Implementation of Reliable Synchronization for 5G

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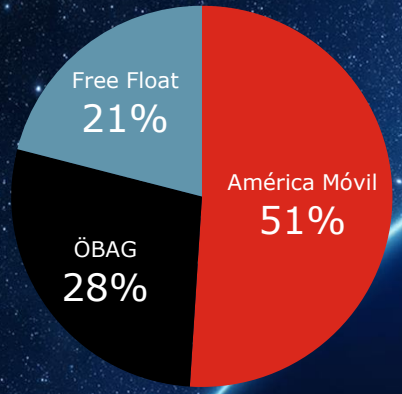
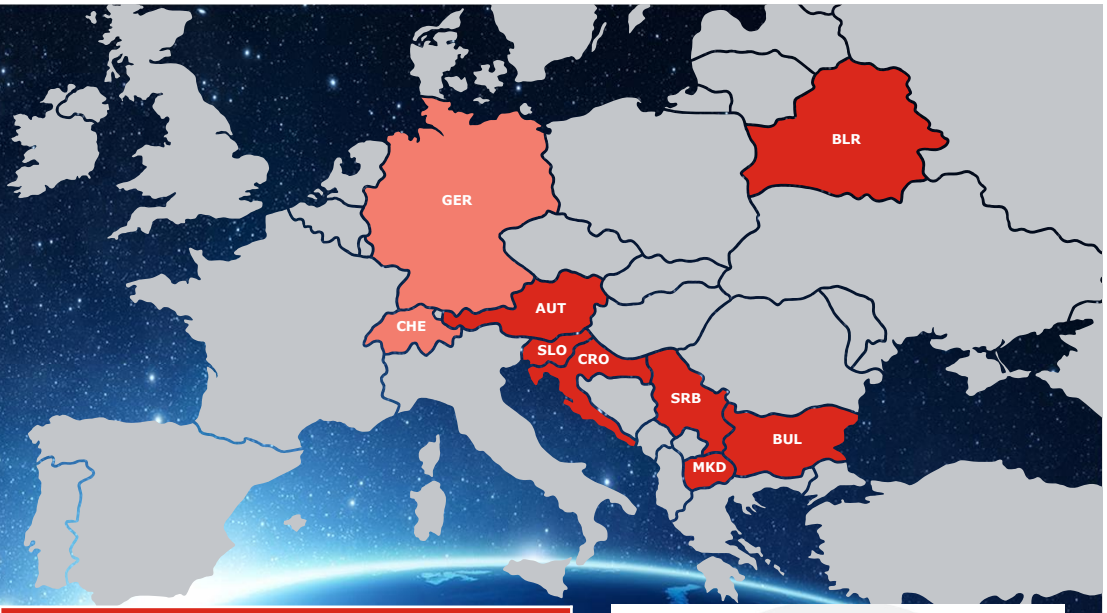


Shareholder Structure



Financial Year 2020

4.55 bn Total Revenues (2.6 bn in Austria)

1.58 bn EBITDA

25 mn Customers

18 mn Employees

5G Synchronization Requirements

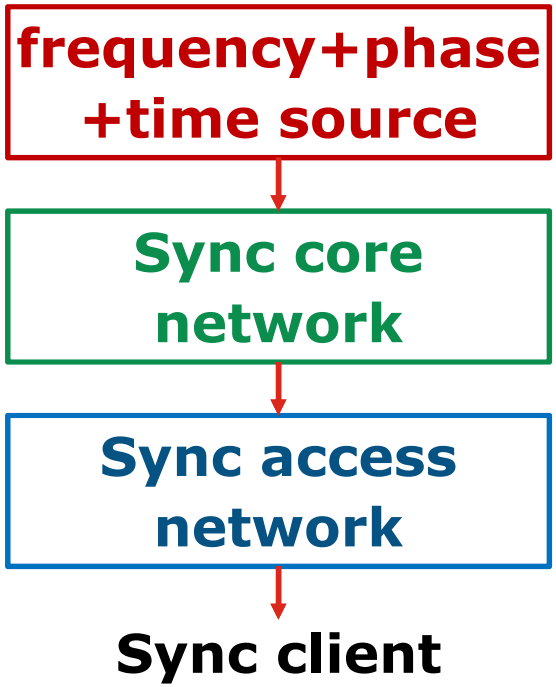
Regulator requirements:

- **|TE| max. ±1.1 µs (ITU-T Rec. G.8271.1 network equipment budget) at sync client input**

High reliability:

