# *Measurement Challenges for Smart Grids in the Americas*

## *Inter-American System of Metrology (SIM)*

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# Energy and Environment

- Energy conversion
- Energy T & D
- Energy and Materials Recovery
- Renewable Energy
- Efficient use of energy
- Risk and life time technology
- Clean Tech and environmental management

# Sensing – a key issue for the Smart Grid

- **Smart grids** – Sensing, embedded processing and digital communications to enable the electricity grid to be
- **observable** (able to measure the states of all grid elements),
- **controllable** (able to affect the state of any grid element),
- **automated** (able to adapt and self-heal) and
- fully **integrated** (fully interoperable with existing systems and have the capacity to incorporate a diversity of energy sources)

# Synchrophasor Measurement

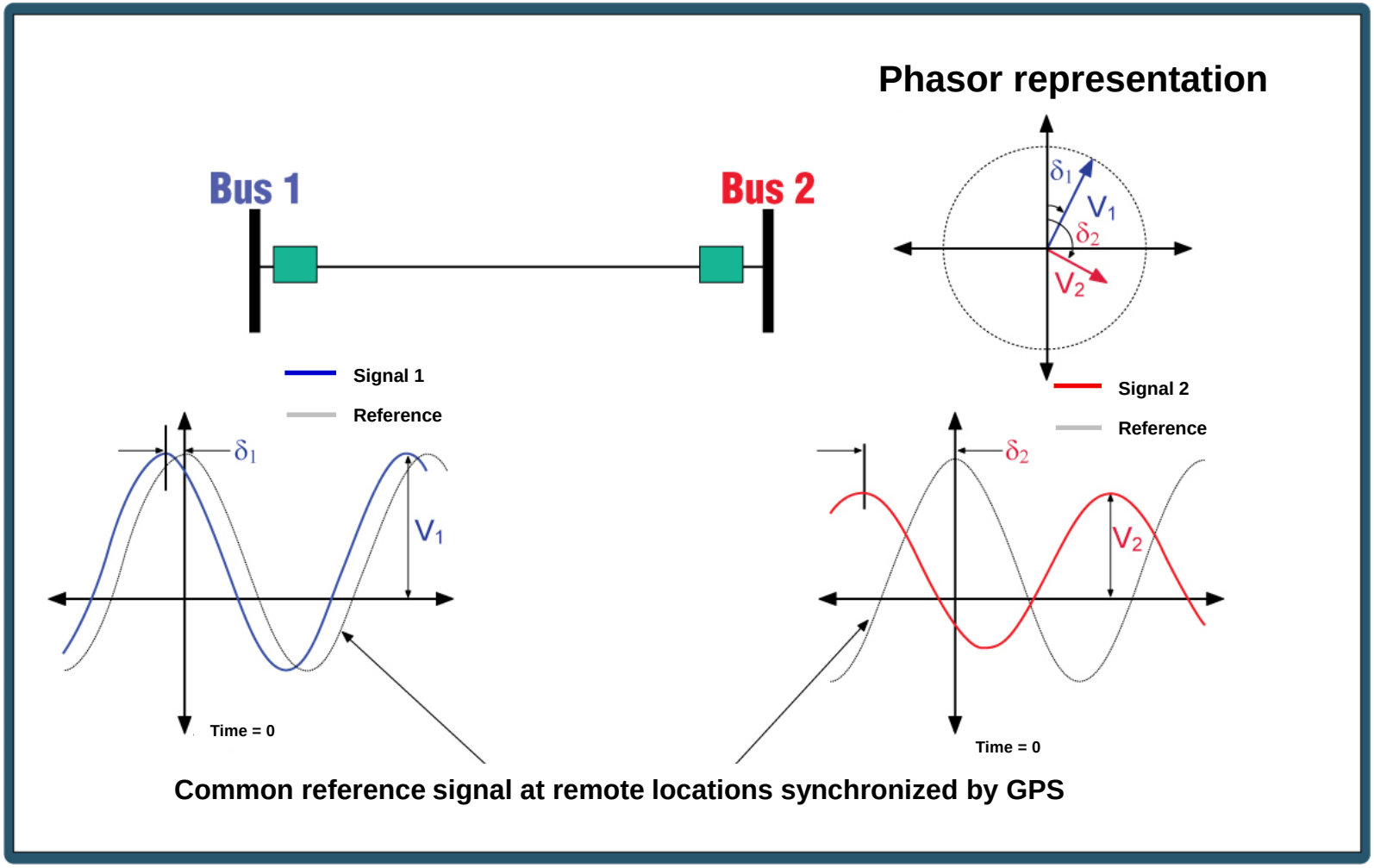
Synchrophasors are precise grid measurements available from monitors called Phasor Measurement Units (PMUs).

PMU measurements are taken at high speed
(typically 30 observations per second, over 100 times faster than conventional SCADA technology).

Each measurement is time-stamped according to a common time reference such as GPS.
Time-stamping allows measurements from different locations and utilities to be time-aligned (synchronized) and combined together providing a precise and comprehensive view of the entire interconnection.

