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BSI

Real-time PMU-assisted Available Transfer Capability (ATC) computation beyond on-line computation of transfer limits

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Project Background

The following funded research project on Real-time PMU-assisted Available Transfer Capability (ATC) is conducted by **Bigwood Systems, Inc. with NYISO.**

The NYISO has not evaluated or endorsed the research findings in the following presentation.

Overview

- **World-Leader** in Developing Advanced Tools for **Power Grid Monitoring, Analysis, Operation, Optimization and Control**
- Broad software solution portfolio with a focus **on on-line and off-line solutions** for **EMS applications**
- Established in 1995 and 18 patents.
- **Practical software for** Energy control center operators and engineers based on **Innovative Technology with 35 major clients worldwide.**

*Bring **Power** to Innovation!*

Core Products

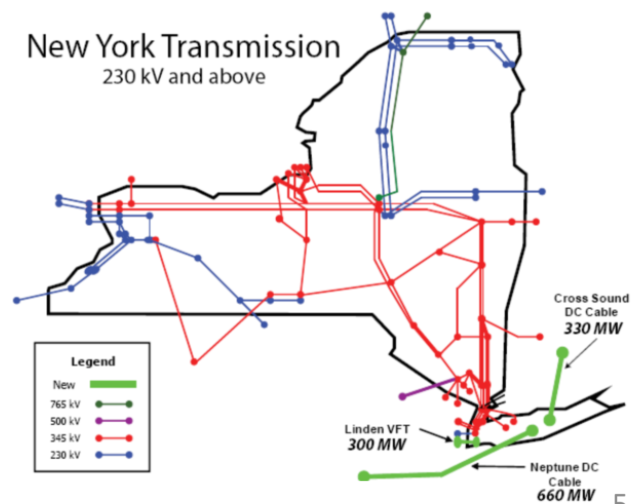
- **System Operating Limit (SOL) Computation for Stability Assessment & Enhancement Control** with system operating limit computation for:
  - **Voltage Stability**
  - **Voltage Violation**
  - **Voltage Drops**
  - **Thermal Limits**
  - **Transient stability**

- **Advanced State Estimator Technology**

Project Background

Currently, Available Transfer Capability (ATC) is calculated based on off-line worst-case scenarios which can be conservative.

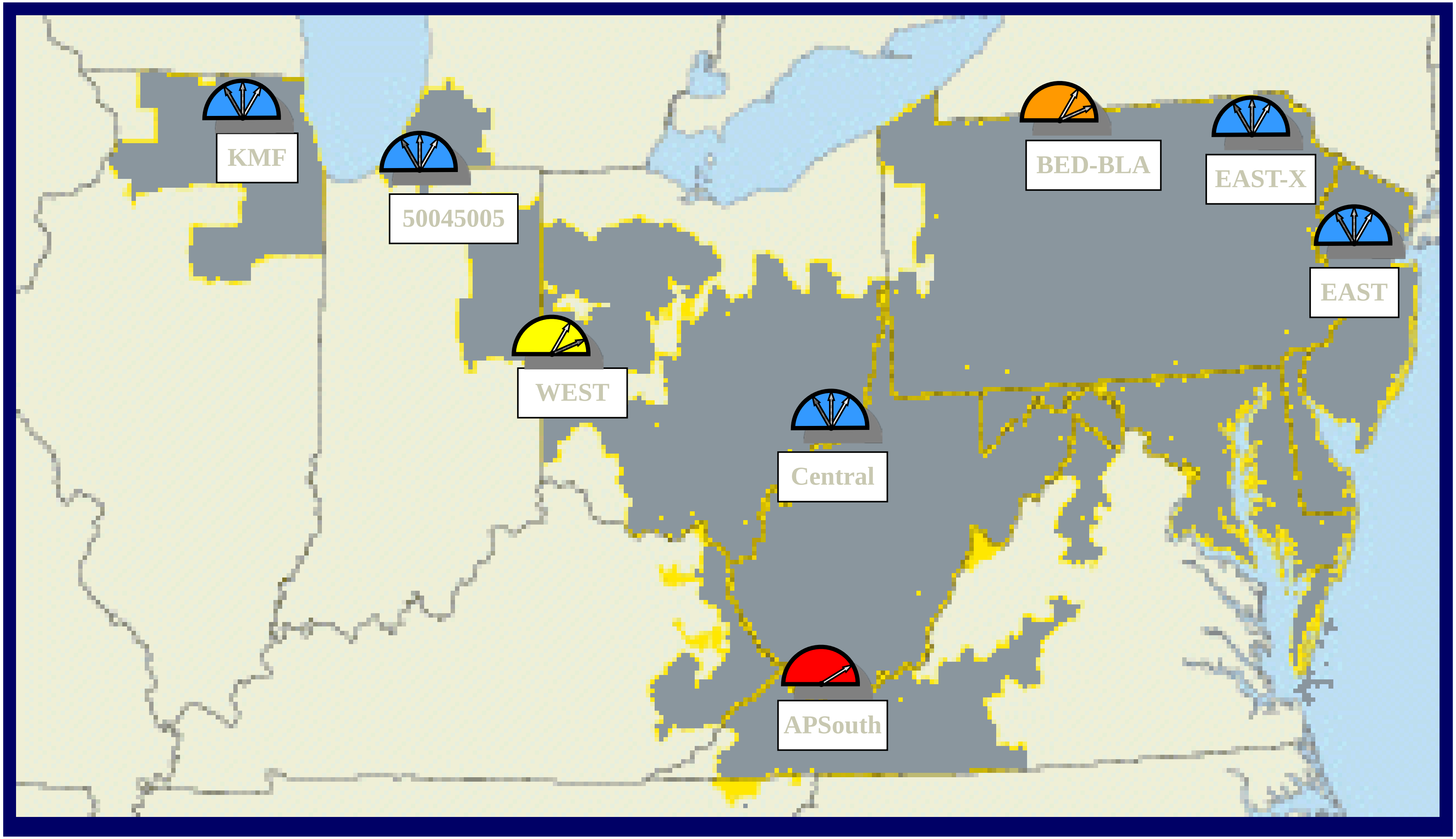
- Transmission assets are substantially under utilized
- Variable renewable energy sources, power transactions, and storage systems can cause new power transfers that need to be seen in real-time



