



Brazil's Open-Source Wide Area Grid Monitoring Capability

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OPENWAMS PROJECT
ONS | BRAZIL
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About ONS



www.ons.org.br

We are the National Electric System Operator - ONS

The mission of ONS is to ensure the supply of electricity in the country, with quality and a balance between safety and the overall cost of operation.

The ONS is a private law legal entity, non-profit, under government's regulation and supervision. ONS does not own any generation, transmission, or distribution assets. The centralized management of the system operation guarantees operational security at the lowest possible cost.



WHY BIPS NEEDS BETTER RESYNCHRONIZATION SUPPORT

System scale, diversification, and restoration complexity

The Brazilian Interconnected Power System combines continental scale, long transmission corridors, HVDC transfers, and a rapidly changing generation mix.

180,000 km

HV transmission lines
230 kV and above

248 GW

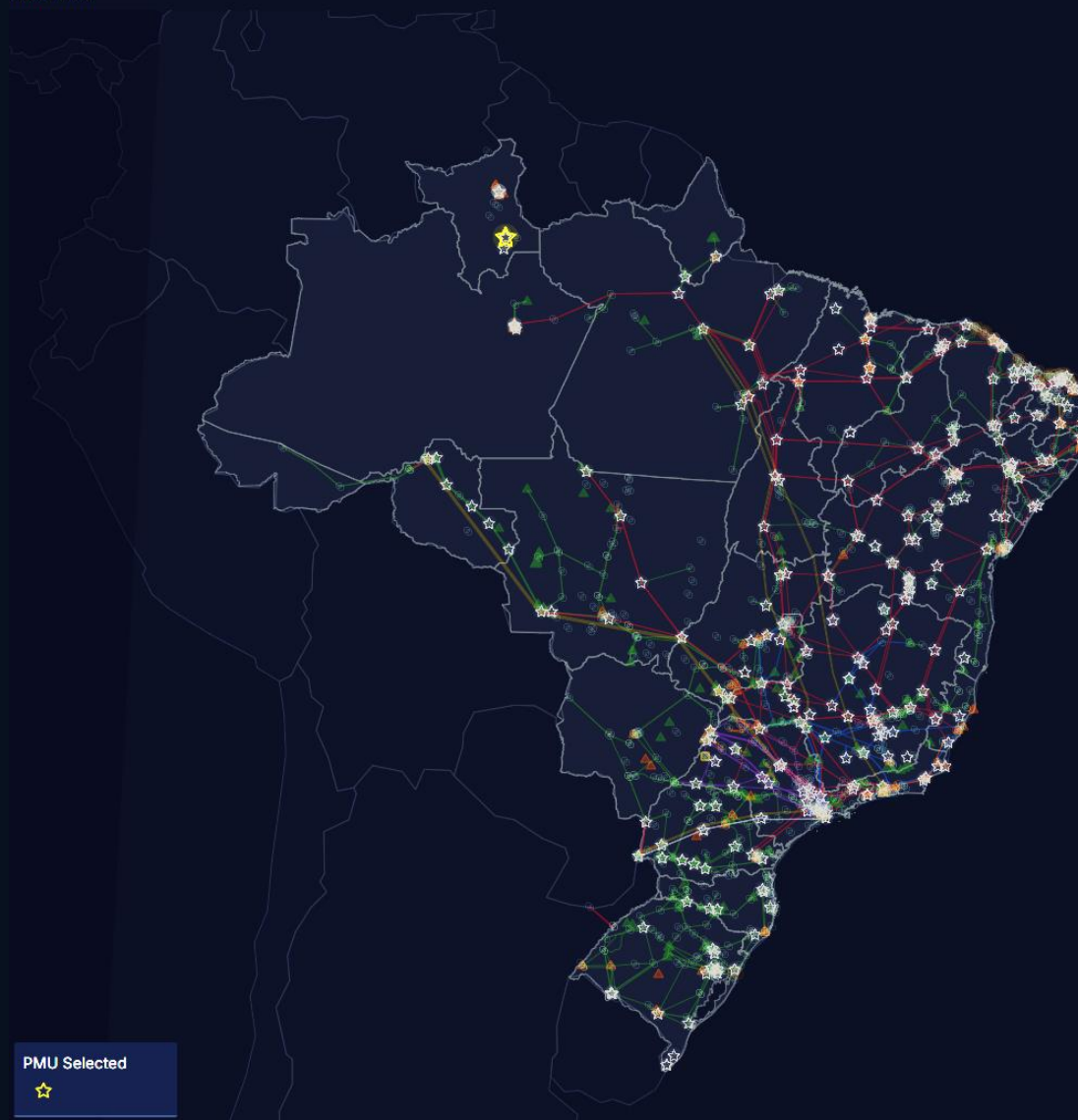
Installed
capacity

>40%

IBR-based share
of the matrix

- Wind $\approx 14\%$, solar PV $\approx 8\%$, and distributed resources $\approx 19\%$ of the energy matrix.
- Less robust interconnections can form electrical islands during high-impact events.
- Restoration depends on reconnecting islands under dynamic conditions that evolve faster than SCADA refresh cycles.

