TerraStar X: Precise Point Positioning with Fast Convergence and Integrity

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Assured Positioning - Anywhere

Land, Sea, and Air

NovAtel

NovAtel pioneers-end-to end solutions for assured positioning in a wide variety of industries

Safety Critical

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The Safety Critical Systems Group continually builds on the experience gained in the aviation industry to create solutions for safety-of-life applications, including autonomous vehicles

Marine Oil and Gas

veripos

Veripos provides the world's most accurate and efficient and best supported precise point positioning for marine oil and gas

GNSS Networks and Reference Stations

Leica Geosystems

Leica Geosystems is a leading provider of measurement solutions. Quality is what we live by in producing premium products and innovative solutions.

GNSS Software

GPS Solutions

GPS Solutions develops GNSS data analysis software for the most accurate and challenging applications

Antennas

ANTCOM

Antcom delivers leading edge design and production of antennas and microwave ancillary products for customers developing solutions for a variety of industries

Autonomy

AUTONOMOUSTUFF

AutonomouStuff provides the best R&D platforms, products, software and engineering services to aid in the advancement of robotics and autonomy.

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Correction Services

Introduction to TerraStar Global 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 L-band and IP with dual beam coverage
  - High accuracy, high availability real-time service

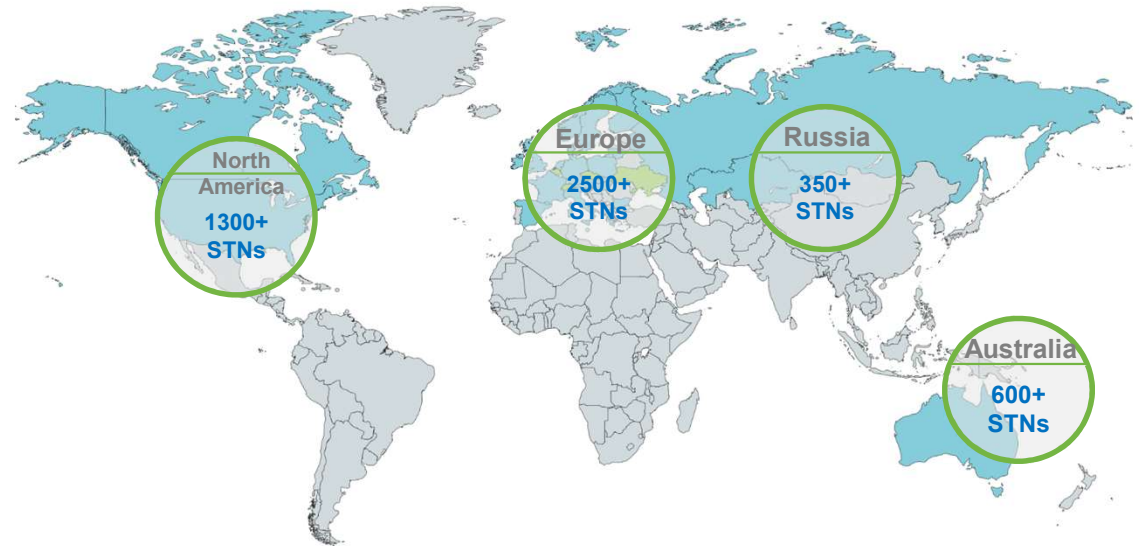- Used in professional applications, e.g. Precision Agriculture and Land Survey

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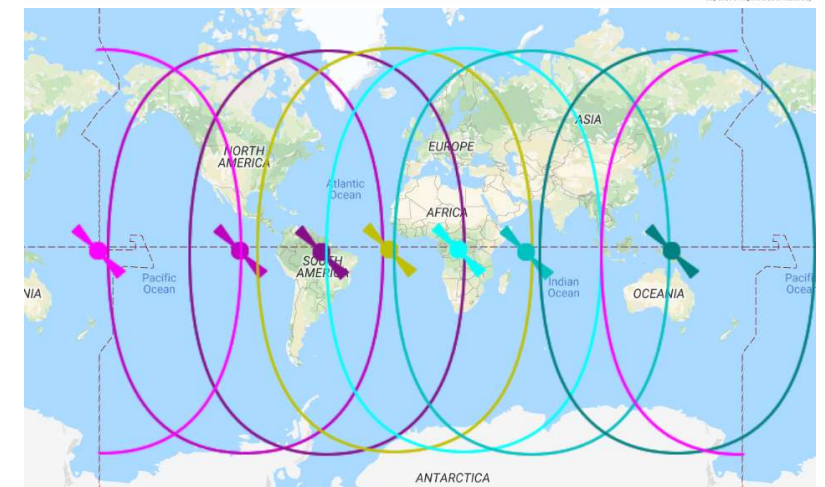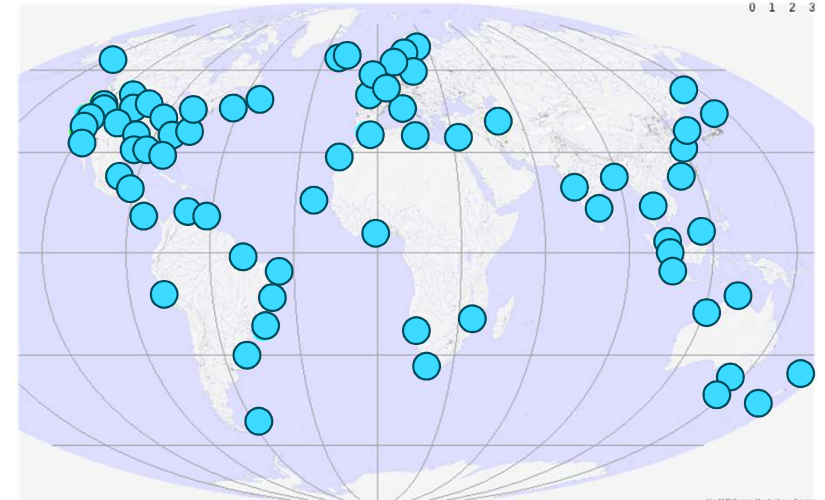
Correction Service Offerings

