Building a National Timing Grid of Ireland – Lessons Learned

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- Motivation for building a National Timing Grid

- NTG requirements, restrictions, architecture

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Introduction

- National Standards Authority of Ireland National Metrology Laboratory (NSAI NML) maintains national measurement standards for a range of physical quantities. These standards represent the best available representations in Ireland of the internationally agreed units of measurement.

- NSAI NML maintains a caesium beam tube atomic frequency/time standard along with various GPS-disciplined and free-running rubidium oscillators ensuring that calibrations performed by the NSAI NML have direct traceability to the SI second.

- Timing Solutions Ltd specializes in Timing Distribution, and Timing Resiliency including Global Navigation Satellite System time transfer.

- National Timing Grid is a project of three main partners: NSAI NML (reference clock), Timing Solutions (HW and SW solutions), and Data Edge (networking technical partner).

NSAI National Metrology Laboratory   **TIMING SOLUTIONS**   **DATA ■EDGE**

NSAI NML reference clock – UTC(NSAI)

- NSAI NML maintains Microchip's 5071A-C001 high accuracy caesium atomic clock.

- By linking atomic clock to BIPM through Mesit's GTR50 receiver, NSAI NML maintains a physical realization of UTC: UTC(NSAI).

- Work underway to make UTC(NSAI) Ireland's legal time representation.

- NSAI NML has initiated the process of acquiring a backup Cs atomic clock in a different location in the country.

- The two clocks will be linked by a (dark) fiber to enable the best possible alignment between the two clocks.

- NSAI NML disseminates time through NTP/PTP for public and industrial use.

What can we do to improve resiliency?

- There is relatively high number of independent caesium atomic clocks in Ireland deployed at different sites and maintained by different companies.

- Each individual atomic clock provides great value to its owner, but having them combined, or interlinked, would be the first step in creating much more resilient timing infrastructure – National Timing Grid of Ireland.

- We have reached out to companies in Ireland that maintain caesium clocks, and the following companies responded to our call: ESB Networks (power network maintainer), Eir (telco), Vodafone (telco), Irish Rail, Microchip (Cork laboratory).

- National Timing Grid currently links six atomic clocks in Ireland and we hope the grow the Timing Grid outside of Ireland for increased resiliency.

- As per **IEEE P1952 Study Group working on Resilient Positioning, Navigation, and Timing (PNT) User Equipment**, over-reliance on any single source of timing (GNSS, or PTP) poses risk to Critical Infrastructure sectors and could have a potential to adversely impact national economy.

NTG operation Requirements and Restrictions

- NTG operation requirements:
  - A timing link between multiple sites referenced to a common timing source – UTC(NSAI).
  - Real-time, or near real-time time error measurements to enable fast reaction times.
  - Easy installation and remote maintenance.
  - Measurement device (NTG node) accepts both 10MHz and 1PPS inputs.
- NTG operation restrictions:
  - No direct wire/fiber connection in between those companies. It is not easy to establish one for multiple reasons, e.g., cost and access restrictions.
  - No data access to outside world through regular wire connections.
  - Many sites are operating a single band antenna only.

NTG Architecture design

- A timing link in between sites is based on GNSS Common in View Time Transfer (yes, we are aware of the downside).

- Data access is provided through mobile broadband.

- All communication is encrypted with elliptic curve cryptography.

- Data visualization through web-based GUI.