SIN MAPS



EVOLUTION OF WAMS AT ONS

2013

Initial Research & Maturity

Partnerships with universities to study the impact of PMUs on post-mortem analysis and real-time operations.

2014

First Deployment

Installation of PMUs in 31 key substations of vital importance to the Brazilian Interconnected Power System (SIN).

2018

CC-PMS: First Production WAMS

GE proprietary solution after an international bid. Full scale system with advanced applications.

2024

Shift to open-source (the dawn of openWAMS)

Move from proprietary solutions to an open-source architecture to reduce costs and improve system integration.

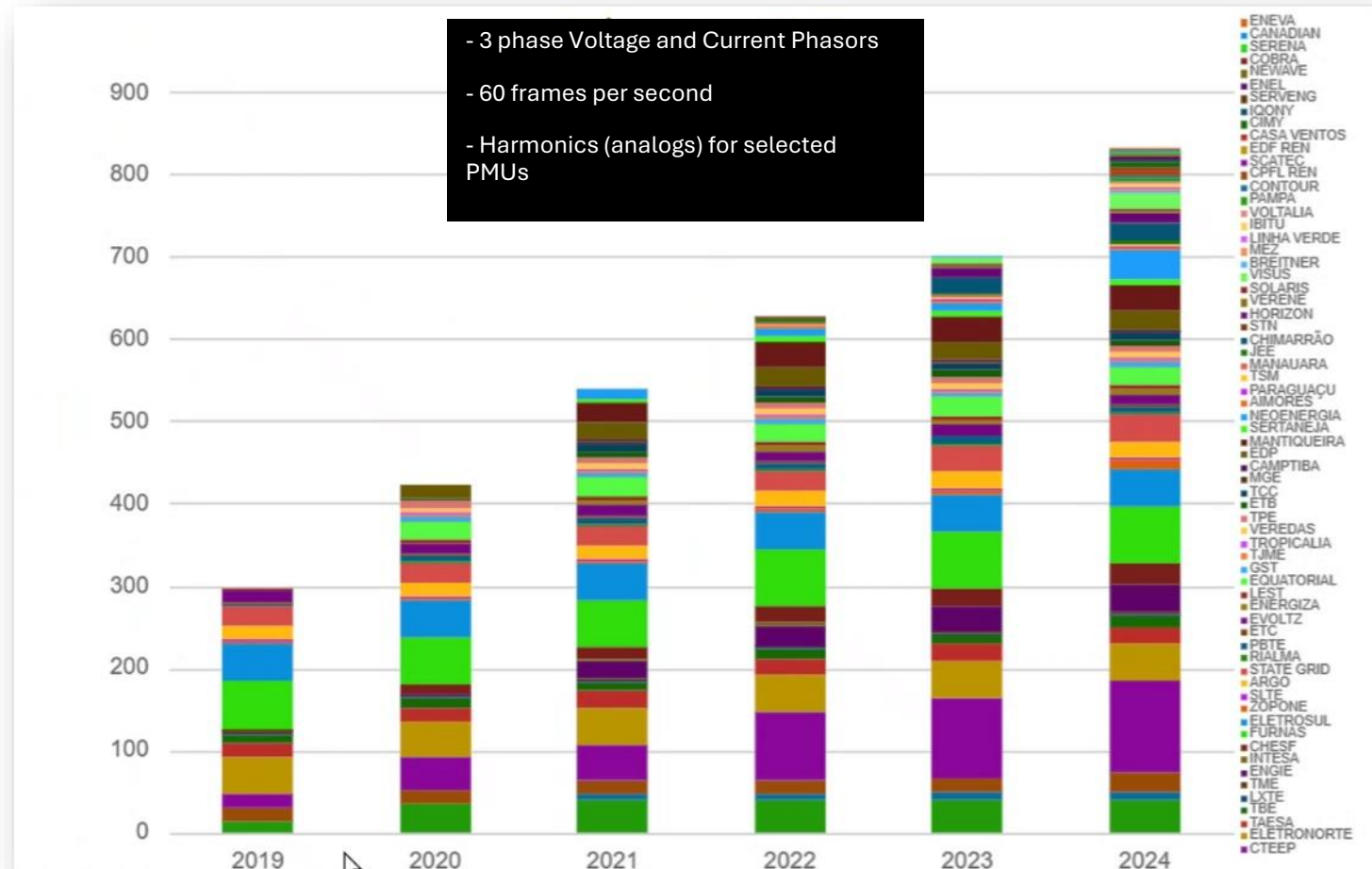
2026

Production WAMS (enterprise level of openWAMS)

Over 1000 PMUs integrated into the OpenWAMS platform, providing high-resolution, advanced alarms, data quality processing and real-time database for modular applications.

