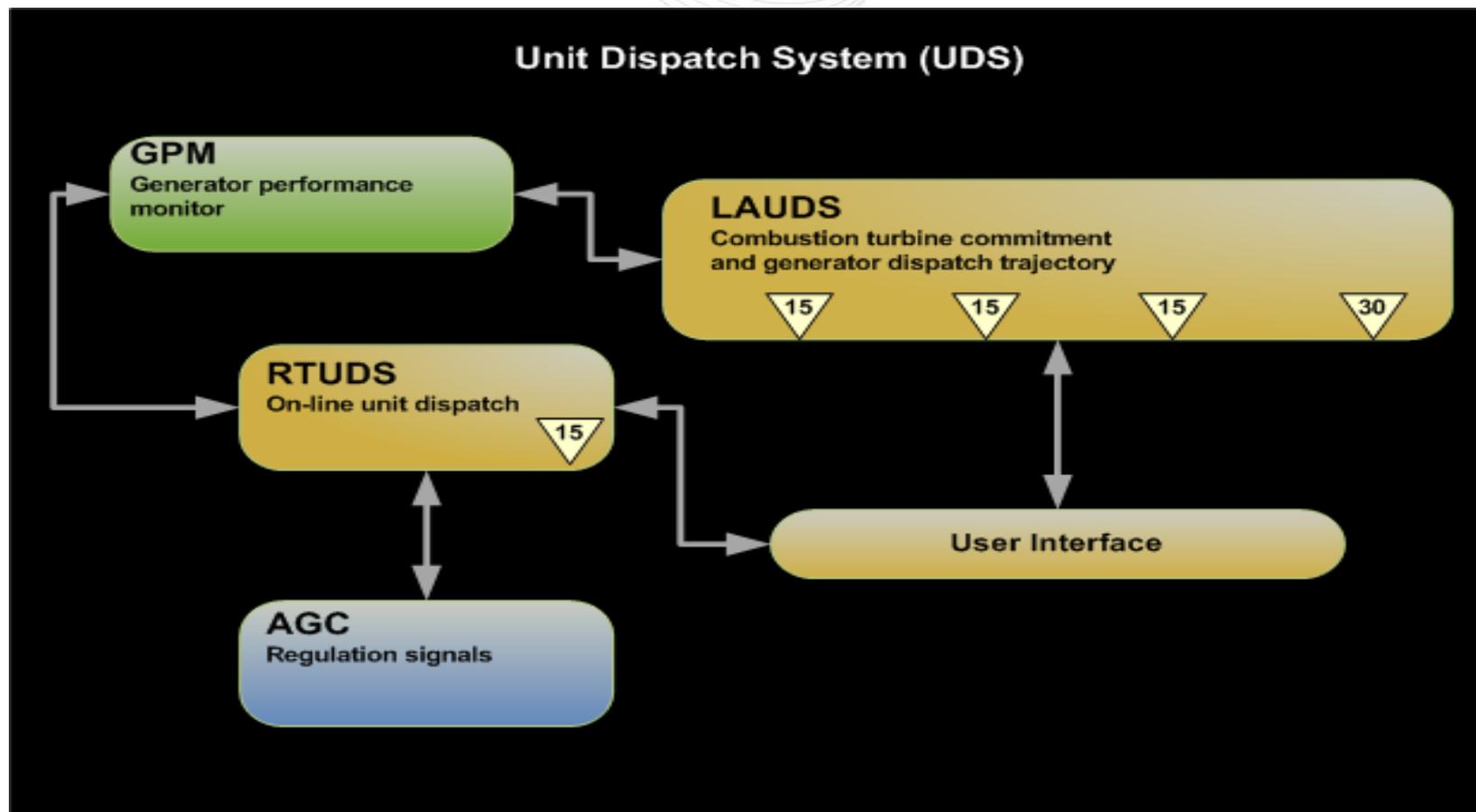


Development of Enhanced Generation/Demand Response Control Algorithm

Andrew Ott
Senior Vice President
PJM Interconnection
June 23, 2010



- Previous Economic Dispatch Tools
 - Real-time UDS
 - Projecting out 15 minutes to dispatch online units
 - No CT commitment, only de-commitment
 - Look-Ahead UDS
 - Projecting out 15, 30, 45, & 75 minutes to commit CTs
 - No coupling of LA solutions or coupling of RT UDS and LA UDS results
- The lack of continuity between solutions was not in synch with dispatcher's operating plan
- Generation offer data is not accurate and modeling not complete.
- Transmission Constraints are not presented to the optimization in an "intelligent" manner

