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An ADVA Optical Networking Company

GNSS optimizations for Urban Canyon and Indoor synchronization

WSTS 2017

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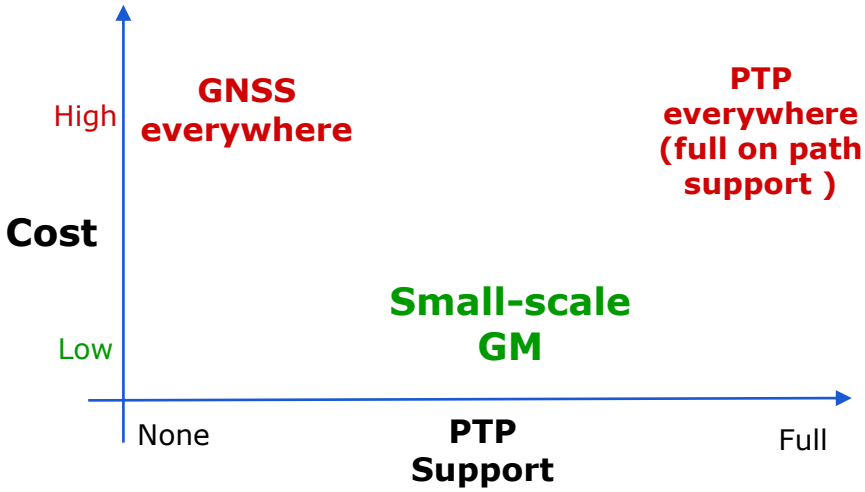
Motivation & Background

- New technologies require higher accuracy time synchronization
  - eICIC, TDD, 5G, small cell ...
- Synchronization service over network “coming” but…
  - Legacy networks
  - Technology diversity
  - Multi-vendor networks
  - Multi-operator networks
- Equipment integration level increases
  - Moore’s law (Cost pressure, competition...)
  - High volumes

Getting Time (1us Accuracy) in a Mobile Network

- Option 1 – GPS/GNSS everywhere
  - GNSS in every base station - Expensive
  - No backup in case of local GNSS outage
- Option 2 – PTP (& Sync-E) everywhere
  - Full on path support (G.8275.1)
  - GNSS+GM in the core – chain of BC
  - Requires expensive network upgrade
- Option 3 – PTP in the access
  - GPS+GM in the mobile aggregation
  - Most cost effective solution
  - Offer protection and scalability



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What it takes to put a GPS antenna on the roof ?

- Permit for roof antenna (may cost)
- Pay for the GNSS antenna kit
- Install e.g. LRM-400 cable and lighting protector (very thick cable and hard to install)
- Pay for the installation cost (technician)
- Limited length – up to 120m without amplifier

Roof top antenna installation is very costly – can reach 1K-10K USD per site

What is the alternative?

- Integrated GNSS antenna with PTP grand master
- Standard Ethernet/IP connectivity
- Easy and cost effective installation - Indoor or simple outdoor locations
- No need to compensate for cable delay (two way time transfer)
- Fiber can be used for very long distances – better protection against lightening