Brazil's PMU Network Scale

Forecast of 2000
PMUs by 2027



+4500 PMUs planned for
Linear Estimation

The openWAMS Project

OVERVIEW

openWAMS is an **open-based WAMS platform designed by ONS** for real-time monitoring and disturbance analysis based on synchrophasors (PMU) measurements. Based on openPDC, openHistorian, Grafana. Receives redundant PMU streams from Rio and Brasília sites.

AVAILABLE APPLICATIONS

Control-Room/Real-Time

- Geo-Localized Navigation
- Real-Time & Historical Trend Graphs
- Short-Circuit Visualisation
- Electric Island Synchronization
- PMU Data Quality Reporting
- Wallboard Support Panels

Advanced Applications

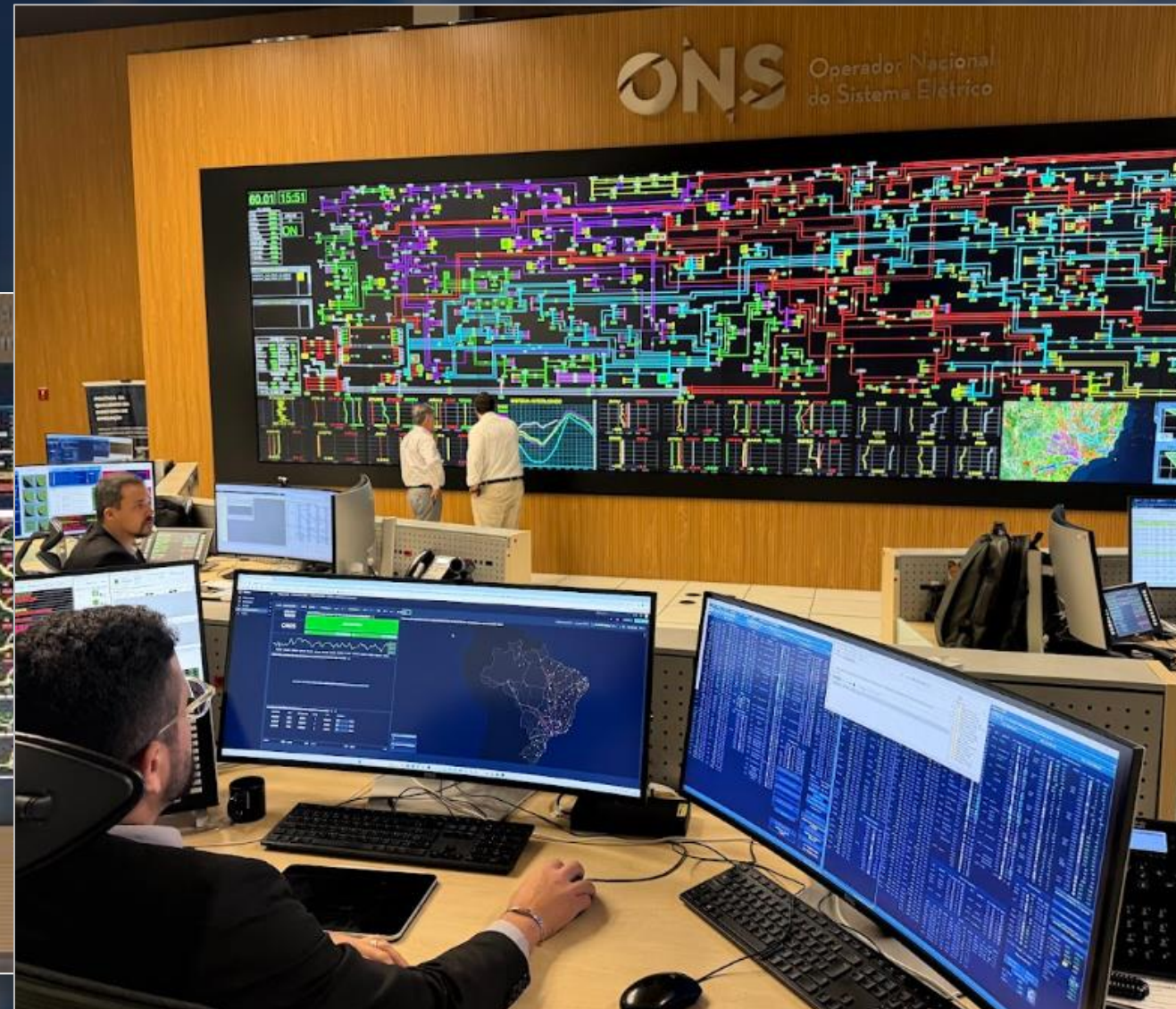
- Oscillatory Stability Detection and Tracking
- Disturbance Detection and Characterization
- PMU Data Quality Assessment

Off-line Analysis (stand-alone application)

- Stand-Alone Analysis Tool (openPlot)
- Historian Trending
- Data Export



High Penetration in the Control-Room!



