The Synchronization Experts.

Implementing Resilient and Reliable Time Synchronization for the Power Grid

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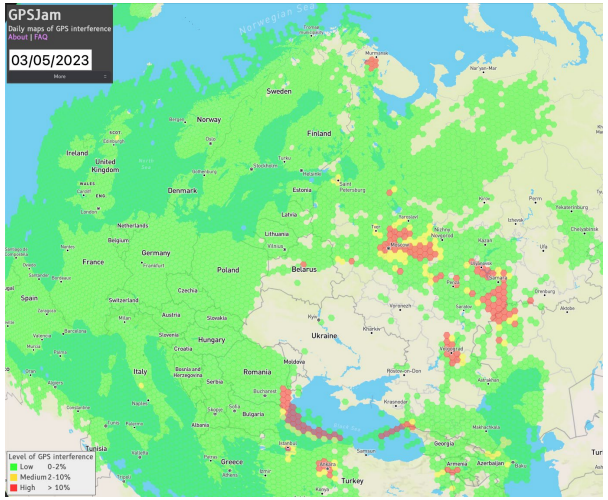
The world is in trouble

- Cold war scenarios come back
- Countries spying on each other
- Cyberwar activities are on the rise
- Positioning, Navigation and Timing are essential for the security of countries
- Cyber security is a huge topic for several industries
- Europe experiences a surge in GPS jamming



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Resiliency, Robustness, and Security for Availability

Critical infrastructure requires 24/7/365 availability

➔Time synchronization is a vital part of the electric grid

How to achieve this with market available technology?

