Next Generation EMS Control Center

JST-NSF-DFG-RCN
Workshop on Distributed Energy Management Systems

Washington DC
April 20th, 2015

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A Modern EMS Control Center

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EMS Functions

SCADA
(Supervisory Control and Data Acquisition)

- SCADA
- Loadshed
- Historical Recording

NETWORK

- State Estimator
- Powerflow
- Contingency Analysis
- Security Enhancement
- Optimal Powerflow

GENERATION

- AGC
- Study Functions
- Load Forecast

System Functions

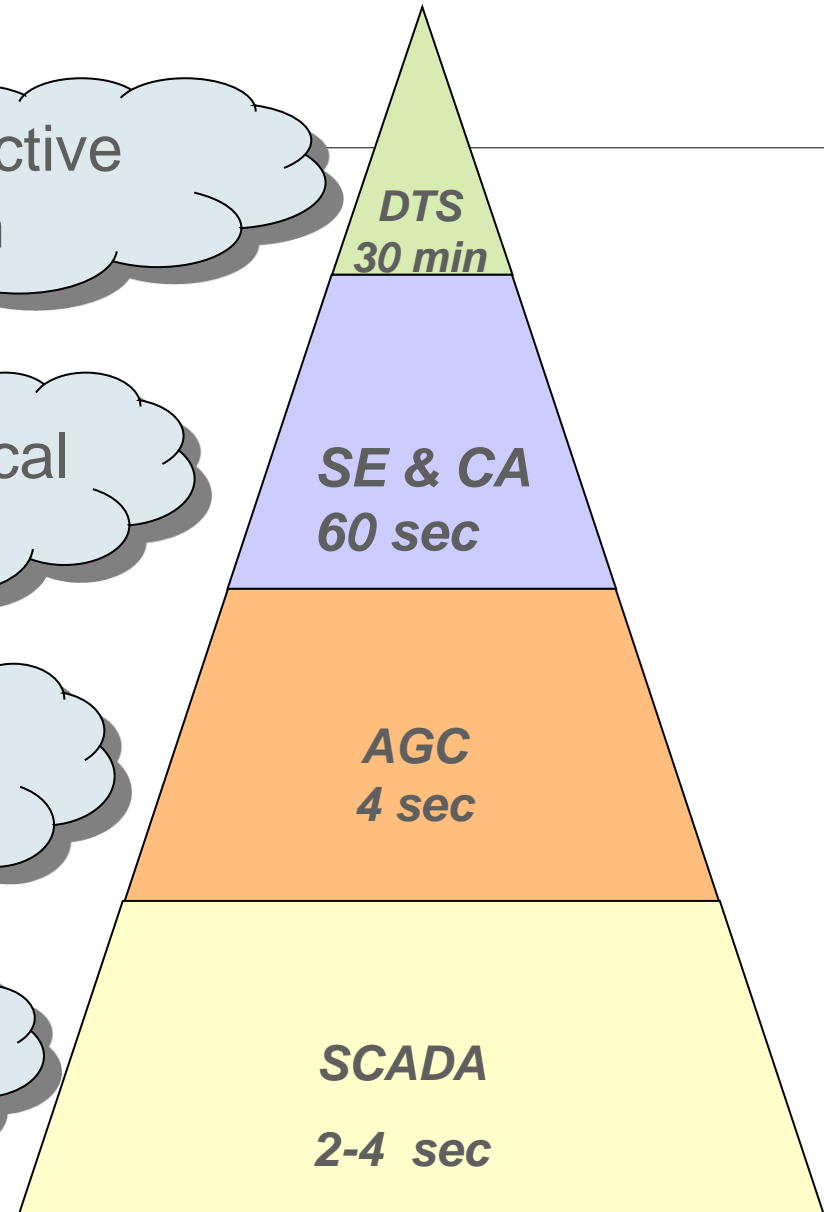|	
Communication Server Data Acquisition	Real-Time Database
User Interface	Inter Control Center Communication
System Modeling	Historical Data Warehouse

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EMS Analysis Tools

Fiscal Brain

Proactive Brain

Market System Tools

Analytical Brain

Reactive Brain

Eyes

DTS 30 min

SE & CA 60 sec

AGC 4 sec

SCADA 2-4 sec

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Evolution of Grid Analytics and Visualization

Data ➝ Information ➝ Insight ➝ Foresight!

