OE Transmission Reliability Peer Review

Synchrophasor Standards Harmonization

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CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

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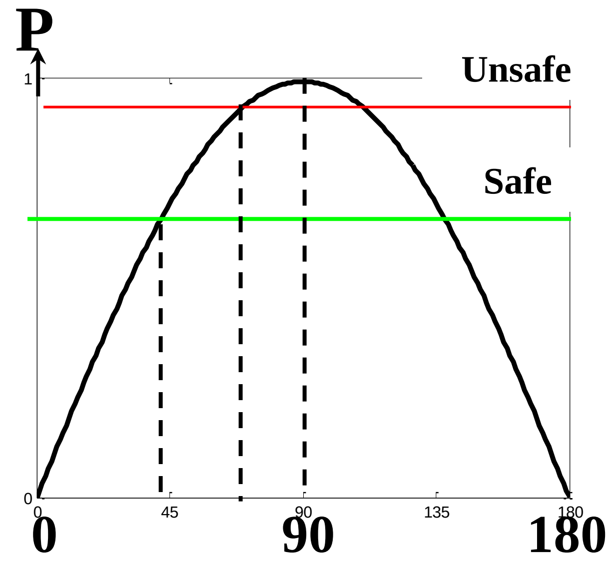
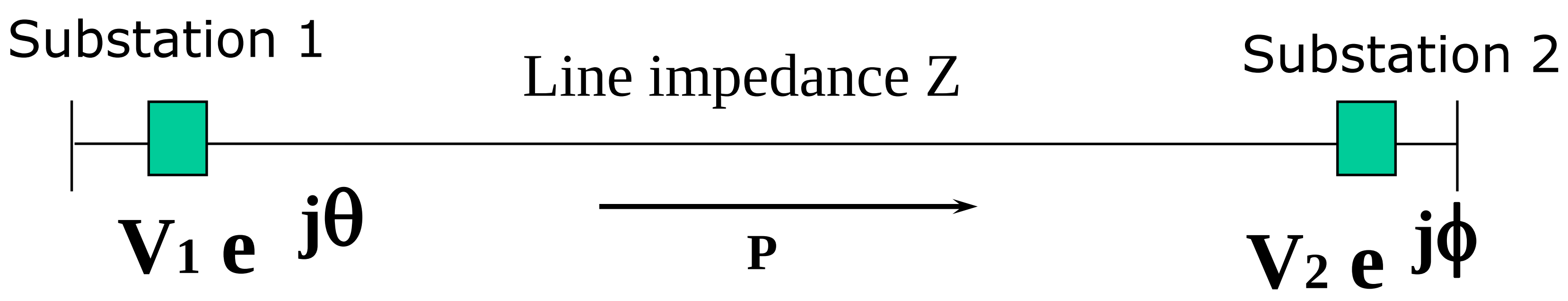
Introduction

- Synchrophasor measurement systems being widely deployed
  - Equipment and systems under rapid development
- Providing a new generation of power system monitor & control
  - Improved power system analysis & models
  - Wide area, high-resolution visibility
- Assurance for interoperability greatly needed
  - Measurement performance
  - Communications
  - Testing
- Common standards for interoperability essential

Phasors represent the power signals for analysis, operation, & control

- Synchrophasors include V & I magnitude
- Synchrophasor values are used to calculate power, frequency
  - $P = V\,I\cos(\theta-\phi) = \mathbf{VI} = V_x I_x + V_y I_y$
  - $Q = V\,I\sin(\theta-\phi) = \mathbf{V}\,(j\mathbf{I})$
  - $F = \Delta(\theta-\phi) / (t_2 - t_1)$
- ***Higher data rates can move point-on-wave measurements, but we still need phasor equivalents for doing the work***