➔Redundancy

➔Backup solutions

➔Mitigation strategies

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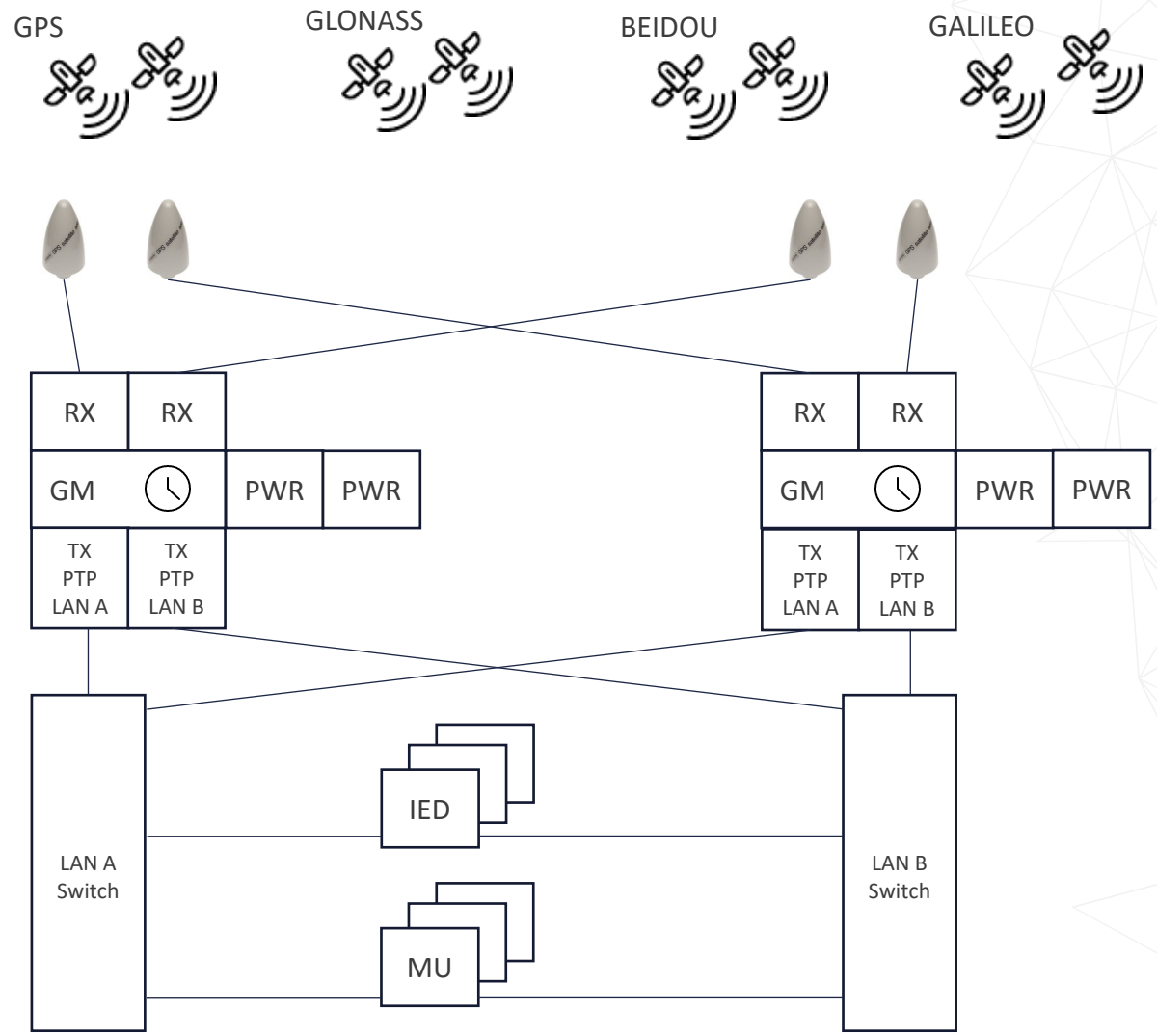
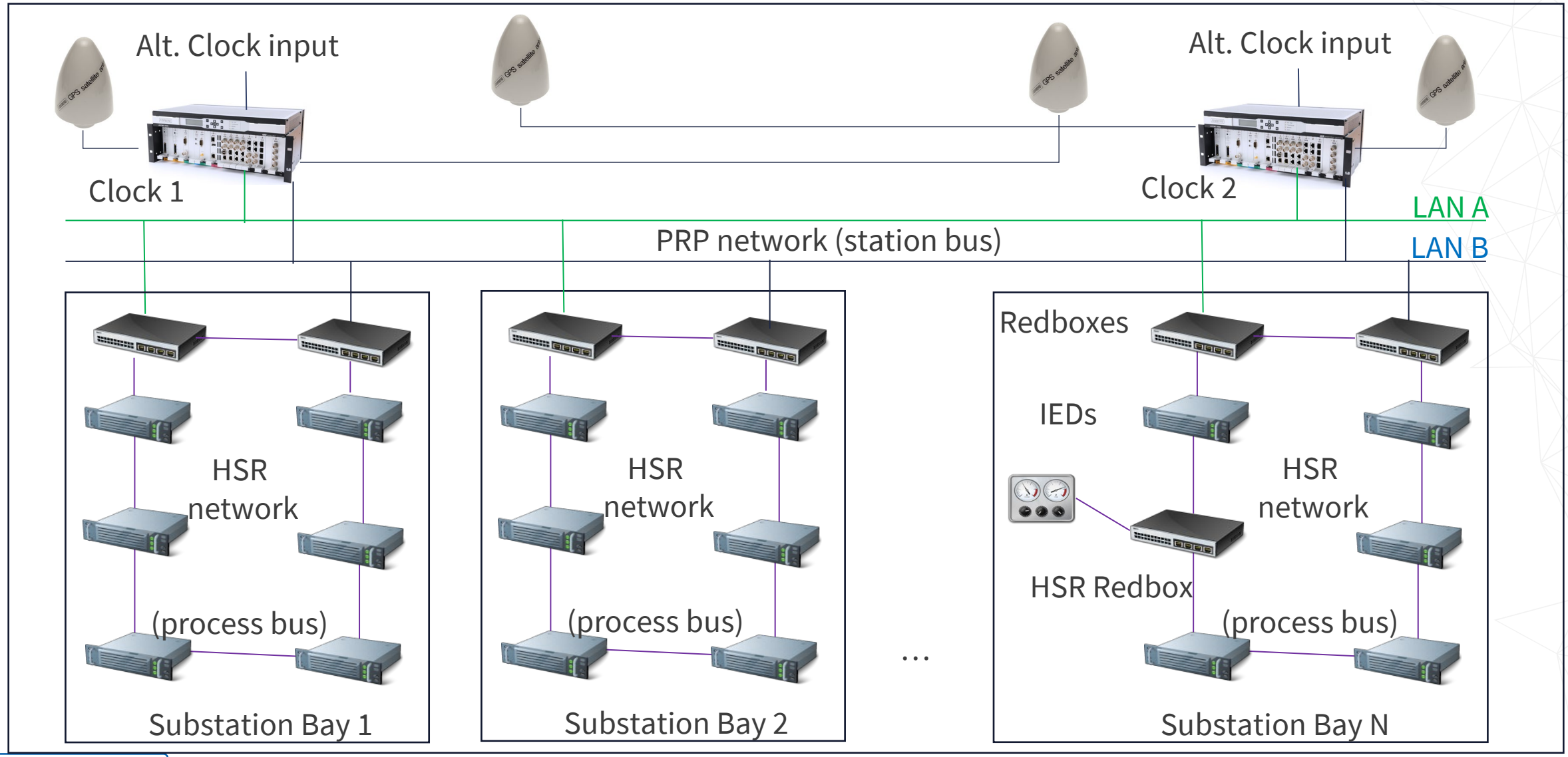
Increasing availability and reliability with redundancy

