RESILIENT GNSS PTP GRANDMASTER – LEARNINGS FROM THE FIELD

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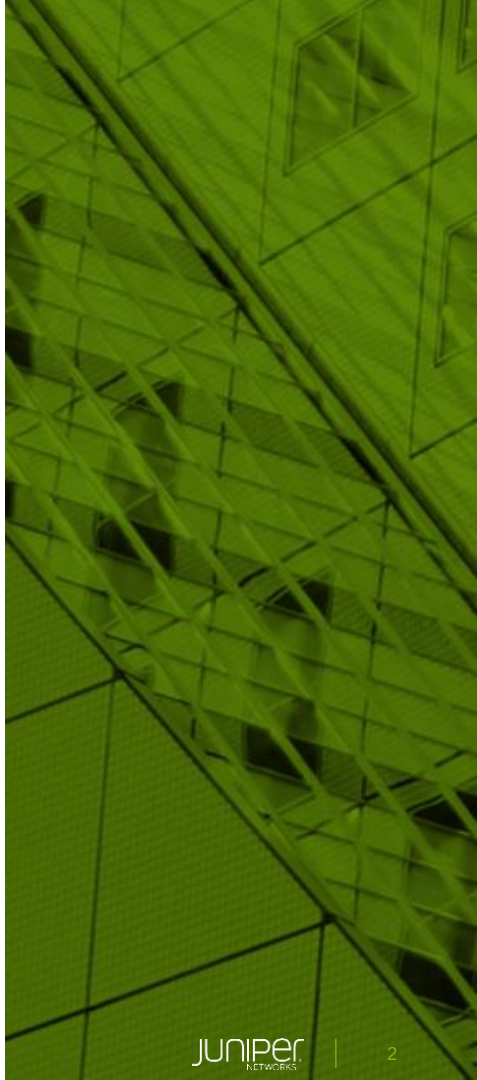
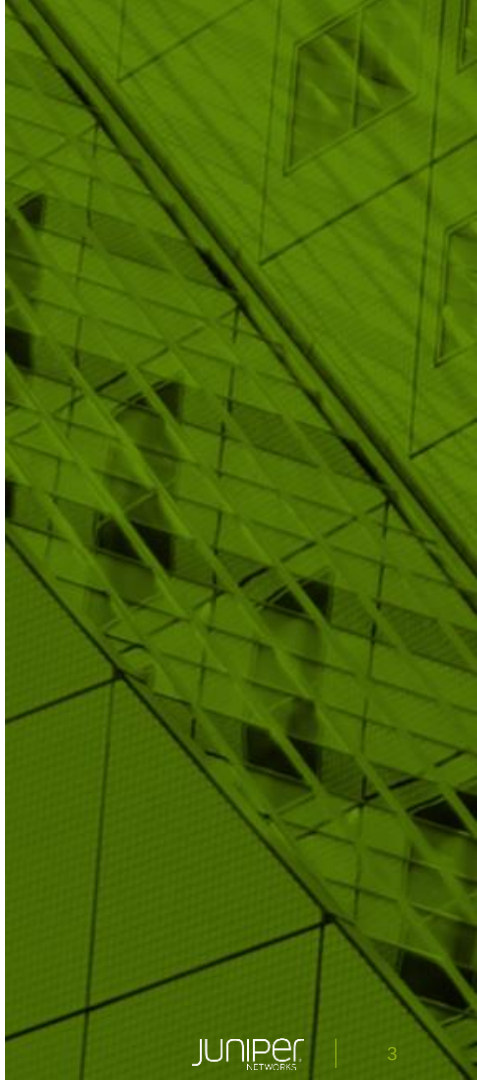
AGENDA

- Introduction
- A standard PTP GM design and how it maps to production
- Choosing the right hardware
  - Thermal handling because of oscillator design
- Choosing the right software
  - GPS events and possible handling, GNSS receiver firmware upgrades
- Choosing the right network design
  - Redundancy and other
- Testing methodologies



