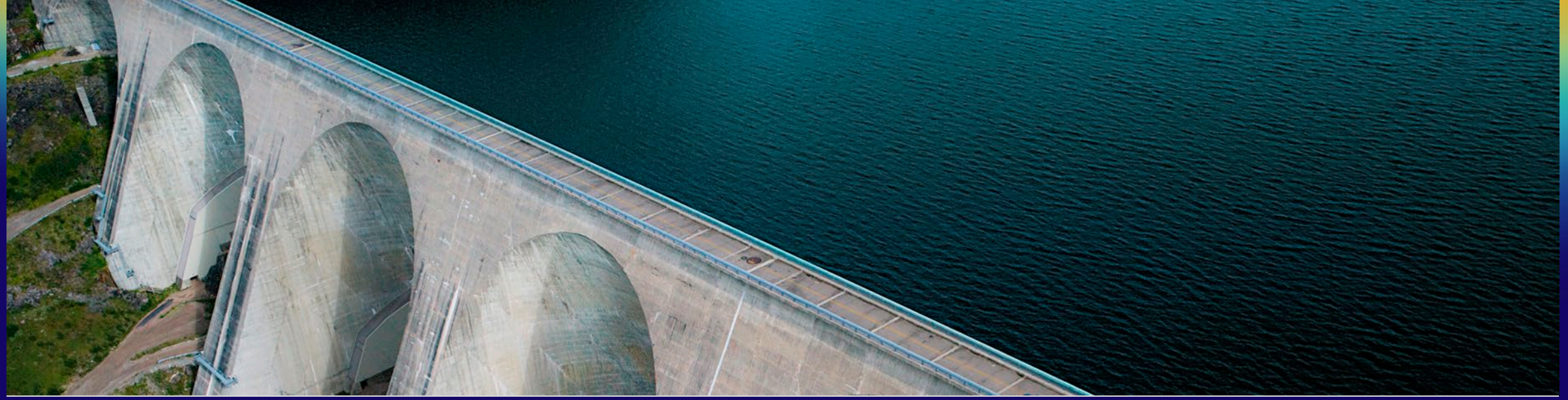

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Hydro-Quebec's Next generation synchronization network

PASCAL MARCOUX, P. Eng.

Pascal Marcoux, P. Eng.

LEAD SYNCHRONIZATION ARCHITECT, HYDRO-QUEBEC

Telecommunication's Engineer with 25 years of experience in RF & microwaves, optics and synchronization for Defense, Broadcasting and Power utility industries

marcoux.pascal@hydroquebec.com

Outline

CONTEXT & REQUIREMENTS

SOLUTION

BENEFITS

CHALLENGES

LESSONS LEARNED

NEXT STEPS

1

CONTEXT & REQUIREMENTS

HQ is modernizing its power plants & stations to IEC 61850

Evolution of MPLS and underlying Optics (DWDM) and Radio (IP) networks

HYDRO-QUEBEC

Outdated Synchronization Networks

Power plant/station

- Transition to last several years
- Current solution end-of-life
- Unavailability of replacement parts

SONET/TDM

- Transition to last several years
- Sync equipment end-of-life

IP

- Current equipment non-functional > Sept 2022 (internal rollover week)

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Requirements

1 µs accuracy

PTP Power profile

Resilient to GNSS outage

Independent alternative source

Need to detect GNSS outage (jamming, spoofing, natural, obstruction) to switch to alternative

Robust NTP

Availability in case of cyberattack

Separation of Electric vs Admin in Data Centers

Address end-of-life of current synchronization networks

2

SOLUTION

Solution

One sync network fulfilling all new & old requirements

Local clocks locked to GNSS, providing :