OSA 5405- Outdoor

OSA 5405- Indoor

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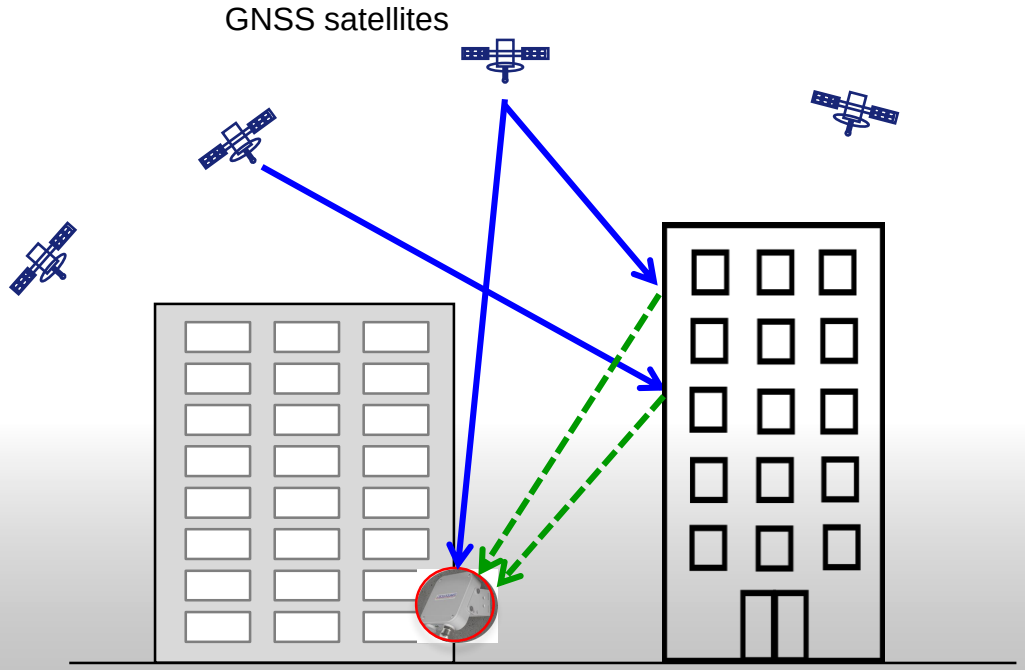
Urban canyon and Indoor Case...

- Roof installation not possible (cost, permit,...)
- Mainly for small cell application
- No clear sky view – many multipath (reflected) signals
- Minimal total cost in line with low cost of small cells
- Backup via APTS (PTP and SyncE) avoiding single point of failure
- Part of overall sync solution

GNSS antenna in the urban canyon and indoor environment



- Reflections from neighboring buildings cause multipath.
- Few satellites with Line of sight to the antenna

Antenna location

Direct signal

Reflected signal

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Urban Canyon GNSS Techniques.

- Choose location – indoor or outdoor?
- Fixed position – initially 4 satellites to determine position
- More satellites – Multiple concurrent GNSS constellations
- Enter co-ordinates – I.e. Enter antenna position
- A-GPS – Almanac & Ephemeris data through network
- Good OCXO – for short term holdover
- GNSS OCXO – (long coherent integration time for code correlation)
- Effective reception of weak and reflected signal
- “SNR and Elevation masks”

Urban Canyon - Needs optimized GNSS solution

Mounting Options for urban canyons
Location choice based on cost.

Window

Pole

Wall

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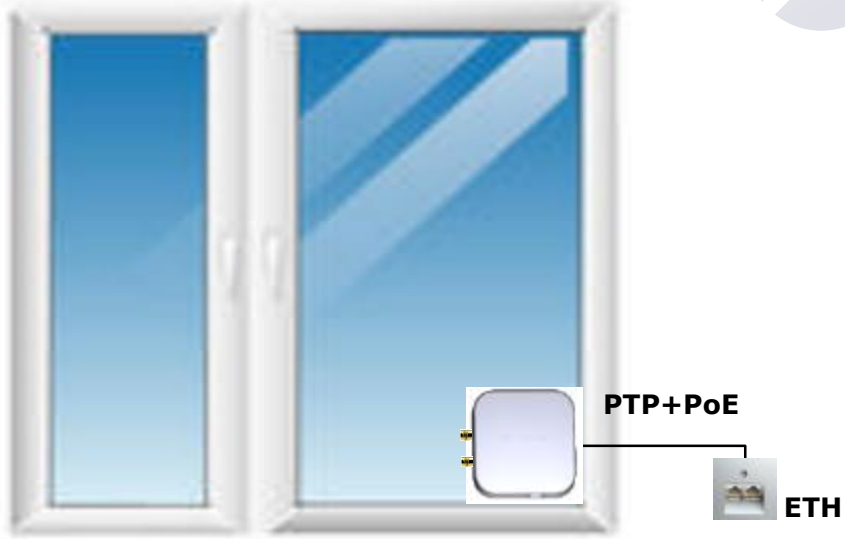
Indoor Small Cell Sync Requirements

- Integrated PTP GM and GNSS antenna – optional external antenna
- PTP capacity for building (~64)
- Cost effective and compact design
- Can be installed on a window
- Ethernet: Fiber / Copper / Power
- Multiple protection options for backup
  - Sync-E /PTP/BITS input
- Support telecom profiles



