US National PNT Advisory Board
Washington DC – June 3, 2014

New Technology for PNT Resilience

Nunzio Gambale – CEO

This Board Understands

Protect, Toughen, Augment: Words to the Wise from GPS Founder

"What can we do to reduce the vulnerability [of GPS] and ensure that the expectations of the public are going to be met?" asked Dr. Bradford Parkinson as he opened his presentation this morning (Tuesday, April 15) at the European Navigation Conference, ENC-GNSS 2014 in Rotterdam, The Netherlands.

Parkinson went through his 61-slide, 50-minute briefing on what he called "PTA" — Protect, Toughen, and Augment — a proposal concerning not only GPS but PNT systems globally. An article by Parkinson based on this talk will highlight the special 25th Anniversary edition of *GPS World*, to appear in conjunction with this year's July issue.

Brad Parkinson

After briefly overviewing the many worldwide applications of GPS and its penetration and participation in several vital markets, Parkinson stated "If we want to ensure the economic benefits of GPS, there are some essential needs that a user has. The first need is availability, and I'm defining availability in a certain way. It's at the required accuracy for the application involved, and it has a bound on the random events that happen out there.

"The second required aspect is integrity, as in 'I know I'm getting this accuracy, the system is not lying to me.' In many cases, it's required that the system not lie to you

TODAY'S NEWS April 2014

"GPS is Vulnerable"
Dr. Brad Parkinson

Space Foundation Report Shows Growth in Global Space Economy

GPS Developers, Manufacturers Highlighted in New Report

Locata

A High-Level Overview

- What has Locata done?
- How is it achieved?
- Where does it lead?

New Positioning Technology

- Locata is a new commercially-developed **TECHNOLOGY PLATFORM** that **LOCALLY** can **INDEPENDENTLY** replicate all **P-N-T** functions of a satellite-based constellation
- **So… in any area a customer wants to cover Locata looks the same as GPS, Glonass, Galileo, BeiDou…**
- In a suitably equipped receiver, Locata is used in a navigation solution as "**just another constellation**"

Locata - A New PNT Tool

A POWERFUL & FLEXIBLE INVENTION DELIVERS NEW TOOLS TO LOCALLY AUGMENT OR REPLACE GNSS

Locata in a Nutshell

Locata delivers all that GPS does…

except the G

In any Locata-enabled local coverage area the Locata PNT result is completely indistinguishable from that of GNSS

Locata

What Have We Invented?

Locata is a…
"**LOCAL CONSTELLATION**"

"**LOCAL**" can be any size, for example:

- **A room or warehouse** (100's mtrs^2)
- **A campus or open-cut mine** (<10's km^2)
- **Airport area coverage** (100's km^2)
- **Wide-area, range or city-wide** (1,000's km^2)

Meet a LocataLite

UNIQUE: world-first device

Meet a LocataLite

UNIQUE: world-first device

REMARKABLE: nanosecond synchronisation

FOUNDATION: of new enabling technology

Locata

Key Technology Advance

Locata = Synchronization

Invented **TimeLoc**

≈1 nanosecond level

WITHOUT ATOMIC CLOCKS!

Locata

How is Locata like GPS?

Both GPS and Locata are one-way ranging systems.

- Small number of transmitters, providing good geometry, can serve an unlimited number of receivers.
- Location of the receiver is known only at the receiver.

Similar signal structure and the same measurements

- Locata and GPS are both direct sequence spread spectrum signals.
- Both receivers generate pseudorange and carrier phase measurements.
- Both receivers can use the pseudorange or carrier phase for positioning.
  - Pseudorange positioning for both is in the order of a meter.
  - Carrier phase positioning for both is in the order of a centimeter.

From a user perspective…

Locata is “just another constellation”

- DOPs matter, just as with GPS.

How is Locata not like GPS?

Locata is "a Local Constellation"

- Cover only areas that need coverage.
- Add additional transmitters where additional coverage strength (for redundancy, reliability, integrity, etc) is required.
- Design a constellation for specific local needs: ***a "GPS hotspot"***

- **Today… Locata utilizes freely available spectrum in the 2.4 GHz ISM band and complies with FCC guidelines for transmitters in that band.**
- **Received signals are much stronger from local Locata transmitters.**
  - Typical Locata received signal strengths range from -60 dBm to -105 dBm. Strongest GPS open-sky signals are -125 dBm.
  - No need for longer integration periods to receive weak signals.

➔ Allows a constellation where GPS cannot reach ←

Locata

Locata and GPS – Side by Side

LOCATA	GPS
Ground based	Satellite based
Direct Sequence Spread Spectrum (DSSS) signal structure	Direct Sequence Spread Spectrum (DSSS) signal structure
2.4 GHz open access ISM band	1.575 MHz licensed navigation band
Unlimited number of receivers	Unlimited number of receivers
Complexity is in the *LocataLites*. Receivers are simple in design and operation	Complexity is in the satellites and ground control segment. Receivers are simple in design and operation
Range and phase measurements (today) at rates up to 50 Hz	Range and phase measurements at rates dependent on receiver (25 Hz or greater is typical)
Position accuracy is primarily determined by DOPs	Position accuracy is primarily determined by DOPs
DOPs are user configurable. *LocataLites* can be placed to suit the application.	DOPs are <u>not</u> user configurable. The satellites are where they are.
Terrestrial system allows great control of almost all operational parameters; great design flexibility	Space-based system is completely out of the user's control; little design flexibility once launched

Locata

IMPORTANT

Locata transceivers

ARE NOT

pseudolites!

They ARE devices that **TimeLoc**
to create local
autonomous synchronized networks
which look like GPS

Locata

A Glimpse into the Future

How well does it work??

Example applications already deployed by our early-stage partners

Locata

CASE STUDY

US AIR FORCE

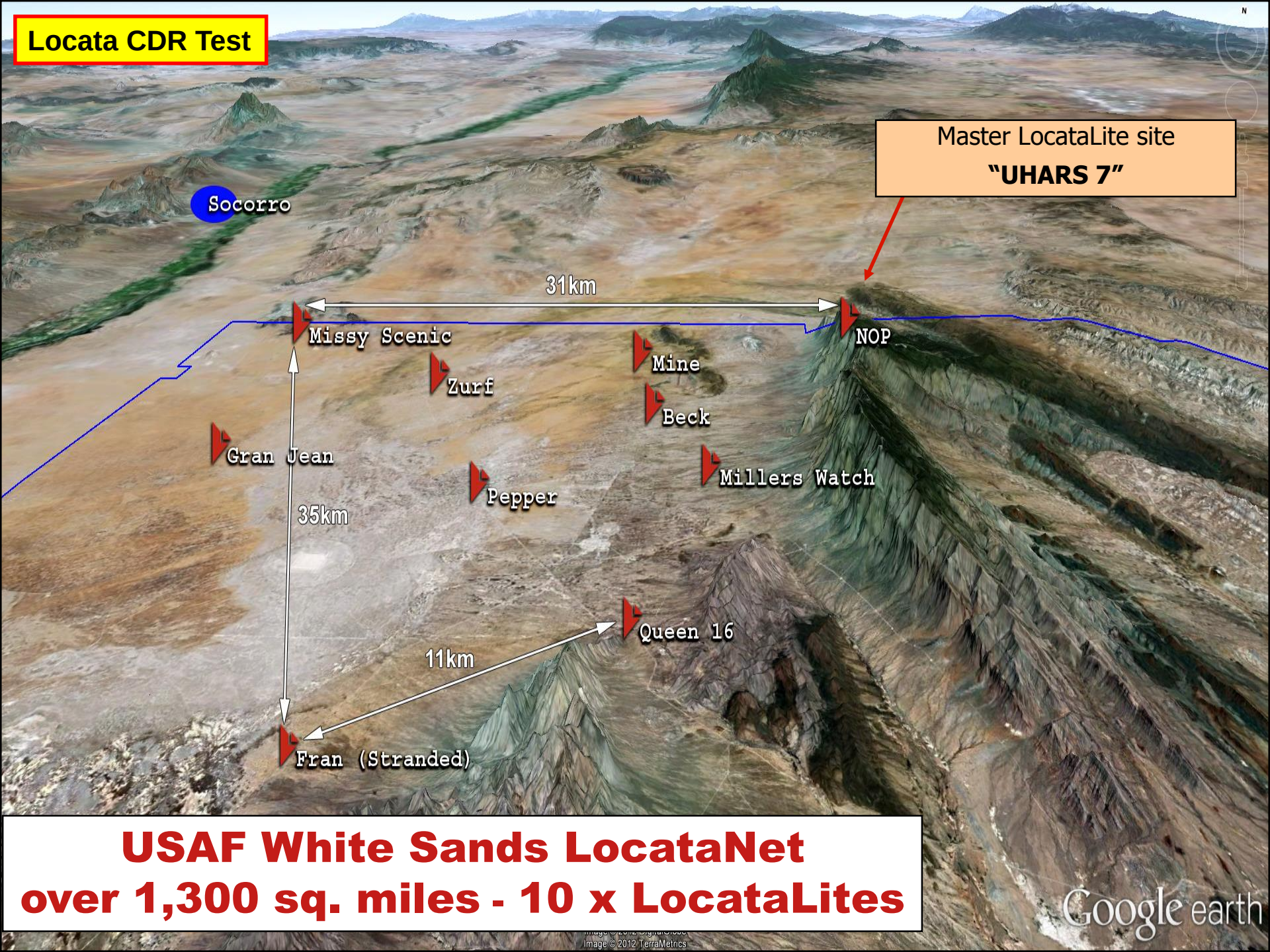
NEW TRUTH REFERENCE SYSTEM

IN GPS-DENIED ENVIRONMENTS

WORLD-FIRST CAPABILITIES

USAF - White Sands Missile Range

CHALLENGE put to Locata: cover large area in New Mexico


Locata CDR Test
Master LocataLite site
"UHARS 7"
Socorro
31km
Missy Scenic
NOP
Mine
Zurf
Beck
Gran Jean
Millers Watch
Pepper
35km
Queen 16
11km
Fran (Stranded)
USAF White Sands LocataNet
over 1,300 sq. miles - 10 x LocataLites
Google earth


Locata CDR Test
USAF White Sands LocataNet
covering approx 1,300 sq. miles
A LocataLite
Slave site
Master LocataLite
at site "UHARS 7"

Locata CDR Test

746th Test Squadron Aircraft fitted with Locata antenna and receiver

Locata CDR Test

The current USAF Truth Reference payload on 746TS aircraft

For CDR trials an unmodified commercial Locata receiver was compared to <u>this</u> unit

Locata.

