Oscilloquartz overview

Artur Voslaev Business Development manager of Oscilloquartz
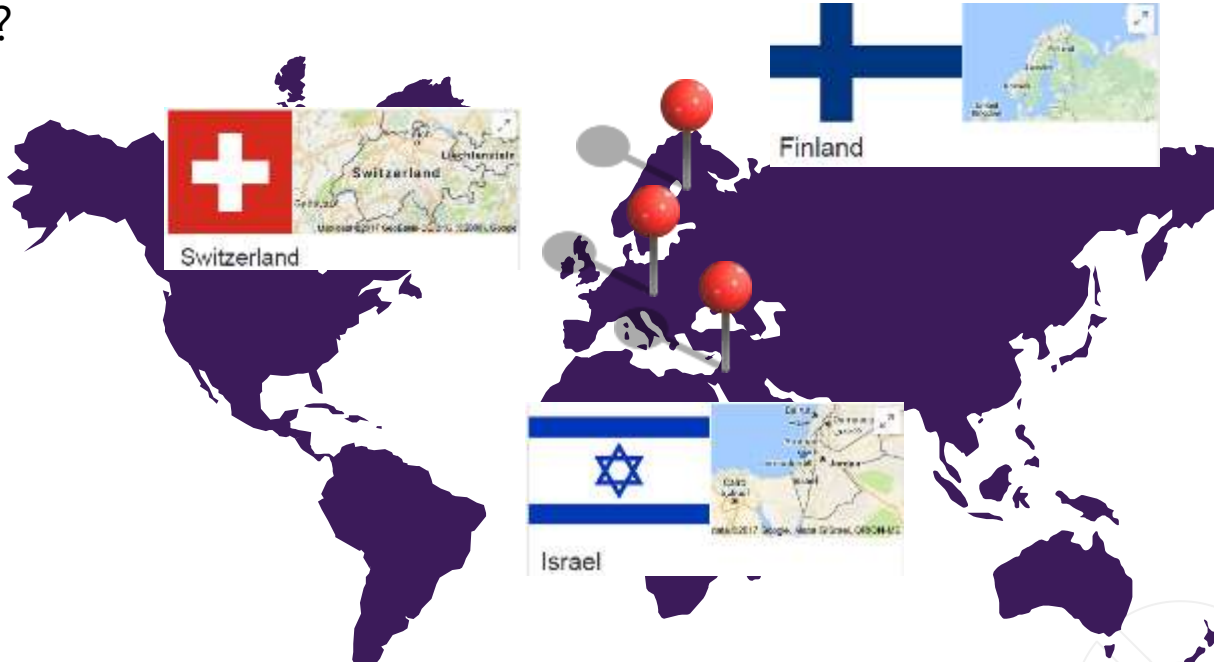March 2018

Oscilloquartz at a glance

- Member of the ADVA Optical Networking Group

- Focused in offerings sync solutions for communications, government and enterprise applications

- Longstanding relationship with customers worldwide since 1949
  - Around 100 sync focused partners in about 80 countries around the globe
  - Driven by customer satisfaction

- State-of-the-art time phase and frequency systems

- End-to-end and most scalable and innovative solutions for all markets

- Timing delivery and assurance excellency

Innovation leader for timing distribution and assurance

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Today's Quiz

According to the World Economic Forum, which are the top 3 countries for innovation ?

Finland

Switzerland

Israel

Oscilloquartz's three R&D facilities

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Our global presence

Munich

Meiningen

Gdynia

York

Shenzhen

Atlanta

Helsinki

Singapore

Neuchâtel

Tel-Aviv

Haifa

Australia

- Headquarter
- Office
- Representative

Application and technology expertise close to our customers

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Synchronization applications and services

Telecoms

- **16PPB or 1usec via PTP moving to 260nsec**
- Wireline ,wireless operators
- Militray & Power Telecom netwroks
- Synchronization to SONET/2G/3G/4G/4.5G

Power & industry

- **1 usec via PTP & NTP**
- Phasor Measurement
- Line Differential Protection
- Industry 4.0

Finance

- **1m-1usec via PTP & NTP**
- Regulation (Sec 613, MIFID II)
- High speed trading
- Algorithmic Trading

Metrology/defense

- **Methrology**
- Cs Clocks
- Time Distribution (UTC)
- **Defense & DC**
- GNSS Backup
- Cesium instead Rb

Leading supplier of timing distribution and assurance infrastructure

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Our timing portfolio

Sources

GNSS-Based Clocks

Cesium Clocks

NTP/ToD Sources

Distribution

SSU/TSG

PTP Grandmaster

Mini Grandmaster
APTS

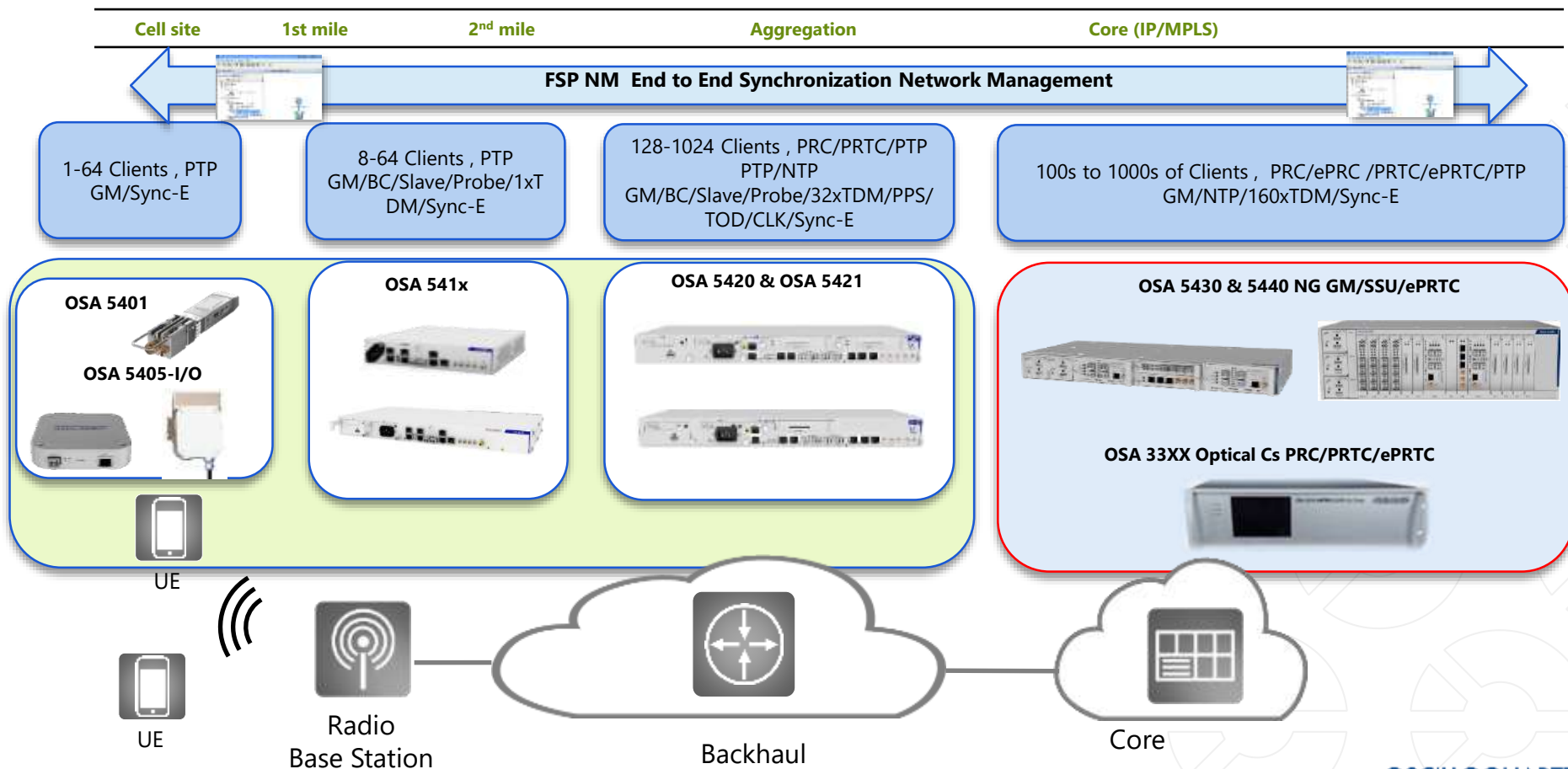## Assurance

Sync Probe Devices

Services

Factory Services

Field Services

Network Survey
and Design

End-to-end solution for timing distribution and assurance

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OSA Product Line Overview -2018

