Timing Synchronization Performance Monitoring

Janis DeWitt | Senior Engineering Manager | janis.dewitt@nav-timing.safrangroup.com | Safran Navigation & Timing

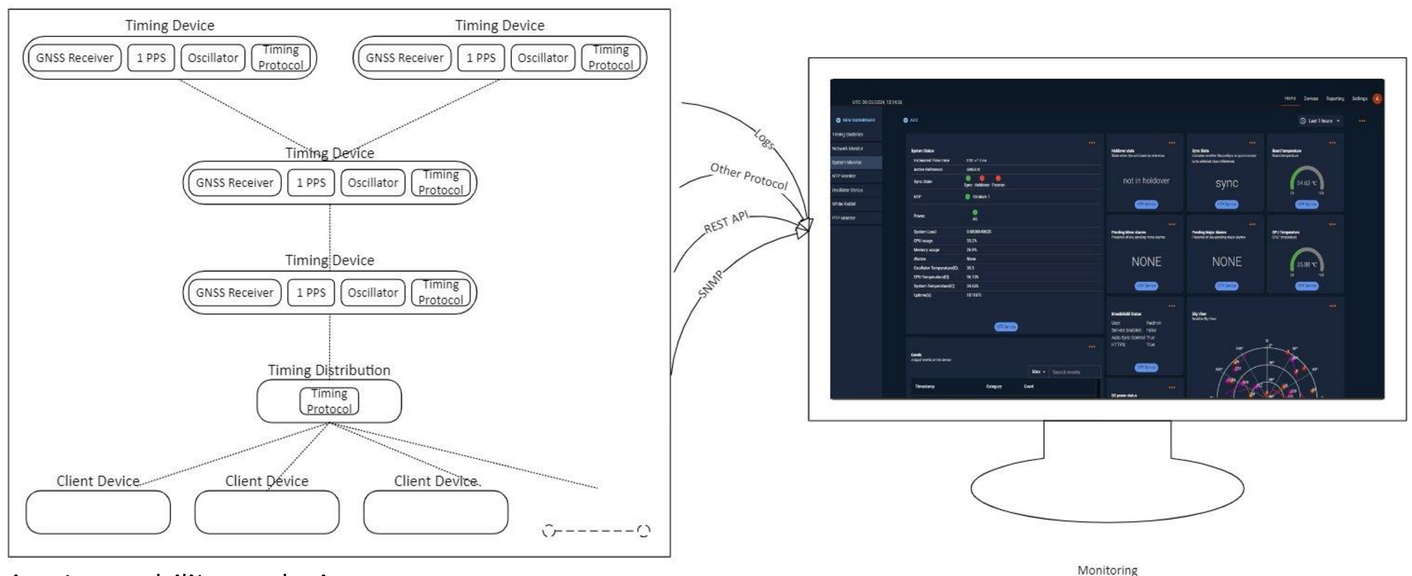
Abstract

Highly accurate and precise timing is critical for defense, commercial industries, and powering essential network operations. Different time transfer and synchronization deployments may have different levels of complexity since they involve diverse components, but all of them require sufficient performance monitoring. It is important to have insight into how all the elements of the system work together and to be able to **identify if any link of the chain is broken**. *Standardizing data access* and management for these systems enables the development of customized monitoring and analysis capabilities beyond the data gathering platform.

Thus, we can distinguish the following key functionalities:

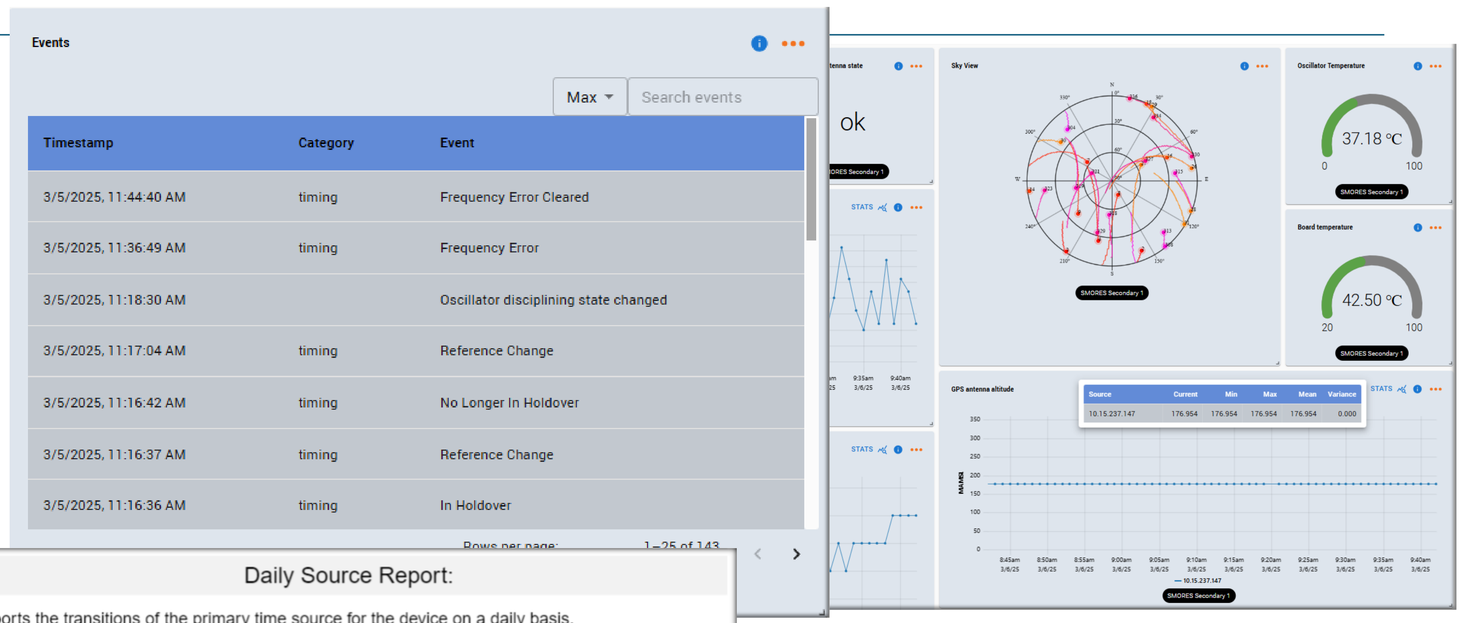
- Secure data collection
- Active monitoring through customizable displays
- Timing traceability analysis
- Extended analysis through domain specific tools