- PTP IEEE C.37.238-2017 Power profile
- IRIG-B004 & B122
- NTPv4
- BITS

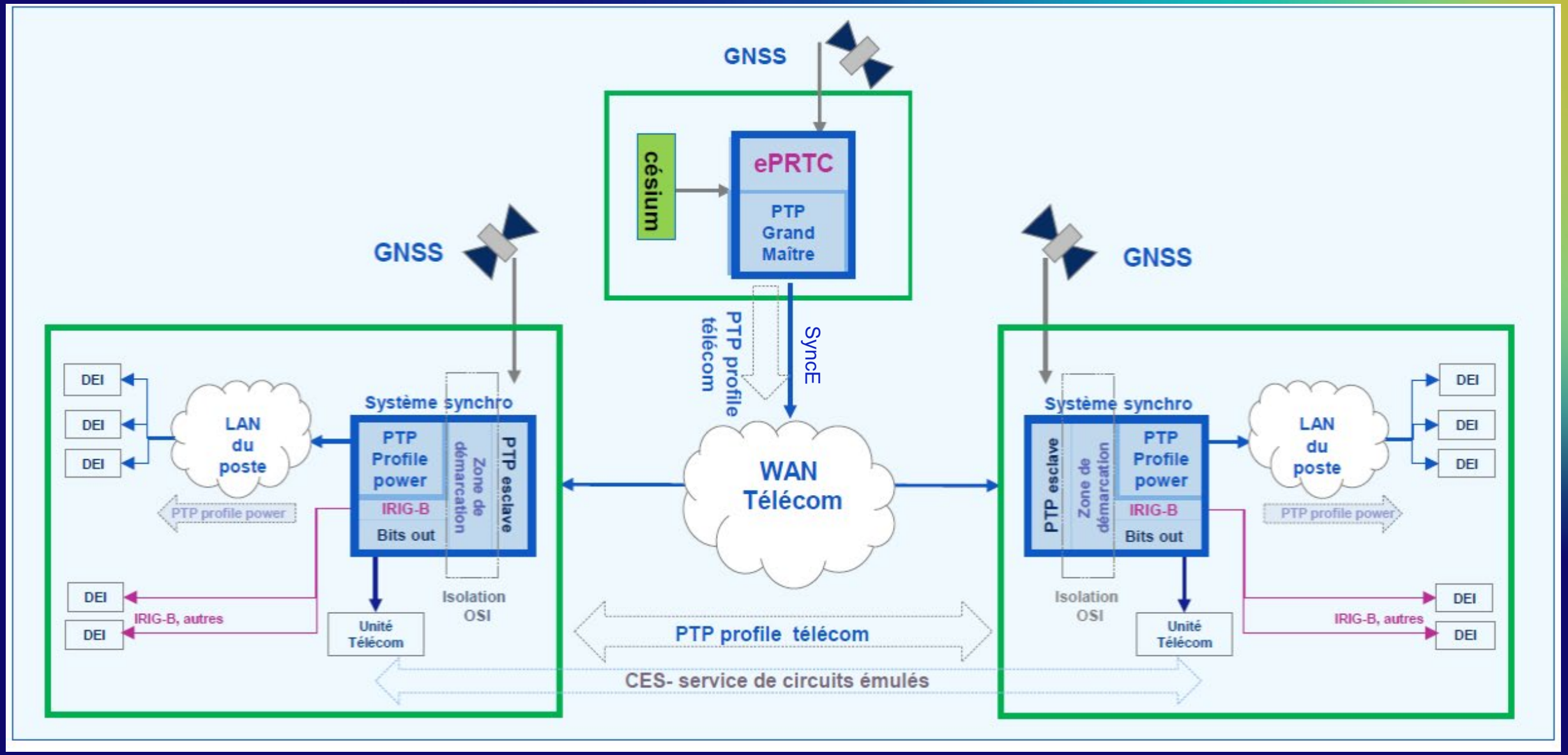
> 600 clocks

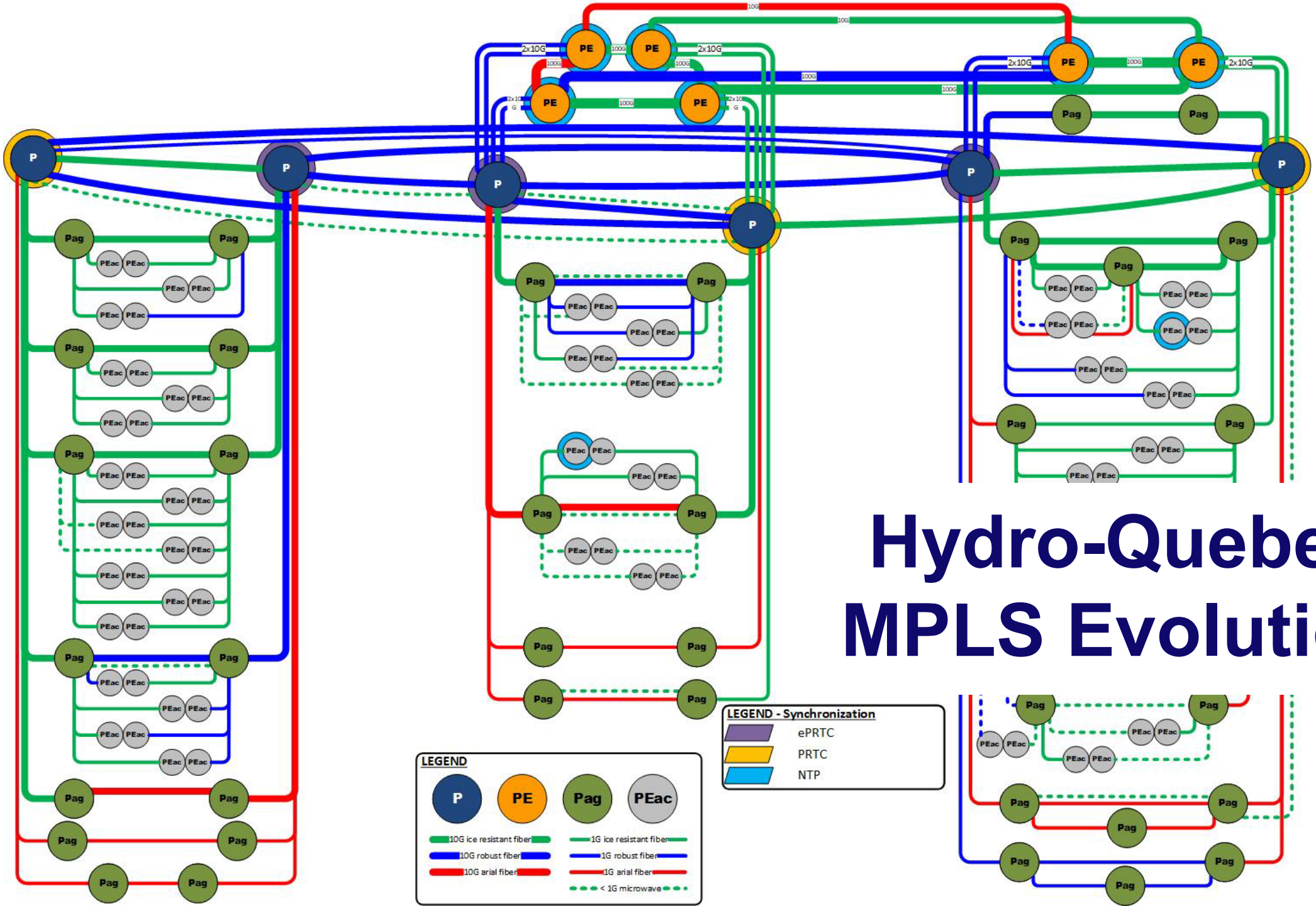
PTP WAN service - backup to local clocks & sync to Telecom network (9 clocks)