- **protection against GNSS outages, network failures etc.**

Synchronization Solutions: Phase 1

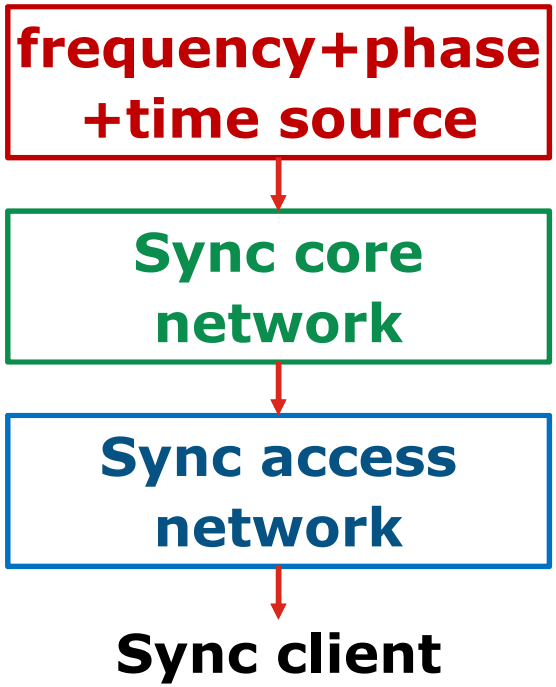


- existing PRC + SSU
- existing GNSS antennas
- regional PRTC-B

- PTP G.8275.1 + SyncE over WDM
- distributed PRTC-A (T-BC Class D)
- East-West Protection

- existing T-BC Class A/B + SyncE
- existing transparent WDM

Synchronization Solutions: Phase 2

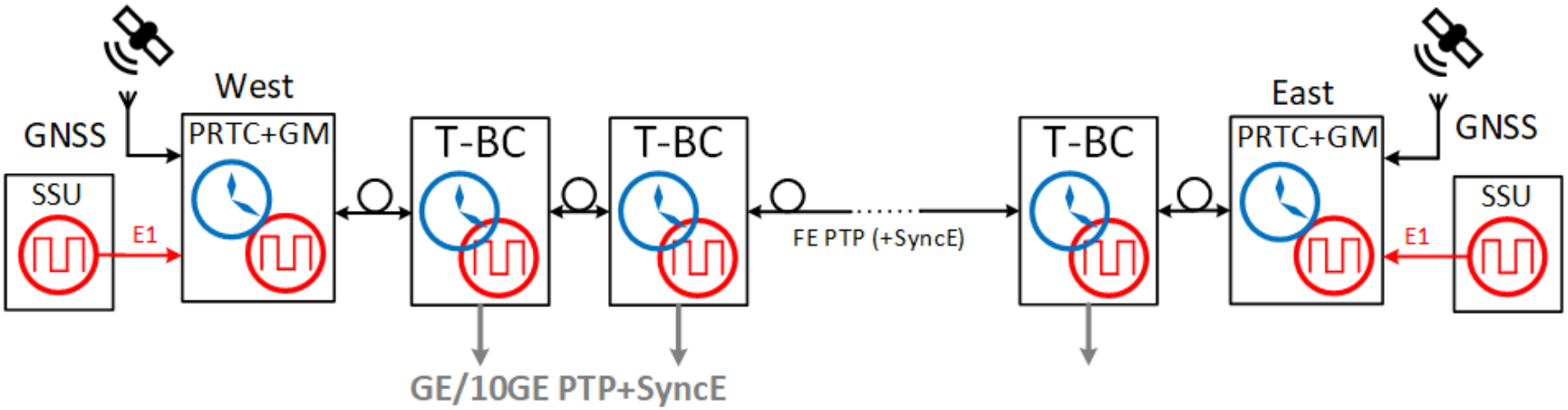


- centralized ePRTC
- multi-band GNSS, GNSS-firewall
- satellite-independent sync signal