Phasors are difficult to measure; measurements can vary

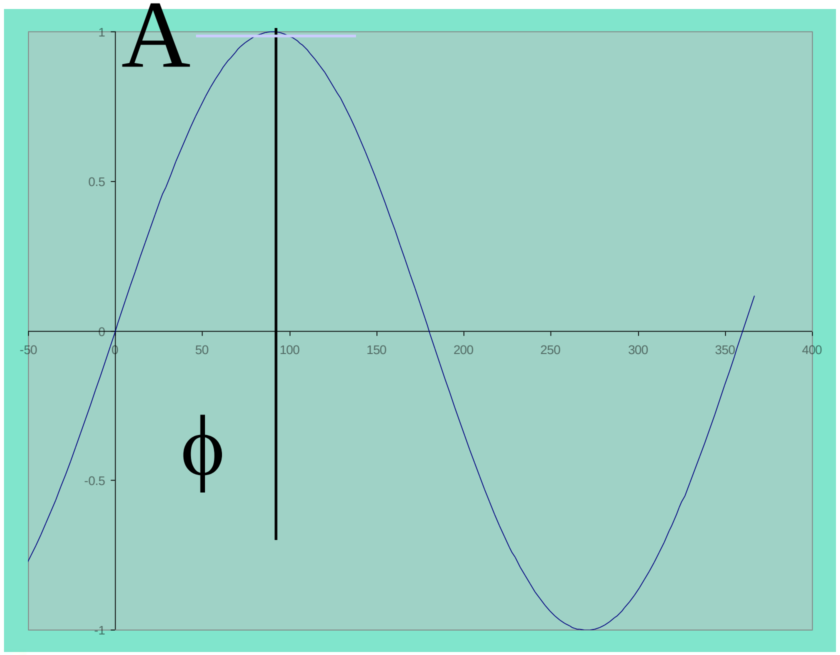
A phasor is the complex form of the AC waveform

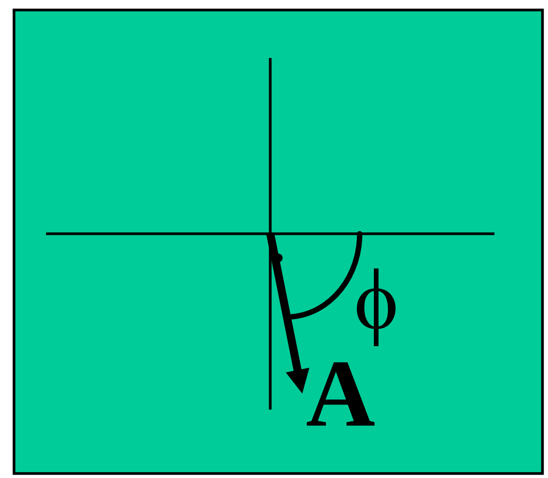
It is a quantity that cannot be read or observed

