



Timing in the Pits

- GNSS in challenged locations

ITSF 2017

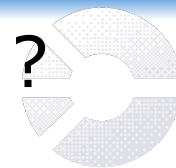
Kenneth Hann

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
- GNSS needs to be widely deployed low in the network
 - Needs a viable solution for Urban canyon and Indoor deployment

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



- Permit for roof antenna (expense?)
- Cost of GNSS antenna kit
- Installation cable and lightning protector
- Cost of installation (technician)
- Cost of additional amplifiers if length >120m



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)
- Fibre can be used for very long distances – better protection against lightning



OSA 5405- Outdoor



OSA 5405- Indoor

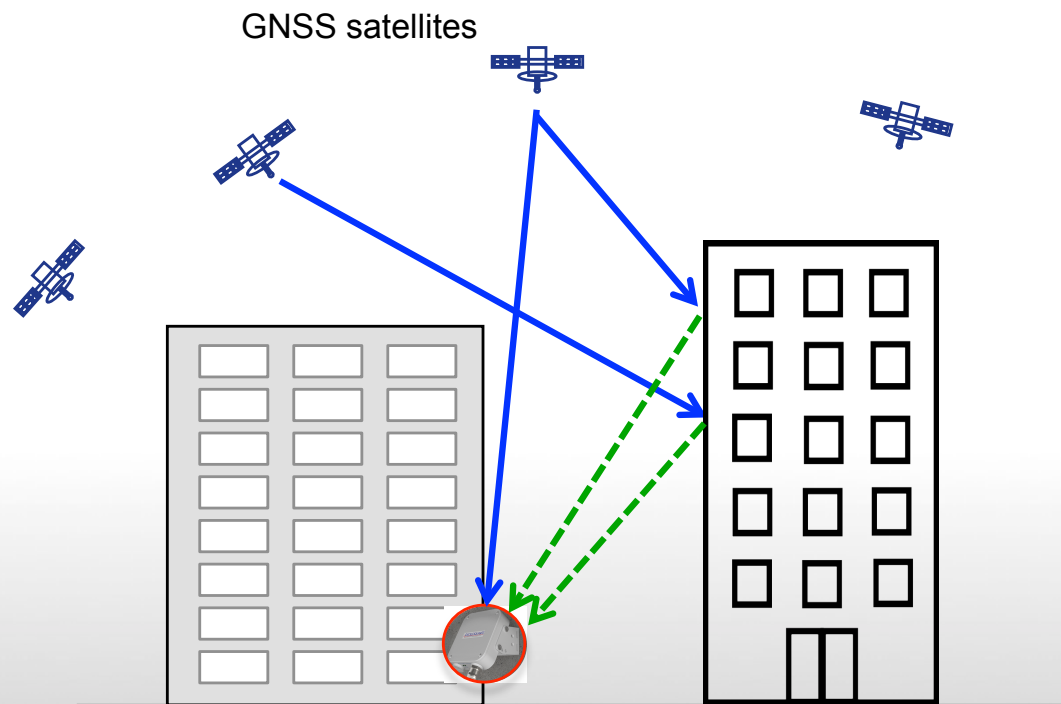


Urban canyon and Indoor Case...



- Roof installation not possible (cost, permit,...)
- Especially 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.
- I.e. paths become longer and
- Few satellites with Line of sight to the antenna
- Algorithms



Antenna location



Direct signal



Reflected signal

Urban Canyon GNSS Techniques.



- Choose location – indoor or outdoor?
 - Fixed position – initially 4 satellites to determine position
 - More satellites – Multiple concurrent GNSS constellations
 - Known co-ordinates – I.e. Enter antenna position
 - Good OCXO – for short term holdover
 - Good GNSS Antenna (Dual Feed)
-
- GNSS chip vendors need to focus on Urban Canyon
(Still seem to be assuming Clear Sky View)

Urban Canyon - Needs optimized GNSS solution

Mounting Options for urban canyons

Location choice based on cost.



Indor - Window



Outdoor - Pole / Wall / Roof

Indoor Small Cell Sync Requirements



- GM with integrated GNSS antenna
 - optional external antenna
- PTP capacity for building (~64)
- Cost effective and compact design
- Window installation
- Ethernet cabling:
 - Copper/POE
 - Fibre
- Multiple protection options:
 - Sync-E
 - PTP
 - APTS
- Support telecom profiles



Outdoor Small Cell Sync Requirement

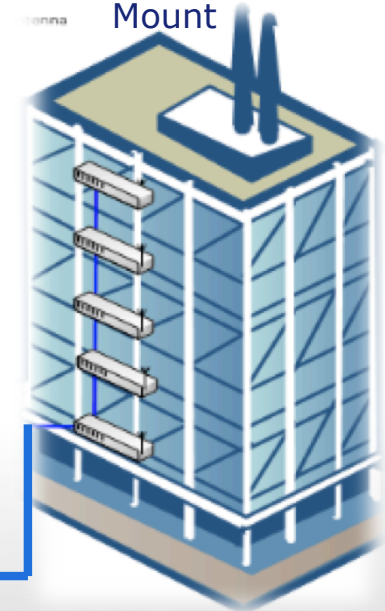


- Features as Indoor plus...
- Options to be installed on:
 - external walls,
 - Pole / lamp post,
 - roof
- Rugged device
 - -40C to +65C
 - IP66 waterproof