THE NETWORK IS UP, AND THEN…



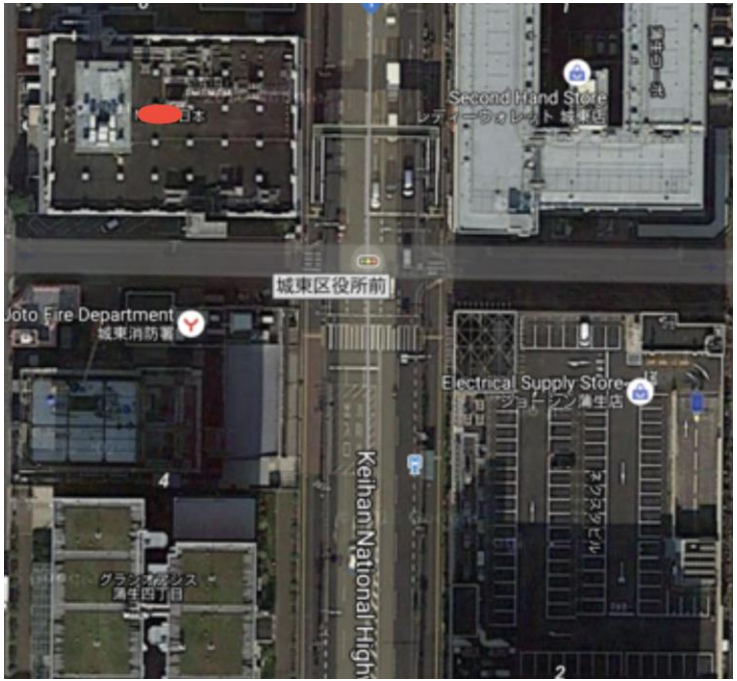
IT WORKS, MOST OF THE TIME…

- GPS Loss of signals
- Downstream devices not stable
- PTP works but SyncE doesn’t (on few ports)
- The GNSS ToD is unstable
- QZSS SVID194 event..

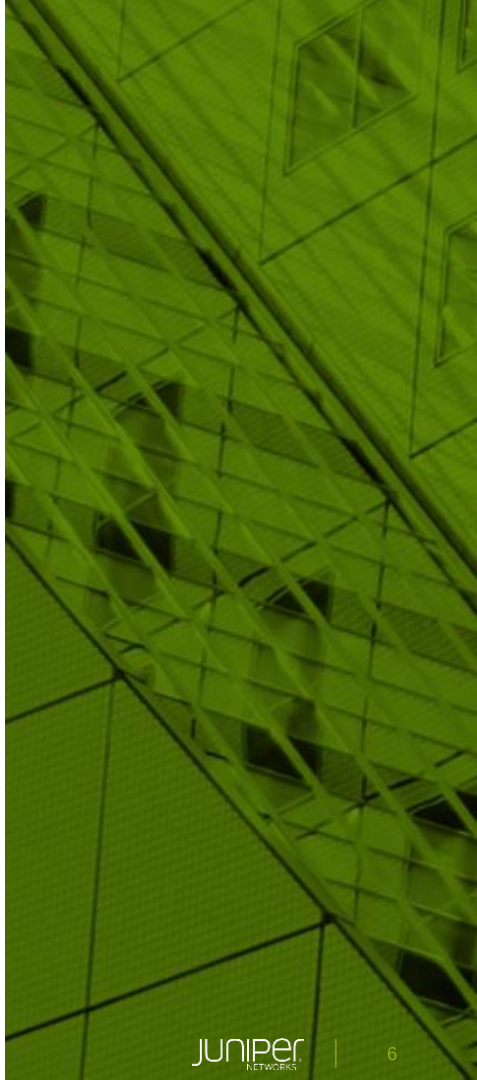
Time of loss	% of incidents
< 16 **seconds**	60
< 30 seconds	80
< 1 minute	95
< 5 minutes	98
< 16 minutes	100