- See NTG web site for more info: https://ntg.ie.
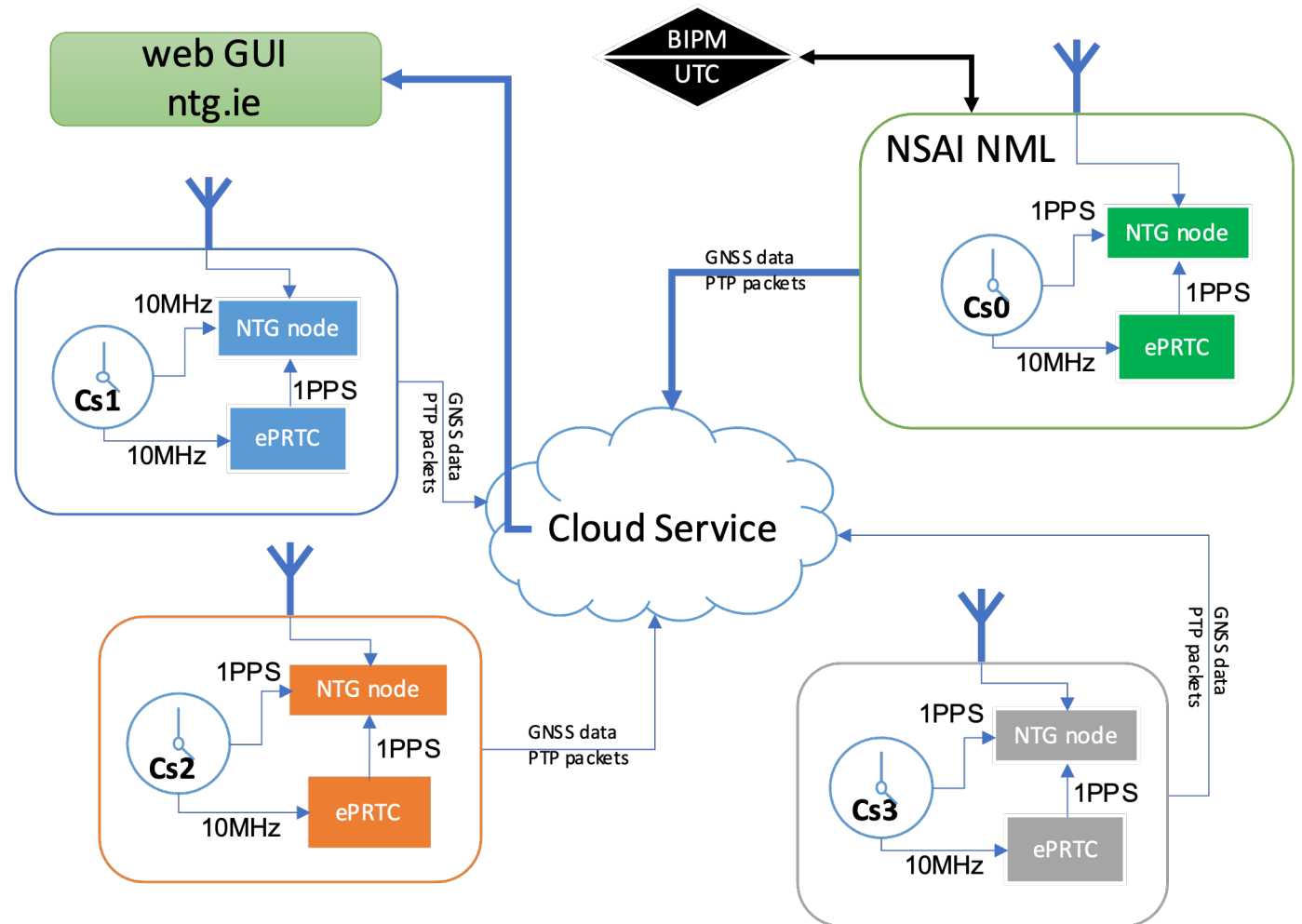
National Timing Grid – NTG node

- Fairly simple device: GNSS block (u-blox's ZED-F9T), phase or frequency inputs (1PPS, or 10/5/2.5/1MHz), Ethernet port or mobile broadband.

- Neg48 voltage input (telco standard), or 5Vdc input.

National Timing Grid – limitations and opportunities

- By connecting multiple Cs clocks, NTG brings a degree of resiliency. It is not a fully resilient system yet, as it has a single point of failure (GNSS). Thanks to Common View Time Transfer, however, all common errors (even whole system errors) are almost completely removed.

- What is missing is a backup (alternative) signal, such as other LEO based satellite signal, or terrestrial link (WR, or eLoran). Alternative/backup signals are currently under investigation.