- GNSS constellation redundancy
- Antenna redundancy
- Receiver redundancy
- Power supply redundancy
- Clock redundancy
- Downstream synchronization redundancy



Substation network redundancy architecture



Preventing and mitigating GNSS jamming and spoofing

Preventing

- Antenna positioning
- Antenna shielding

Mitigating

- Holdover capacity
- Backup synchronization technologies

There is no 100% strategy to prevent jamming or spoofing

➔ The faster you detect the attack, the more time you have to defeat it!

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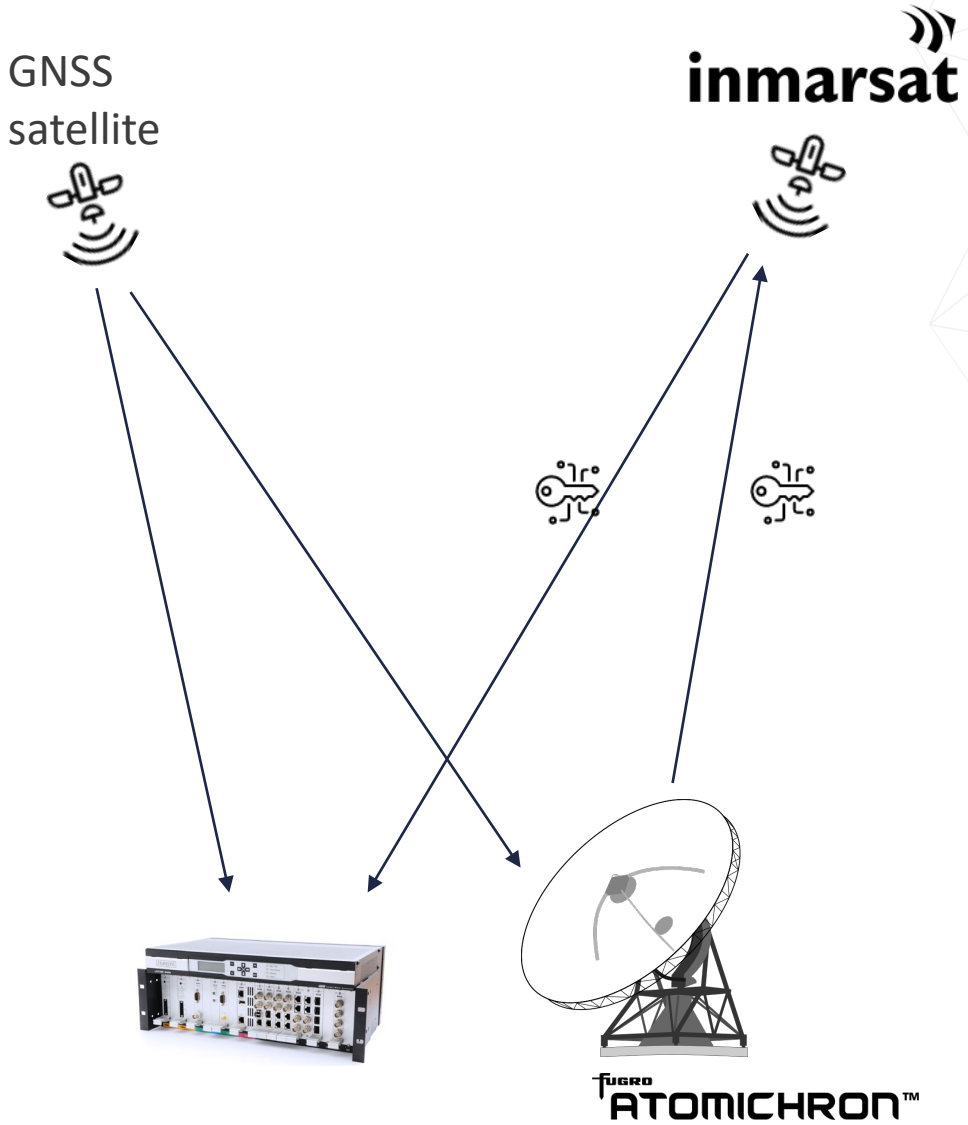
Hash based spoofing detection