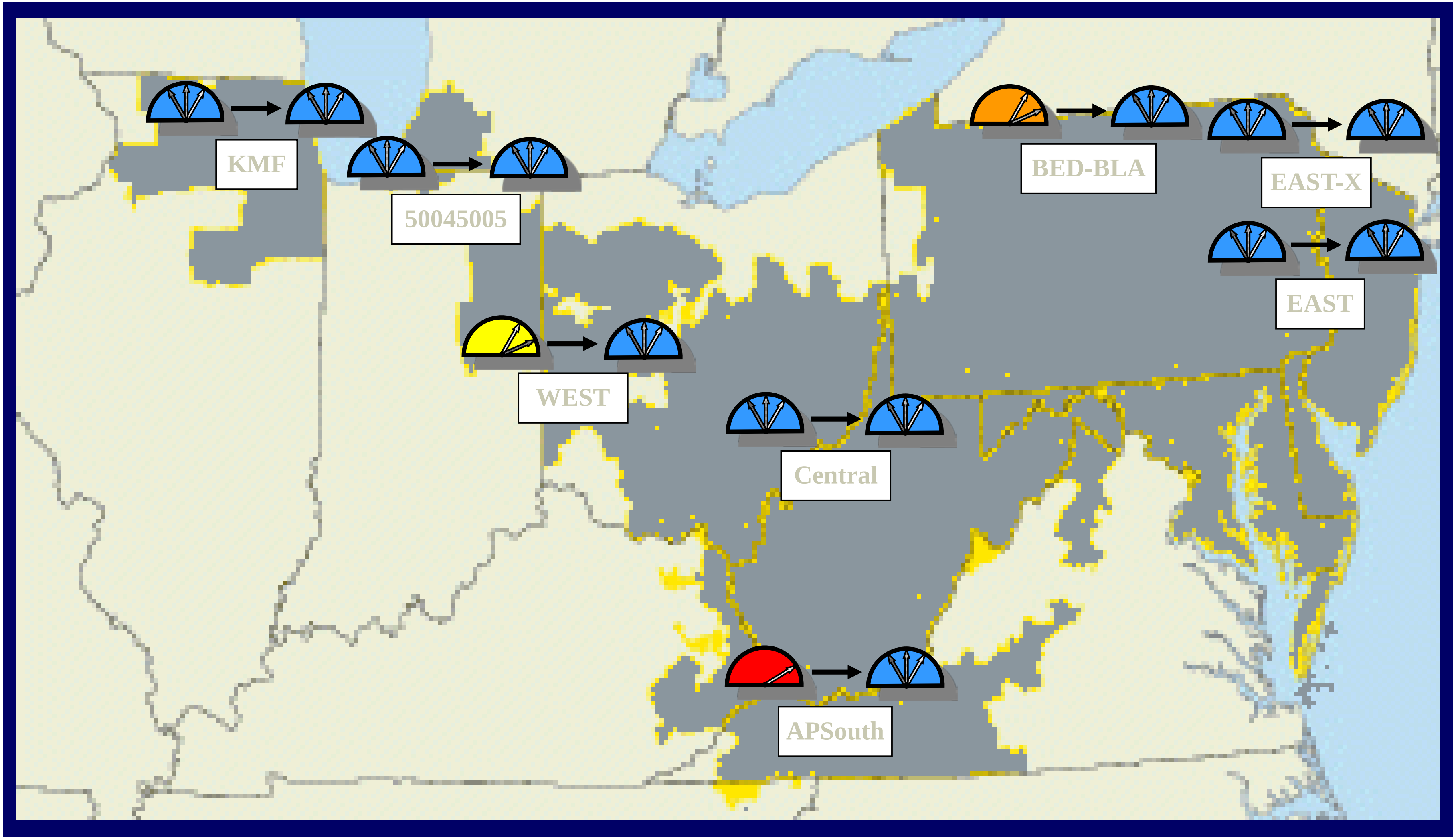
Project Objective

- Project team seeks to use SCADA and PMU data and BSI on-line SOL engine to develop an on-line ATC Computation system to determine **real-time** available transfer capability (ATC)