We need standards to assure comparable measurements

$$\sqrt{2}\, A \cos(2\pi \omega_0 t + \phi)$$

$$A e^{j\phi}$$

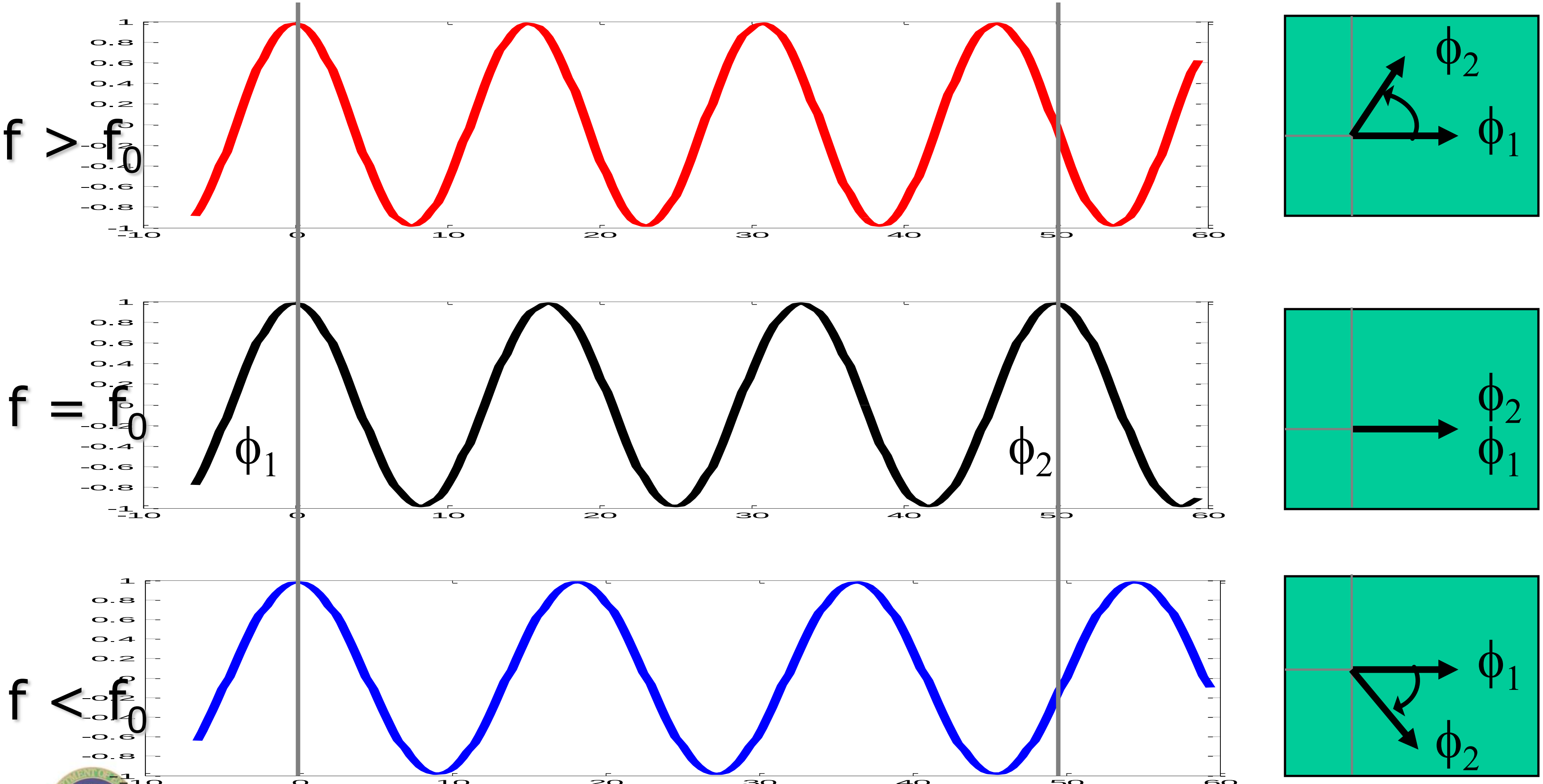




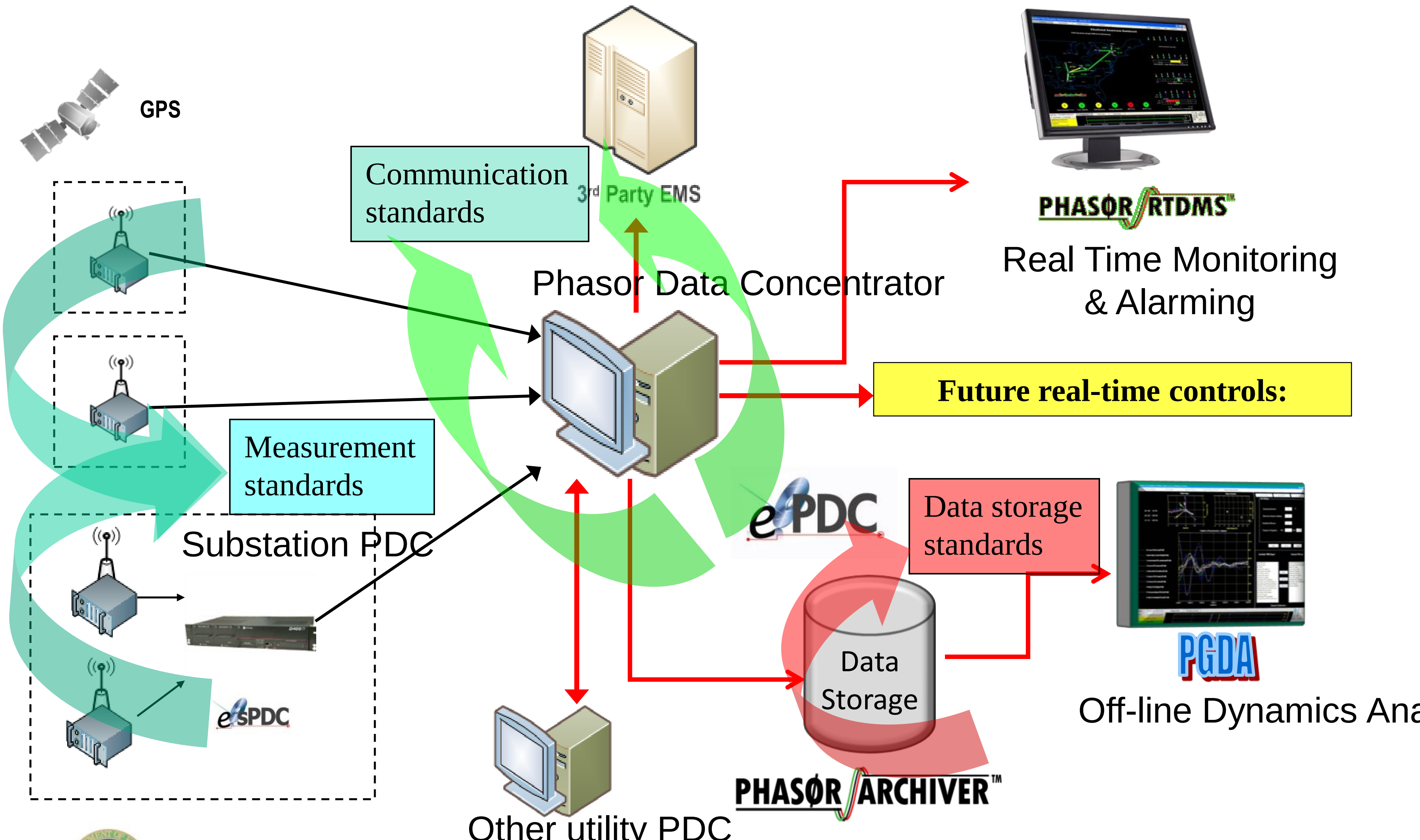
Even steady-state signals can vary

$f > f_0$, CCW rotation; $f < f_0$, CW rotation

Performance requirements & test procedures are required for consistency



Phasor Measurement System



This Project

- Develop & harmonize IEEE & IEC synchrophasor standards
  - Measurement standards
  - Communication standards
  - User and equipment guides
  - Data storage & management
- Support development of technology
  - Assess implementation issues for standards updates
  - Assist in standard & guide interpretations
  - Disseminate information about standards & guides

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Project Impact

- Synchrophasor measurements - key modernization technology
  - Improve situational awareness
  - Improve models for security, reliability, and economy
  - Ensure safe power system operation
  - Facilitate recovery after an event
- Standards are a critical element in systems and technology development & deployment
  - Assure consistent performance and interoperability
  - Supports current infrastructure & projects
  - Provide a development path for longer term

Brief Synchrophasor Standards History

- **IEEE 1344 synchrophasor standard in 1995**
  - Time sync & measurement defined by sample timing
  - Simple communication loosely based on COMTRADE
- **IEEE C37.118-2005 in 2005**
  - Total Vector Error for measurements, steady-state performance requirements
  - Extended data communication profile
- **C37.118.1-2011 – Measurement requirements**
  - Extended for dynamic operating conditions
  - Include frequency and rate of change of frequency
- **C37.118.2-2011 – Communication requirements**
  - Improvements in critical areas, compatible with 2005 standard