- national sync network (direct fiber)
- in-service monitoring of sync quality

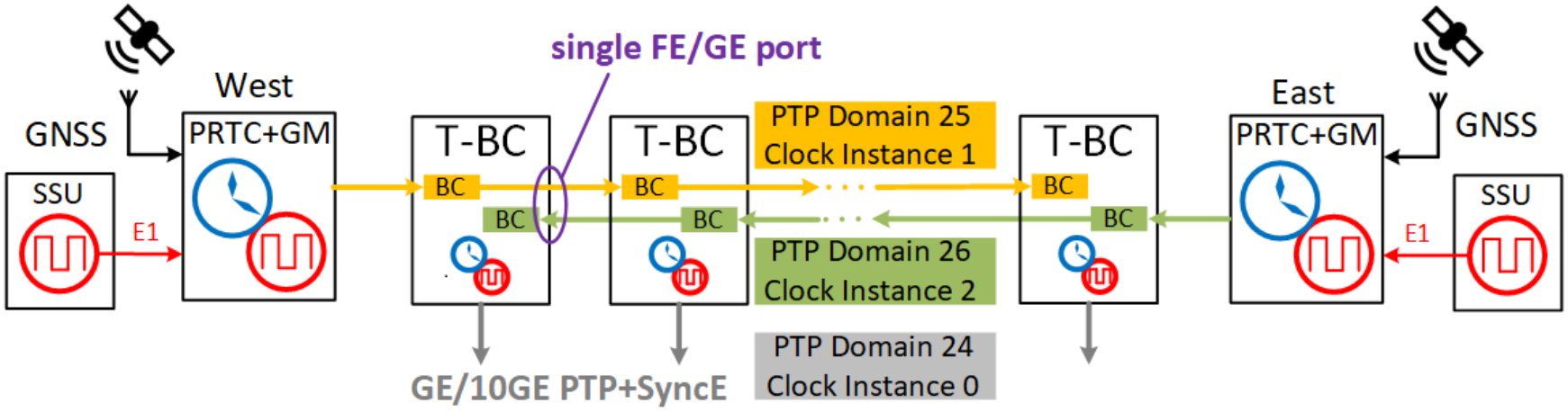
- T-BC Class B/C + SyncE

Phase 1: Regional PRTC-B



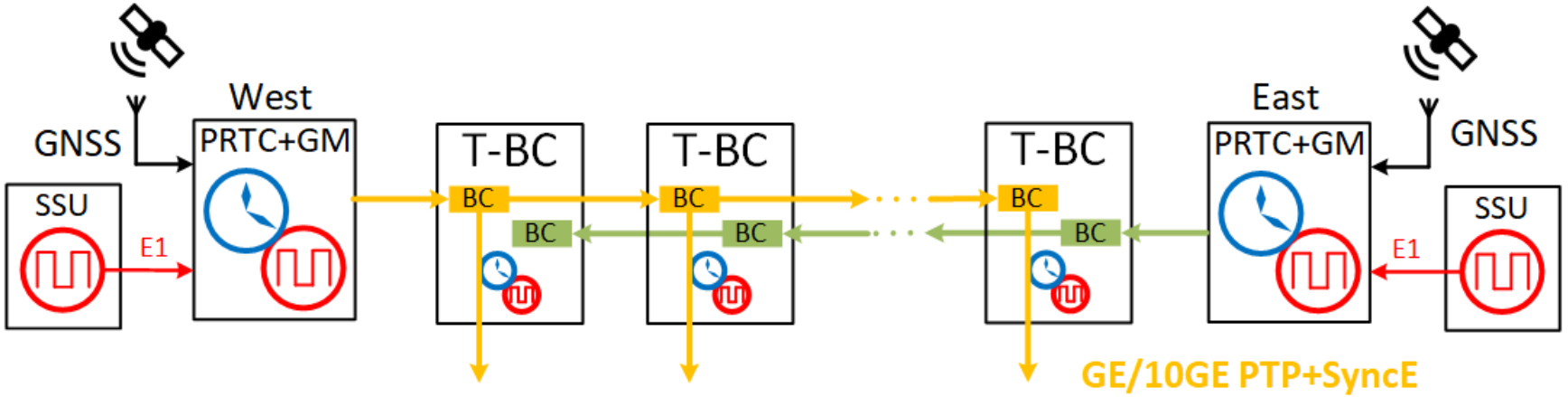
- Time+Phase from GNSS (GPS+Galileo)
- Frequency from PRC (Cesium) via SSU
- FE (100 Mbit/s): PTP + optional SyncE
- T-BC Class D, ITU-T Rec. G.8275.1 Phase Profile