Monitoring & On-Line Computation
Main Window

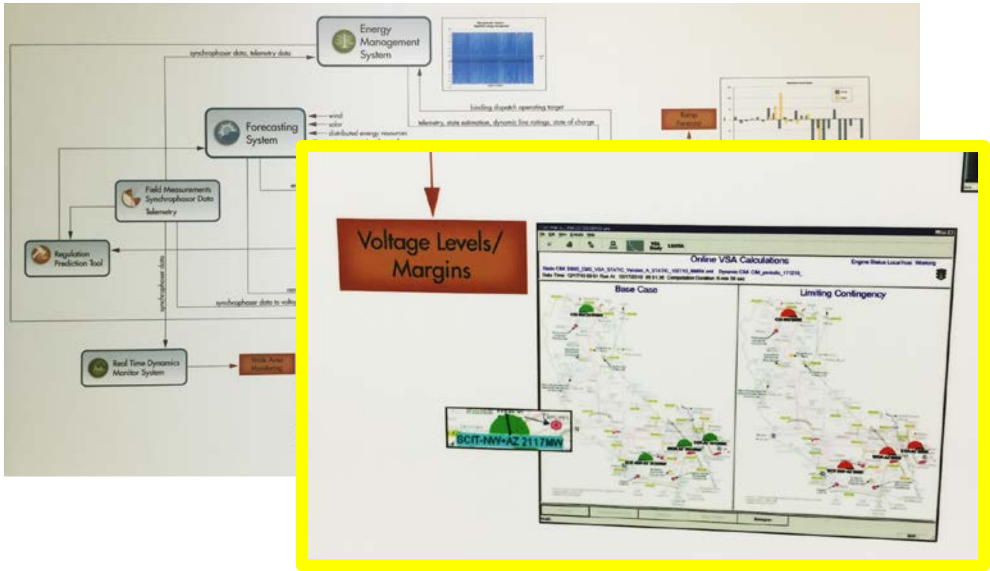


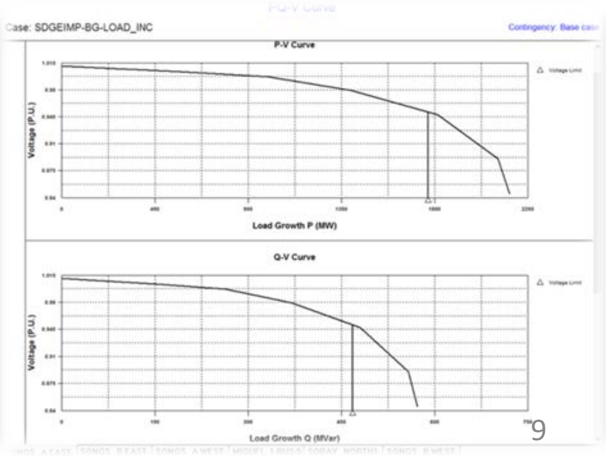
Preventive & Enhancement Control Main Window