- **IEC 61850-90-5 – Phasor measurement communications**
  - Technical Report that adds wide-area capability for phasors

Project Development

- C37.118 split into two parts for IEC harmonization
- Measurement extended with C37.118.1
  - Capability under dynamic operating conditions
  - Requirements for frequency measurement
  - Expect adoption by IEC TC 95
- Existing systems supported with C37.118.2
- New communication profile for synchrophasors in IEC TC 57 as part of IEC 61850

Synchrophasor Measurement Standard IEEE C37.118.1 – 2011

- C37.118.1 standard covers phasor, frequency, & rate of change of frequency (ROCOF)
- Improved phasor, frequency, & ROCOF measurement definitions
- Updated existing steady-state requirements
  - Temperature variation, frequency range, current magnitude range
- Added measurement requirements under dynamic conditions
  - Modulation, ramp, & step tests (determine bandwidth & response time)
- Added requirements for frequency & ROCOF measurement
- Annexes for measurement interpretation & sample algorithms
- Time annex includes IRIG-B profile from previous standard
  - Updated for compatibility with IEEE 1588

Synchrophasor Data Transfer Standard IEEE C37.118.2 – 2011

- C37.118.2 covers communication portion of 2005 standard
- C37.118 communication covers messaging only
  - Describes messaging structure & contents
  - Can use any communication protocol or hardware
    - TCP/IP & UDP/IP methods well established by industry
- Backward compatible with 2005 standard
  - Same messages and content as previous version
  - Changes are detectible by old and new versions
- Added new configuration message
  - Extendable for large data sets (remove limitations for developments)
  - Include fuller data and measurement definitions
- Added time quality & clarified definitions

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IEC 61850-90-5 Synchrophasor