East-West Protection switching



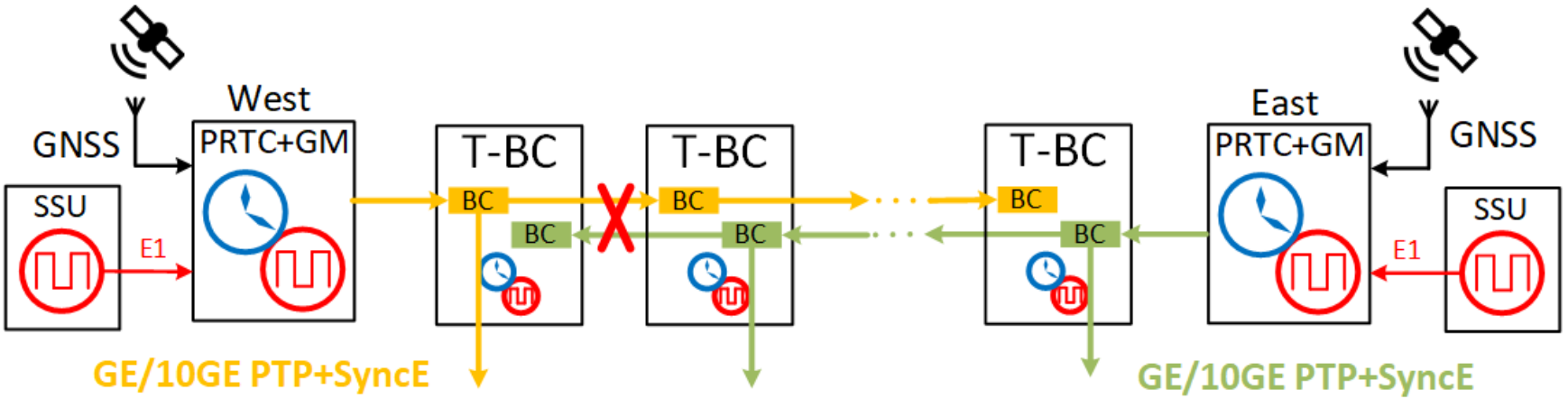
- 2 PTP+SyncE directions active at the same time
  - different PTP domains and clock instances on the same Ethernet port
- each T-BC contains 2 boundary clock instances plus local clock

East-West Protection switching



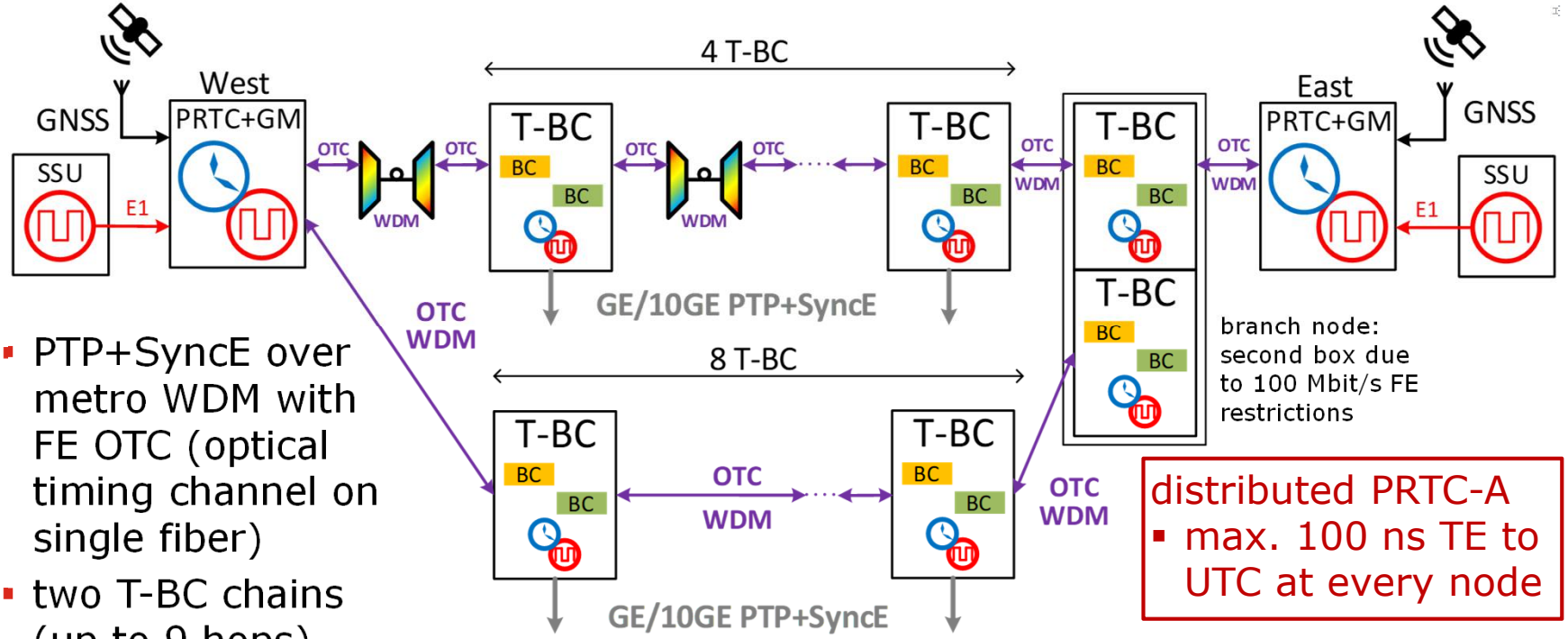
- in normal operation all T-BC are synchronized from one T-GM (according to priority)

