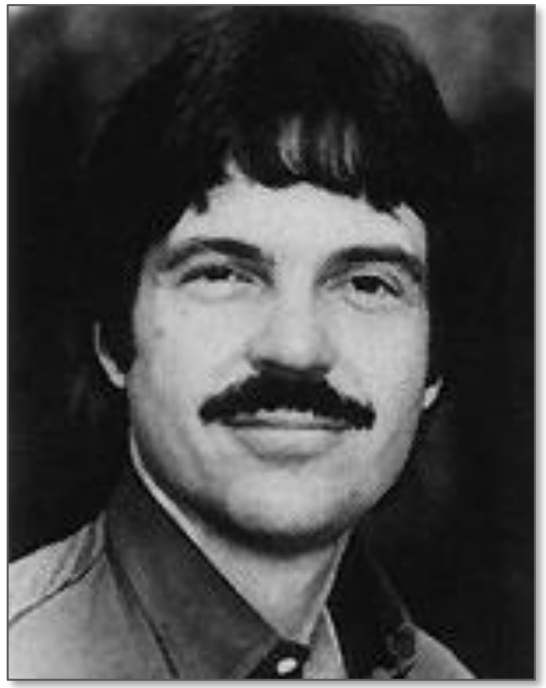
DEFIS Alt-PNT "Demo Day"
Locata Technology Overview
Timing Tests Results

JRC Ispra Campus
18 May 2022

JRC
EUROPEAN COMMISSION

We exist to raise the bar for the future of PNT…



The legendary leader
of **Xerox Park** in 1982

“The best way to predict the future is to invent it”

Alan Kay
Xerox Parc

Today you will see the future we are creating.
EC engineers will report on how well we’re doing.

To revolutionize PNT you first have to reinvent fundamental concepts of synchronization

TimeLoc

Sub-nanosecond synch

Without atomic clocks

Without GNSS satellites

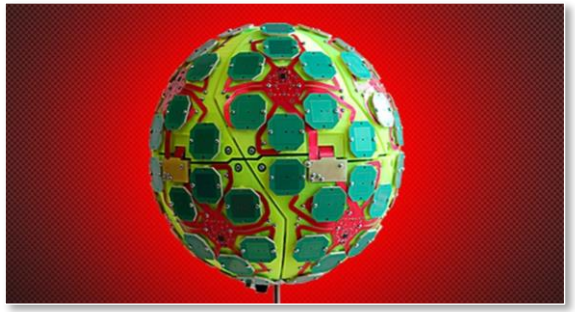
Without external corrections

Locata Technology Platform Components

Over 150 patented advances have made Locata the world leader for enabling new capabilities in next-generation positioning applications

NETWORK Creates the Signals

- **A LocataLite** - the heart of Locata developments
- Ground-based hardware equivalent of a $250M satellite
- World-first capabilities = unprecedented performance



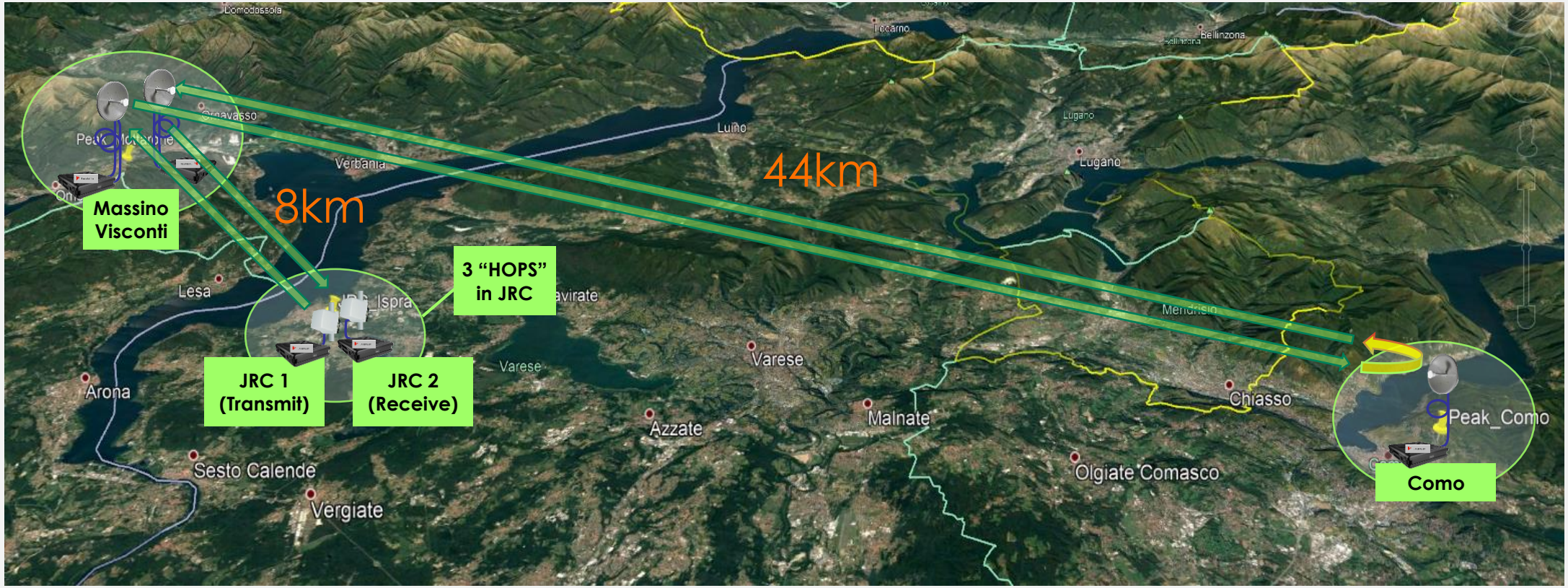
ANTENNA Maximizes Mobile Use

- **VRay Antenna** is the enabler for myriad new apps
- Totally new concept – first major change in 80 years
- Delivers high-accuracy in areas where GPS just *fails*

SOFTWARE Extremely Adaptable

- **Locata IP** - the brains for Locata, with >150 patents!
- Over 3.6 million lines of code = reinvented GPS
- **Delivers new capabilities that GPS will <u>never</u> replicate**

Frankly TimeLoc sounds…. “unbelievable”

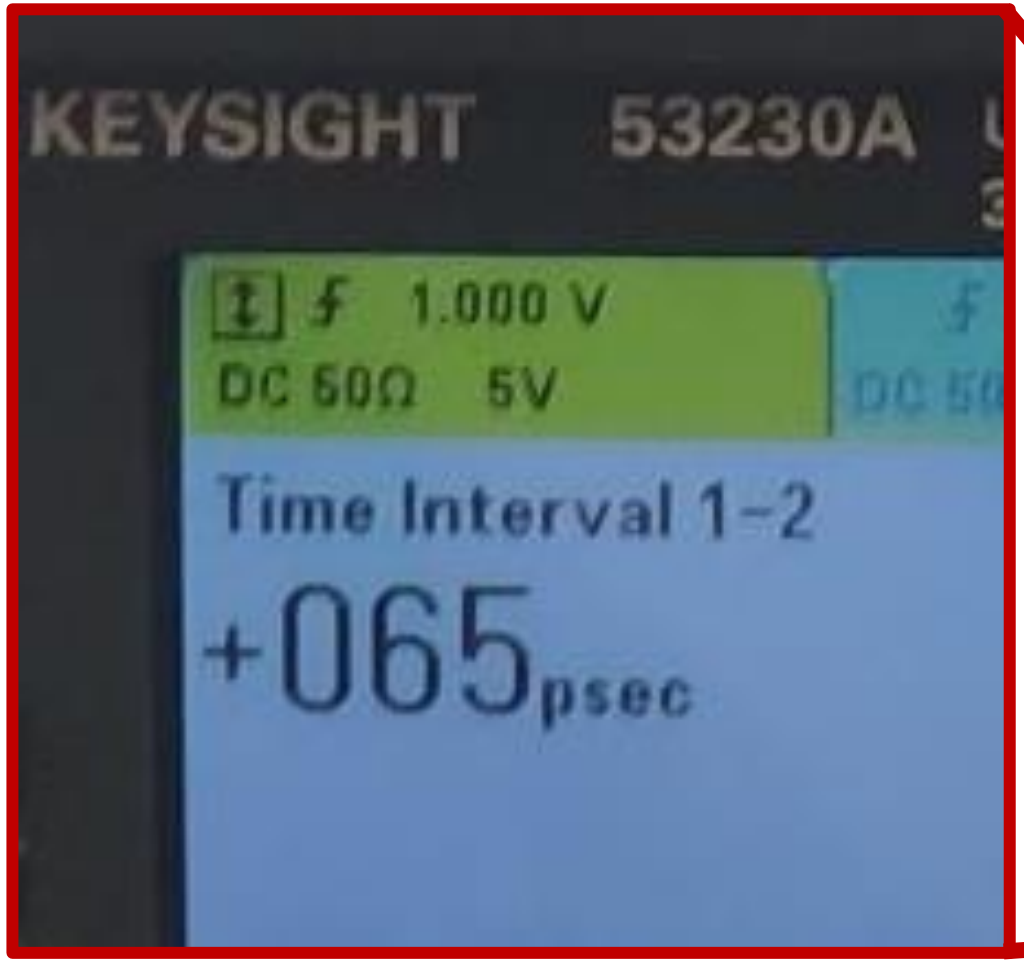


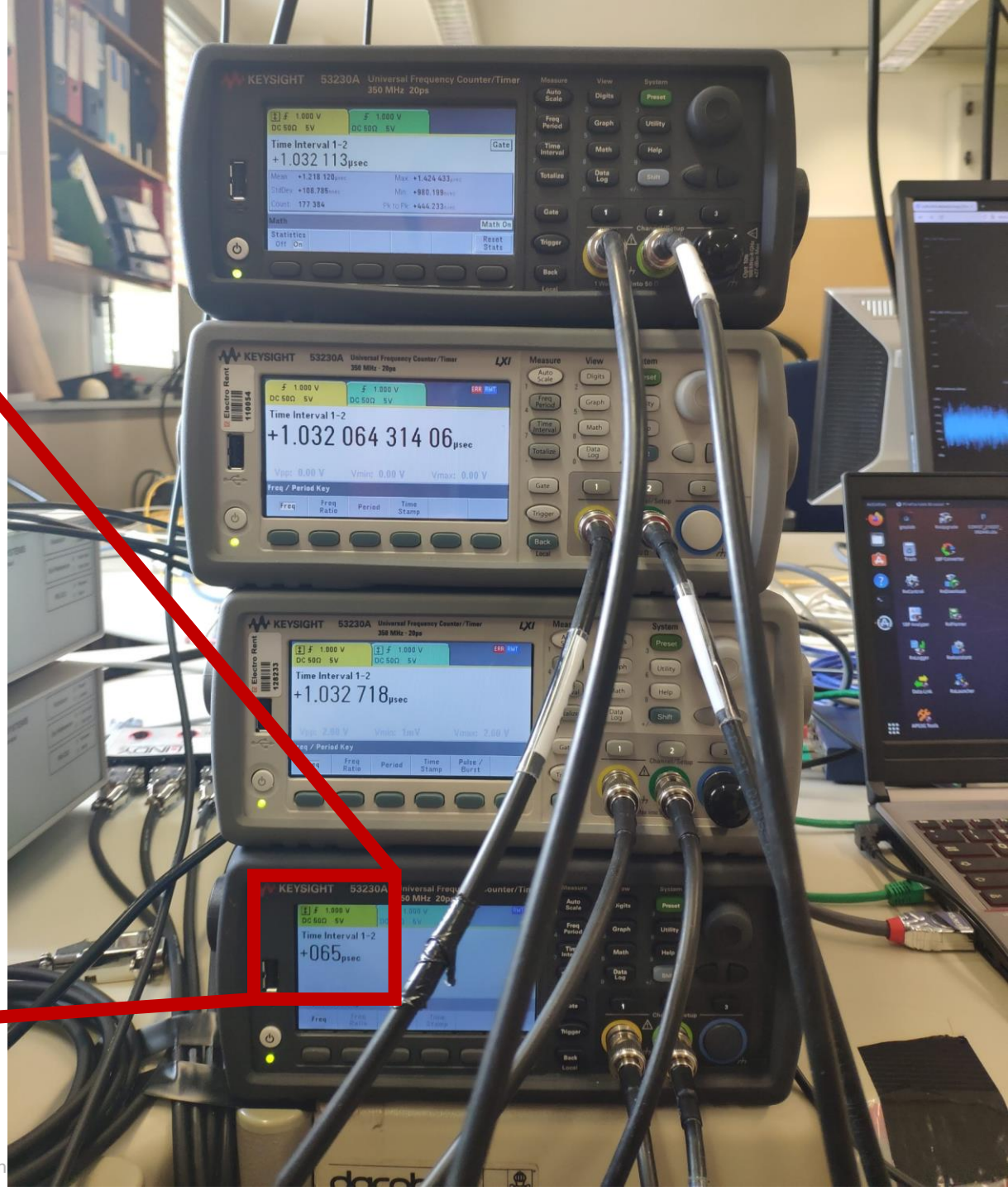
Details of Test Configuration				
	106km total Time Transfer distance – JRC to Como & back	TimeLoc Cascaded through **8 “HOPS”**	**>24-hour test. Just 1 milliwatt transmission power!**	Tropospheric adjustments generated and applied continuously, in real time