- Fully integrated to new MPLS network (PTP aware network)
- Based on ITU-T G.8275.1 Telecom L2 profile
- ePRTC at the core (Cesiums to provide resilience in case of GNSS outage)
- G.8275.2 under evaluation for small locations with leased links (no PTP support)

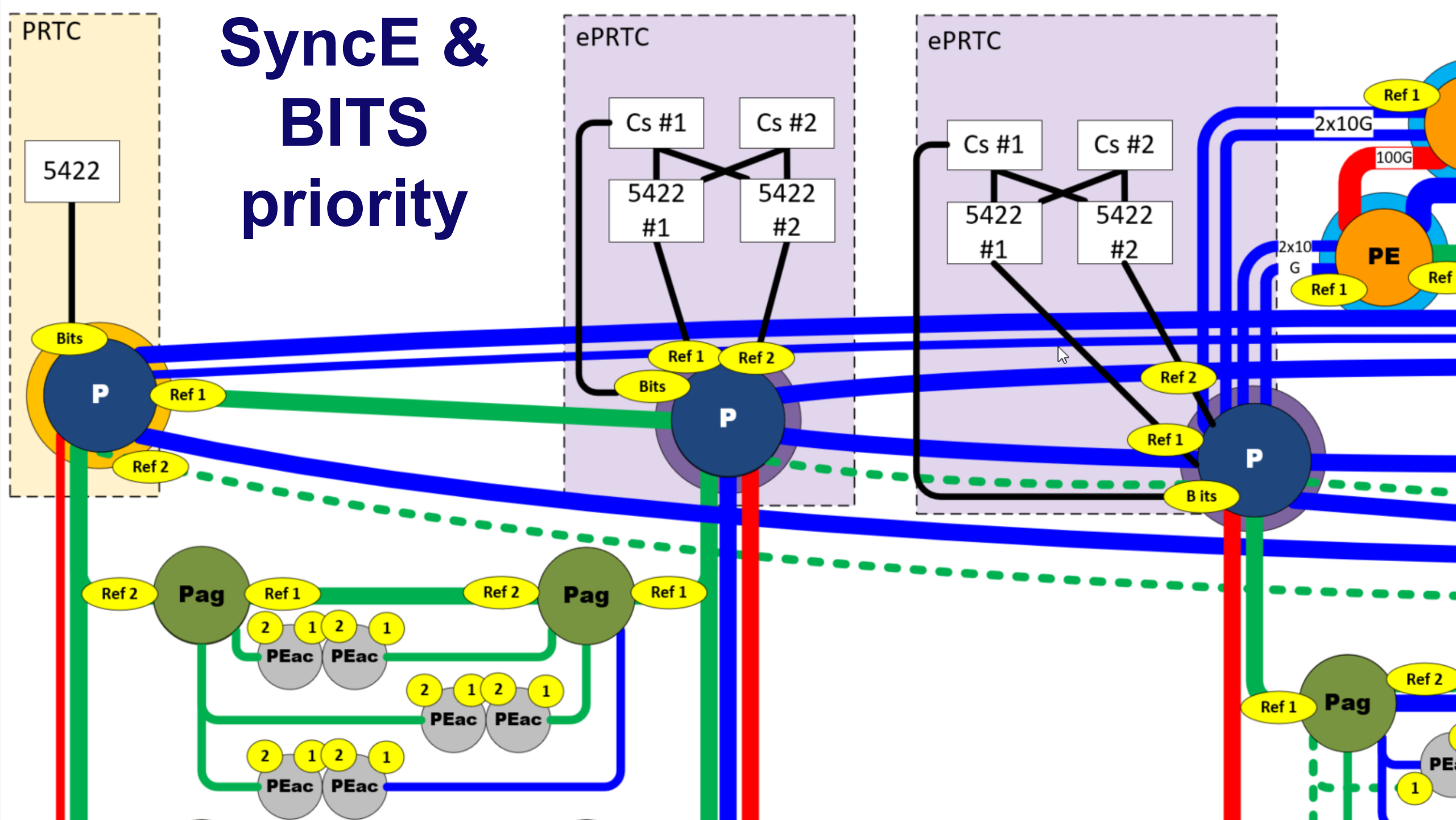
NTPv4 WAN service (6 clocks)