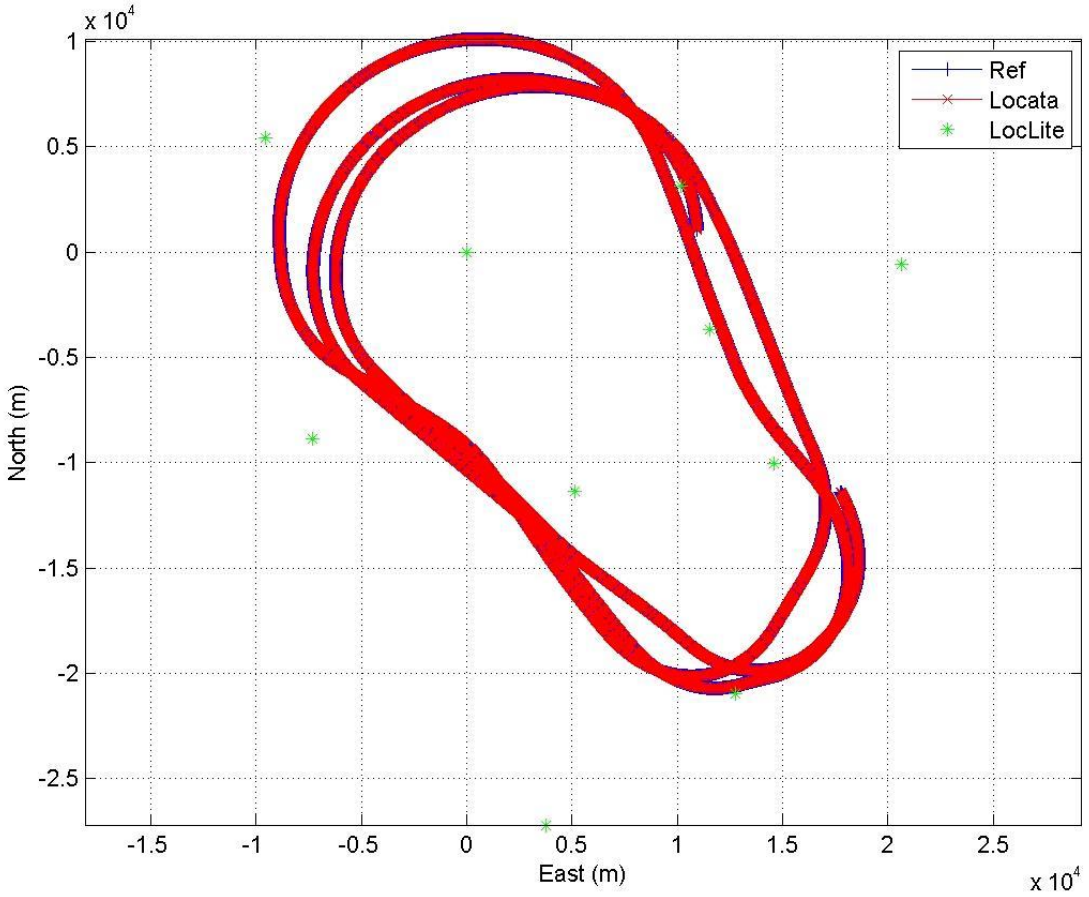
Results?

USAF CDR Acceptance Tests

White Sands Missile Range, NM
Results Generated by USAF

NOTE: Distribution Statement A
Approved for public release.
Distribution is unlimited.
PA number: 96ABW-2012-0116