Applications 1.0

Applications 2.0

Applications 3.0

Monitoring — Control — Information — Decisions — Action — Exposure — Risk

Visualization 1.0

Visualization 2.0

Visualization 3.0

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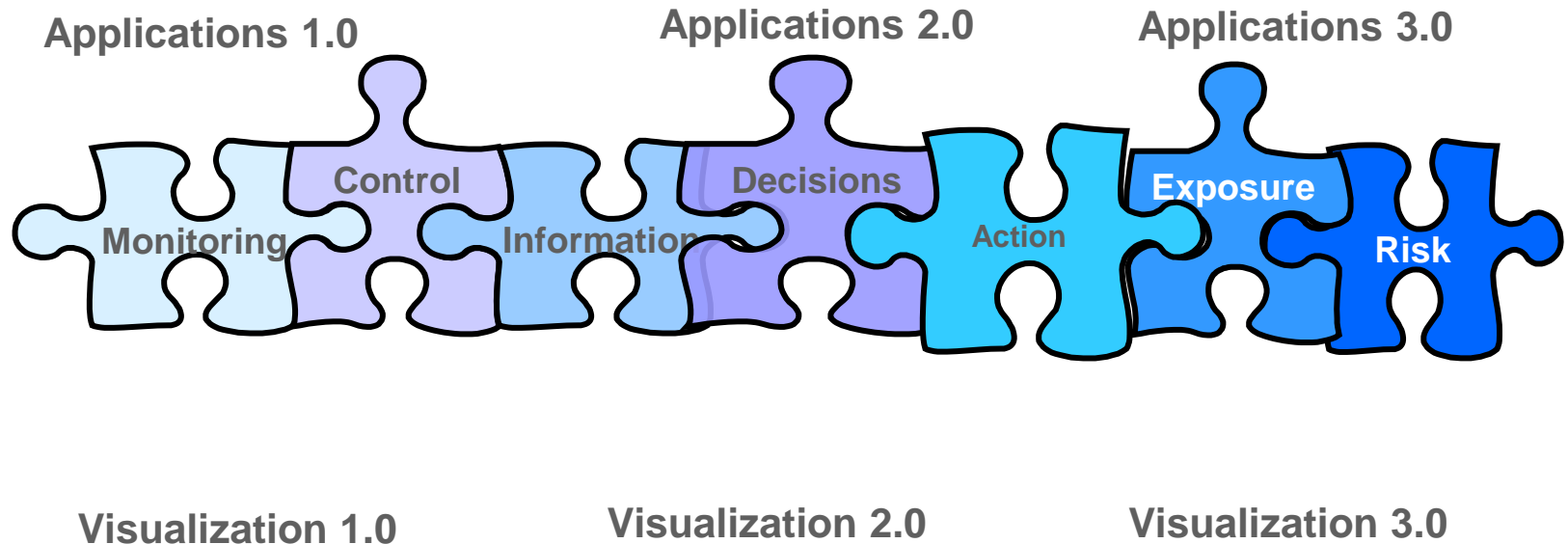
Synchrophasor Technology

- Synchronous measurements:
  - Voltages, currents:
    - a,b,c phases
    - Positive, negative and zero sequnces
  - Frequency, frequency rate-of-change,
  - Status

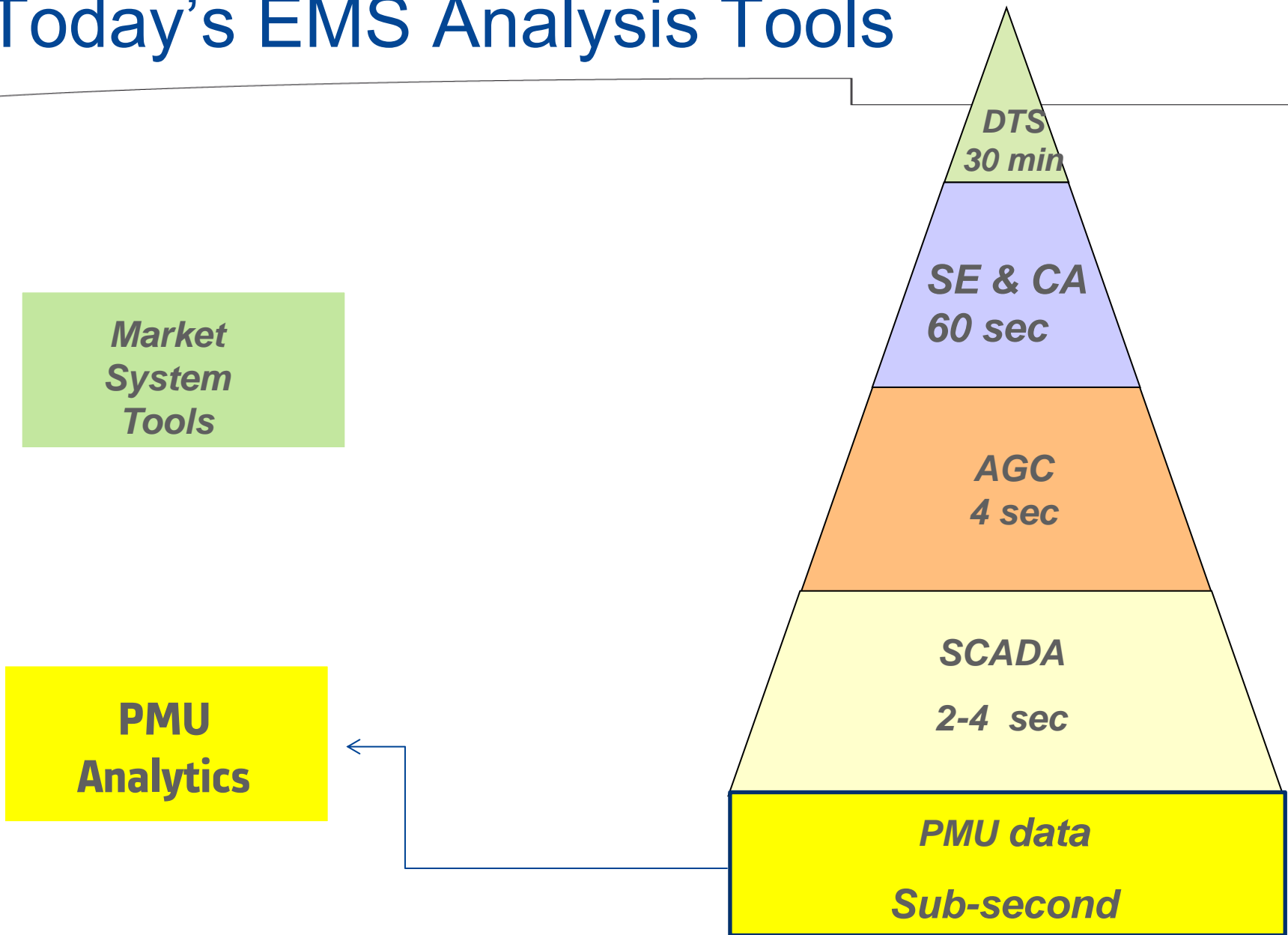- Higher resolution sub-second scans

- Precise GPS time-stamping

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The New SCADA Frontier

SCADA Data - Today	Phasor Data (PMU) - Tomorrow
Refresh rate 2-5 seconds	Refresh rate 30-60 samples/sec
Latency and skew	Time tagged data minimal latency
'Older' legacy communications	Compatible with modern communication technology
Responds to quasi-static behavior	Responds to system dynamic behavior
Frequency change means: Sudden Gen-Load MW imbalance somewhere in the grid	Angle-pair change means: Sudden MW change in a specific location of the grid
X-ray	MRI