Synchronization network architecture





Hydro-Quebec MPLS Evolution


SyncE & BITS priority
PRTC
5422
ePRTC
Cs #1
Cs #2
5422 #1
5422 #2
ePRTC
Cs #1
Cs #2
5422 #1
5422 #2
Ref 1
2x10G
100G
2x10 G
PE
Ref 1
Ref
Bits
P
Ref 1
Ref 2
Ref 1
Ref 2
Bits
P
Ref 2
Ref 1
P
B its
Ref 2
Pag
Ref 1
Ref 2
Pag
Ref 1
2
1
2
1
PEac
PEac
2
1
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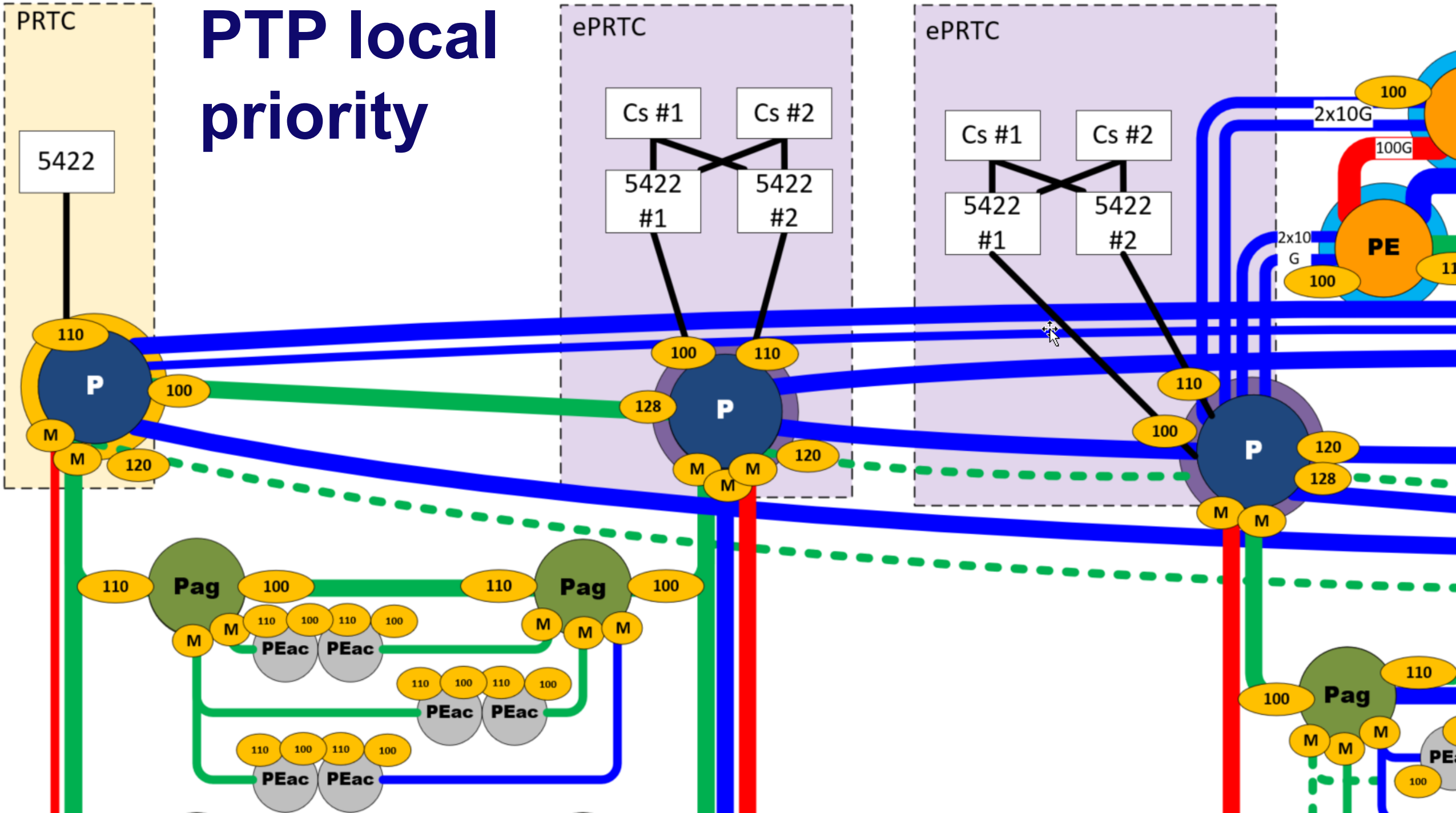
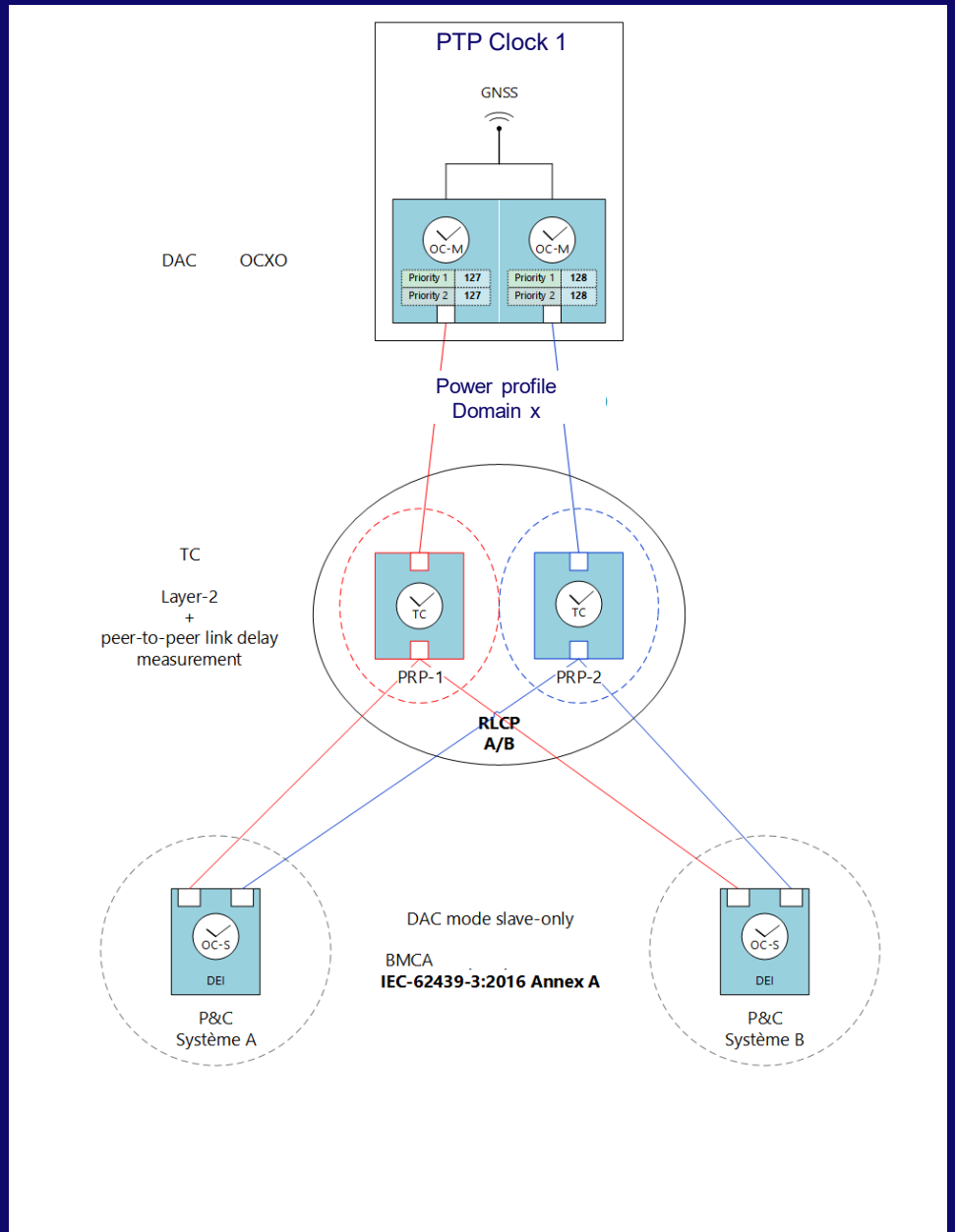
PEac
Ref 2
Ref 1
Pag
Ref 2
1