International Publications 2026



11320

C2 Power System Operation and Control

PS1 Advanced Decision Support, Training and Skills for Control Room Personnel

A Multi-Criteria Method for Continuous PMU Data Quality Evaluation

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SUMMARY

This paper proposes a multi-criteria approach to evaluating PMU (Phasor Measurement Unit) data based on practical experience gained from addressing data quality issues. The aim is to enhance the reliability of PMU data for decision-making.

The paper addresses nearly all known issues related to PMU data quality, such as temporal variations, data gaps, and "outliers" due to unforeseen reasons. The proposed method complies with industry standards but also enhances data quality by leveraging data exclusively from high-quality PMUs.

Based on inconsistencies observed among the PMU data over months of ongoing observations, this study aims to stimulate the development of a multi-criteria approach to improve the management of PMU data quality.

Paris Session 2026



Paris Session 2026

August 23 to 28, 2026

Palais des Congrès, Paris, France

FEATURE

OPENWAMS

Brazil's Open Source Leap in Wide Area Grid Monitoring

Ricardo Lira, Janio Los, and Arthur Mouco



THE RELIABLE AND SECURE OPERATION

of large-scale power systems increasingly relies on high-fidelity, synchronized data. Unlike traditional supervisory control and data acquisition (SCADA) systems, phasor measurement units (PMUs) provide real-time, high-sampling-rate data, which enhances the observability of dynamic phenomena. The precise, synchronized, and real-time measurements of fundamental frequency components, including three-phase currents and voltages, and phase angles, are essential for the reliable and secure operation of power systems. This enables immediate disturbance detection, grid stability monitoring, and accurate postevent analysis.

Within this context, this article introduces the reader to the openWAMS project, an innovative open source wide area monitoring system (WAMS) implemented by Brazil's independent system operator (ONS), operational in the control room since mid-2024. Its open source nature facilitates customization, adaptability, and future proofing, allowing engineers to customize the platform and integrate algorithms tailored to the country's grid challenges.

To provide context, the article first outlines the role of ONS and the current challenges in operating

IEEE PES

T&D

CONFERENCE & EXPOSITION

73

In-house Development: Advanced Apps

OPEN PLATFORM ARCHITECTURE

Facilitates easy deployment of new real-time control room applications
Built on the STTP protocol for seamless real-time data streaming

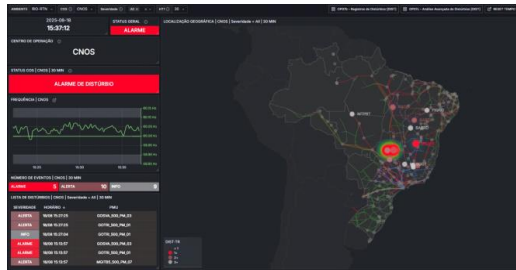
DATA INTEGRATION & DISTRIBUTION

Retrieves real-time streams from the main historian system
Distributes data across independent application modules via a common data bus

ORCHESTRATION & ANALYTICS

The orchestrator:
Converts STTP streams into discrete data packages and provide the metadata
Performs basic analytics and injects results into the data bus
Actionable Business Insights
Applications generate real-time analytics for improved situational awareness.
Results are stored in a relational database for:
(i) Visualization in Grafana
(ii) Triggering of alarms for proactive decision-making

Disturbance Detection (DIST)



Oscillation Monitoring (MOSC)



User-Interface

Serving as a central hub, the web UI provides both the analytical results and the raw PDC/Historian measurement data. It also features an embedded alerting engine to notify subscribed users.

openWAMS in-house coding

Analytics Database

Analytical results processed by the application modules are stored in a relational database, enabling easy consumption by the web UI dashboards.

APP 1

APP 2

...

APP n

The real-time application modules connect directly to the data bus infrastructure. They operate as self-contained units, eliminating the need for external information.

DATA BUS

All data required by the application modules is streamed directly over the data bus. This bus serves as the central message traffic system, conveying both measurement data and metadata.

STTP Orchestrator

This module connects to the PDC/Historian using the STTP protocol. It structures the incoming information into discrete message blocks before injecting them into the data bus.

PDC/Historian

Reliable source for real-time PMU streams and metadata, this component offers dual functionality: real-time streaming via STTP and on-demand retrieval of historical data for offline applications.

PMU Data Quality Assessment

Table 1 - Description of the data quality criteria

Status	Description
1-Reliable	The data complies with all applicable quality criteria and is suitable for use in real-time applications, analytical processing, and control-room visualization.
2-Suspect	The data exhibits some quality deviations and may be used for non-critical analysis; however, its use in real-time operational functions is not recommended.
3-Bad	The data exhibits important quality deviations and/or data is invalid or inconsistent, indicating that the measurements shall not be used, even if the values appear plausible.
4-Unavailable	The data is missing or could not be evaluated, and therefore no quality assessment can be assigned.