SERVICE LEVELS

PERFORMANCE	TerraStar-C PRO	TerraStar-C	TerraStar-L[1]
Horizontal Accuracy	2.5 cm (RMS) 3 cm (95%)	4 cm (RMS) 5 cm (95%)	40 cm (RMS) 50 cm (95%)
Vertical Accuracy	5 cm (RMS)	6.5 cm (RMS)	60 cm (RMS)
Convergence Time	< 18 min	< 45 min	< 5 min
Supported GNSS	GPS/GLO/GAL/BDS	GPS/GLO	GPS/GLO
Supported Platform	OEM7	OEM6	OEM7, OEM6

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HxGN **SmartNet**

- Cloud service to provide **centimeter accuracy** and 24/7 **availability**

- Over **4500 Reference Stations** world-wide

- Open standard GNSS correction for RTK positioning

- Over **13 years** of experience in the correction service market

- Based on the **Network Reference Station Technology** by Leica Geosystems

- Assured **traceability**

- **National reference frames** accessibility

North America
1300+ STNs

Europe
2500+ STNs

Russia
350+ STNs

Australia
600+ STNs

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TerraStar-X

RTK From the Sky™

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What is "X"?

- Combining global and regional solutions

- Regional solutions provide atmospheric information (ionosphere and troposphere)

- Providing precise ionosphere corrections to a rover can reduce convergence times from tens of minute to tens of seconds – near instantaneous ambiguity fixing

- Data delivered over L-Band

- Receivers track and use existing global corrections (TSC Pro) alongside the regional data for increased robustness and ability to transition out of fast-convergence region

New TerraStar-X™ Correction Service

TerraStar-X delivers RTK From the Sky performance – 2 centimeter accuracy in under a minute.

TSX Benefits through the Cornbelt

- **Speed:** converges in under a minute, significantly reducing wait time

- **Accuracy:** 2cm RMS horizontal accuracy; 2cm (sub-inch) pass-to-pass accuracy for agriculture applications

- **Reliability:** Network Control Center ensure over 99.9% availability.

- **Value:** No cellular plans needed

- **Peace-of-Mind:** no worrying about RTK network coverage and outages

- **Exclusive Services:** automatic fallback and seamless operation with existing TerraStar-C Pro services

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Datasheet for Correction Services

SERVICE LEVELS

PERFORMANCE	TerraStar-X	TerraStar-C PRO	TerraStar-C	TerraStar-L[1]
Horizontal Accuracy	2 cm (RMS) 2.5 cm (95%)	2.5 cm (RMS) 3 cm (95%)	4 cm (RMS) 5 cm (95%)	40 cm (RMS) 50 cm (95%)
Vertical Accuracy	5 cm (RMS)	5 cm (RMS)	6.5 cm (RMS)	60 cm (RMS)
Convergence Time	< 1 min	< 18 min	< 45 min	< 5 min
Supported GNSS	GPS/GLO	GPS/GLO/GAL/BDS	GPS/GLO	GPS/GLO
Supported Platform	OEM7	OEM7	OEM6	OEM7, OEM6
Coverage Area	Regional	Global	Global	Global