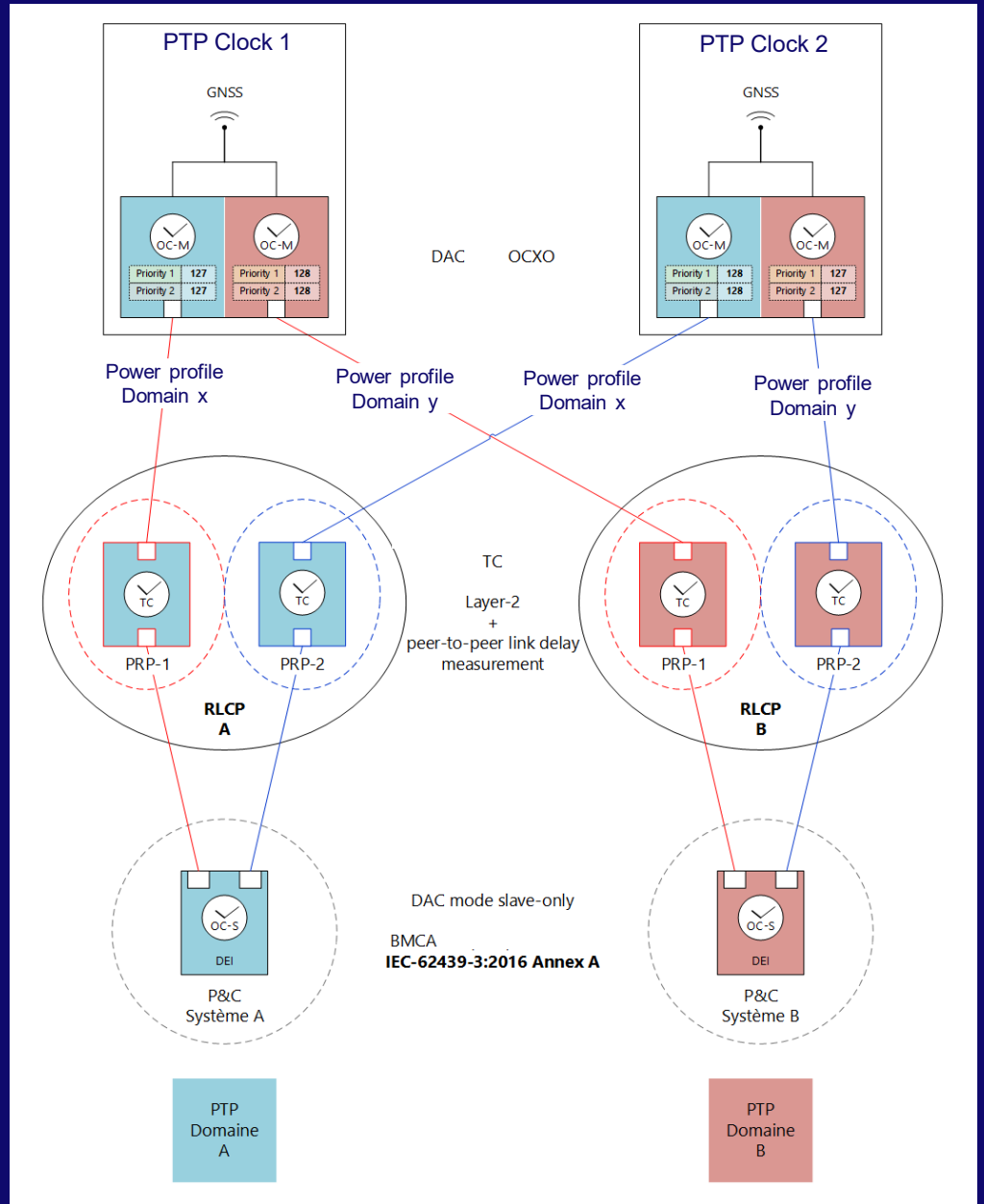
PTP local priority



Small substation config



Large substation config (HA)



3

BENEFITS

Benefits

Accuracy (1µs)

Redundancy - PTP WAN backup

Resilience - GNSS & PTP monitoring

Central management (EMS) & Platform uniformity

- Ease of operations
- Reduced downtime
- High availability
- Optimal sparing strategy
- Reduced training requirements

4

CHALLENGES

Sync through microwave

Upon testing in our lab, we've been able to confirm that our microwave vendor's design with a dedicated channel for PTP and SyncE can compensate asymmetry dynamically on RF links. Good news!!

