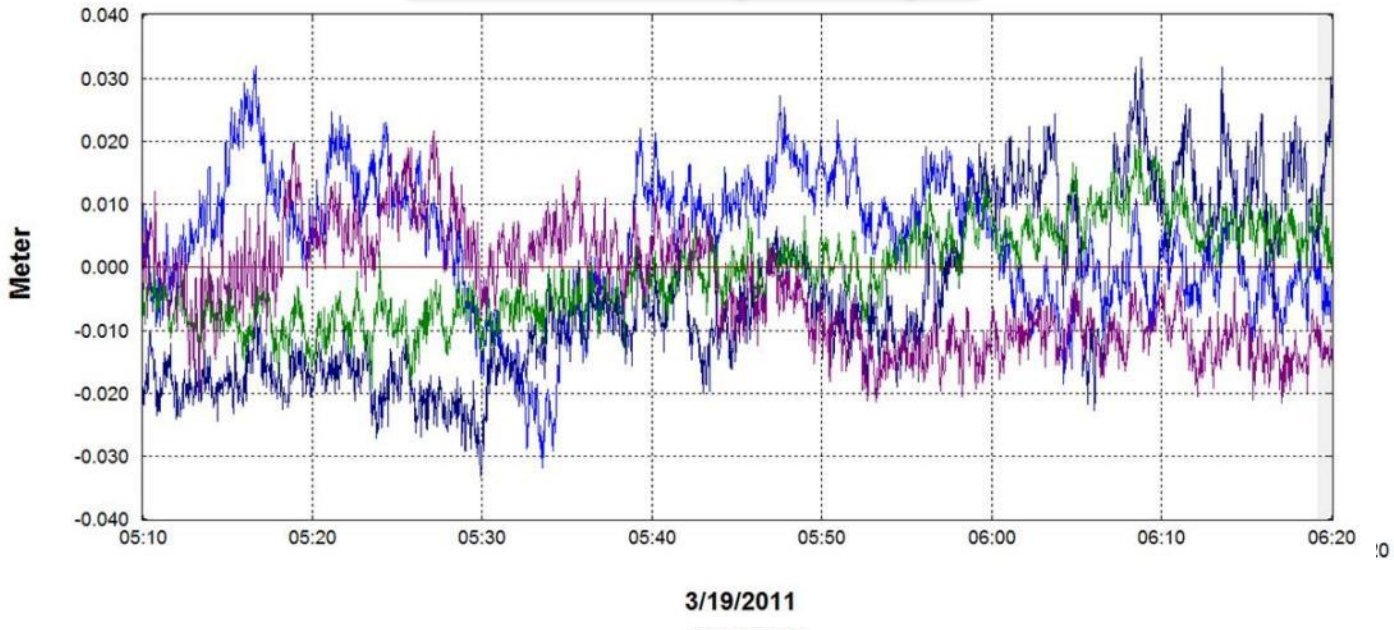
- **Requirements:**
  - **Accuracy**
  - **Continuity**
  - **Process robustness**
- **Orbit estimation parameters**
  - **Position, velocity, troposphere**
  - **Integer ambiguities**
  - **Solar radiation**
  - **Harmonic coefficients**
  - **Earth orientation**



RTX clock processing

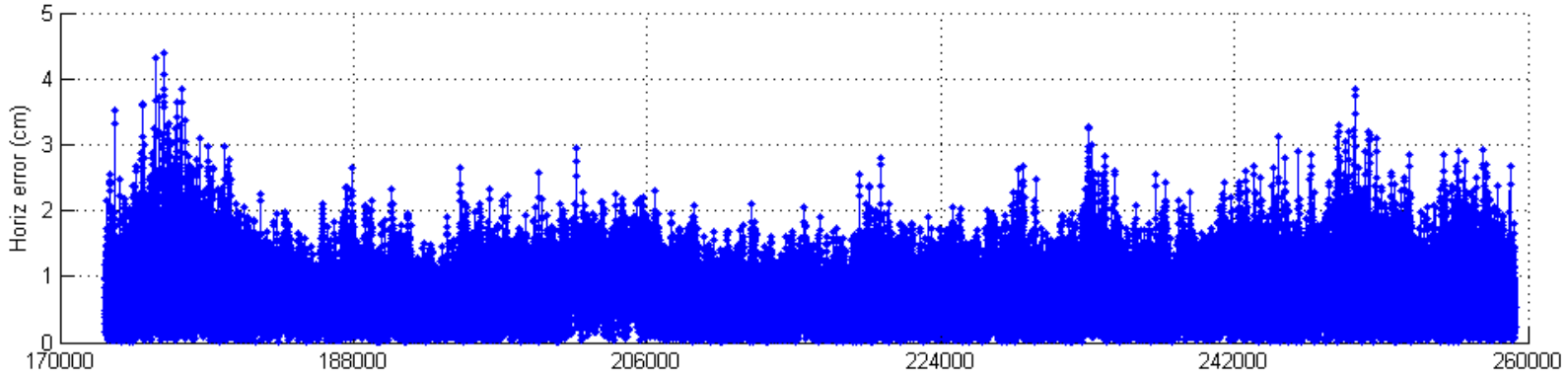
- **Allows ambiguity resolution on the rover**