Locata Results at White Sands

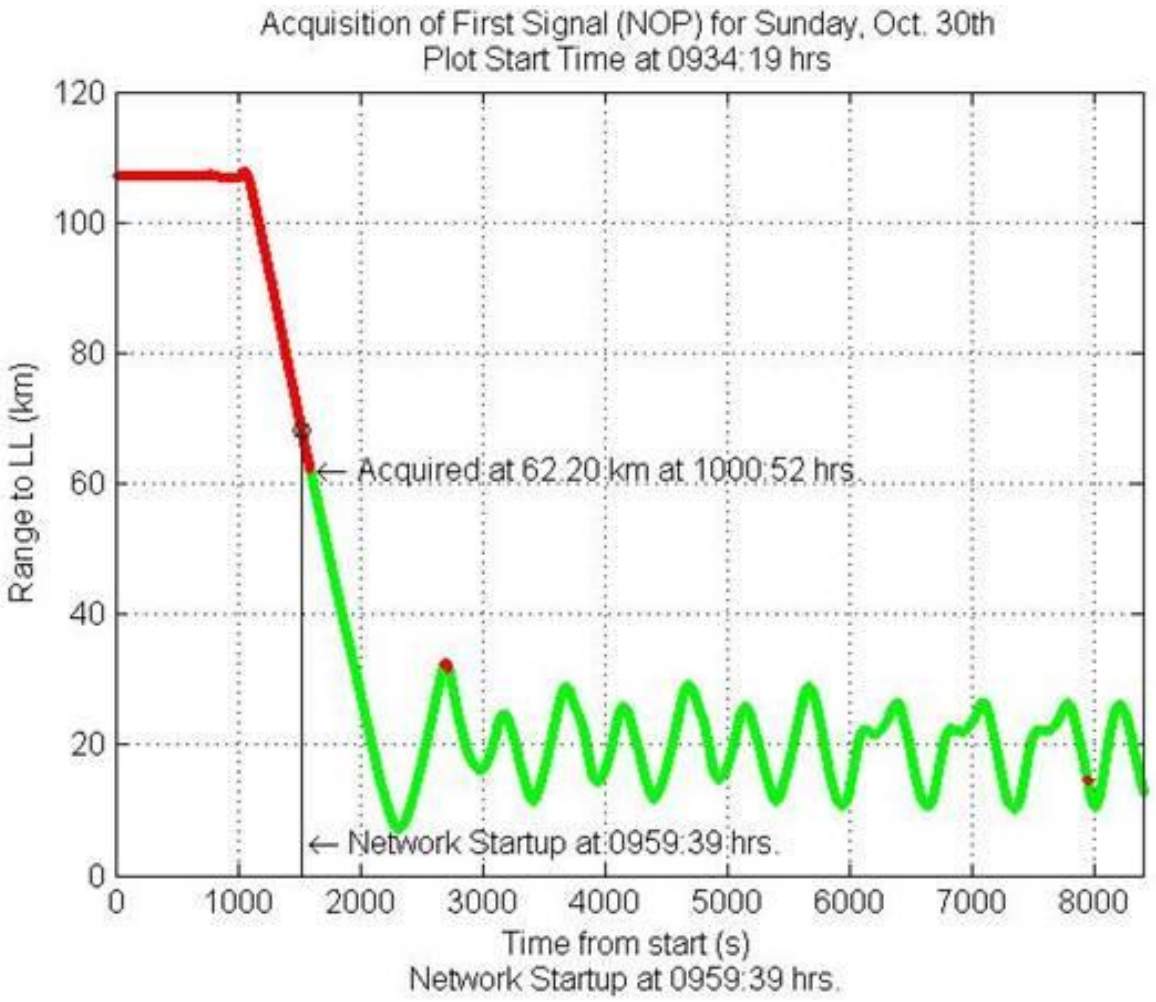


Example Flight

Aircraft @ 25,000 ft @ up to 300 kts

Example: ~30 minutes of one typical test flight

Locata Results at White Sands

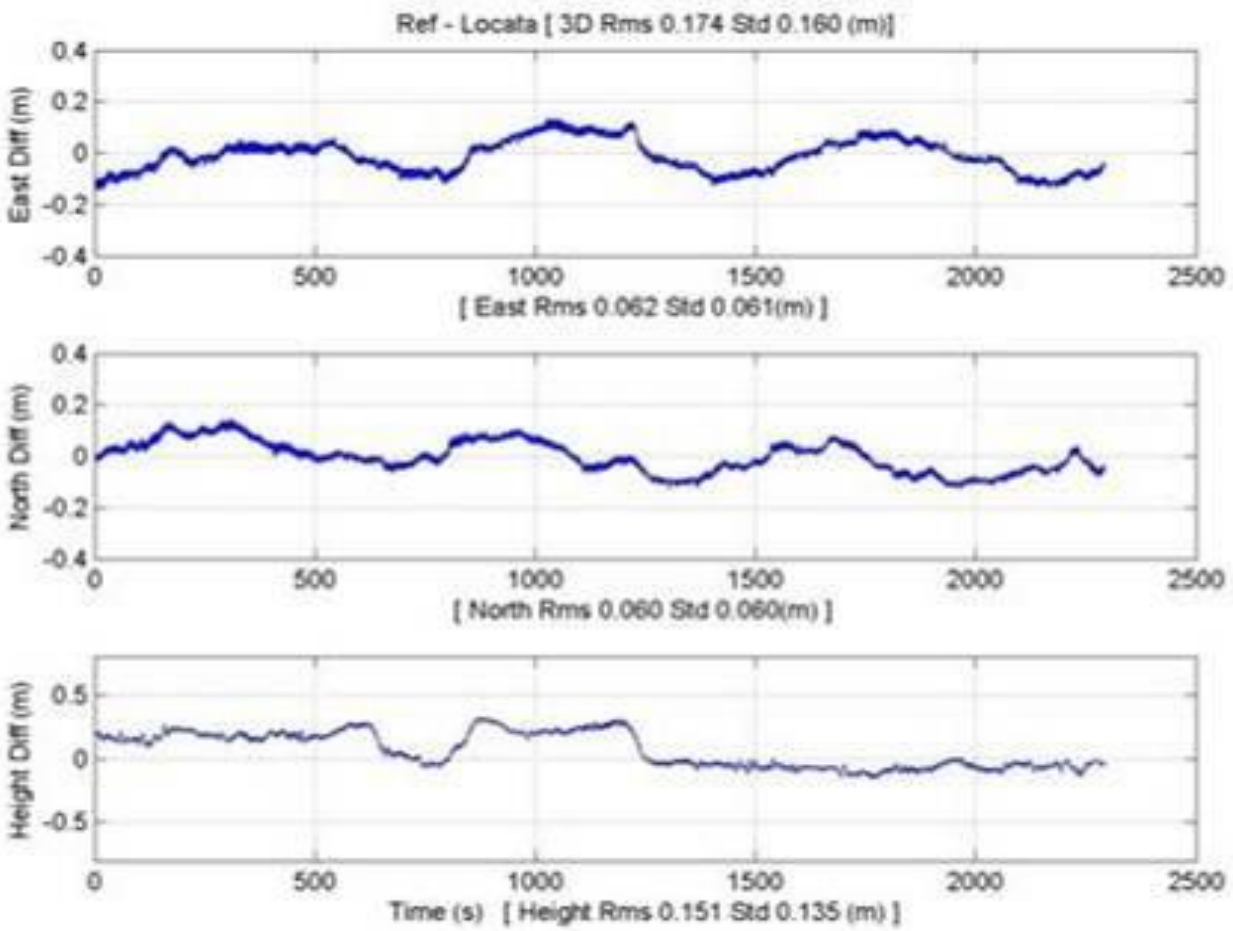


Example Flight

Locata Signal acquired & tracked at

more than 38 miles

Locata Results at White Sands



From All Flights Tested

Locata v. Truth

ACCURACY

~35 mile range

Horizontal:

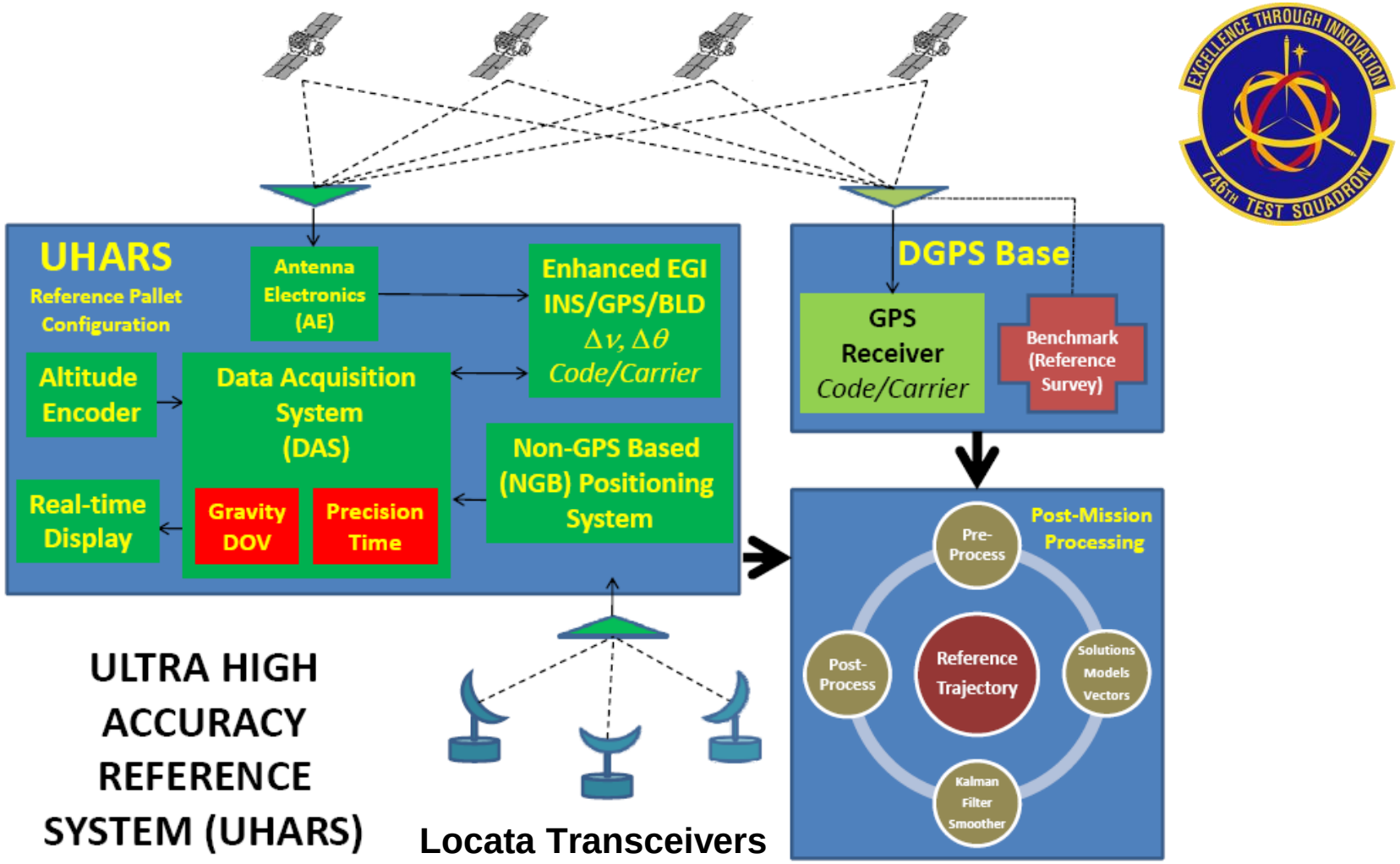
~6cm (2.5”)

Vertical:

~15cm (6”)