THE HUNT FOR MISSING SIGNALS

- Jammer detector
- CCTV camera logs
- Oscilloscopes



A SIMPLE REFERENCE PRTC/T-GM DESIGN



IDEAL V/S ACTUAL

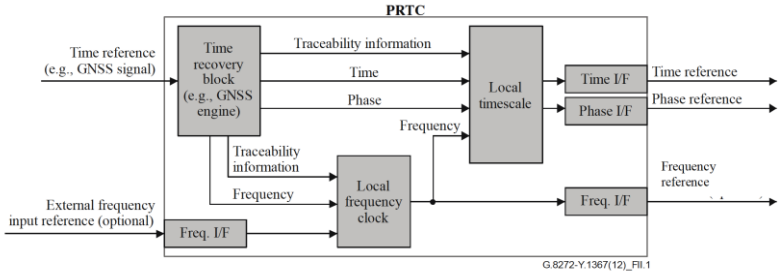
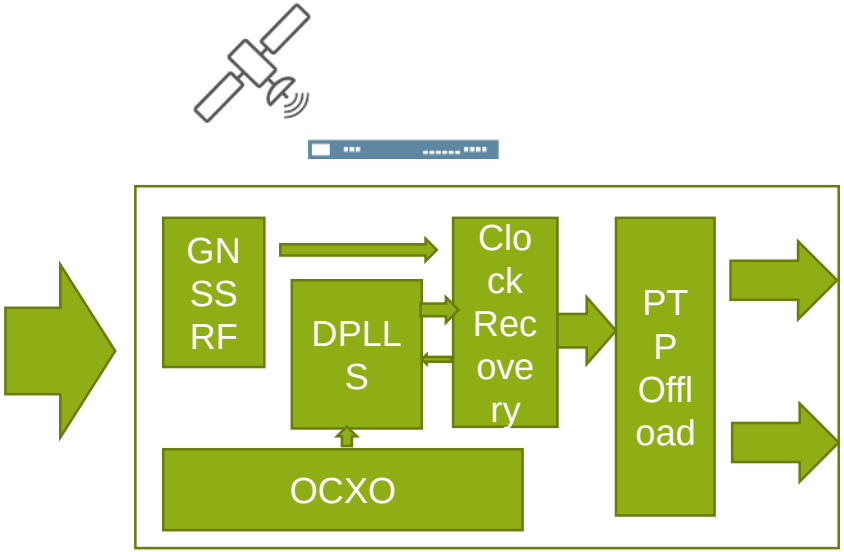
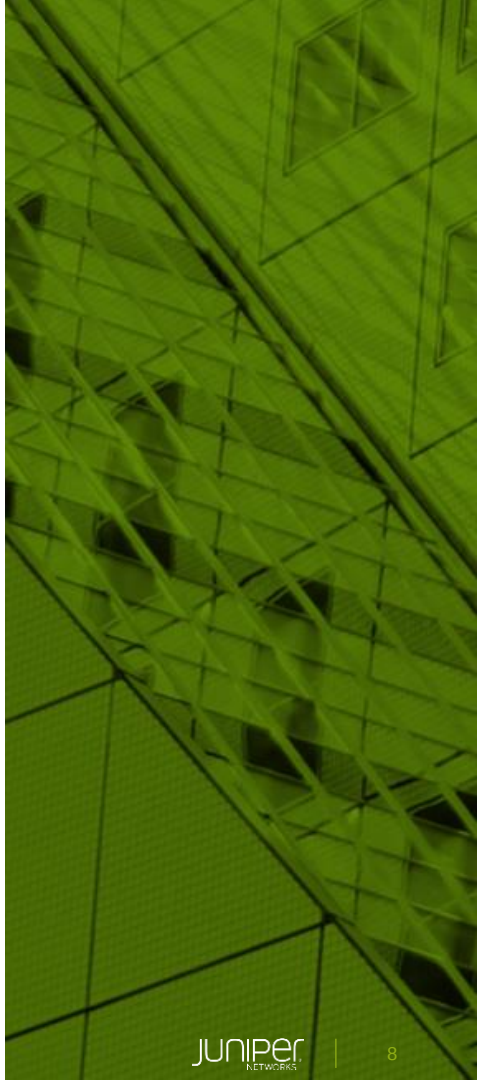