BSI On-Line SOL Engine

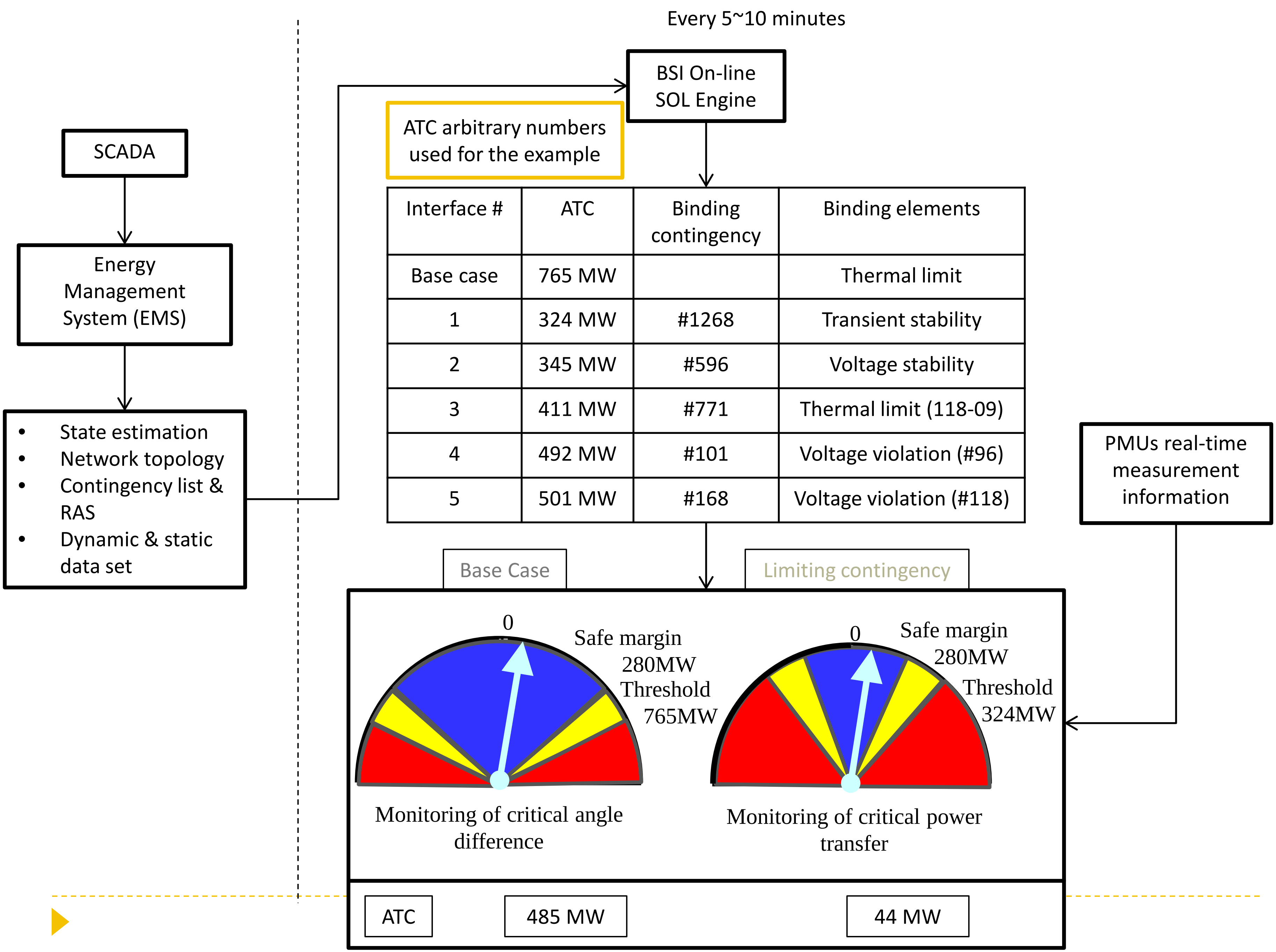
- Core technology used in the on-line ATC tool is the **BSI System Operating Limit (SOL) Computation Engine** which is used as an operating guideline at California ISO (running every 4 minues).
- **Solutions based on 3 U.S. Patents by BSI**