Pole Mount

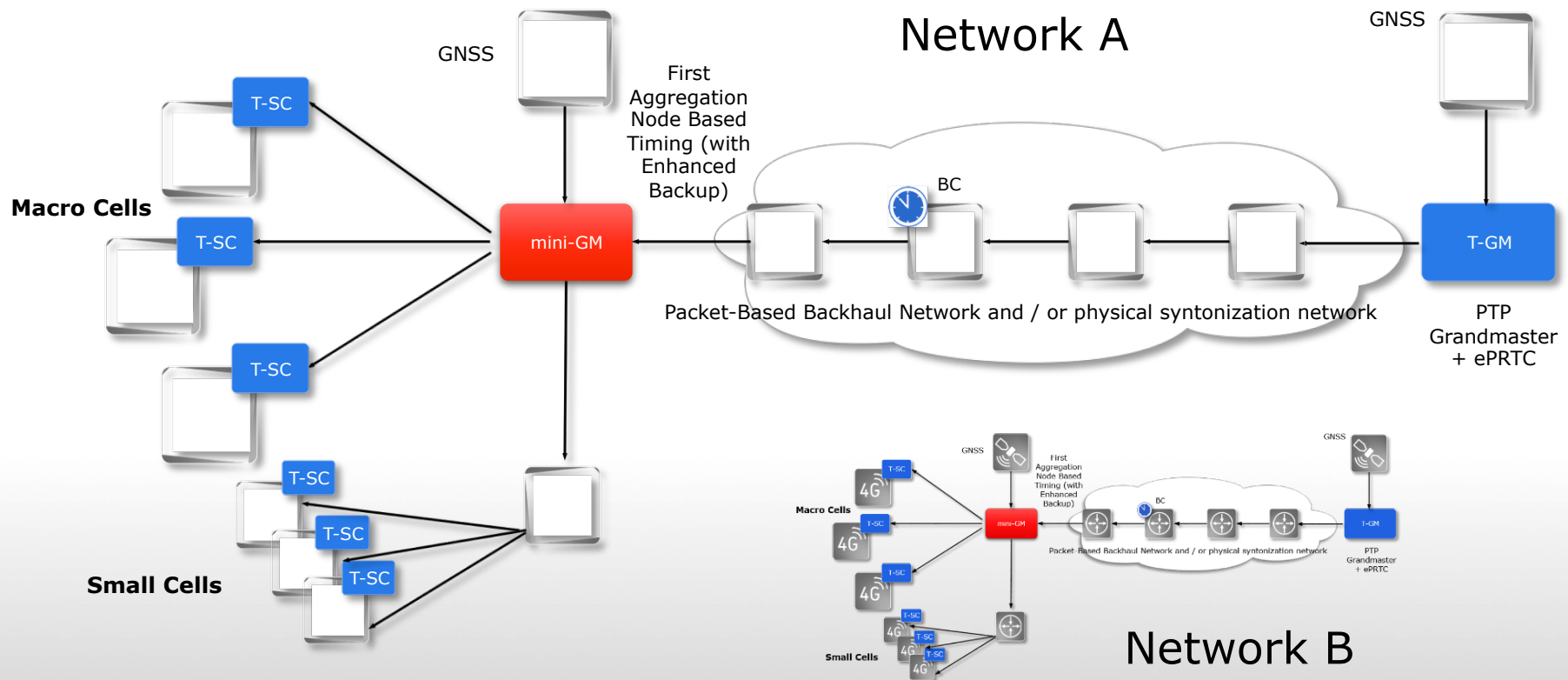
Street
Cabinet
Top

Externa
Wall
Mount



GNSS/PRTC/PTP GM

Complementing Local GM with network backup



Testing in the pits – needs good UTC reference Sites in Espoo Finland



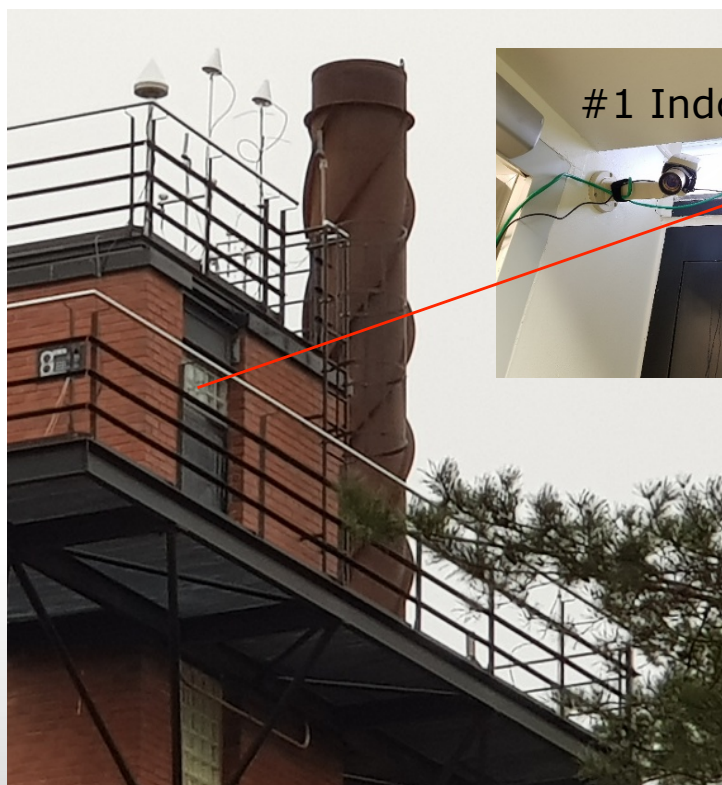