East-West Protection switching



- in case of failure (ethernet port down) → immediate switchover to redundant clock instance
- automatic switchover of whole T-BC chain in a few minutes
- no interruption of "southbound" PTP+SyncE outputs (if bridging time is set correctly)

Field Trial in Carinthia

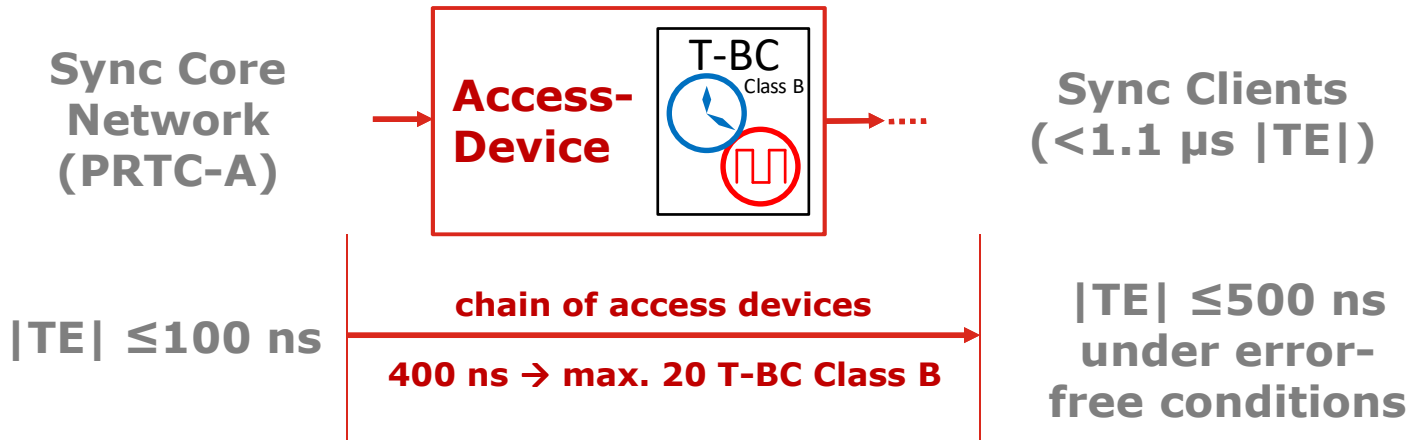


- PTP+SyncE over metro WDM with FE OTC (optical timing channel on single fiber)
- two T-BC chains (up to 9 hops) with branch node