Cell site	1st mile	2nd mile	Aggregation	Core (IP/MPLS)

FSP NM End to End Synchronization Network Management

1-64 Clients , PTP GM/Sync-E	8-64 Clients , PTP GM/BC/Slave/Probe/1xT DM/Sync-E	128-1024 Clients , PRC/PRTC/PTP PTP/NTP GM/BC/Slave/Probe/32xTDM/PPS/ TOD/CLK/Sync-E	100s to 1000s of Clients , PRC/ePRC /PRTC/ePRTC/PTP GM/NTP/160xTDM/Sync-E

OSA 5401

OSA 5405-I/O

OSA 541x

OSA 5420 & OSA 5421

OSA 5430 & 5440 NG GM/SSU/ePRTC

OSA 33XX Optical Cs PRC/PRTC/ePRTC

UE

UE

Radio
Base Station

Backhaul

Core

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Products overview

Mobile Backhaul Synchronization Needs

Application	Radio Interface		Backhaul	
	Frequency	Phase	Frequency	Phase
CDMA 2000	±50ppb	±3 to 10µs	GPS	GPS
GSM/WCDMA	±50ppb	n/a	±16ppb	n/a
LTE (FDD)	±50ppb	n/a	±16ppb	n/a
LTE (TDD) (large cell)	±50ppb	±5µs	±16ppb	±1.1µs
LTE (TDD) (small cell)	±50ppb	±1.5µs	±16ppb	±1.1µs
LTE-A MBSFN	±50ppb	±1 to 5µs	±16ppb	±1.1µs
LTE-A CoMP*	±50ppb	±500nsec to 5µs	±16ppb	500ns - ±1.1µs
LTE-A eICIC*	±50ppb	±1 to 5µs	±16ppb	±1.1µs

The new phase requirements of **+/-500ns to 5000ns** requires a New timing distribution architectures and new standards !

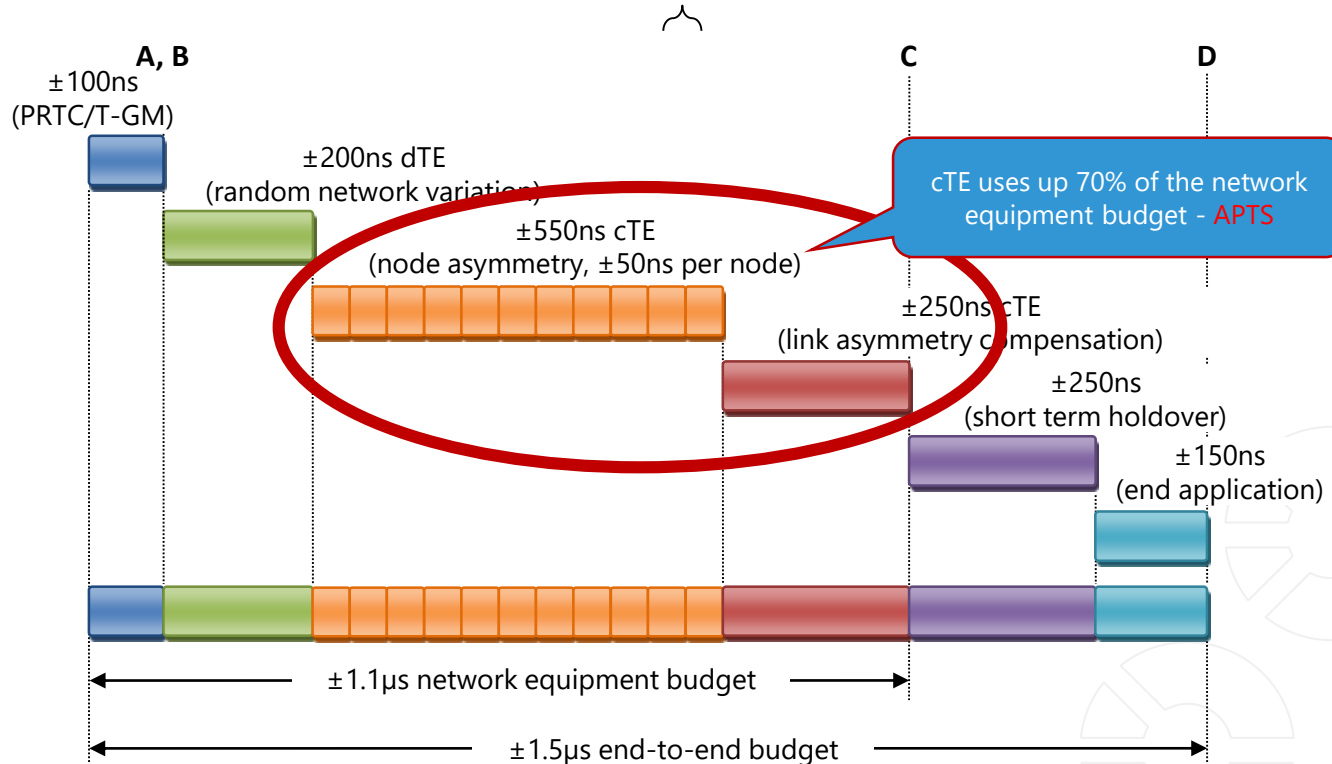* The performance requirements of the LTE-A features are under study by 3GPP

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Distributed sync architecture using GM/APTS

1.1 uSec Here!

GNSS

GM closer to EDGE/end application

GNSS

T-SC

First aggregation node

BC L3

BC

Macro cells

T-SC

mini-GM

Packet-Based Backhaul Network

T-GM

T-SC

PTP grandmaster

Smallcells aggregation node

GNSS

High

GNSS everywhere

PTP everywhere G.8275.1

T-SC

T-SC

micro-GM

Cost

Small cells

T-SC

T-SC

APTS/PTS G.8275.2

Low

0.25-0.5 uSec Here!

Dr. Brad Parkinson the "Father of GPS" call it "...a single point of failure..."

None

PTP support

Full

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G.8271.1: Time Error Budget Example

dTE- Dynamic TE
cTE- Constant TE

G.8271.1 Network Reference Points

A, B

±100ns
(PRTC/T-GM)

±200ns dTE
(random network variation)

±550ns cTE
(node asymmetry, ±50ns per node)

cTE uses up 70% of the network equipment budget - APTS

C

±250ns cTE
(link asymmetry compensation)

D

±250ns
(short term holdover)

±150ns
(end application)

±1.1μs network equipment budget

±1.5μs end-to-end budget

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Cesium clock as time source

PRC (G.811)
Frequency

PRC : Cs or GNSS

↓

SSU

↓

Sync Network

↓

SSU

↓

NE	NE	NE
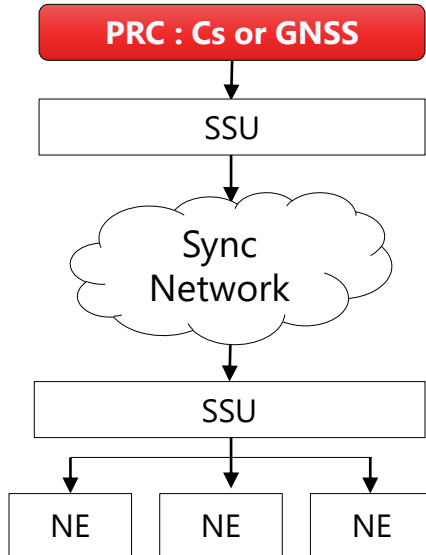
PRTC (G.8272)
Frequency + Phase