Locata

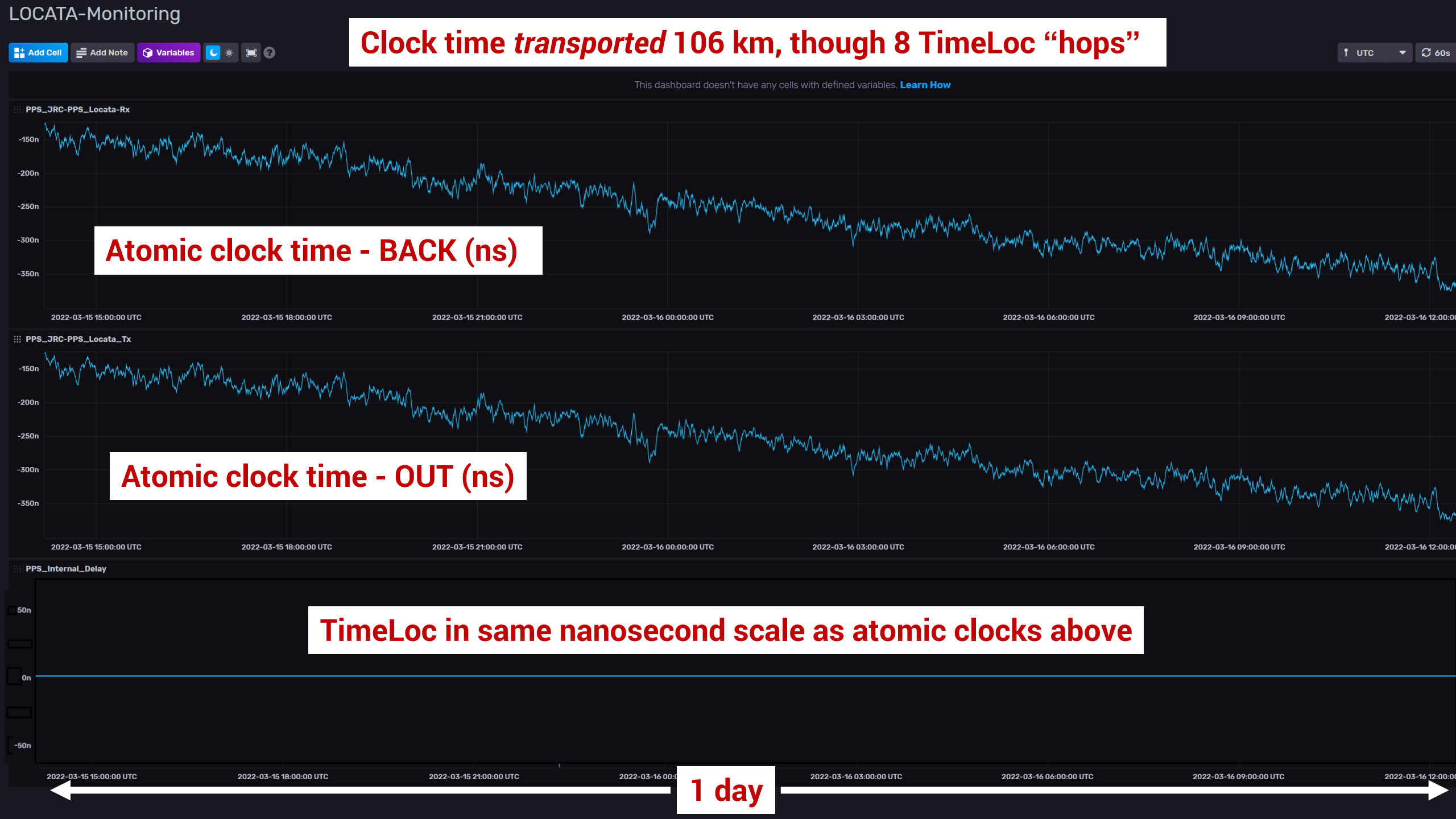
JRC TimeLoc testing

After 8 TimeLoc “hops” over 106km

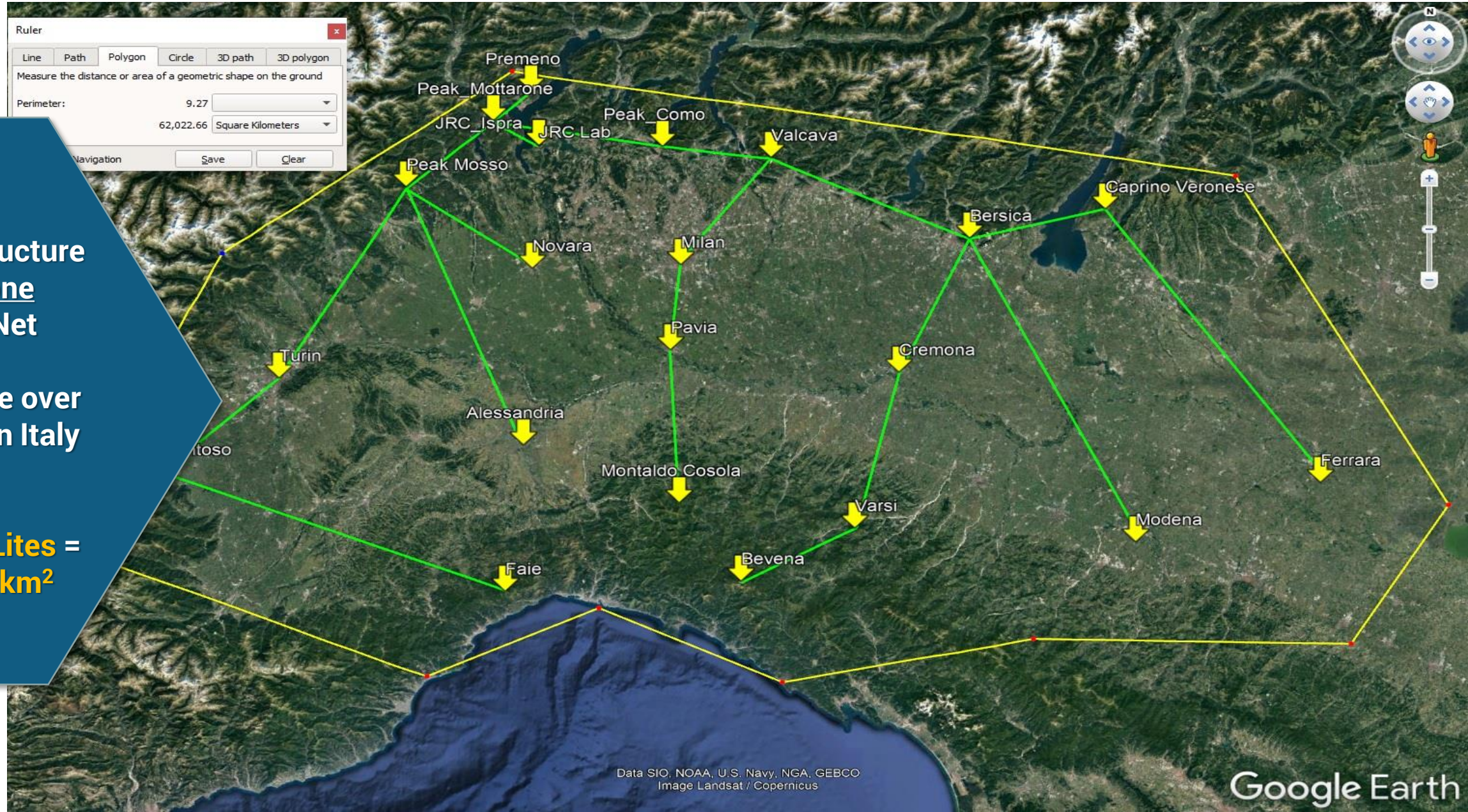




65 picoseconds


LOCATA-Monitoring
Add Cell
Add Note
Variables
UTC
60s
Clock time *transported* 106 km, though 8 TimeLoc "hops"
This dashboard doesn't have any cells with defined variables. Learn How
PPS_JRC-PPS_Locata-Rx
-150n
-200n
-250n
-300n
-350n
2022-03-15 15:00:00 UTC
2022-03-15 18:00:00 UTC
2022-03-15 21:00:00 UTC
2022-03-16 00:00:00 UTC
2022-03-16 03:00:00 UTC
2022-03-16 06:00:00 UTC
2022-03-16 09:00:00 UTC
Atomic clock time - BACK (ns)
PPS_JRC-PPS_Locata_Tx
Atomic clock time - OUT (ns)
PPS_Internal_Delay
50n
0n
-50n
TimeLoc in same nanosecond scale as atomic clocks above
1 day

Example Deployment – Locata as a PNT Backbone



Critical Infrastructure Backbone LocataNet

Example over northern Italy

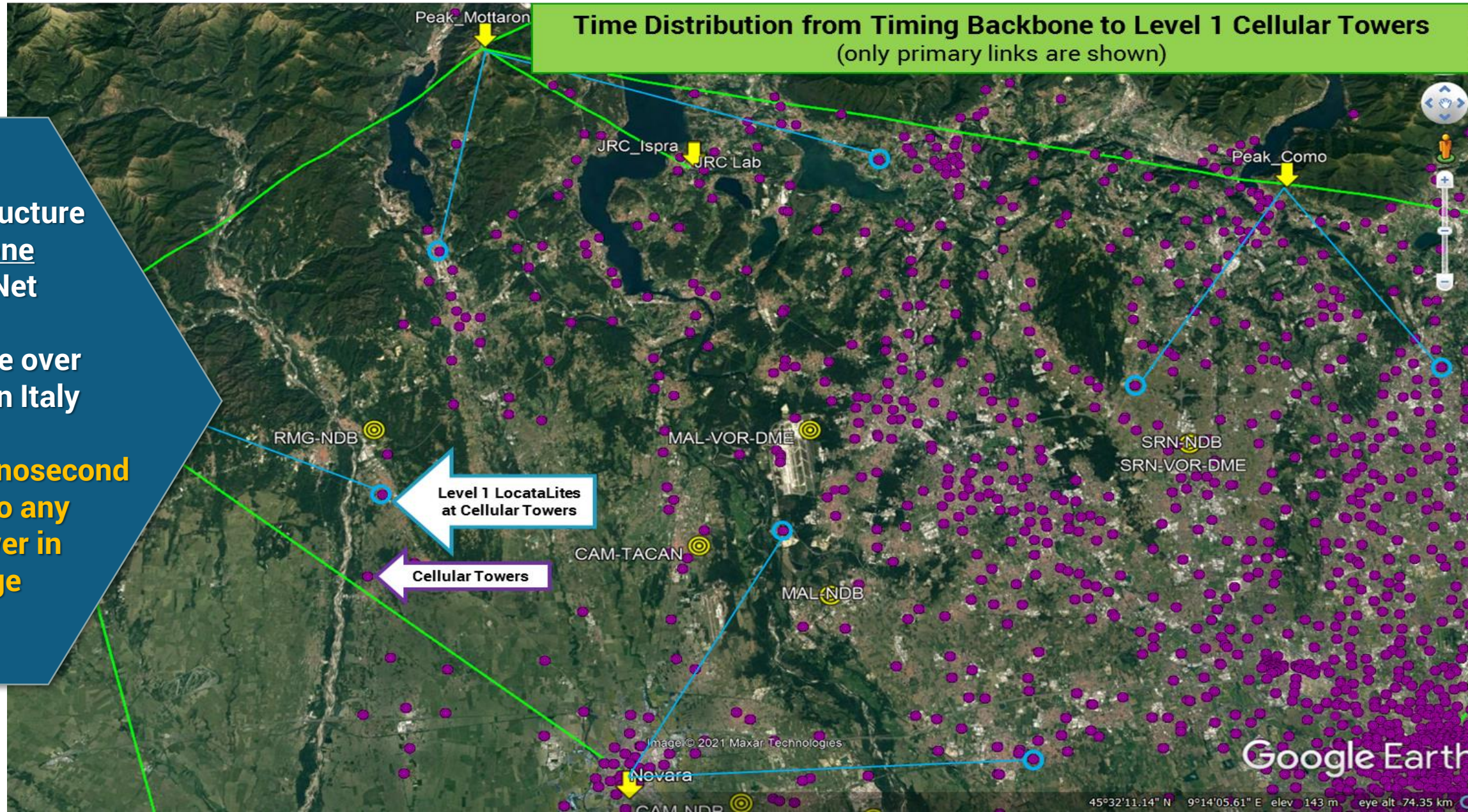
Just 21 LocataLites = 62,000 km²

Example Deployment – Time Distribution to Cell Networks

Critical Infrastructure Backbone LocataNet

Example over northern Italy

Sub-nanosecond synch to any cell tower in coverage area



Locata Timing Tests

Multiple Timing Tests were run over a period of 14 days

They included:

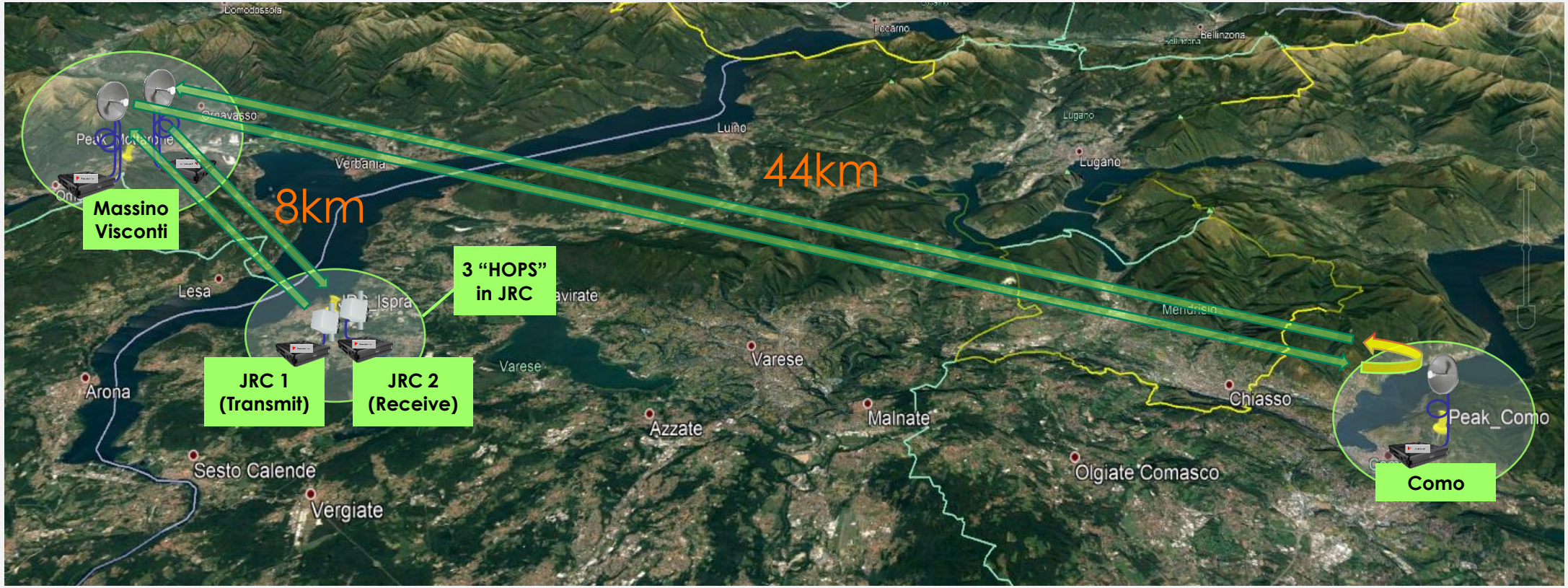
- Over-the-air outdoor wide area
- Over-the-air outdoor local area
- Over-the-air outdoor to indoor
- Over-the-air indoor
- Fibre optic cable
- Copper/coax cable

Indicative Test Results Follow…

RESULTS
#1

OVER-THE-AIR LONG-RANGE WIDE-AREA 24 HOUR TIME TRANSFER TEST

Test configuration



Details of Test Configuration

106km total Time Transfer distance – JRC to Como & back

TimeLoc Cascaded through **8 "HOPS"**

>24-hour test. Just 1 milliwatt transmission power!

