Angle Separation Limit Calculation for WECC Path & IROL Stress Monitoring

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Outline

- Practical examples of angle separation on system events
- TSAT software enhancement to enable calculating angle separation limit for a WECC Path and IROL
- TSAT limits benchmarking
- Challenges on practical angle separation monitoring

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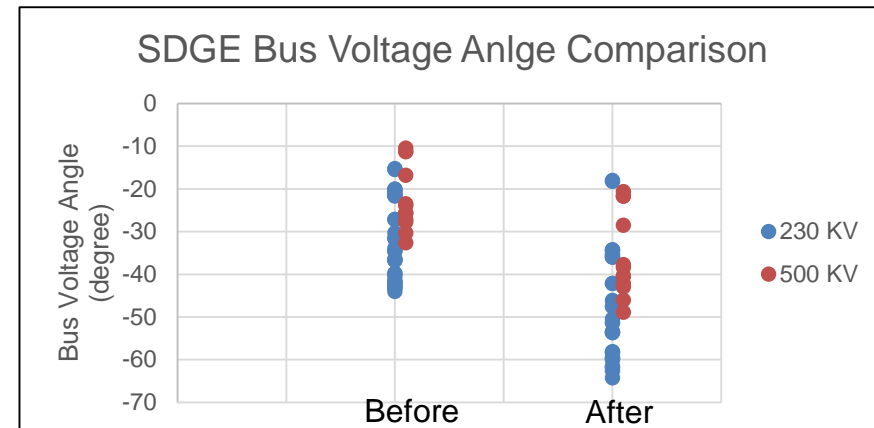# Practical Examples of Increased Angle Separation Indicating System Stress
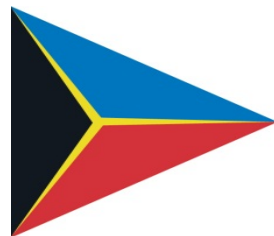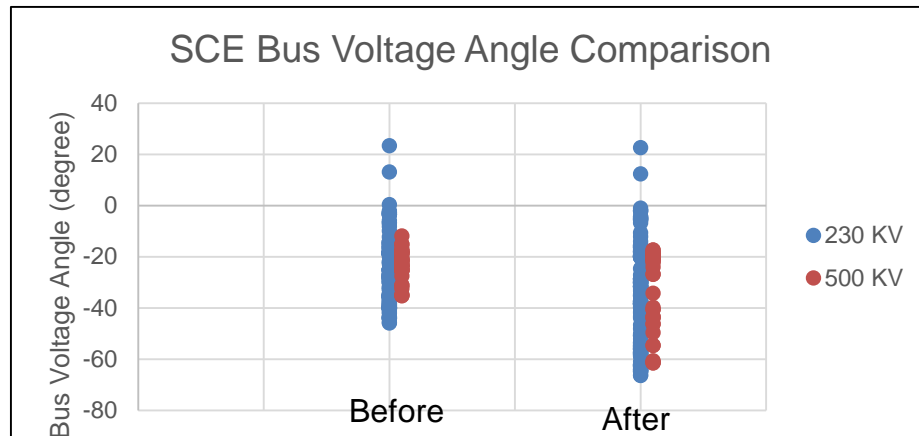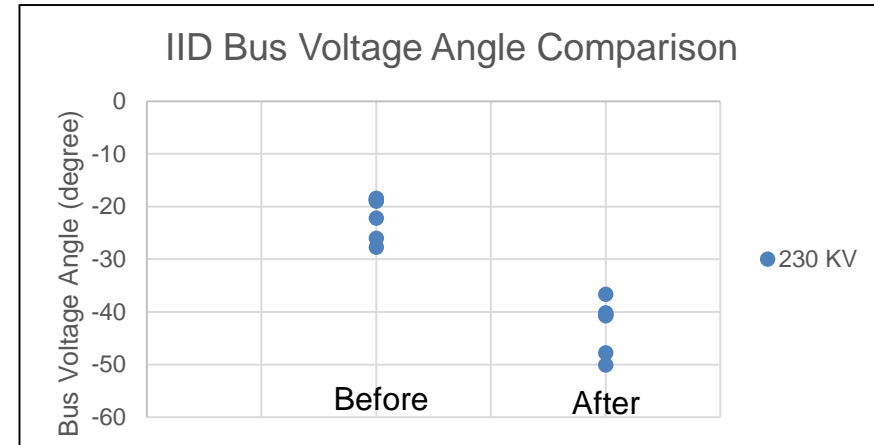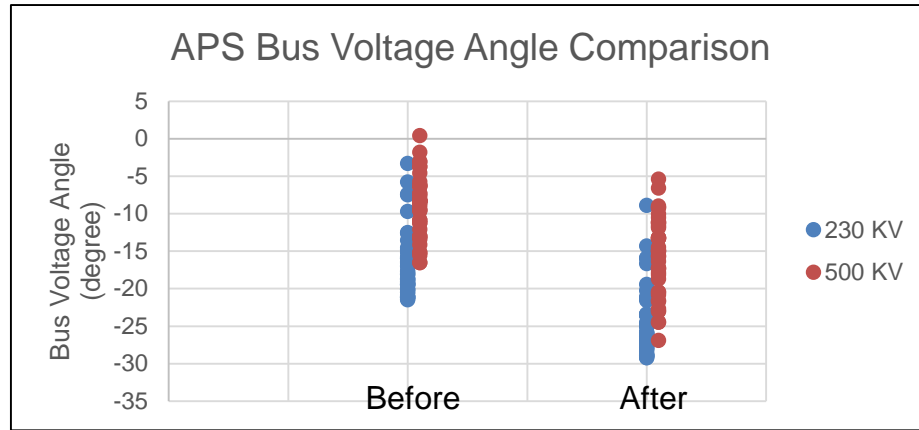
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Indication of a Major Operating Condition Change