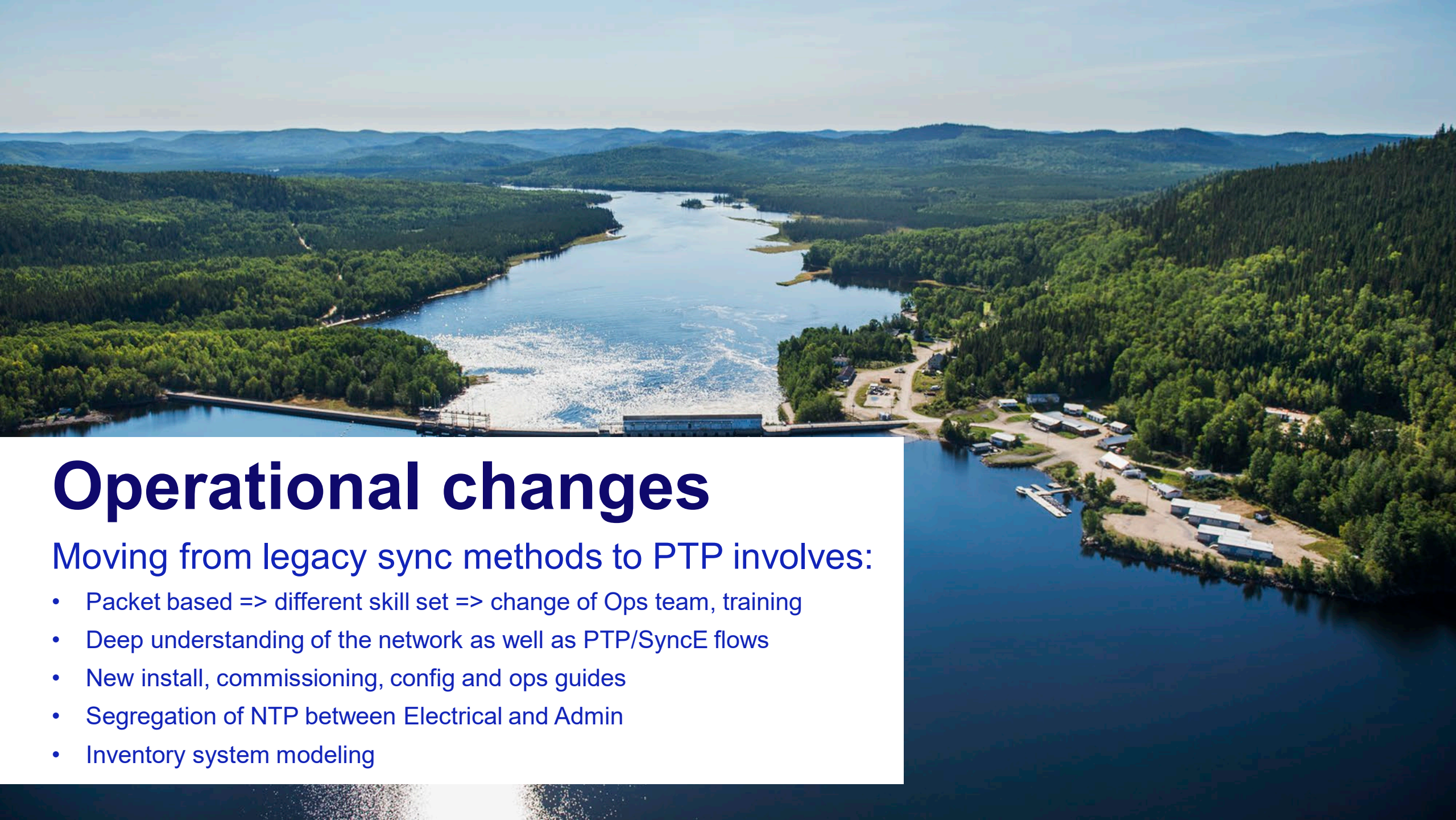
Sync through DWDM

HQ has long optical DWDM Raman amplified links on which a solution of dedicated Sync channel cannot be implemented (OSC is not amplified). Even with support from vendor, asymmetry (2WTE) is still from 3 to 8 µs.

Options to cope with it are manual compensation in routers (measured value) or automatic compensation in slave clock (with comparison to GNSS).

Cybersecurity constraints