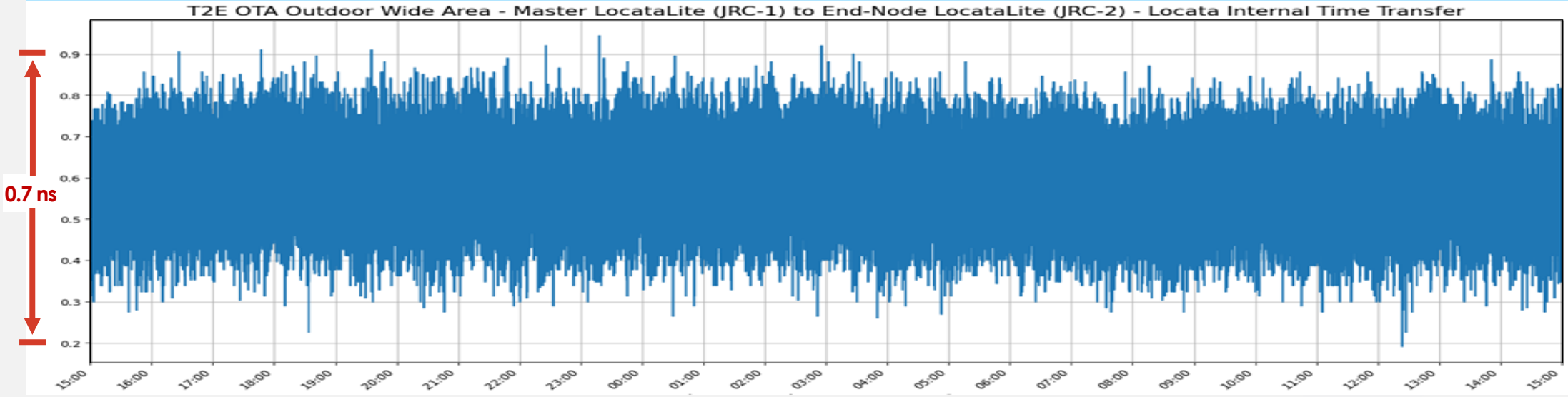
Tropospheric adjustments generated and applied continuously, in real time

Locata

RESULTS
#1

OVER-THE-AIR LONG-RANGE WIDE-AREA 24 HOUR TIME TRANSFER TEST
(106km JRC-Como return, 8 TimeLoc hops)

Locata Internal Time Transfer 24-hours



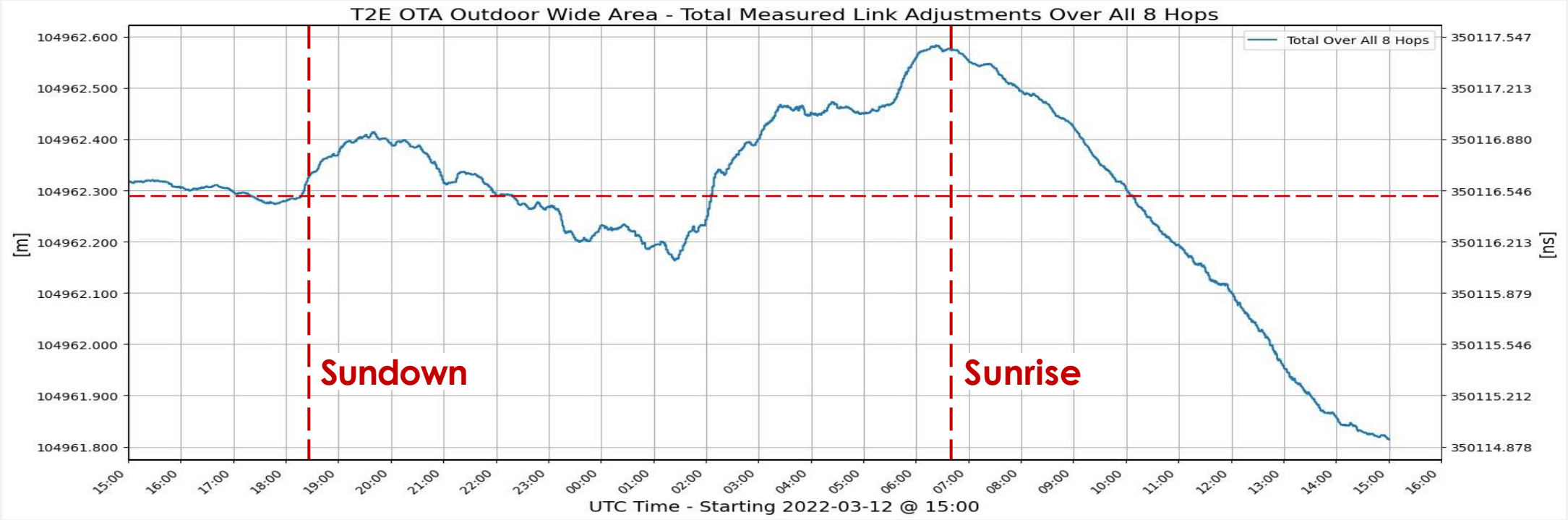
#1A Internal Time Transfer	#1B External Time Synchronization	#1C External Time Transfer
MEAN: **584** picoseconds	MEAN: **180** picoseconds	MEAN: **404** picoseconds
STD DEV: **85** picoseconds	STD DEV: **551** picoseconds	STD DEV: **545** picoseconds
ALAN DEV: **4.044E-15**	ALAN DEV: **3.209E-14**	ALAN DEV: **2.992E-14**

Locata

RESULTS
#1

OVER-THE-AIR LONG-RANGE WIDE-AREA 24 HOUR TIME TRANSFER TEST
(106km JRC-Como return, 8 TimeLoc hops)

TimeLoc synchronization automatically adjusts to counter tropospheric effects that change the speed of light

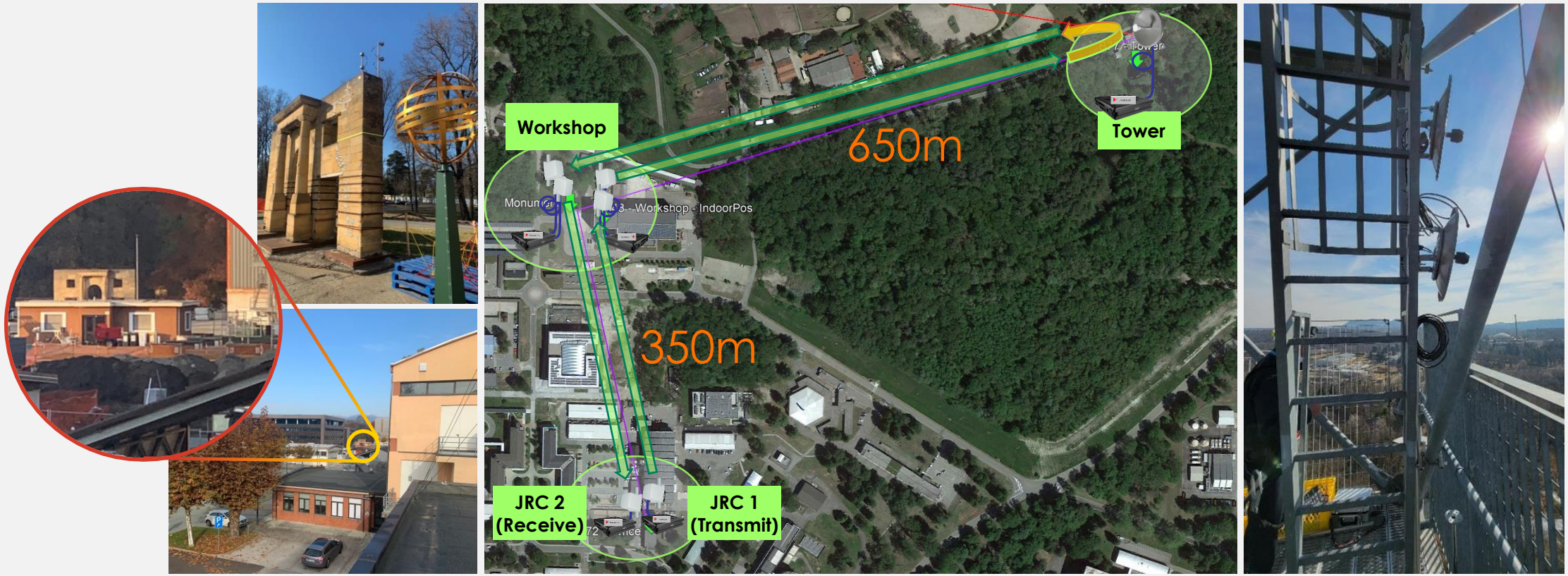


Peak-to-Peak Time Adjustment (over 24 hours)	Peak-to-Peak Distance Adjustment (over 24 hours)
2.6 nanoseconds	**0.8 metres**

Locata

RESULTS
#2

OVER-THE-AIR LOCAL-AREA 24 HOUR TIME TRANSFER TEST
Test configuration



Details of Test Configuration				
	2.2 km total Time Transfer distance – all inside JRC campus	TimeLoc Cascaded through **4 "hops"**	**24-hour** duration	Tropospheric adjustments generated and applied continuously, in real time

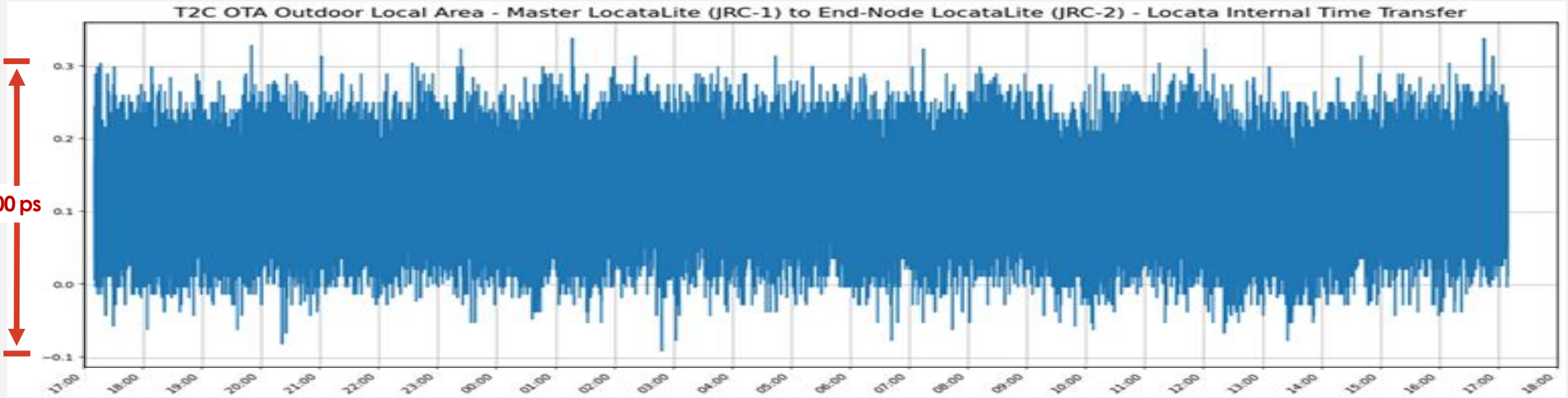
Locata

RESULTS
#2

OVER-THE-AIR LOCAL-AREA 24 HOUR TIME TRANSFER TEST

Test configuration

Locata Internal Time Transfer 24-hours



#2A Internal Time Transfer	#2B External Time Synchronization	#2C External Time Transfer
MEAN: **126 picoseconds**	MEAN: **0 picoseconds**	MEAN: **125 picoseconds**
STD DEV: **50 picoseconds**	STD DEV: **616 picoseconds**	STD DEV: **613 picoseconds**
ALAN DEV: **5.204E-15**	ALAN DEV: **6.002E-14**	ALAN DEV: **6.433E-14**