- Bus angles reflect more dramatic changes than actual path flows under the condition of major transmission outages,
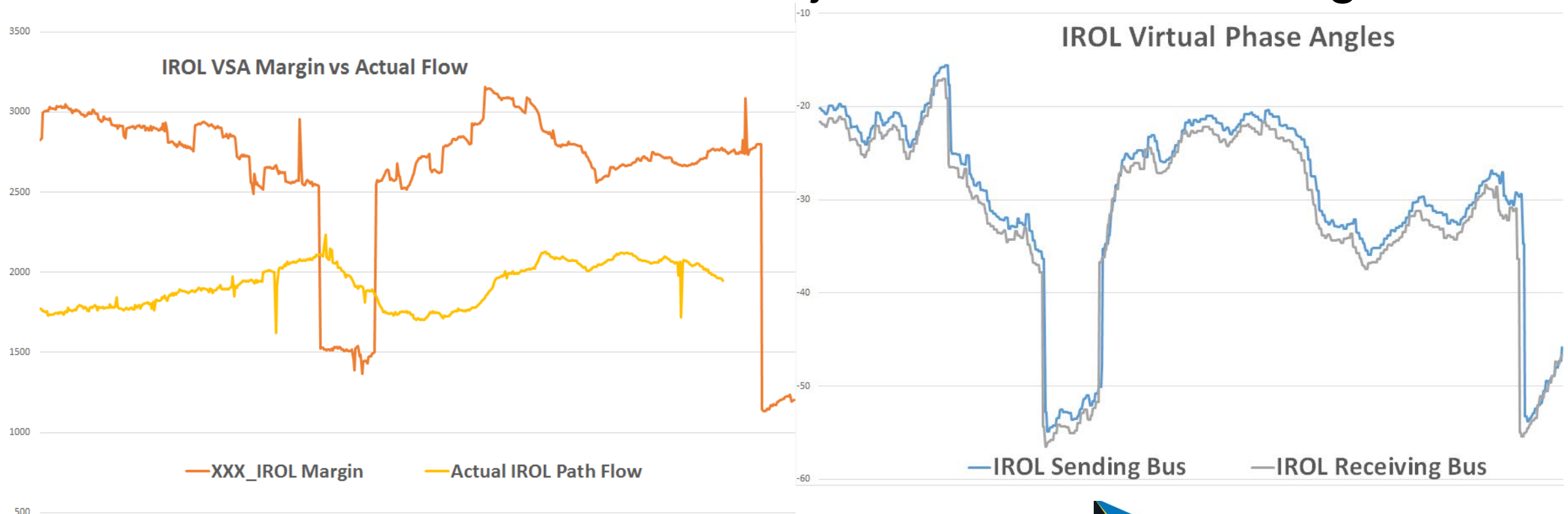
# *Bus Angles Pattern Shift during Major Outage Event*