1. TerraStar-L is available on OEM628™, FlexPak6™, SMART6-L™, SMART2™ and all OEM7 products.

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Convergence Time Experience

TerraStar-X™
Delivers RTK From the Sky™

< 60 sec

1"
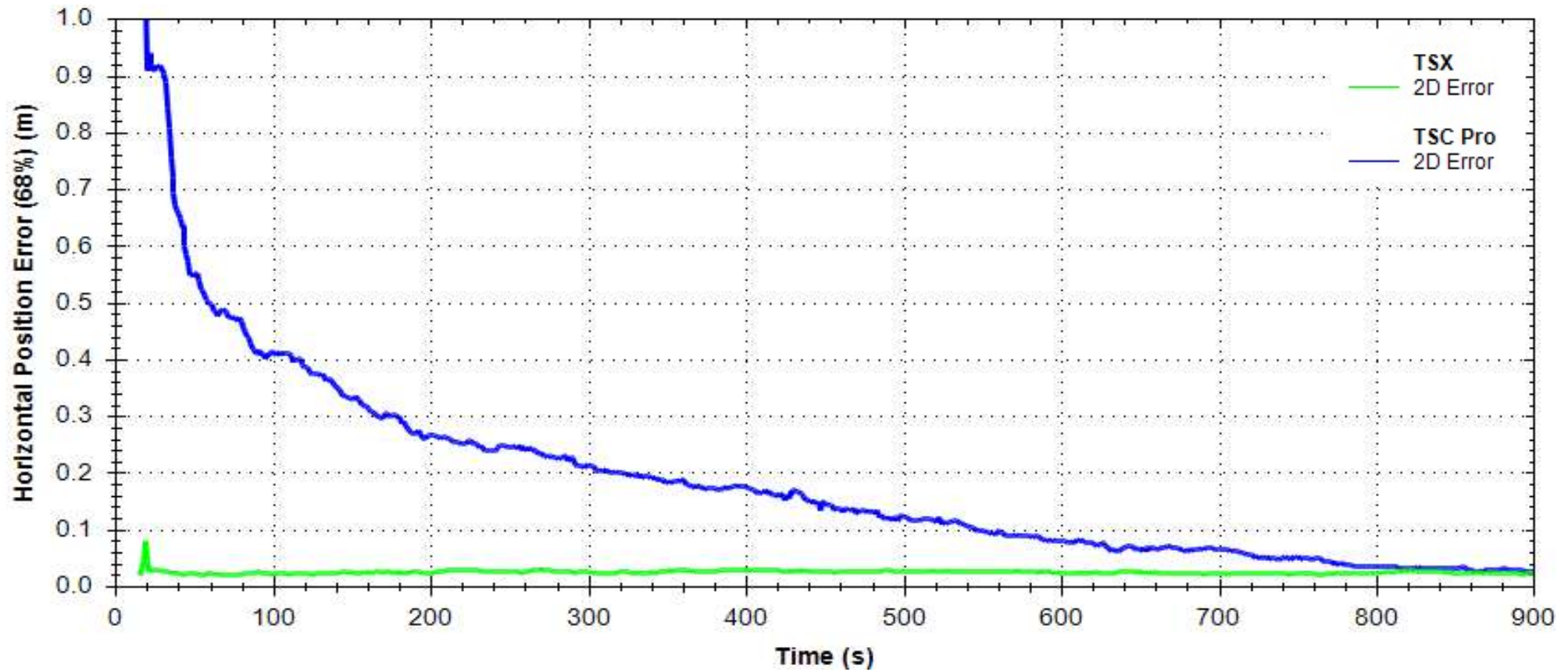
TSX in the Field
Data Samples

Corn Belt region in the US
- Static Convergence
- Open Sky and Headlands (end of planting field, edged with trees)
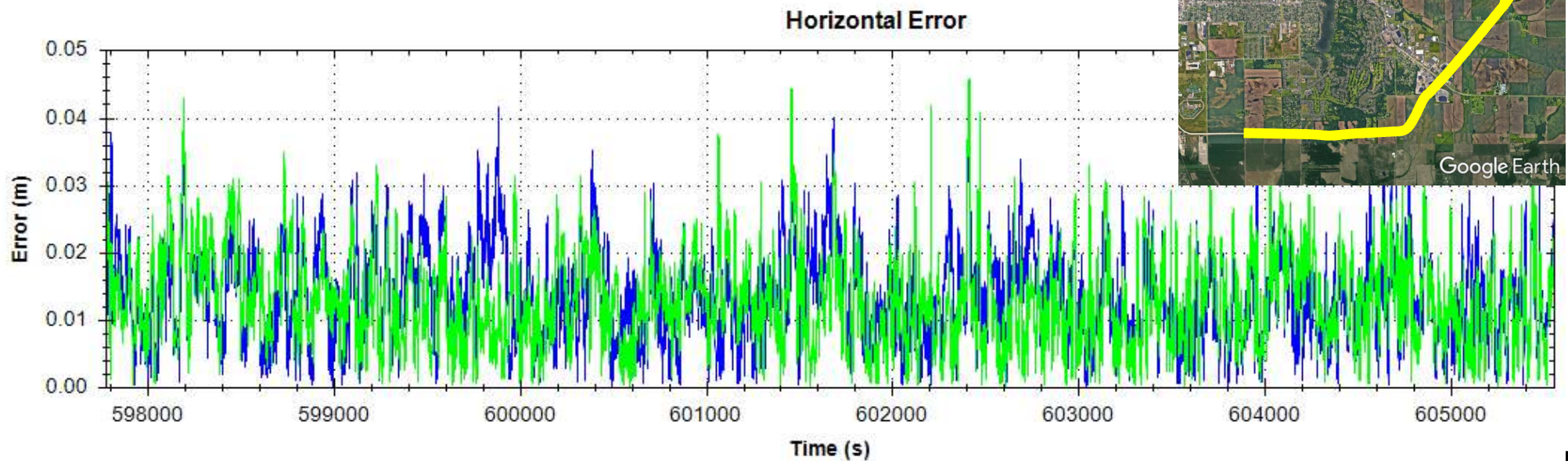- Outage Performance and Recovery