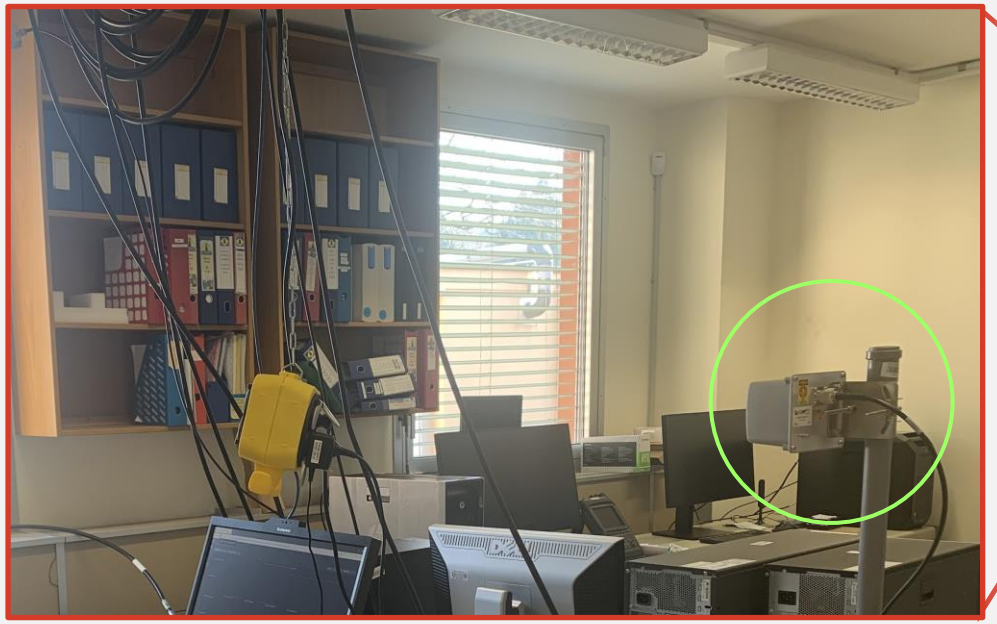
Locata

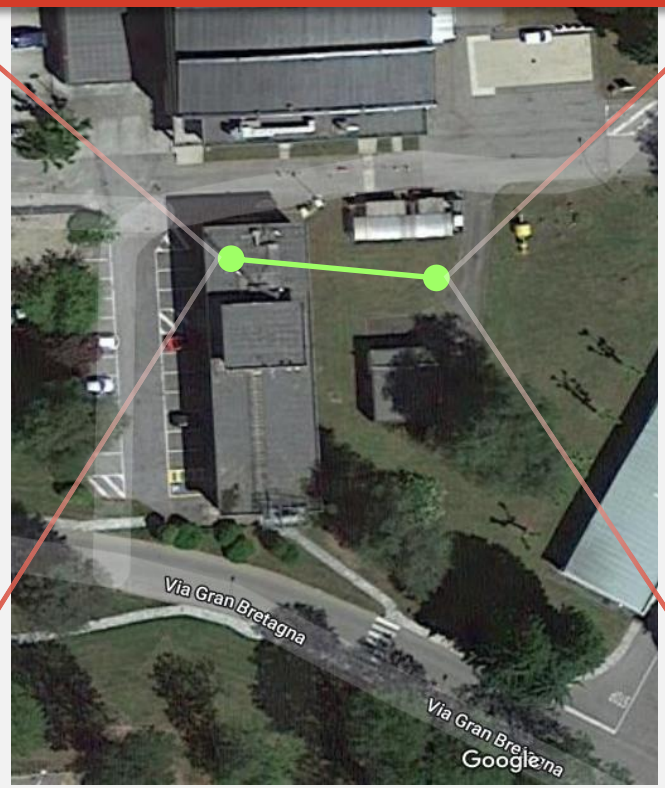
RESULTS
#3

OVER-THE-AIR OUTDOOR to INDOOR 24 HOUR TIME TRANSFER TEST

Test configuration

THROUGH BRICK WALL and BOOKCASE





Details of Test Configuration				
	92 m total Time Transfer distance – through brick-wall, non line-of-sight	TimeLoc point-to-point	**24-hour** duration	Tropospheric adjustments generated and applied continuously, in real time

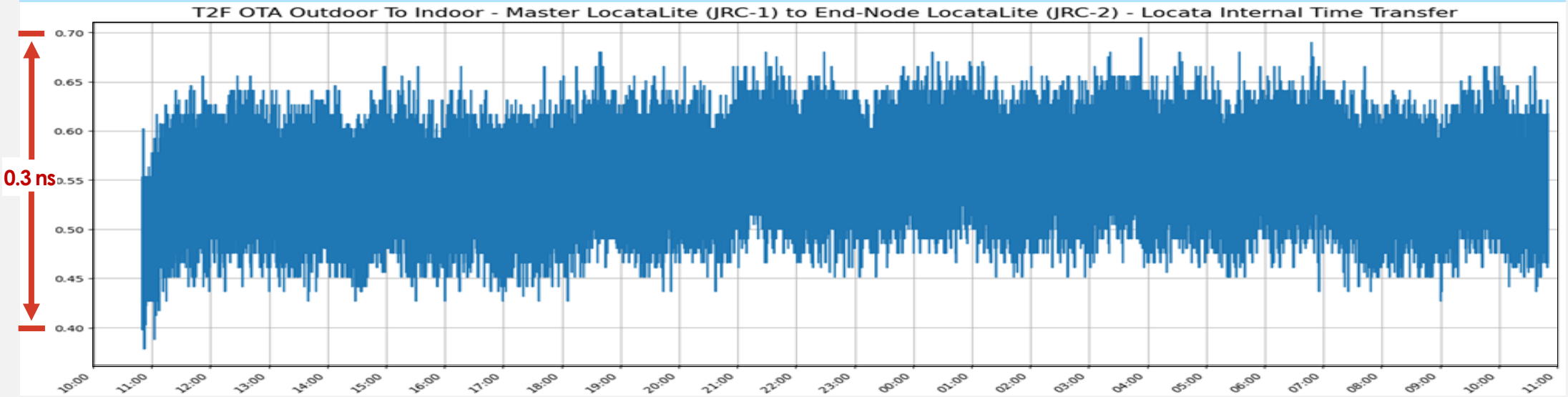
Locata

RESULTS
#3

OVER-THE-AIR OUTDOOR to INDOOR 24 HOUR TIME TRANSFER TEST

TimeLoc through brick wall, non-line-of-sight

Locata Internal Time Transfer 24-hours

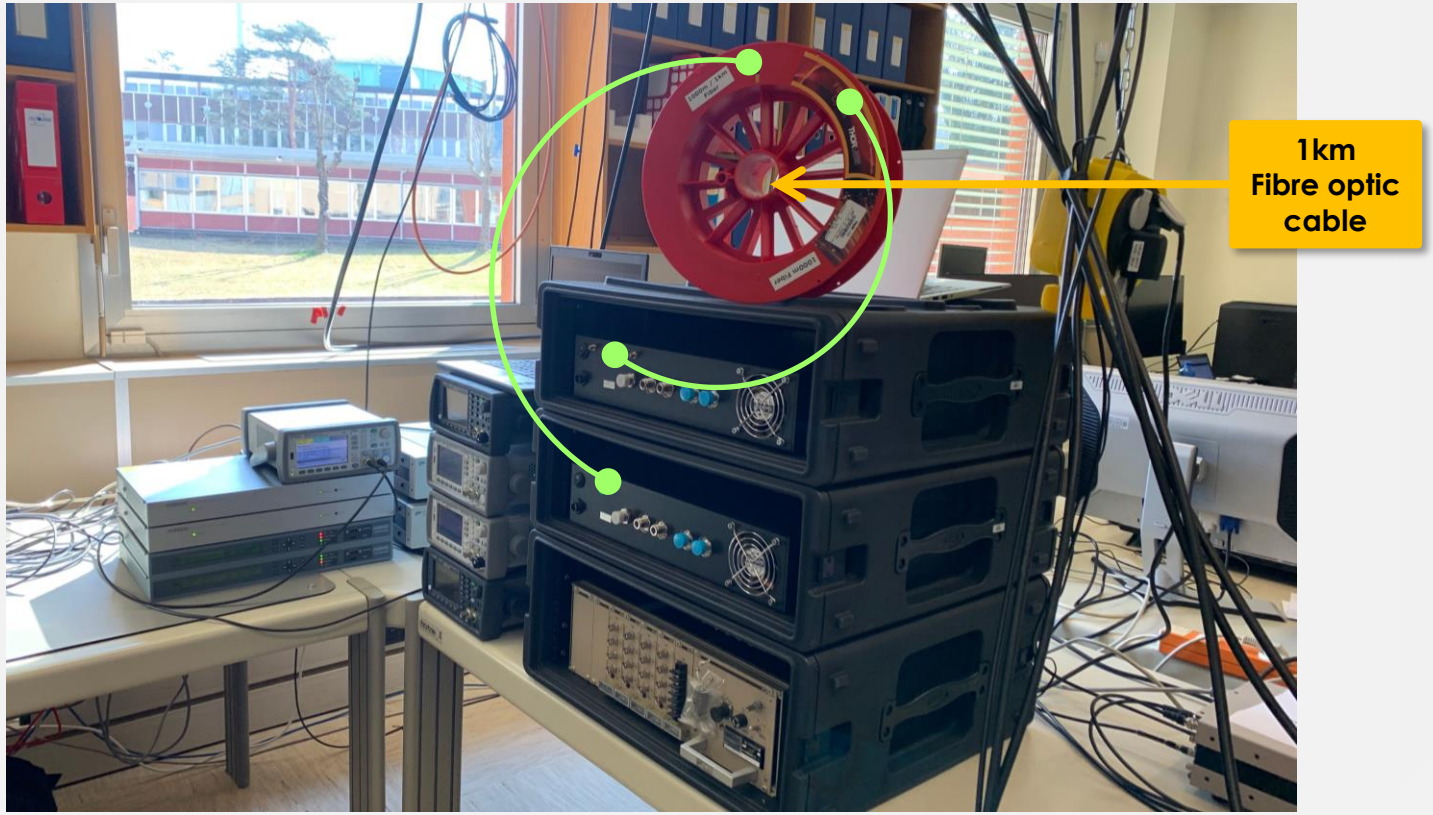


#3A Internal Time Transfer	#3B External Time Synchronization	#3C External Time Transfer
MEAN: **552** picoseconds	MEAN: **81** picoseconds	MEAN: **624** picoseconds
STD DEV: **35** picoseconds	STD DEV: **571** picoseconds	STD DEV: **570** picoseconds
ALAN DEV: **2.040E-15**	ALAN DEV: **3.289E-14**	ALAN DEV: **3.386E-14**

Locata

RESULTS
#4

TIMELOC OVER FIBRE 24 HOUR TIME TRANSFER TEST
Test configuration



Details of Test Configuration				
	1 km of Fibreoptic Cable	TimeLoc from LocataLite to LocataLite (no prior calibration!)	**24-hour** duration	Real time adjustments even adjusted for sunlight on cable during parts of the tests

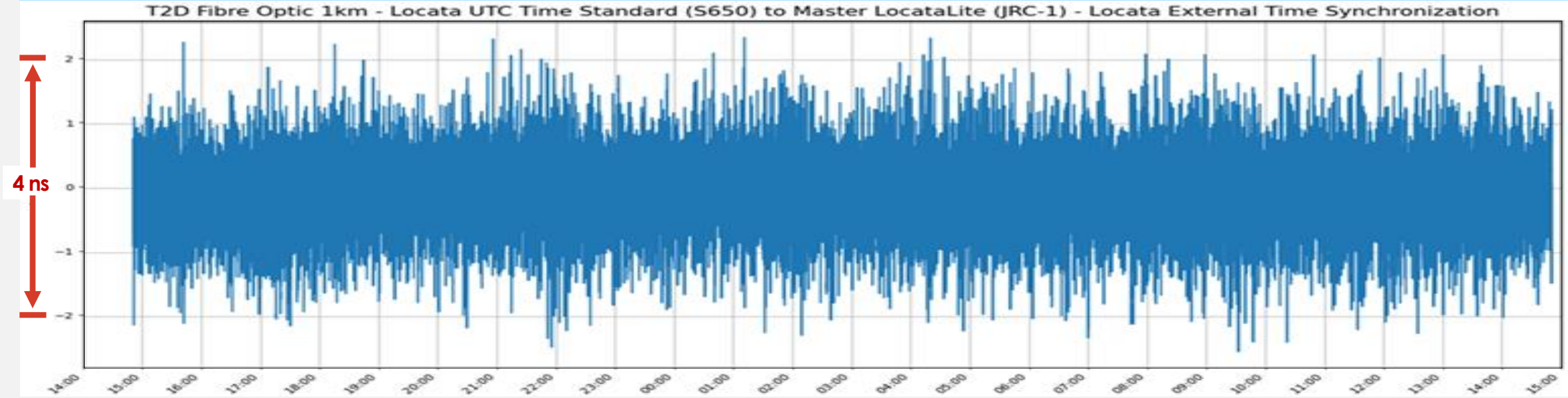
Locata

RESULTS
#4

TIMELOC OVER FIBRE 24 HOUR TIME TRANSFER TEST

(1 km spool of fibre optic cable at JRC lab – no prior calibration required)

Locata Internal Time Transfer 24-hours



#4A Internal Time Transfer	#4B External Time Synchronization	#4C External Time Transfer
MEAN: **207 picoseconds**	MEAN: **-93 picoseconds**	MEAN: **114 picoseconds**
STD DEV: **42 picoseconds**	STD DEV: **549 picoseconds**	STD DEV: **550 picoseconds**
ALAN DEV: **4.106E-15**	ALAN DEV: **1.437E-14**	ALAN DEV: **1.064E-14**

Locata

Summary of Timing Test Results

OVER 6 DAYS OF TESTING
Internal Time Transfer

MEAN: **261 picoseconds**

STD DEV: **49 picoseconds**

OVER 6 DAYS OF TESTING
External Time Synchronization

MEAN: **218 picoseconds**

STD DEV: **565 picoseconds**

Locata Time Transfer Type	Mean [ns]	Std Dev [ns]	MTIE [ns]	Peak-to-Peak [ns]	Samples [1 Hz]
Average Internal Time Transfer (over 6 days)	0.261	0.049	0.494	0.434	518,406
Average External Time Transfer (over 6 days)	0.218	0.565	3.062	5.641	518,406

Locata

DEFIS Alt-PNT "Demo Day"
Locata Technology Overview
Positioning Tests Results

JRC Ispra Campus
18 May 2022

JRC
EUROPEAN COMMISSION

Navigation Revolutions are Synchronized!