Earlier Information for Better Decisions

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The Grid Monitoring landscape is Changing

- <u>Real-time grid measurements moving towards being 50-60 to 100-120 times faster!</u>

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Today's EMS Analysis Tools

Market System Tools

PMU Analytics

DTS 30 min

SE & CA 60 sec

AGC 4 sec

SCADA 2-4 sec

PMU data Sub-second

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August 14th, 2003 Blackout Timeline
Monitor wide area grid stress

An hour to react, analyze & mitigate!

Normal Phase Angle is approx. -25°

1 hour

4 mins

10 SEC

Phase Angles Diverged Prior To Blackout

Cleveland   West Michigan

Relative Phase Angle

Time (EDT)

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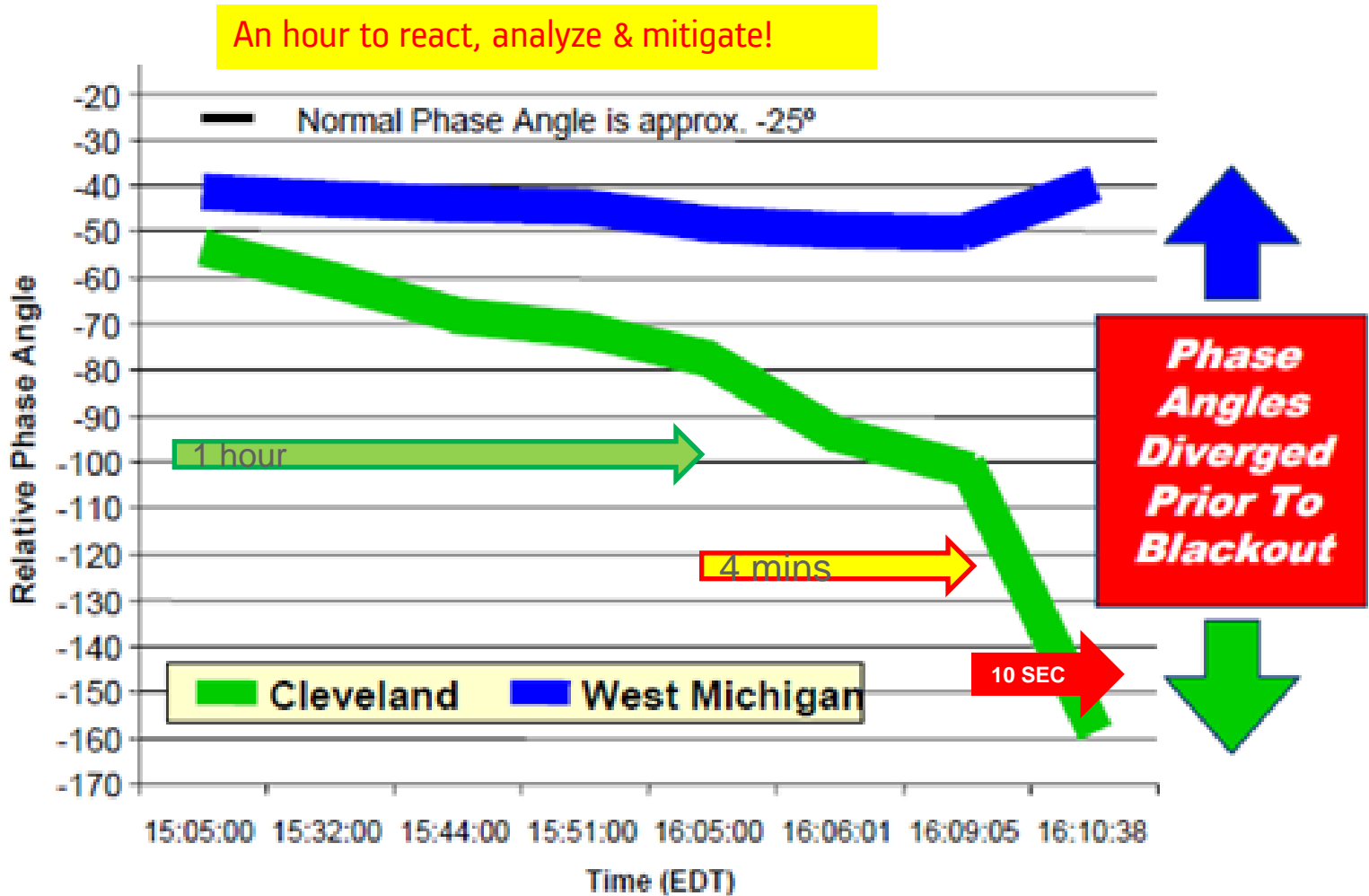
Integrated "Measurement-Based" and "Model-Based" Stability Analysis