- What we can do with the NTG system:

    - Track GNSS status for each satellite/constellation/signal observed.

    - Monitor performance of ePRTC devices (trust them but monitor them).

    - Provide real-time alert system for non-nominal status or performance.

    - Traceability for contributing companies (with clock performance data continuously recorded and stored).

    - Advise on steering recommendations to align the frequency to UTC reference of choice.

    - Improve performance of single band GNSS receivers and receivers under jamming/spoofing attack.

# National Timing Grid – lessons learned

- Access to outside world (internet connection) is difficult. Most companies have a long approval process for newly installed equipment. We avoided that through mobile broadband connection.

- GNSS infrastructure is nowhere near NML standards: single band, low multipath rejection antennae (think cost, rather than performance). The antenna can have poor sky visibility (reflections, obstructions).

- Having a partner with good contacts makes a difference: establishing relationship is easier through a common trusted company/person.

- Government mandates were not necessary, Critical Infrastructure sector understands the value of timing distribution chain. What helped, obviously, that there was no direct cost involved, as the NTG nodes are provided for free for contributors.

National Timing Grid – data visualization
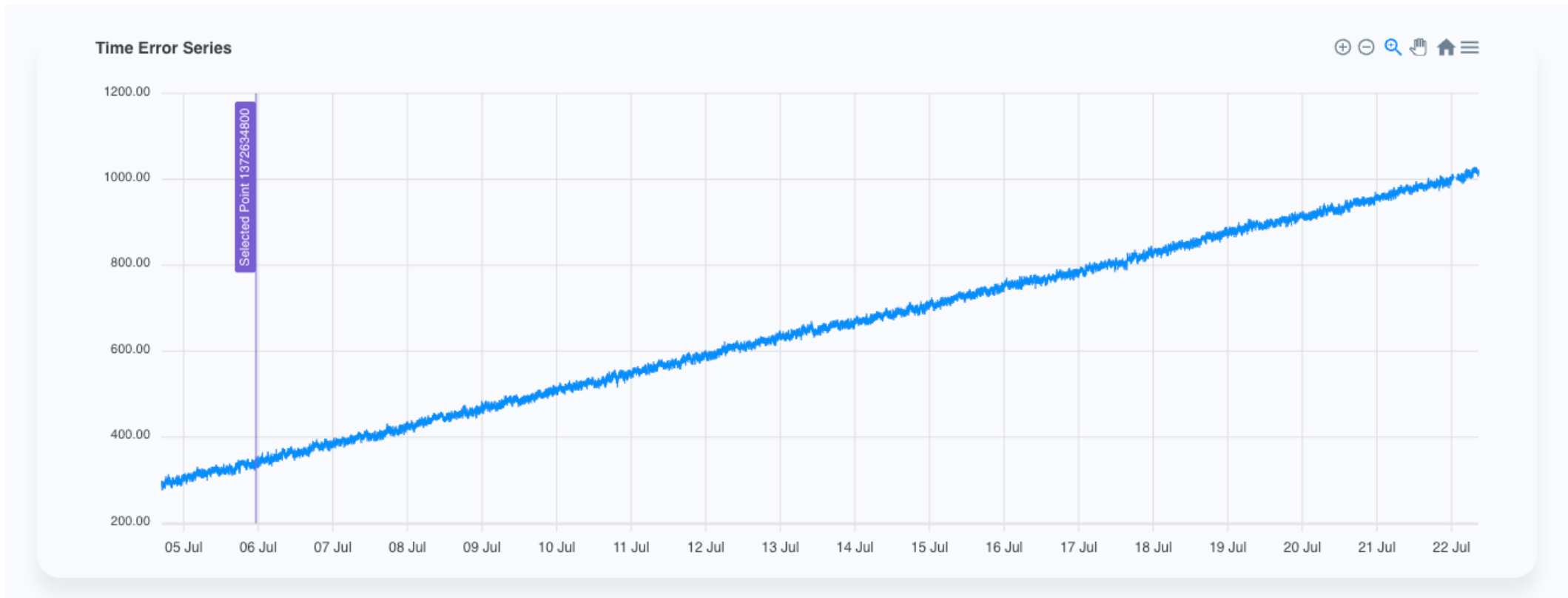
- Time error series of free running clock (frequency offset of ~40ns per day). Technically unlimited window in the past (limited only by a database size restrictions). By selecting a specific point, a new graph rolls out.