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Positioning Experience: Open Sky Example

TerraStar-X

Error (cm)	RMS	95%
Horizontal	1.5	2.5
Height	3.6	7.5

TerraStar-C Pro

Error (cm)	RMS	95%
Horizontal	1.5	3.0
Height	3.7	7.0

Horizontal Error

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Positioning Experience: Open Sky – Agriculture Headland Turns

TerraStar-X

Competitor A

Headlands Foliage
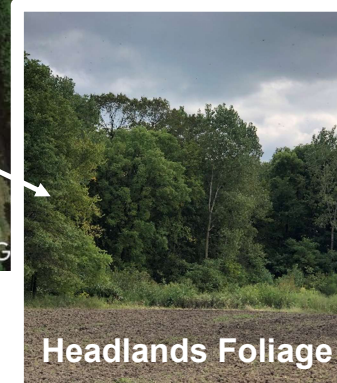
Positioning Challenge: Foliage

Environment

TerraStar-X

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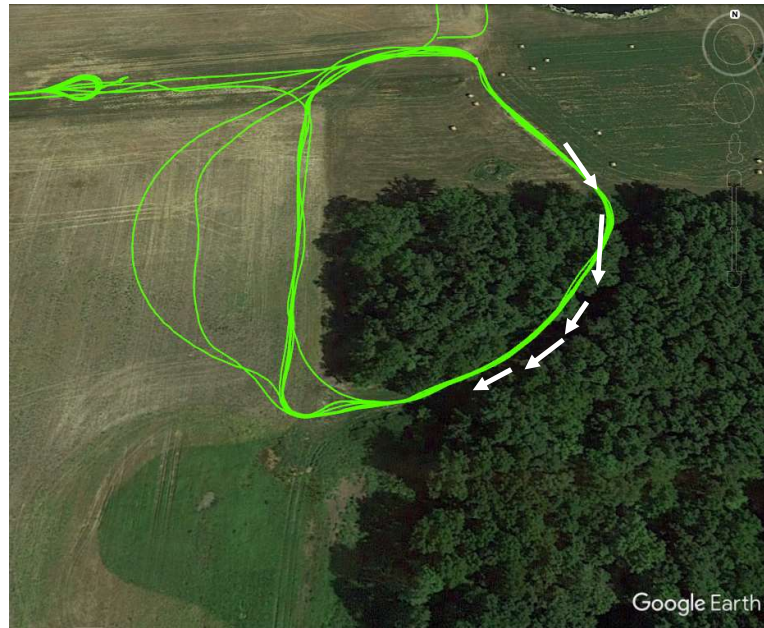
Positioning Experience: Open Sky Horizontal Error
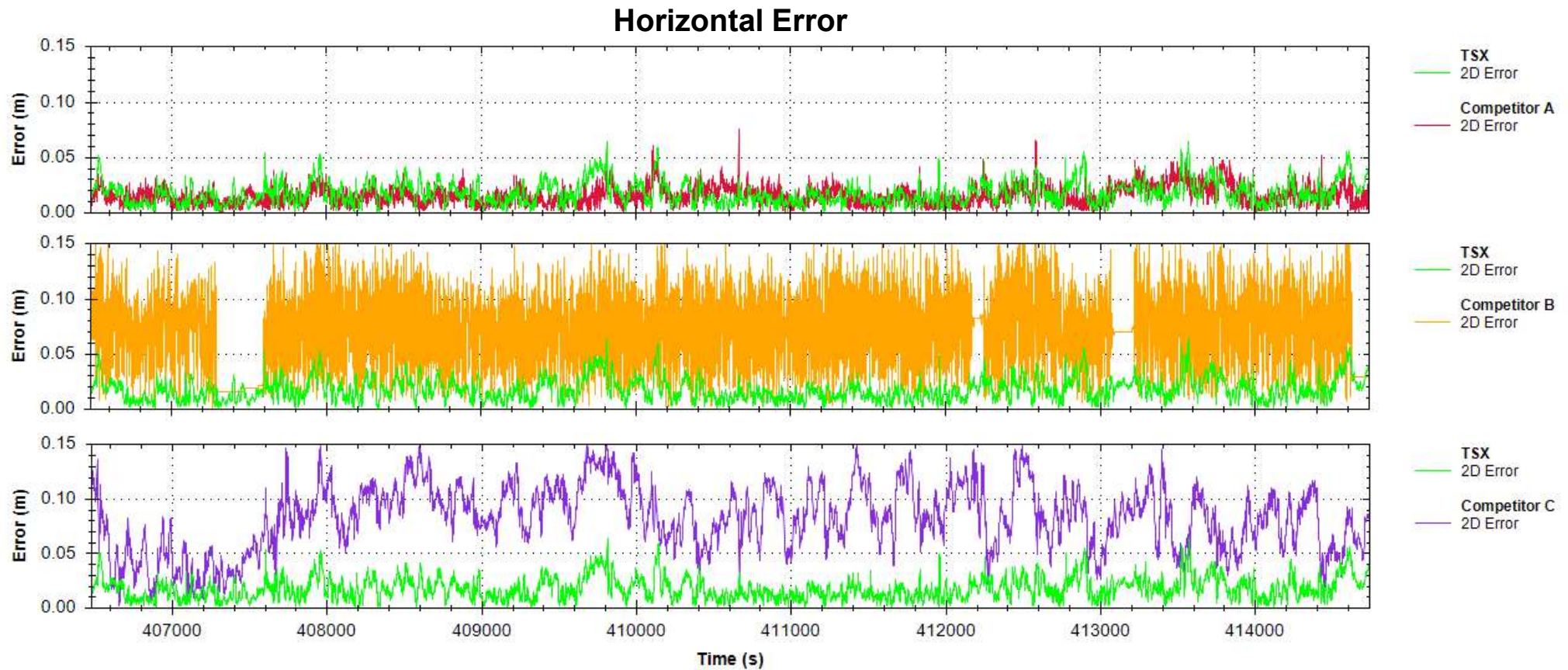
Horizontal Error