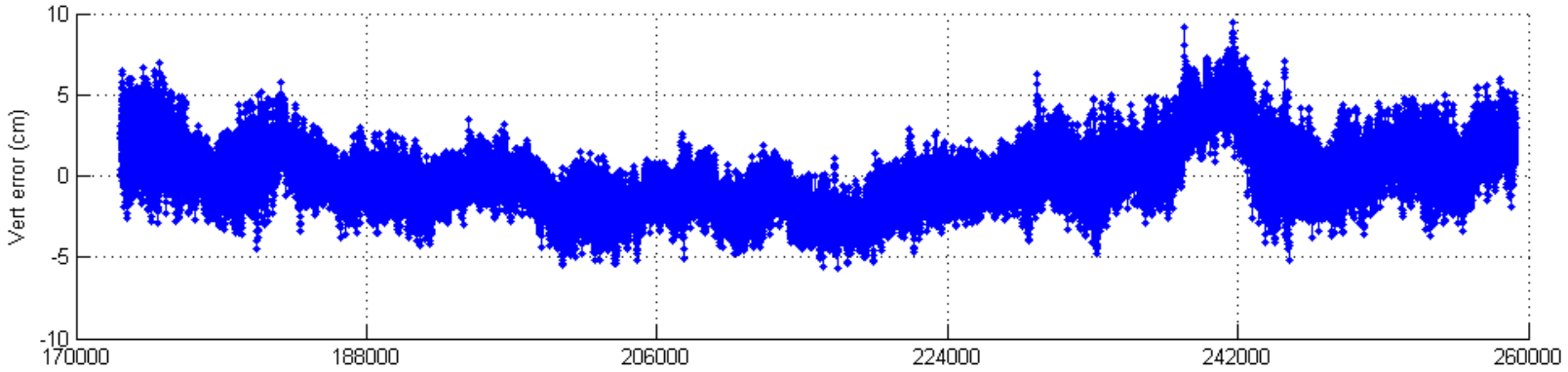
Example of phase residuals for different satellites (GLONASS)



RTX Real-Time Positioning Results

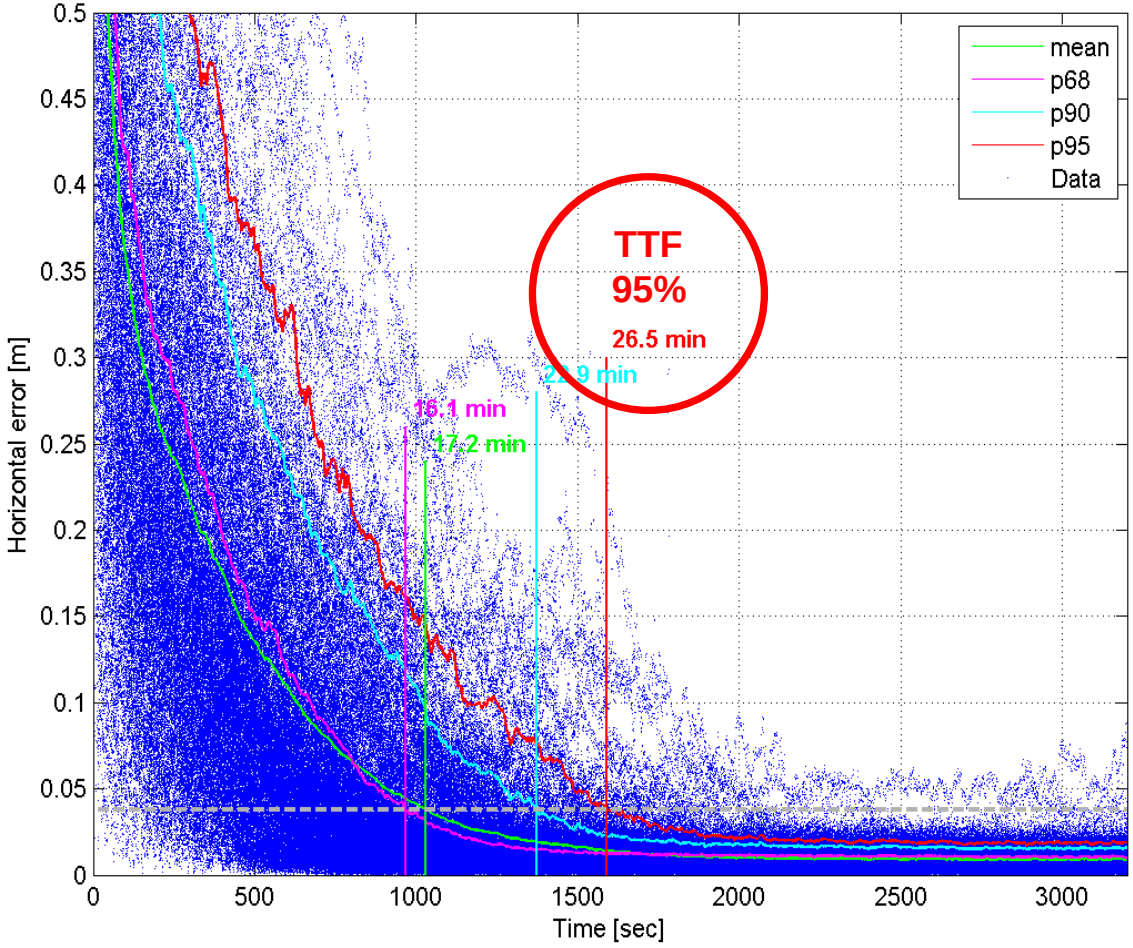
Munich Feb 14, 2012, 24h, Horiz. rms: 9 mm, Vert. rms: 19 mm