Cs as backup

PRTC : GNSS

↓

Packet Master Clock

↓

Sync Network

↓

Packet Slave Clock

↓

NE	NE	NE
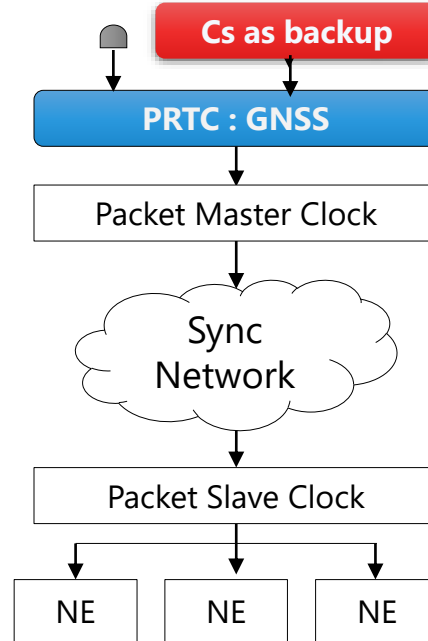
ePRTC (G.8272.1)
Frequency + Phase

GNSS	→	Combiner	←	Cs

↓

Packet Master Clock

↓

Sync Network

↓

Packet Slave Clock

↓

NE	NE	NE

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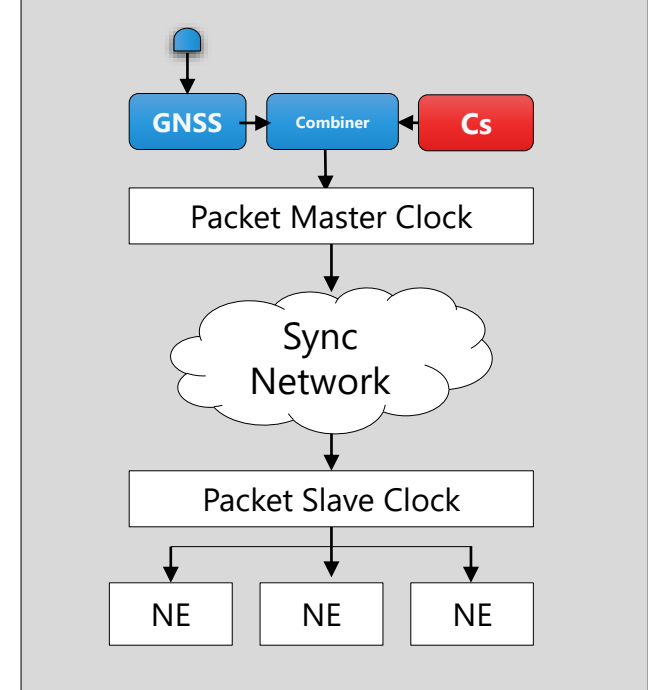
OSA 3300/50 optical Cesium clock

- Target application
  - Metrology & Time keeping - Time scale, units measurement
  - Defense – secured telecom, submarines
  - Space (ground segments) - Satellite mission tracking, GNSS systems
  - Science - astronomy, nuclear and quantum physics
  - Telecom - ePRTC

- Operating principles and benefits
  - Cesium Beam clock with atoms preparation and detection by Laser pumping
  - 100x more efficient use of 133Cs atoms (vs Magnetic deflection)
  - 10x higher stability (vs Magnetic deflection)
  - 2x longer life time (vs Magnetic deflection), optimal use of atoms

- Main features
  - Metrology low noise outputs 5MHz, 10MHz, 100 MHz
  - Telecom E1, T1 or 2048 KHz, 1 x TOD + 1PPS output
  - Stability:3.0E-12 t-1/2 , floor=5E-15
  - VS. 8.5E-12t-1/2 , floor = 5E-15 with Microsemi 5071A
  - Lifetime:10 years VS. 5 years with Microsemi 5071A
  - Low jitter timing outputs, synchronization input, remote monitoring

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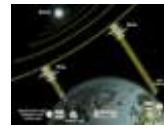
Cesium tube and optics integration

Pump
Oven
Collector
Cavity
Magn shields
Vac encl.

349 mm

Cs beam

Laser beam

407 mm

a)

Optical Bench

Cesium Oven

Ramsey Cavity

Light Collectors

Holding frame + coil

Magnetic shields

Barries of Entry

- First concept demo in 1998
- 10M EUR R&D cost
- Unique knowhow in NCH
- Strong Relations with ESA and NCH Observatory
- 100 Mech. components
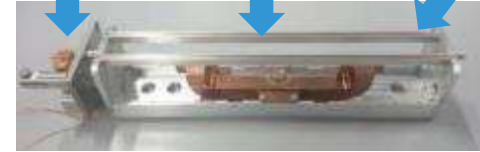- Ten suppliers around NCH
- Few patents

Optical Cesium Tube

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OSA 3300/50 key features

Metrology grade variant: OSA 3300

- Low noise outputs 5 MHz, 10 MHz, 100 MHz
- 1 hour Battery autonomy for lab applications
- Remote monitoring and Large Graphic and Touchscreen
- Battery Backup

Telecom PRC & ePRTC variant: OSA 3350

- Embedded ePRTC features
- GNSS Input
- 2xPTP/SyncE 100M/1000M output and Input
- Telecom: E1, T1 or 2048 KHz output
- 1 x TOD + 1PPS output (G.703 Amendment 1)
- Local / Remote management
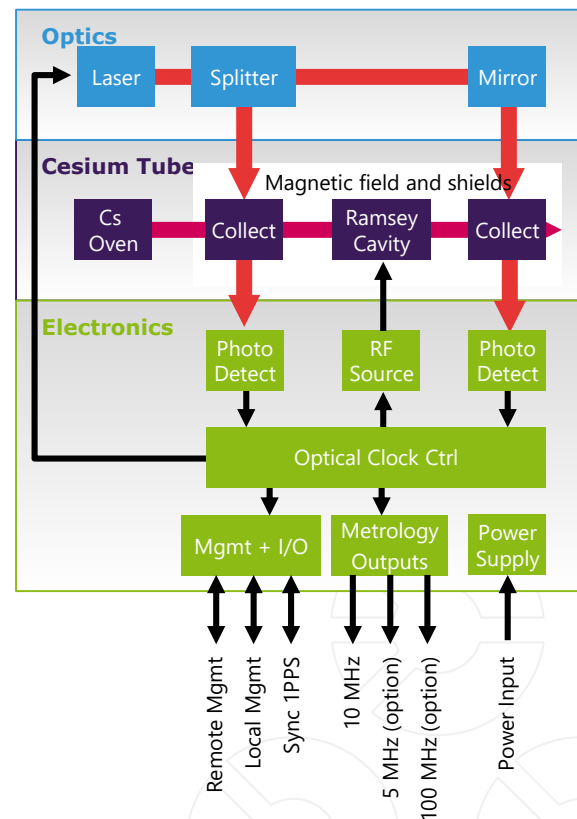
5548C SSU key features

- SSU function plus GNSS-receiver
- SSU (E1-based)
- Small (60 outputs) and large (200 outputs) versions
- Fully redundant
- OCXO only, Rubidium only or mixed version
- PTP Grandmaster with scalable PTP cards
  - One or two-step clock
  - High remote client capacity (up to 1024) per card
  - G.8265.1 PTP telecom profile compliant
  - Primary reference time clock .G.8272 compliant
  - Support Sync-E ,G.8264 and G.8262 compliant
- NTP server with scalable NTP cards
- Remotely manageable and upgradable

Large version (200 outputs)

TCC-PTP/NTP for OSA
5548C

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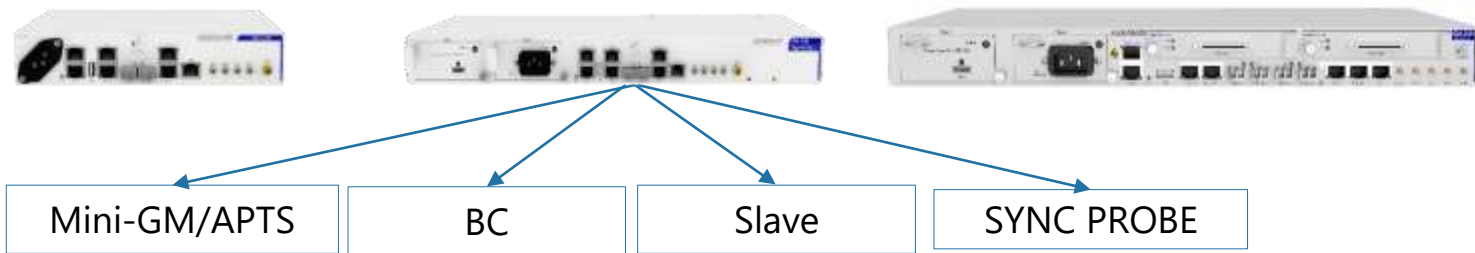# TCC PTP telecom high-capacity IEEE 1588 PTP line card