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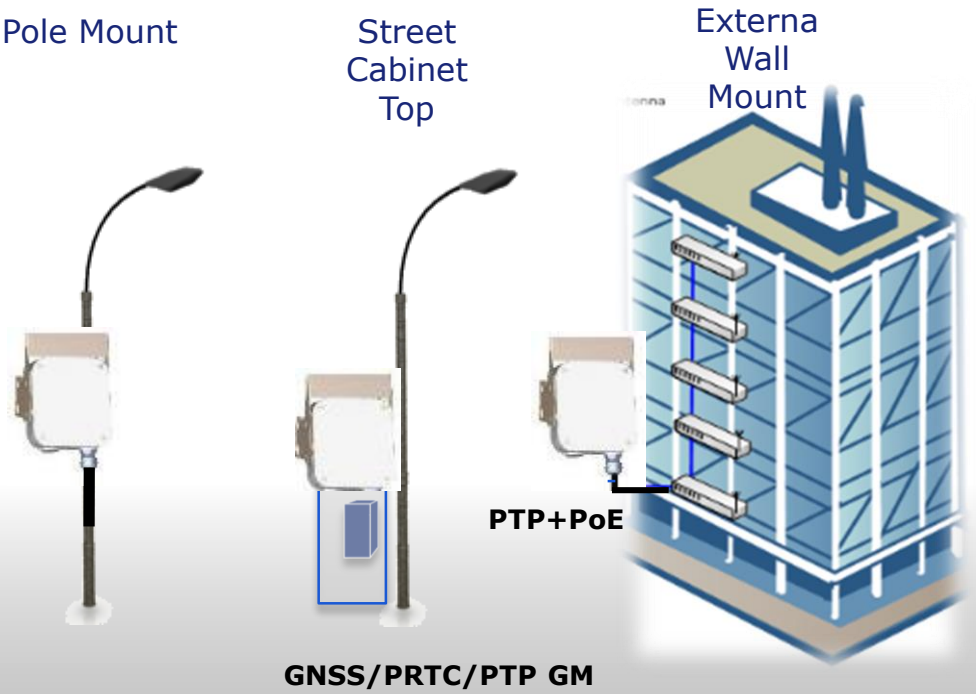
Outdoor Small Cell Sync Requirement

- As Indoor plus
- Options to be installed on a external walls, lamp post and roof
- Need to be rugged device
- Need to work at wide temp range from -40C to +65C
- Need to support IP65 for water proof



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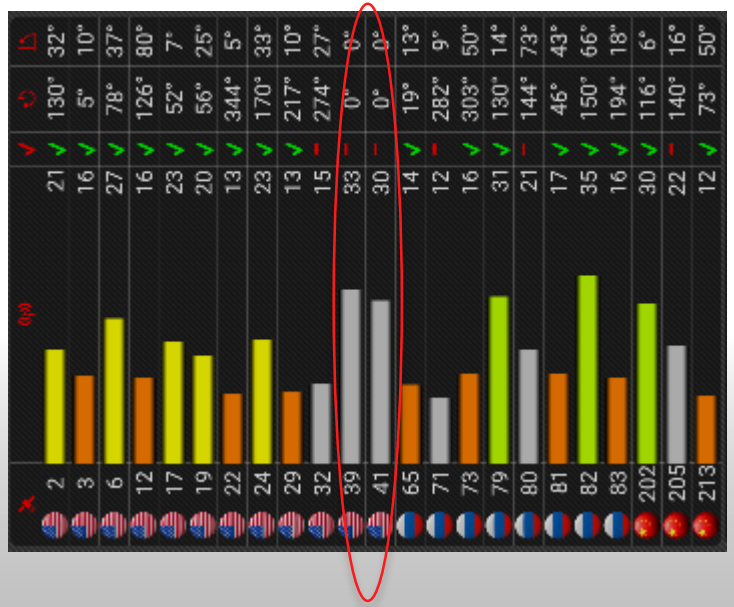
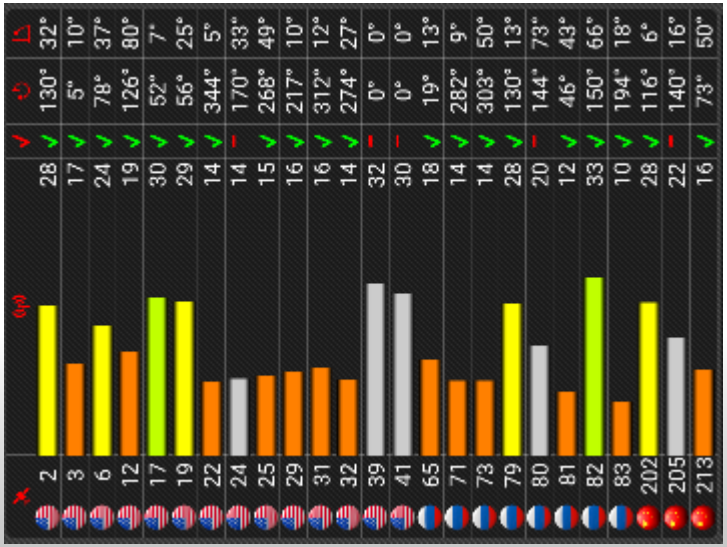
Many Constalations = more satellites?

