SNAP Lab

UNSW THE UNIVERSITY OF NEW SOUTH WALES

Locata: Serving Those Positioning, Navigation & Timing (PNT) Applications That GNSS Can Not

Never Stand Still

School of Civil & Environmental Engineering, UNSW, Sydney, Australia

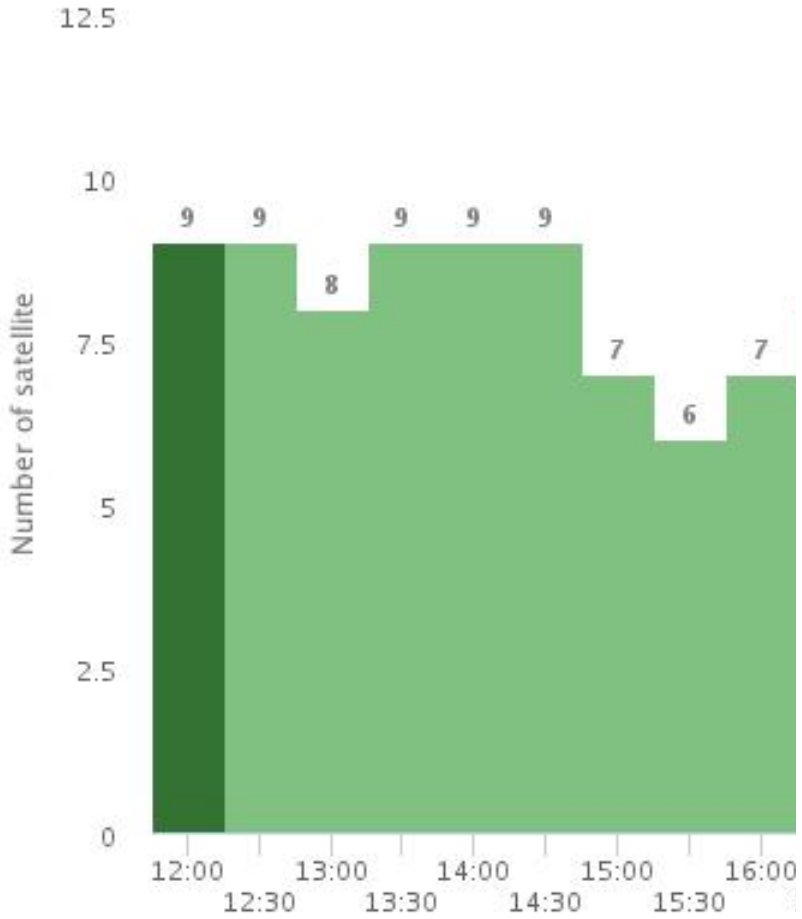
Chris Rizos

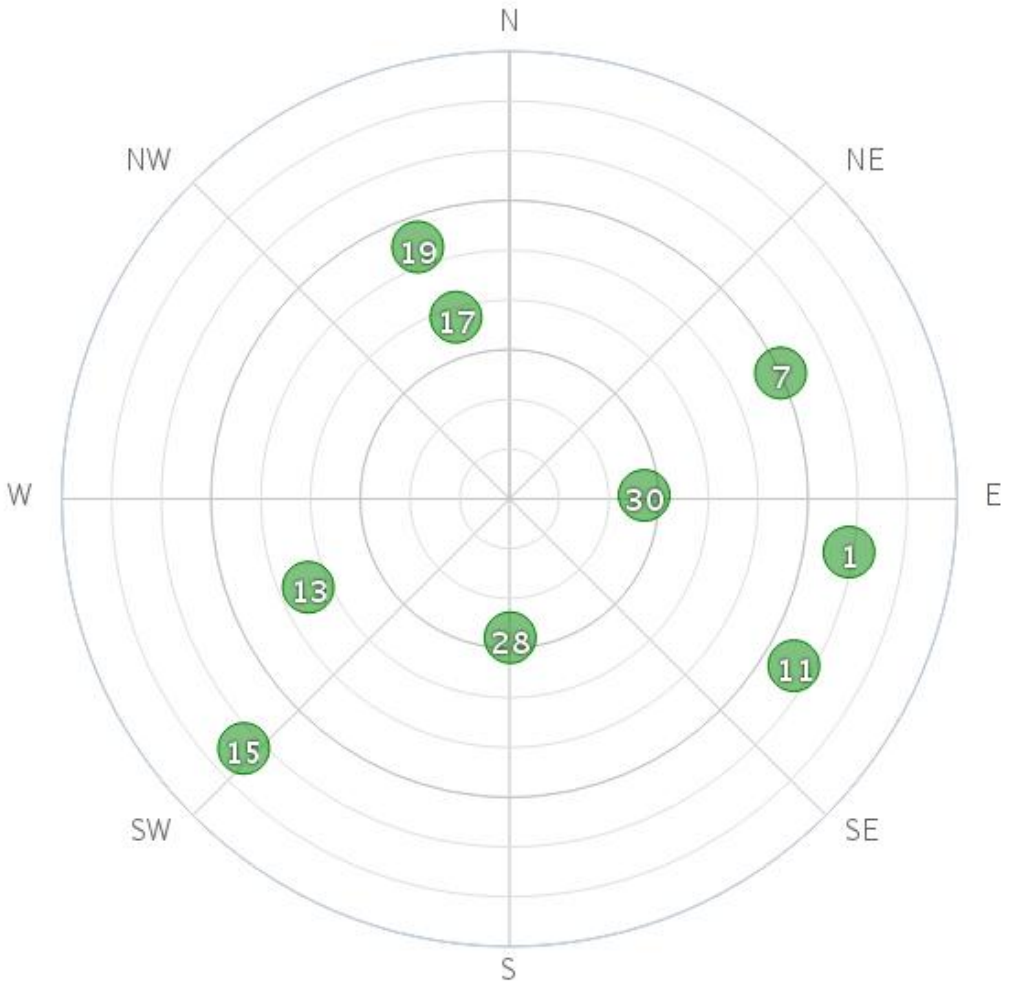
Introductory remarks…*GNSS*

- U.S.'s GPS has been a fully operational GNSS since 1995
- Russia's GLONASS system is fully operational
- EU's Galileo and China's BeiDou are currently in deployment phases, nearing completion
- Many economically valuable industries in Australia are reliant on augmented GNSS to deliver gains in productivity
- Sophisticated DGNSS techniques can now deliver cm-level accuracy, in real-time, for precision navigation & guidance applications
- There will be an expansion of applications that require Precise Positioning
- *GNSS cannot address PNT requirements in many environments where it is increasingly needed...*