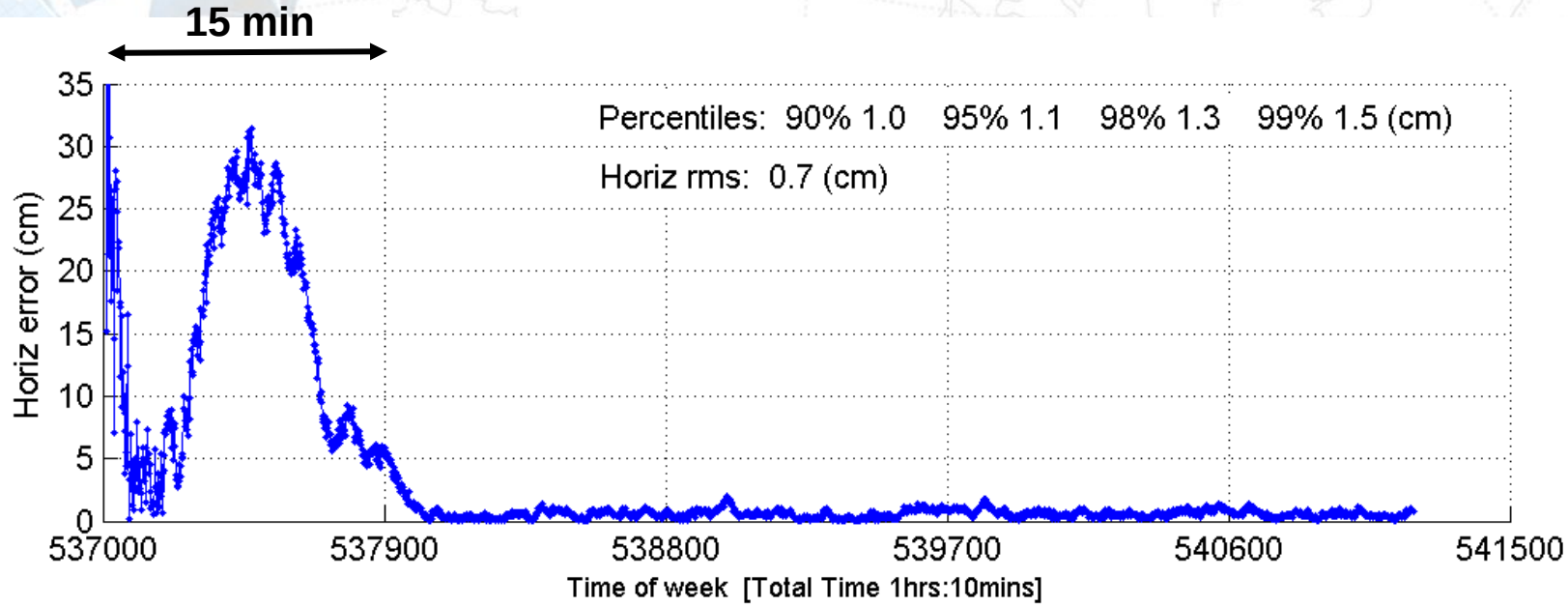
RTX Convergence Runs

Cold starts every hour, 289 runs over 12 days



Position Convergence

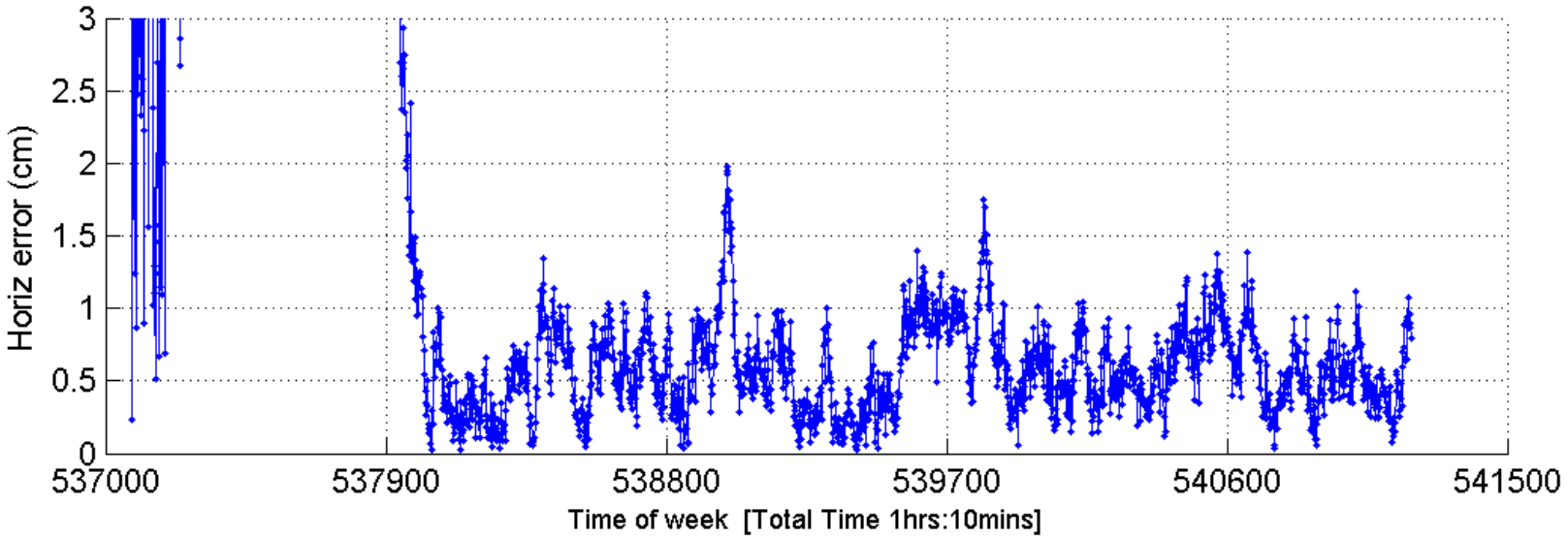