Table 2 - General Quality Status (Total: 921 PMU / Date: 29-dec-2025)

Status	Quantity	Percentage
1-Reliable	692	75%
2-Suspect	10	1%
3-Bad	48	5%
4-Unavailable	171	19%



THE DIST ALGORITHM

PRINCIPLES



High-Resolution Sync Data

Utilizes synchronized, high-resolution measurements exclusively from PMUs to observe continuous three-phase quantities and frequency. Detection and localization of disturbances in milliseconds, bypassing SCADA's blind spots.



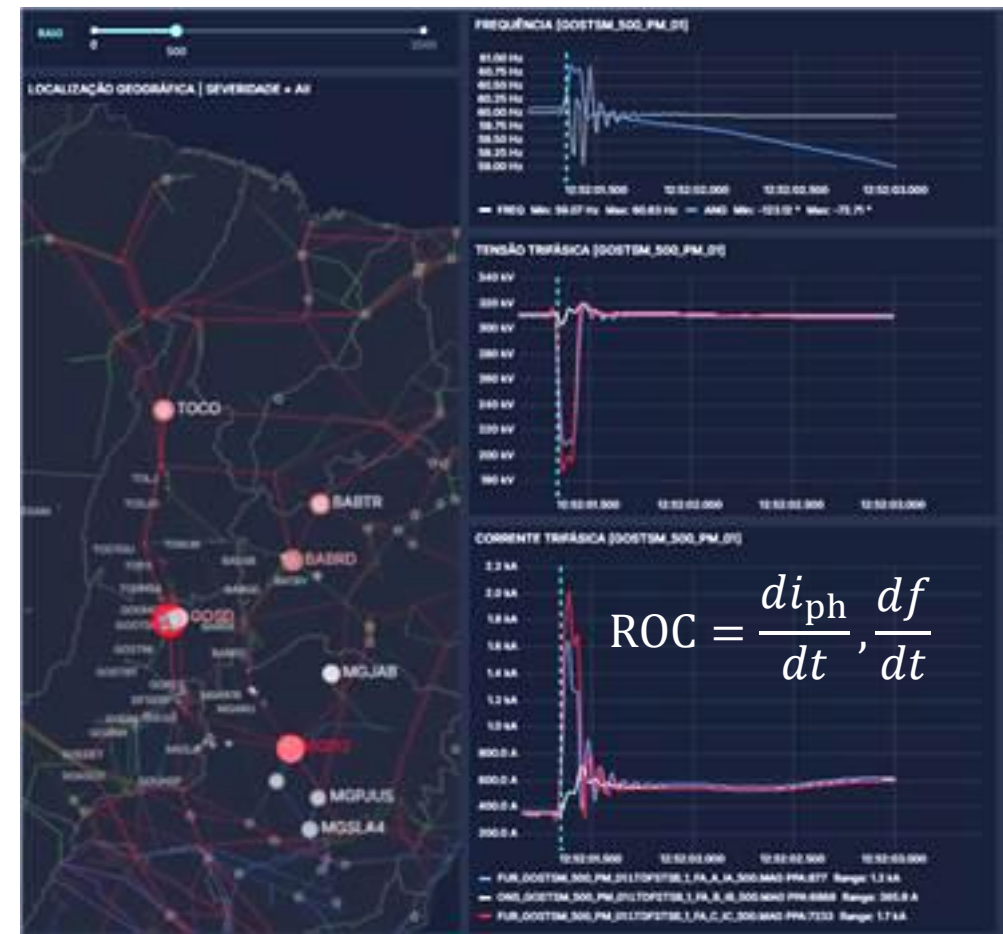
ROC Methodology

Based on the real-time analysis of the Rate of Change (ROC) of current and frequency to identify instantaneous dynamic phenomena. Does not require detailed network models.