*Every major positioning revolution in the past 250 years has been built on the foundation of **a new way of synchronizing!***

John Harrison - inventor

Harrison's Chronometers – **synchronized to the sun**

- 18th Century British navigation revolution - **chronometer**
- Synchronization accuracy = 1 second in a month
- Helped make Britain's Navy the master of the seas

Modern GNSS – **synchronized to ground-based clock**

- 20th Century navigation revolution – **atomic clocks**
- Synchronization accuracy = ~50 nanoseconds
- Changed the world, enabled myriad new ideas for apps

David Small - inventor

Locata's TimeLoc – **synchronized to each other**

- 21st Century – synchronized **<u>without</u> atomic clocks**
- Synchronization accuracy = < 1 nanosecond
- Game-changer, enables new apps & national sovereignty

IMPORTANT! Our Business Model is for partnerships

How Locata delivers technology markets

3 fundamentals

1. **INTEL INSIDE** - to markets via OEM partners
2. Market development is **NOW-SOON-LATER**
3. Ever-larger markets via **MINIATURIZATION**


Locata Partner
Container Terminals

Fully-Autonomous Port Straddles “**Powered by Locata**”

Locata = Unprecedented accuracy for automation

Locata **Partner**

Mining

Locata **Partner**

Warehousing & Logistics Hubs

Locata **Partner**

UAV Research

Locata **Partner**

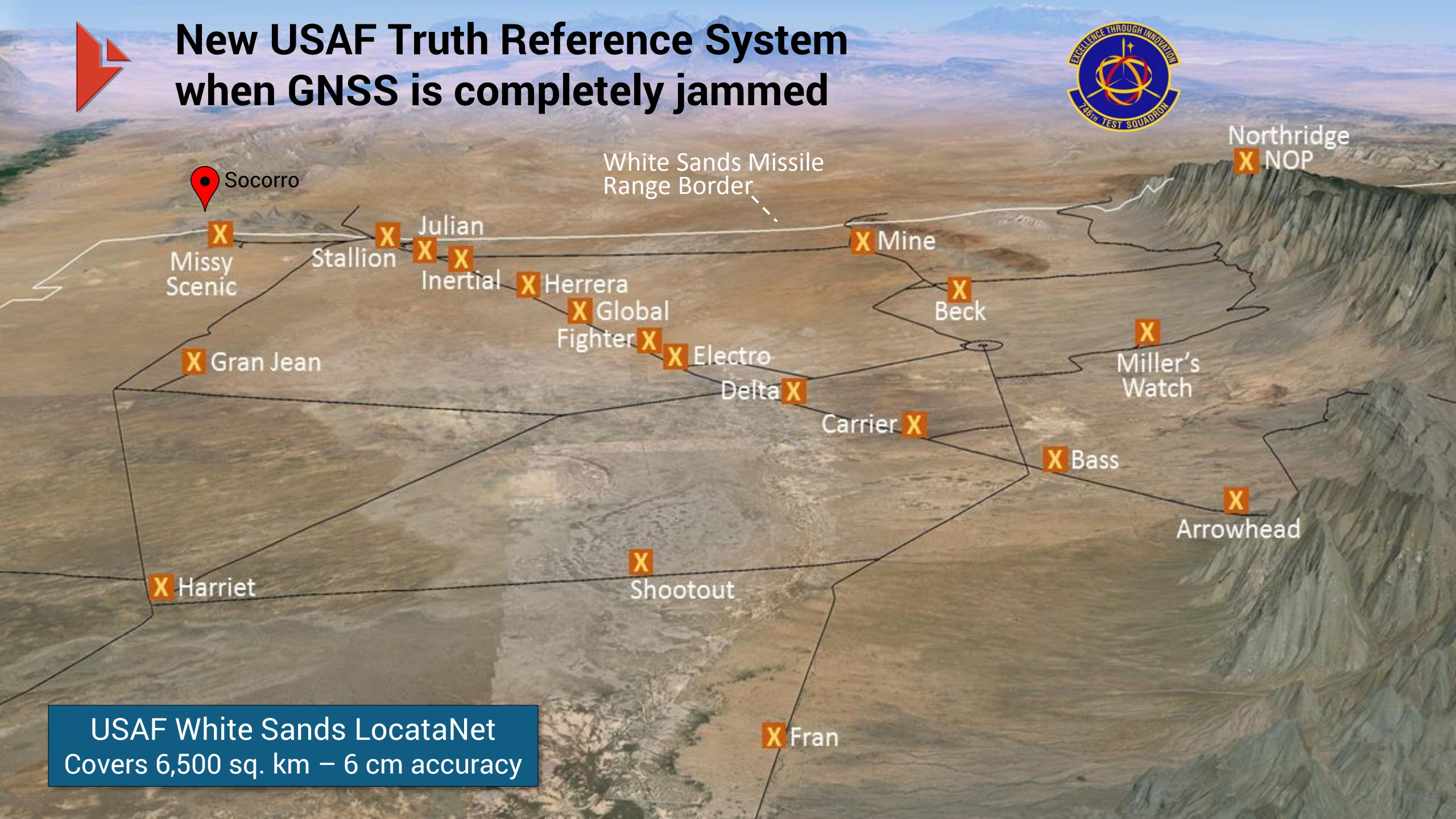
Master LocataLite Transmitter
White Sands Missile Range, USA

Military

Locata

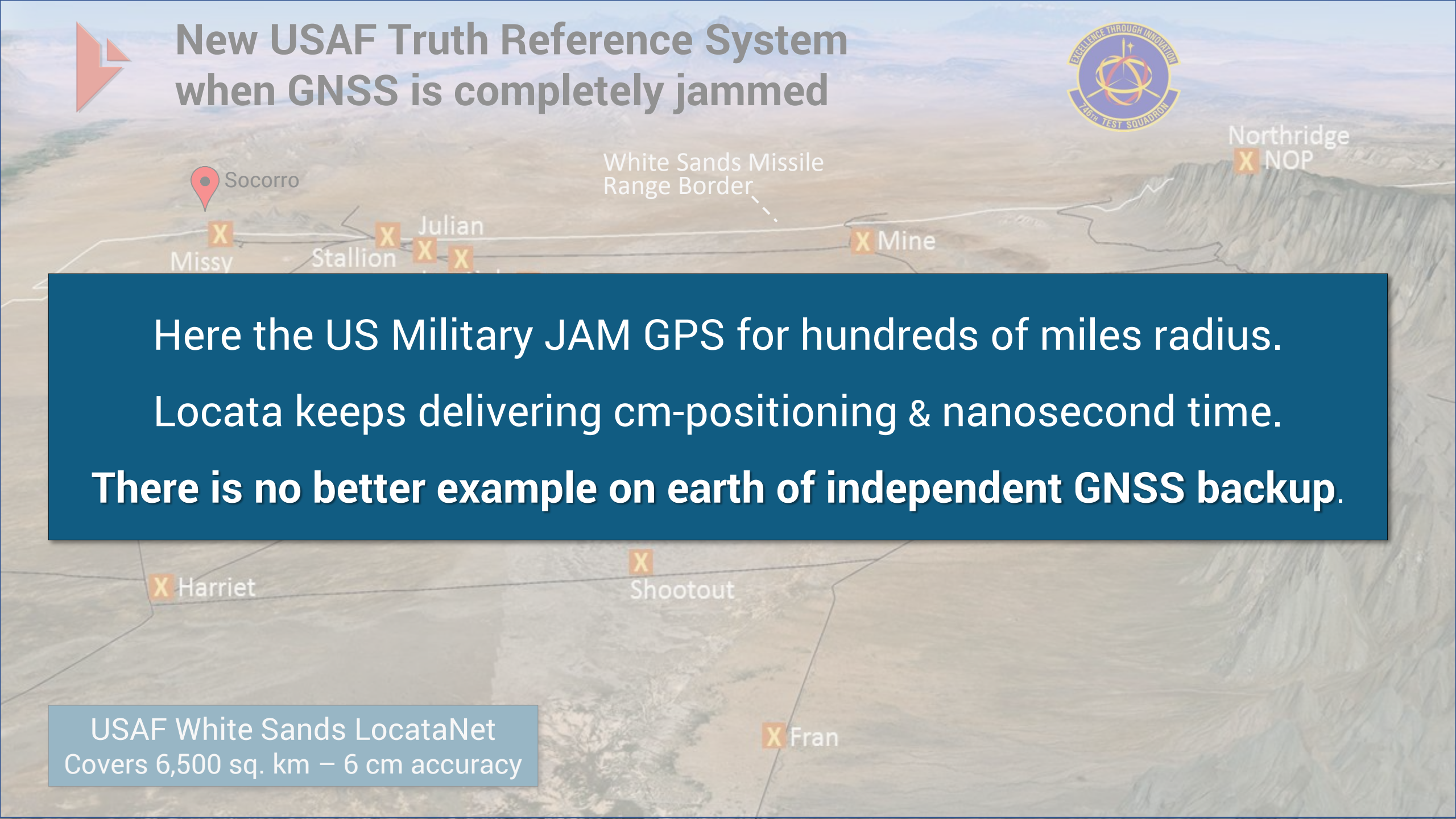

UNITED STATES AIR FORCE
HT
60080
DANGER
DANGER
Locata Antenna

New USAF Truth Reference System when GNSS is completely jammed



USAF White Sands LocataNet
Covers 6,500 sq. km – 6 cm accuracy

New USAF Truth Reference System when GNSS is completely jammed



Here the US Military JAM GPS for hundreds of miles radius.

Locata keeps delivering cm-positioning & nanosecond time.

There is no better example on earth of independent GNSS backup.

USAF White Sands LocataNet
Covers 6,500 sq. km – 6 cm accuracy

Indoor Positioning Tests

Multiple Position Tests were run over a period of several days, in JRC Workshop Building 48

They included:

- Static occupation over surveyed points on the floor, measured against a Total Station prism on the Locata VRay Orb Antenna
- Kinematic positioning measured against Total Station cross-track

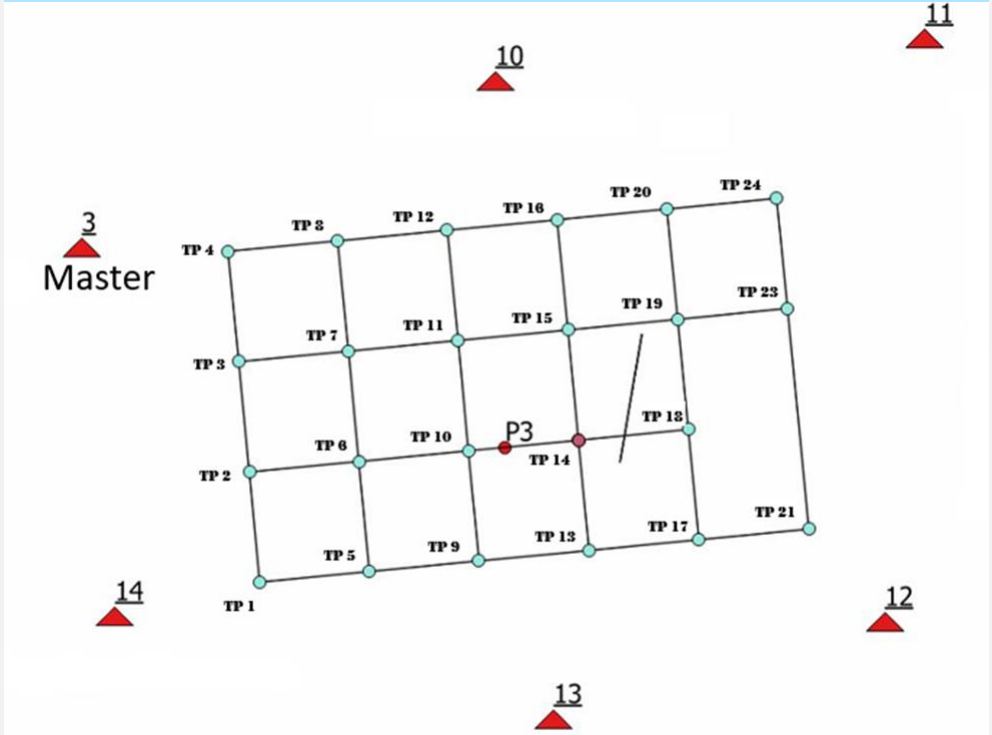
Indicative Test Results Follow...