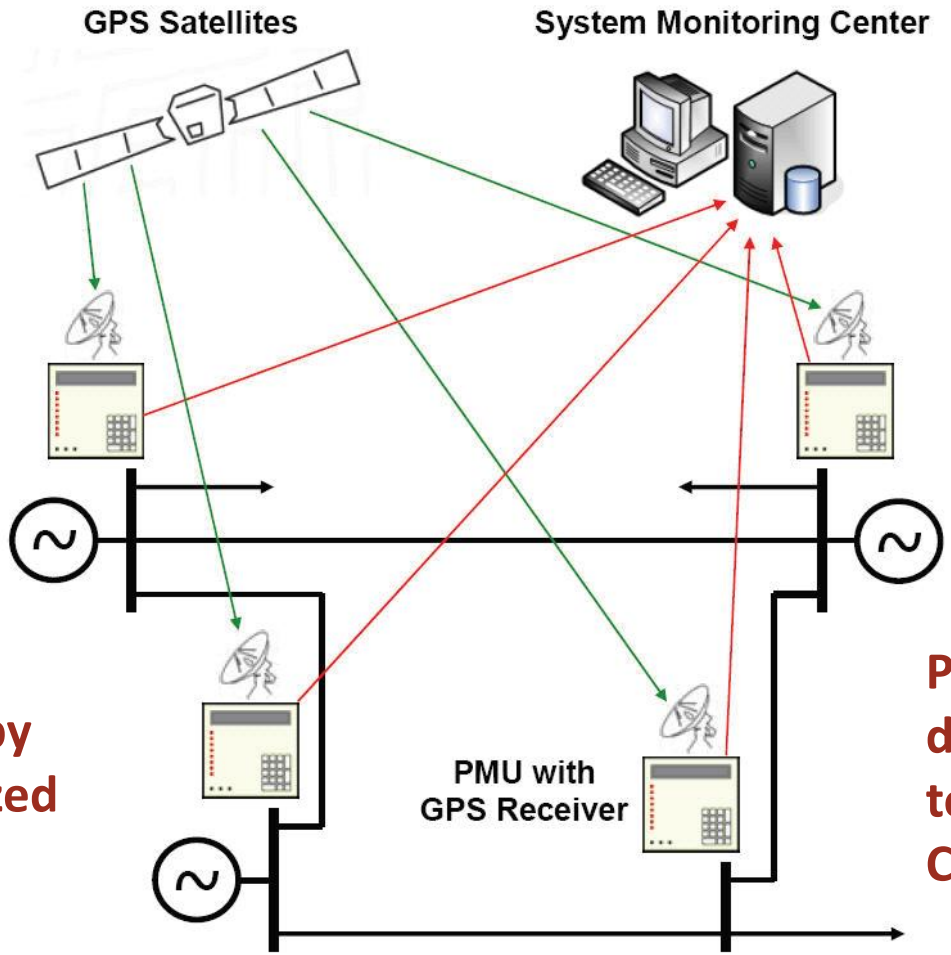
Synchrophasor measurements can be used to indicate grid stress, and can be used to trigger corrective actions to maintain reliability.

# Synchrophasor Measurement




Common reference signal at remote locations synchronized by GPS

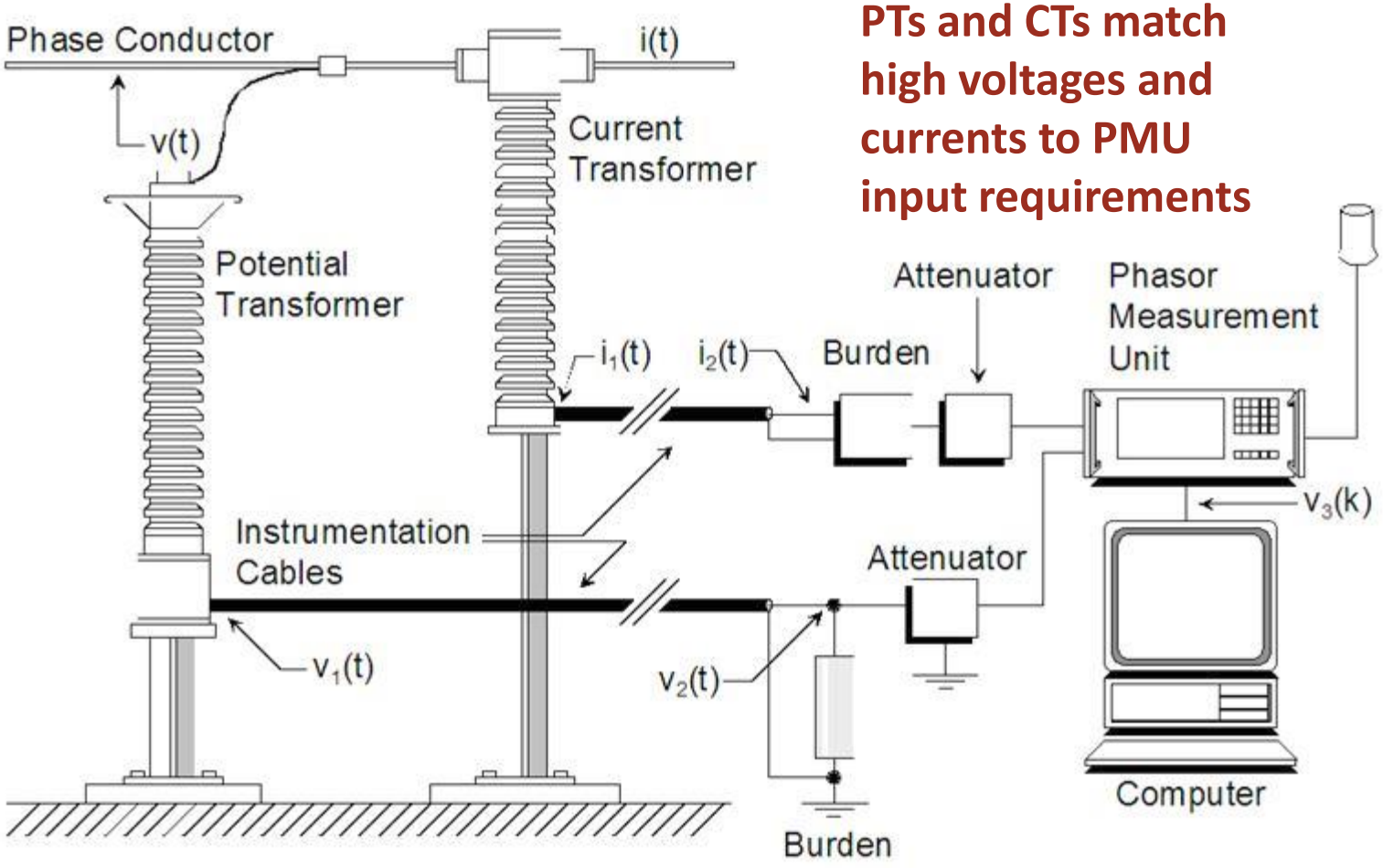
# Synchrophasor Measurement System (SPMS)