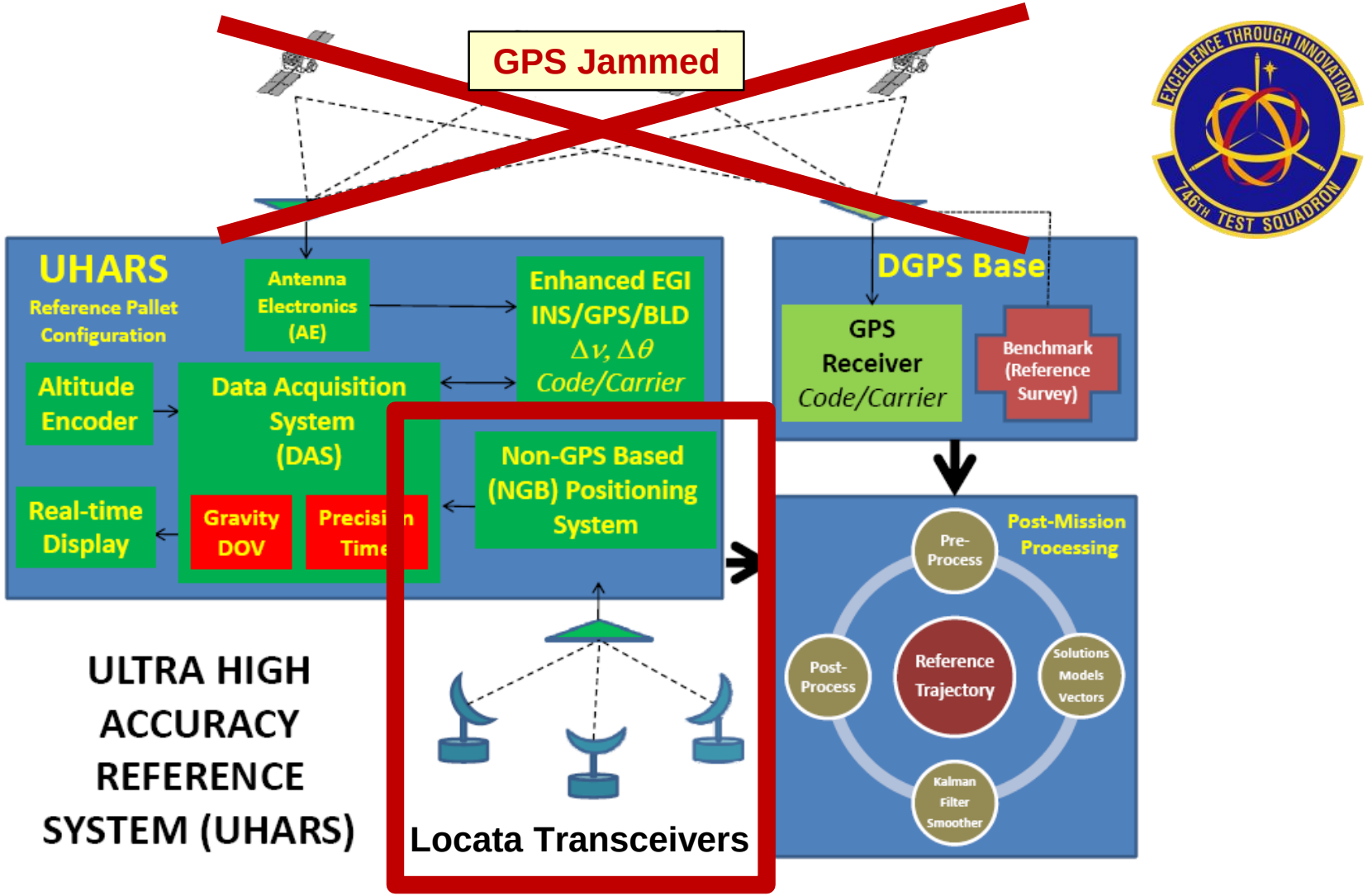
New USAF GPS Truth System

USAF Ultra High Accuracy Reference System (UHARS)



New USAF GPS Truth System

USAF Ultra High Accuracy Reference System (UHARS)



USAF Contract

- Multi-year **sole-source** contract
- First **White Sands** installation to blanket up to **2,500 square miles of the Range**
- 13 year contract to deliver support and upgrades **through to year 2025**
- Locata partners - build & install
- Locata is **the key component** for USAF's next-gen GPS Truth Reference System

White Sands Install Under Way

Locata system operational at WSMR in Q3/2014

Locata partner TMC - testing first Locata WSMR equipment trailer

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Locata.

Example Future Use - UAV Back-up Zone

Locata

CASE STUDY

LEICA GEOSYSTEMS

RESPECTED PRO GPS COMPANY
NOW **SELLING** A NEW MINING SYSTEM
WHICH **REPLICATES GPS** IN THE PIT

WORLD-FIRST CAPABILITIES

Extract: **Leica Mining's – Fleet Management System PowerPoint**

Leica Geosystems Locata-enabled GNSS Augmentation for Mining

Craig Robertson – Mining Division, Hexagon Geosystems

JIGSAW 360

Locata

- when it has to be right

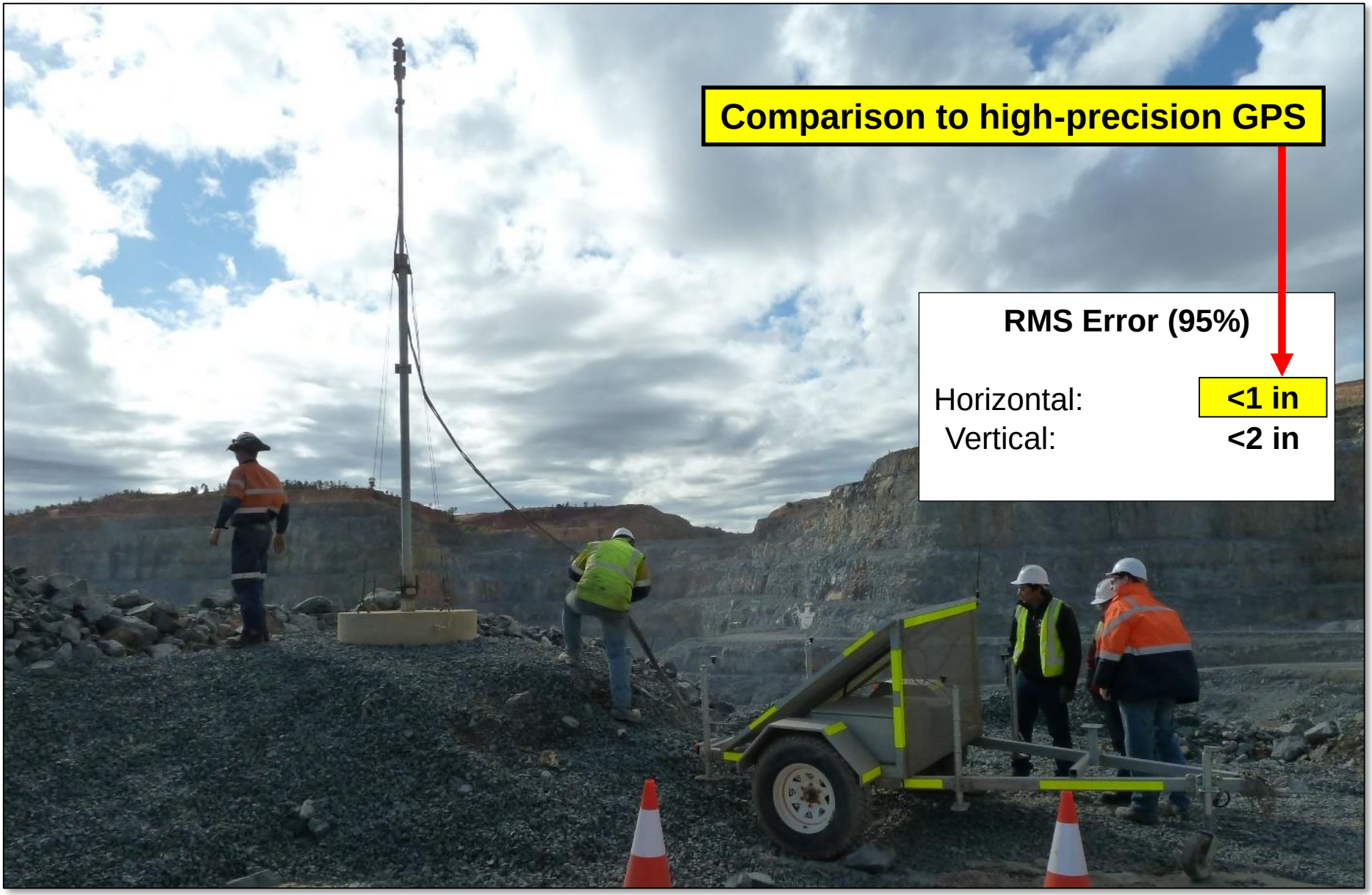
Leica Geosystems

Leica JPS - Powered by Locata

- **World's first commercial, fully-operational LocataNet for mining**
- Located 140 kms (90 miles) south of Perth in Western Australia
- Consists of two Pits, North and South Pit. South Pit is now about 300m (1000ft) deep, going to over 850m (2800ft)

Newmont Boddington Gold Mine

Leica production version now installed & operational in 2 pits at Newmont's Boddington Gold Mine in Western Australia



Leica production version now installed & operational in 2 pits at Newmont's Boddington Gold Mine in Western Australia

As of May 2014 LocataNet running with:

- **4 Semi-permanent fixed LocataLite sites**
- **12 mobile trailers**
- **Locata receivers installed and running on Drills, Shovels & other heavy machinery**

Newmont now mandated all high-precision machines in mine must be fitted with Locata

