IEEE Panel Session: Implementation of Remedial Action Schemes in Real-Time Contingency Analysis in Control Centers

CAISO's experience in implementation of real-time contingency analysis with remedial action schemes

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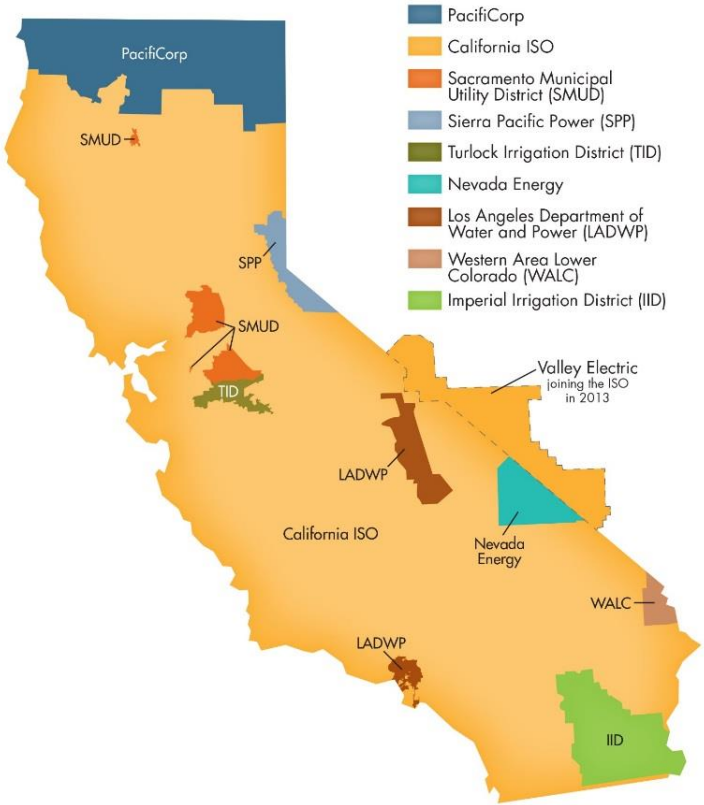
2019 IEEE PES General Meeting, Atlanta

California Independent System Operator

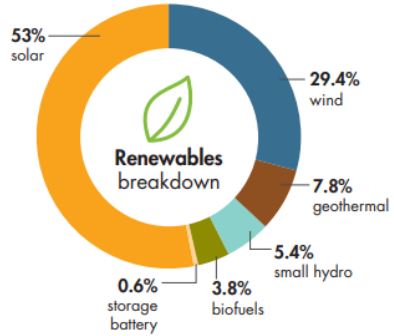


- One of the 9 ISOs
- Largest of the 38 BAs in the Western Interconnection
- Handles 35% of the electric load in the West
- Manages load for about 80 percent of California and a small part of Nevada (over 26000 circuit miles)

Demand & resources *(as of 8/01/2019)*

Resource adequacy net qualifying capacity (NQC) = 52,122 MW
Does not include current outages

Renewable resources *(as of 8/01/2019)*



	Megawatts
Solar	12,072
Wind	6,714
Small hydro	1,229
Geothermal	1,785
Biofuels	878
Storage battery*	136
TOTAL	**22,814**

See Today's Outlook

California Independent System Operator

Historical stats & record peaks

11,473 MW
Solar peak
July 2, 2019 at 12:53 P.M.

Previous record:
11,435 MW on July 1, 2019

5,309 MW
Wind peak
May 8, 2019 at 3:21 P.M.

Previous record:
5,193 MW on June 8, 2018

78%
Demand served by renewables
April 20, 2019 at 12:40 P.M.

Previous record:
73.9% on May 26, 2018

50,270 MW
Peak demand
July 24, 2006 at 2:44 P.M.

Previous peak demands:
50,116 MW on September 1, 2017 at 3:58 p.m.
48,615 MW on August 31, 2007 at 3:27 p.m.

Annual peak demand

46,427 MW
Jul 25, 2018 at 5:33 p.m.