Current Operating Point

EMS Limit

New Limit

Safety Margin

True Limit

Monitoring

PMU Measurement-based analysis

Improves Model data

Dynamic Limits

Model-based analysis: Corrective actions based on 'what-if' analysis

SynchroPhasor Applications

Dynamic Security Assessment

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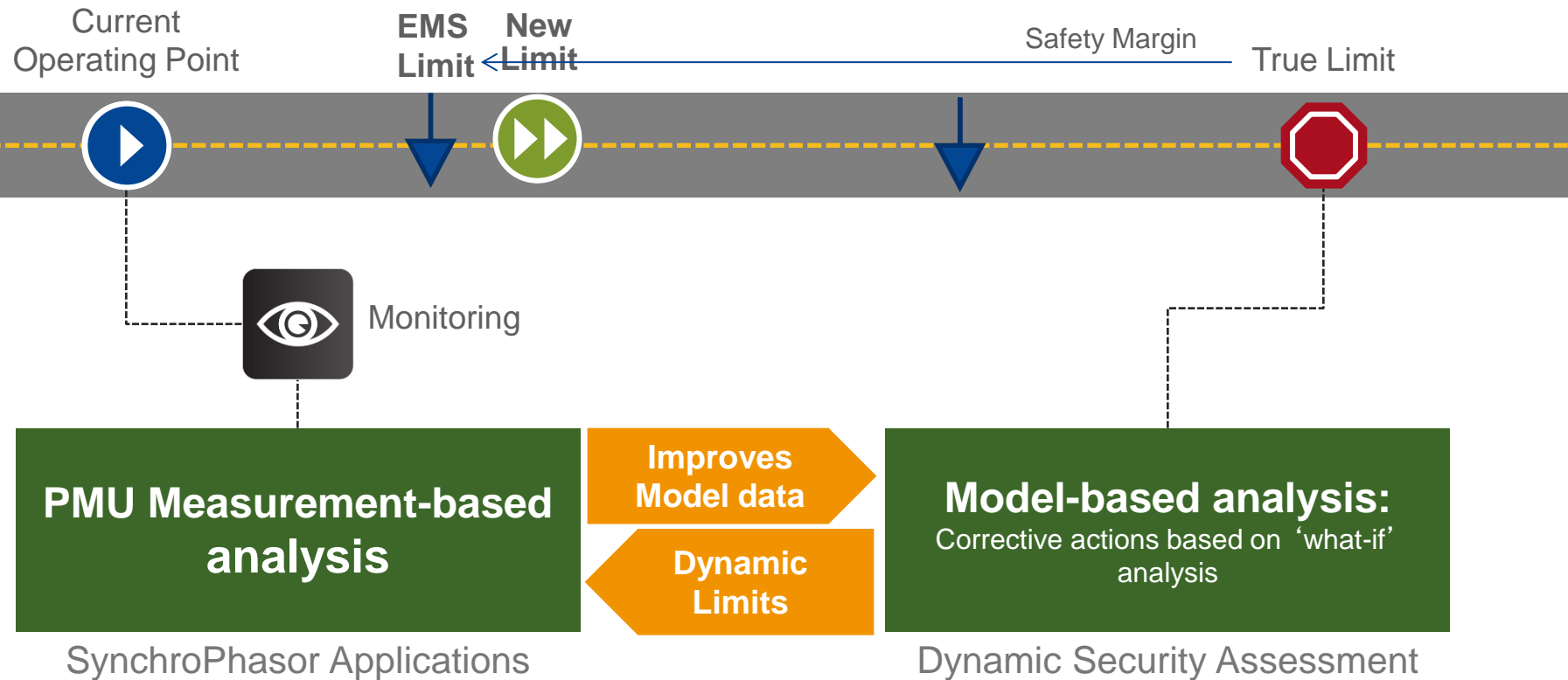
PMU Benefits to Grid Operations…..