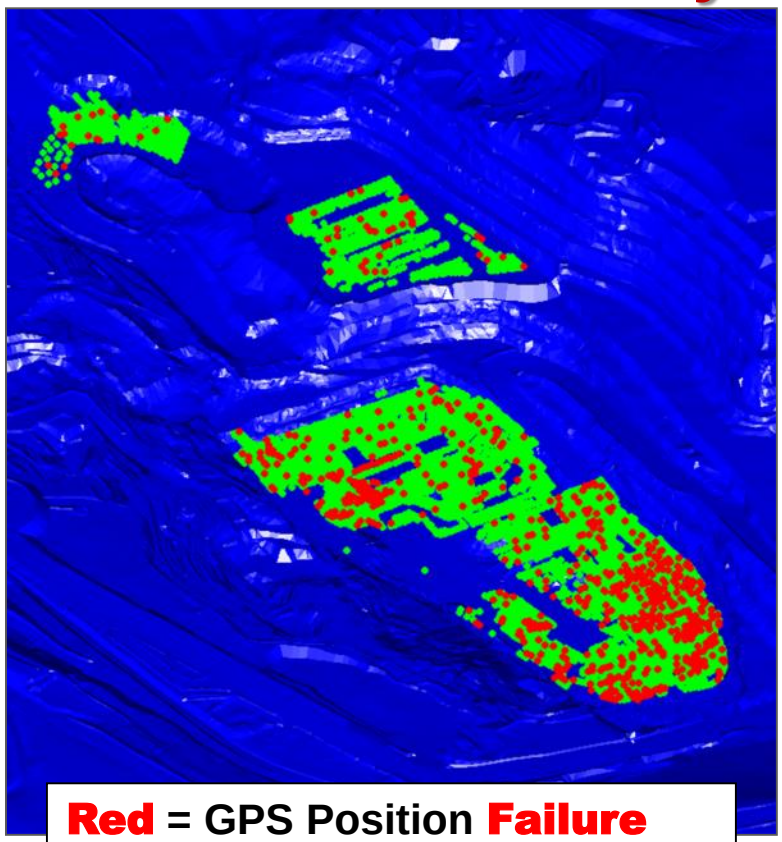
- when it has to be **right**

Leica Geosystems

Leica Jps

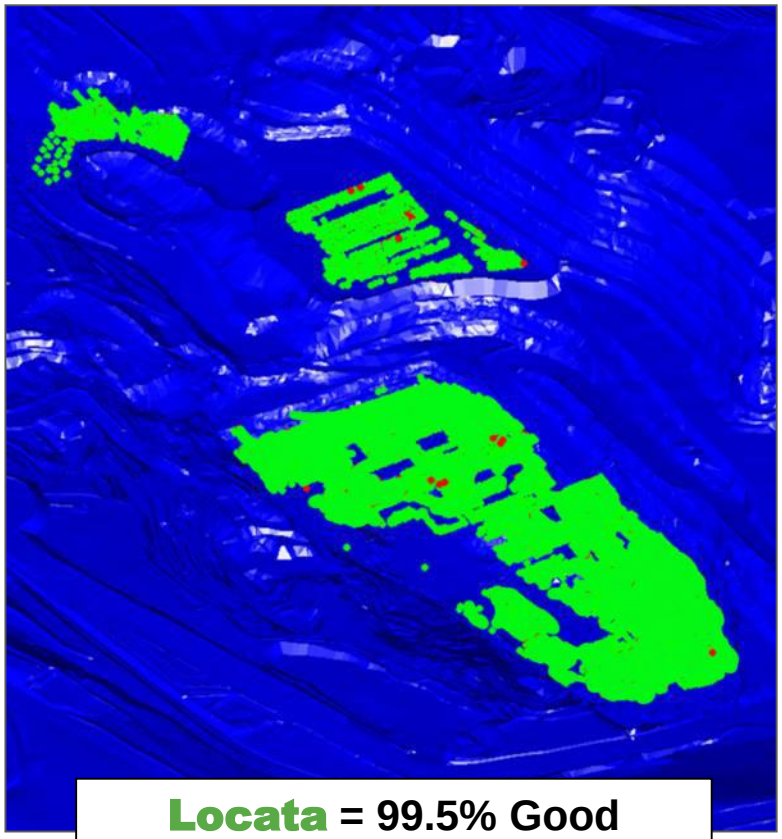
Drill Performance – Typical availability over 1 week

North Pit – GPS only



Red = GPS Position **Failure**

North Pit – With Locata



Locata = 99.5% Good

Jigsaw

NEWMONT

- when it has to be right

Leica Geosystems

World first: GNSS+Locata receiver

Leica Geosystems

NovAtel

Powered by Locata

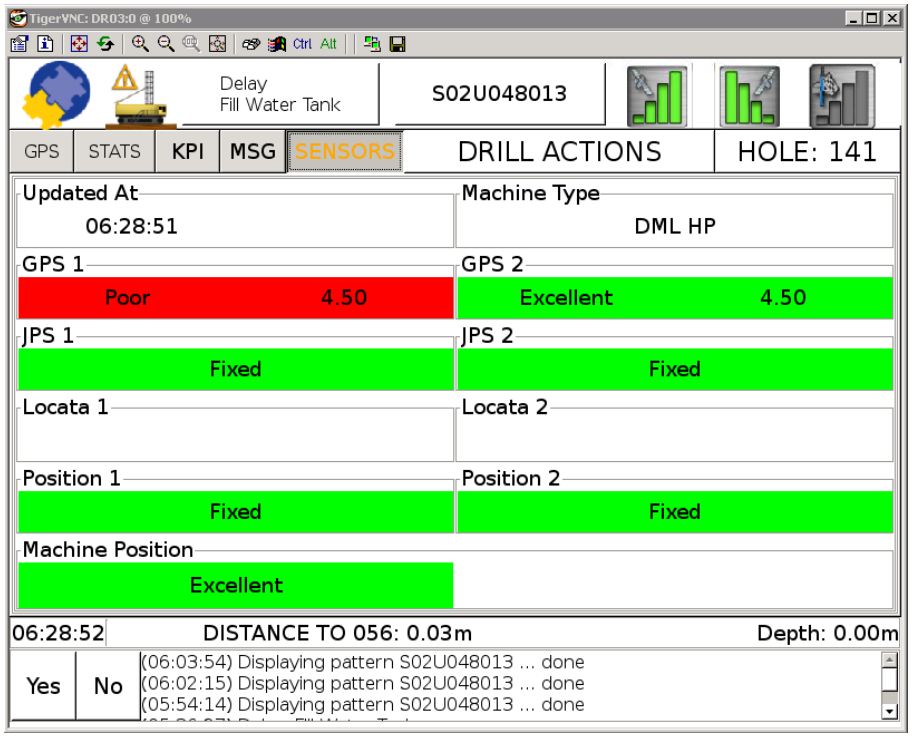
Fully integrated COMBINED solution… GNSS+L

IMPORTANT! Seamless transition from GNSS to Locata

Onboard Diagnostics

NEWMONT ASIA PACIFIC

Typical Example of Locata Performance



Onboard Diagnostics

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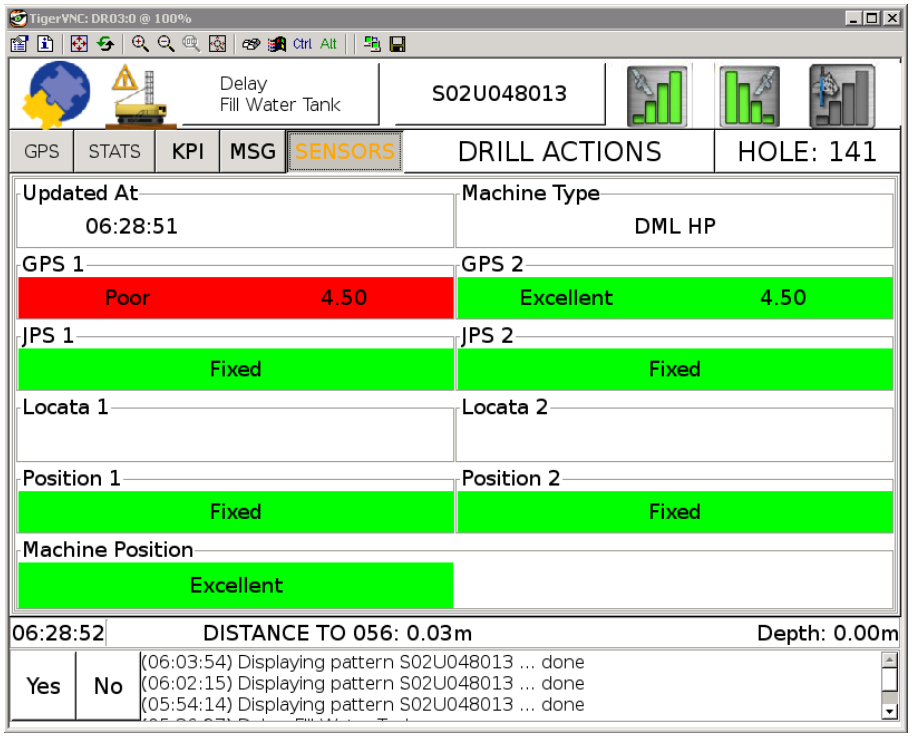

- Dual receivers for attitude determination
- One GPS receiver has “no position” **(red)**
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- **Machine position: Excellent**

Onboard Diagnostics

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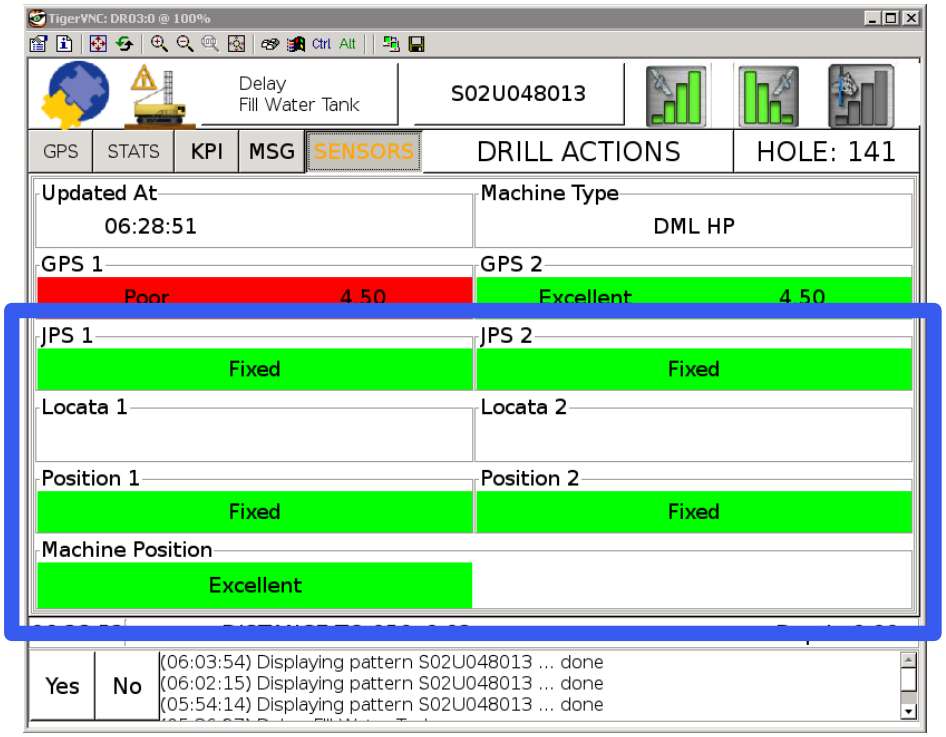