RESULTS
#5

INDOOR POSITIONING TESTS (BOTH STATIC & KINEMATIC) EXTREME MULTIPATH

Workshop – JRC Building 48

23 Indoor Surveyed Test Points on Workshop Floor



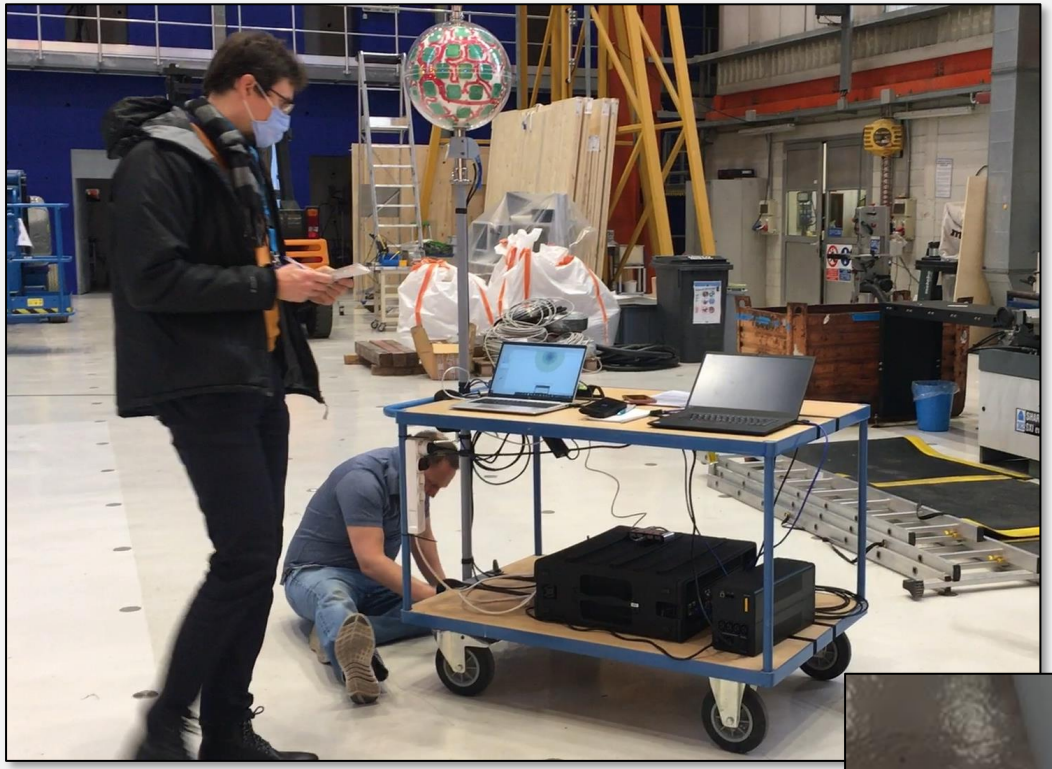
Details of Test Configuration	Large Indoor Workshop – JRC Building 48 – metal walls & ceiling = **extreme multipath**	**TimeLoc Synchronization Cascaded indoors** from Outdoor Locata Network	6 LocataLites mounted on the walls **– No GNSS – – No IMU's –**	**Locata Positioning compared against Total Station surveyed points**

Locata

RESULTS
#5A

STATIC INDOOR POSITIONING TEST – vs TOTAL STATION

#5A – STATIC Indoor Positions vs Total Station



Multiple Tests Conducted. This is Test 2 – Static Points Measured

Locata position solutions output at 10Hz

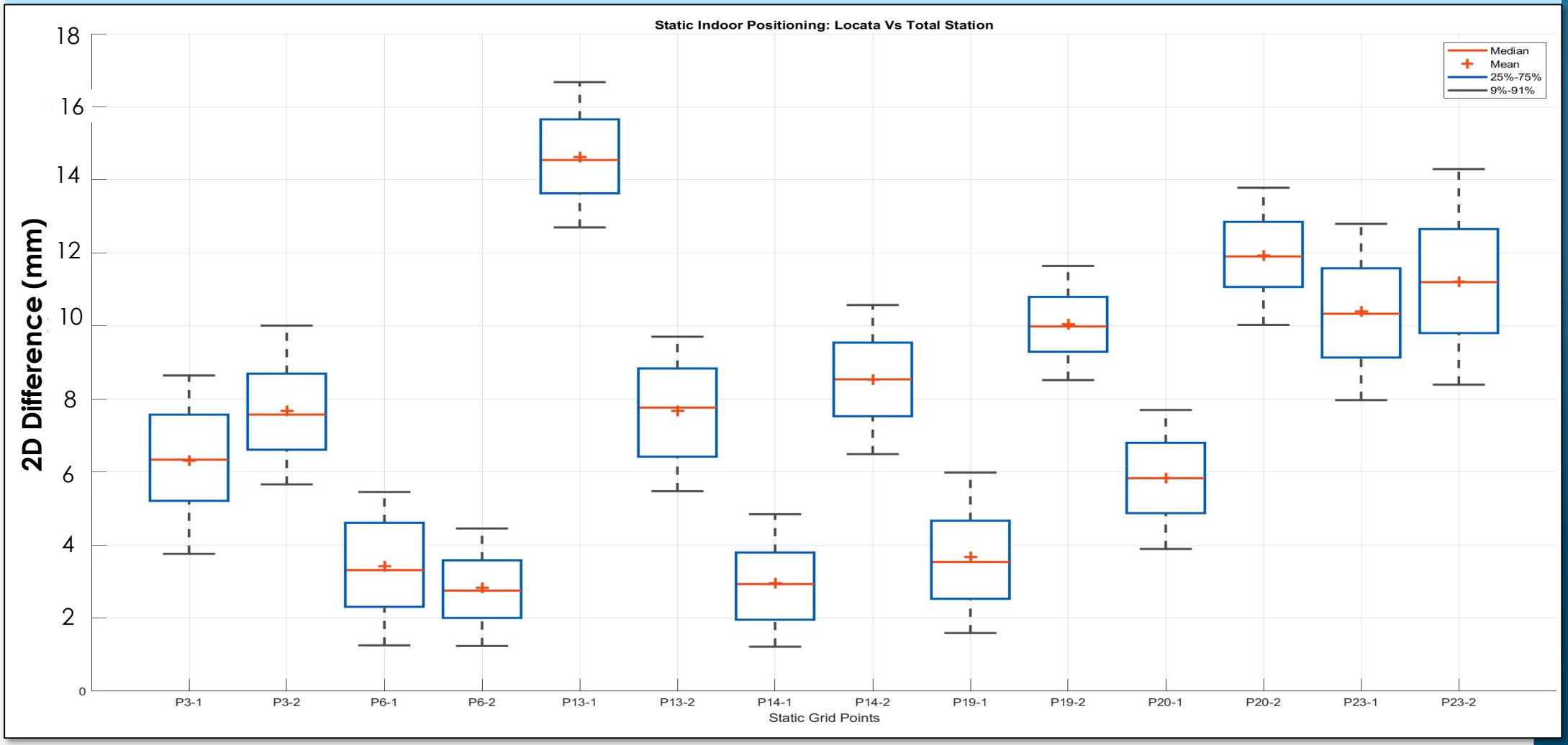
Locata

RESULTS
#5A

STATIC INDOOR POSITIONING TEST – vs TOTAL STATION

18 mm

#5A – STATIC Indoor Positions vs Total Station Box Plot

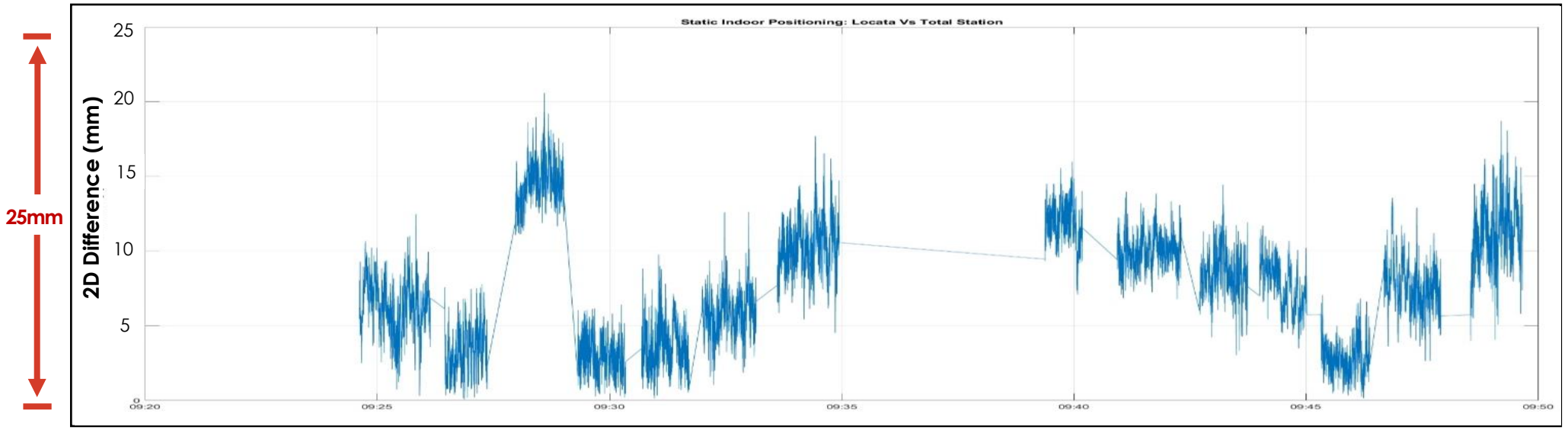


Locata

RESULTS
#5A

STATIC INDOOR POSITIONING TEST – vs TOTAL STATION

#5A – STATIC Indoor Positions Time Series



RESULTS ALL TESTS

Mean Difference	Standard Deviation	RMS Error
8 millimetres	4 millimetres	9 millimetres