GPS visibility: *Sydney*

10deg elev, 7 December 2016

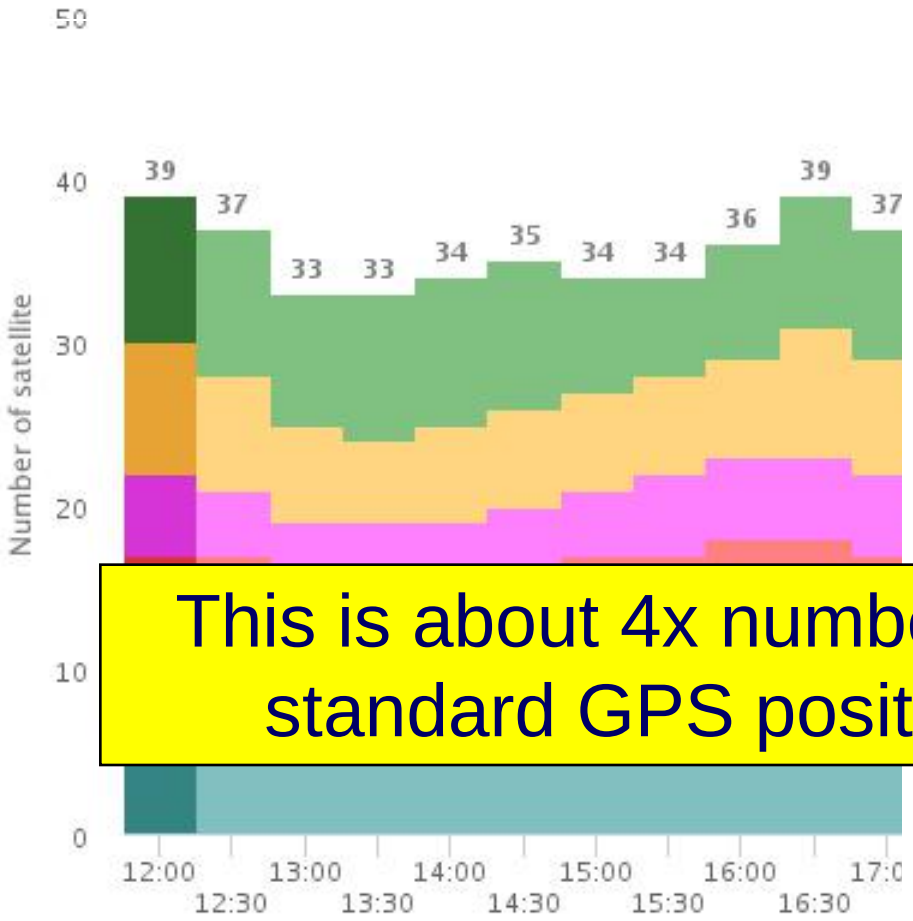


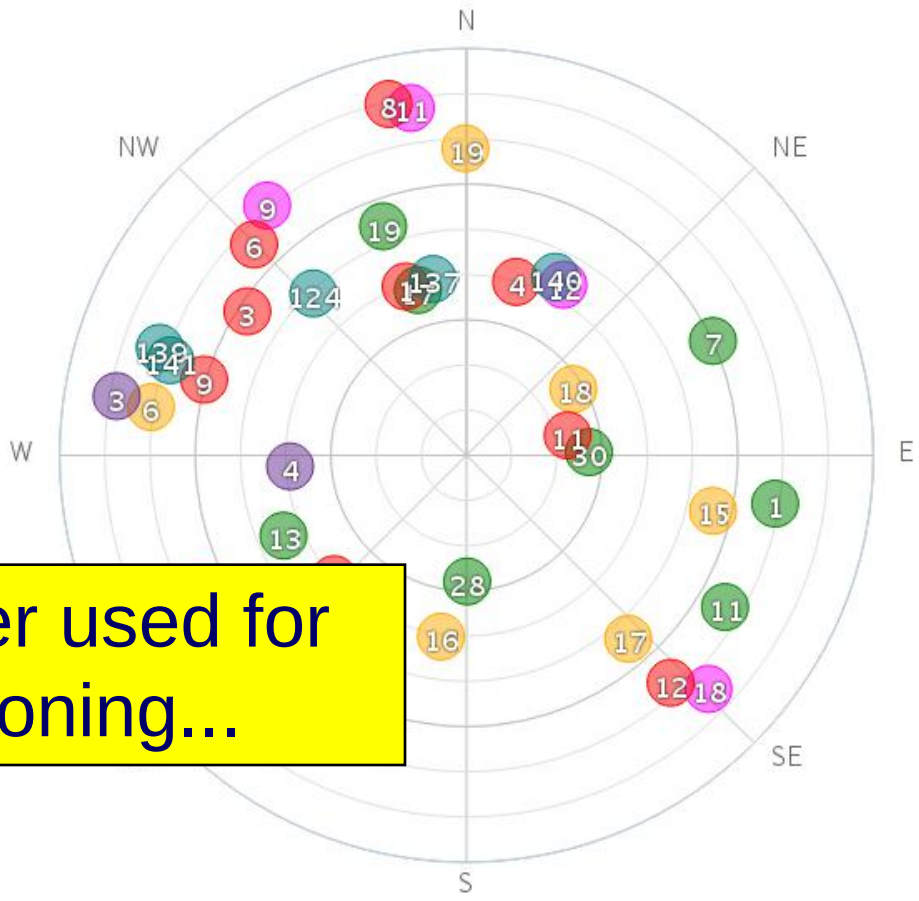


http://www.taroz.net/GNSS-Radar.html

GNSS visibility: *Sydney*

10deg elev, 7 December 2016

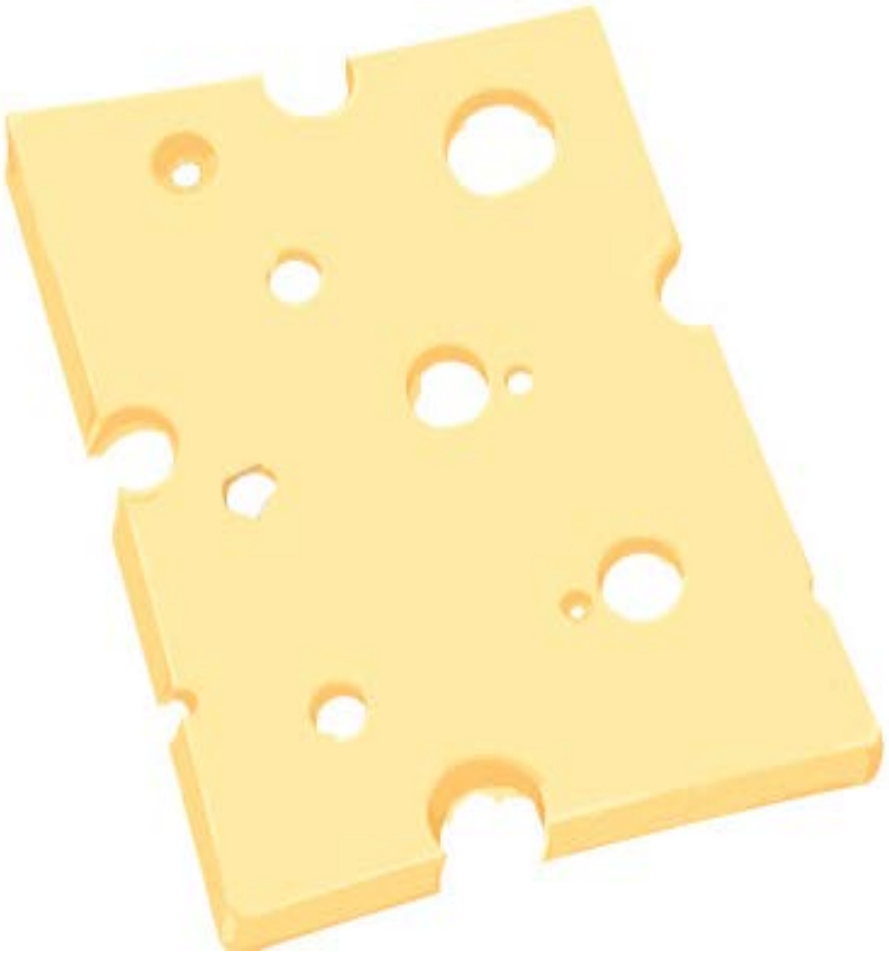




This is about 4x number used for standard GPS positioning...