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During Recent GLONASS Failure…

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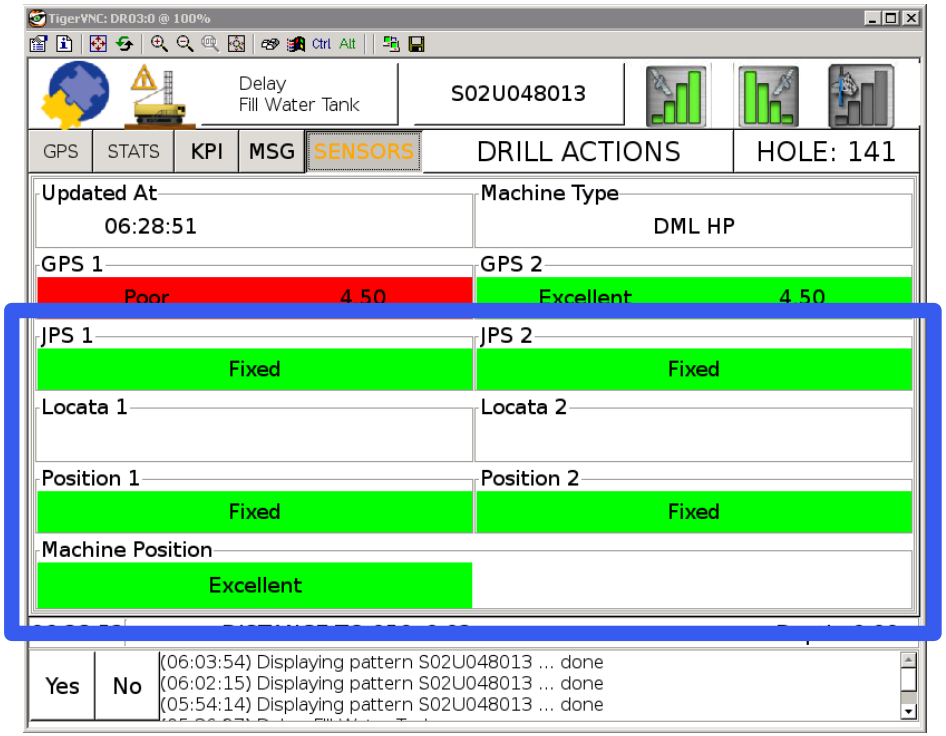

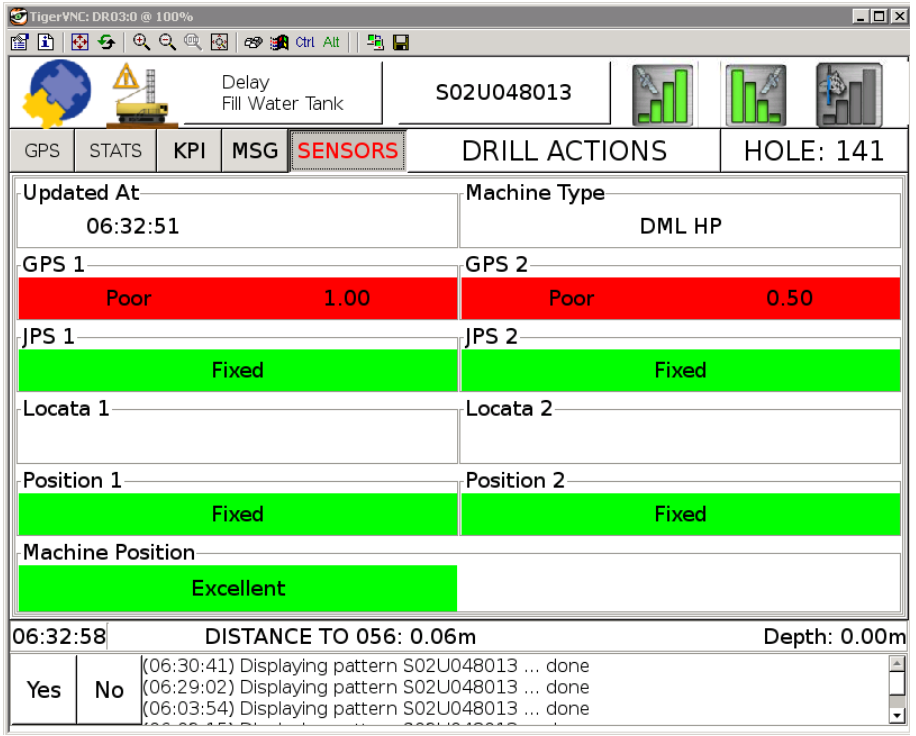

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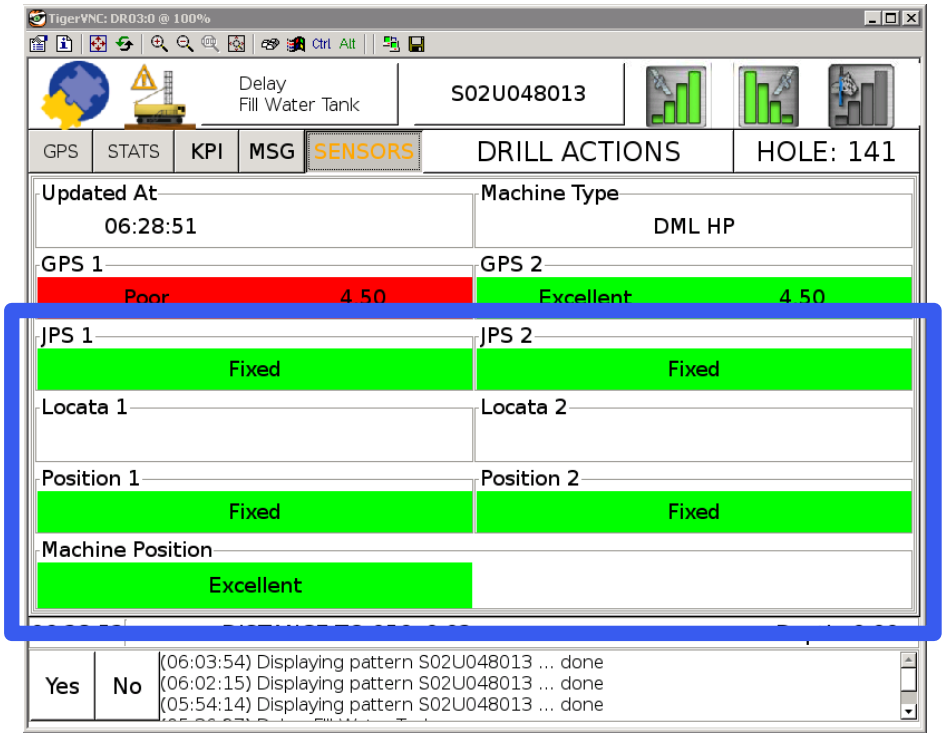