HQ has several internal firewalls. PTP G.8275.1 (L2) can’t go through and need to bypass them.



Operational changes

Moving from legacy sync methods to PTP involves:

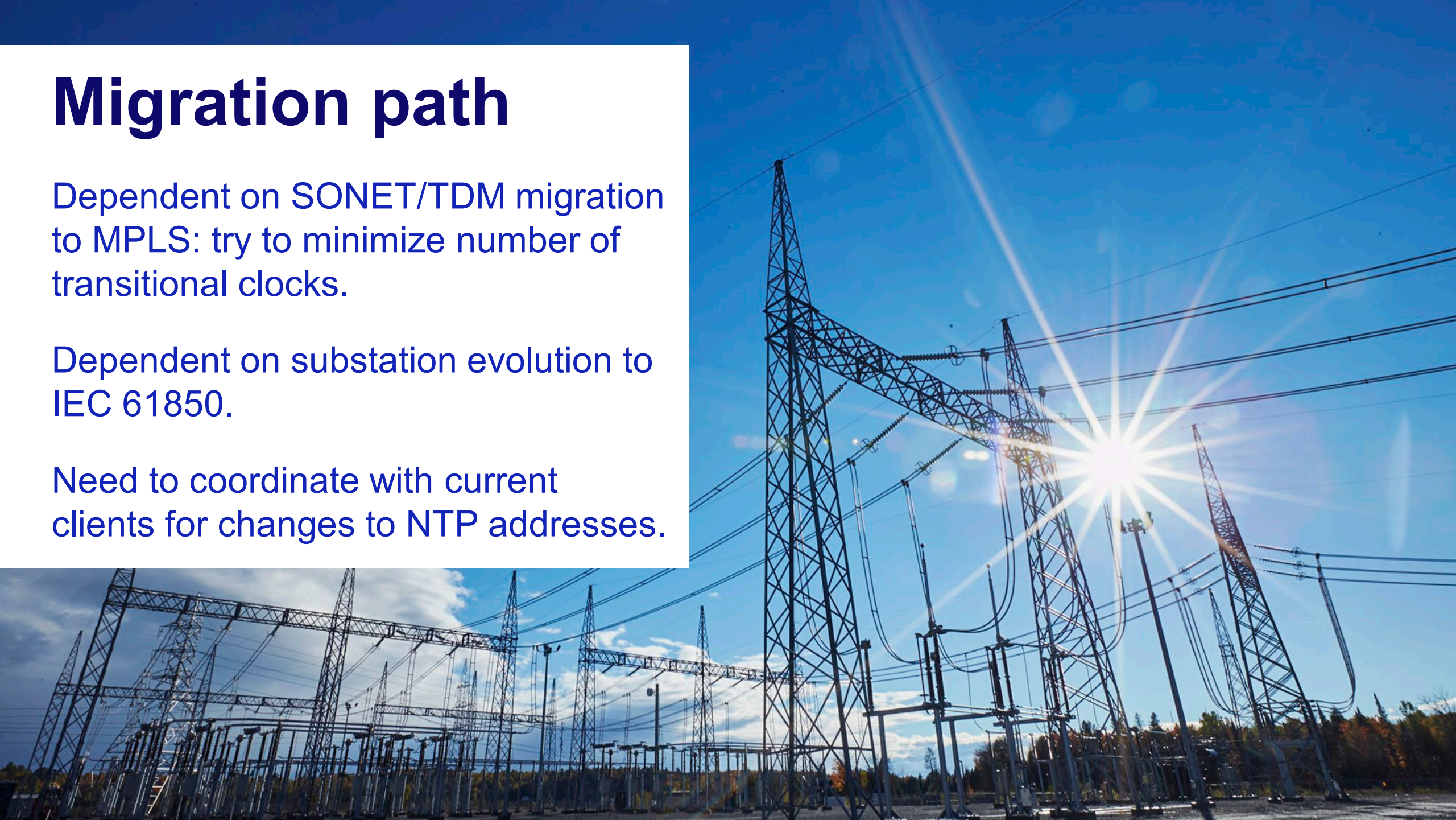
- Packet based => different skill set => change of Ops team, training
- Deep understanding of the network as well as PTP/SyncE flows
- New install, commissioning, config and ops guides
- Segregation of NTP between Electrical and Admin
- Inventory system modeling