**Grid monitored by PMUs synchronized with GPS**

**PMU time-stamped data communicated to Phasor Data Concentrators (PDC)**

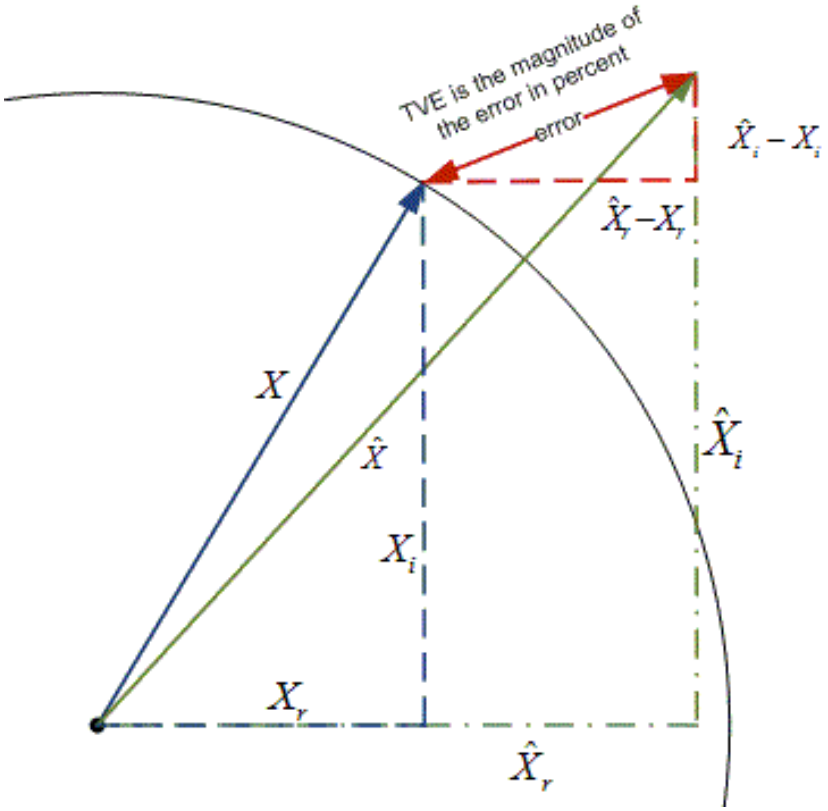
# Phasor Measurement Unit (PMU)




**PTs and CTs match high voltages and currents to PMU input requirements**

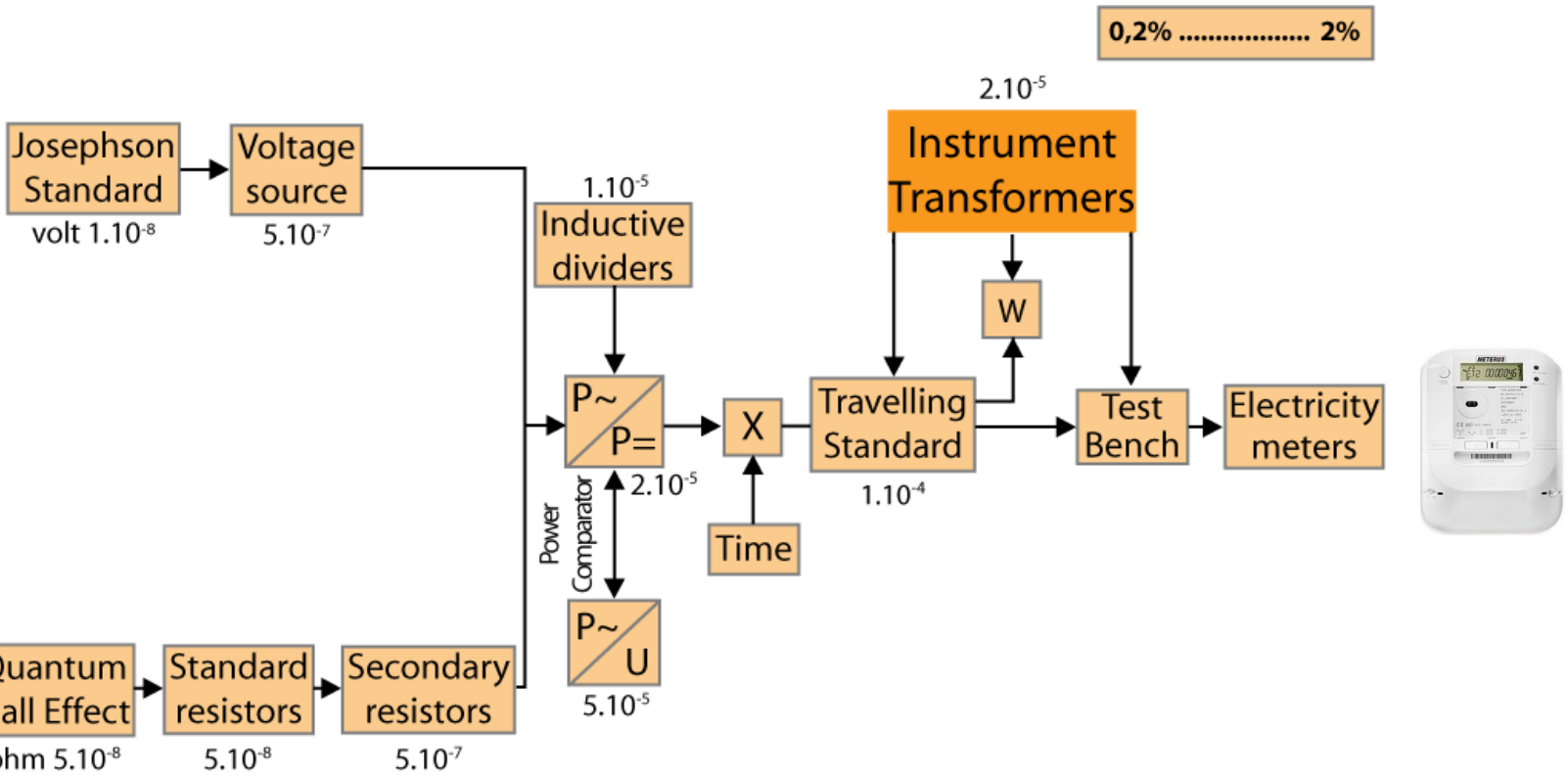
# Synchrophasor Measurement Accuracy

- Voltage measurements - 1%
- Current measurements - 10%
- TVE (Total Vector Error) - 1%
- Such accuracies encompass the whole chain, including PMU, Potential Transformers, Current Transformers and other transducers