distributed PRTC-A
- max. 100 ns TE to UTC at every node

in-service performance monitoring:
→ up to 100 ns between PTP-directions

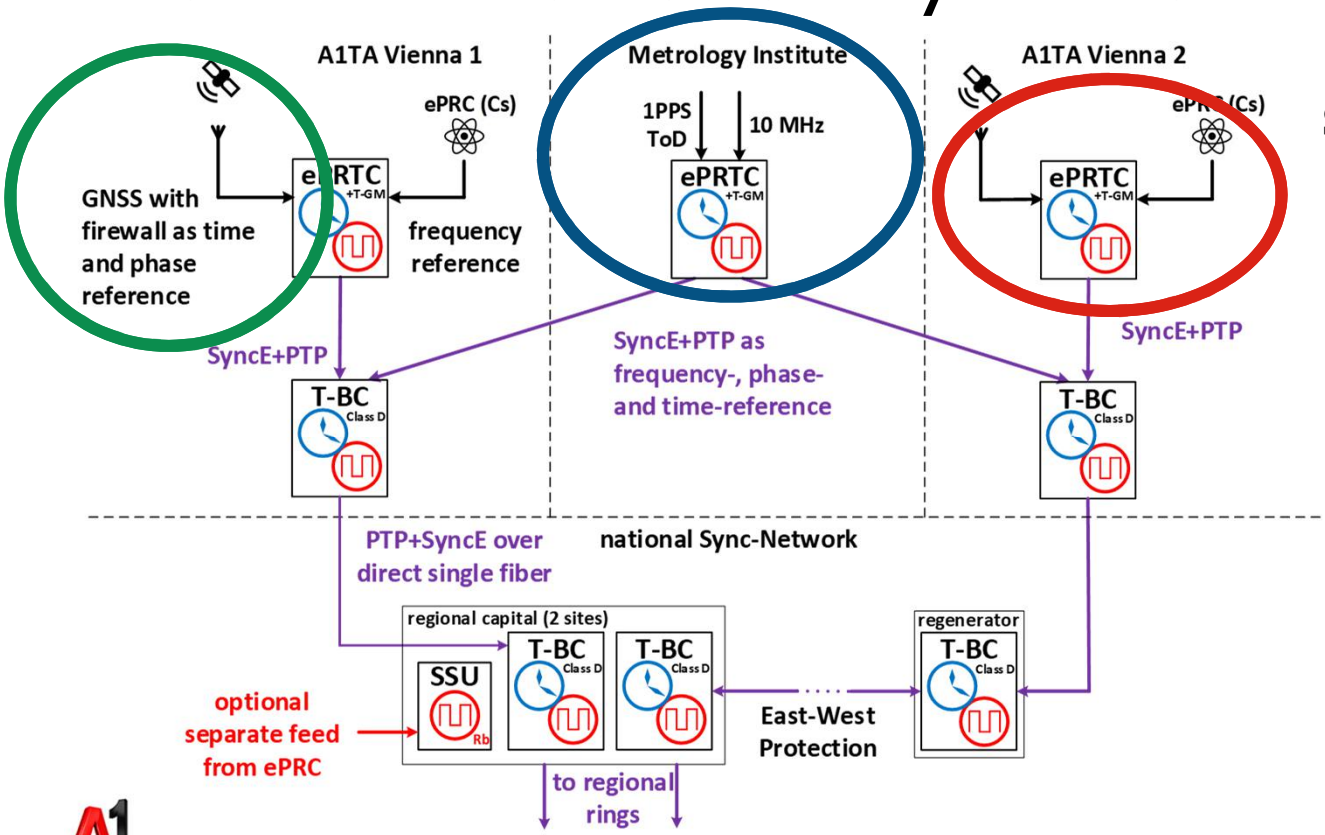
Sync-Access



Input/Output:

- accept/provide SyncE+PTP (T-BC Class B or C) on single optical GE/10GE Port
- accept/follow signalling (SSM PRC/SSU-A/SSU-B, Clock Class 6/7)
- in case of fault (holdover...) → SSM EEC, Clock Class ≥135