- VTT provides UTC MIKES
- Distance 876m
- Fibre (Telia) ~6km
- PTP White Rabbit
- Accuracy UTC ~5ns



Fibre link to Finnish Time keeper VTT MIKES

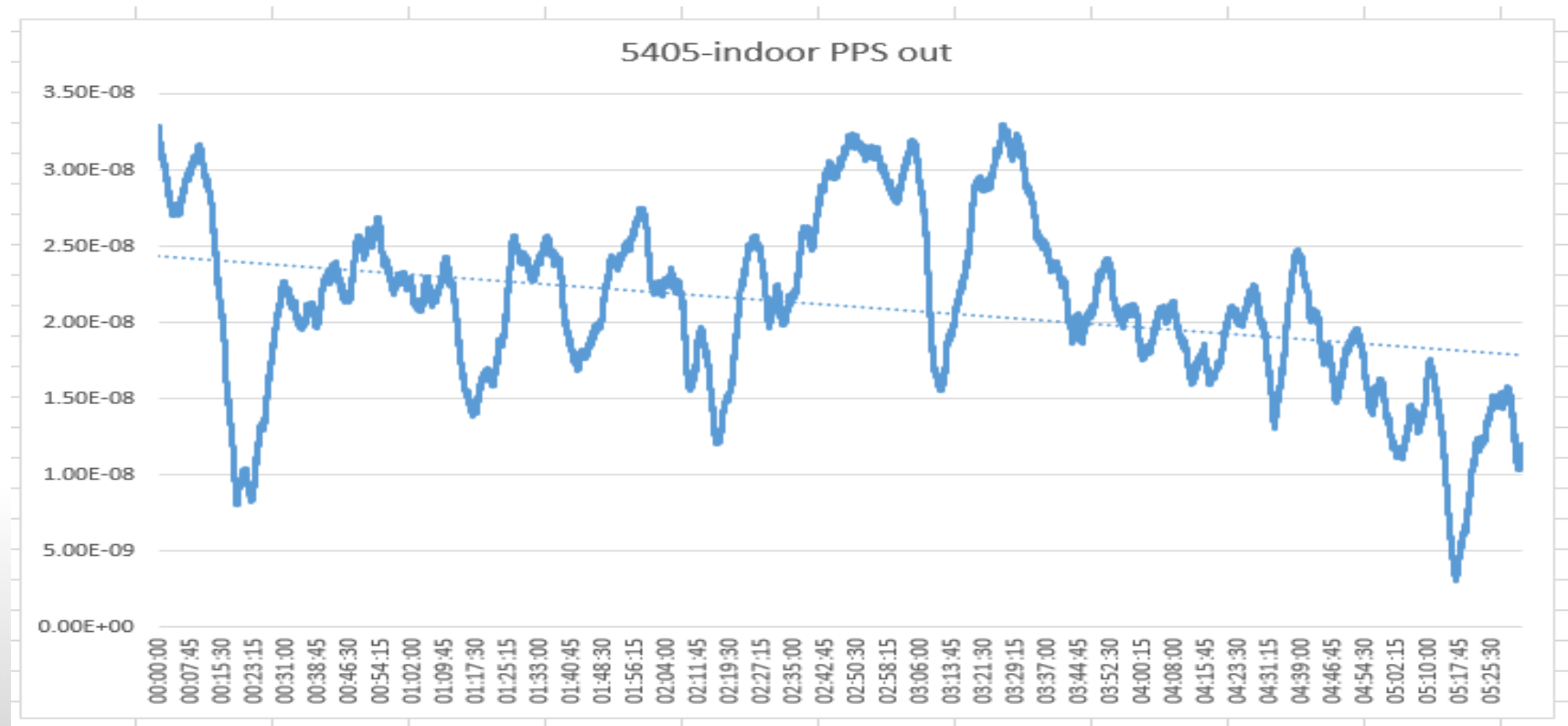
Antenna/GM testing locations at VTT

#1 Indoor (glass bricks); #2 Outdoor (wall)