GPS(9) GLO(8) GAL(5) BDS(10) QZS(0) IRNS(2) SBS(5)

http://www.taroz.net/GNSS-Radar.html



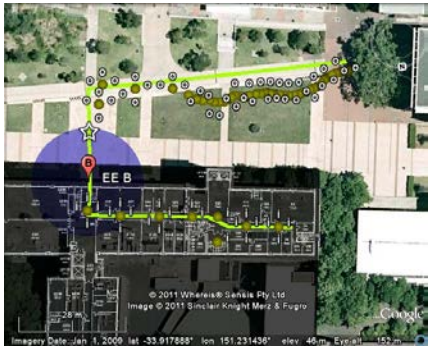
“But...

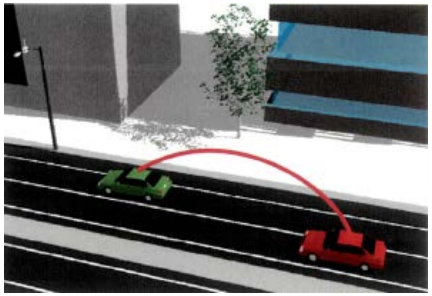
GNSS is like Swiss cheese…

… it’s full of holes”

Nunzio Gambale
Locata Corp

Non-GNSS solutions?... *which one?!*





- There is no shortage of non-GNSS engineering options
- Some technology options:
  - “signals-of-opportunity”
  - bespoke ranging systems
  - autonomous (non-signal) systems
- Some are appropriate for mass market applications
- Few can provide high accuracy PNT capability for pedestrian or vehicle applications
- ***Locata*** *is one such solution... considerable media interest*

GPS WORLD

GNSS POSITION NAVIGATION TIMING

GNSS Almanac

Constellation Data

WWW.GPSWORLD.COM

NEW TRUTH vs. JAMMING

Ultra High-Accuracy Reference System

The August 2016 edition of GPS World Magazine contains a Front Cover feature article written by the US Air Force 746 Test Squadron, the US military's Centre of Excellence for GPS. In this article the 746TS describes the superb performance of their new Truth Reference System, now deployed operationally at the White Sands Missile Range. This "New Truth" is considered to be the best radio positioning system in the world. The core enabling technology which creates this new benchmark is the network designed and installed by Locata for the USAF at White Sands. *Even when GPS is being completely jammed*, the new Locata-based system continues to provide the USAF with cm-level positioning and nanosecond synchronization in the total absence of GPS.

ION GNSS+ PREVIEW

GALILEO AND THE BREXIT

POKÉMON GO!

A NORTH COAST MEDIA PUBLICATION

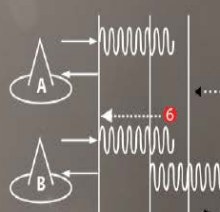
AUGUST 2016 | Vol 27 | No 8

WWW.GPSWORLD.COM

GPS World

THE BUSINESS & TECHNOLOGY OF GNSS

OCTOBER 2015



JUST IN TIME: PICOSECONDS!

BETTER SYNCH FOR BOOMING WIDEBAND

+ INTERGEO AND ION PRODUCT SHOWCASE
+ LANDFORMING IN PRECISION AG
+ NEW GNSS NAV MESSAGE FOR FAST TTFF

Locata's TimeLoc developments, independently tested in Washington DC by the US Government, makes for a seminal Front Cover article in the most widely read magazine in the industry - October 2015

WWW.GPSWORLD.COM
GPS World
THE BUSINESS & TECHNOLOGY OF GNSS
AUGUST 2013

UAV/UGV
TARGET ROBOT TAKES A HIT FOR SAFETY

PLUS
DETECTING UNDERGROUND NUCLEAR EXPLOSIONS
PRODUCT SHOWCASE
GNSS ALMANAC

Photo Brian Geiger.

Robot: Target on Its Back

Two Autonomous Vehicles Seek Safe Avoidance in Critical Tests

A new state-of-the-art research center runs car-makers' safety systems through their paces, in tandem with a soft-target robot that can be crash-impacted without adverse effects. Precise positioning and exact repeatability of test sequences are key criteria.

Paul Perrone, *Perrone Robotics*

The Insurance Institute for Highway Safety has undertaken a $30 million expansion project at its Vehicle Research Center near Washington, D.C., enlarging and enhancing a state-of-the-art vehicle test track and building a new 700 x 300-foot (213 x 91-meter) covered track for weather-resistant testing.

The VRC will use new robotic and positioning technologies to achieve required levels of precision and repeatability for vehicle testing of frontal collision avoidance and other safety systems. Tests of both the same and different vehicles must be conducted under identical, controlled conditions for the results to have comparable fidelity.

Crash tests and research conducted at the VRC help drive life-saving improvements in vehicle designs. The new facility will enable staff to evaluate emerging automated vehicle technology in commercial vehicle systems intended to prevent crashes or lessen their severity, with the goal of encouraging the entire industry to adopt the most effective new features.

Safety systems in vehicles to be tested include the following:

- Adaptive cruise control
- Collision-imminent braking
- Lane-departure warning/correction
- Other automated technologies.

Such functions represent semi-automated functions aboard vehicles now on the road. The system is also designed to address and test the full spectrum of semi- to fully-automated vehicles, addressing evolving levels of autonomy and ultimately producing driverless vehicle technology.

IIHS has contracted Perrone Robotics, Inc. (PRI), to deliver a robotic system for testing such vehicles. PRI develops new applications using its MAX robotics and suite of automation software building blocks. MAX enables rapid integration of a range of sensor and actuator types and has evolved with several frameworks, including MAX-UGV for unmanned ground vehicles. PRI has used MAX-UGV to build automated passenger cars, all-terrain vehicles, tractors, custom platforms, and rockstar Neil Young's long-range electric LincVolt, a converted 1959 Lincoln Continental.

Synchronized Ground Networks Usher in Next-Gen GNSS

Locata Fills Satellite Availability Holes in Obstructed Environments

Chris Rizos, Nunzio Gambale, and Brendon Lilly

An integrated GNSS+Locata system installed on drills, shovels, and bulldozers — the full complement of high-precision machines on site — at Australia's Newmont Boddington Gold Mine has increased positioning accuracy and availability, as well as mine operational efficiencies, demonstrating an improvement in availability over GNSS-only of 75.3 to 98.7 percent.