- Highly accurate PTP Grandmaster

- Can be used by the OSA 5548C SSU and OSA 5335 GM

- Combo Ethernet 100/1000BaseT or 100/1000BaseX (SFP)

- Compliant with ITU-T G.8272 Primary Reference Time Clock

- Compliant with ITU-T G.8265.1 Telecom Profile

- Compliant with ITU-T G.8275.1 Telecom Profile

- Support up to 1024 PTP clients per line card

- Scalable system and SW licensing – expanded as network grows (256/512/1024 PTP clients)

- Support one and two step clock

- Accurate Hardware based time stamping

- Supports Synchronous Ethernet (Sync-E) , Compliant with ITU-T G.8262 and G.8264

- Intuitive graphical user interface enabling full management via SNMP (future) and TL1

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OSA 54XX family summary

Variant	Image	Width	PSU	Eth Ports	Slots
OSA 5401		SFP	NA	1	NA
OSA 5405-I/O		Miniature	PoE	1	NA
5410/QUARTZ		Half rack	1 Integrated	2	NA
5411/QUARTZ		Full rack	2 Swappable	2	NA
5411/QUARTZ/HQ++		Full rack	2 Swappable	2	NA
5411/RUBIDIUM		Full rack	2 Swappable	2	NA
5420/QUARTZ		Full rack	2 Swappable	4 (+8)	2
5420/QUARTZ HQ+		Full rack	2 Swappable	4 (+8)	2
5421/QUARTZ HQ++		Full rack	2 Swappable	4 (+4)	1
5421/ RUBIDIUM		Full rack	2 Swappable	4 (+4)	1

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OSA 5410/11 and 5420/21

| Mini-GM/APTS | BC | Slave | SYNC PROBE |

Sync delivery

- PTP Telecom Slave
- PTP Boundary Clock
- PTP Master Clocks
- NTP Sync Server (542X only)
- GNSS (GPS+GLONASS) Clock
- Sync-E
- BITS/SSU

Sync assurance

- Active/Passive probing and monitoring of Sync (Sync SLA, network PDV)
- First level testing

"All in one" cost effective sync toolbox

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OSA 5410/11/20/21- sync tool box

- Two/Four 10/100/1000BaseT or 100/1000BaseX (SFP) PTP traffic ports
- Timing & Synchronization interfaces:
  - ITU-T G.8261 / G.8262 / G.8264 Synchronous Ethernet
  - BITS-in and BITS-out (E1 or T1)
  - PPS in/out, PPS in
  - Time of Day
 - CLK in/out, CLK in
  - GNSS Antenna in

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OSA 5410/11/20/21- sync tool box

- Comprehensive SyncjackTM technology for timing distribution and delivery of SLA-based sync services

- Delivers precise frequency, phase and time-of-day signals based on multiple options:
  - Recovered PTP Slave Clock with self calibrated clock recovery algorithm
  - Grandmaster clock (Mini-GM) and Boundary clock
  - Combined SyncE for frequency and IEEE1588 for phase and time-of-day delivery
  - Integrated GNSS receiver

- IEEE 1588v2 PTP
  - PTP Telecom Profile for Frequency Synchronization – ITU-T G.8265.1
  - PTP Telecom Profile for Time/Phase Synchronization – ITU-T G.8275.1
  - Telecom Profile for Time/Phase Synchronization – ITU-T G.8275.2

- NTP server (Stratum 1 when locked to GPS) in 542X
  - NTP v2,v3,v4 support

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Syncjack GUI concept

- Several layers of indicators allowing for step by step monitoring and troubleshooting
  - Peeling the onion approach

- First layer provides global indication of the Synchronization status

- Second layer shows performance indication of each reporting tool

- Third layer provides detailed information for fault localization of performance analysis
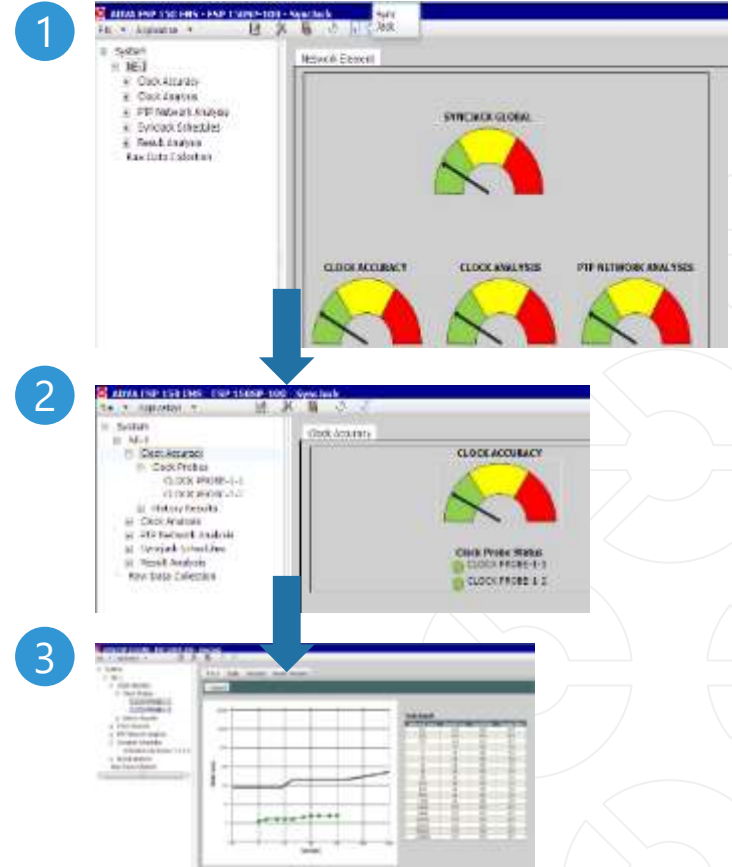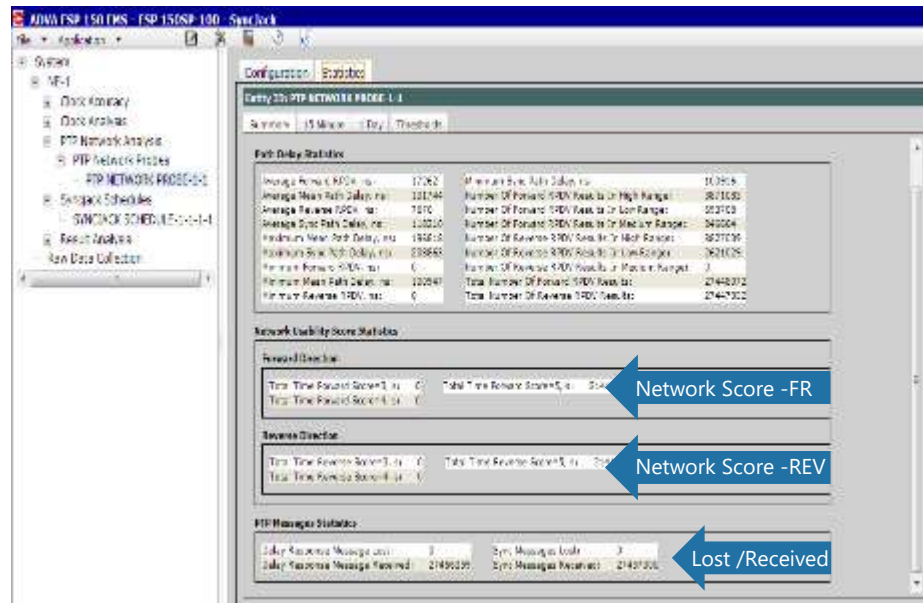
Clock probe and PTP clock probe
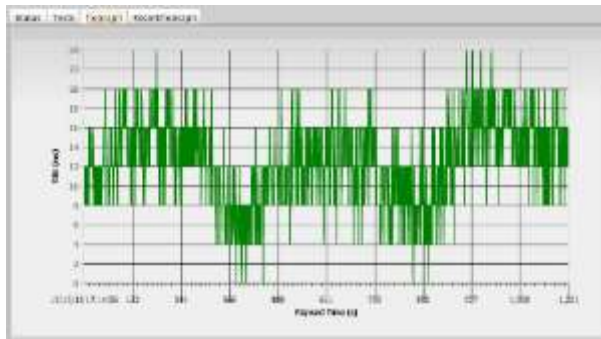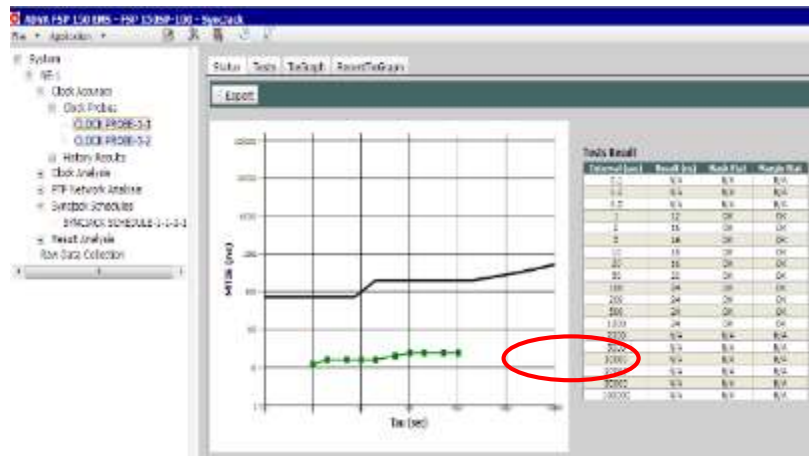
PTP network probe statistics and results