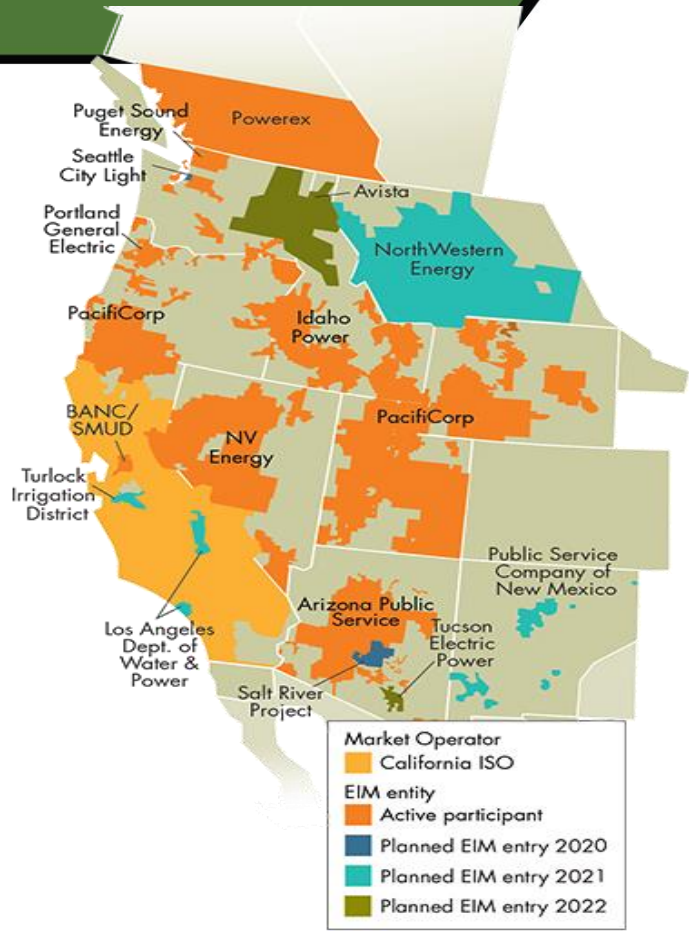
50,116 MW
Sep 1, 2017 at 3:58 p.m.

46,232 MW
Jul 27 , 2016 at 4:51 p.m.

47,358 MW
Sep 10, 2015 at 3:38 p.m.

Western Energy Imbalance Market

- Real-time bulk power trading market
- Finds lowest cost energy across a wide geographic area
- Improves integration of renewable energy



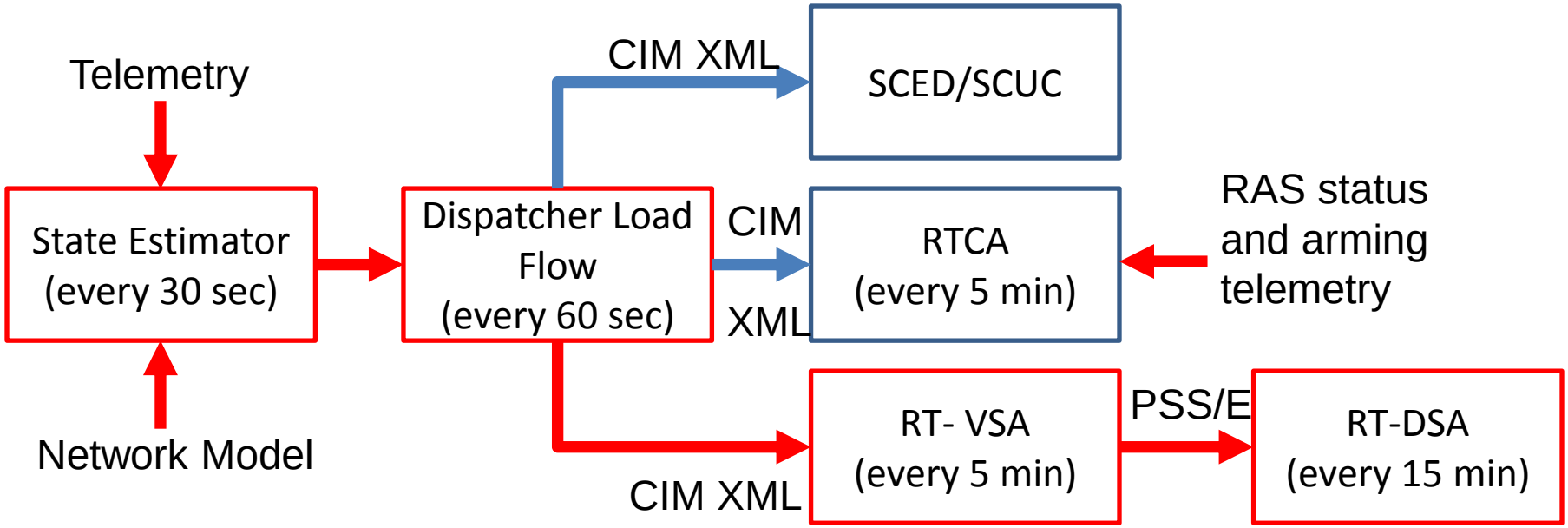
Reliability Coordinator Services Services

- The ISO's Reliability Coordinator, named RC West, launched operations on July 1, 2019,
- Official Reliability Coordinator of record for 16 electricity BAs and TOPs primarily in California, and one in Mexico.
- Finalized service agreements with 39 BAs and TOPs.