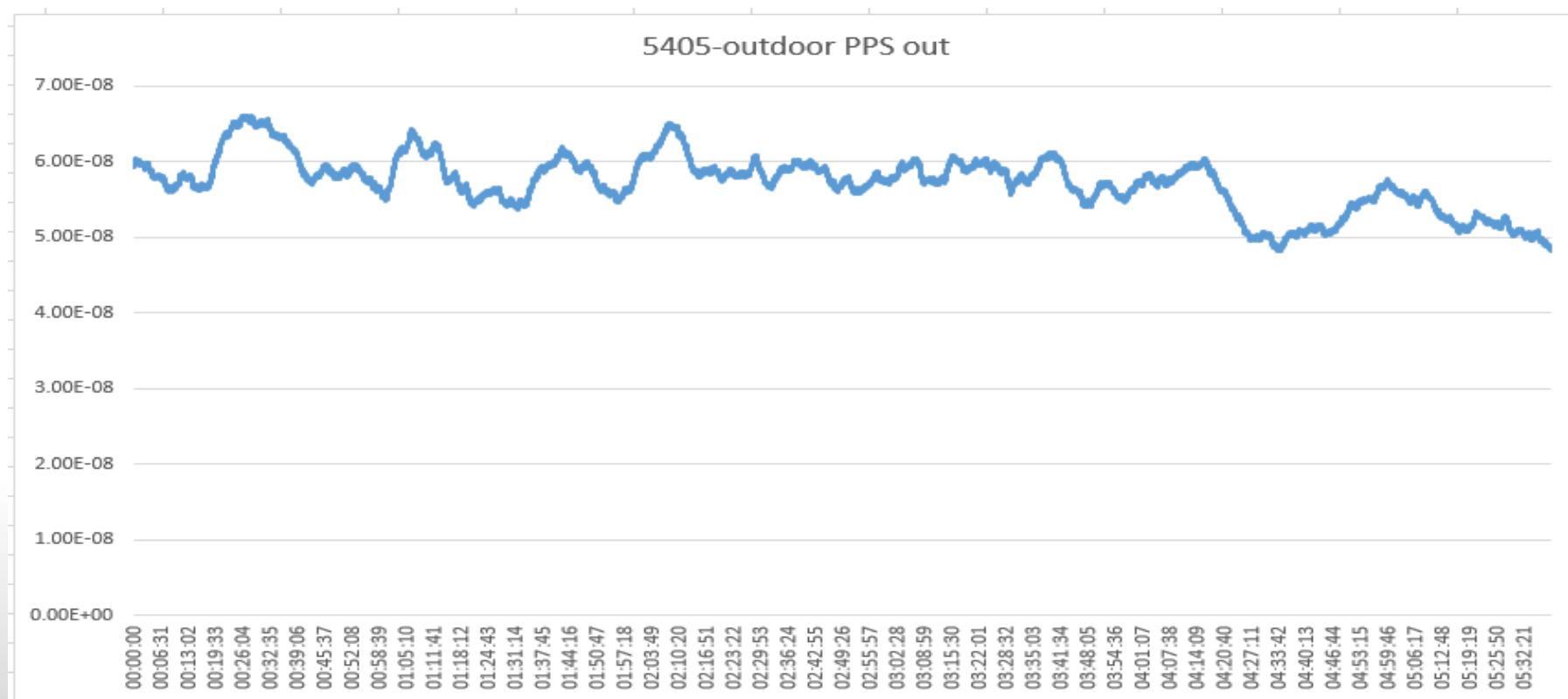
Measurement Result #1

Indoor (behind glass brick) at VTT (GPS + Glonass)