- Packet Counters (arrived, lost)

- PD (Path Delay) – min, max, avg., forward only

- MPD (Mean Path Delay) – min, max, avg., both directions

- RPDV (Residual Path Delay Variation) – min, avg., both directions (based on observed Delay Floor); Current Value and Histogram

- Network Usability (based on G.8261.1 FPP); Current Value and Histogram

Syncprobe Syncjack assurance tools scale

- 2 x Clock Probe
  - Calculate MTIE and provide clock Performance Statistics measured for physical sources (E1, 2.048MHz)
  - Programmable Source and reference signals
- 4 x PTP Clock Probe
  - Calculate MTIE and provide clock Performance Statistics measured for PTP packets timestamp information
  - Diagnostic and monitoring of PTP Master or Slave ports
  - Support parallel and tapping modes
- 1 x PTP Network Probe
  - PTP communication path Packet Delay and delay variation performance statistics, Network usability statistics, Packet loss statistics; Delay data export to NM

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OSA 54XX holdover performance

	400nsec	1.1usec	1.5usec	5usec	10usec	16ppb
Quartz	2 h	4 h	5 h	8 h	14 h	1 m
Quartz HQ+	8 h	13 h	15 h	1.2 d	1.7 d	0.5 y
Quartz HQ++	15 h	1.3 d	2 d	4 d	6 d	>1.5 y
Rubidium	15 h	1.3 d	2 d	4 d	6 d	>5 y

* Effective daily aging after device was powered for one month and locked to GPS for 3 days, for the following 3 days.

h = hour(s) / d = day(s) / m = month(s) / y = year(s)

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OSA 5410 & OSA 5411 comparison

OSA 5410

- Small scale ½ 19" or 19" w/adapt.
- GM, APTS, BC, Slave, Probe
- G.8265.1 and G8275.1/2
- Two PTP/SyncE GigE ports
- up to 128 slaves
- OCXO
- Single DC or AC power feed

OSA 5411

- Small scale 19" / 1U rack
- GM, APTS, BC, Slave, Probe
- G.8265.1 and G8275.1/2
- Two PTP/SyncE GigE ports
- up to 128 slaves
- OCXO, DOCXO or **Rubidium**
- **Redundant** AC and /or DC power

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OSA 542x – synchronization "Swiss knife "

PTP GM/BC/Slave	NTP Server	SSU	Multiple I/F fan-out	Syncprobe

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OSA 5420 & OSA 5421

- Slaves capacity (IP unicast G.8265.1)
  - 128, 256, 512 and 1024 slaves at 128pps
- G.8275.1 and G.8275.2 Telecom Profile for phase & Time delivery
- OSA 5420
  - Up to two expansion Slots
  - "Quartz" OCXO– better than Stratum 3E/G.812 Type III
  - "Quartz HQ+" High quality OCXO - better than G.812 Type I
- OSA 5421
  - One expansion Slot
  - "Rubidium" or "Quartz HQ++" High quality DOCXO - better than Stratum 2 G.812 Type I/II

OSA 5420 Quartz

OSA 5420 Quartz HQ+

OSA 5421 Quartz HQ++

OSA 5421 Rubidium

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OSA 5420 & OSA 5421 expansion cards options

- 16 x BITS E1/T1

  - 16 x BITS outputs using RJ-48/BNC patch panel ; T1 balance (100Ω), E1 balanced (120Ω), E1 unbalanced (75Ω), 2.048MHz

  - E1/2.048MHz Configured in group of 8

- 16 x 1PPS unbalanced (50Ω) or 16 x CLK (10Mhz,50Ω)

  - 16 x 1PPS unbalanced (50Ω), 16 x CLK (10Mhz,50Ω)

- 16 x 1PPS + ToD

  - 16 x 1PPS + ToD over RJ-45

- 4 x 1G Fiber Ethernet ports

  - Support Sync-E /PTP/NTP

  - Support copper SFP

16xBITS

16xToD+PPS

16xCLK/PPS

4x1G Ethernet

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NTP server – our key advantages

- Largest capacity of Ethernet ports in 1U !

- Up to 12 Fiber/Copper ports , Up to 16 NTP Server IP's

- 7000 TPS (without PTP)

- Hardware timestamping -/+ 100 nsec from UTC

- PTP + NTP – Same box – Same port

- Comprehensive PTP solution (GM/BC/Slave/Probe) + multiple profiles , PTP to NTP Conversion

- Backup of PTP input /10MHz/E1/T1/Sync-E

- Support for PRC/SSU – up to 32xE1/T1

- Multiple Fanout options – PPS/CLK/ToD+PPS

- Secured management (SSH/SCP/RADUIS/TACACS+...)