Convergence

Horizontal Error

Closer Look
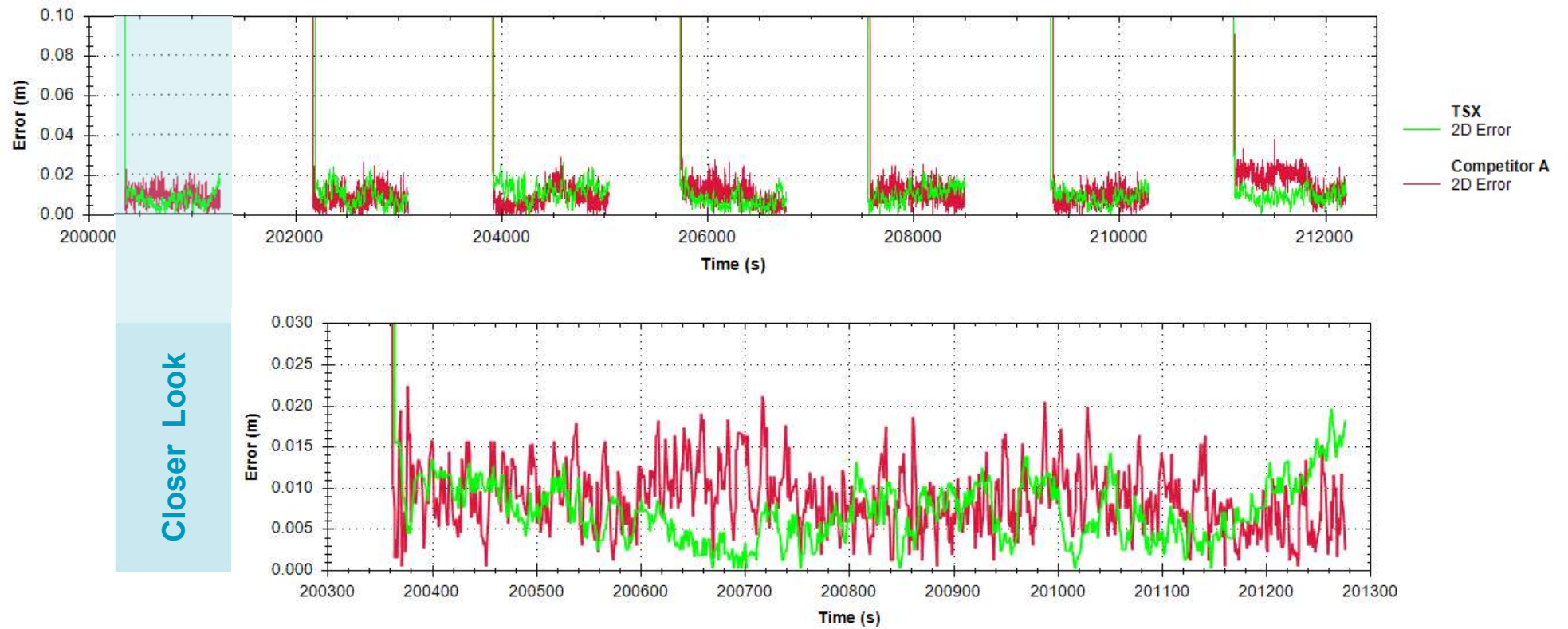
Positioning Challenge: GNSS Outage – Quonset Hut