# Measurement Traceability

**Quantum Standards**



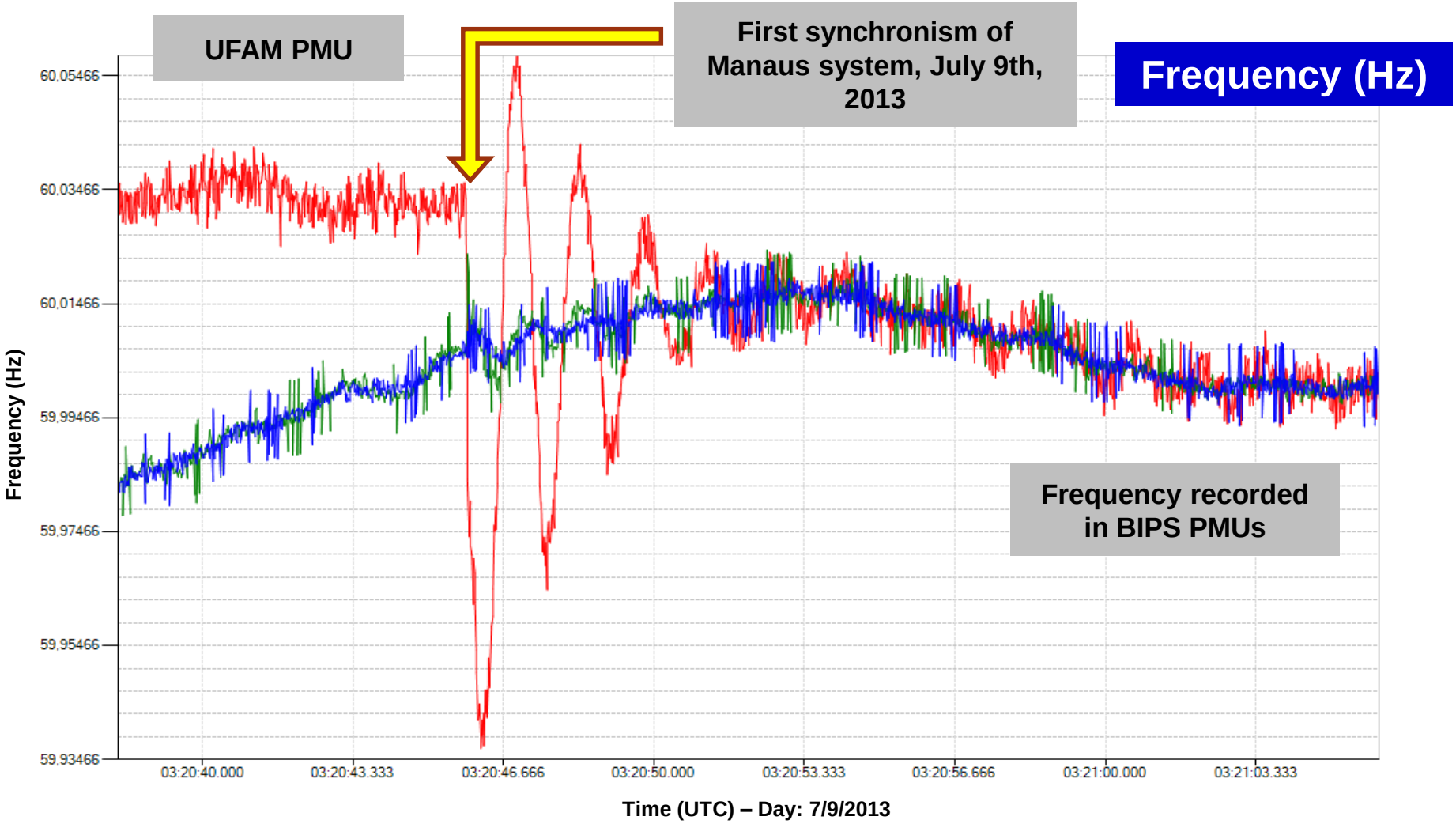

**An unbroken chain of comparisons all having stated measurement uncertainties**

# Inter-American System of Metrology (SIM)

# PMU Applications for Wide Area Monitoring, Analysis and Control

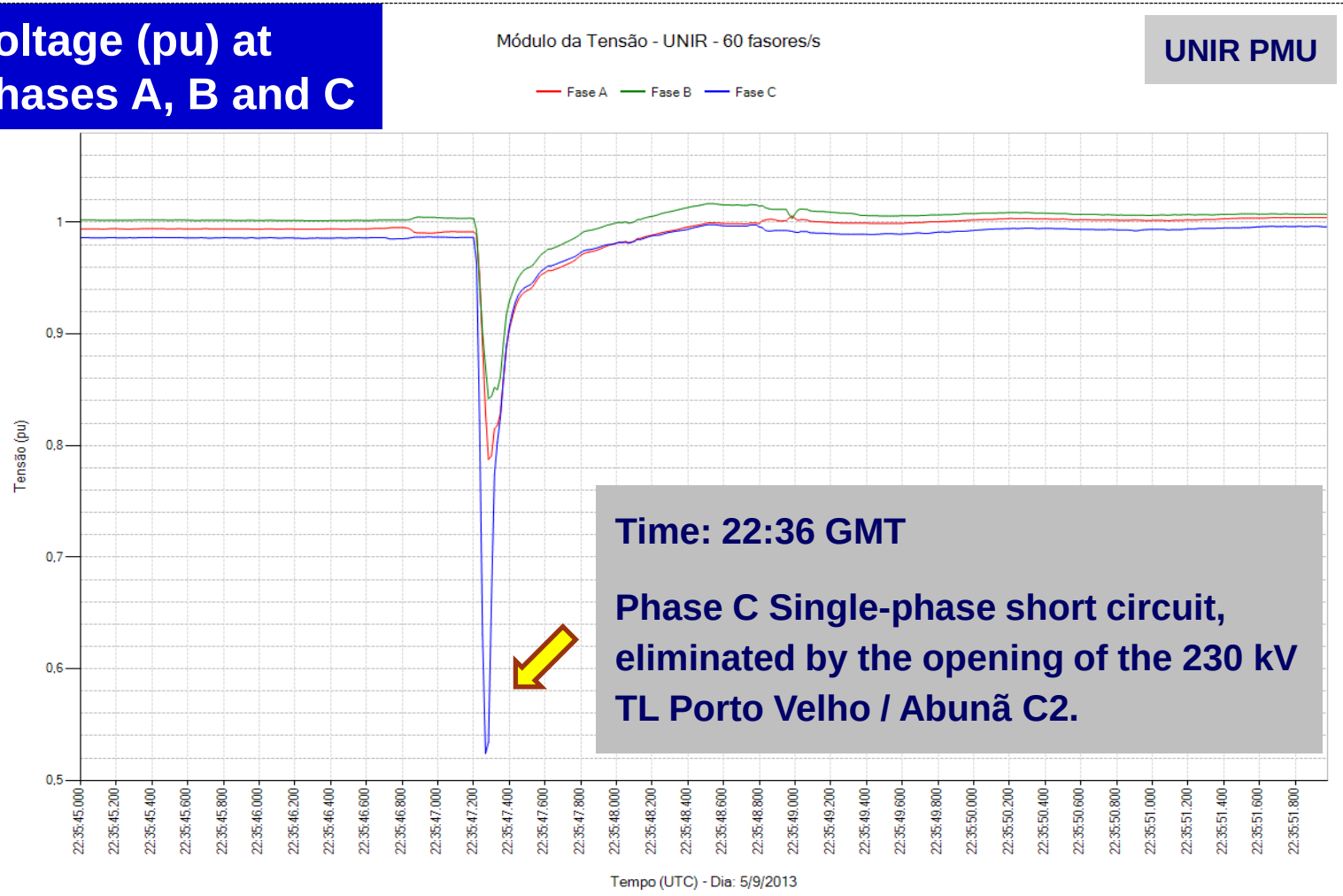
| Monitoring | Analysis | Control |
|---|---|---|
| Frequency | Post Event Analysis | Adaptive Islanding |
| Voltage | Model Validation | Adaptive Relaying |
| Oscillation Detection | State Estimation | Power System Stabilizing / Power Oscillation Dampers |
| Wide-area Visualization | | Black-start Restoration |
| Operator Decision Support | | Automated Remedial Action Schemes |
| State Estimation (hybrid or linear state estimation / state measurement) | | |
| Renewables Integration | | |