- Situational awareness tools

- More Robust, Improved State Estimation

- Fast online stability solutions

- Maximize utilization of congested corridors

- Disturbance Locator

- Identification of coherent groups of generators

- Improved forensic analysis

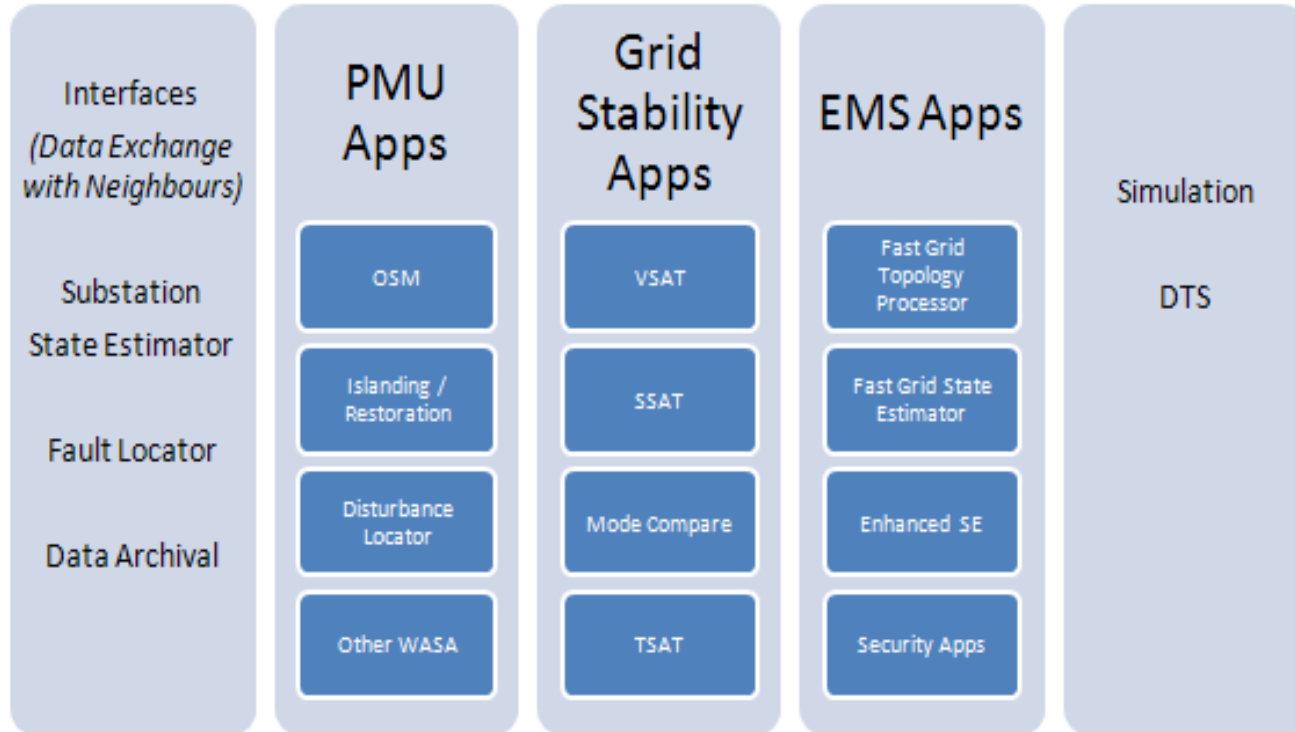**ALSTOM**

I have a fully functional EMS..
Tell me, why do I need Synchrophasor WAMS?

- Observability of the grid - **beyond your SCADA system**

  - Disturbances, oscillations, islanding, angles diverging, overloads, etc

- Detect **undamped grid oscillations** that may lead to a blackout

- **Calculate line impedances** online with a PMU at each end of the line

- Monitor **diverging voltage angles** that may lead to a blackout

- Monitor **low voltage regions & reactive margins** to prevent instability

- **Maximize MW capacity** across existing congestion corridors

- **Immediate online replay of a recent disturbance**

- **Faster forensic, post-event analysis** and detailed event re-creation

- **Detection of islanding** in the grid; assist in **re-synchronization**

  - "Synchrocheck relay for the grid"

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EMS with PMU Analytics

EMS Visualization and Alarming Platform
(Cognitive Task Analysis & Information Processing)

Interfaces *(Data Exchange with Neighbours)*	PMU Apps	Grid Stability Apps	EMS Apps	Simulation
Substation State Estimator	OSM	VSAT	Fast Grid Topology Processor	DTS
Fault Locator	Islanding / Restoration	SSAT	Fast Grid State Estimator	
Data Archival	Disturbance Locator	Mode Compare	Enhanced SE	
	Other WASA	TSAT	Security Apps	

PMU and SCADA Data
(Redundancy/Data Synchronization)

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Control Room Operations

The Next Generation Energy Management System!

EMS

MODEL-BASED Analysis

PhasorPoint
PMU MEASUREMENT-BASED Analysis

Other EMS Applications

| SCADA & Alarms |
| State Estimator |
| Small Signal Stability |
| Transient & Voltage Stability |
| Island Management |

New Applications

| WAMS Alarms |
| State Measurement |
| Oscillation Monitoring |
| Stability Monitoring & Control |
| Island Detection, Resync, & Blackstart |
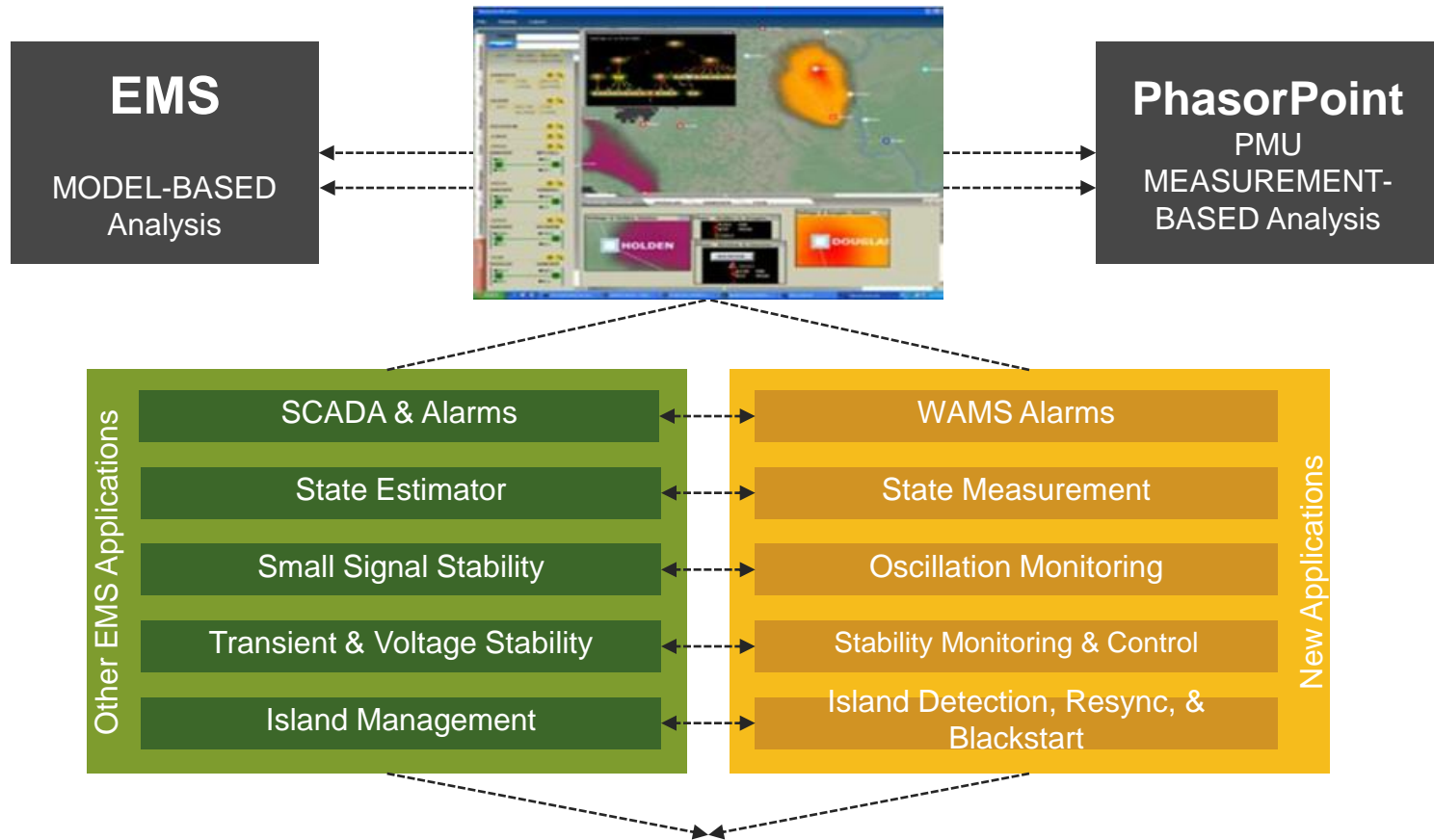
Transitioning from traditional "steady-state" view to enhanced "dynamic" situational awareness.