Many of the new paradigms in mining have at their core the requirement for reliable, continuous centimeter-level positioning accuracy to enable increased automation of mining operations. The deployment of precision systems for navigating, controlling, and monitoring machinery such as drills, bulldozers, draglines, and shovels with real-time position information increases operational efficiency, and the automation reduces the need for workers to be exposed to hazardous conditions.

GPS singly, and GNSS collectively, despite their accuracy and versatility, cannot satisfy the stringent requirements for many applications in mine surveying, and mine machine guidance and control. Increasingly, open-cut mines are getting deeper, reducing the sky-view angle necessary for GNSS to operate satisfactorily.

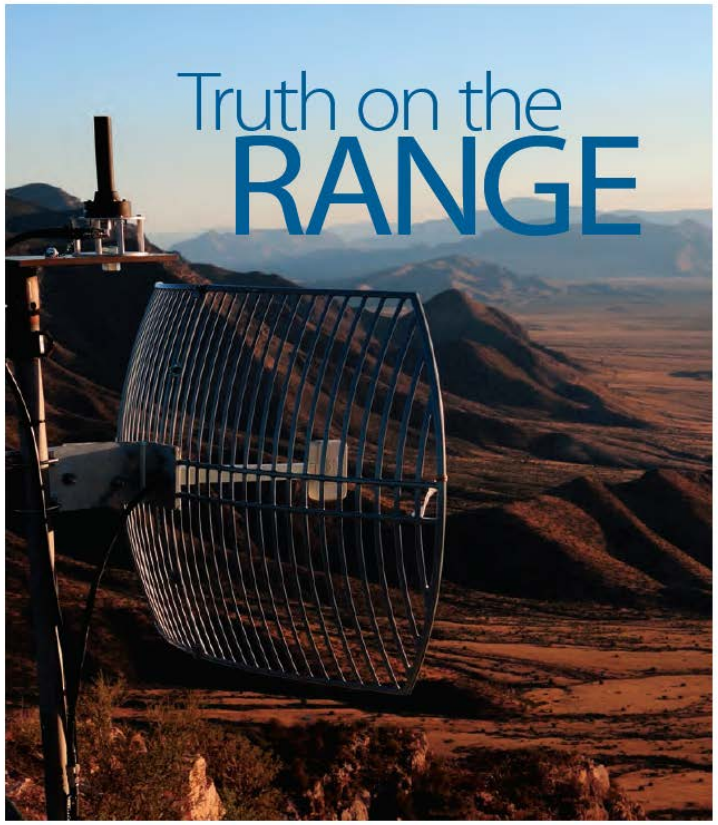
A new terrestrial high-accuracy positioning system can augment GNSS with additional terrestrial signals to enable centimeter-level accuracy, even when there are insufficient

▲ **LOCATALITE INSTALLATION** showing Jps transceiver tower.

May/June 2012 | Engineering Solutions from the Global Navigation Satellite System Community | www.insidegnss.com

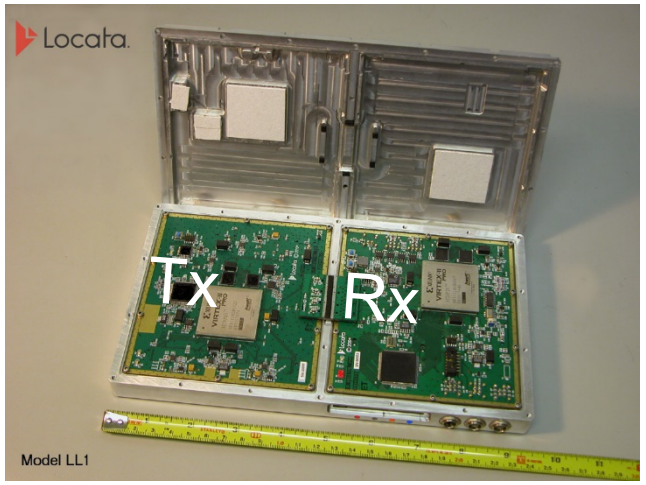
InsideGNSS

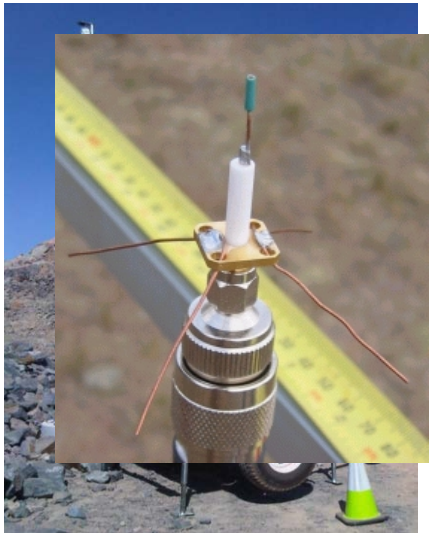
GPS | GALILEO | GLONASS | COMPASS

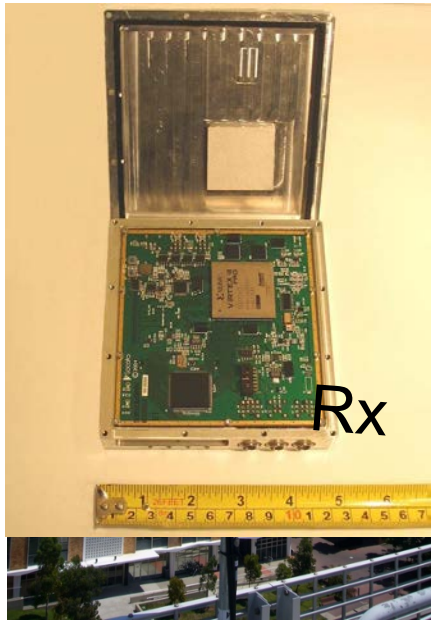


Locata components...

- Signal Structure
  - Licence-free ISM frequency band (2.4GHz)
  - Dual-frequency carrier signals
  - CDMA PRN codes
  - Precise TDMA pulsing
  - >1 Watt output power - *range of over 10's km*
- *LocataLite*
  - Time-synchronised transceiver network
  - Dual Tx antennas
  - Uses low-cost clock, shared by receiver section
  - Network time is "relative" to master LL
- *Locata Receiver*
  - CPH or PR single point-positioning
  - CPH requires ambiguity resolution
  - Real-time positioning at 10Hz