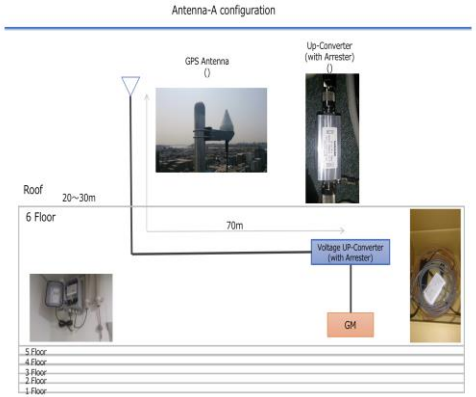
Figure II.1 – PRTC functional model



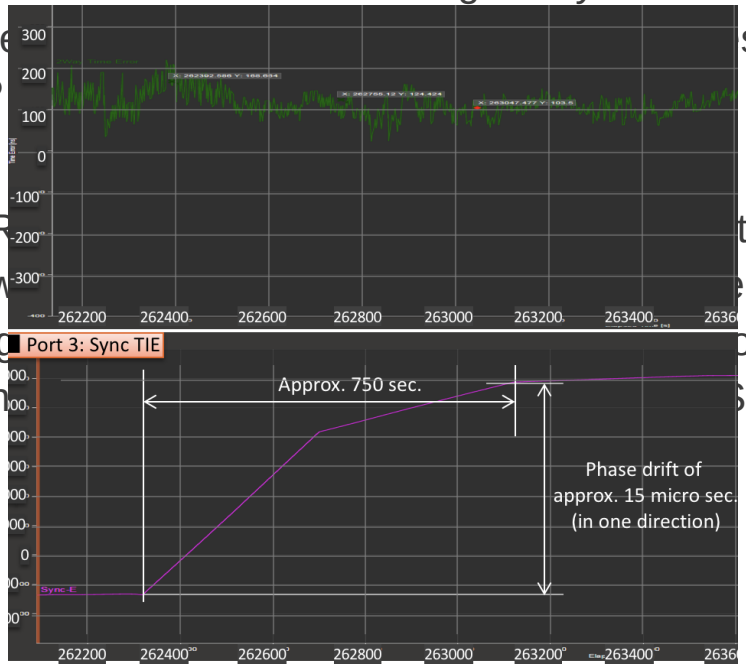
CHOOSING THE HARDWARE



HARDWARE

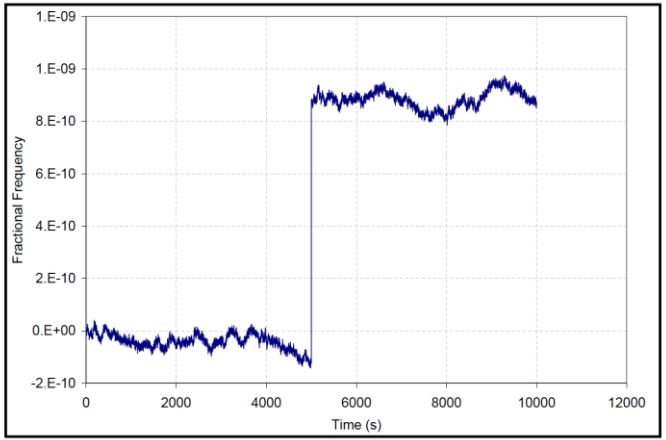


- Oscillator, and oven design
  - Single oscillator for the whole timing subsystem
  - Otherwise see and is
  - Like PTP
- Do antenna/R ts, and convertors
  - Comply w ement with antenna itself
  - GNSS sig o disrupt with electrical noisy components
  - Complian S receiver is a must for stable operation.



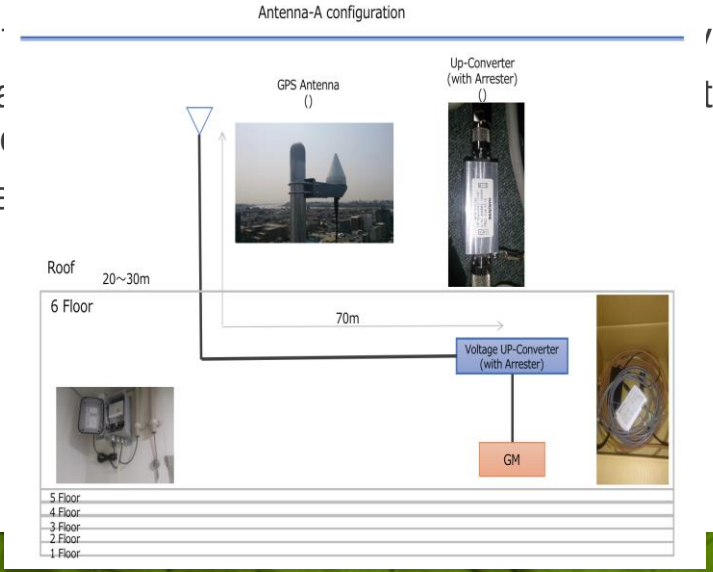
SHORT TERM INSTABILITY

- Typical control loop for alignment works well for normal drifts of the OCXO
- For short term drift/jumps that are beyond the specification, the loop unlocks and need to retune itself.
- Solution : Implement screening of the OCXO for compliance.
  - Stabilization time