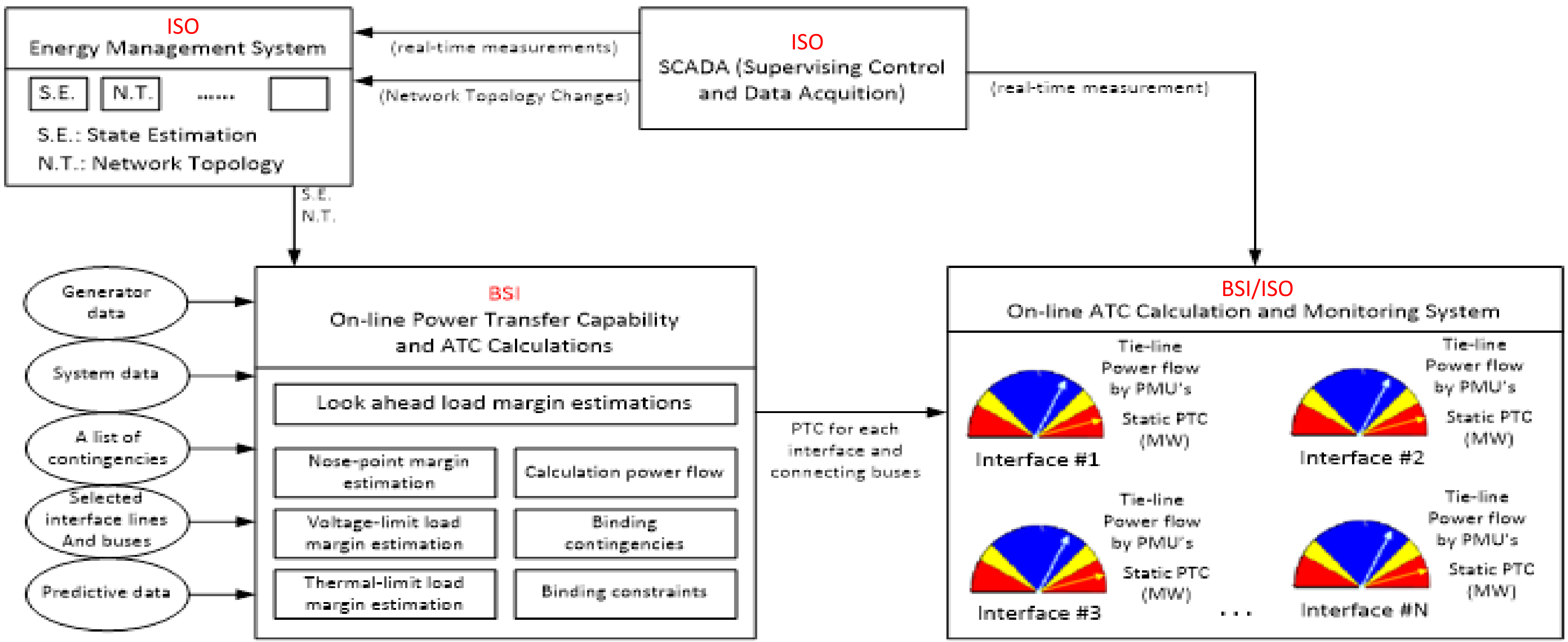
ATC System

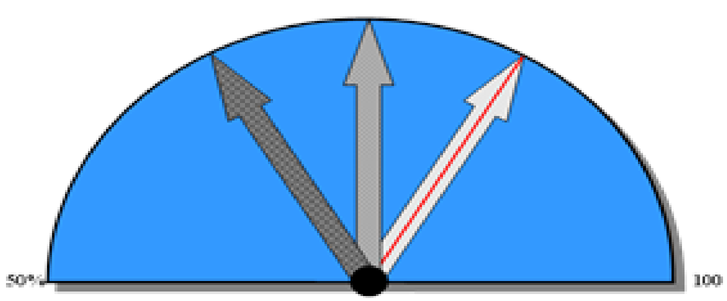
- The ATC System will be composed of
  - ATC Determination Subsystem (based on actual system operating condition)
  - ATC Monitoring Subsystem (SCADA, PMU, and State Estimator)
  - Real-Time Critical Contingency Detection Subsystem.
- **Testing:** System will be simulated off-line with real-time data and benchmarked against current NYISO off-line computation



Interface #	ATC	Binding contingency	Binding elements
Base case	765 MW		Thermal limit
1	324 MW	#1268	Transient stability
2	345 MW	#596	Voltage stability
3	411 MW	#771	Thermal limit (118-09)
4	492 MW	#101	Voltage violation (#96)
5	501 MW	#168	Voltage violation (#118)

ATC Computation and Monitoring System





Voltage Security Threat Key

Red	Danger of Voltage Collapse
Orange	Danger of Thermal Limit
Yellow	Danger of Voltage Violation
Blue	Safe

Voltage Violation Type Key

	Voltage Collapse
	Thermal Limit
	Voltage Violation

Static and Dynamic Security Assessment

- It is imperative in determining the ATC to take into account **all credible contingencies**.

Approaches:

(i) **Look-Ahead Contingency Screening, Ranking and Detailed Analysis,**

(ii) **Real-time detection of the occurrence of Critical Contingency (smart RTCC system)**

Look-Ahead Contingency Screening and Ranking

The objective of look-ahead contingency screening and ranking is two-fold:

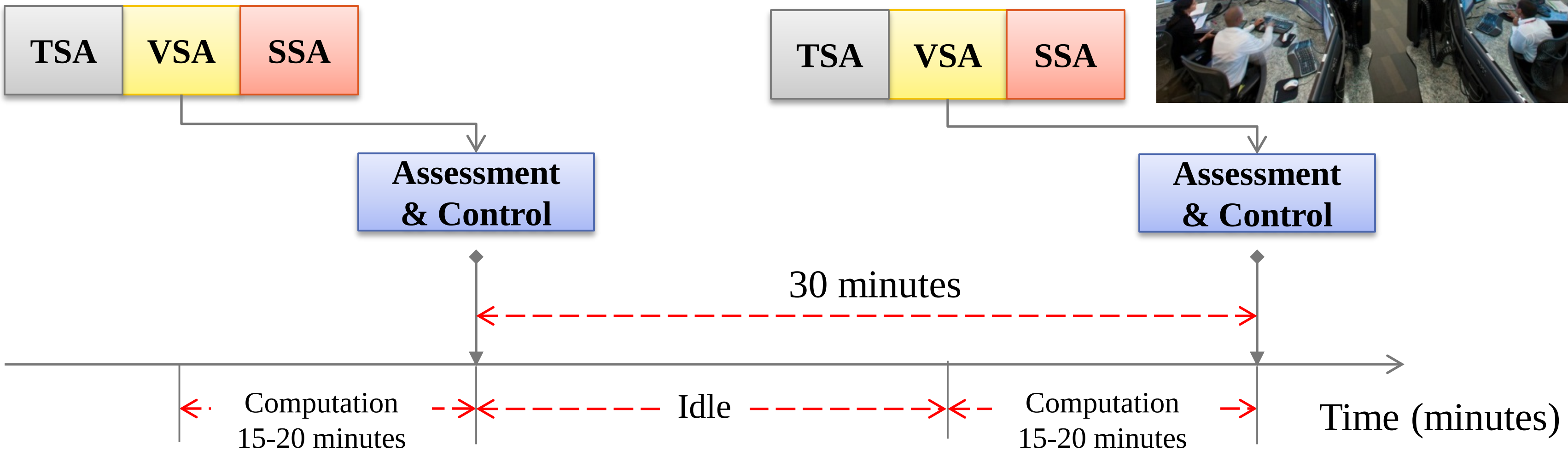
1. **Screen** out (rapidly) set of **insecure and severe contingencies** from a large set of credible contingencies on a power system with committed power transactions
2. **Rank** set of **severe contingencies** according to their impacts on the power systems with committed power transactions.