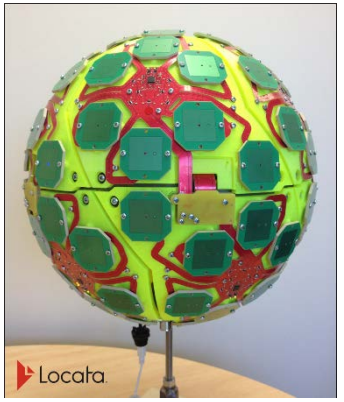




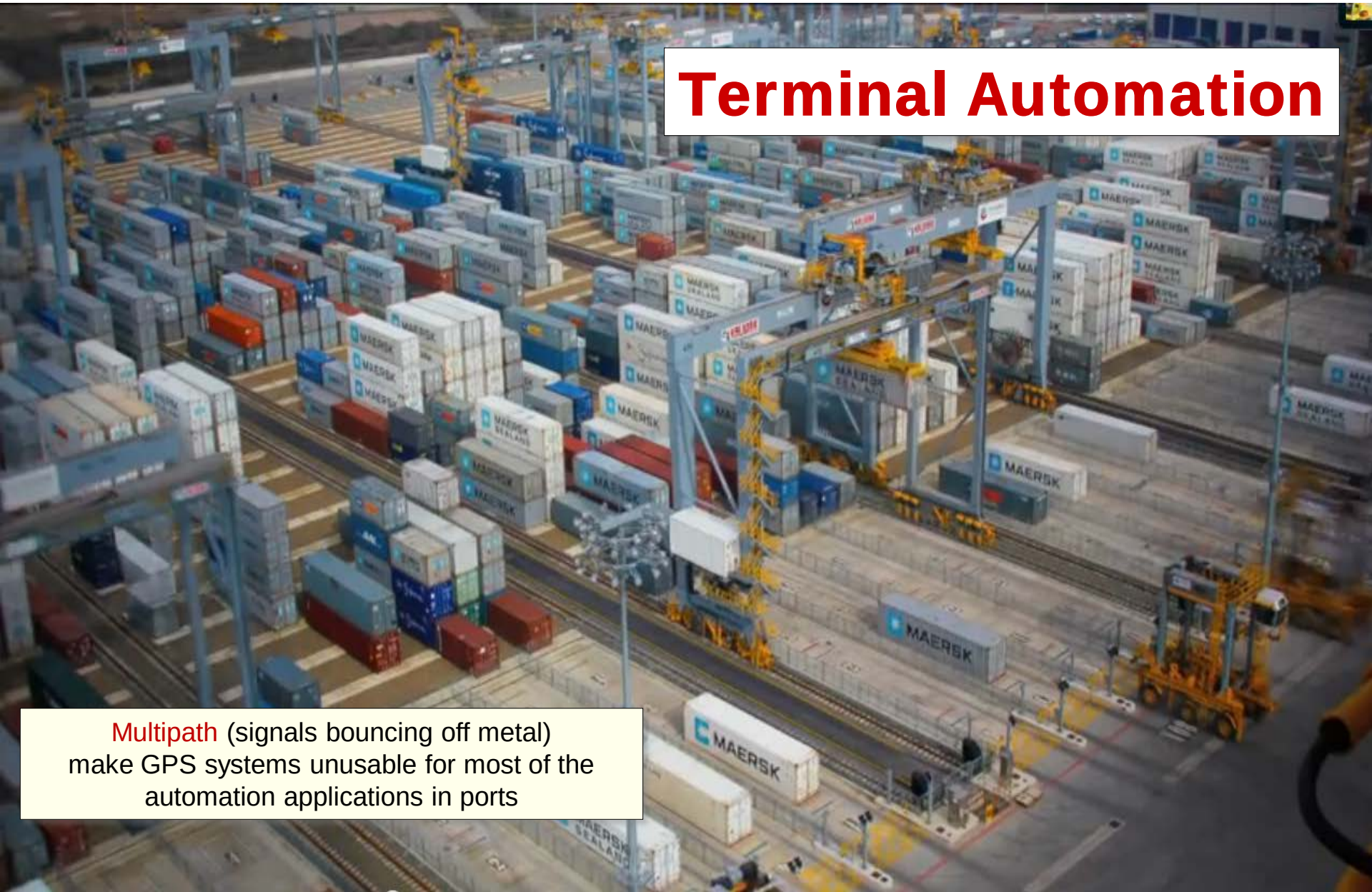


Locata deployments & tests... *over the last few years...*

- Static Deformation Monitoring
- GNSS+Locata Open-Cut Mine Positioning
- Static & kinematic Indoor/Outdoor Positioning
- Multi-Sensor Positioning
- Timing & Time Transfer