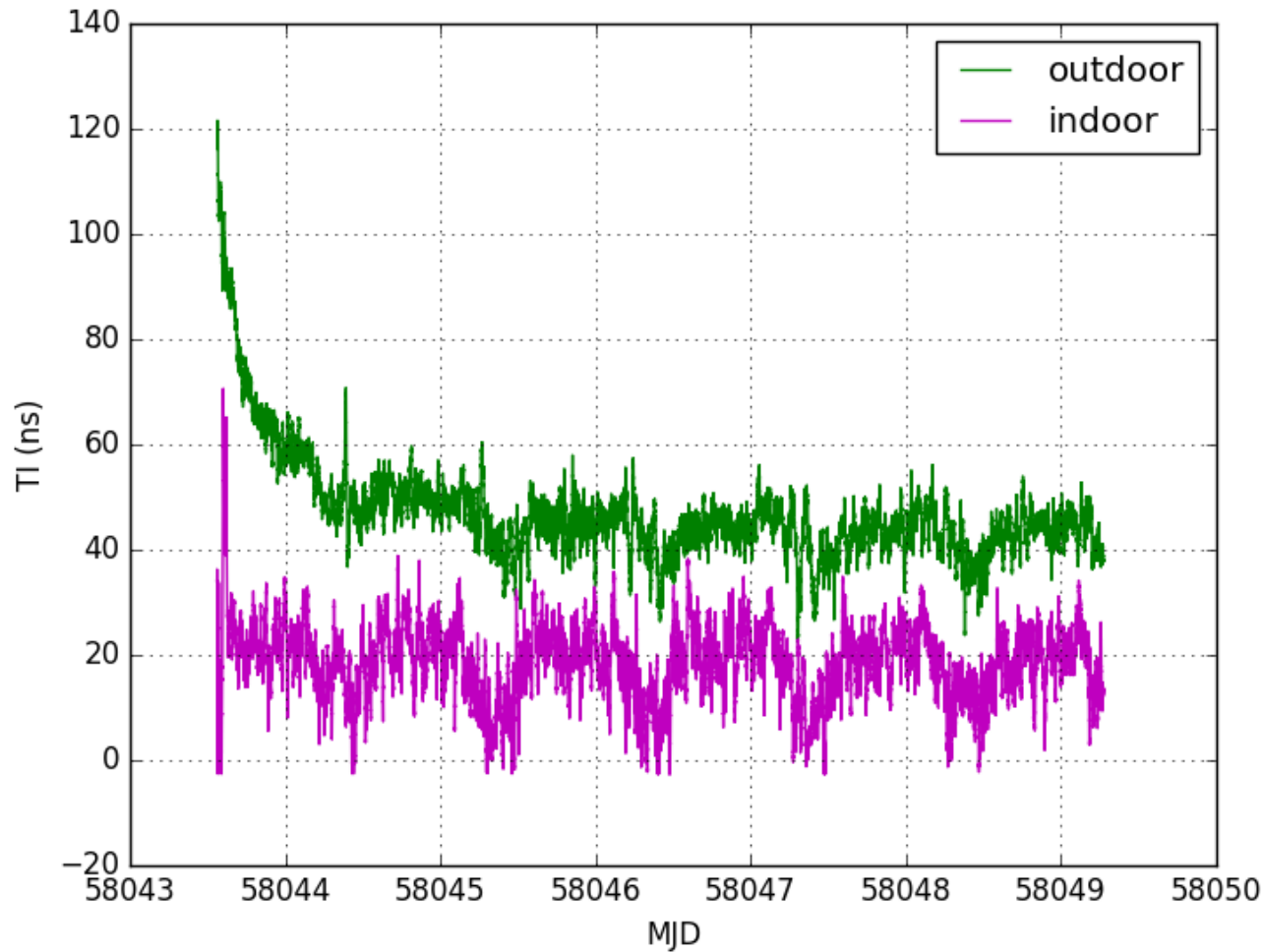


Measurement Result #2

Outdoor wall at VTT (GPS only)

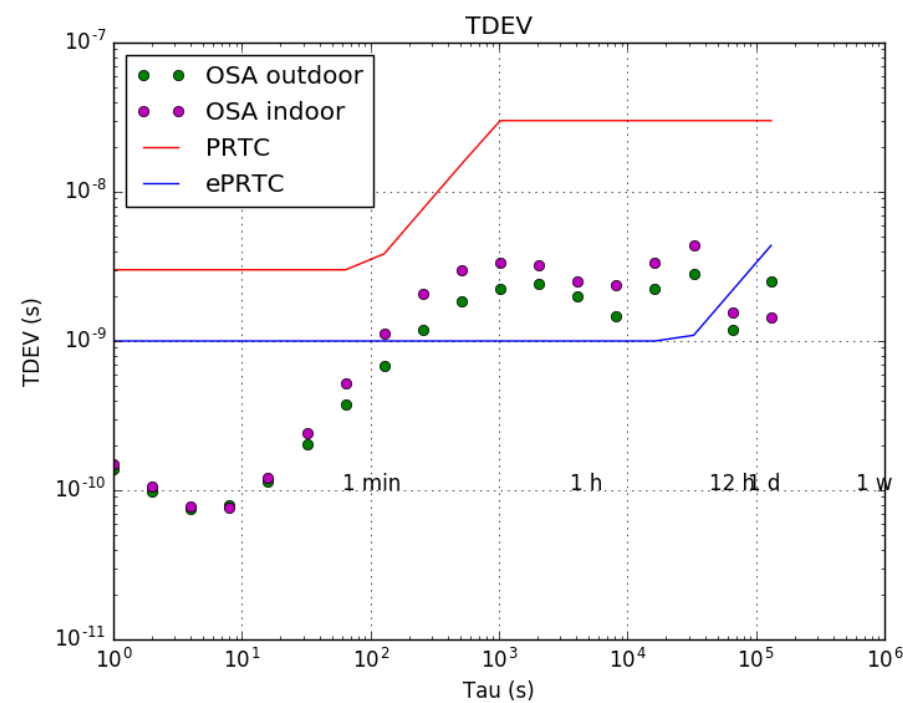
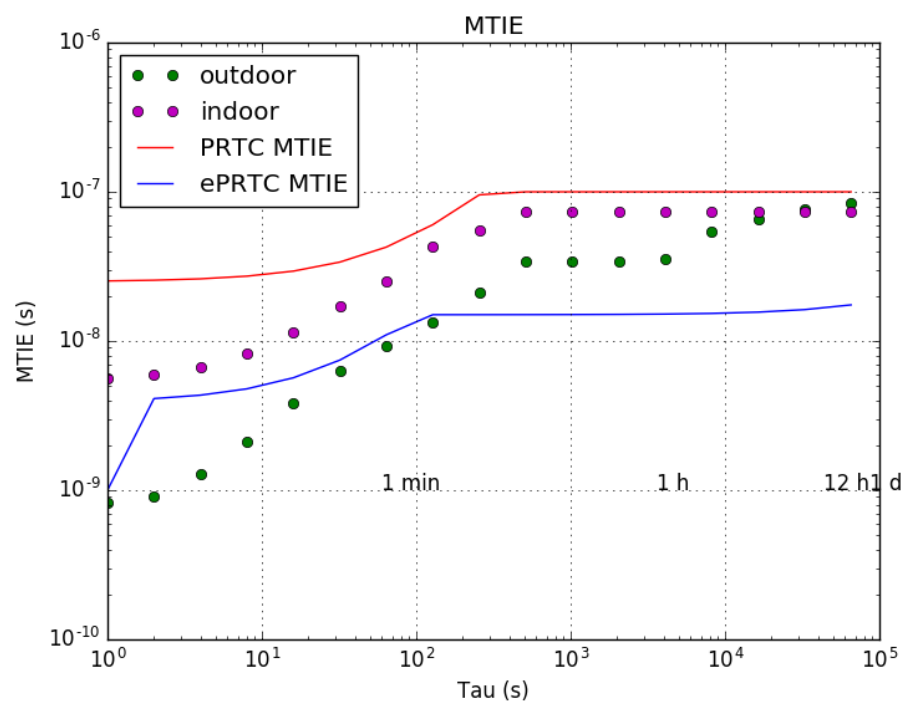