- Bus angles changes across the region (especially SCE and SDGE) indicates a more stressful operation condition.

Early Indication for Increased Transfer Stress

- Peak monitors line-based phase angle difference again synchro-check relays settings in EMS tools to provide critical awareness of operational limitations to RC

- For Paths or IROLs, virtual angle pairs (VAP) were created in Test EMS servers to monitor transfer stress changes
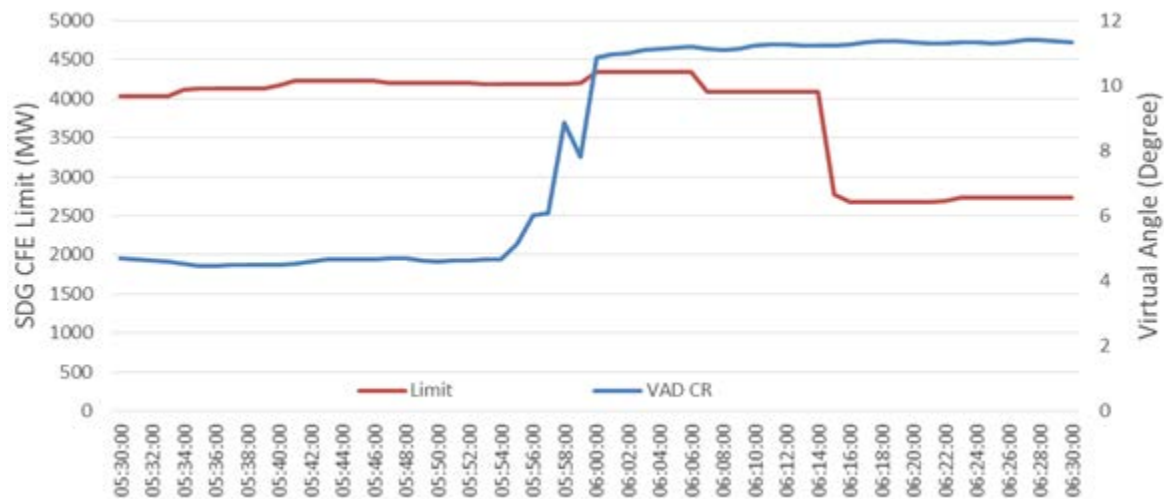
- VAP detected a system stress change 15 minutes earlier than the IROL limit dropped in the plot

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Software Enhancement to Calculate Angle Separation Limit for A Transmission Interface

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Peak Online TSAT Implementation Project

- Peak is implementing online transient stability analysis tool (TSAT) to monitor system dynamic stability and frequency stability issues

- Three initial use cases were developed and being validated:
  - COI limit calculation
  - Fast voltage collapse monitoring against two IROLs in California
  - System frequency monitoring under post-contingency

- Targets to roll out the TSAT tool in production in 2017

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Angle Separation Limit Calculation Capability