# Connecting Isolated system to Interconnected System



# Detecting Electric Faults

**Voltage (pu) at phases A, B and C**




**UNIR PMU**

**Time: 22:36 GMT**

**Phase C Single-phase short circuit, eliminated by the opening of the 230 kV TL Porto Velho / Abunã C2.**

# Synchrophasor Measurement in North America

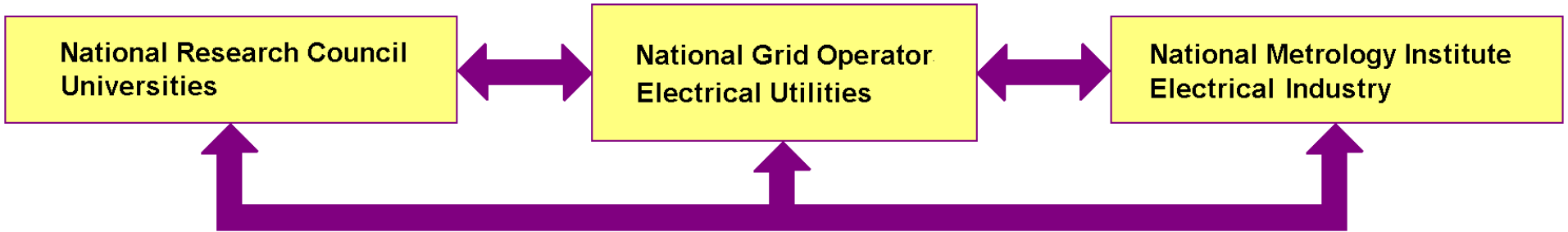
- NASPI is a voluntary collaboration between the electric bulk power system community (industry, vendors, academics, consultants), North American Electric Reliability Corporation (NERC) and DOE to advance the deployment and use of synchrophasor technology

https://www.naspi.org/

- NASPI priorities are set and executed by industry volunteers

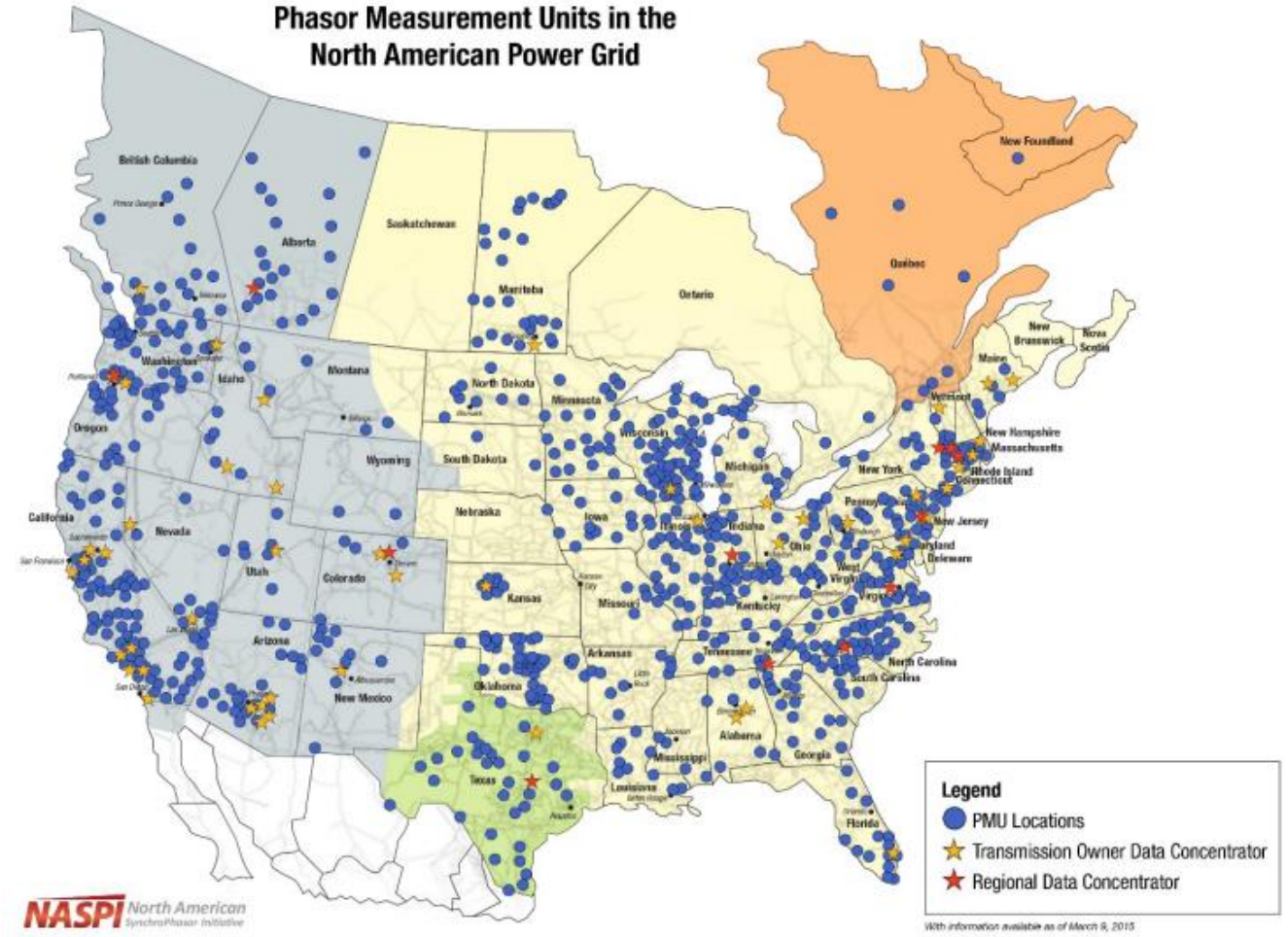
- NERC funds the NASPI meetings, and Grid Protection Alliance work on phasor infrastructure development