VTT measurement results – 1 week



VTT measurement results – 1 week

MTIE / TDEV



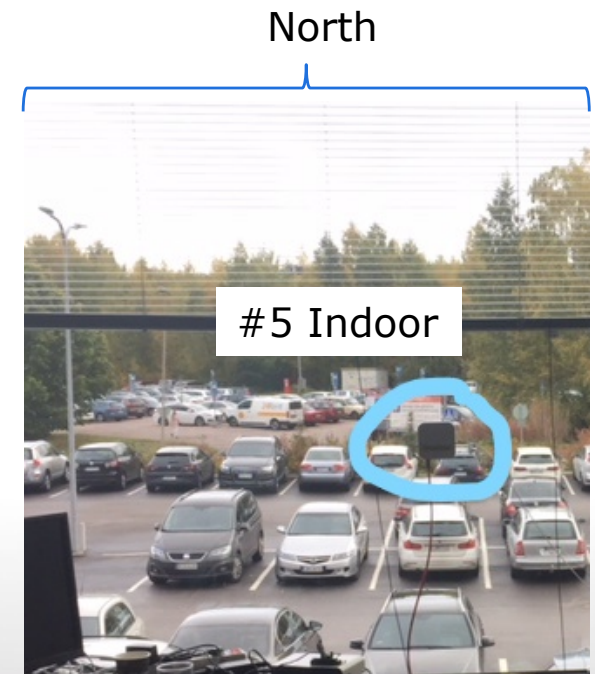
Oscilloquartz office testing

East – Aluminium panels producing extreme multipath (reflections)