- Needs concurrent constellations - **<u>also for position fix</u>**
- Changing SNR(GPS-39 retired 2014; GPS-41 should be operational)





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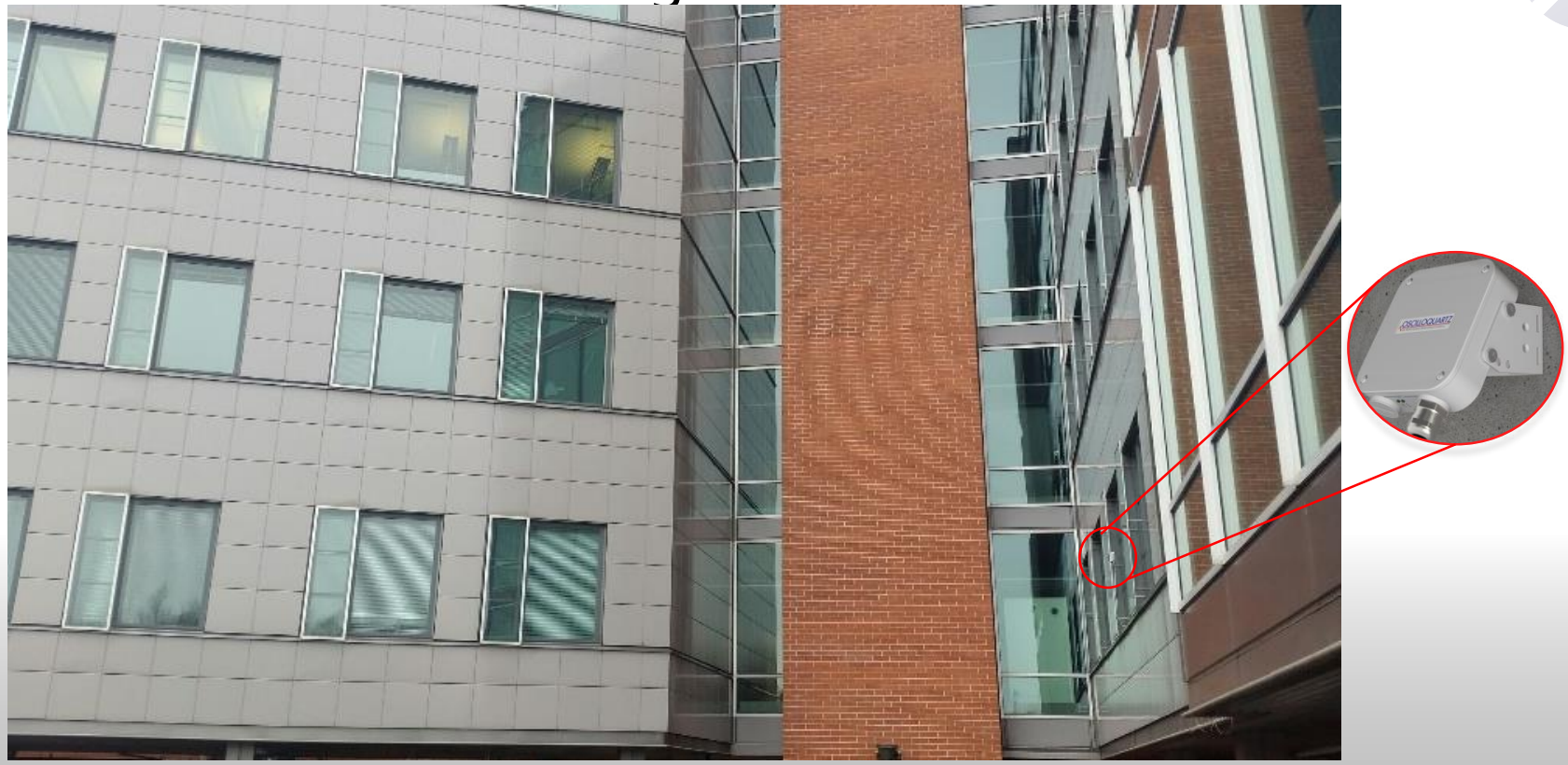
Installation Test Case – Helsinki office building 1st floor