- DOE funds phasor research projects and support to NASPI Task Teams by National Lab staff and Consortium for Electric Reliability Technology Solutions (CERTS) program contractors



# Synchrophasor Measurement in North America

Almost 1800 PMUs were installed across North America in 2015




Courtesy of the North American Synchrophasor Initiative () and the U.S. Department of Energy.

# Standardization Efforts on PMU Testing

**2006**
IEEE C37.118.1-2005 Published

Synchrometrology Lab founded with support from Department of Energy

**2009**

2009 – 8 PMUs tested by NIST and none met the 2005 standard

Synchrophasor testing performed for ONS Brazil

**2010**

NIST-ARRA Grant to Fluke Calibration to develop a commercially available PMU Calibration System

**2011**

**IEEE Standard for Synchrophasor Measurements for Power Systems**

IEEE C37.118.1-2011 Published with tests developed at NIST

**2012**

2012-2014 NIST assessed the electrical performance of 15 PMUs (some "legacy" PMUs in use at the time) and none met the 2011 standard

ICAP Synchrophasor Conformance Assessment Steering Committee founded

**2014**

IEEE C37.118.1a-2014 amendment based on NIST recommendations

**2015**

ICAP Test Suite Specification Published
First ICAP Test Lab assessed by NIST
ICAP Synchrophasor Performance Assessment Pilot

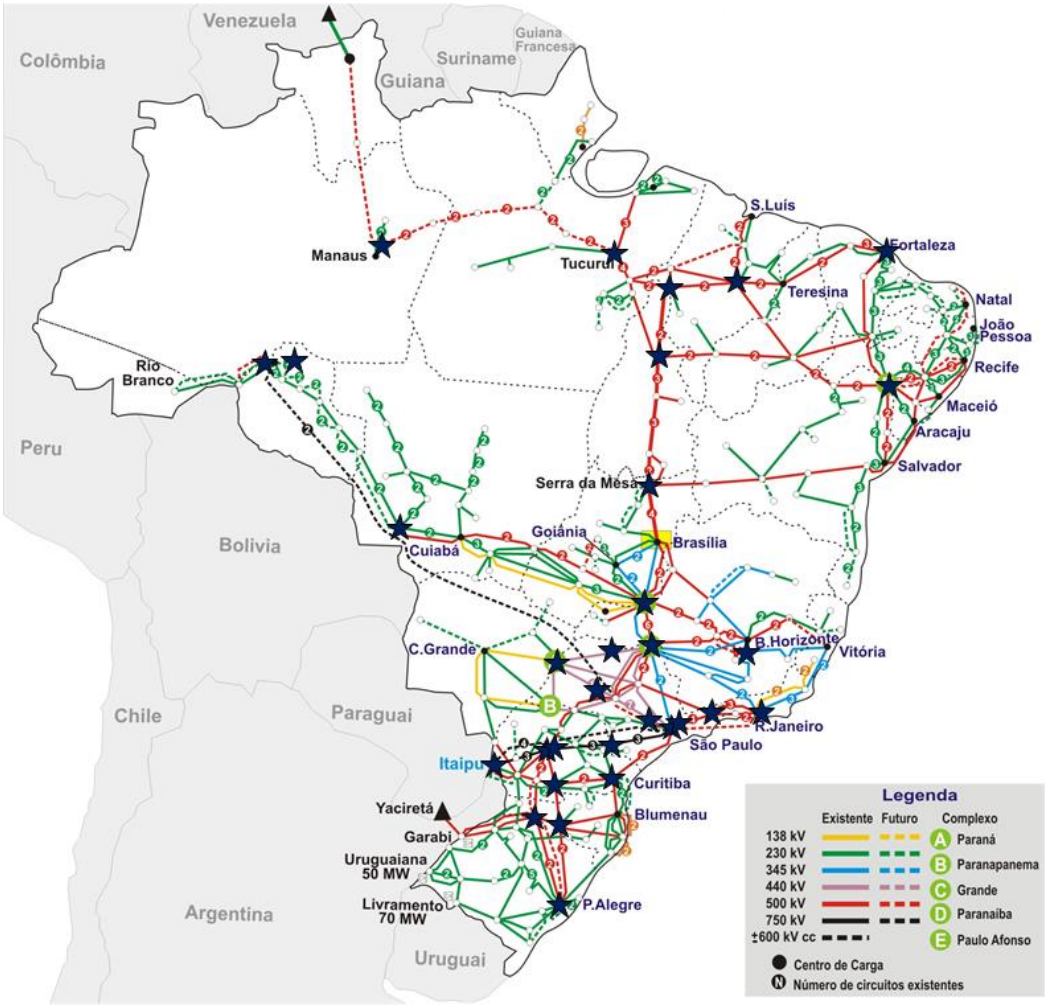
IEEE Synchrophasor Conformity Assessment Program begins (ICAP)