The following (3) look-ahead ranking lists are thus obtained:

1. Look-ahead ranked list of contingencies for **steady-state stability limit**
2. Look-ahead ranked list of contingencies for **voltage limit**
3. Look-ahead ranked list of contingencies for **thermal limit**

Why we need Real-Time Critical Contingency (RTCC) Detection

- Current generation
  - On-line Security Assessment and Enhancement

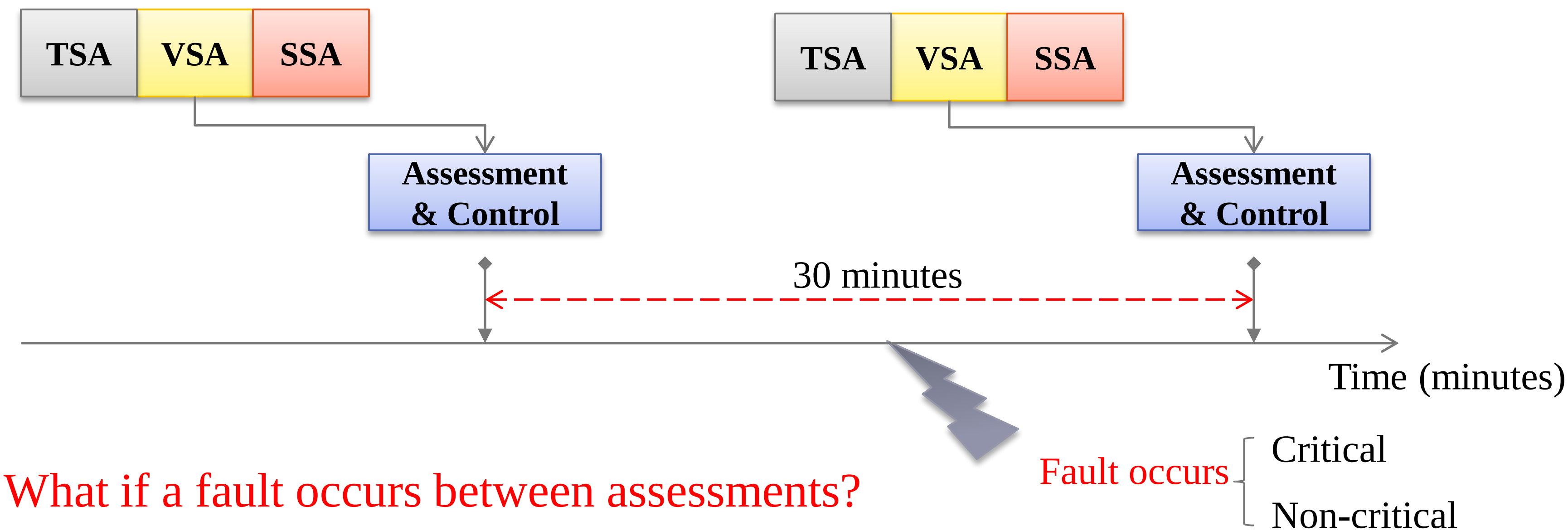


- Goal:
  - Meet (N-1) criterion at all time

Current EMS can't meet with this criterion !