Migration path

Dependent on SONET/TDM migration to MPLS: try to minimize number of transitional clocks.

Dependent on substation evolution to IEC 61850.

Need to coordinate with current clients for changes to NTP addresses.



Technology maturity

PTP clocks w/ both Telecom & Power profiles are new, lack some features & require bug fixes.

Optical Cesiums also new & missing adv. mgmt.

Environmental & EMC requirements for power stations require modification to telecom clocks.

5

LESSONS LEARNED

Don’t underestimate the task

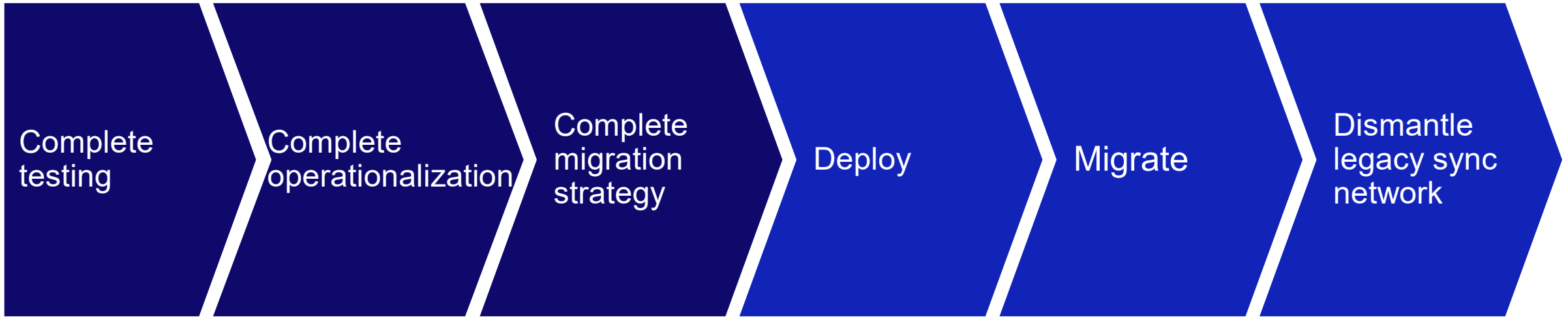
Testing is key

Standards are implemented differently among vendors

6

NEXT STEPS

Next steps


Complete testing
Complete operationalization
Complete migration strategy
Deploy
Migrate
Dismantle legacy sync network

Special thanks to our vendor's staff as well as HQ contributors:

Robert Sigouin, P. Eng.
Sync Expert, HQ

Carl Verret, P. Eng.
Sync Architect, HQ

Mario Marcoux, P. Eng.
Telecom Planner, HQ

Philip Delisle, P. Eng.
Sync Expert, HQ

Richard Boubau, P. Eng.
Sync Architect, HQ

Johan Niat, P. Eng.
Telecom Engineer, HQ

Adam Fadlallah, P. Eng.
Sync Architect, HQ

André Baron, P. Eng.
Telecom Architect, HQ

Thank you!

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