Localization

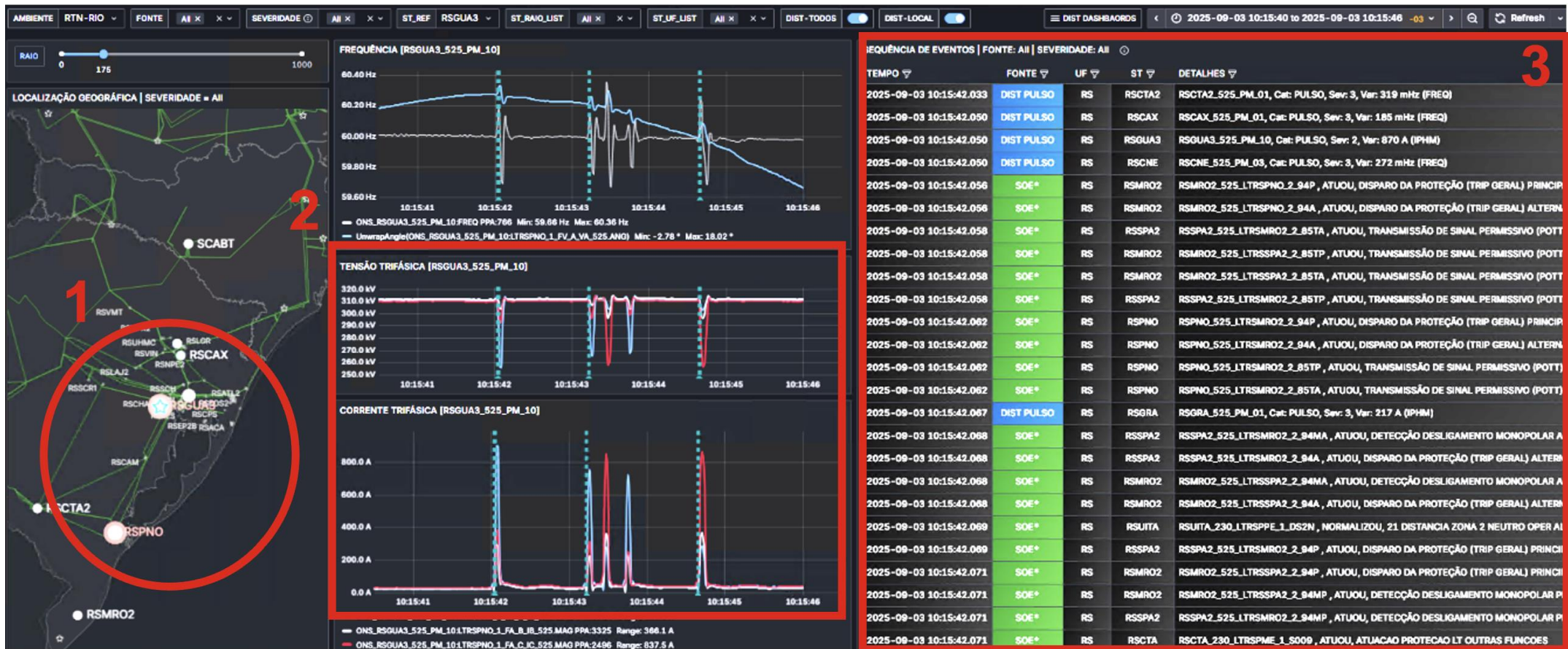
Estimates the disturbance epicenter based on the intensity of current variation, eliminating the need for complex network models.



DIST Case Study

RS Local Event (Sept 3, 2025)

Severe winds collapsed towers in a 525 kV corridor. openWAMS identified reclosing attempts and pinpointed epicenters at Guaíba 3 and Povo Novo, allowing crews to safely halt reclosing operations.



DIST Results Overview

Reference Database: Sept 25 - Mar 26

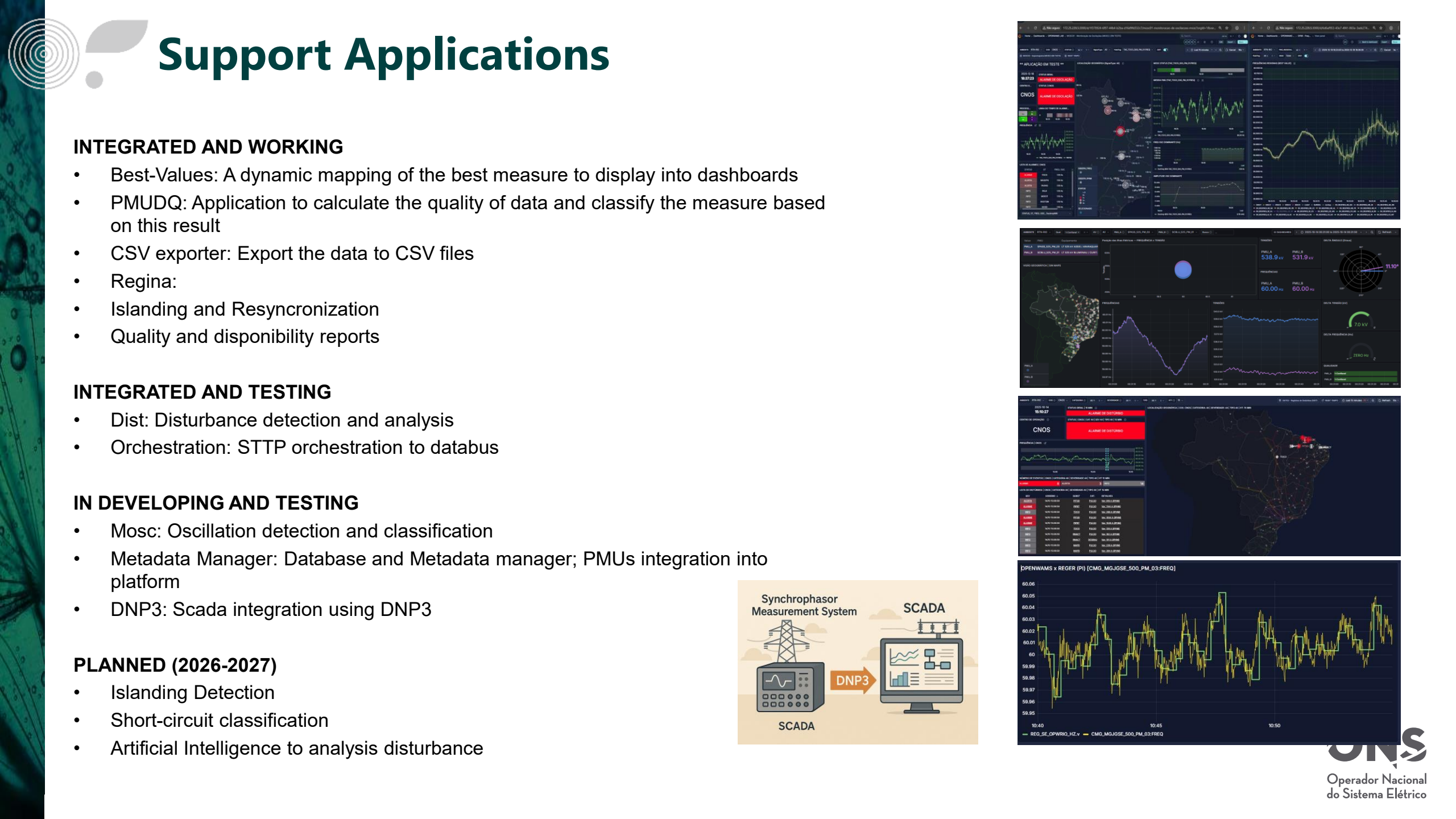
COSR-SE (Southeast)	528 Events (31%)	} 1684 Events
COSR-NE (Northeast)	519 Events (31%)	
COSR-NCO (North)	453 Events (27%)	
COSR-S (South)	184 Events (11%)	