Horizontal Error over 1h 10m



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

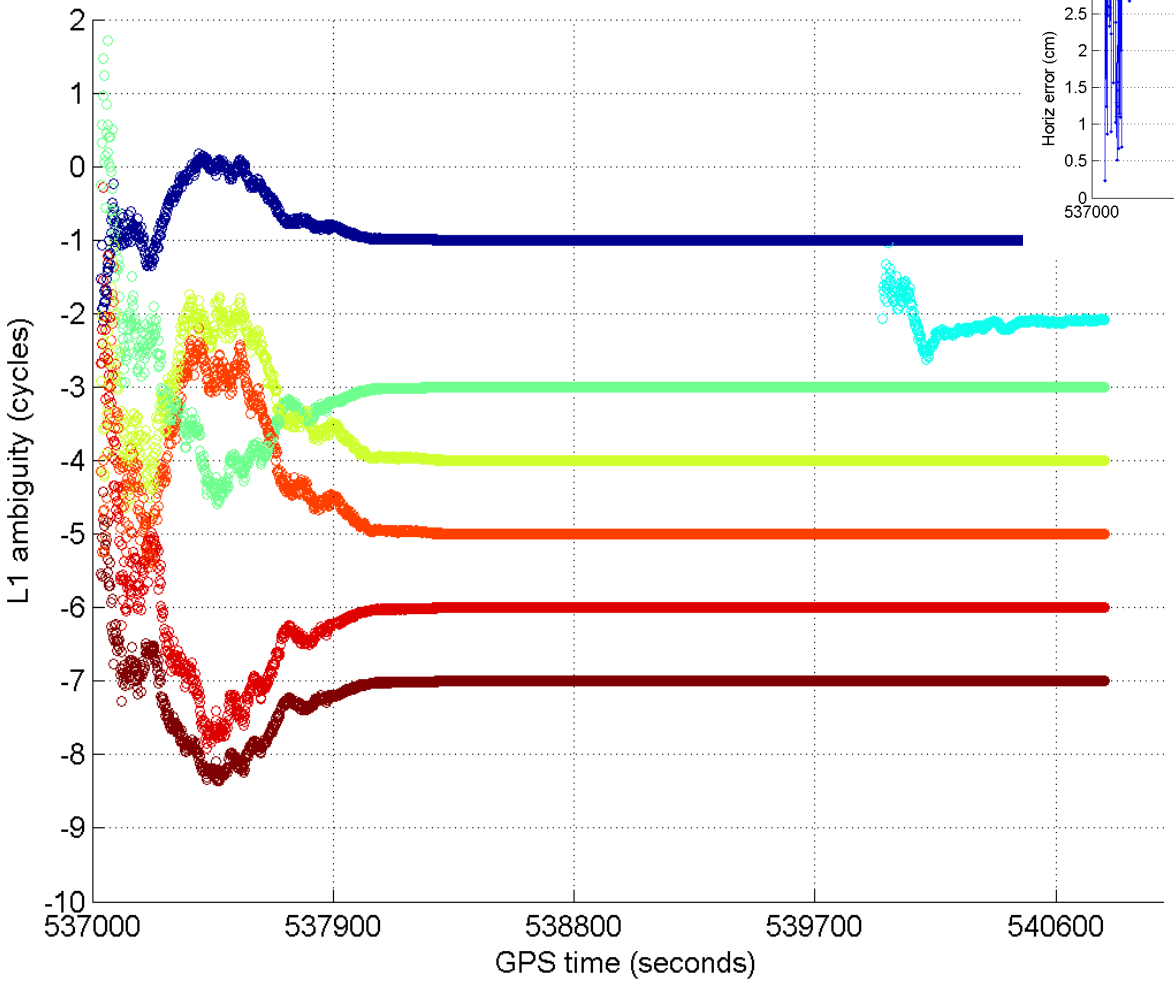
Position Convergence (zoom in)