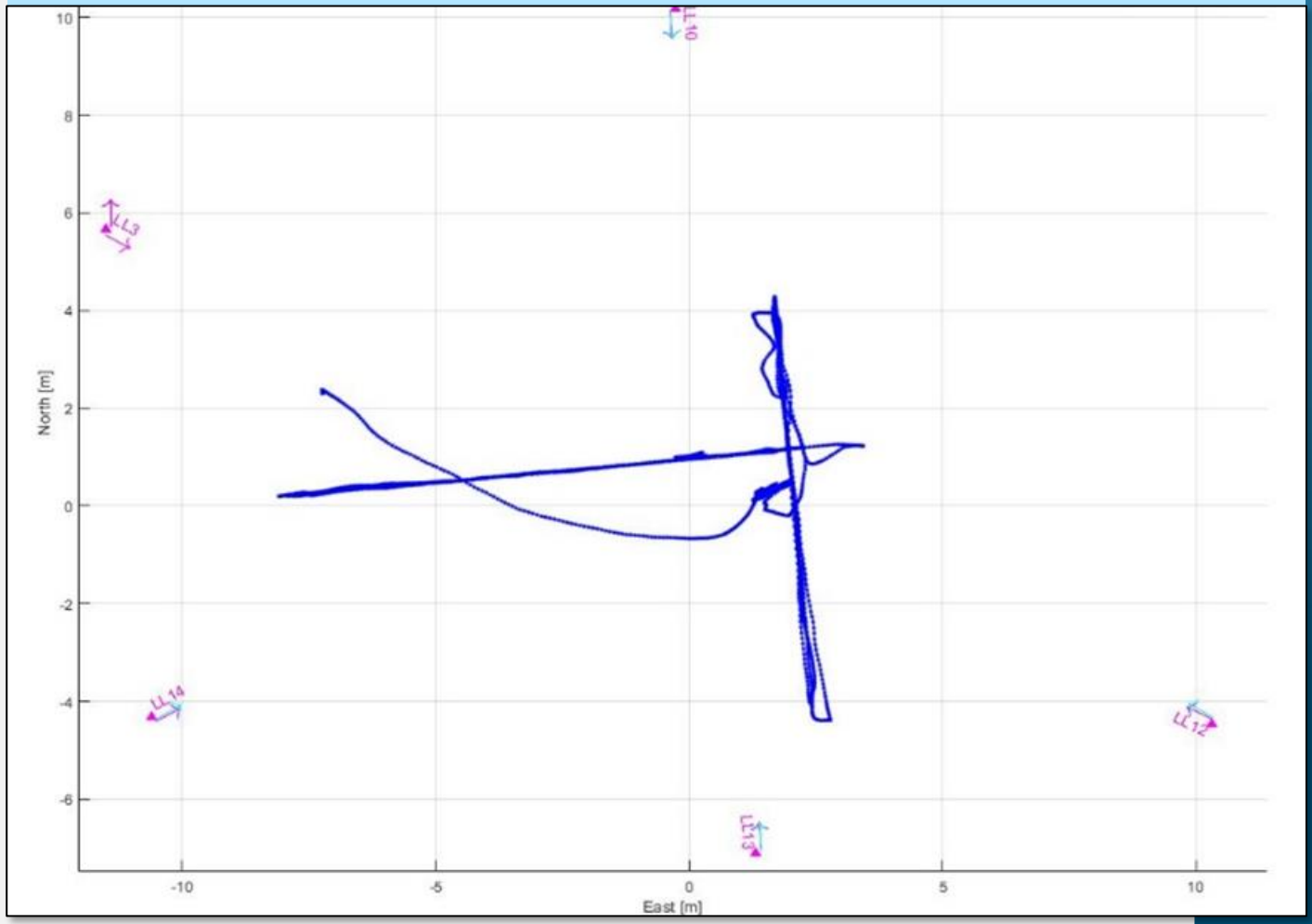
Locata

RESULTS
#5B

KINEMATIC INDOOR POSITIONING TEST – RANDOM MOVEMENT

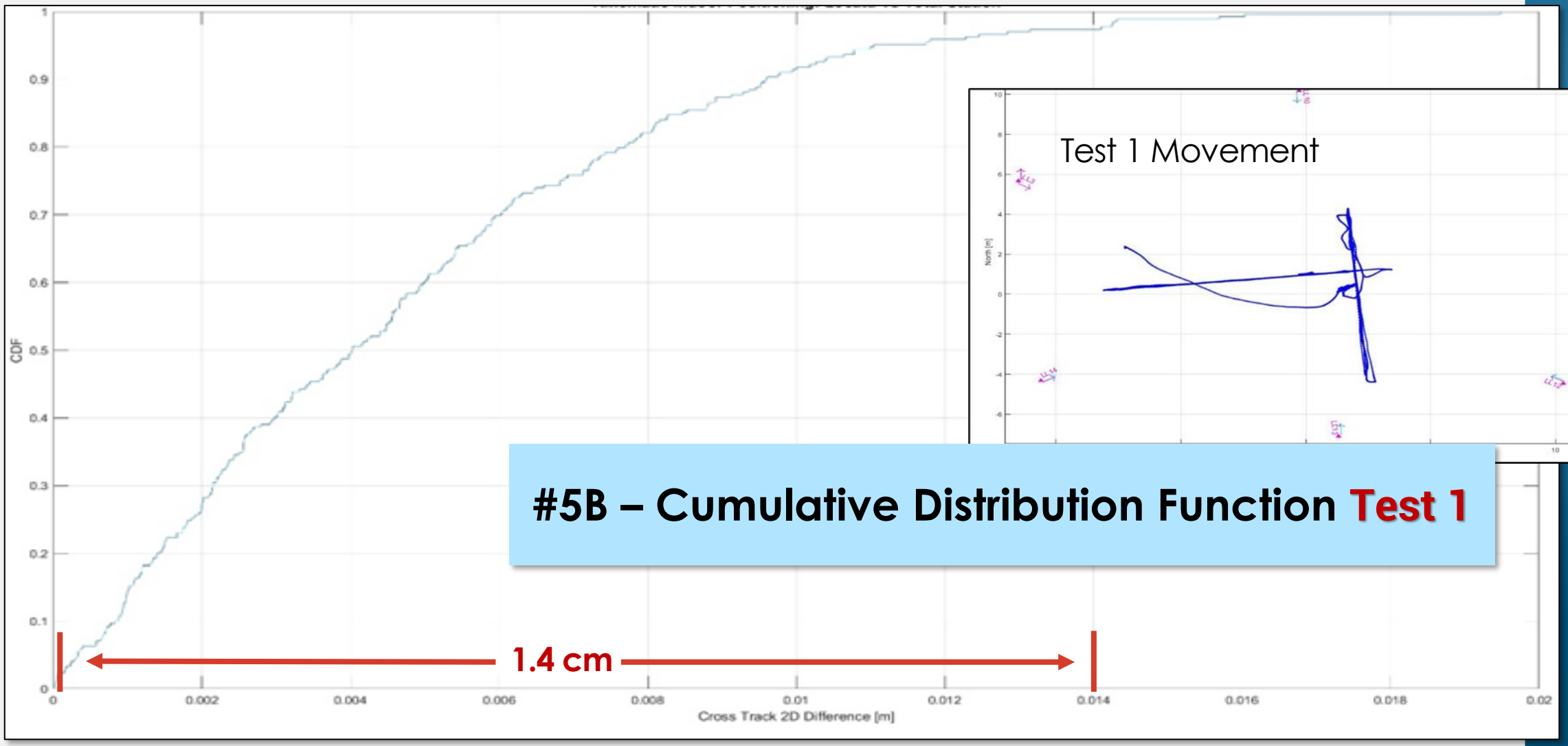
Locata position solutions output at 10Hz

#5B – Example Indoor Random Movement over 30 x 30 metre area (Test 2)



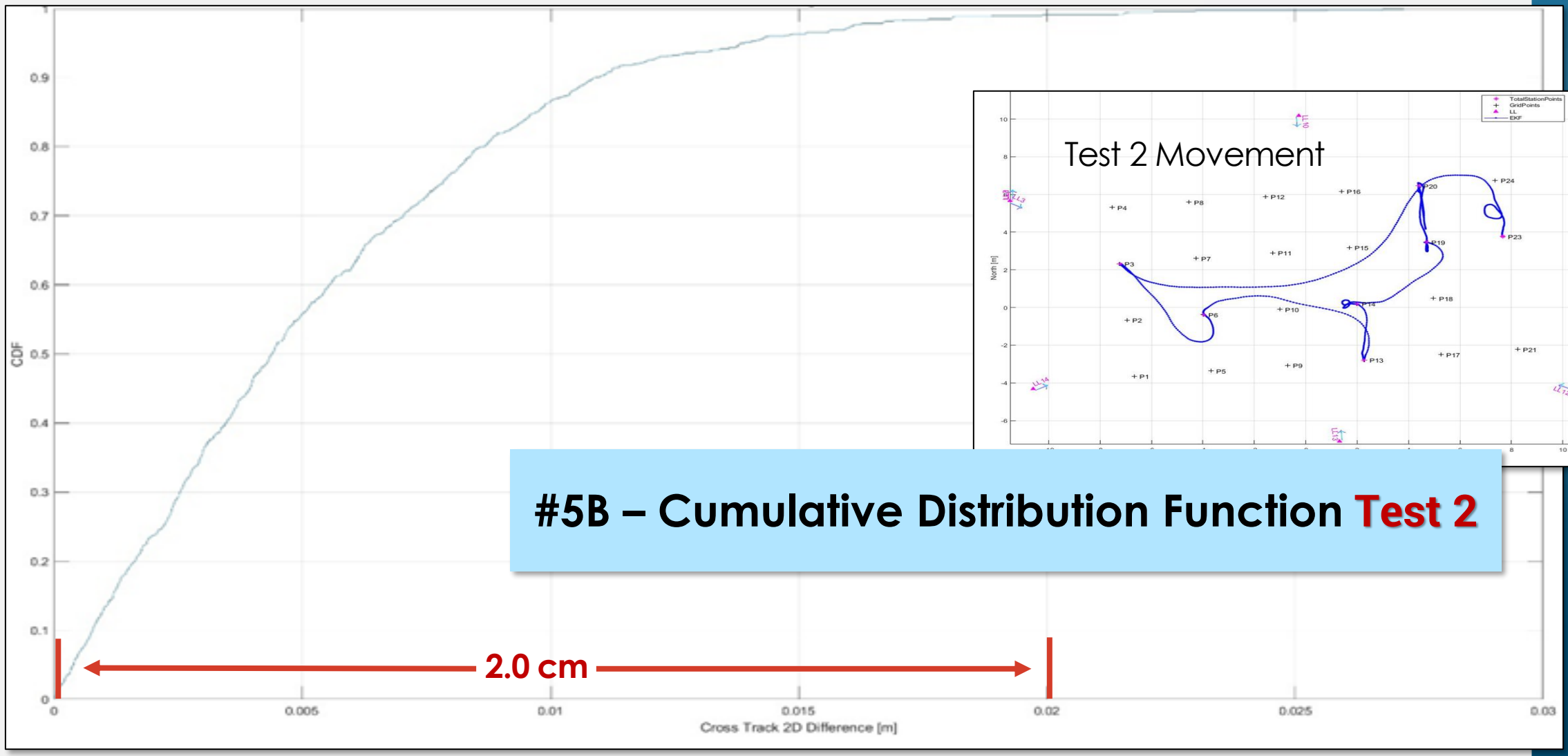
Locata

KINEMATIC INDOOR POSITIONING TEST – RANDOM MOVEMENT



Locata

KINEMATIC INDOOR POSITIONING TEST – RANDOM MOVEMENT



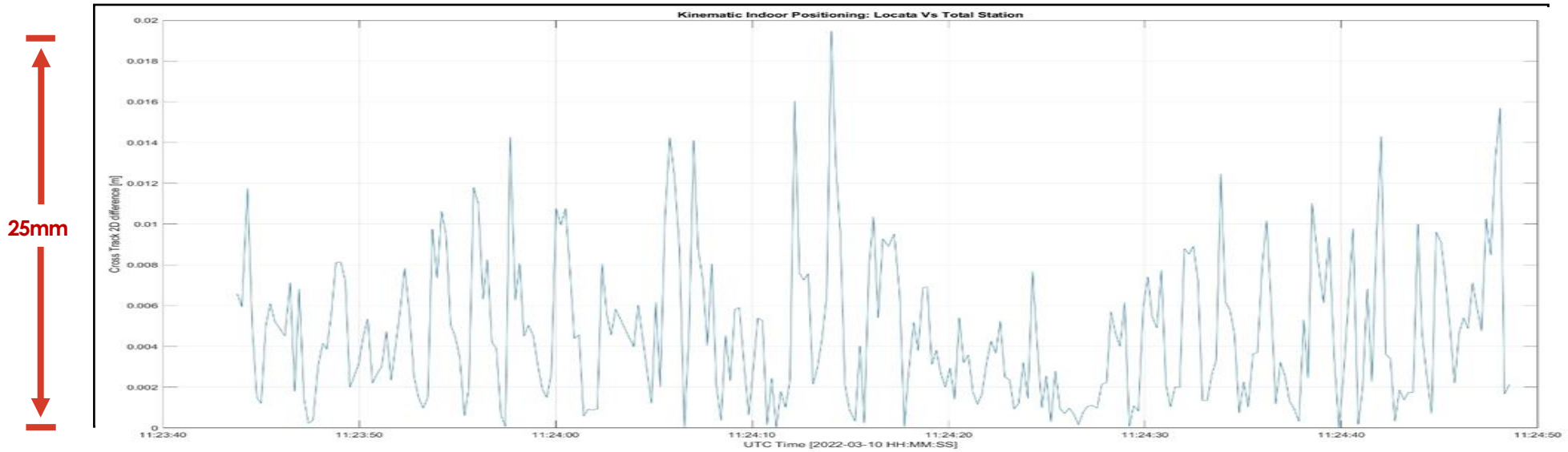
#5B – Cumulative Distribution Function Test 2

Locata

RESULTS
#5B

KINEMATIC INDOOR POSITIONING TEST – RANDOM MOVEMENT

#5A – KINEMATIC Indoor Positions Time Series



RESULTS ALL TESTS

Mean Difference	Standard Deviation	RMS Error
5 millimetres	4 millimetres	6 millimetres

Locata

Outdoor Positioning Tests

Multiple Position Tests were run over a period of one day.
Customer Test Site, Germany

They included:

- Static occupation over surveyed points on the ground, measured against a Total Station prism on the Locata VRay Orb Antenna
- Kinematic positioning measured against Total Station cross-track

Indicative Test Results Follow...

RESULTS
#6

OUTDOOR POSITIONING TESTS (REAL-WORLD GERMAN TEST FACILITY)

Konecranes Dusseldorf Test Field

Konecranes Autonomous Straddle at Test Field

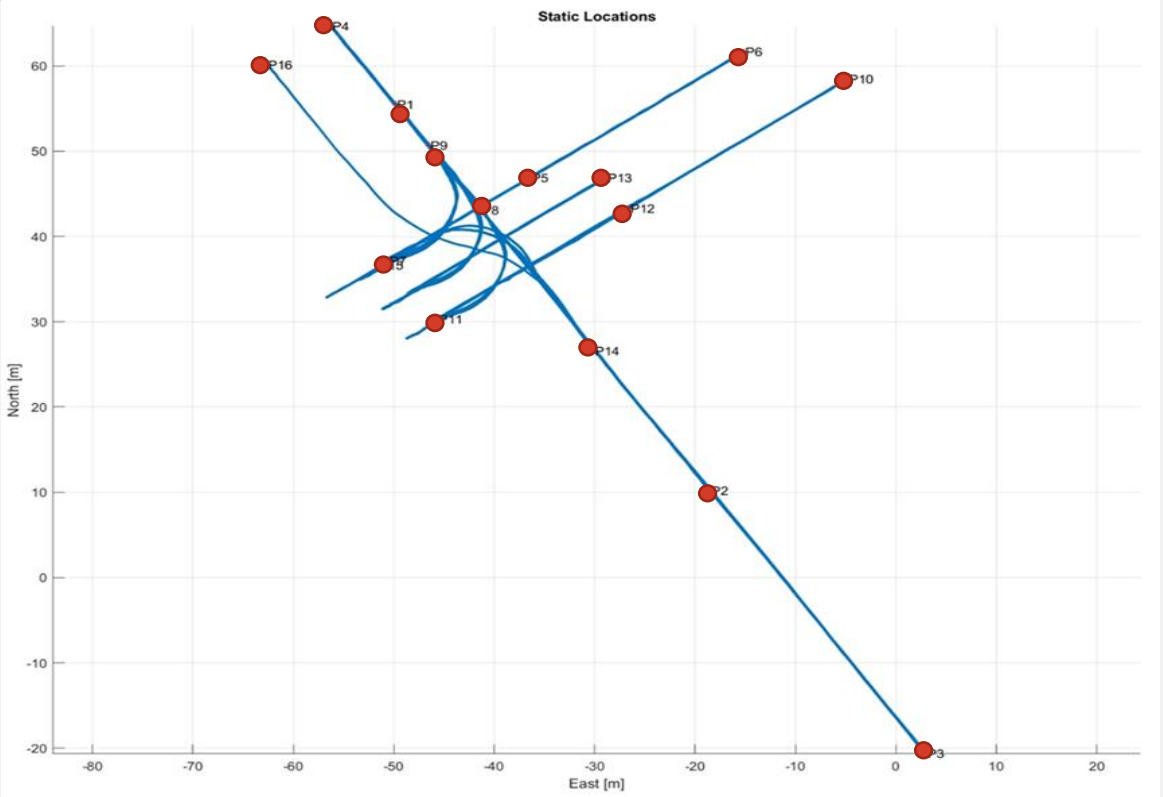
Details of Test Configuration	Large Outdoor Test Facility – Konecranes Dusseldorf Test Field	Real-world facility replicating container port environment – 6 LocataLites permanently installed	Fully-autonomous 60-ton, 4-story high straddle machines use Locata-only solutions – NO GNSS	Locata Positioning tested against surveyed points, measured with Total Station

Locata

RESULTS
#6A

OUTDOOR POSITIONING TESTS (BOTH STATIC & KINEMATIC)