- Peak worked with Vendor to implement a new feature of calculating phase angle difference (PAD) limit (physical and virtual angle pair-VAP) on a given Path or IROL cut-plane
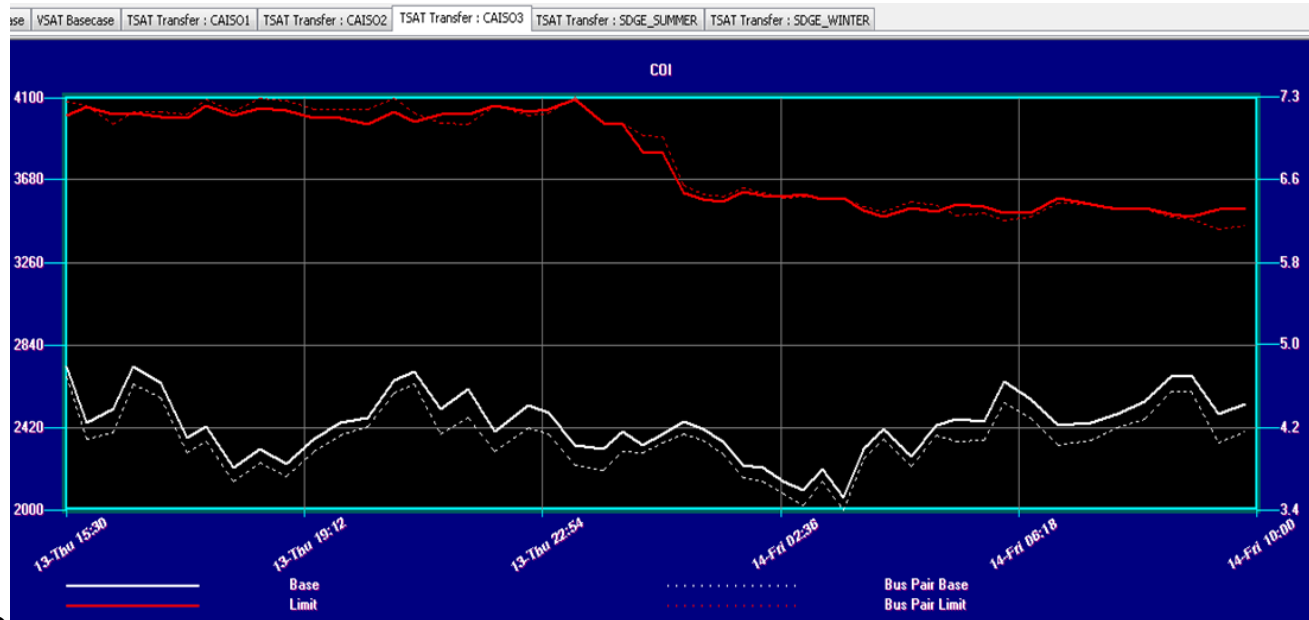

- The PAD limits stored in PI enable monitoring power transfer stress by comparing with PMU phasor data

Enable Bus Angle Separation Monitoring

- Calculated PAD limits are visualized in online TSAT and stored in PI Historian

- Angle limits in PI can be used to compare with down sampled (DS) PMU phasor data if there is any angle separation exceedance

Note:
- Virtual PAD is proven strongly dependent on the path flow
- Combine model based solution with PMU data for path or IROL stress monitor

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Benchmarking Online TSAT Calculated Limits

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Benchmarking COI Limit with SCADA Path Limits

- Stability Interface Limits are generally calculated using most limited scenario in the offline studies.

- By taking advantage of the capabilities of Real-Time Stability Limit Calculations we will possible **reliably** maximize system transmission use.

Validating TSAT calculated COI limits against RT limit measurements received via ICCP and benchmarking with CAISO TSAT tool results