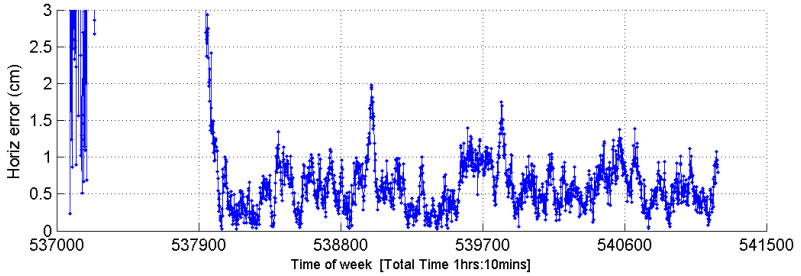
Horizontal Error over 1h 10m



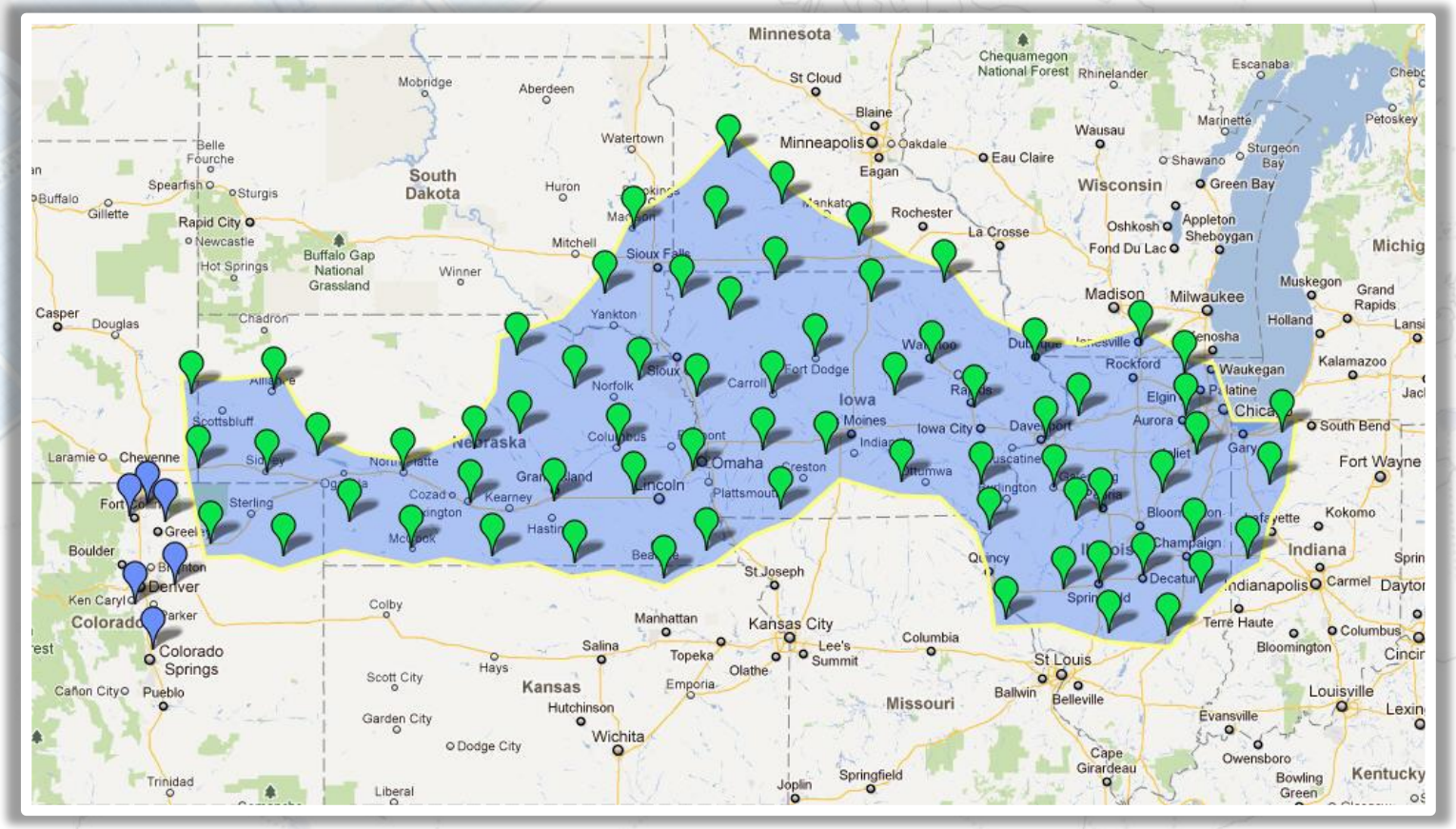
- Converged to better than 5 cm over 15 minutes
- 2D RMS after convergence: 7 mm