# NIST-SIM Engagement Opportunity

- 4th cycle of support for NIST-SIM collaborations
- This program is aimed at strengthening the metrology infrastructure within SIM and is limited to staff of SIM National Metrology Institutes and Designated Institutes
- In 2017 Brazilian NMI (Inmetro) and Argentinian NMI (INTI) sent experts to be trained on PMU calibration and testing at NIST. They will be also exposed to the IEEE Synchrophasor Conformity Assessment Program

**We now present the initiatives of these two countries concerning the PMU technology**

# Synchrophasor Measurement System in Brazil




**31 Substations**
**181 Line Terminals**

# Synchrophasor Measurement in Brazil

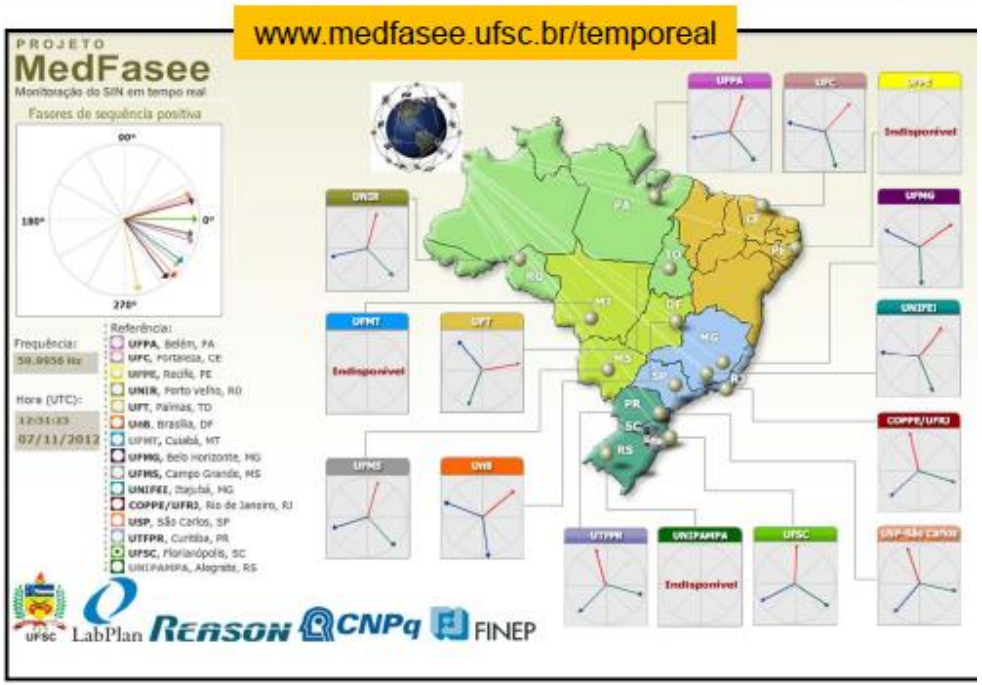
| Year | Brazilian National Grid Operator (ONS) Activity |
|---|---|
| 2005 | Technical Studies for PMU Location |
| 2006/2007 | Synchronized Phasor Measurement System Technical Specification |
| 2008 | Technical Studies for Application of Phasor Measurements Technology for Real-time Decision Making |
| 2009 | PMU Certification Process (ONS contracted NIST to test 8 PMUs and none passed the tests) |
| 2011 | Partnership with Universidade Federal de Santa Catarina (UFSC) |
| 2012 | MME / IBRD understandings for funding SPMS |
| 2013 | Telecommunication Technical Specification |
| 2014 | PDC Infrastructure / Applications Acquisition |
| 2015 | PDC Contracting and Applications |
| 2016/2017 | Beginning of Operation |

# Synchrophasor Measurement in Brazil

## MedFasee: the Brazilian Low-Voltage WAMS

### Current Configuration: Characteristics

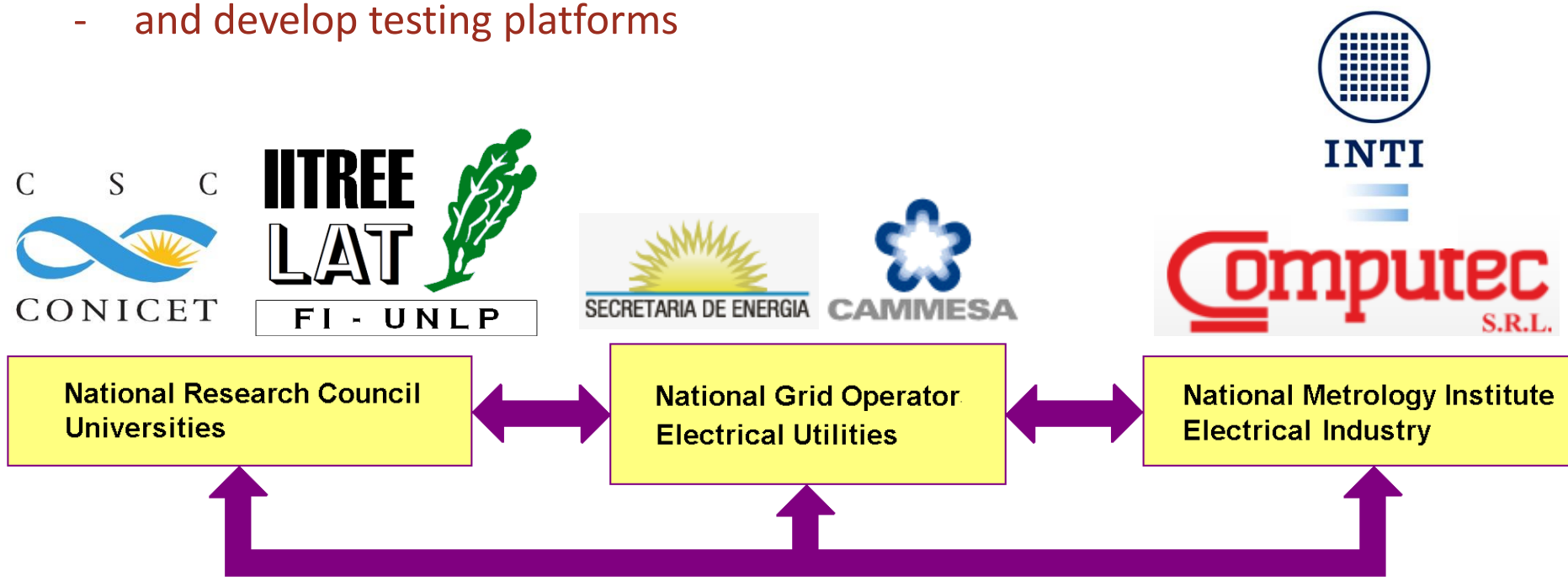
- **Project scope:**
  - ✓ 15 universities participate in the project, covering the 5 geographical regions of the country
- **Main objective:**
  - ✓ Development, dissemination and educational use of the SPMS technology
- **Aditional benefits:**
  - ✓ 2011 – Beginning of an oficial partnership between UFSC and the National Operator of the Brazilian Power System (ONS) to access the data base of the MedFasee Project