- Traditional spoofing detection technology
  - Check Rx power of signals
  - Check signal against other GNSS constellations
  - Check frequency drift vs. local reference

  ➔ Time consuming, sometimes result is just a probability

- Hash based spoofing detection
  - Reference stations measure satellite signals vs. local reference
  - Reference stations hash the signal
  - Hash checksum is communicated via secured Inmarsat communication to the grandmaster clocks

  ➔ Grandmaster clock is enabled to compare to its local received signal via comparing hash checksum



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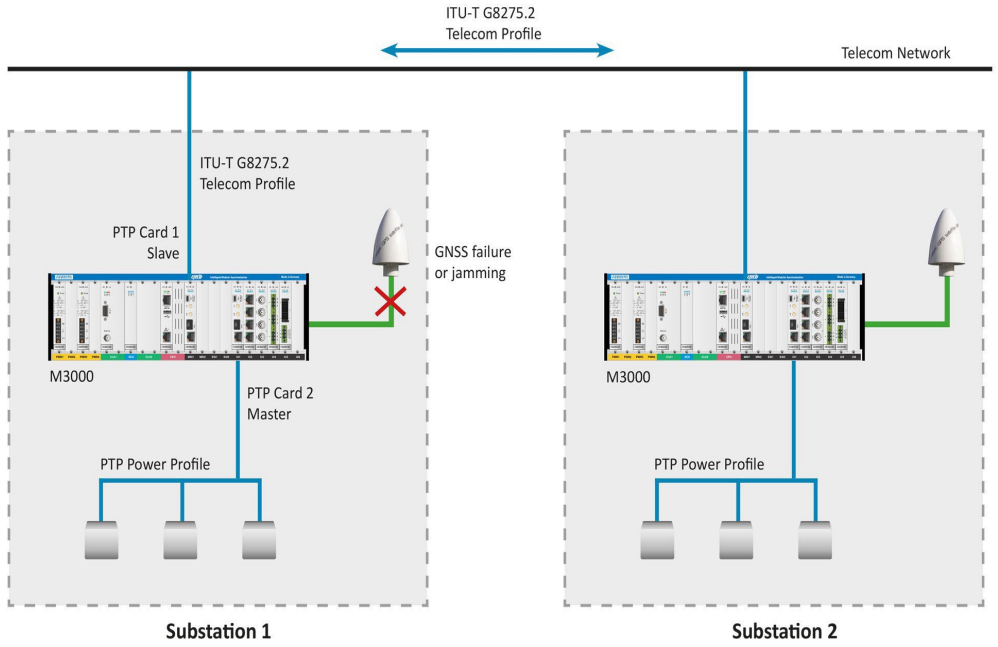
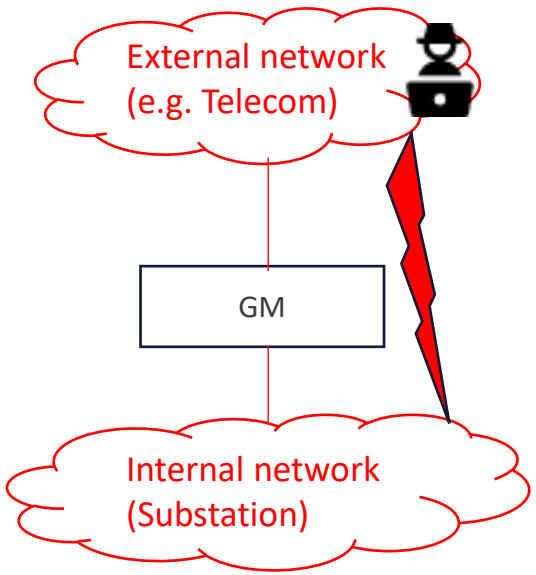
Landline based synchronization