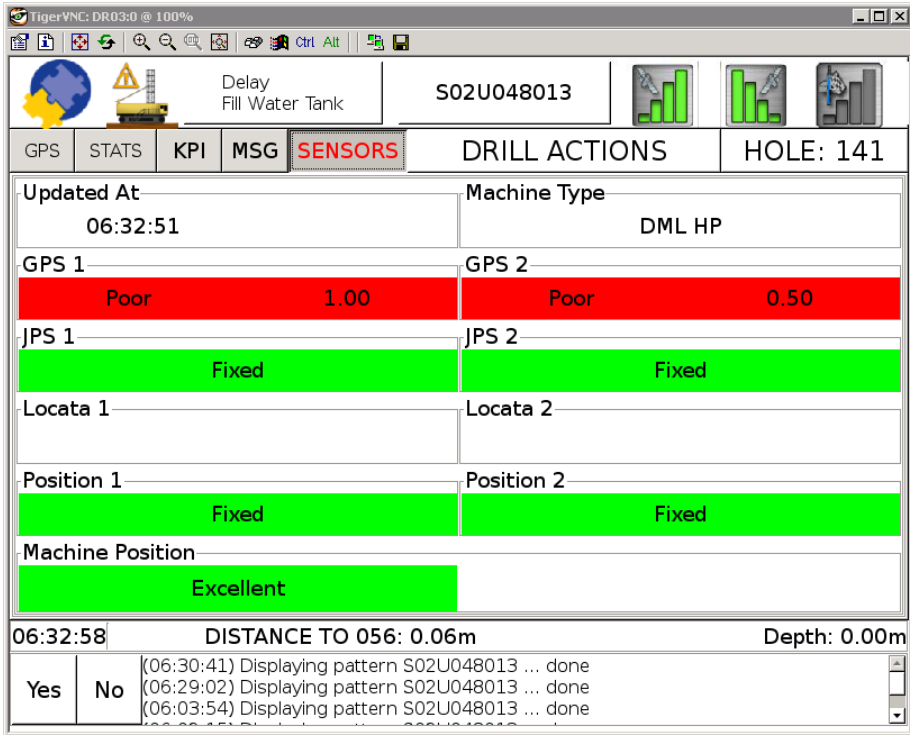

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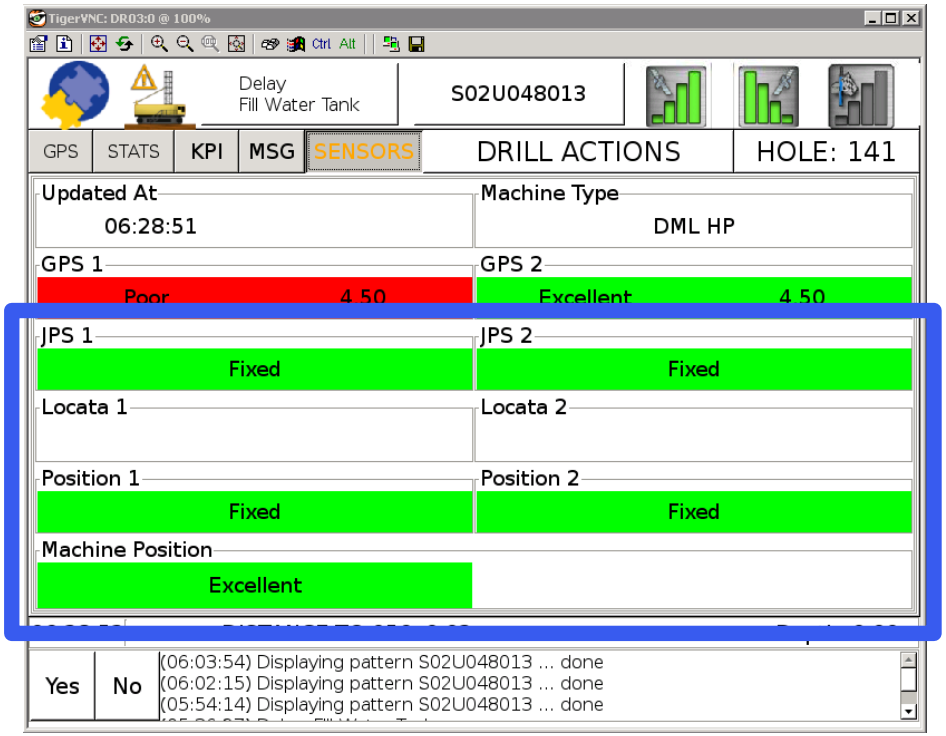

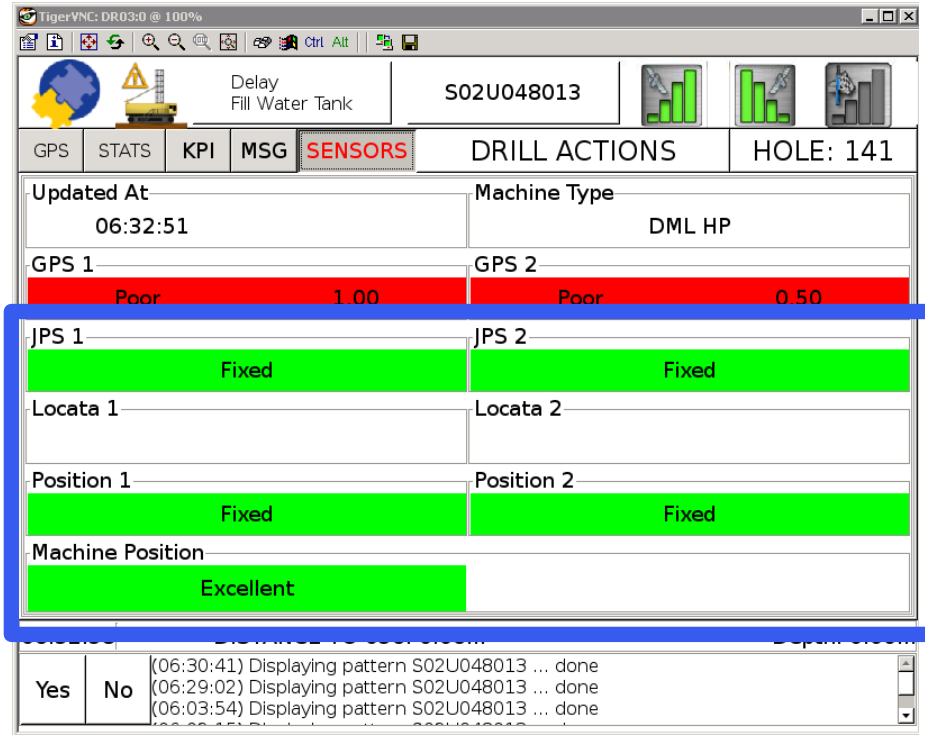

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Locata.

This is EXACTLY What We Need

What happened here?

NO GPS.

STILL WORKS

LIKE GPS.

Locata

What does Locata's development now deliver to radiopositioning?

Illustrative examples of NEW CAPABILITIES available from Locata integration

Locata

New Capabilities - #1

- **GNSS:** Extremely weak signal - easy to block/jam/spoof/accidentally interfere
- **LOCATA:** Increase power **to the level required** to resist jammer. So…
- Much harder to "hide jammer" because jamming signal must be more powerful – jammers much easier to find

New Capabilities - #2

- **GNSS:** Cannot guarantee adequate number of signals (or their quality) for many apps. *"You get what you get"*

- **LOCATA:** *"You design what you need"*
- Locata ICD already allows for 200 Locata signals in view. Even more can be added…
- Place transmitters as required or needed – move, remove, add, modify… etc

Locata

New Capabilities - #3

- **GNSS: Global infrastructure** is critically dependent on the "superb clock in the sky"
- **LOCATA: TIME SYNCHRONISATION** is the core invention – **it's what we do!**
- Distribute NANOSECOND-LEVEL TIME over specified area WITHOUT requiring cables or physical links – easy to add "nodes"
- Excellent, distributed time sync "back-up"

Locata

New Capabilities - #4

- **GNSS:** Space-based - so very expensive to design, launch, maintain, modernise…

- **LOCATA:** **Very inexpensive "nodes"**
- Only used where required – GPS hotspot
- NO SINGLE POINT OF FAILURE. Similar to **Internet Model** of cheap, redundant and easily deployed nodes: **Total Local Control**

New Capabilities - #5

- **GNSS:** It takes **15-30 YEARS** for a satellite constellation to change or "modernise". We believe this is now **untenable** given the relative development rate of new threats

- **LOCATA:** Can **evolve** at a rate that keeps it **relevant** to new electronic developments
- Satellite-based systems will **never** be able to evolve or up-date at a similar rate

Locata

New Capabilities - #6

- **GNSS:** Civilian signals not secure – no encryption or authentication

- **LOCATA:** Can readily be encrypted
- Signals can be evolved rapidly to take up "most modern" authentication methods
- As required, both public and secure signals can be transmitted simultaneously

GNSS+Locata receiver in production

Leica Geosystems

NovAtel

Powered by Locata

Fully integrated COMBINED solution… GNSS+L

IMPORTANT! Seamless transition from GNSS to Locata

Locata

Partner Applications Now Underway

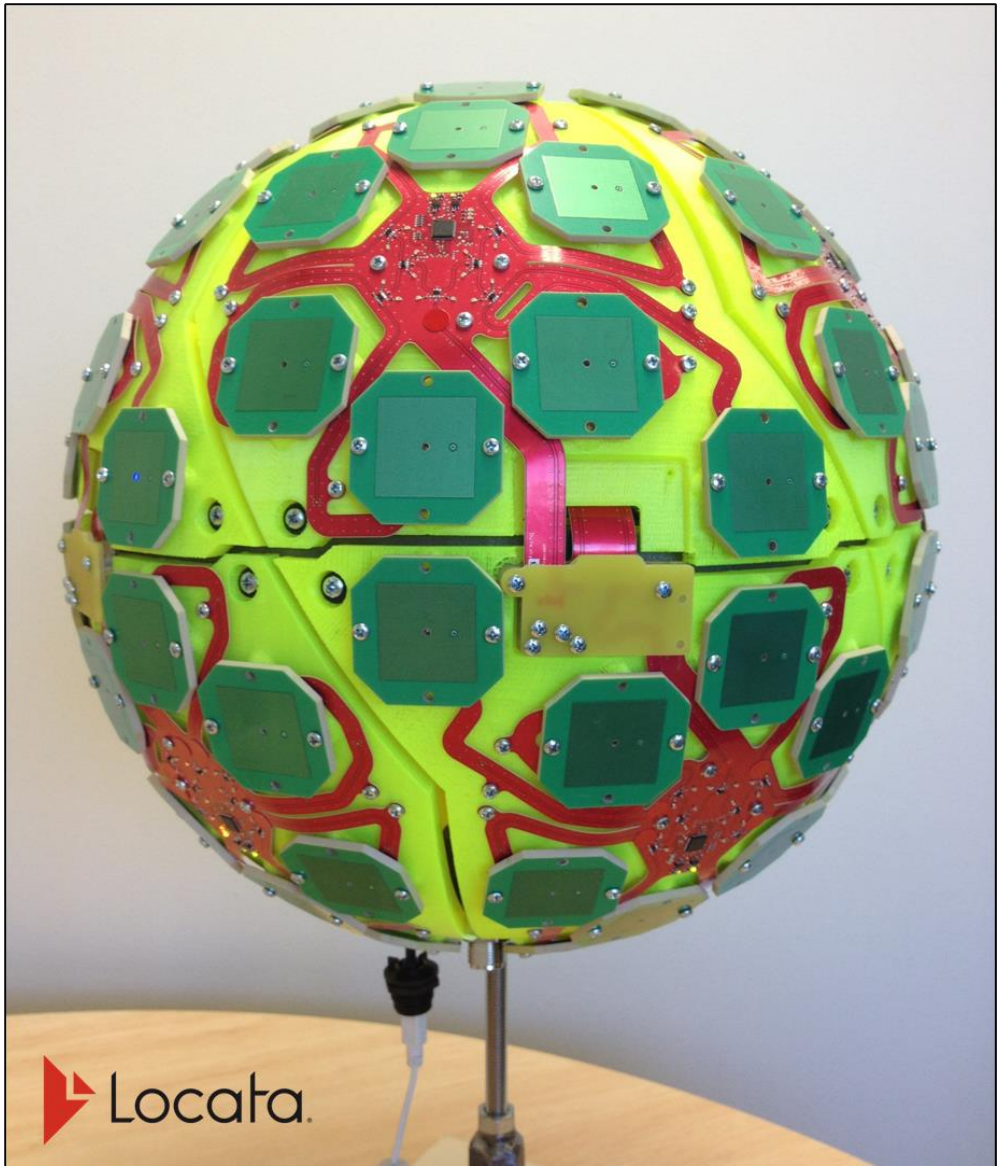
- **PORT AUTOMATION for large machines**
  - **Extremely difficult multipath** areas
  - cm-level positioning with no GNSS
  - Will deliver large efficiency gains to ports
- **STRUCTURAL MONITORING**
  - Demonstrating **mm-level** precision with transmitters over 3 km away
  - Dam deformation, bridges, buildings, etc