Seasonality: October 2025 accounted for 42% of "severe" cases, correlated with the wildfire season and intense drought in the Central/Northeast regions.

Bannefits:

- System captured phenomena not visible in conventional SCADA.
- Reduced diagnostic uncertainty and response time.
- Better coordination for line restoration after faults





Support Applications

INTEGRATED AND WORKING

- Best-Values: A dynamic mapping of the best measure to display into dashboards
- PMUDQ: Application to calculate the quality of data and classify the measure based on this result
- CSV exporter: Export the data to CSV files
- Regina:
- Islanding and Resincronization
- Quality and disponibility reports

INTEGRATED AND TESTING

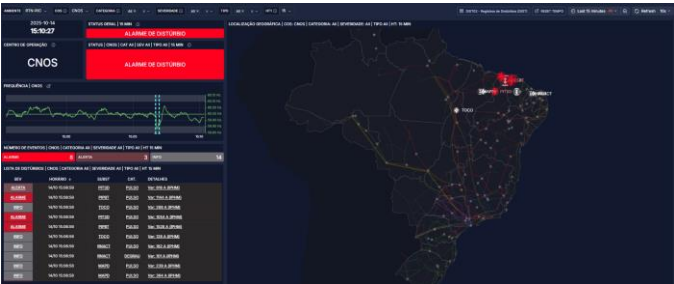
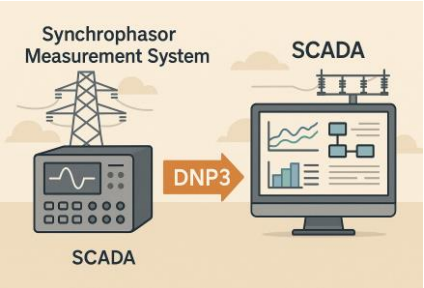
- Dist: Disturbance detection and analysis
- Orchestration: STTP orchestration to databus

IN DEVELOPING AND TESTING

- Mosc: Oscillation detection and classification
- Metadata Manager: Database and Metadata manager; PMUs integration into platform
- DNP3: Scada integration using DNP3

PLANNED (2026-2027)

- Islanding Detection
- Short-circuit classification
- Artificial Intelligence to analysis disturbance



OpenPLOT: Offline Analysis Tool

Data Management & Visualization:

- Historical Data Retrieval
- Local Data Storage
- Time-Series Plotting of Electrical Quantities