We present these different building blocks and how all this can be integrated into a timing synchronization performance monitoring system which provides that necessary insight.



Secure Data Collection

It is imperative to ensure that any monitoring of timing and synchronization systems is done securely and that it does not negatively impact the service. SNMP is an existing standard protocol for accessing network device data and requires configuration on the devices being monitored. ***SNMP v3*** is preferred as it uses encryption and authentication keys. Some devices may also provide a ***RESTful interface*** for accessing specific device configuration values and metrics. When using REST, or any web-based protocol, it should be secured with TLS. Timeseries databases used for this type of data collection, such as Prometheus or VictoriaMetrics, should also secure the metrics endpoints using TLS.



Customizable Display

There are standard metrics that are important to track when monitoring timing synchronization, such as **OFFSET**, **TDEV**, **TIE/MTIE**, or **Sync Status**, which makes having pre-defined templates or at least a simplistic basic mode dashboard creation functionality extremely useful when getting started with monitoring.

Time Traceability

In a timing synchronization deployment, it is important to be able to follow the time propagation to understand the system's performance. This kind of traceability is required for financial compliance through **MiFID II (Markets in Financial Instruments Directive II)** and **MiFIR (Markets in Financial Instruments Regulation)**. A traceability report should include device timing sources/outputs and time flow through the device network.

Daily Source Report:

Reports the transitions of the primary time source for the device on a daily basis.

Date/Time	Source	Phase Error Min-imum (ns)	Phase Error Max-imum (ns)	Phase Error Aver-age (ns)
3/10/20251:00:00 AM	PTP eth1	-42	40	-2
3/10/20255:37:00 PM	GNSS 0	-71	-1	-31
3/10/20255:54:00 PM	PTP eth1	0	74	23

Source Configurations:

Reports the current configuration for the sources utilized by the device.

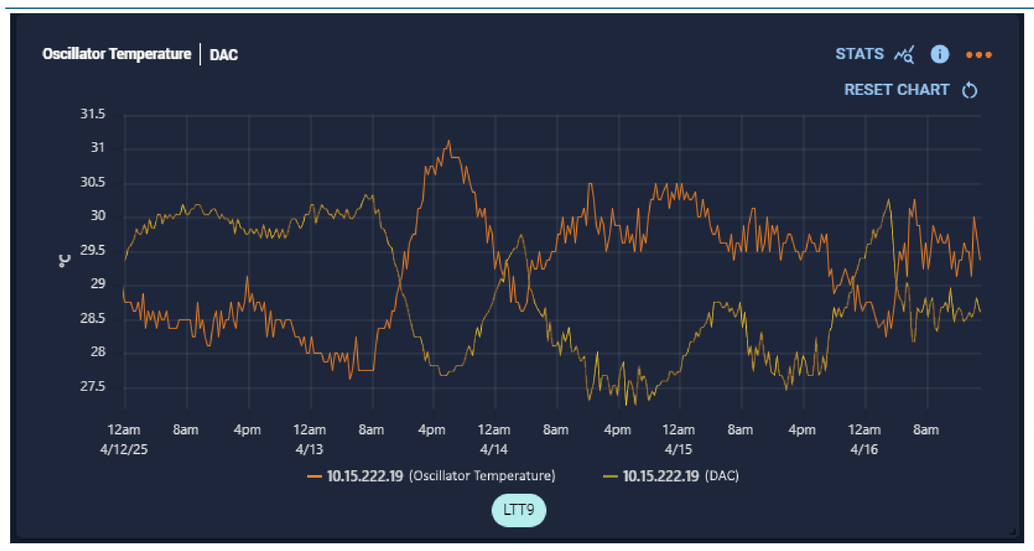
GNSS 0

Field	Value
Receiver Mode	Mobile
Receiver Dynamics	Land
Input offset	0
Constellations	GPS Galileo

Extended Analysis

Having access to monitor, view, and collect all this data paves a pathway for further investigation, possibly through ***AI and Machine Learning***:

- Usage analysis
- Predictive maintenance
- Fault prediction
- Anomaly detection
- Simulation
- Digital twin development
- Performance Optimization



Monitoring Test Observation

When comparing these two metrics, we can see that the **oscillator temperature** has a direct effect on the **DAC value**.

Data Correlation

Temperature affects the Frequency of the oscillator. The oscillator frequency is managed by a control loop where the DAC is one of those variable control values. This means that any change in the oscillator temperature will affect the oscillator frequency such that the value of the DAC must change to compensate for this frequency change.

Actions to Take

Given the above, swings in temperature will affect timing performance of the Securesync device. To remedy this, action must be taken to properly insulate the timing device(s) and manage the temperature of its surrounding environment.

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