#4 Indoor

#3 Outdoor

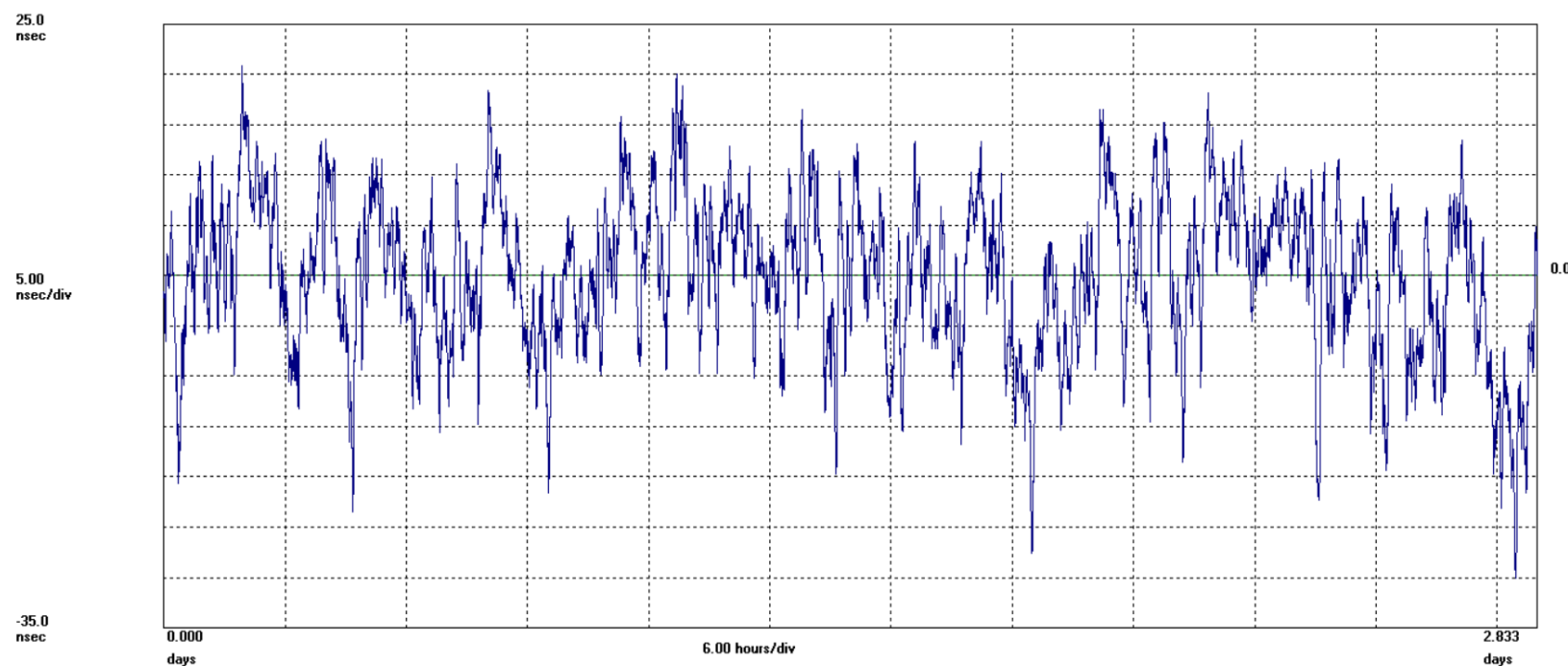


#5 Indoor

Measurement Result #3 Outdoor



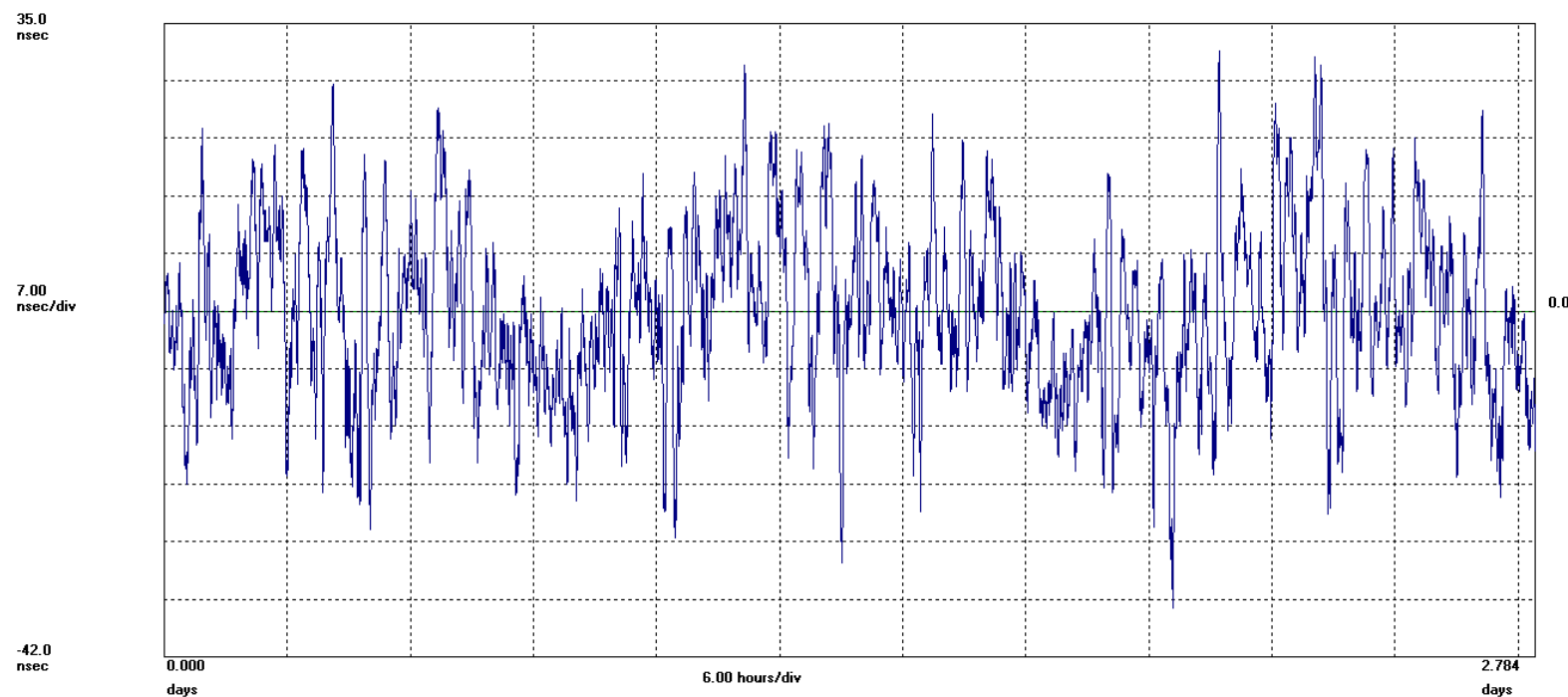
Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=200.0$ MHz; $F_o=1.0000000$ Hz; *13/10/2017 14:02:00*;
HP 53132A; Test: 21; 5405 MarieWindo; Samples: 48956; Gate: 5 s; Ref ch1; TI/Time Data Only; TI 1->2;