# Synchrophasor Measurement in Argentina

An **Argentinian project** to

- develop a Synchrophasor Measurement System for direct application in the Argentinian Interconnected Power System (SADI),
- establish the basis for its serial production,
- and develop testing platforms



# Argentinian Project Activities

**Activity 1. Development of a commercial IEEE C37.118.1-2011 - compliant PMU**


**Component 1: Testing and selection of algorithms for synchrophasor estimation**

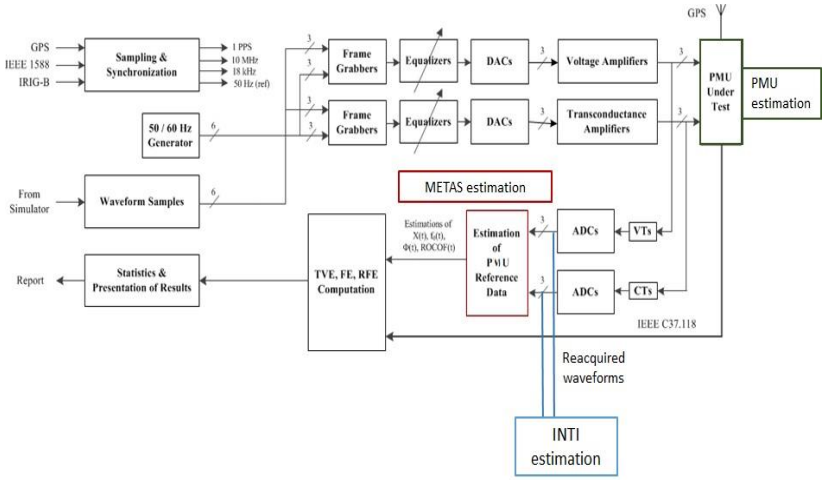
**Component 2: Development of voltage and current transducers to reduce signal magnitudes to PMU input requirements**

**Component 3: Development of PMU communication module**

**Component 4: Implementation of PMU electronics and embedded software**

# Argentinian Project Activities

## Activity 2. Development of PMU testing platform according to IEEE C37.118.1-2011 and IEC 61000




**Component 1: Development of reference system for calibrating PMUs**

INTI

**Component 2: Implementation of Electromagnetic Compatibility and Electric Safety Testing**

INTI

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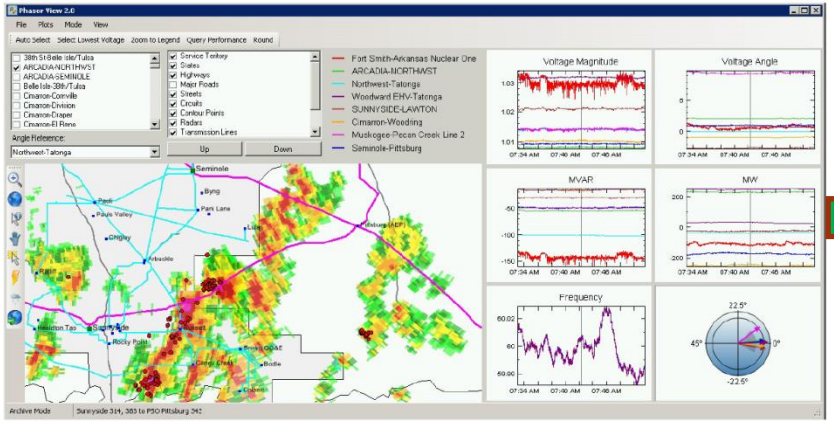
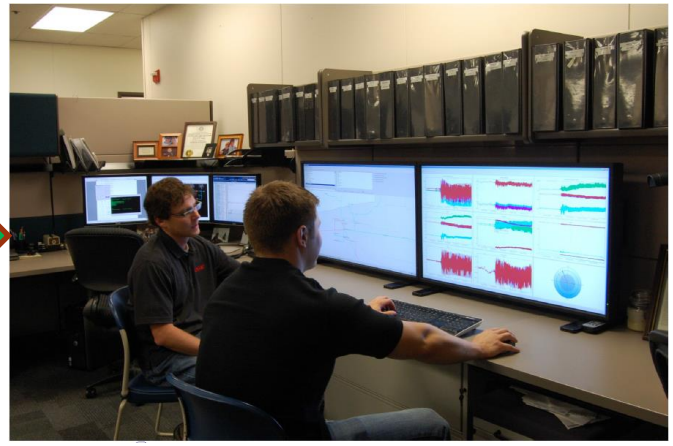
FI - UNLP

# Argentinian Project Activities

**Activity 3. Development of software tools for synchrophasor data processing & analysis. Grid analysis tools are useful for decision & diagnostic based on PMU network data.**



**Component 1: Development and implementation of software for synchrophasor data processing and analysis**

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**Component 2: Optimization of the sensing network**

CSC CONICET

# Sharing experience, insights and knowledge


Creating what's possible together

**Wise Measurements for Smart Grids**

'a smart grid is never smarter than the quality of its measurements'