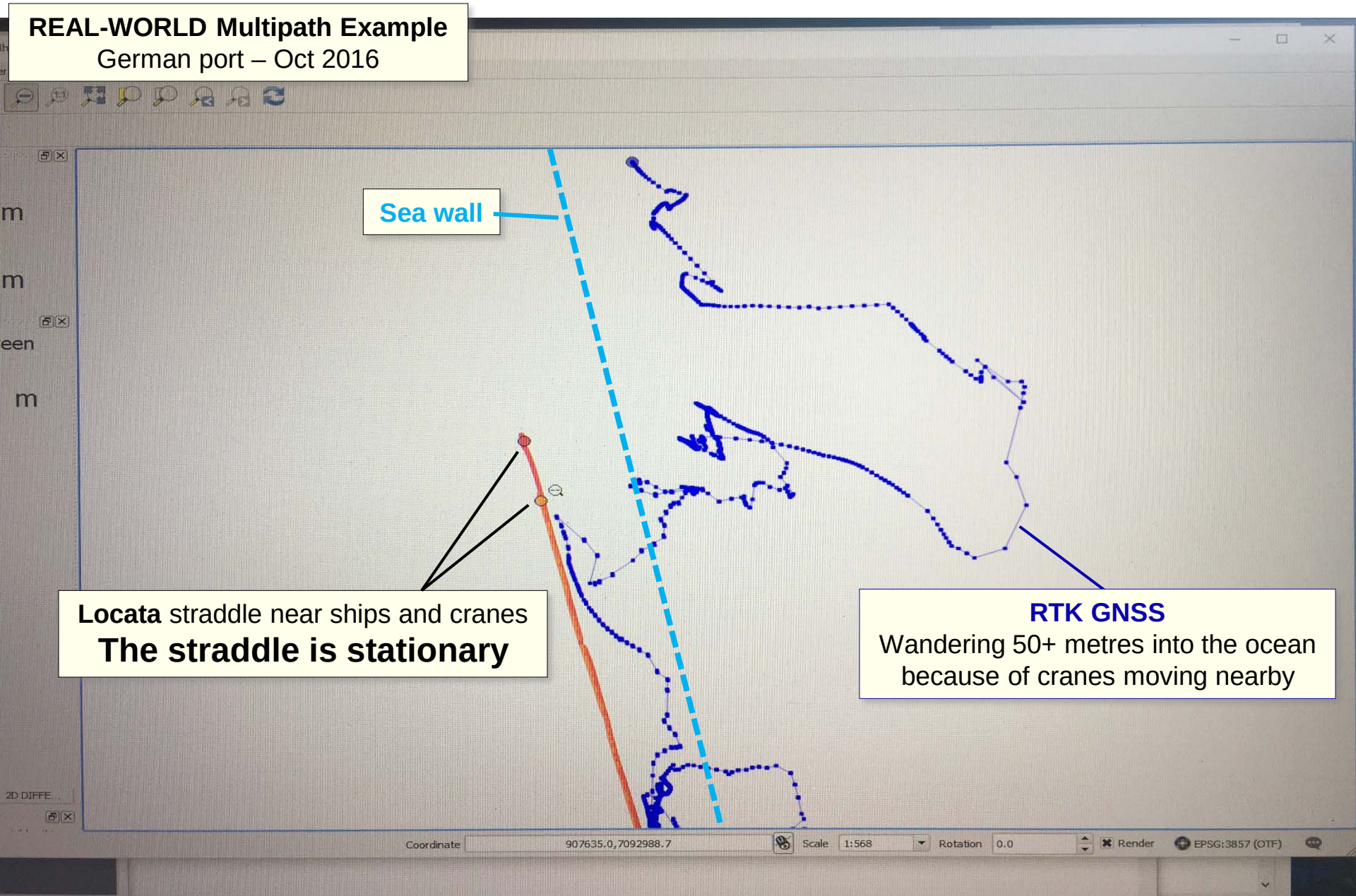


GNSS problem in ports... *is multipath*



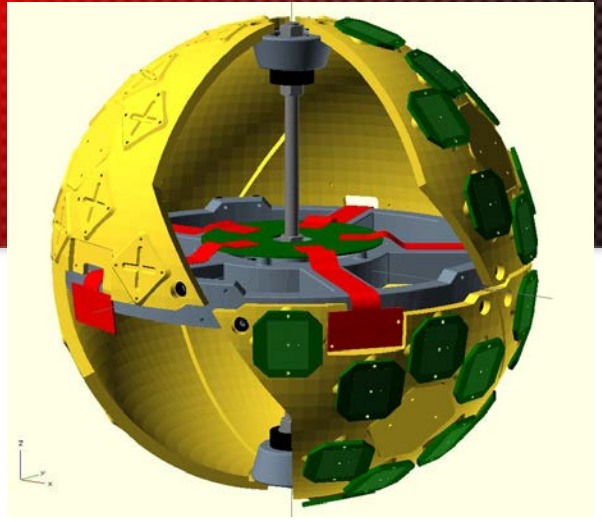
Multipath (signals bouncing off metal)
make GPS systems unusable for most of the
automation applications in ports

The problem with RTK-GNSS in ports... *multipath*



Locata's VRay Orb Antenna

A decade of development by Locata

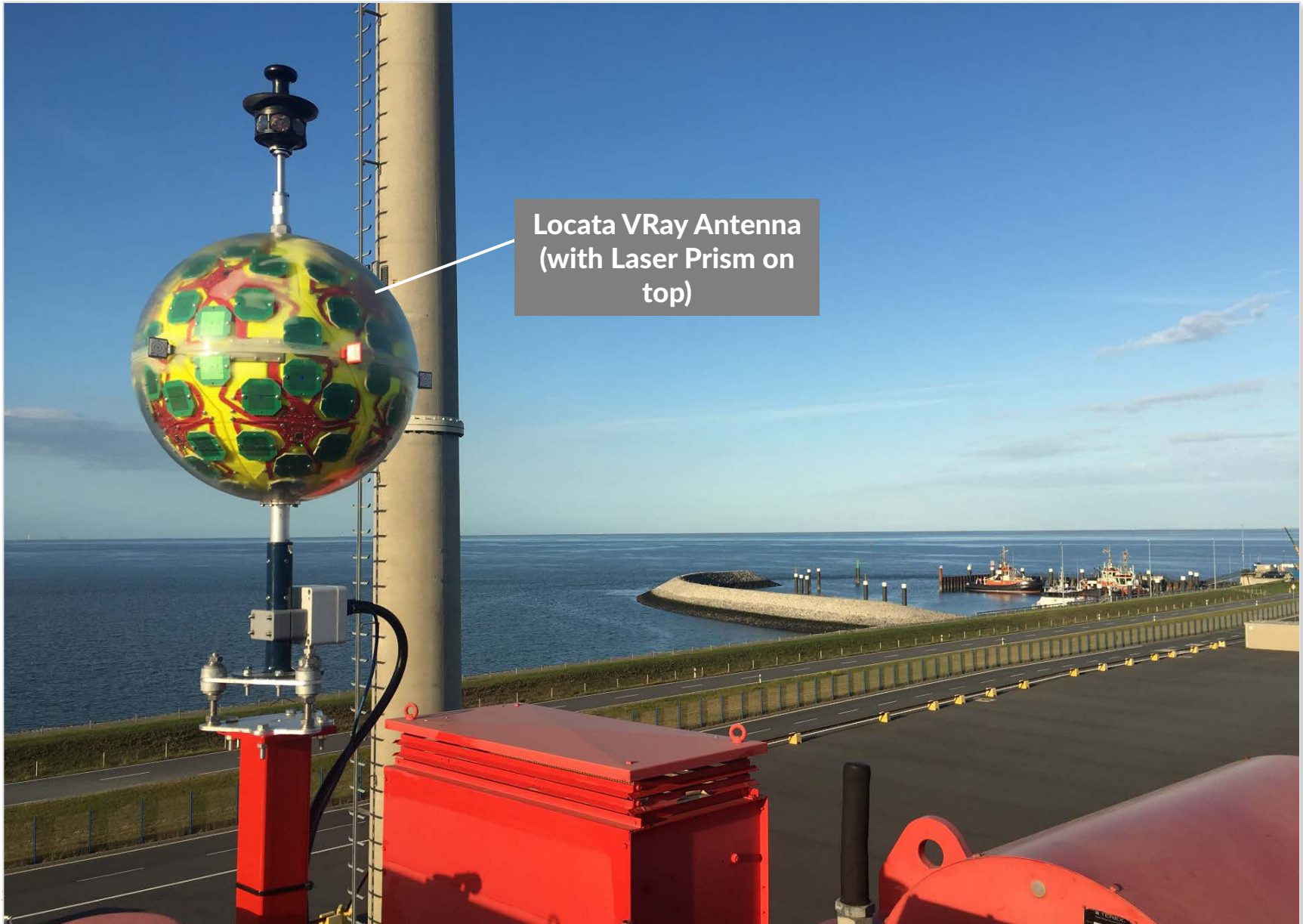


Produces 2.5 MILLION Virtual
BEAMS PER SECOND!