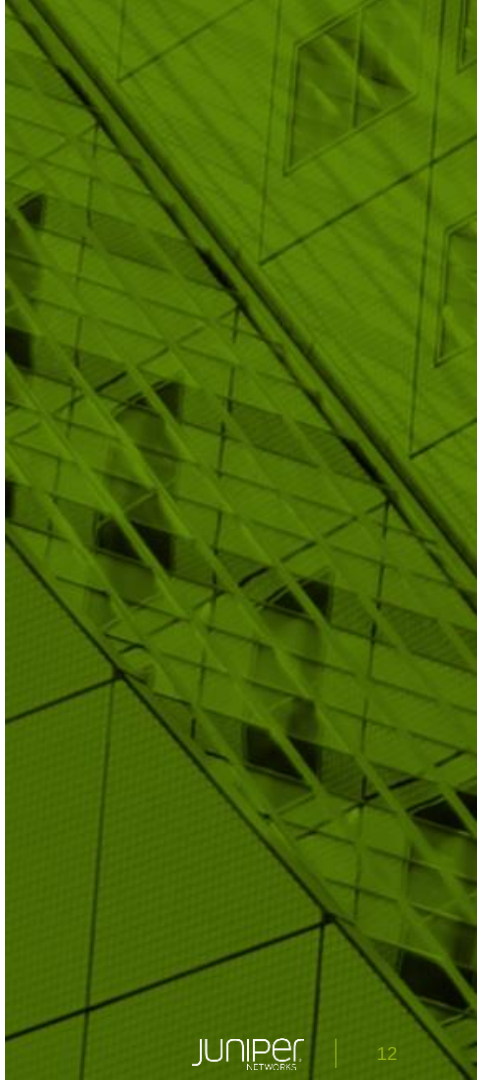


GNSS ANTENNA INSTALLATION

- The typical antenna installation best practices are to have clear sky and less multipath reflection.
- Every receiver has different gain requirements which needs to be followed.
- The non-obvious issues are when over-engineering is done to adapt an antenna system to the GNSS receiver
  - Typical example is o systems.
  - These convertors ma t could cause the GNSS receiver to malfuncti
  - Particularly when the being met.



RESILIENT SOFTWARE



RIGHT SOFTWARE DESIGN

- Unreliable GNSS receiver behavior
- GPS losses short and long
- GPS multipath
- OCXO short term instability
- GNSS event logging and design for debuggability.
- Firmware upgrades

UNRELIABLE GNSS RECEIVER BEHAVIOR

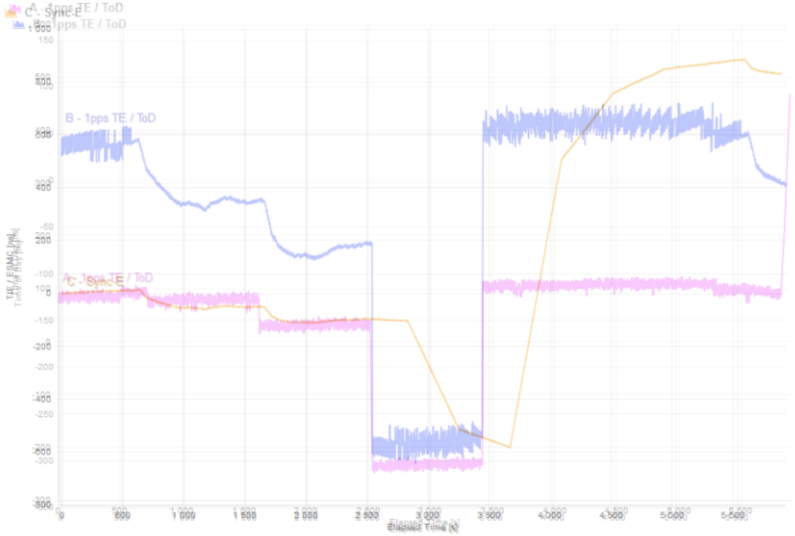
- Stopping 1PPS
- Stopping time update packets
- Skipping time
- Time going backwards
- Wrong week number updates
- Unexplained GPS Loss events due to new satellites transmitting unhandled data
- Reset of receiver for recovery
- Solution: Implement filtering of such events, and rely on OCXO stability for providing short term holdover