TOP/RC Requirements

- Conduct real-time assessment and monitor the status of facilities. All facilities need to be within their thermal, voltage and stability in the pre and post-contingency states
- Need to ensure that instability, uncontrolled separation or cascading will not occur

Real-Time Assessment Setup



RTCA Setup

- Utilize parallel processing to execute ~10k contingencies within 5 minutes.
- Evaluation of each contingency also includes processing of Remedial Action Schemes (RAS) that may be triggered by the post-contingency topology or conditions (flows, voltages etc)
- Summarize and present results to operators

RTCA Results

- Thermal Violations
- Voltage Violations
- Bus Angle Violations
- Non-Converged contingencies
- RAS Action Summaries
- Gen drop summaries
- Generation Effectiveness Factors

Remedial Action Schemes Modeling

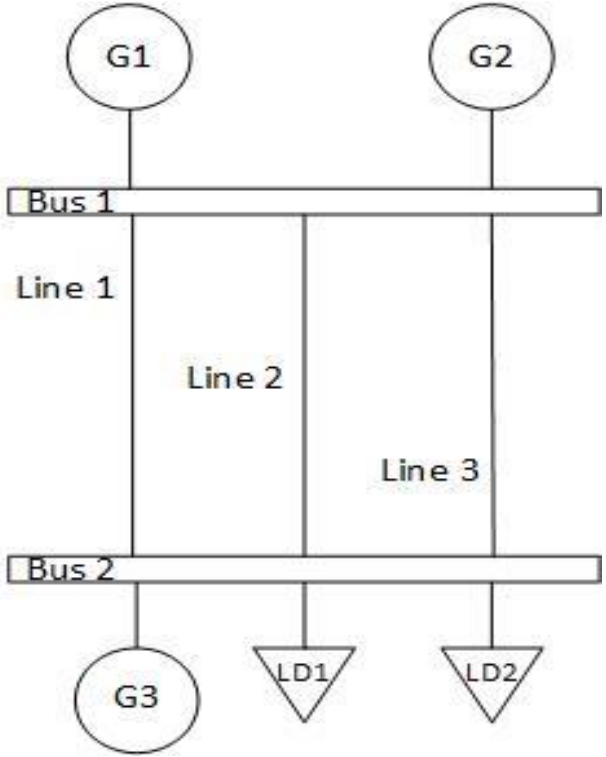
Typically RAS can be categorized as:

- Flow/Voltage-based: when an overload or abnormal voltage is detected
- Contingency-based: RAS action is based on the loss of a specific element in the system
- Flow and contingency combinations: Multiple conditions are checked, including flow and statuses of other equipment.

RAS Example (Contingency Based)

Scenario 1: RAS A for Path A that comprises of Line 1 + Line 2 + Line 3

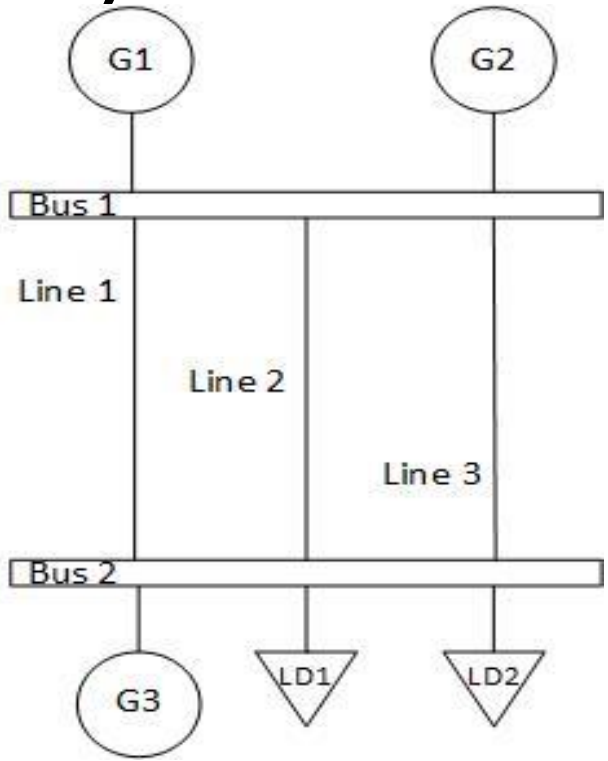
- RAS A protects for the loss of two of the lines when there is high flow from Bus 1 to Bus 2
- A combination of generation group G1 or G2 on the Bus 1 side and Load group LD1 and LD2 on the Bus 2 side are “Armed” to drop to alleviate the overload on the Path.
- This is a dynamic RAS where the load group and generation group that are armed rotate between the different available groups.
- CAISO receives SCADA/ICCP Points (digital points) that indicate if the RAS is cut-in and if a generation or goad group is armed to drop.