Automation... *where GNSS does not work well*

Locata multipath mitigation... *VRay antenna*

Locata VRay Antenna on Straddle - Germany

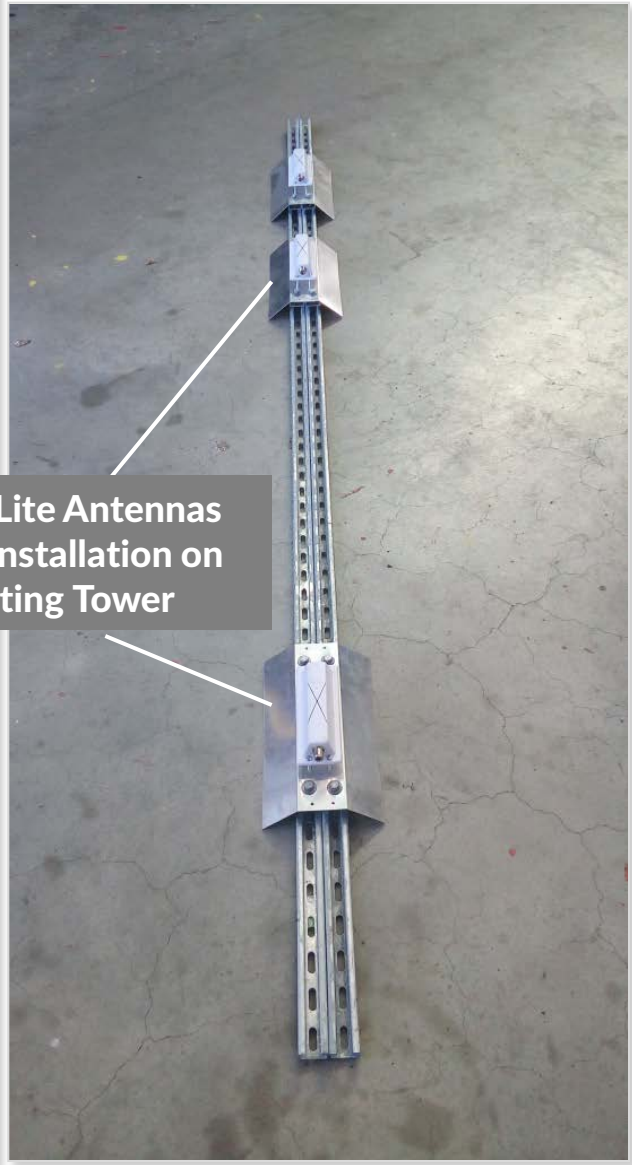


Locata VRay antennas on straddle

LocataLite infrastructure...

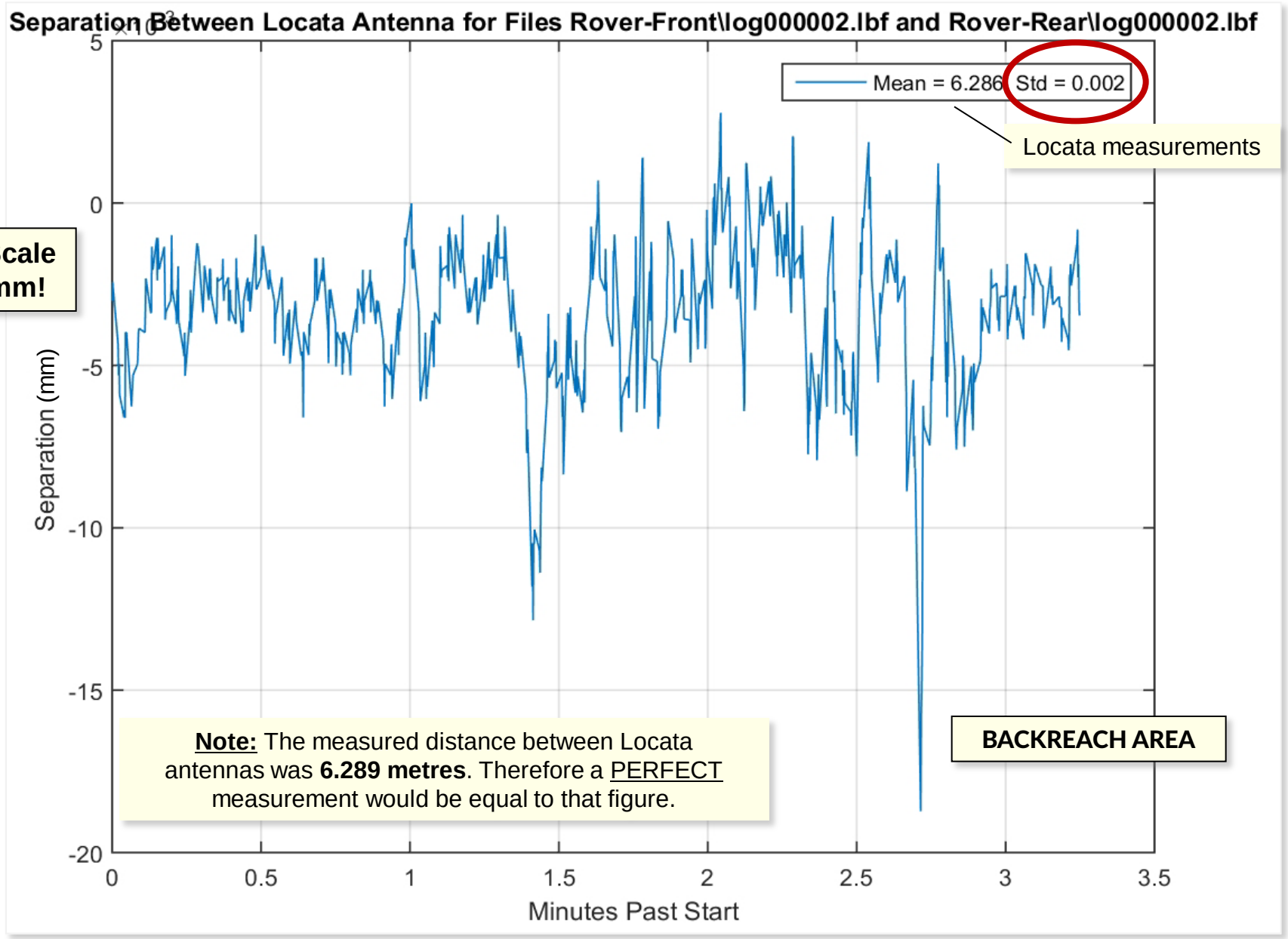
LocataLite Transmitter Enclosure (with Power and Comms)