Outdoor Site Layout for Static & Kinematic Tests @ Konecranes Dusseldorf



Picture of part of Konecranes Test Field Area

Details of Test Configuration

Approx. Size of Available Test Area: **110 x 100 metres**

16 Static Points compared against Total Station solution

Locata Kinematic Solution compared to RTK GNSS

Straddle moves ran fully-autonomous – no human control

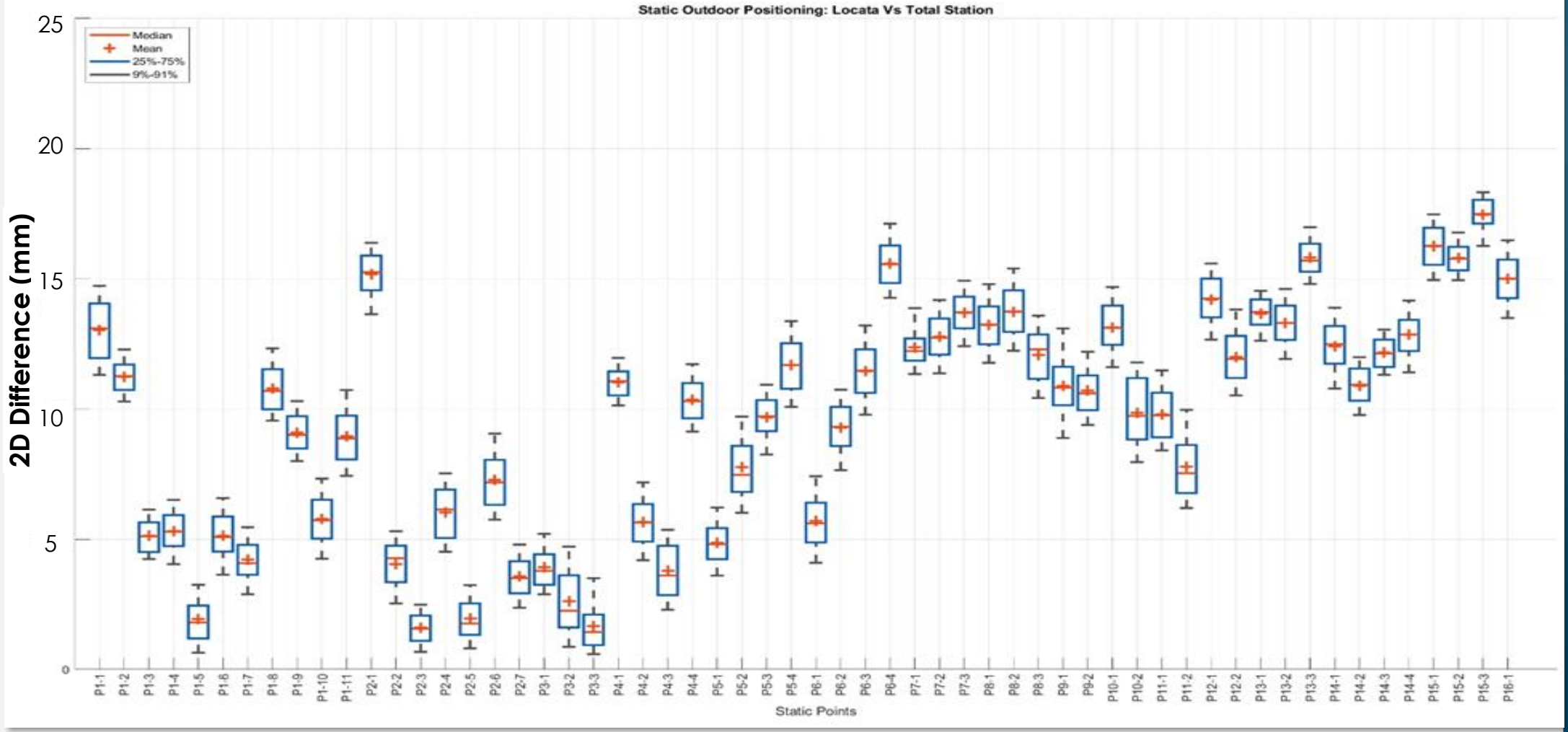
Locata

RESULTS
#6A

STATIC OUTDOOR POSITIONING TEST – vs TOTAL STATION

#6A – All STATIC Outdoor Positions vs Total Station

25 mm



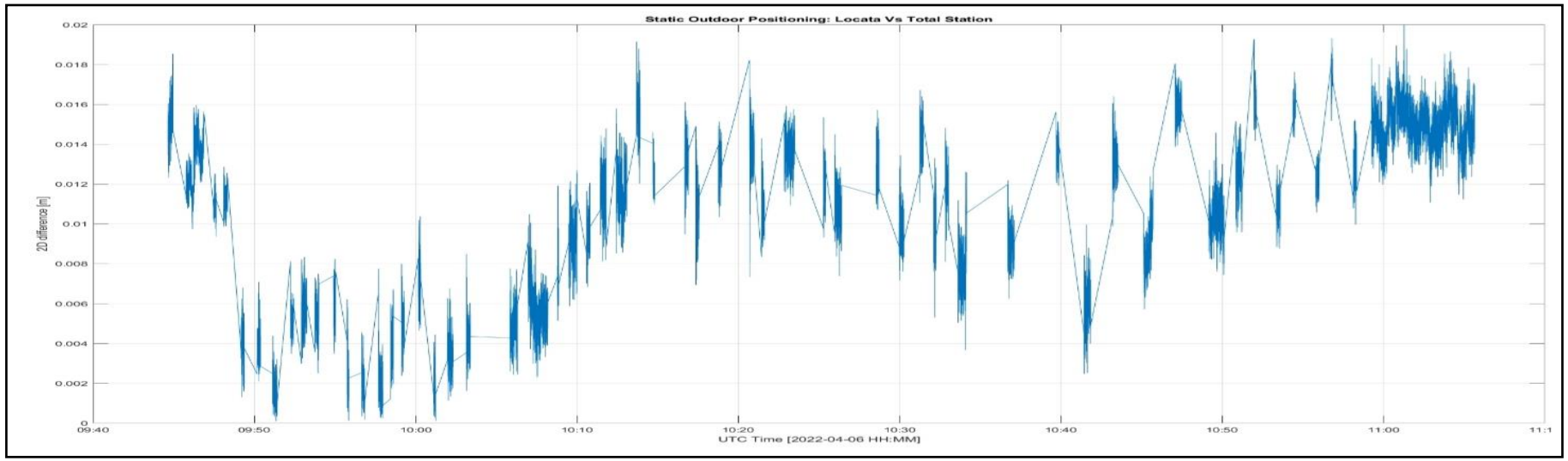
Locata

RESULTS
#6A

STATIC OUTDOOR POSITIONING TEST – vs TOTAL STATION

#6A – STATIC Outdoor Positions Time Series

20mm



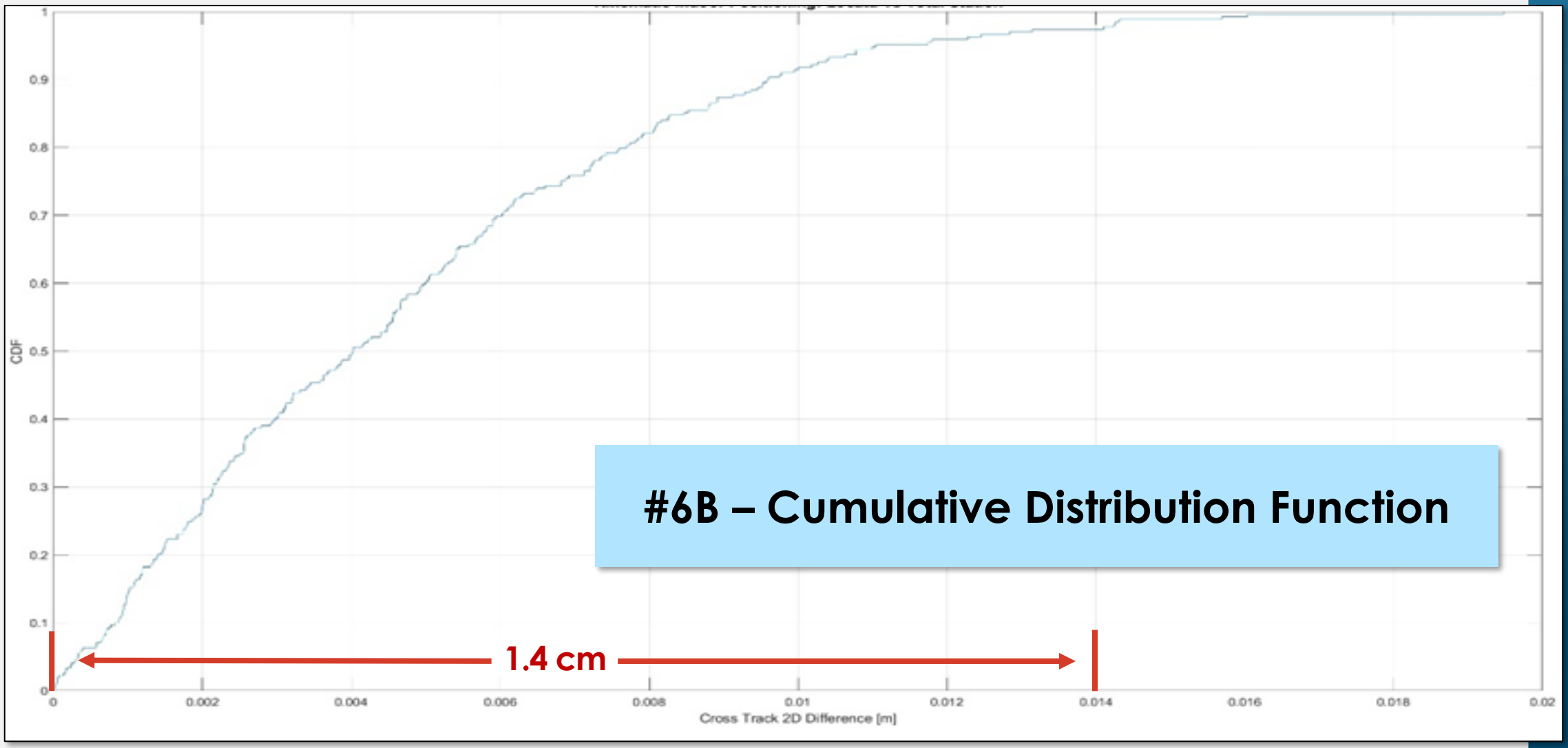
RESULTS ALL TESTS

Mean Difference	Standard Deviation	RMS Error
1.1 centimetres	4 millimetres	1.2 centimetres

Locata

RESULTS
#6B

KINEMATIC OUTDOOR POSITIONING TEST – RANDOM MOVEMENT



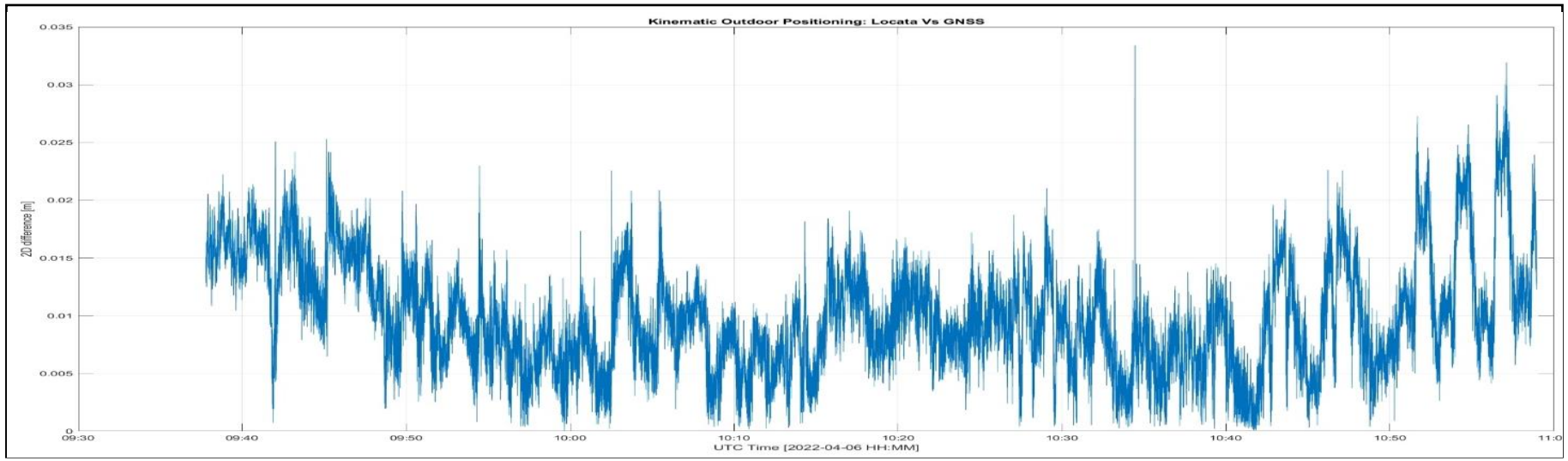
Locata

RESULTS
#6B

KINEMATIC OUTDOOR POSITIONING TEST – RANDOM MOVEMENT

#6A – KINEMATIC Outdoor Positions Time Series

35 mm



RESULTS ALL TESTS

Mean Difference	Standard Deviation	RMS Error
1 centimetre	5 millimetres	1.1 centimetres

Locata

Summary of Positioning Test Results

INDOOR POSITIONING	OUTDOOR POSITIONING
STATIC: **8 millimetres**	STATIC: **11 millimetres**
KINEMATIC: **5 millimetres**	KINEMATIC: **10 millimetres**

Locata Positioning Type	2D Mean Difference (mm)	2D Standard Deviation (mm)	2D RMSE (mm)	Reference	Number of Points
Average Outdoor Static	11	4	12	Total Station	58
Average Outdoor Kinematic	10	5	11	GNSS (2D difference)	48,701
Average Indoor Static	8	5	10	Total Station	14
Average Indoor Kinematic	5	4	6	Total Station (cross-track)	269

Locata

Demonstrated Bottom Line

PICOSECONDS & MILLIMETRES

- Over the air
- Over fibre
- Over cable

New enabling technology for the industry & our partners