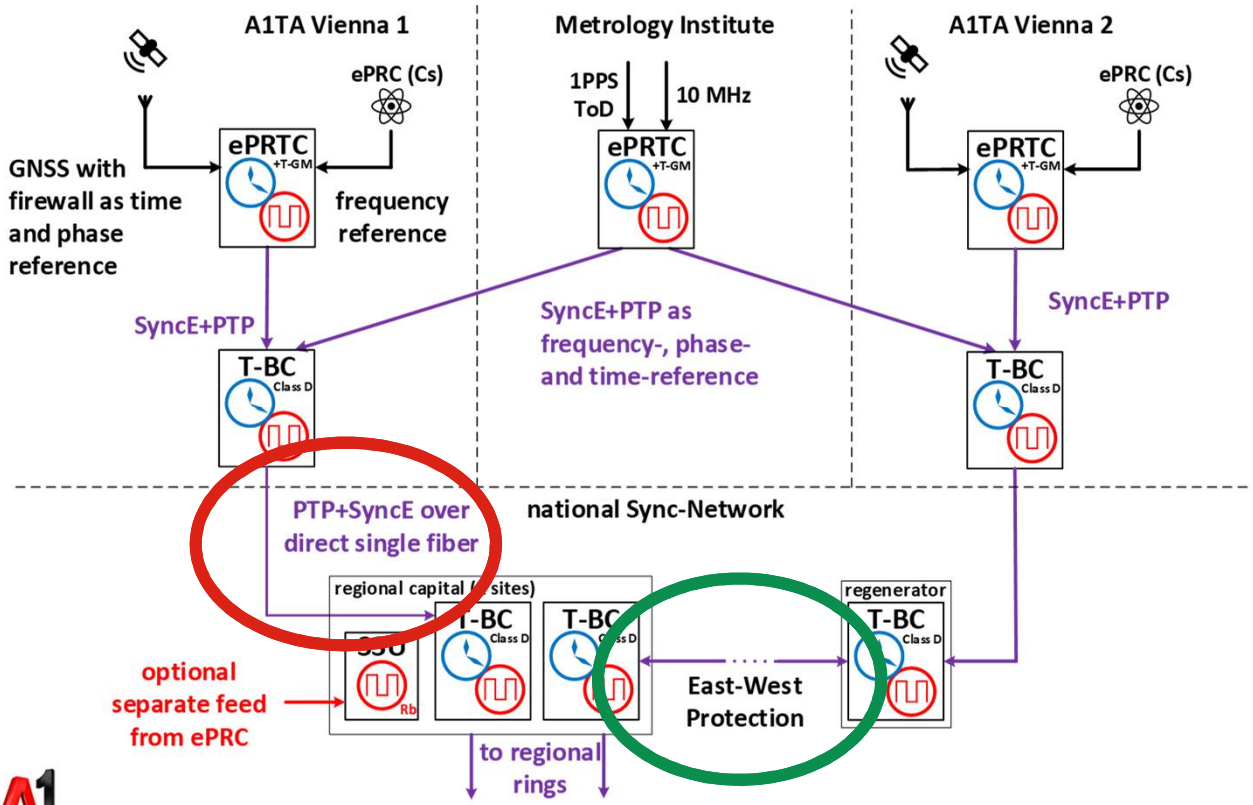
Phase 2: National Synchronization



Sync-Source:

- ePRTC (max. 30 ns abs TE) with atomic clocks
- multi-band GNSS
- GNSS firewall functionality
- Satellite-independent source from metrology institute

Phase 2: National Synchronization



Sync-Transport:

- PTP+SyncE over direct single fiber (no WDM)
- East-West Protection in redundant national rings

Phase 2: National Synchronization

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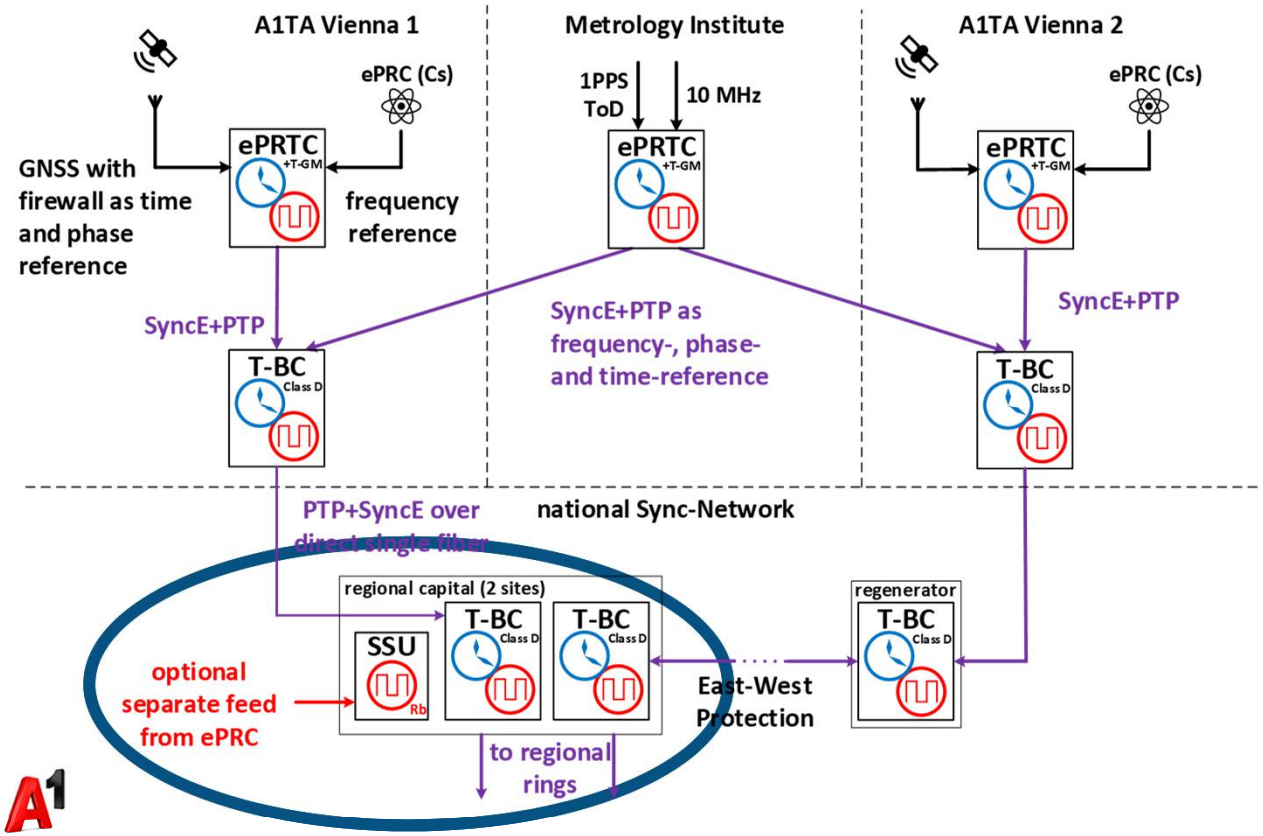
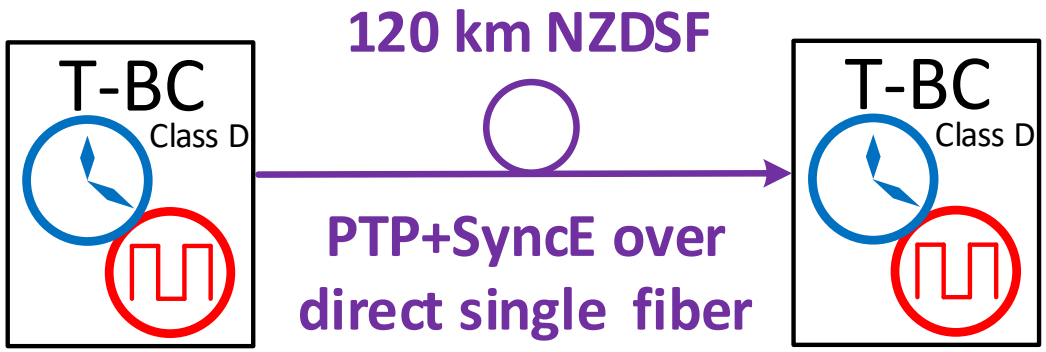