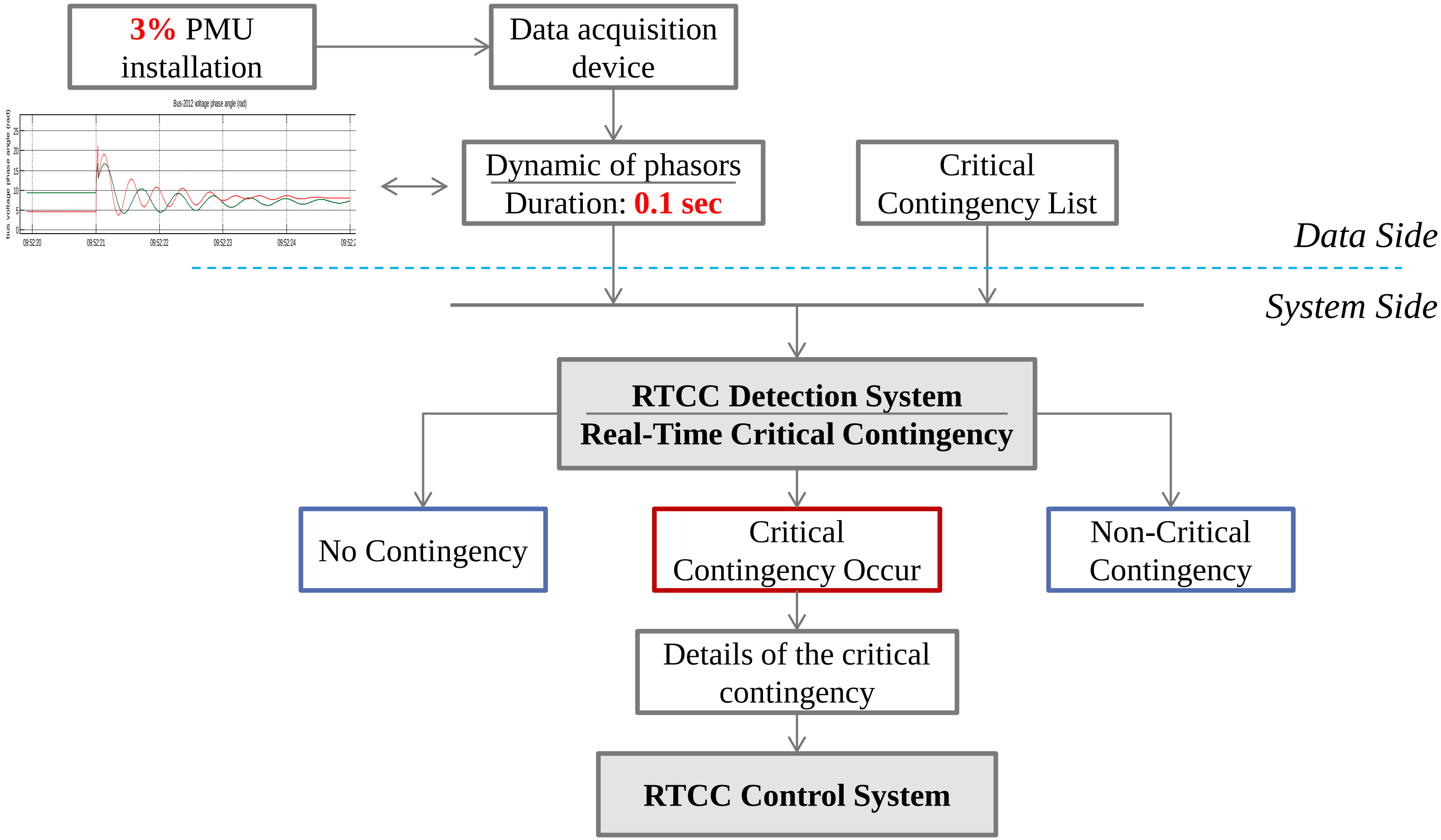
- Assumption:
  - No critical contingency occur between each security assessment

Why we need RTCC detection



- What if a fault occurs between assessments?
- Problems:
  - (N-1) criterion can be violated (i.e. the possibility of system instability increase
  - System security is at risk
  - The intermittence of renewable energy can worsen the situation
  - At present, operators cannot obtain the occurrence of critical contingencies in real time

RTCC Detection System



Data Flow

Input

- Solved Power Flow solutions
- Network Topology
- Contingency List
- Interface (Flow gate) definition
- Look-Ahead Conditions
- Actual Power Transfer of each interface (via PMUs or SE)

Output

- ATC for Entire Network
- Binding Contingencies
- Violating Elements

Violations detailed include:

- Thermal Limit
- Voltage Limit
- Voltage Stability

Data formats include PSS/e and CIM/XML

Output on ATC Display Interface

Project Benefits

Real-Time ATC will provide several benefits including:

- ✓ **Energy benefits** (on-line reliability improvement and the ability to transfer more power from renewable energy resources based on on-line calculation)
- ✓ **Environmental benefits** (support more penetration of renewable energy reducing pollutant emissions from conventional generators)
- ✓ **Economic benefits** (remove transmission congestion to allow the transfer of low-cost energy resources to load centers)
- ✓ In compliance with the recommendation from NERC regarding ATC calculations.
- ✓

On-line ATC system provides a more accurate ATC calculation based on on-line data.