- See https://ntg.ie/next-gen-gui/.

National Timing Grid – data visualization
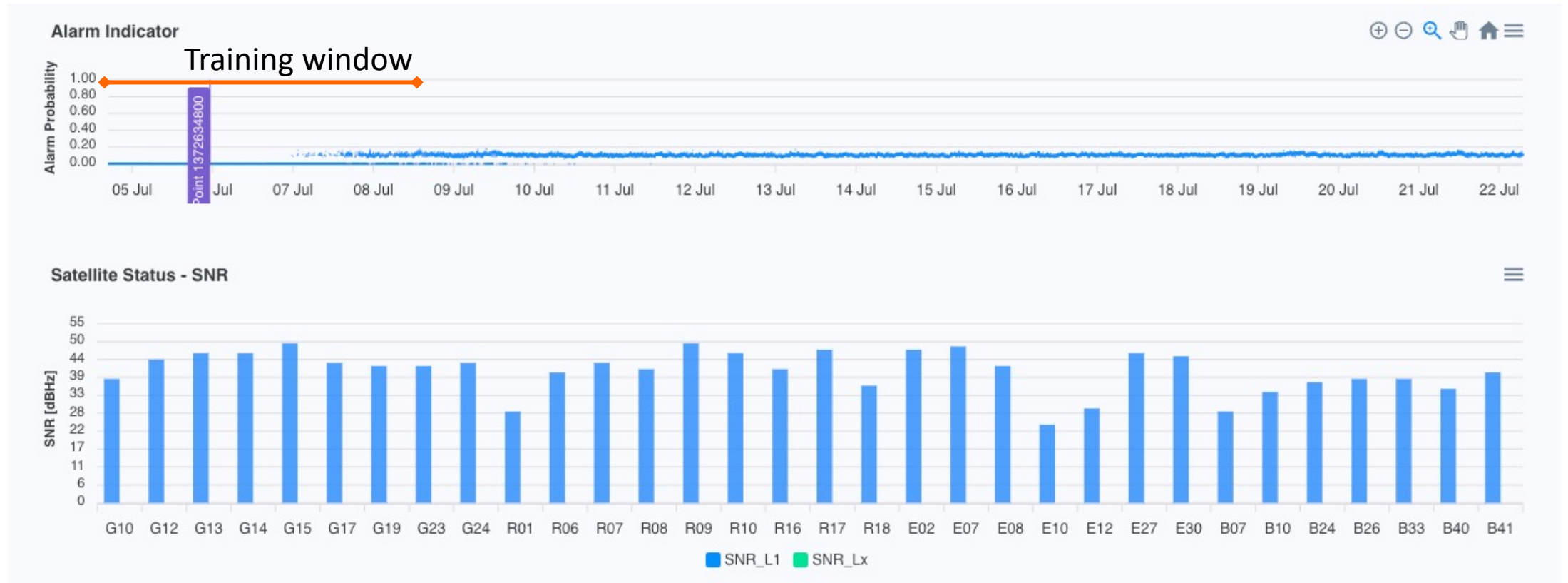
- Alarm indicator, and satellite CN0 visibility for each point on the Time Error series.