Locata

Partner Applications Now Underway

- **CAR INDUSTRY for collision avoidance**
  - **Working with Vehicle Research Centre** (world-leading test facility - Virginia, USA)
  - cm-level position for cars - outdoor & indoor
- **TIME TRANSFER at nanosecond level**
  - Already demonstrated ≈ 50 mile radius (cover infrastructure in ≈7,500 sq miles)
  - For **cell tower synchronization** and other precise time for large areas (e.g. city-wide)

New Indoor Positioning Technology



Locata VRAY Orb Antenna

Available Now

MULTIPATH SOLUTION FOR LARGE MACHINES

- ✓ Warehousing
- ✓ Supply-chain
- ✓ Ports
- ✓ Machine automation
- ✓ Indoor positioning
- ✓ Industrial environments

MANY SMALLER VARIANTS COMING

Locata

IMPORTANT

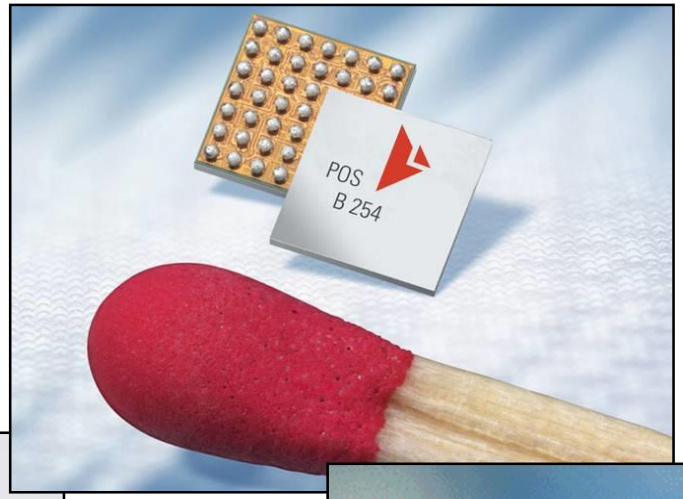
US Air Force Institute of Technology

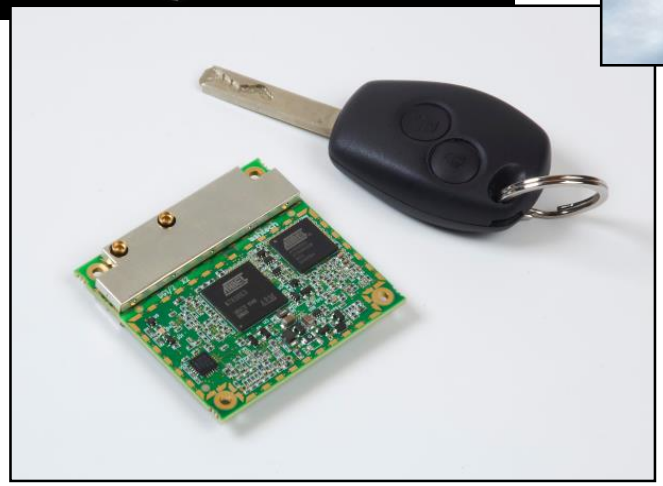
AFIT & LOCATA NOW WORKING TO
IMPROVE GPS AS WELL…

TAKING LOCATA **VRAY** MULTIPATH MITIGATION CORRELATOR INTO **NEXT-GEN GPS** DEVICES

EVOLVING A COMPLETELY
NEW GPS CAPABILITY

Product Evolution





Now → **+5 yrs**

What the World Needs Now

Sustained

Upgraded

Precision

Augmented

PNT

Satellite + Terrestrial = Inevitable

Locata

Take-away Message

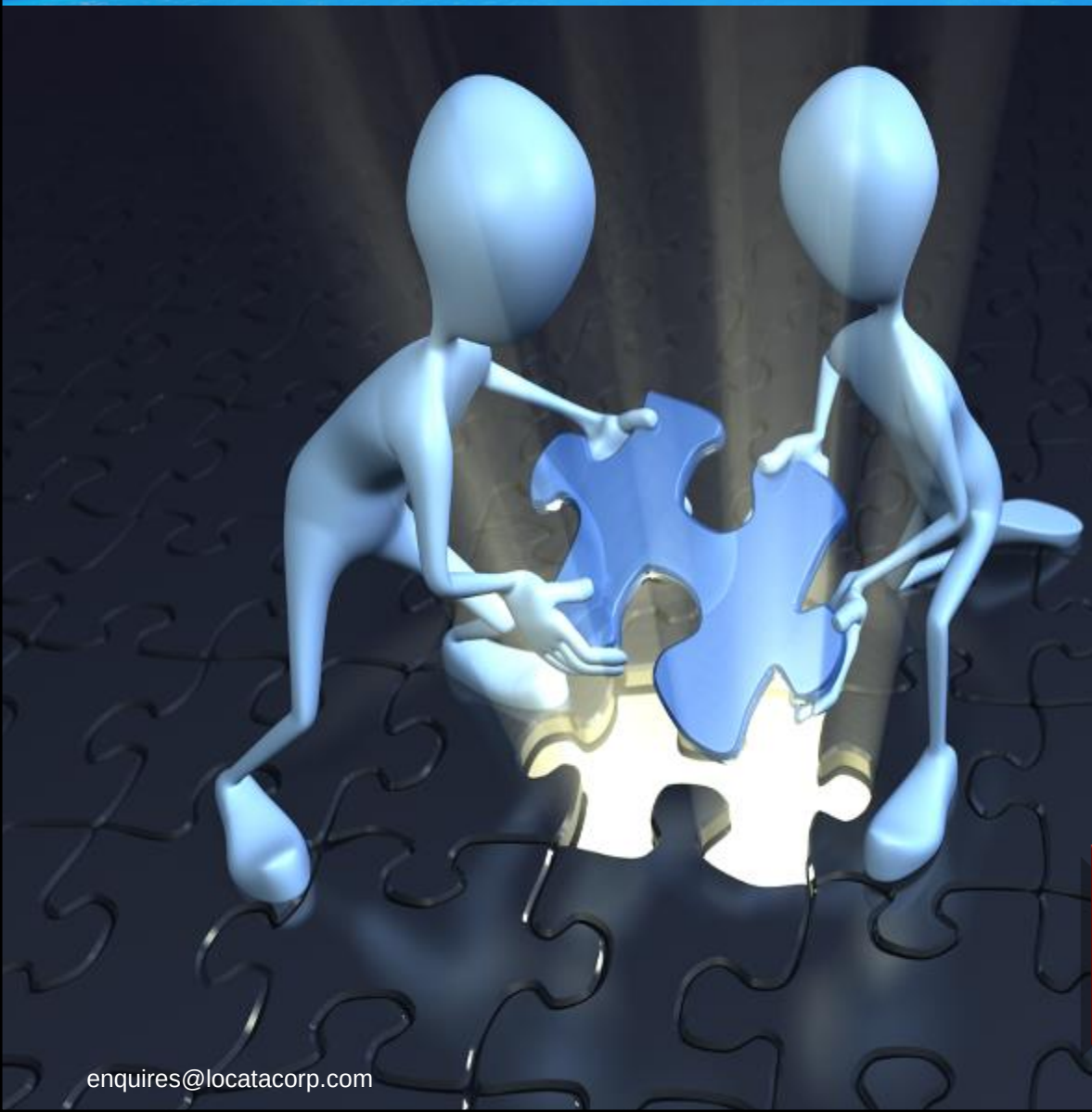
Locata is an
IMPORTANT ADVANCE
delivering new terrestrial capabilities for next-gen SUPA-PNT

These are early days and Locata will only get better from here

Locata is a AVAILABLE TO ALL partners for more development…

Locata

Positioning for the Future



Locata has **invented new GPS-like technology** which will provide **important added capabilities** to future GPS-based positioning devices

Locata®

enquires@locatacorp.com