Measurement Result #4 Indoor



Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: Fs=200.0 mHz; Fo=1.0000000 Hz; *16/10/2017 13:37:34*;
HP 53132A; Test: 24; MRI; Samples: 48114; Gate: 5 s; Ref ch1; TI/Time Data Only; T1 1->2;



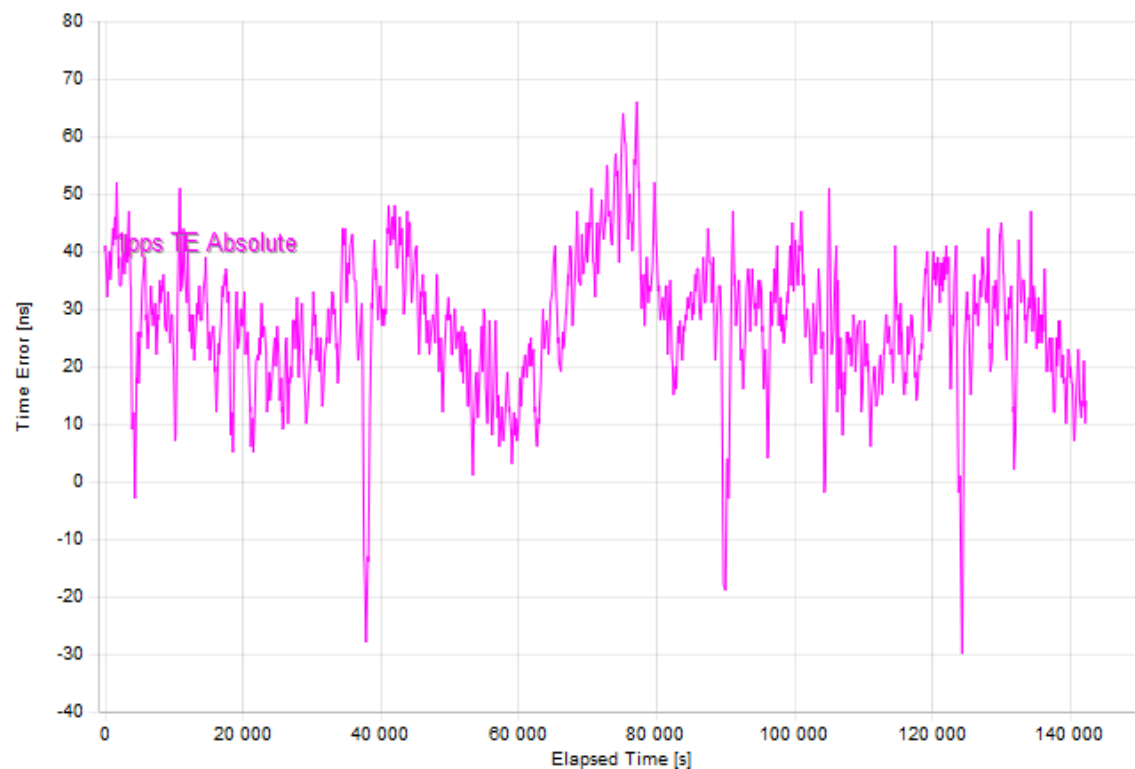
Measurement Result

#5 Indoor (GPS + Glonass)



1pps TE Absolute

Date: 2017-10-14 File: 10-33-188-8_20171014_16-49-05_1ppsAcc.cpd Offset Removal Applied: False Zero Offset: 40ns



Metric Statistics

Mean [ns]	27.397
Min [ns]	-30
Max [ns]	66
Max-Min [ns]	96

All GNSS Antennas are not created equal.

Time accuracy



Location	Time Accuracy GM + Internal Antenna (Dual-Feed)	Time Accuracy GM + External Antenna (RHCP Patch)
#3 Outdoor	51ns	66ns
#4 Indoor	70ns	98ns
#5 Indoor	96ns	132ns

For the same location...

- Dual-feed antenna (e.g. OSA5405) improves result
- I.e. Better multi-path rejection = Better time accuracy

Conclusions



- Strong motivation for breaking GNSS "Sky-View" model
 - PRTC (100ns UTC) achievable Indoors and in deep Urban Canyons
- Improved flexibility and lower cost:
 - Ethernet cabling e.g. direct to small-cell switch
 - Fibre provides greater reach
- Urban Canyon / indoor requires optimization of GNSS:
 - Antenna optimization - helps
 - Backup from core - helps
 - GNSS chip vendors have some work to do



Selecting the right wave improves packet clock performance

Thank You



Telecom!
Can't you
behave like an
Ordinary clock?



Sorry Telecom!
This PDV would cause
you too much wander.



Most kind Telecom, but
Ordinary clocks don't
surf PDV.





Thank You



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