National Timing Grid – data visualization
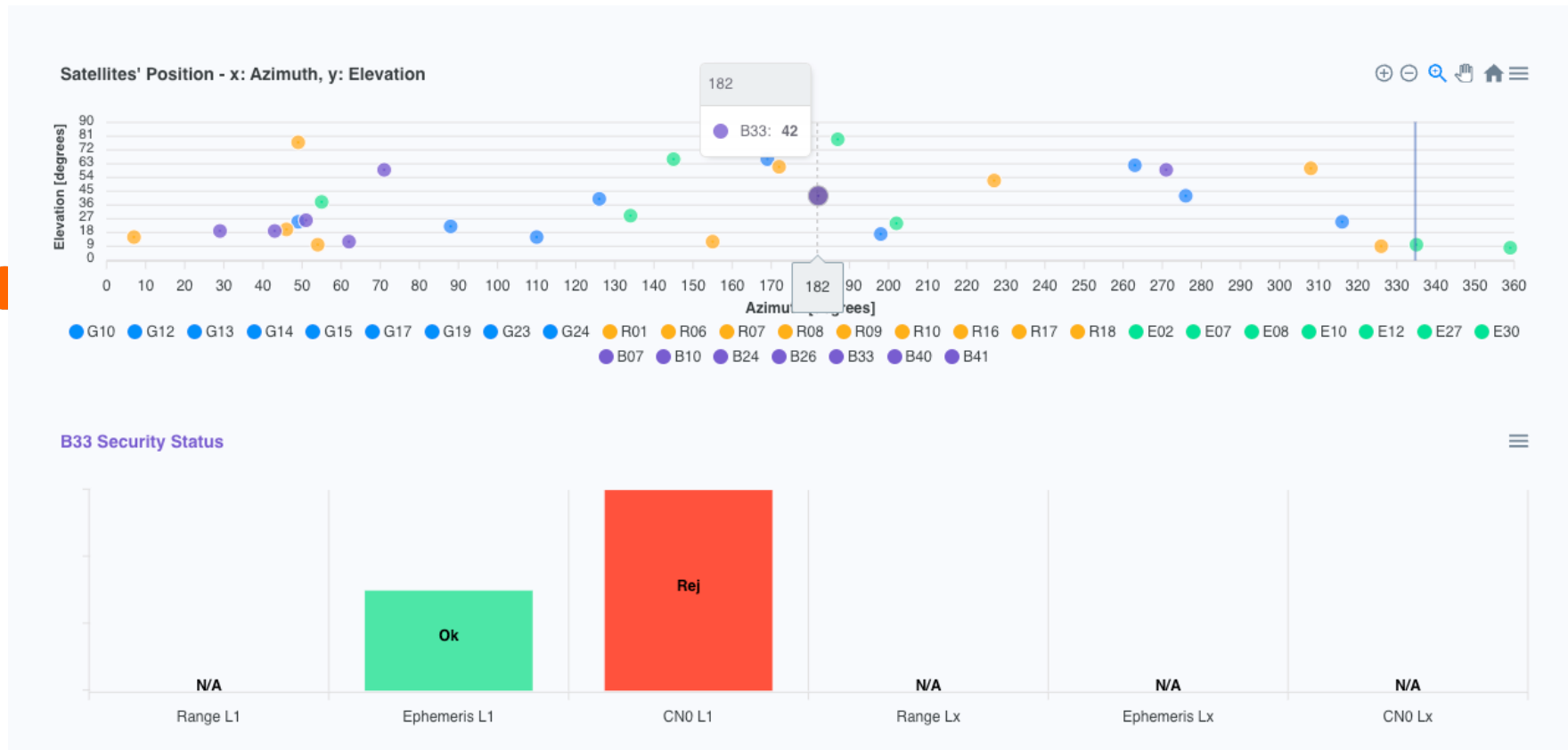
- Security status detail.

National Timing Grid - summary

- The next phase will focus on the following:
    - Finding an alternative (wire/fiber) connection between contributing sites.
    - Expanding Timing Grid beyond Ireland to bring basic timing resiliency for everybody.
- The following services are available for immediate benefits of the participants:
    - Near real time tracking of stability against other atomic clocks providing early warnings in case of performance degradation.
    - Direct traceability to UTC through physical realization of UTC.
- **We are looking for participants with good clocks anywhere around the world.** Participation is for free, you only need an atomic clock, GNSS signal and internet connection!

Thank you for your attention!