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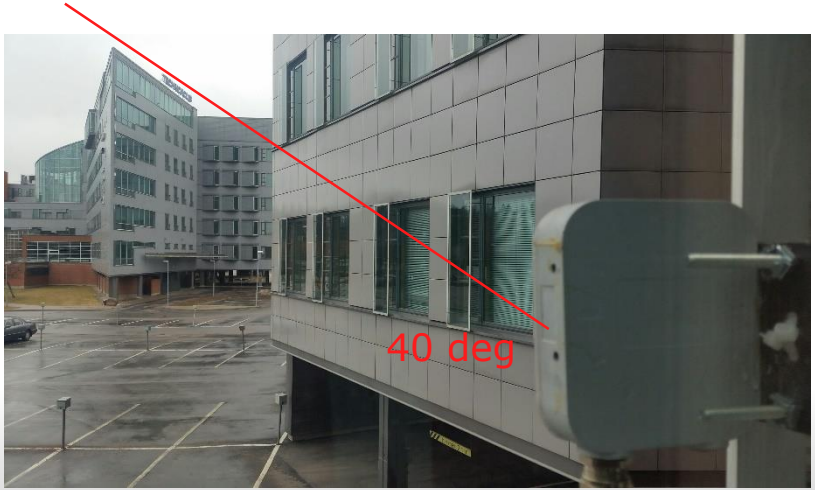
Installation – Arial and Facing views



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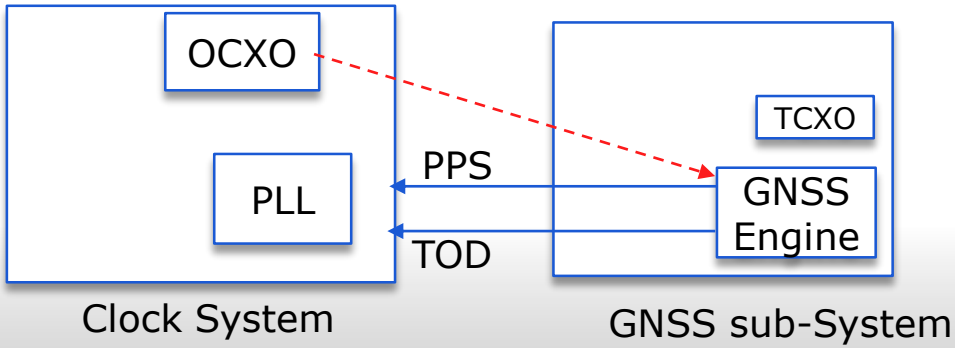
Can GNSS timing solutions be further optimized?

- GNSS OCXO – (long coherent integration time for code correlation)
- Antenna improvements?
- Other algorithm improvements?