Redundancy:

- fall-back to regional PRTC with GNSS if national network fails

PTP+SyncE over direct fiber



- GE uplink around 1506 nm
- GE downlink around 1514 nm
- CD (chromatic dispersion) ≤5 ns
  → cTE ≤2.5 ns
- CD compensation in T-BC available

Lab measurement results (without CD compensation):

- -2 ns cTE over 3 m patchcord
- -1 ns cTE over 3*40 km NZDSF coils

Summary

5G Synchronization requirements: accuracy, reliability

Synchronization concept phase 1:

- distributed PRTC-A quality in every regional sync core node

East-West Protection for PTP+SyncE

- Field trial with up to 9 T-BC hops

Synchronization concept phase 2:

- National sync core network with ePRTC and direct fibers
- PTP+SyncE over 120 km direct single fiber

Acronyms and Abbreviations

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1PPS	…	1 Pulse Per Second
10GE	…	10 Gigabit Ethernet
5G	…	fifth generation technology standard for cellular networks
CD	…	Chromatic Dispersion
Cs	…	Cesium (oscillator)
cTE	…	constant Time Error
EEC	…	Ethernet Equipment Clock
ePRC	…	Enhanced Primary Reference Clock
ePRTC	…	Enhanced Primary Reference Time Clock
FE	…	Fast Ethernet (100 Mbit/s)
GE	…	Gigabit Ethernet
GM	…	Grandmaster
GNSS	…	Global Navigation Satellite System
GPS	…	Global Positioning System
IEEE	…	Institute of Electrical and Electronics Engineers
ITU	…	International Telecommunication Union
ITU-T	…	ITU Telecommunication Standardization Sector
NZDSF	…	non-zero dispersion shifted fiber (G.655)
OTC	…	Optical Timing Channel
PRC	…	Primary Reference Clock
PRTC	…	Primary Reference Time Clock
PTP	…	Precision Time Protocol (IEEE 1588v2 1988)
SSM	…	Synchronization Status Message
SSU	…	Synchronization Supply Unit
SyncE	…	Synchronous Ethernet
T-BC	…	Telecom Boundary Clock
T-GM	…	Telekom Grandmaster
TE	…	Time Error
ToD	…	Time of Day
UTC	…	Coordinated Universal Time
WDM	…	Wavelength Division Multiplexing

Thank you

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