Ambiguity Convergence





Regional Augmentation (USA)

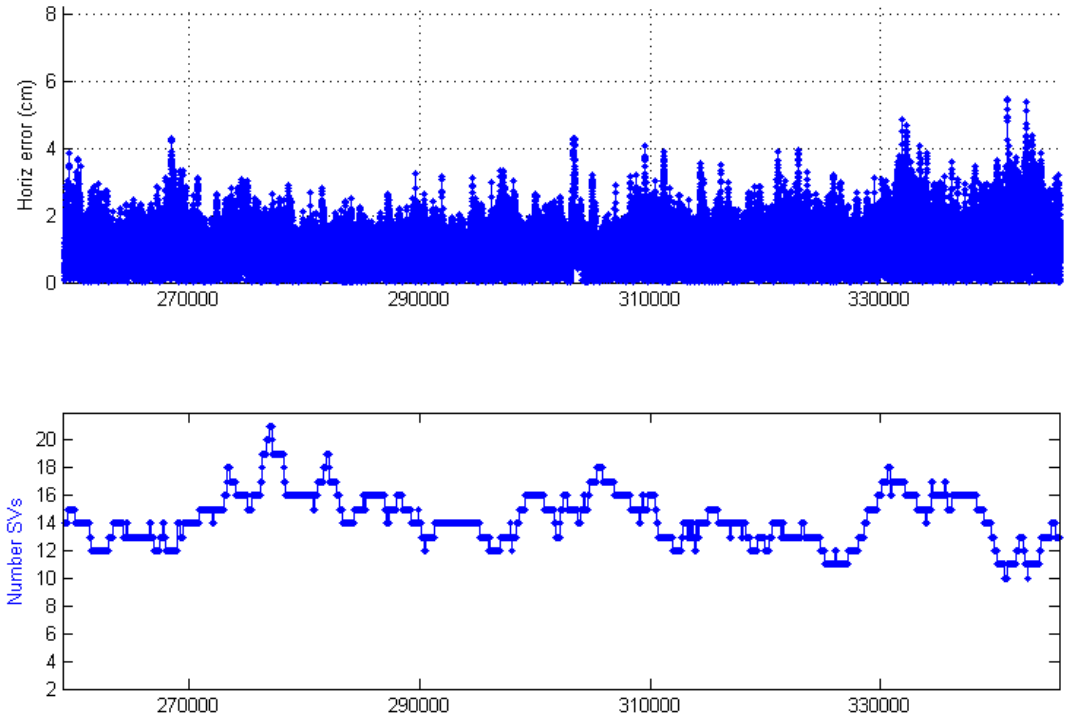


80 Stations, 1.3 times the size of Germany

Atmospheric models generated, TTF < 1 minute

Regional RTX Performance: 21 mm (95%)