GPS LOSSES SHORT AND LONG

- The GPS Loss of signal can be real
  - Jamming
- Or, it can be a bug in GNSS receiver
  - Almanac missing conditions
  - Time update unreliable
- Solution : implement internal holdover for some time.
- Solution : Implement network redundancy

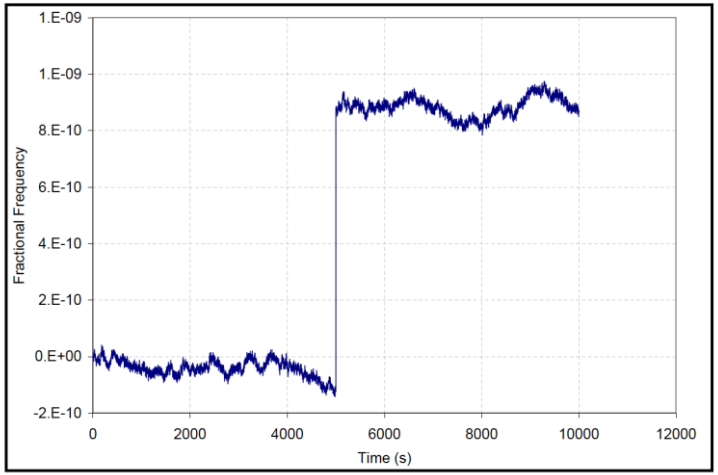
GPS MULTIPATH

- This typically manifests in sudden phase offsets appearing in the 1PPS of the receiver.
- Solution: implement filtering for more than expected phase offset



OCXO SHORT TERM INSTABILITY

- This typically results in the loss of control loop locking
- Tricky to handle in software but can be mitigated to some extent by changing the parameters of the control loop dynamically, on indication of short term instable conditions.



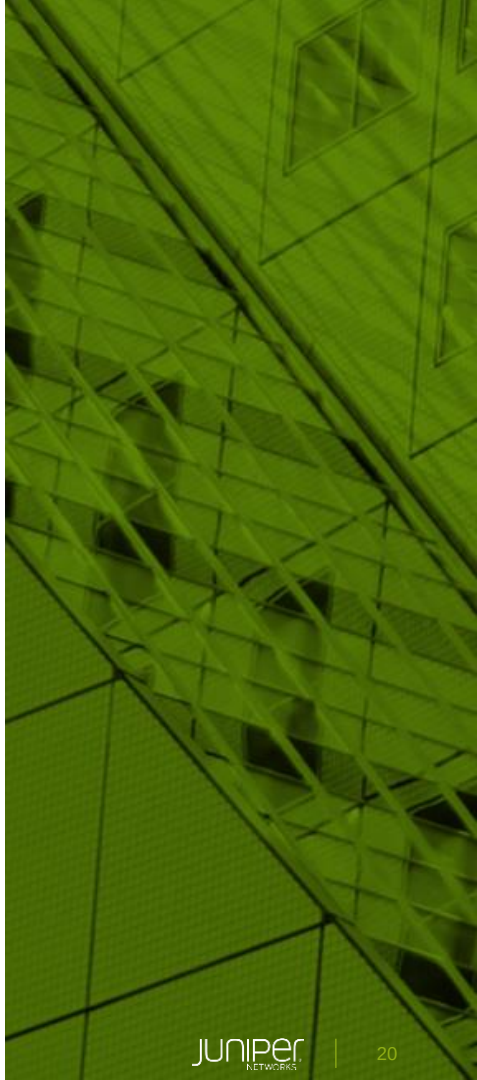
GNSS EVENT LOGGING AND DESIGN FOR DEBUGGABILITY.