TerraStar-X
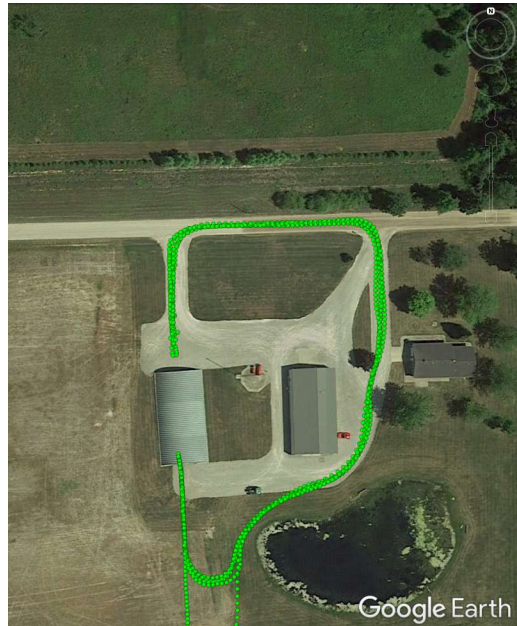
Automotive

Traditional Market vs High Volume with Functional Safety

- Priorities

- Operating Environment

- User Hardware
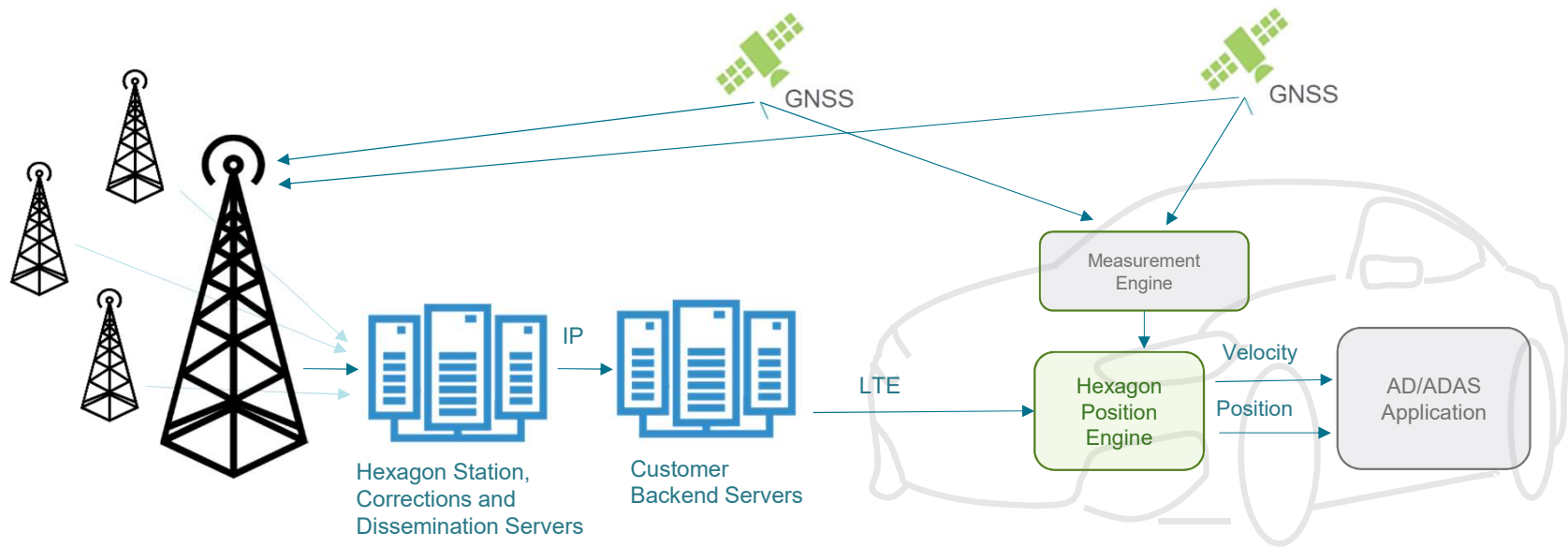
- Role of GNSS

- Data Delivery

Traditional Market vs High Volume with Functional Safety

- Priorities
  - Availability
  - Accuracy
  - Equipment Cost
  - Service Cost
  - Integrity/safety
- Operating Environment
  - Open sky or light obstruction
  - Low multipath
- User Hardware
  - Professional Grade Receiver and Antenna
  - Multi constellation and multi-frequency
- Role of GNSS
  - Primary or only position sensor
- Data Delivery
  - LBand primary, IP secondary
  - Broadcast only (1-way)
  - Unit specific subscription controls
  - Very limited bandwidth

