NAVISP INDUSTRY DAYS

TOWR: A TIME SERVICE OVER WHITE RABBIT FOR THE FINANCIAL SECTOR IN MADRID

ESTEC, THE NETHERLANDS
JANUARY 18, 2019
PROBLEMS IN GNSS TIMING

- Lack of roof space or lack of permission for GNSS antenna installation
- Cluttered rooftops, possibly with rogue antennas (interference)
- GNSS signal blocking and reflections by obstacles or adjacent buildings
- GNSS jamming and spoofing
- No GNSS calibration, poor traceability to UTC (required by MiFID II regulation)
- Possible anomalies in GNSS timing (e.g., GPS glitch on Jan 26, 2016)
THE TOWR APPROACH

- Generate the time from very stable and autonomous atomic clocks, not directly from GNSS
- Use GNSS “only” for fine adjusting the clocks by means of time-transfer to UTC labs (weekly corrections typically)
- Use Galileo in addition to GPS
- Place the GNSS antenna in a controlled, clean environment away from the city
- Apply GNSS calibration and metrological practices, for traceability to UTC
- Distribute the time by the network (White Rabbit) to the end user downtown
44 km optical fibre path between GMV and the Stock Exchange building
Critical hardware at the server is duplicated

NOTE: Black lines denote data interfaces via Ethernet, Serial, or USB port, depending on the type of equipment.
GPS AND GALILEO TIME-TRANSFER

- GNSS Common-View (CV) between the TOWR and UTC(k) labs
- Similar results (within 1 ns) for GPS and Galileo when averaging several UTC(k) labs
- Left: GPS CV; right: Galileo CV
PASSIVE HYDROGEN MASER (PHM)

Allan deviation, $\sigma_y (\tau)$

- TCXO
- OCXO
- Commercial Rb
- Cs Beam Std
- Hydrogen maser

Time interval, $\tau$ (s)

- $10^{-6}$
- $10^{-8}$
- $10^{-10}$
- $10^{-12}$
- $10^{-14}$
- $10^{-16}$

FREQUENCY STABILITY

Overlapping Allan Deviation, $\sigma_y (\tau)$, $10^{-12}$

Averaging Time, $\tau$, Seconds

- $10^0$
- $10^1$
- $10^2$
- $10^3$
- $10^4$
- $10^5$

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PHM AUTONOMY ("HOLDOVER")

- Assumes zero time offset at T=0, and daily PHM steering for the deterministic part (frequency offset and drift)
- Simulates total loss of GNSS after T=0
- Accumulated time error: **3 ns every 10 days** (at 95% confidence level)
USER EQUIPMENT: THE WR SWITCH

- White Rabbit switch: no GNSS antenna required!
- Time distribution error at the level of 1 ns over tens of km
### TOWR Key Performance Indicators (KPIs)

<table>
<thead>
<tr>
<th>Criticality ID</th>
<th>KPI ID</th>
<th>Requirement</th>
<th>Description of criticality</th>
<th>Evaluation method</th>
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<tr>
<td>1</td>
<td>KPI #1</td>
<td>Maximum continuous downtime per month &lt; 1 hour</td>
<td>Impact for the end customer of having a downtime of the timing service lasting a continuous duration of more than one hour over one month</td>
<td>Log System</td>
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<tr>
<td>2</td>
<td>KPI #2</td>
<td>Average monthly service availability &gt; 99.9%</td>
<td>Impact for the end customer of having an average availability of the timing service of less than 99.9% over one month</td>
<td>Log System</td>
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<tr>
<td>3</td>
<td>KPI #3</td>
<td>Maximum time error (versus UTC) at the customer endpoint &lt; 10 ns</td>
<td>Impact for the end customer of having a timing error larger than 10 ns over one month</td>
<td>Comparison between source and endpoint 1PPS signals</td>
</tr>
</tbody>
</table>

It has been decided to maintain the proposed Maximum Time Error (versus UTC) KPI #3 to 10 ns as described in the original TOWR proposal and also in its specifications and requirements, however, it is worth to mention that BME will only need 100 ns.

4.2.1. KPI 1: MAXIMUM CONTINUOUS DOWNTIME

It is expected for the TOWR that the maximum continuous downtime per month must be less than one hour per month. By this, we plan to reduce considerably the impact for the end customer caused by a downtime of the timing service, lasting a continuous duration of more than one hour over one month.

4.2.1.1. EVALUATION METHOD

The measurement method that applies to the uptime of the service will be carried out by retrieving, generating and using log systems from the devices that form the network service. The results will be analysed by using different analytics tools.

4.2.2. KPI 2: AVERAGE MONTHLY SERVICE AVAILABILITY

It is expected that the TOWR service presents an averaged monthly availability higher than a 99.9%, ensuring the less disruption possible for the most demanding applications developed at BME.

4.2.2.1. EVALUATION METHOD

The measurement method that applies to the downtime of the service will be carried out by retrieving, generating and using log systems from the devices that form the network service. The results will be analyzed by using different analytics tools.

4.2.3. KPI 3: MAXIMUM TIME ERROR AT CUSTOMER ENDPOINT

It is expected that the TOWR timing service disseminates the time reference from the TOWR to the WR-ZEN TP client device with a maximum time error below 10 ns (UTC time). By this, we expect to provide a high-accuracy time reference to the final user.

For the TOWR requirements from BME, we will consider the limit at 100 ns (UTC time).

4.2.3.1. EVALUATION METHOD

In order to validate the maximum time error between the TOWR timing reference and the one received at BME’s WR-ZEN TP device, we plan to compare the 1PPS output signals in both sides of the network. To this end, two approaches have been defined:

- The usage of a calibrated GNSS receiver such as Septentrio’s PolaRX5TR or Seven Solutions’ DOWR.
- The usage of a calibrated Passive Hydrogen Laser, such as the T4Science PHM 1008.
WORK IN PROGRESS
Phase A
System Specification & Design
(3 months)

Phase B
System Integration and Verification
(3 months)

Phase C
Early Operations
(3 months)

Phase D
Routine Operations
(9 months)
The objective of TOWR ("tower") is the development of a robust and accurate time distribution service via optical fibre (White-Rabbit) over the Madrid region, and traceable to UTC(ROA), the Spanish legal time.

Key technologies:
- Time generation from very stable clocks (Passive Hydrogen Masers)
- GNSS time-transfer to UTC(k) laboratories (using GPS and Galileo)
- IEEE-1588 PTP / White Rabbit (WR)

Exploits the concept of Time as a Service (TaaS)

Mainly (but not only) oriented to banking and finance applications, in particular to fulfil the “business clocks” synchronization requirements derived from the new European MiFID II regulation.

Pilot project for a first customer: the Madrid Stock Exchange (Bolsa de Madrid)

Builds on the combination of GMV’s experience developing and operating the Galileo Time Validation Facility (TVF), and Seven Solutions’ experience in precise time distribution via optical fibre (WR-PTP).