- Many GNSS events are localized to regions
  - Japan, QZSS satellites launching and unexpected data given to earth stations.
- Not everything will be simulated in the internal software testing.
- Hence, data capture of events in the field is a must.
- Typical logging requires
  - 1PPS offsets
  - Time of day
  - GNSS receiver status

FIRMWARE UPGRADES

- GNSS receivers are typically third party devices
- They need updates and the firmware upgrade utility should be a day-1 availability

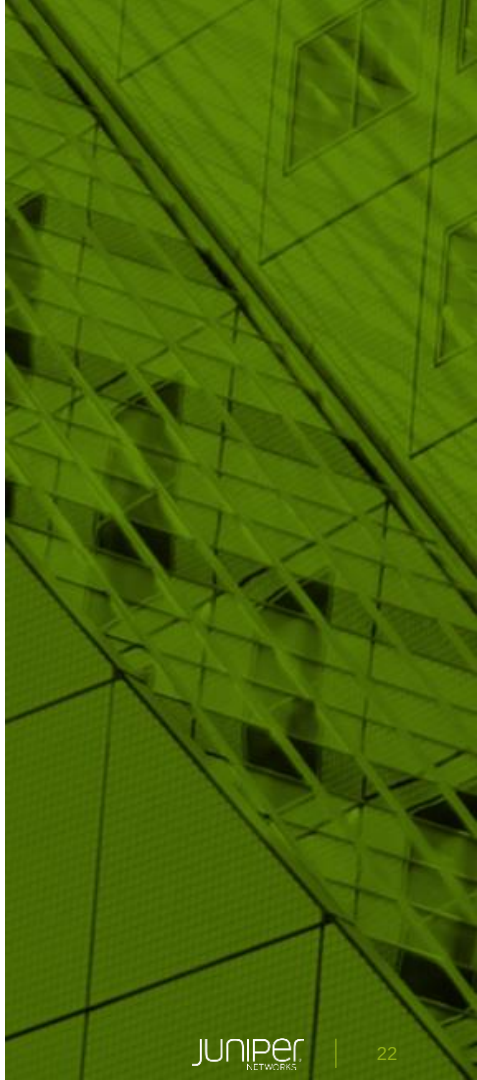
NETWORK REDUNDANCY



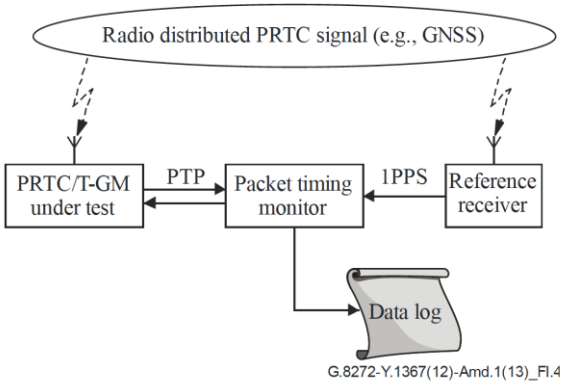
NETWORK DESIGN SUGGESTIONS

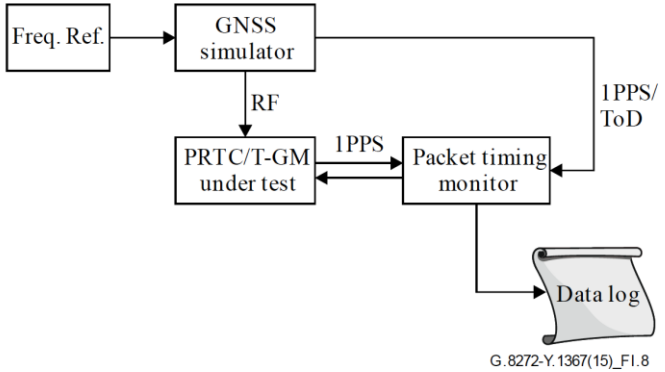
- Multi T-GM
- PTP and SyncE redundancy
- PTP with SyncE backup. Less expensive and easy to maintain.