Urban canyon application needs some GNSS optimizations

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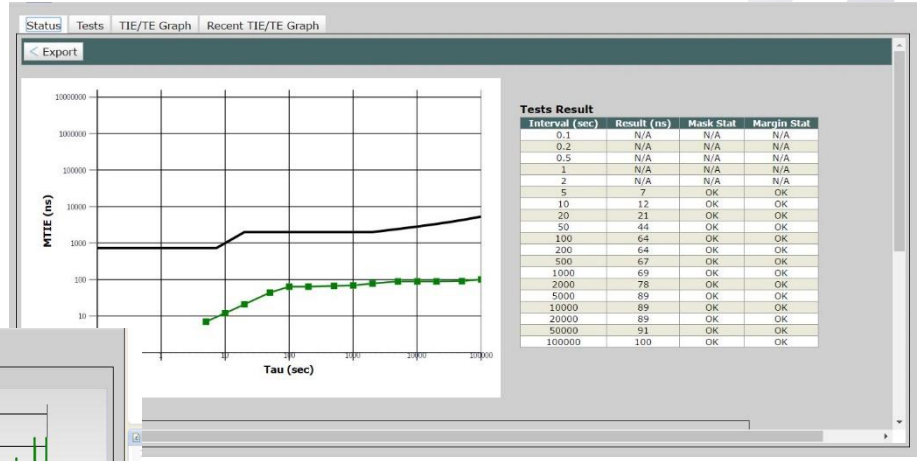
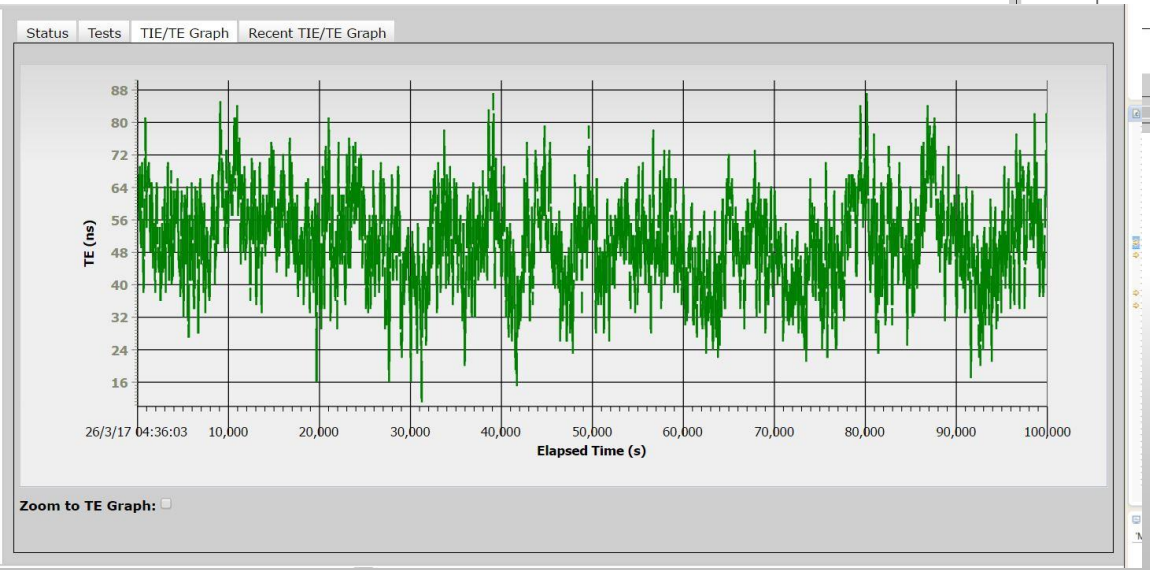
Results meets PRTC

- DC offset +50ns (delayed)
- Variation +/-40ns



Interval (sec)	Result (ns)	Mask Stat	Margin Stat
0.1	N/A	N/A	N/A
0.2	N/A	N/A	N/A
0.5	N/A	N/A	N/A
1	N/A	N/A	N/A
2	N/A	N/A	N/A
5	7	OK	OK
10	12	OK	OK
20	21	OK	OK
50	44	OK	OK
100	64	OK	OK
200	64	OK	OK
500	67	OK	OK
1000	69	OK	OK
2000	78	OK	OK
5000	89	OK	OK
10000	89	OK	OK
20000	89	OK	OK
50000	91	OK	OK
100000	100	OK	OK



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Conclusions

- Strong motivation for breaking traditional GNSS installation model
- Ethernet gives improved flexibility and lower cost:
  - Cabling direct to small cell switch
  - Fibre provides greater reach

- Urban Canyon / indoor requires optimization of GNSS:
  - Antenna optimizations
  - GNSS algorithm optimizations

Thank You

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