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Benefits of WAMS
"Model, Measure, Monitor, Mitigate!"

Control Room Operations
Wide-Area situational awareness and coordination across seams.

Create and manage robust real-time variable stability limits.

Add Operational Response Guidance to

Situational Awareness for Critical Conditions

Wide Area Control
Co-ordinated control hierarchy, centralized (via EMS/DMS), or decentralized as appropriate.

Electrical Grid

Control

Operations

Analysis

Engineering Analysis
Big Data Analytics
Risk assessment, data mining, baselining for grid vulnerability.

Analysis tools for condition monitoring, model validation, control tuning, post-event analysis, compliance monitoring.

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DoE Smart Grid Investment Grants Synchrophasor Projects
courtesy DoE, NASPI

Phasor Measurement Units in North American Power Grid

With information available as of September 22, 2009

Legend
- Networked
- Installed
- Aggregators
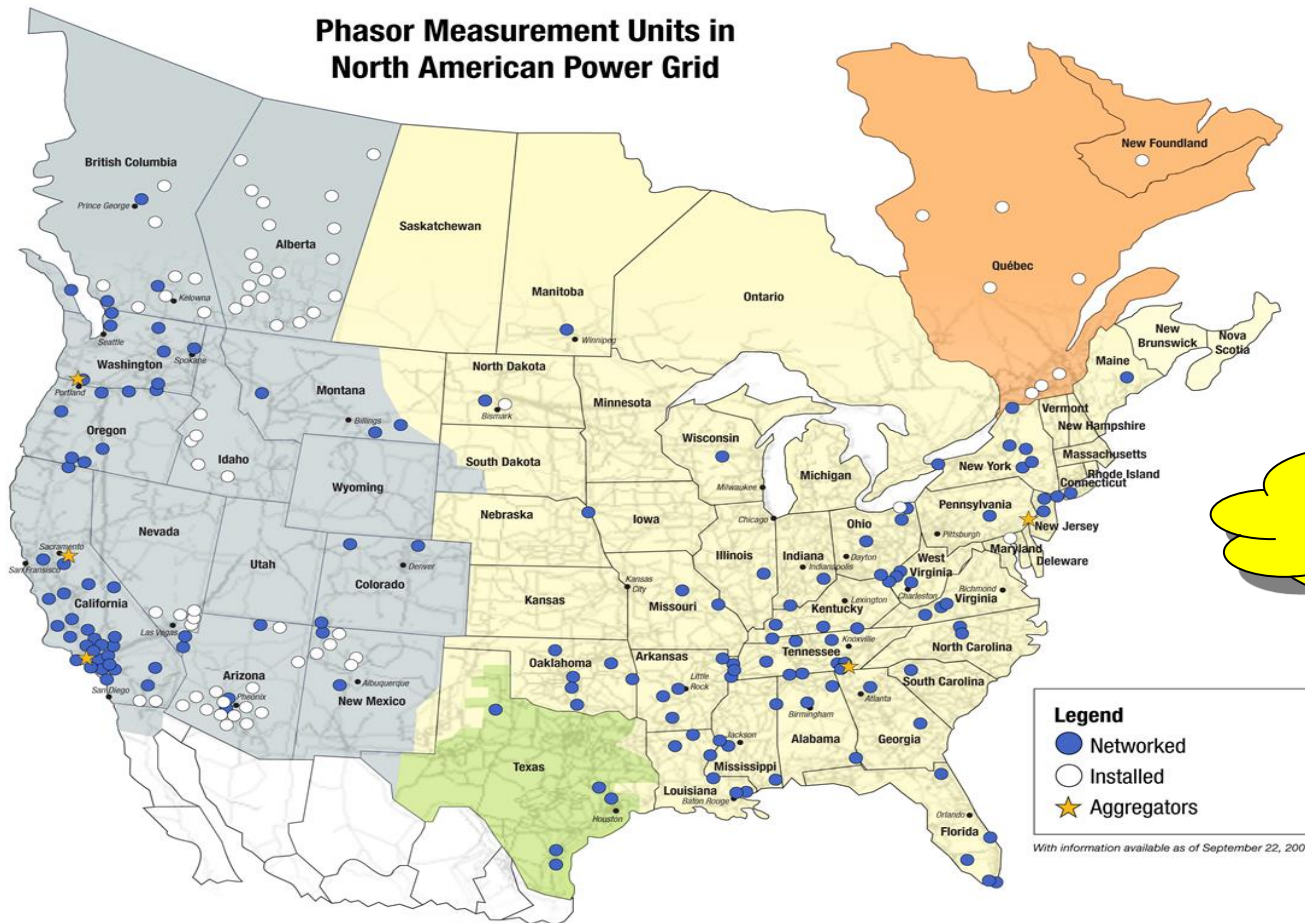
$300M for Synchrophasor projects in 2009