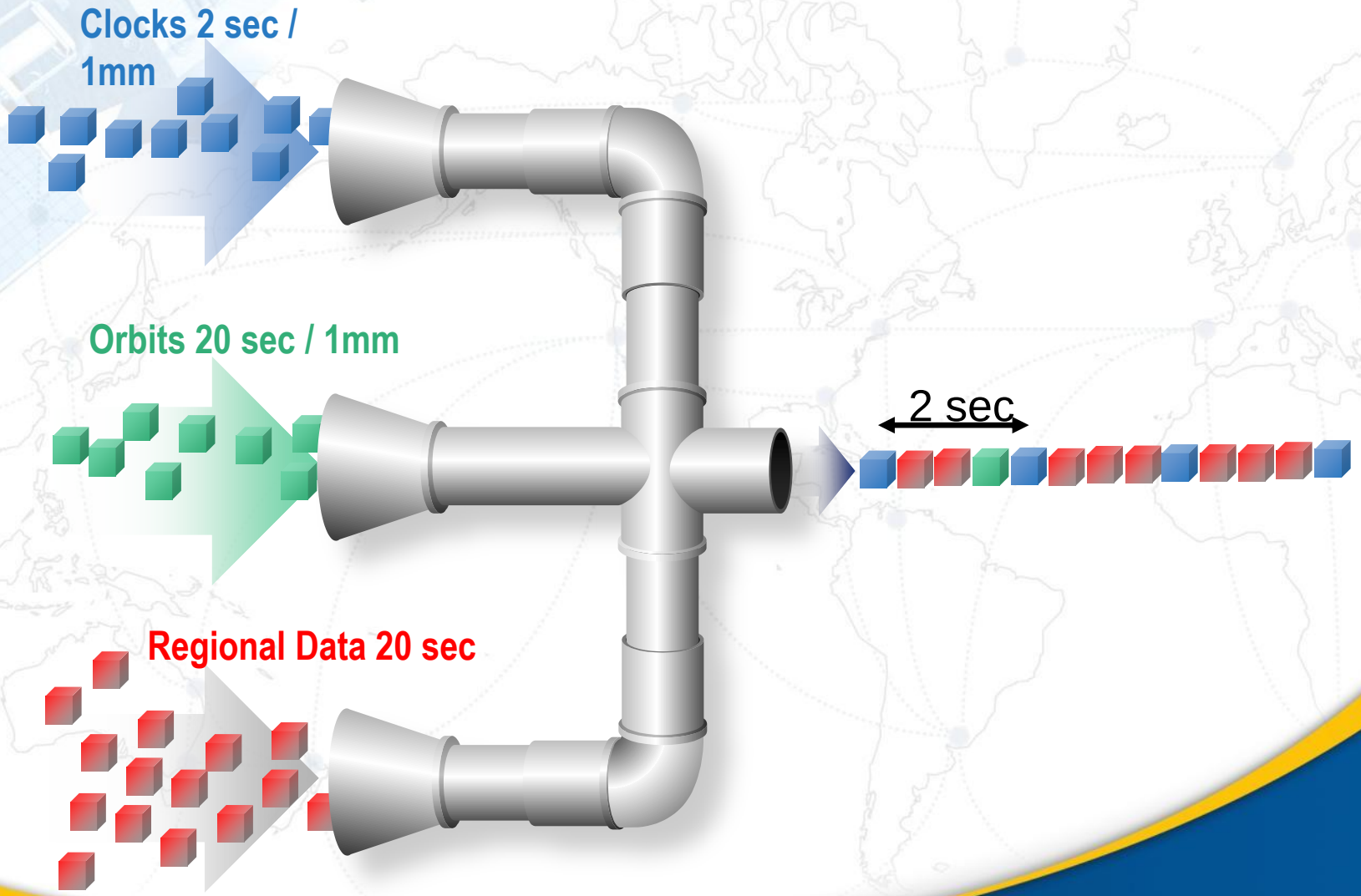
Jan 11, 2012, 24 hours - Chicago, Illinois