- New development for synchrophasors
  - Based on current C37.118 usage & established practice
- Extensive use cases establish requirements
- Modeling establishes logical devices & nodes, and communications
  - PMU uses MMXU or MSQI logical node
  - PDC is a proxy server or gateway
- New R-SV and R-GOOSE (routable sample values & event data)
  - Previously restricted to local substation net
- Security model includes optional end-to-end encryption
  - Key management & message details referenced
- Services describe messaging semantics
  - Details for existing & new variable assignments provided
- Message structure defined in detail

NERC adoption of 61850-90-5

NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Announcement

New Technical Standard for Synchrophasors Adopted by the International Electrotechnical Commission

May 18, 2012

ATLANTA – The North American Electric Reliability Corporation (NERC) and the North American SynchroPhasor Initiative (NASPI) is pleased with the International Electrotechnical Commission's (IEC's) adoption of a technical standard that establishes improved synchrophasor data communication. The approval of technical interoperability standards is an important milestone marking the maturity synchrophasor technology and systems. Further, industry consensus allows manufacturers to standardize their offerings.

"Adoption of this IEC standard supports the integration of synchrophasor technology into day-to-day grid operations," said Mark Lauby, vice president and director of Reliability Assessment and Performance Analysis at NERC. "We appreciate the hard work of volunteer experts from IEC, the Institute of Electrical and Electronics Engineers (IEEE), NASPI and the federal government who contributed to the development of this technical standard."

IEC 61850-90-5 is one of several key technical interoperability standards adopted to advance smart grid technology. The new standard addresses delivery of high-speed data collected by synchronized phasor measurement devices over wide-area

COMTRADE C37.111 – Schema for Synchrophasor Data

- Schema uses standard COMTRADE features
  - Will follow all COMTRADE updates
- Preserves important features of synchrophasor data
- Includes all data quality indications
- Completed & approved in 2009
- Will be included as an annex in the latest revision
- Has been implemented by several companies

Guide for PMU Synchronization, Calibration, Testing, & Installation PC37.242

- Guide drawn from NASPI documents of same topic
- Synchronization
  - Describes time sources, connections, and problems
- Measurement accuracy
  - Analyzes accuracy contributions & limitations from complete measurement chain
- Installation, commissioning and maintenance
  - Recommended guidelines and procedures for given steps
- Test and calibration
  - Required test equipment and methods to confirm PMU performance
  - Probably most important part of guide
- Extensive annexes with supplemental information

PDC Guide PC37.244

- Expectation for PDC not clearly defined
  - Lengthy discussion of processes
  - Decision to publish as a guide
- Functional descriptions
  - Defines and describes all functions a PDC could perform
- Functional requirements
  - Lists which functions should be required for all PDCs
- Testing requirements
  - Defines tests and outlines a test plan

2012 Deliverables

- C37.118.1 & C37.118.2 completed in October 2011
  - Published December 2011
- IEC 61850-90-5 completed in October 2011
  - Published in May 2012
- PC37.242 first ballot finished in April 2012
  - Publication expected in September 2012
- PC37.244 completion expected in July 2012
  - Publication expected in December 2012
- May initiate C37.118.1/.2 revisions in 2012

Risk Factors

- **The C37.118.x standards are developmental**
  - Technology is new and not fully developed
  - Risk making requirements that cannot be met
  - Risk industry non-acceptance
- **Approach to minimize risk**
  - Industry professionals included in development
  - Comments from world-wide audience
  - Following testing for compliance to revise if needed
- **Other synchrophasor standards support 37.118 or cooperate with it**

Current issues

- **Design & implementation**
  - Designs inadequate to serve purpose
  - Installations without competent validation
- **Inadequate maintenance**
- **Implementations vary**
  - Different interpretations of standards
  - Complexity of standard prevents consistent practice
- **Progress & obsolescence**
  - New development not backward compatible
  - Progress slowed by current development

Follow-on for 2013

- **Present information on IEEE standards and guides**
  - Meetings, workshops, conferences, NASPI, utilities, etc.
- **Solicit feedback on implementation & use issues**
  - Monitor and coordinate with NIST, University & other test beds
  - Gather information from NASPI participants
  - Initiate revision process to correct problems & errors
- **Coordinate further development**
  - IEC 60255-118-1 synchrophasor proposal
  - Chinese synchrophasor standard development
- **Implementation of 61850-90-5**
  - At least one vendor working on software drivers
  - EPG looking for utility partner for field demonstration

End of presentation

Questions?