COI Base Flow and Limits
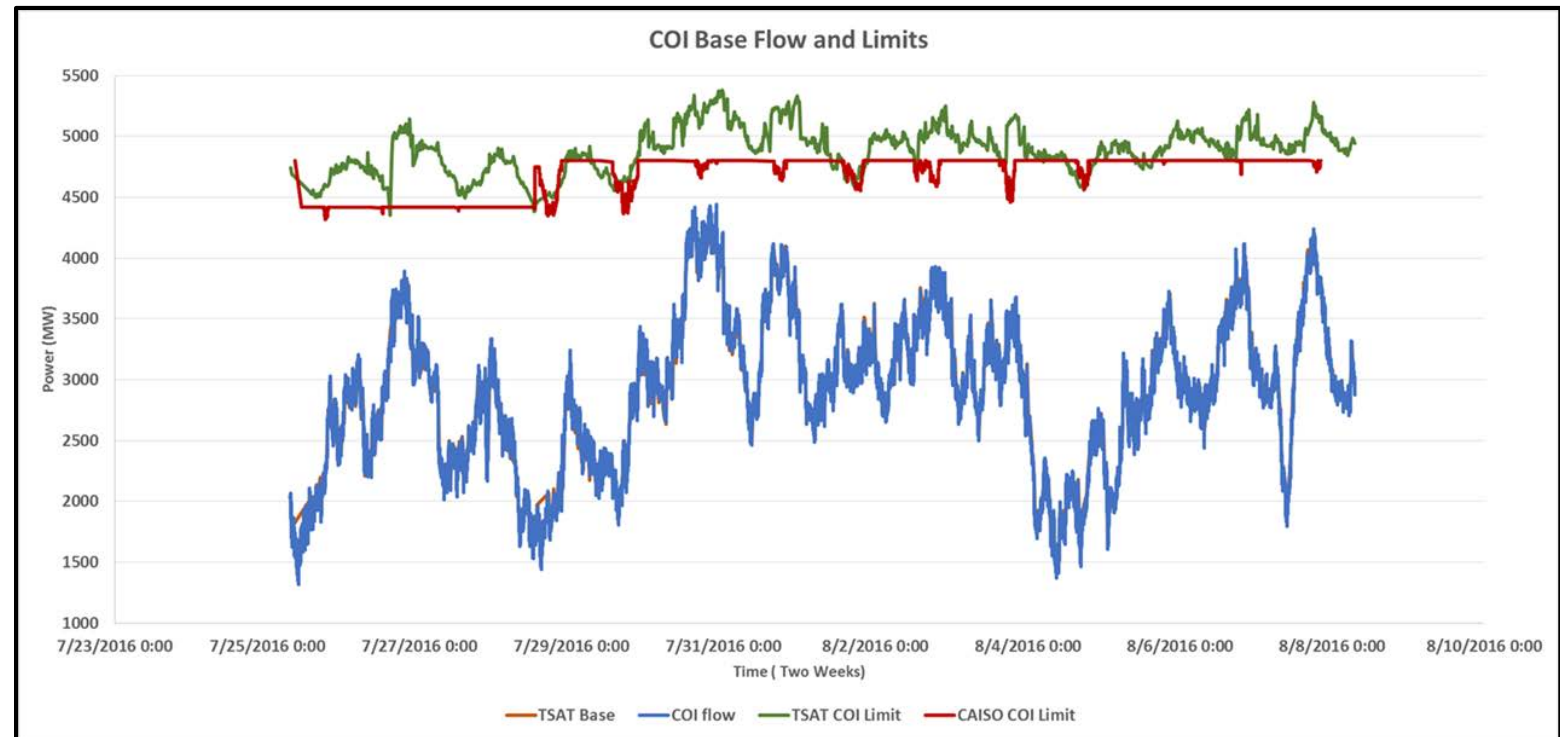
# *Validating TSAT Results for the IROLs Calculation*

- Two IROL scenarios defined in TSAT:
  - xxxx Non-Summer Import
  - xxxx Summer Import