TESTING METHODOLOGIES AND LEARNINGS

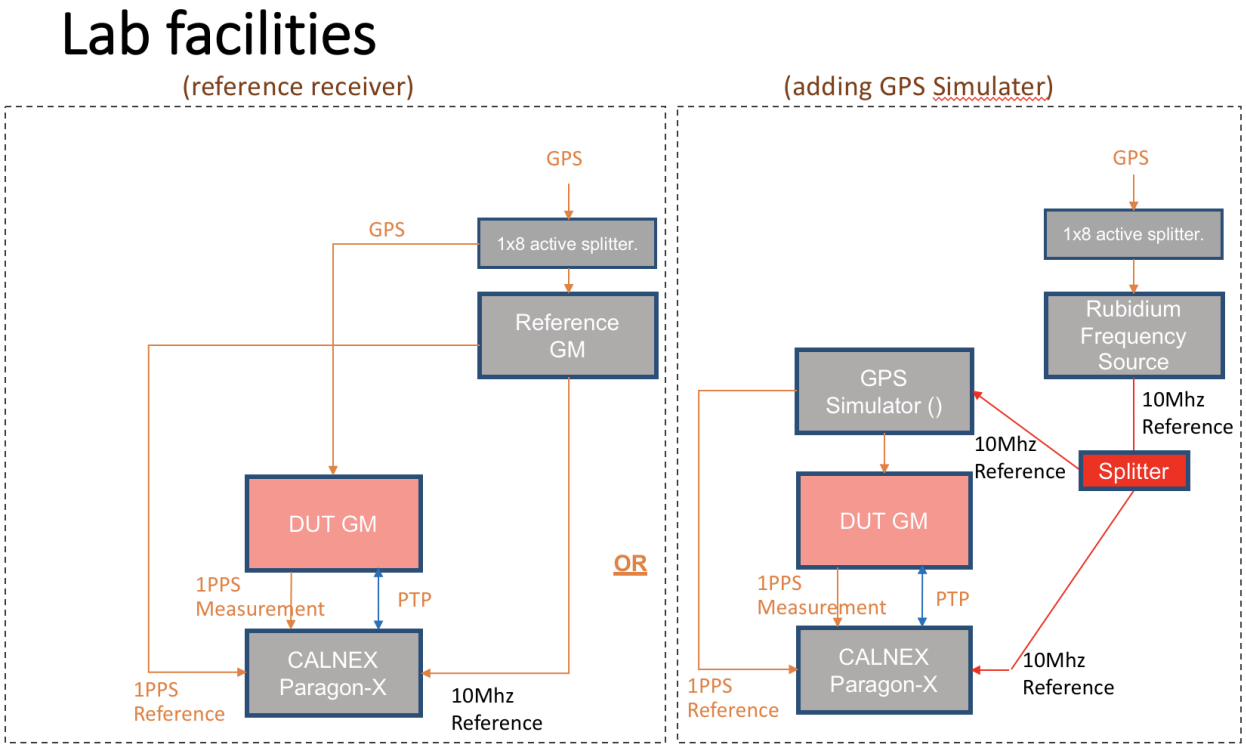


TESTING A PRTC/T-GM – STANDARD METHODS FOR G.8272





TESTING SETUP GOOD => BETTER



APART FROM G.8272…

- Can not assume the testing done by the GNSS receiver vendor would translate to how the receiver behaves in your system
- Test with customer RF implementation (lightning arrestor, voltage convertor, antenna systems)

REAL TESTING OF A PTP-GM

- Test constellations that are launching new satellites
  - QZSS, IRNSS, Baidu
  - New satellites typically confuse/results in corner cases for the GNSS receiver
  - Causing wrong time updates or,
  - Loss of satellites or,
  - In worst cases GNSS receivers reset for recover

REAL TESTING OF A PTP-GM

- Test low elevation, and arrival/departure of satellites off horizon
  - This confuses the anti-jamming, satellite filtering logic of the GNSS receivers
  - Causing wrong time updates or,
  - Loss of satellites or,
  - In worst cases GNSS receivers reset for recover

CONCLUSION

- GPS is reliable, but plan for failure, both at network and within device
- GNSS receivers might behave in undefined manner, plan to work around them.
- Testing for performance in ideal condition is must; but test in non-ideal conditions for failure planning. Use simulators.
- Site planning and monitoring methods are must
- OCXOs are getting better, use the holdover wisely.
- Implement methods for cross-vendor troubleshooting.