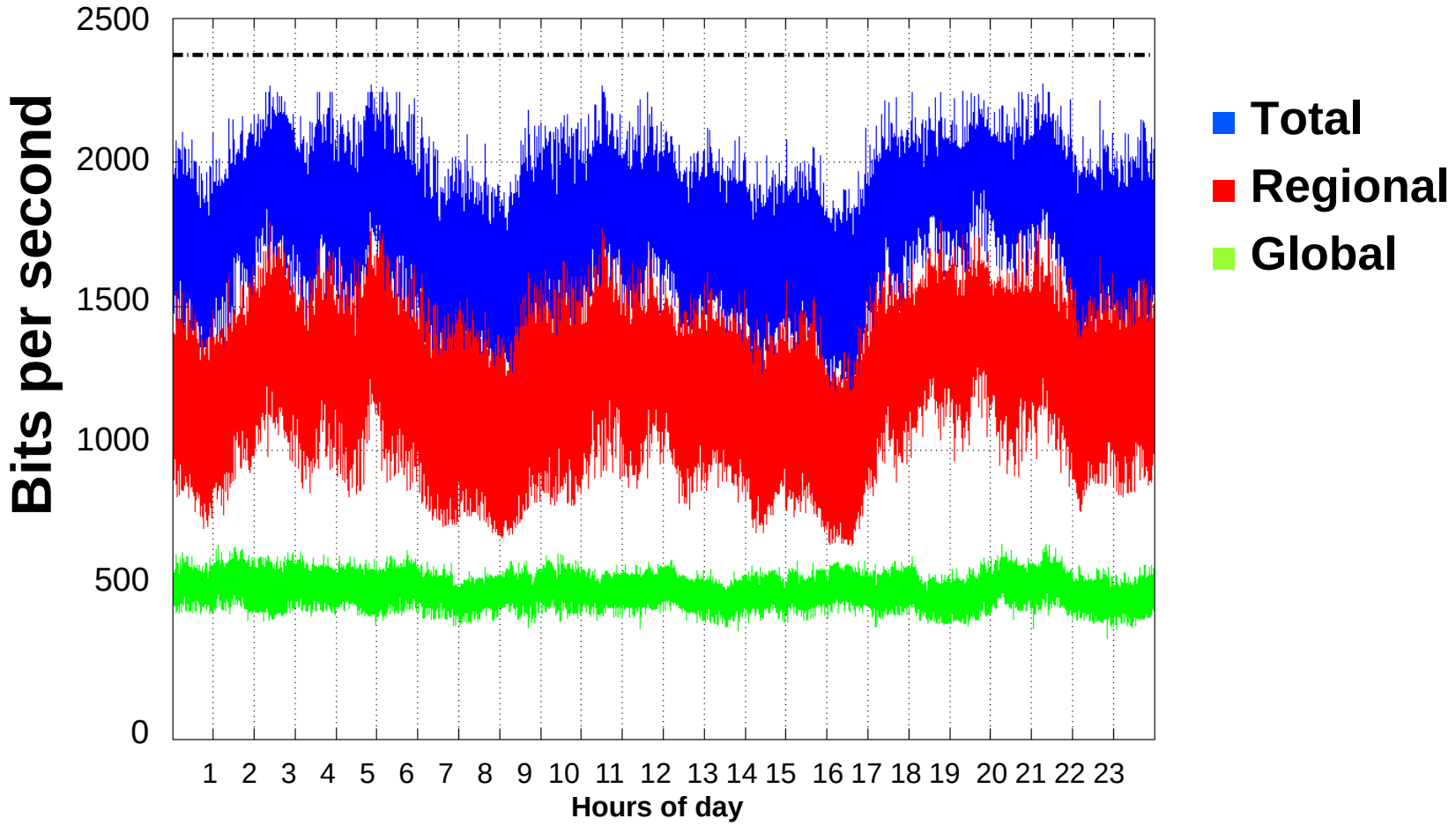
24 hours

Initialization in < 1 minute

RTX Data Stream via a 2400 baud L-Band Link



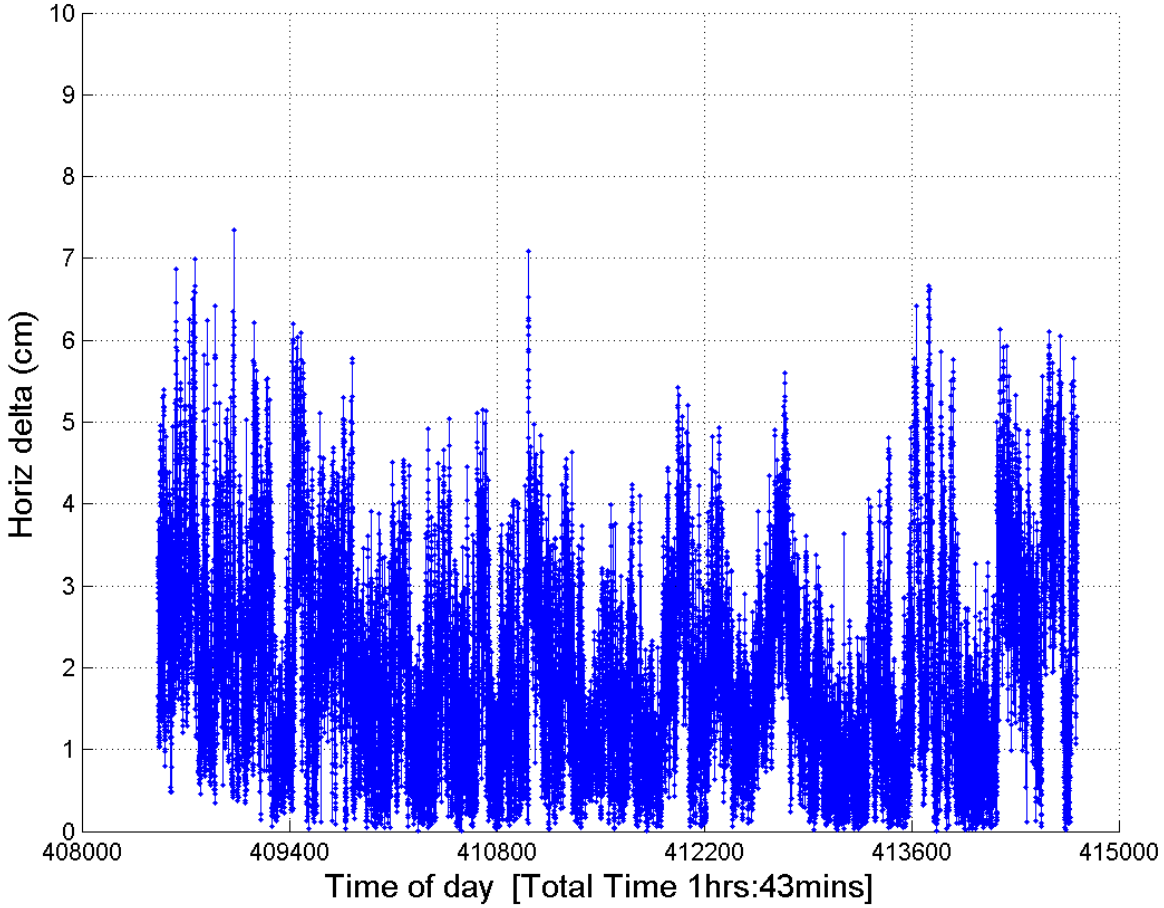
Bandwidth usage in L-Band Link GPS&GLONASS



Dynamic Tractor Test

- **Illinois, US**
- **103 minutes**

Dynamic Tractor Test Results



Comparing with short range RTK

2D RMS = 2.3 cm

95% = 4.2 cm

Outlook

- RTX Service available anywhere, anytime
- Desired availability (>99.9%)
- Provide system solutions for all Trimble markets

Precision Agriculture

Machine Control

Survey

GIS