200 PMUs in 2009... 1800+ PMUs by 2015

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India URTDSM
Unified Real-Time Dynamic State Measurement

The World's Largest WAMS Project,

on one of the World's largest Grid Interconnection!

- **Customer**:
  - Power Grid Corporation of India Limited, INDIA

- **Scope**:
  - Two Packages covering all 5 Regions of India
    - Phasor Data Concentrator for 34 Control Centers
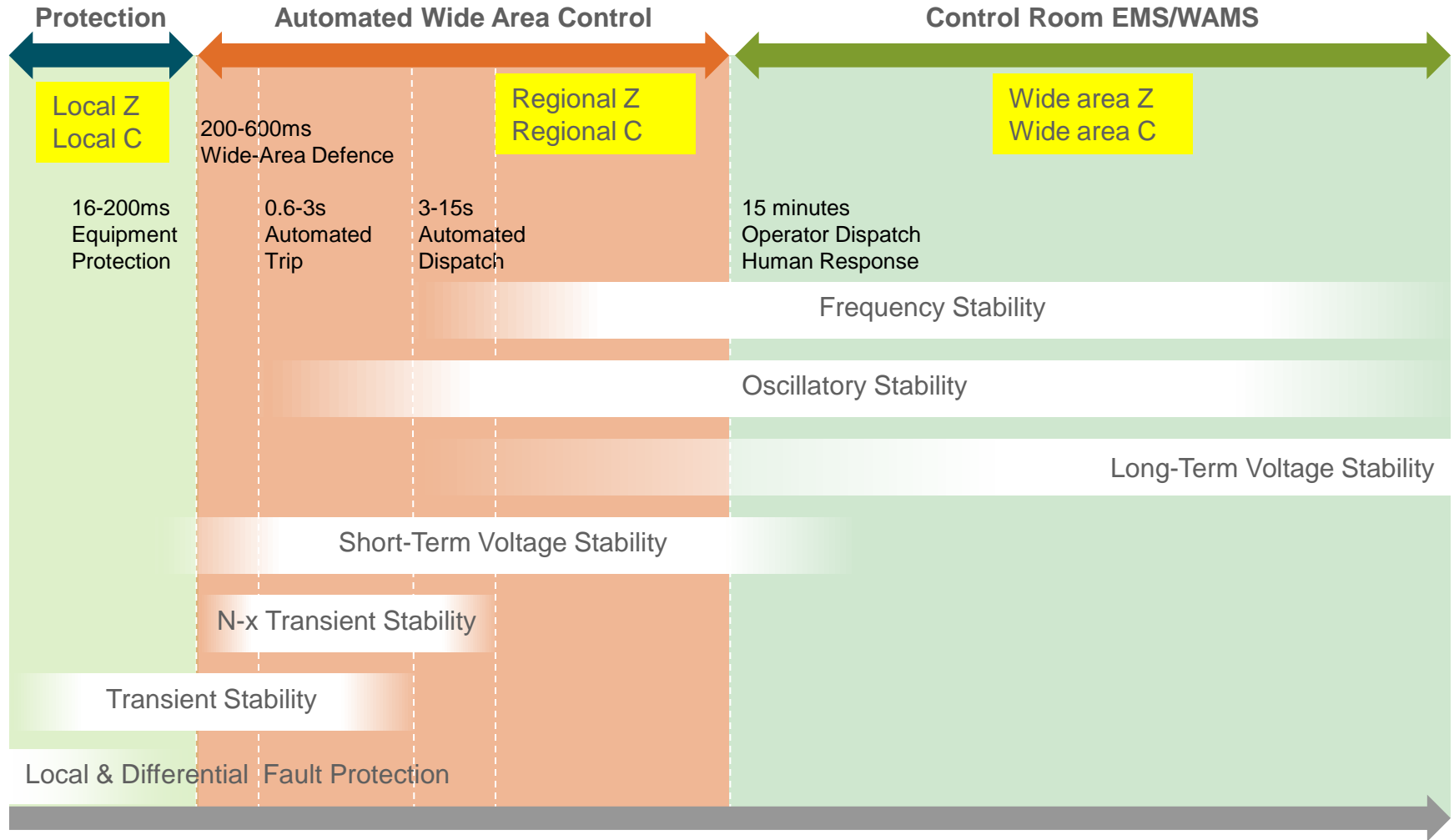   - \> 1000 Phasor Measurement Units for 351 Substations
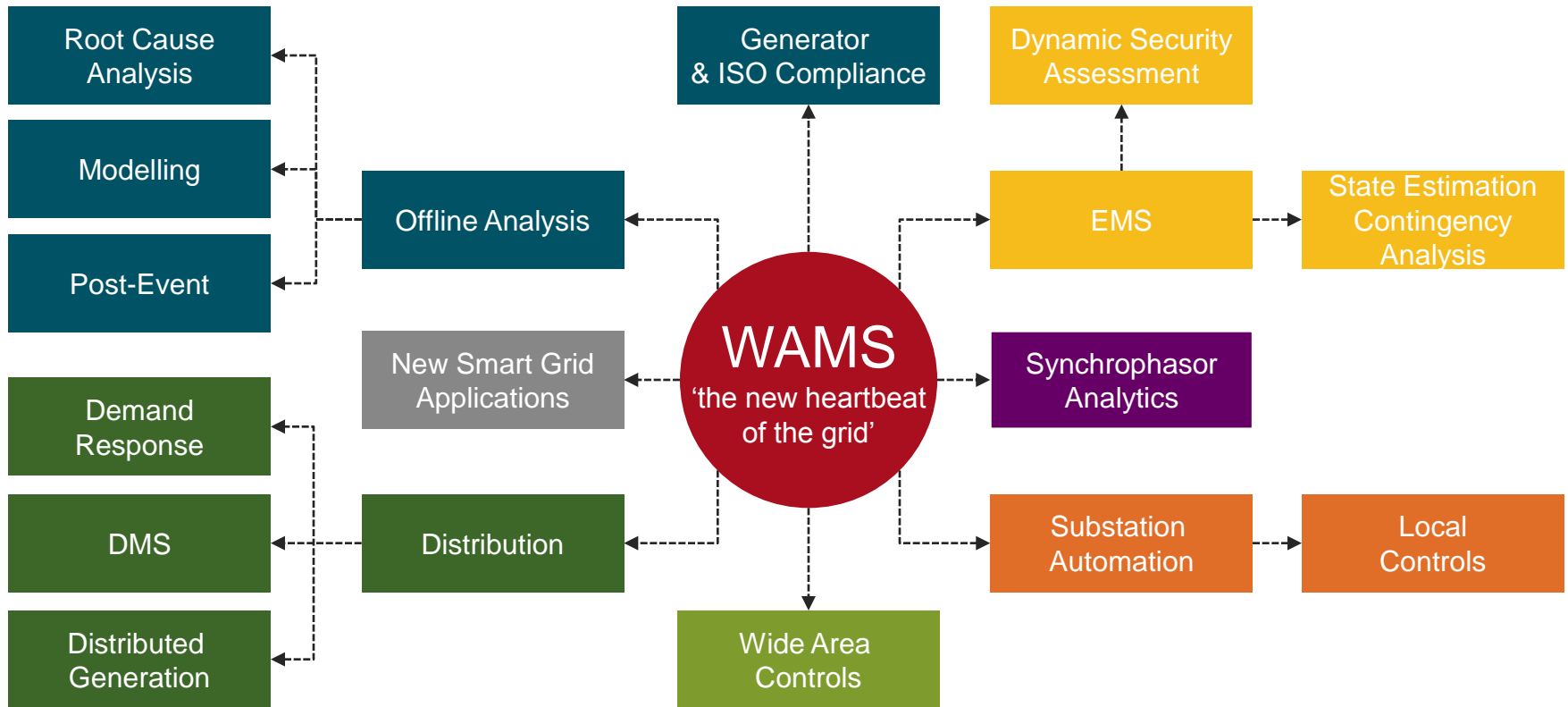
source: www.powergridindia.com