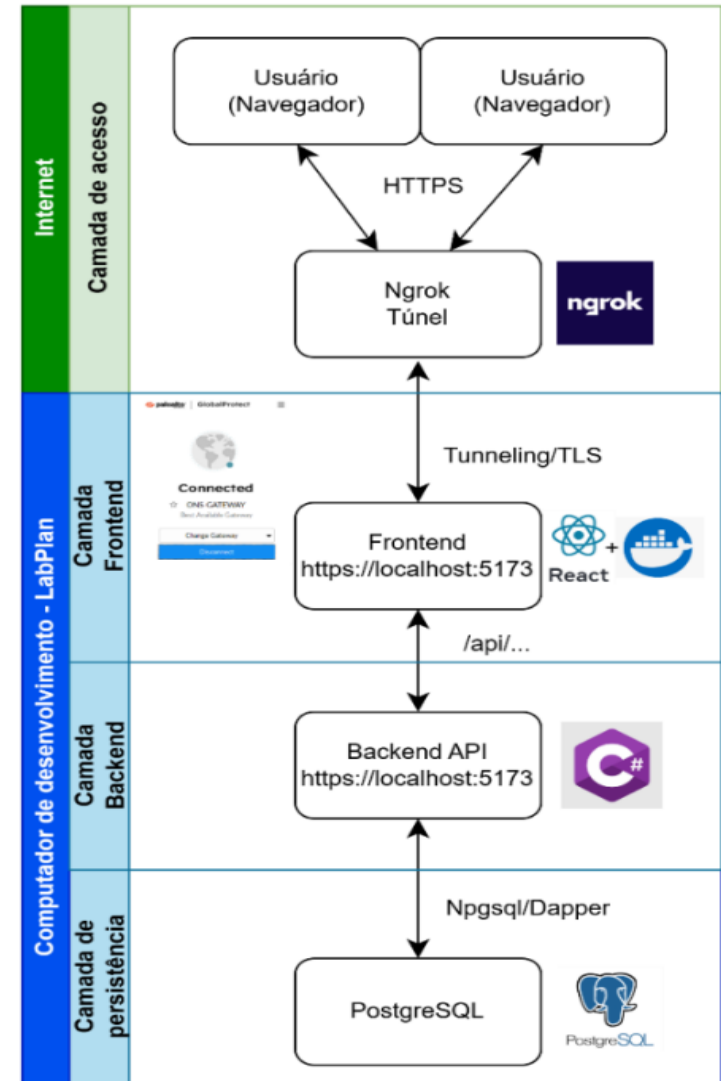
Analytical Features:

Oscillation Analysis:

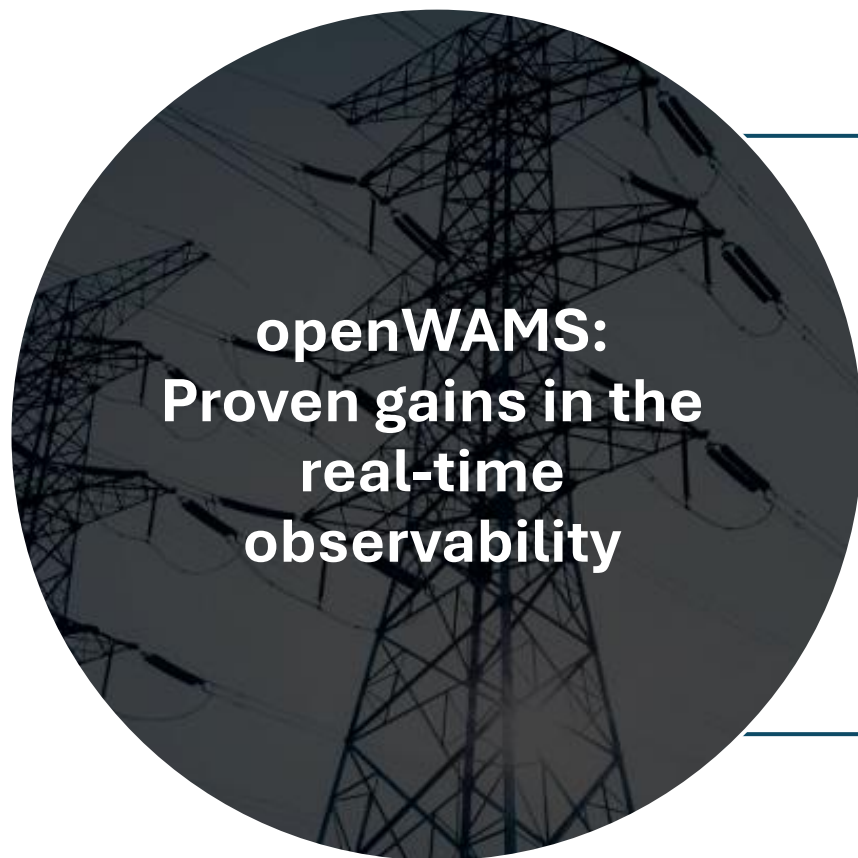
- **Transient Oscillation Analysis Module**
 - DFT/FFT Method - Discrete/Fast Fourier Transform
 - Prony's Method
- **Ambient (Normal Operation) Oscillation Analysis Module**
 - CVA Method - Canonical Variate Analysis or Canonical Correlation Analysis (CCA)

Event Detection:

- Event Identification
- Event Localization



IT'S WORTH IT!



PMU-based monitoring enables near real-time disturbance detection.



Integrated PMU and SOE analysis enhances operational awareness.



Future developments:
More refined algorithm,
Artificial Intelligence
Analytics etc