- 12 [N-1] and 2 [N-2] contingencies plus 11 RAS were modeled for two IROL calculation
- 20% induction motor load applied to 5000 loads mapped up for fast voltage collapse monitoring
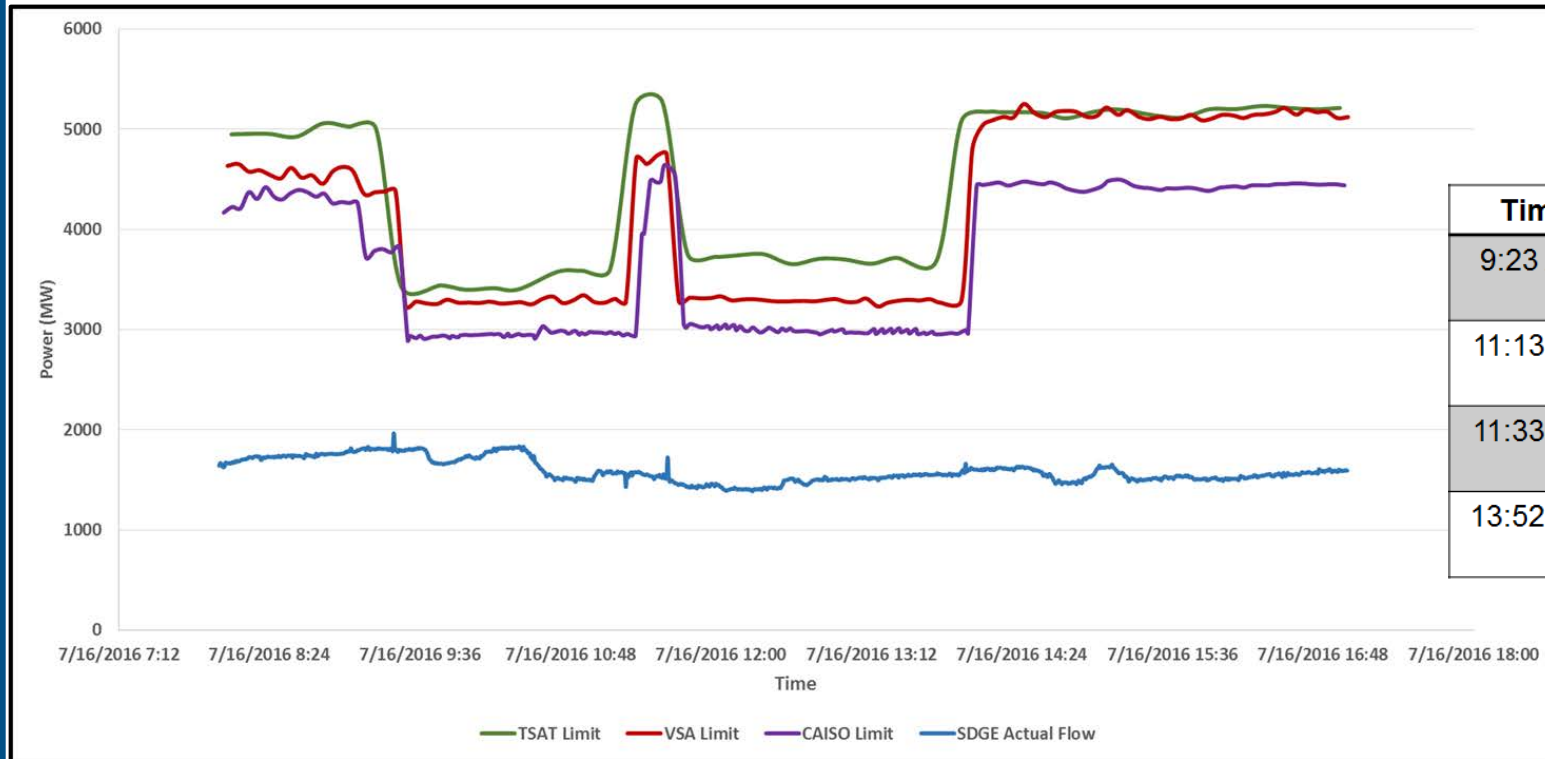
Summer Import Limits (Two Weeks Period)
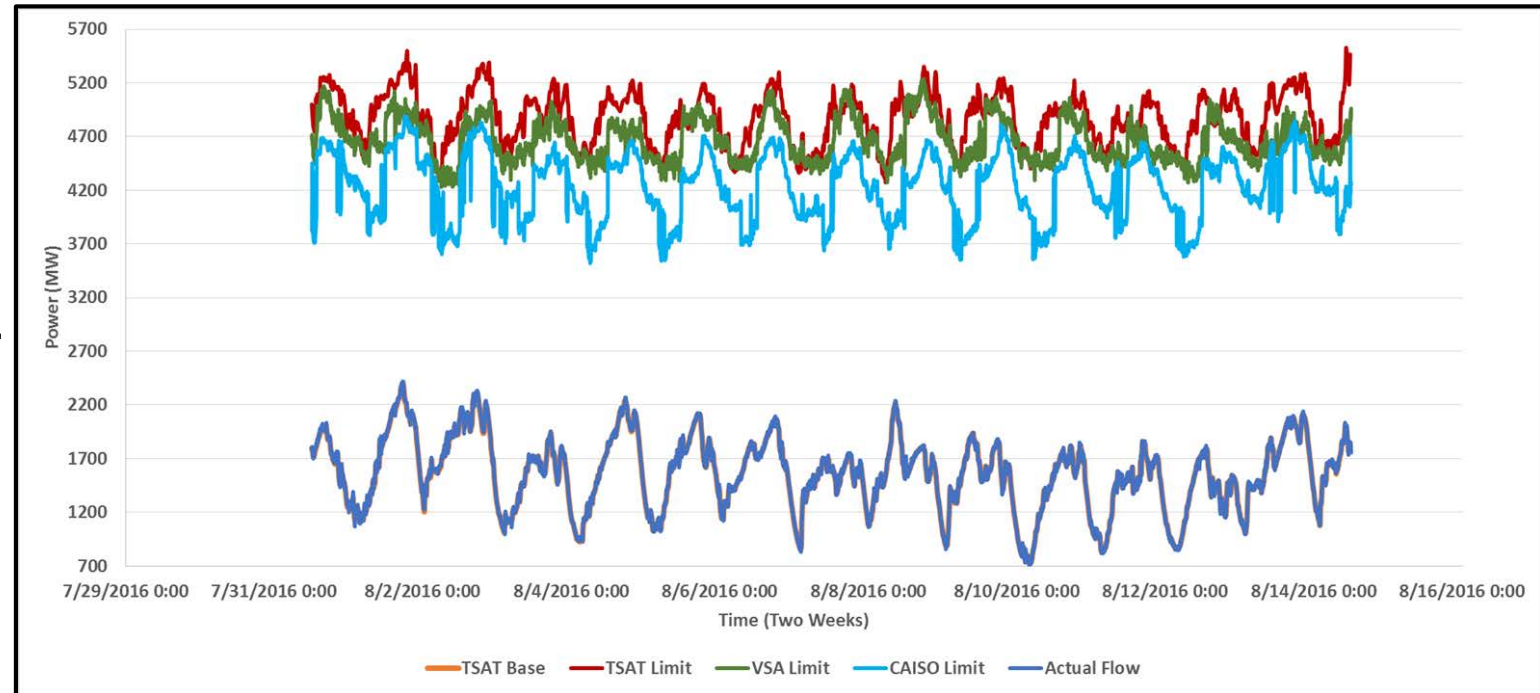
Benchmarking with RTVSA Tool under Normal Operation