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Wide Area Control

Bridging the grid control gap!

Z – Measurements
C - Controls

Protection	Automated Wide Area Control	Control Room EMS/WAMS

Local Z
Local C

Regional Z
Regional C

Wide area Z
Wide area C

200-600ms
Wide-Area Defence

16-200ms
Equipment
Protection

0.6-3s
Automated
Trip

3-15s
Automated
Dispatch

15 minutes
Operator Dispatch
Human Response

Frequency Stability

Oscillatory Stability

Long-Term Voltage Stability

Short-Term Voltage Stability

N-x Transient Stability

Transient Stability

Local & Differential Fault Protection

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Future Grid Management System

WAMS
'the new heartbeat of the grid'

- Root Cause Analysis
- Modelling
- Post-Event
- Offline Analysis
- Generator & ISO Compliance
- Dynamic Security Assessment
- EMS
- State Estimation Contingency Analysis
- New Smart Grid Applications
- Synchrophasor Analytics
- Demand Response
- DMS
- Distribution
- Distributed Generation
- Substation Automation
- Local Controls
- Wide Area Controls

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''Electrification' was voted the most important engineering achievement of the last century! – US NAE, 2000

"The best minds in Electricity R&D have a plan:

Every node in the power network of the future will be

Awake,

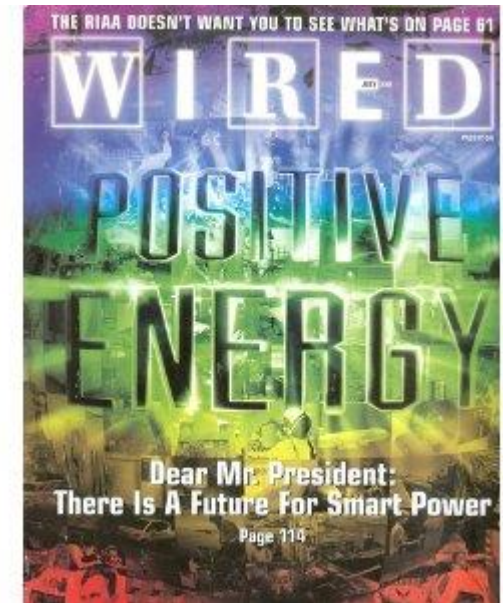*Responsive,*

Adaptive,

Price-smart,

Eco-sensitive,

Real-time,

Flexible,

Humming....

and interconnected with everything else."

July 2001

**Today,
We continue to make
progress towards this!**

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Thank you…

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