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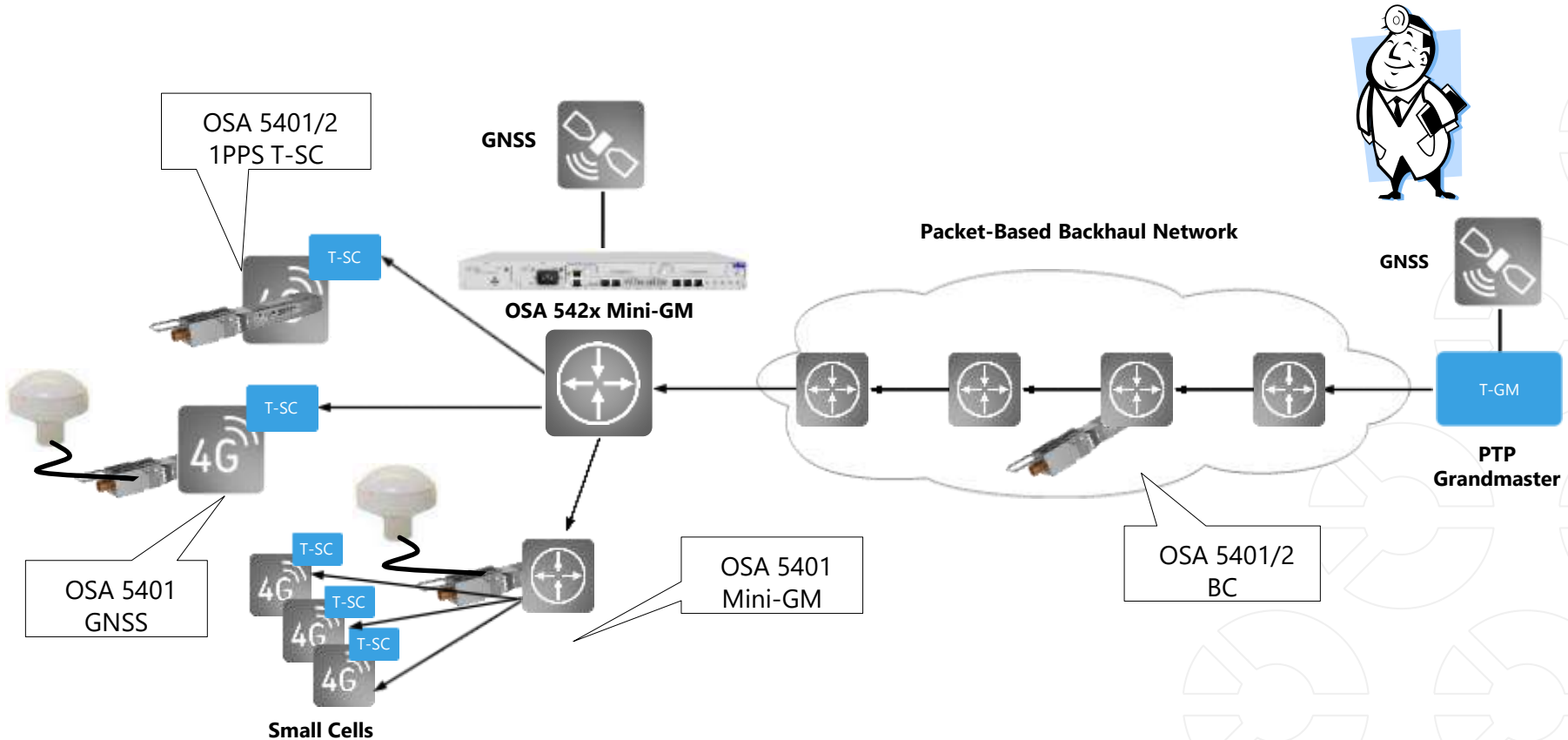An ADVA Optical Networking Company

OSA 5401 'Syncpill' key advantages

- Low OPEX and CAPEX

  - Miniature form factor

  - No additional footprint – plugged into existing equipment

  - Easy to install and operate

  - Very low power consumption (<1.5W)

- Cost effective solution

  - Optimized in cost for mass deployment

  - Cost effective antenna kits

- High Performance

  - Accurate to within 100nsec from UTC (G.8272 PRTC , G.811 PRC)

  - Wide Operational temperature range (-40 to 80C)

  - Support PTP and Sync-E

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Distributed Monitoring architecture using 'Syncpill'

OSA 5401/2
1PPS T-SC

GNSS

T-SC

OSA 542x Mini-GM

Packet-Based Backhaul Network

GNSS

T-SC

T-GM

OSA 5401
GNSS

T-SC

OSA 5401/2
BC

PTP
Grandmaster

OSA 5401
Mini-GM

T-SC

T-SC

T-SC

Small Cells

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OSA 5401 'Syncpill' feature highlights

- IEEE1588v2 grand master clock
    - G.8275.1; G.8265.1; G.8272…
    - Up to 32 remote slaves

- Sync-E master/slave (time holdover) – G.8262/64 compliant

- Fully configurable via secured CLI (Telnet & SSH) & SW upgrade via FTP & SCP

- Dual IP's (for Clock and management) and VLAN's support

- FSP NM generic device support via SNMP (v2 & v3)

- Dual frequency GNSS
    - GPS, GLONASS , BeiDou; GLONASS+GPS , GPS+BeiDou;
    - Supports fixed positioning mode (single satellite mode)
    - Support SNR and Elevation screening
    - HW ready for Galileo

- Interfaces
    - Input GNSS antenna, (3.3V feed) – SMA
    - Output configurable 2nd port (default PPS out) – RP-MMCX

- New antenna kits options

OSCILLOQUARTZ
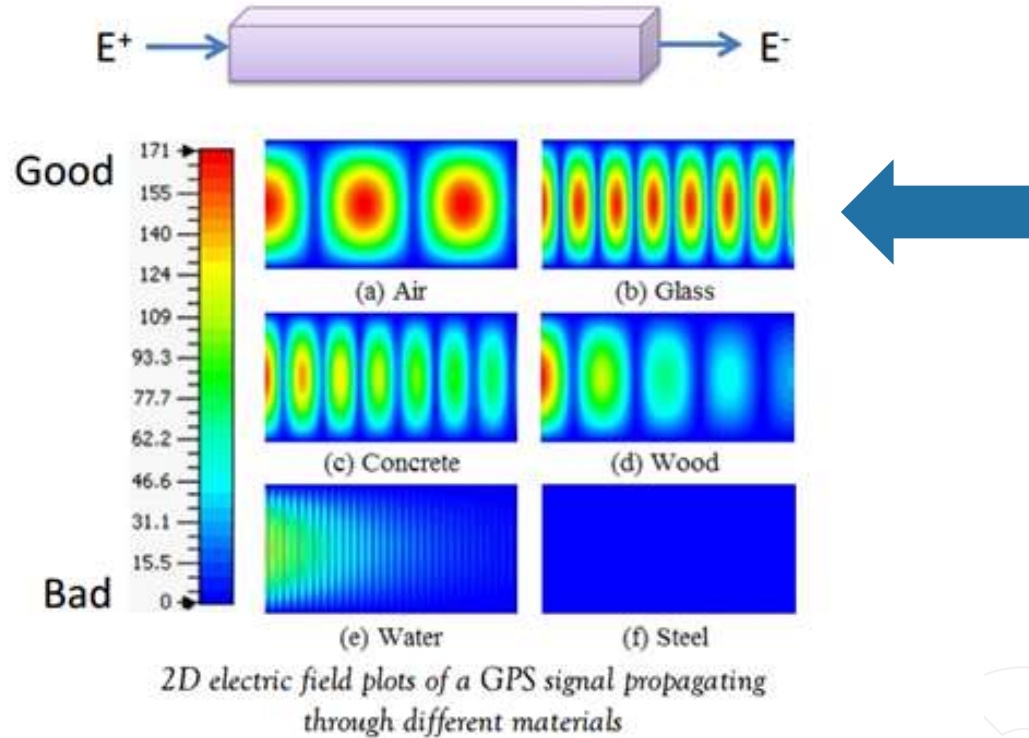An ADVA Optical Networking Company

Indoor small cell sync – OSA 5405- indoor SMART ANTENNA

- Features

  - Integrated PTP GM and GNSS antenna – optional external antenna

  - PTP capacity up to 64 Slaves

  - Cost effective and very compact design

  - Can be installed on a window

  - Single Combo port – Fiber/ Copper

  - Powered by PoE or -48VDC over RJ45

  - Multiple GNSS options

    - GPS/BEIDOU/GLONASS/GALILEO

    - Single Satellite mode

  - Multiple protection options

    - Sync-E /PTP/BITS input

  - Support frequency and phase telecom profiles

PTP+PoE

ETH

GNSS/PRTC/PTP GM

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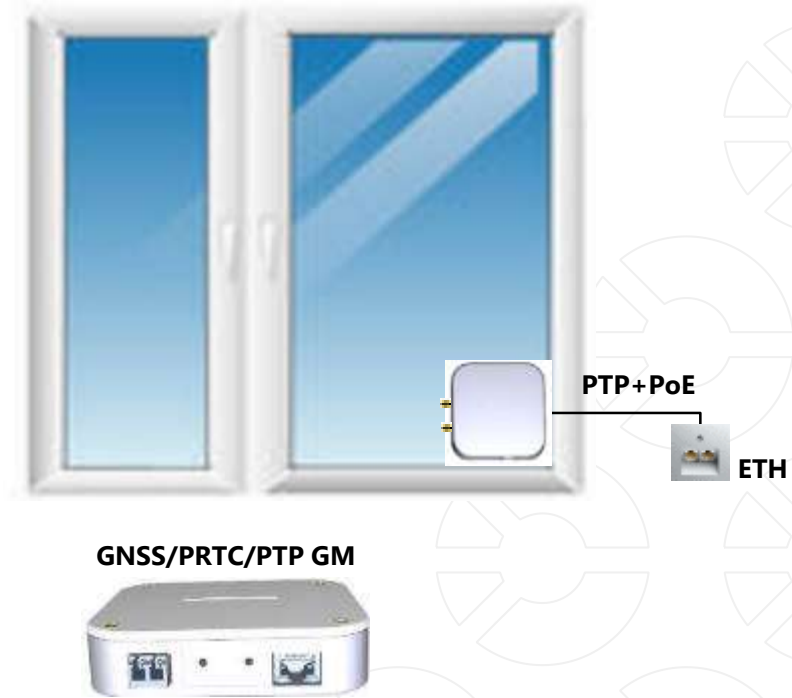
GPS signals thorough building materials