IROL Limits Calculated by V&R ROSE-VSA and PowerTech TSAT

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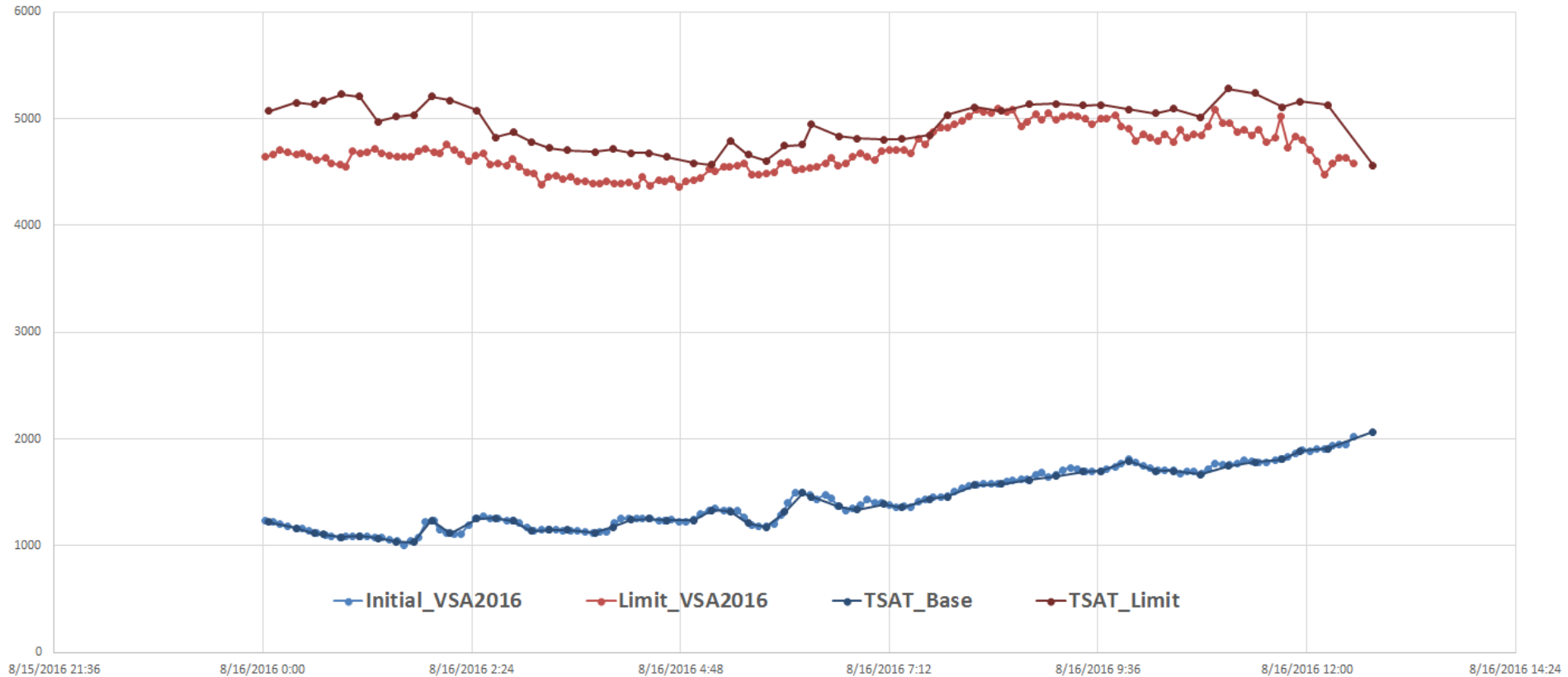
Benchmarking with RTVSA Tool on System Events

- TSAT calculated limits matches the event in the system
- TSAT limits change with the same pattern as RTVSA limits (TSAT cases are on ~15 min intervals)

XXX 16th, 2016 Events Summary

Time	Event	Limit Change in TSAT
9:23 AM	OCOTILLO- IMPERIAL VALLEY Line Outage	~1570 MW Decrease
11:13 AM	OCOTILLO- IMPERIAL VALLEY Line Reconnected	~1400 MW Increase
11:33 AM	ECO- IMPERIAL VALLEY Line Outage	~1500 MW Decrease
13:52 PM	ECO- IMPERIAL VALLEY Line Reconnected	~1400 MW Increase

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Challenges of Practical Angle Separation Monitoring

- Require extensive work on validating TSAT models, stability criteria and software capability for an acceptable performance

- Lack of PMU measurements on the substations related to COI and the IROLs
  - Over 200 PMUs installed in California did not come in Peak till date
    - Require more support and collaboration with the PMU owner entities
    - Presently Peak uses SE solved angles for monitoring and analysis in Test.

- For wide area angle separation with no reference to interface definition, the current VAP approach is not applicable

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Questions?

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