Data Used

BSI used the following data:

- EMS Case
- Contingency and Interface Definitions
- Substation limits
- Monitored facilities
- Generator Data
- Concept for Performing Power Transfers

ATC Evaluation

- 3 Scenarios:
  - Base Case ATC
  - Limiting Contingency ATC
  - Strategic Line Switching to improve ATC

ATC Summary
Available Power Transfer Margin
Weakest Bus (Experiences most significant delay at voltage level)
Limiting Bus (Bus location with first voltage violation
Cause of Potential Collapse (Real power transmission based or reactive power based)

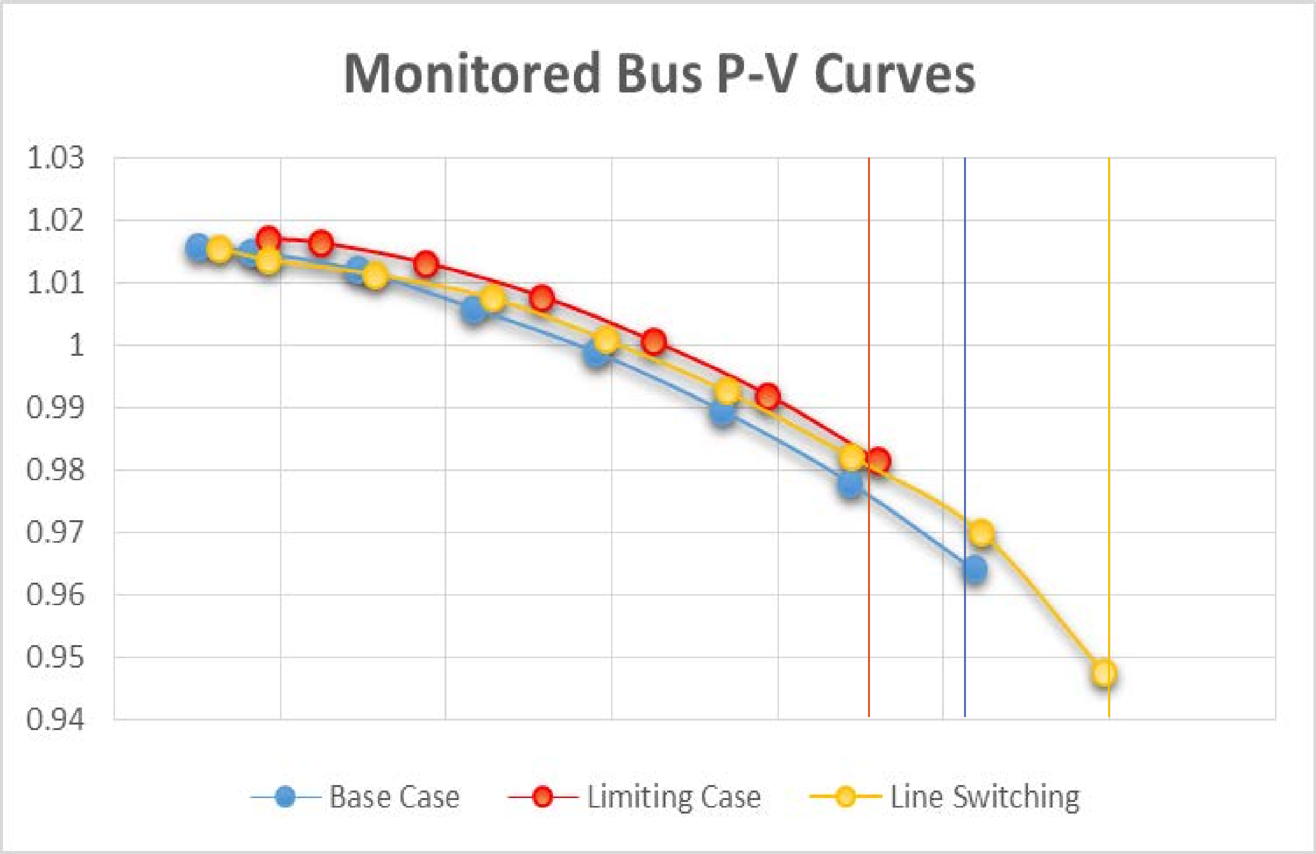
ATC Assessment and Enhancement Results

Base Case Power Transfer Margin	Limiting Contingency Power Transfer Margin	Line Switching Power Transfer Margin
MW	Reduced MW	Increased MW

***NYISO reviewing numerical results before release to public**

Optimal Line Switching Location identified

Monitored Bus



Base Case ATC

Limiting Contingency Case ATC

Line Switching Case ATC

Future Research

- Next Steps
  - Procure PMU-data for same time window as Power Flow data
  - Analyze results of computed ATC with PMU Inputs
  - Incorporate the RTCC subsystem
  - Develop an Enhancement subsystem for Increasing ATC.

Innovation prevails!

Questions?

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