2D electric field plots of a GPS signal propagating through different materials

Source - Microsoft Research, Redmond , University of Virginia

OSA 5405-I indoor PRTC/GM

- Window/Wall/Ceiling mounting options
  - High bond tape for glass installation
  - Rugged, low profile housing for minimum visibility (10.4x10.4 cm)
- Two Integrated GPS/GLONASS/BEIDOU/SBAS/GALILEO (GNSS) receivers and antennas for multipath environment immunity
  - Fix positioning (single satellite mode)
  - Selecting satellite based on elevation mask and SNR mask
  - External antenna option
- Sync-E input and output, PTP input for backup (APTS)
- PTP Grandmaster and PRTC – up to 64 remote slaves at 32pps
  - Profiles - G.8265.1 (L3 unicast), G.8275.1 (L2 multicast), G.8275.2 (L3 Unicast) and Telecom 2008 and default profiles
  - Accuracy - G.8272 : +/-100nsec form UTC
- CLI/SSH/GUI, Logs/syslog/RADIUS/TACACS+/SNMPV2&V3
  - In band management, IPv4 and IPv6
  - FSP NM used for alarms and SNMP traps
- Low touch provisioning - Plug-and-Play features
  - Discovery, Configuration, TR-069 & DNS servers

Reuse of existing IP's and design from OSA 5401 SFP

Fiber PTP   **RJ-45 PTP+PoE**

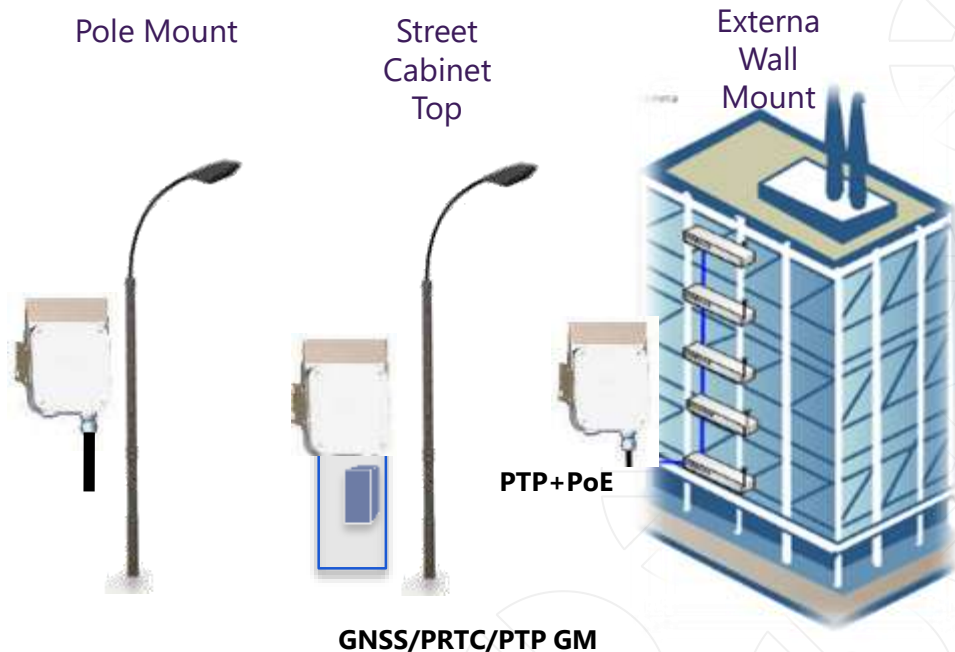**Indication LEDS**
Sync, Network, Alarm

GNSS input –optional (SMA)
PPS/CLK out – optional (SMA)

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Outdoor small cell sync – OSA 5405- outdoor

- Features
  - Integrated PTP GM and GNSS antenna
  - PTP capacity up to 64 Slaves
  - Cost effective and very compact outdoor design
  - Can be installed on a external walls, lamp post and roof
  - Single Combo port – Fiber/ Copper
  - Powered by PoE over RJ45
  - Multiple GNSS options
    - GPS/BEIDOU/GLONASS/GALILEO
    - Single Satellite mode
  - Multiple protection options
    - Sync-E /PTP/BITS input
  - Support frequency and phase telecom profiles BOTH

Pole Mount   Street Cabinet Top   Externa Wall Mount

PTP+PoE

GNSS/PRTC/PTP GM

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OSA 5405-O outdoor PRTC/GM

- Outdoor waterproof External-Wall/Roof/Pole mounting options
  - Rugged, low profile housing for minimum visibility
  - Rugged and compact (10.4x11.4 cm), pole mount GNSS antenna housing
  - Outdoor waterproof IP-65 protection
- Single device support field installation of both copper and fiber
- Two Integrated GPS/GLONASS/BEIDOU/SBAS/GALILEO (GNSS) receivers and antennas for multipath environment immunity
  - Fix positioning (single satellite mode)
  - Selecting satellite based on elevation mask and SNR mask
- Sync-E input and output, PTP input for backup (APTS)
- PTP Grandmaster and PRTC – up to 64 remote slaves at 32pps
  - Profiles and Accuracy – Same as 5405-I
- CLI/SSH/GUI, Logs/syslog/RADIUS/TACACS+/SNMPV2&V3
  - In band management, IPv4 and IPv6
  - FSP NM used for alarms and SNMP traps
- Low touch provisioning - Plug-and-Play features
  - Discovery, Configuration, TR-069 & DNS servers