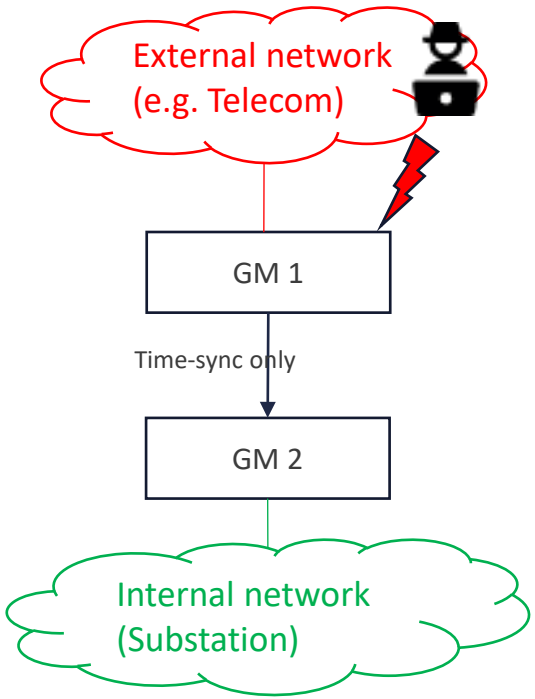
- Fallback solutions
  - Access to telecom timing systems and their ePRTCs
  - Utility owned private Ethernet systems
  - Established landline-based systems
    - NetNOD in Sweden (ePRTCs)
    - Turk Telecom executes a successful network in Turkey
    - NIST
    - Others to follow

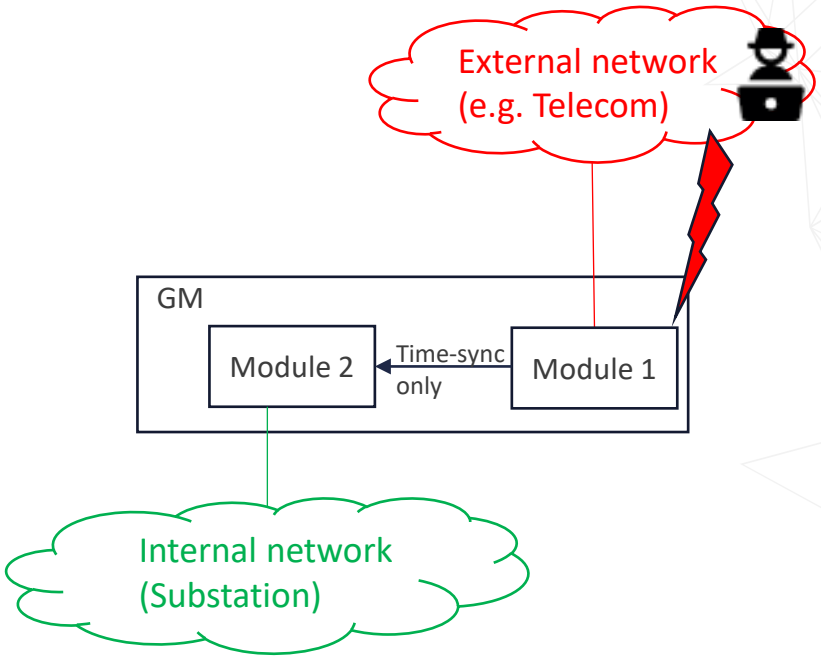


Overcoming cyber vulnerabilities

- Clock interworking function bridges between synchronization technologies
- Clock creates a bridge from the external network into the substation
- Need to implement cyber security measures
- Best in class security is to have the separation physically
  - Two clocks connecting via timing information only
  - Two modules in one clock connected via proprietary protocol







GNSS and network security for power infrastructure

- We need to strengthen critical infrastructure
- Redundancy
- Jamming and spoofing mitigation
- Holdover is your friend
- Fast event detection buys precious holdover time
- Terrestrial backup solutions
- Cyber security

➔ Solutions are available today – these problems are all solved!

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Thank you !

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