- Priorities
  - Integrity/safety
  - Equipment Cost per unit
  - Availability
  - Service Cost
  - Accuracy
- Operating Environment
  - From open sky to urban canyon, though focus open highway first
  - Low to moderate multipath
- User Hardware
  - Low-cost Receiver and Antenna
  - Dual frequency dual constellation best case
- Role of GNSS
  - One part of a multi-sensor and system for positioning and proximity sensing
- Data Delivery
  - IP primary
  - Broadcast primary but 2-way comms possible
  - Block/fleet activation
  - Authentication and Encryption

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Automotive Test Areas

Overall Positioning System Concept

GNSS

GNSS

Measurement
Engine

Hexagon Station,
Corrections and
Dissemination Servers

IP

Customer
Backend Servers

LTE

Hexagon
Position
Engine

Velocity

Position

AD/ADAS
Application

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Kinematic Setup

- System was setup in the back of a vehicle

- Antennae were magnetically mounted to the vehicle roof

- Environments analyzed:
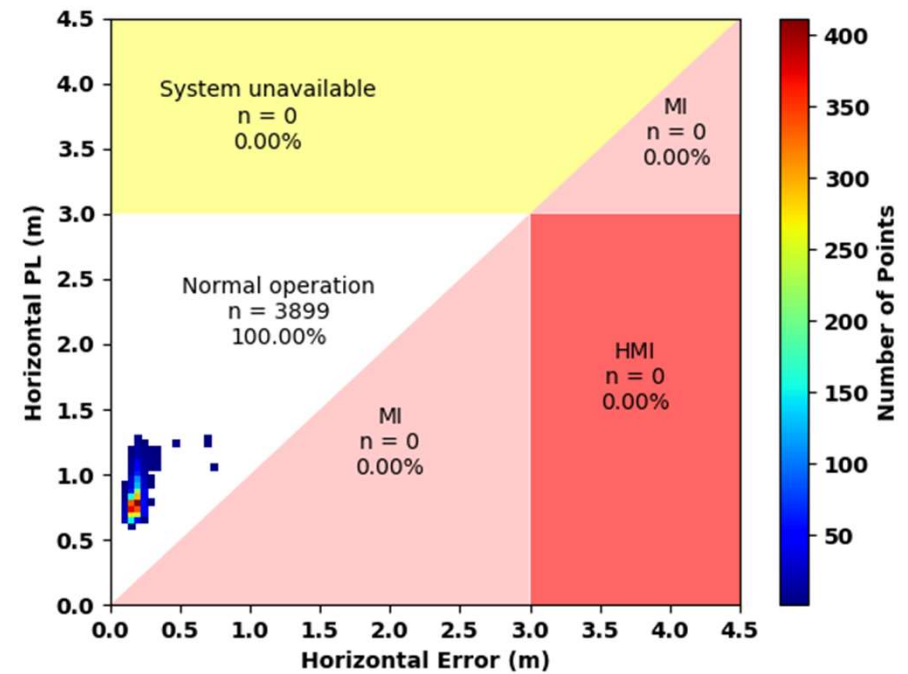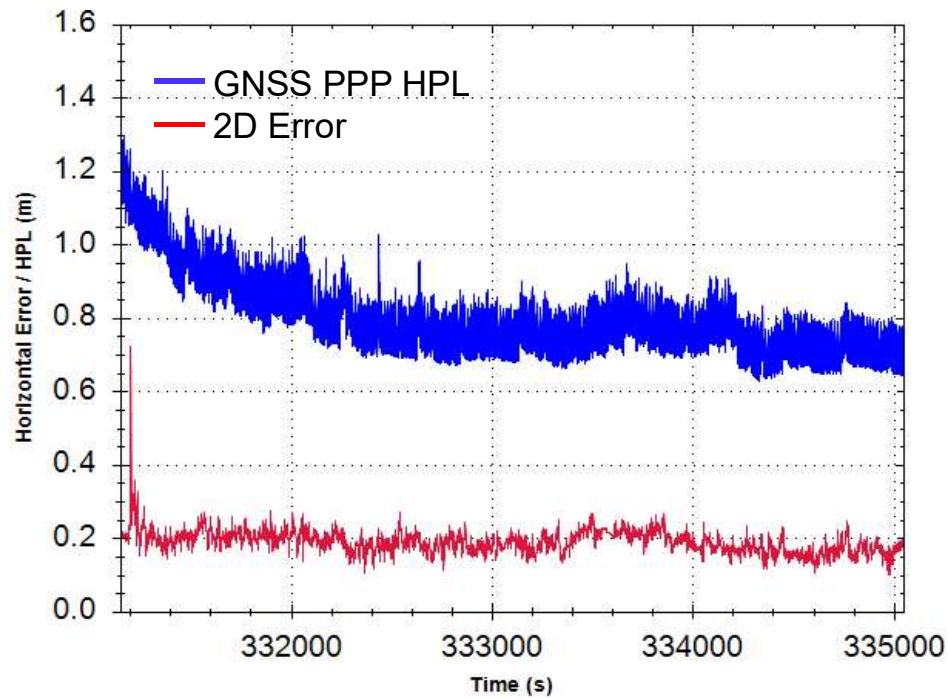 - Open sky
  - Highway/Suburban