Reuse of existing IP's and design from OSA 5401 SFP

Fiber PTP

RJ-45 PTP+PoE

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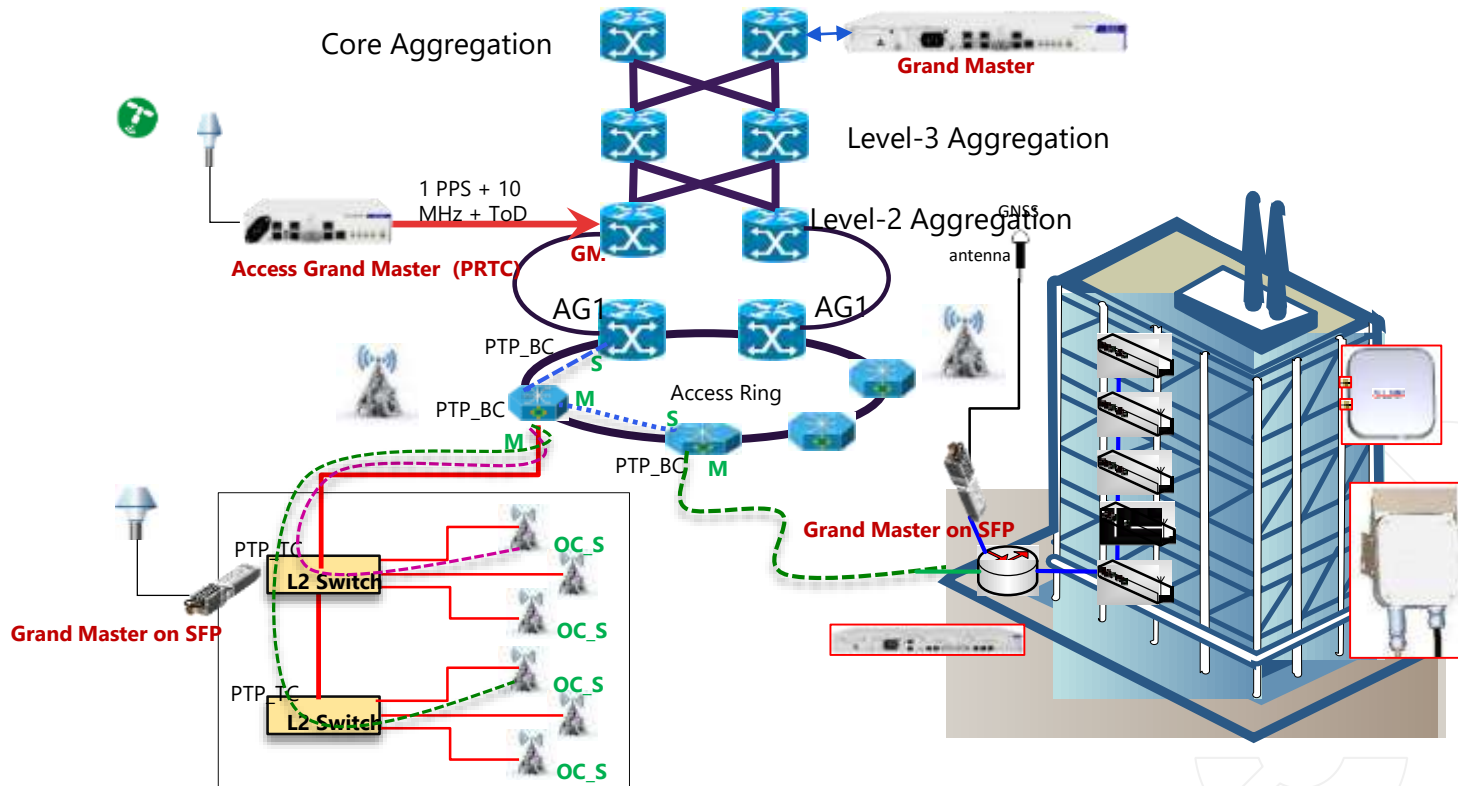An ADVA Optical Networking Company
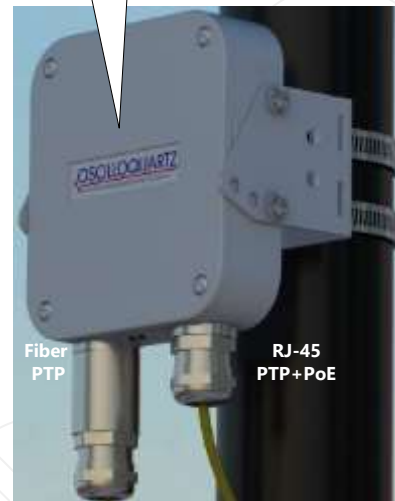
OSA 5405-I and O mounting options

OSA 5405 - outdoor

OSA 5405 - indoor

Use of 5410/20 and 5401/5 for Phase Sync (real case from green field Tier 1 operator)


Core Aggregation

Grand Master

Level-3 Aggregation

1 PPS + 10 MHz + ToD

Level-2 Aggregation

GNSS antenna

Access Grand Master (PRTC)

GM

AG1   AG1

PTP_BC   S

PTP_BC   M

Access Ring

S

PTP_BC   M

PTP_TC

L2 Switch

OC_S

OC_S

Grand Master on SFP

Grand Master on SFP

PTP_TC

L2 Switch

OC_S

OC_S

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Network Management System

Network management

- Build, Monitor and Expand a Reliable Sync network
- Reduce on-site Operation with a Centralized Management process
- Performance monitoring, Fault and Event management

- Dedicated for sync network monitoring
- Provide access to:
  - Core, edge and access sync equipment
  - Some competitor's equipment
  - ADVA products range

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ADVA/OSA sync NEs network management
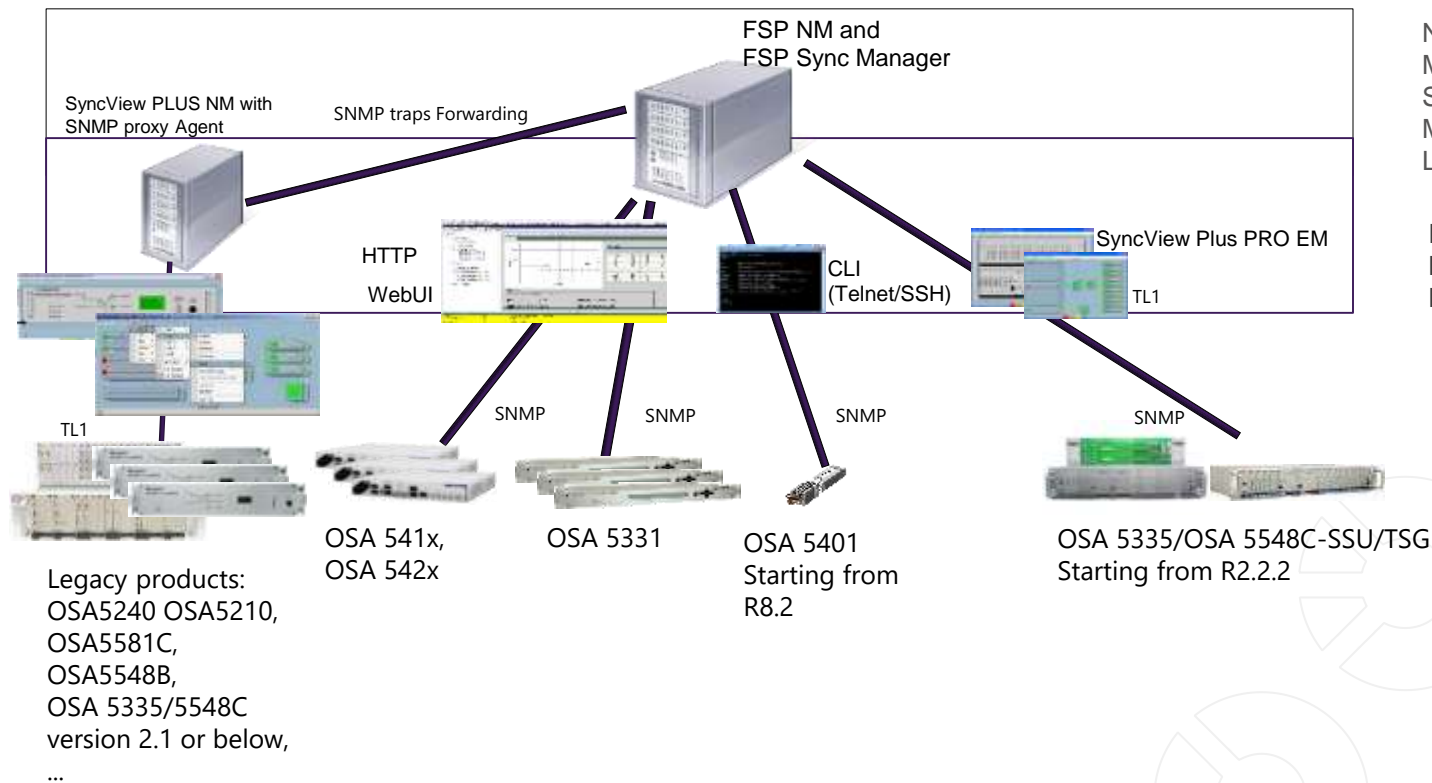
Sync manager functions

- SyncMap
  - Topology Map and Tree
  - Hierarchy and clock distribution
  - Clock status
  - Sync Health
- SyncRoutes
  - Route Info
  - Route alarm and status
  - Route Statistics
- Sync Components
  - SyncE Node
  - PTP OC-M (GM)
  - PTP BC
  - PTP TC
  - PTP OC-S (Slave)
  - Network Clock Domains

- **Syncjack monitoring and diagnostics -** Clock Accuracy, Clock Analysis, PTP Network Analysis

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Thank you

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