LocataLite Antennas (x3) & Installation on Lighting Tower

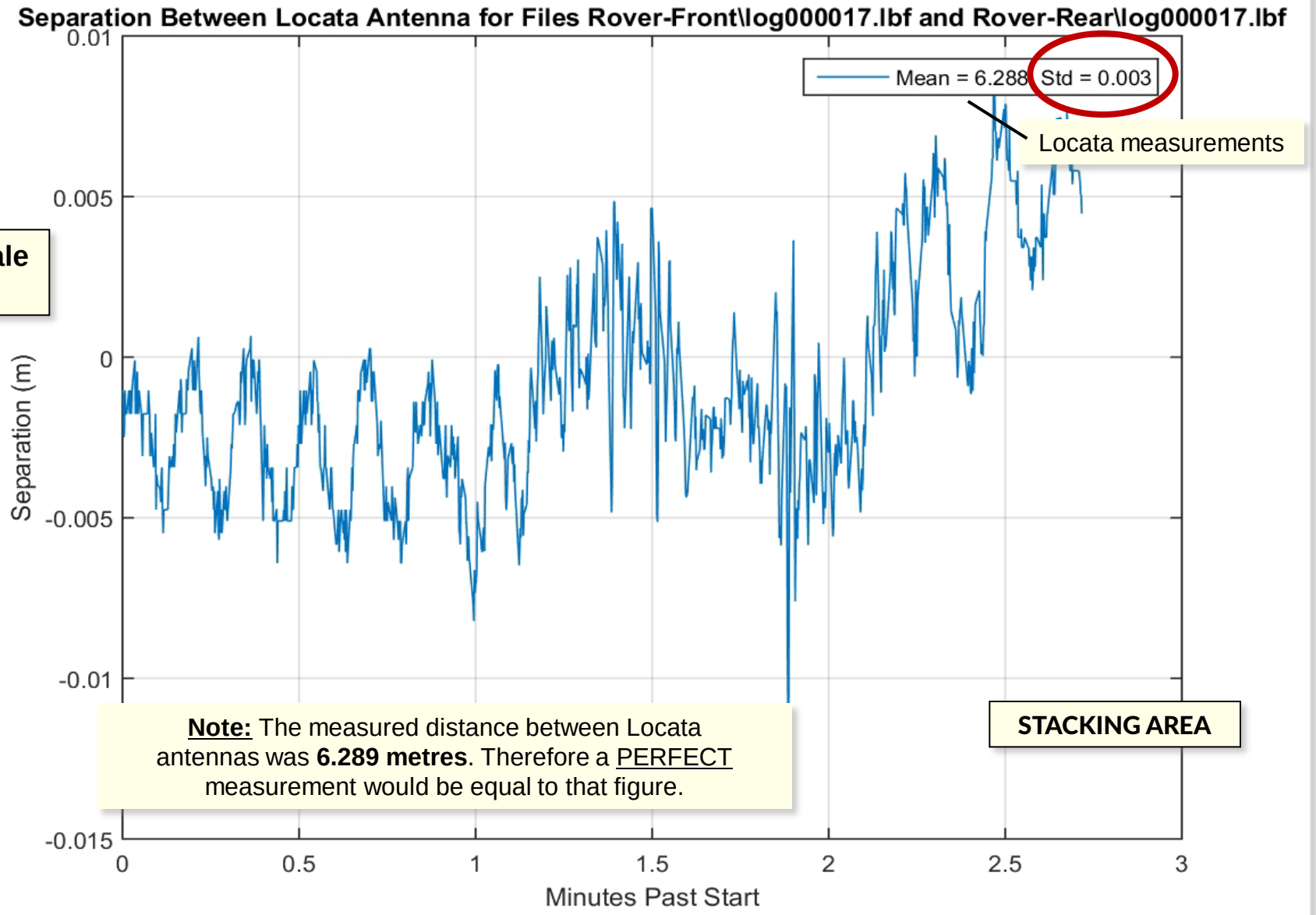


Example test runs... *29 September 2016*

Typical result...*Test Case 2*



Typical result...*Test Case 17*



Note Scale is mm!

Note: The measured distance between Locata antennas was **6.289 metres**. Therefore a PERFECT measurement would be equal to that figure.

BREAKING NEWS – 15 November 2016

LECTURA press

Ports of Auckland aims high with pioneering automation concept from Terex Port Solutions

tags:

Auckland NZ

Ports of Auckland aims high with pioneering automation concept from Terex Port Solutions

Published: 15.11.2016, company: Terex Port Solutions

Terex Port Solutions (TPS), the pioneer and technological pacesetter in terminal automation, starts a new chapter for operators of container terminals with Terex®

Locata partner TEREX (Germany) announces the first container terminal contract using Locata across the entire port as the radiopositioning technology (no GNSS will be used for completely automated machines)

TEREX®


Port of Auckland NZ
~3cm positioning for autonomous straddles
LocataNet coverage area – Auckland NZ
~1.1 x 1.3km, ~50 autonomous straddles

What Locata automation is enabling...

USAF shows results –
First time CBF used **for GPS**

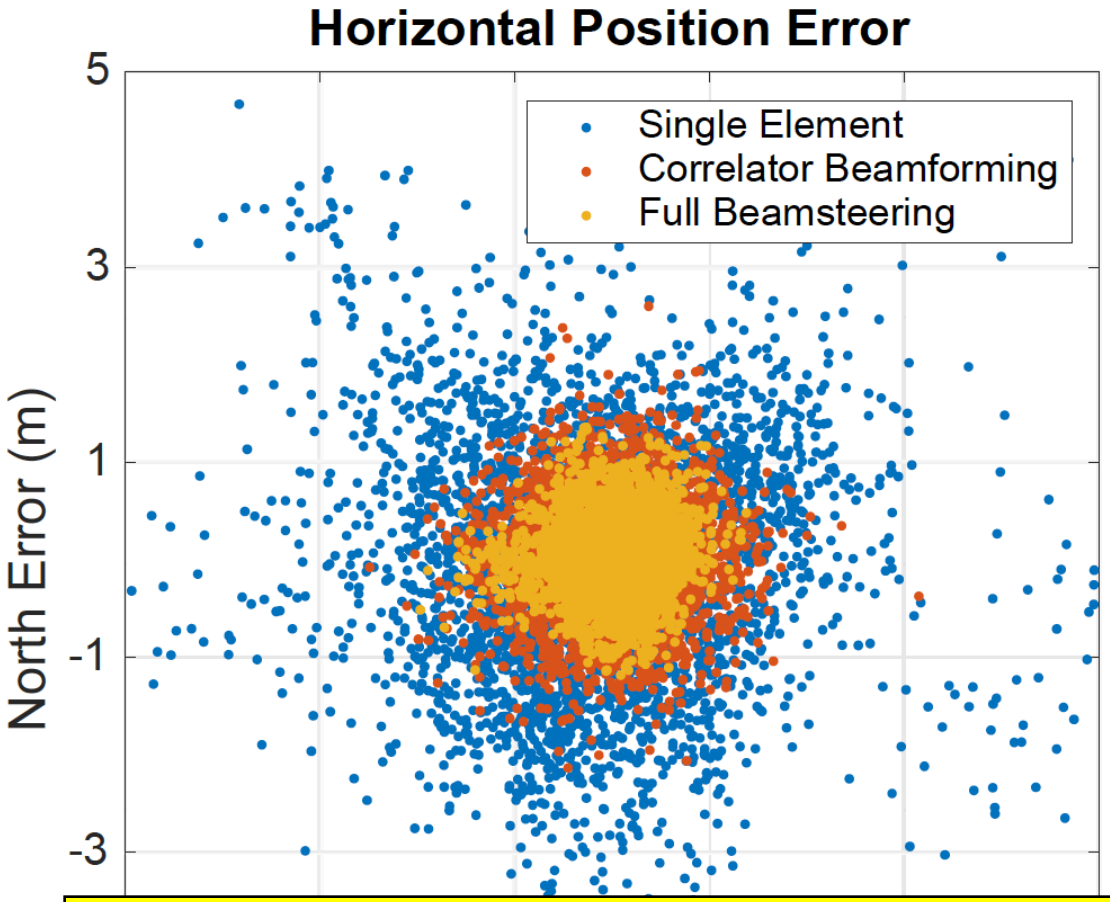
Locata Correlator Beamforming for Multipath Mitigation at Relatively Low Cost: Initial Performance Results

Dr. Sanjeev Gunawardena
Dr. John Raquet
Dr. Mark Carroll

Air Force Institute of Technology
Wright-Patterson AFB, Ohio

ION GNSS+ 2016
Portland OR
September 2016

Positioning Results (DGPS)



Antenna based on correlator beamforming could be **3 orders of magnitude cheaper** than standard CRPA...

Concluding Remarks

- LocataLite deployments are a viable solution to providing continuous, high accuracy positioning capability for machine automation in environments where GNSS-RTK *does not work*
- Apart from GNSS signal obstructions, GNSS multipath is the most critical factor preventing cm-level positioning accuracy using GNSS-RTK
- **Locata addresses signal availability challenges, not just because of its extra ranging signals, *but because it also has sophisticated multipath mitigation technology***
- Locata is an Australian innovation that *addresses high accuracy PNT requirements for industrial applications*