Kinematic Performance – Open Sky Trajectory

- Industrial district north of Calgary airport
- Mix of 1-2 storey warehouses, controlled access freeway

Photo credits: Google Earth, Google Streetview

Kinematic Performance – Open Sky Results

Percentile	50	68	95
2D Error (m)	0.19	0.20	0.23
HPL (m)	0.78	0.83	1.04

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More Positioning Results

See Norman, L., "Integrity Performance for Precise Positioning in Automotive" (Session C4)

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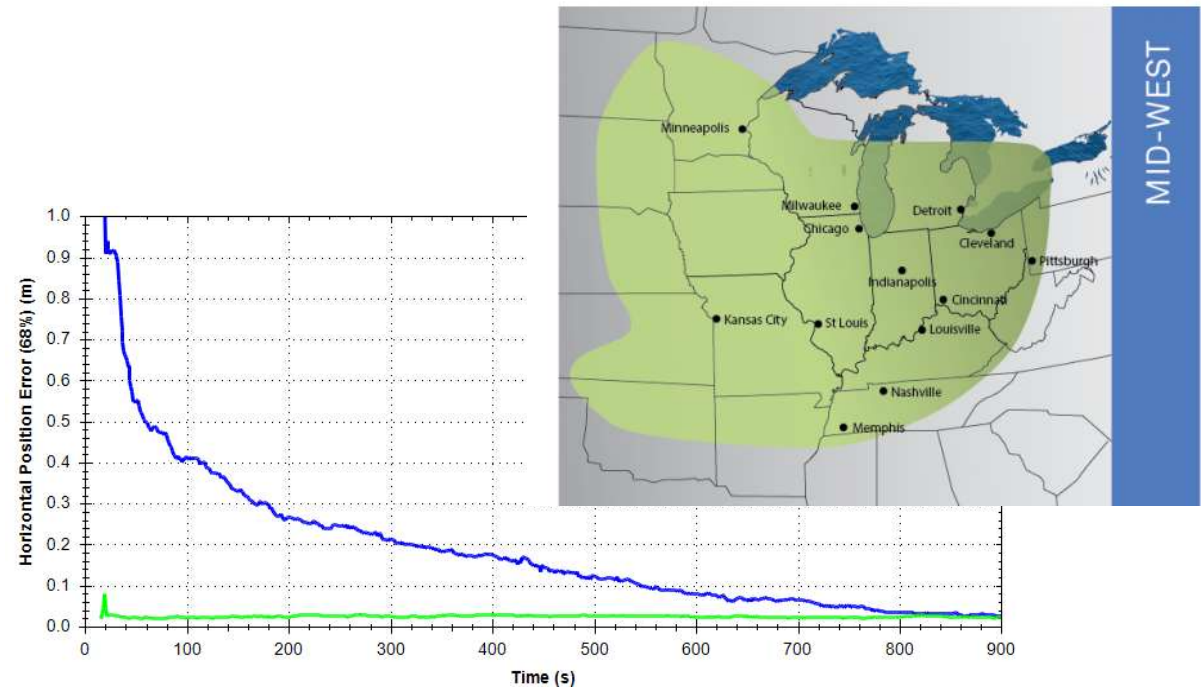POSITIONING INTELLIGENCE

Conclusions

- TerraStar X out now

TerraStar-X

Error (cm)	RMS	95%
Horizontal	1.5	2.5
Height	3.6	7.5

TerraStar-C Pro

Error (cm)	RMS	95%
Horizontal	1.5	3.0
Height	3.7	7.0

- Automotive demonstrations are available
- For detailed integrity results, see Norman, L., "Integrity Performance for Precise Positioning in Automotive" (Session C4)