RAS Example (Flow Based)

Scenario 2: RAS B for the Path B that comprises of Line 1 + Line 2 + Line 3.

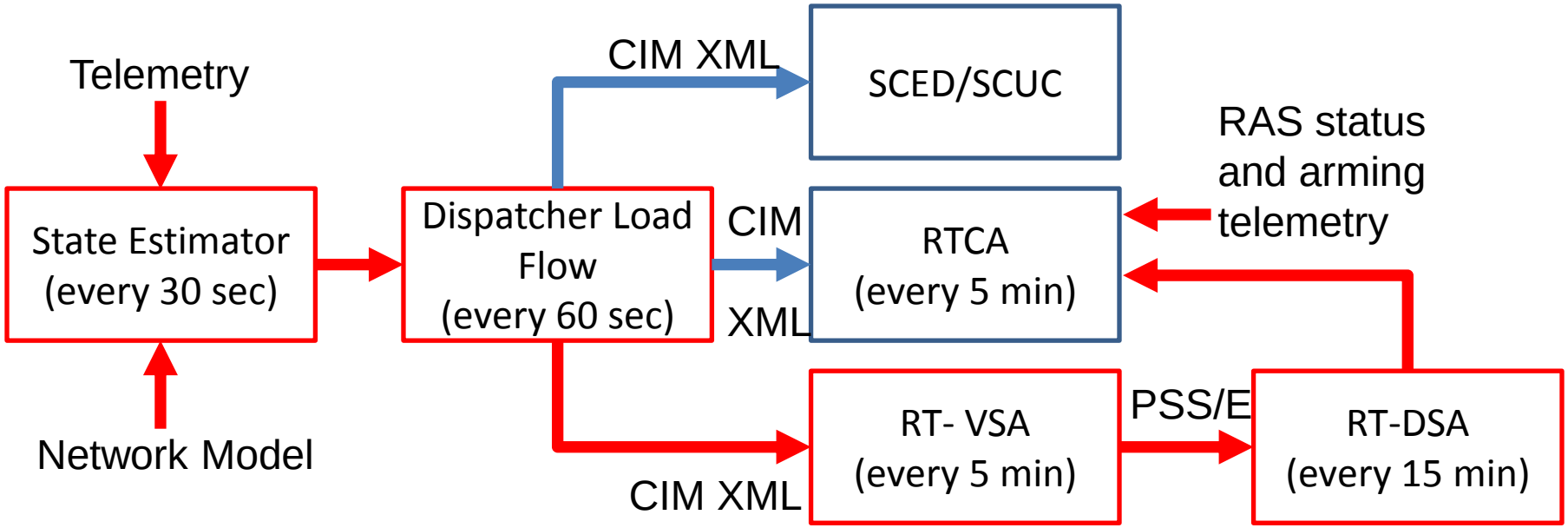
- RAS B is triggered for an overload on Path B above certain MW flow from Bus 1 to Bus 2 dropping Load LD1 to mitigate the overload.



RAS Association to Contingencies

- RAS actions triggered by unique contingencies (monitoring breaker status): Associate RAS to unique contingency
- RAS actions triggered by any contingency (monitoring flows/voltages): Execute RAS for all contingencies
- RAS actions triggered by combination of contingencies/flows/voltages

Feedback from DSA to RTCA



Other Ongoing Activities

- Modeling of RAS that triggers based on conductor temperature
- Extension of RTCA to Look-Ahead Mode
  - Utilize the same RAS modeling
  - Link Arming status to Logic
- Archiving RTCA results for further analysis

Challenges with Implementation of RAS

- Sufficiency of functionality to model RAS logic
- Integration of all the required ICCP data to arm/disarm RAS in RTCA
- Impact of Network Model changes on RAS modeling

Thank You

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