- At certain times, resource owners perceive dispatch instructions as ‘unrealistic’
- Advances in operator visualization tools have demonstrated value in continued emphasis on operational trend analysis to increase situational awareness.
- Technology advances provide opportunity to integrate trend analysis into optimization and to accommodate more sophisticated and adaptive resource models

Generation, and Demand Resource, Control Application

Generation Control Application (GCA)

AGM
realistic generator
response profiles

ACM
intelligent
constraint control

IT-SCED
demand trajectory, generator loading strategy, CT commitment

15 30 75 120

RT-SCED
final dispatch contour, pricing

10 20

Current Operating Plan (COP)
generator dispatch range & sequence solution

AGC
regulation signals

- The objective is to yield a time-coupled resource operating plan
 - Realistic generator characteristics and behavior
 - Intelligent transmission constraint control
 - Multi interval dispatch solution for unit commitment and dynamic contour projection for individual resource dispatch instructions
- Expected Benefits
 - Higher quality resource dispatch instructions
 - Increased situational awareness of operating trends
 - Reduction in operating margins

- Operational history of resource used to predict response to certain dispatch instructions
- Predicted response used in determining dispatch instruction to be issued to resource
- Six parameters are created by AGM
 - Control (Min, Max) MW
 - iRamp Rate(Up,Down)
 - icontrol (Min,Max) MW
- Concept is ... probabilistic response model replaces need to correct bad offer data or explicitly model mill points, dead bands, forbidden zones etc.

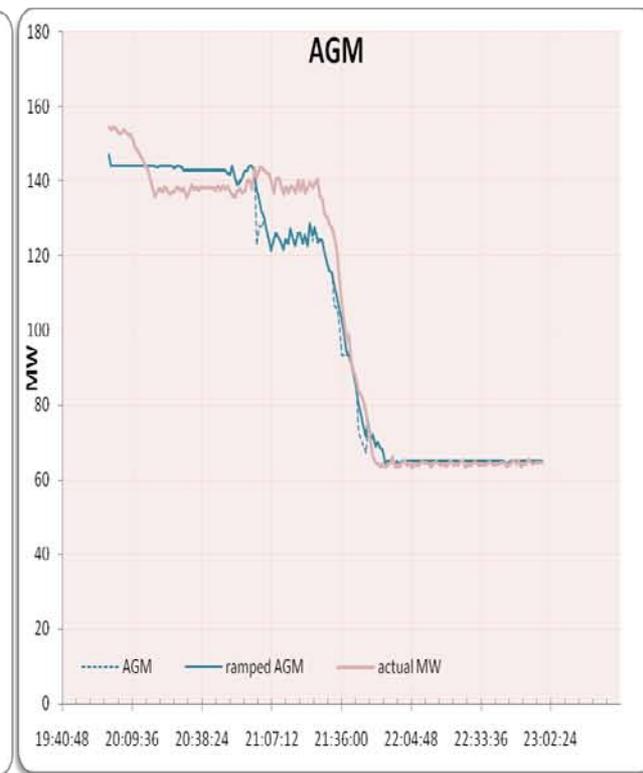
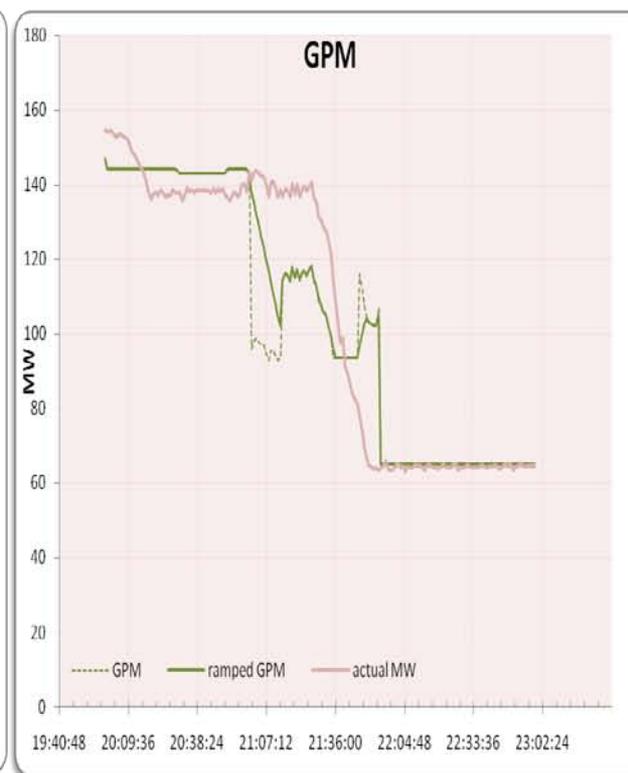
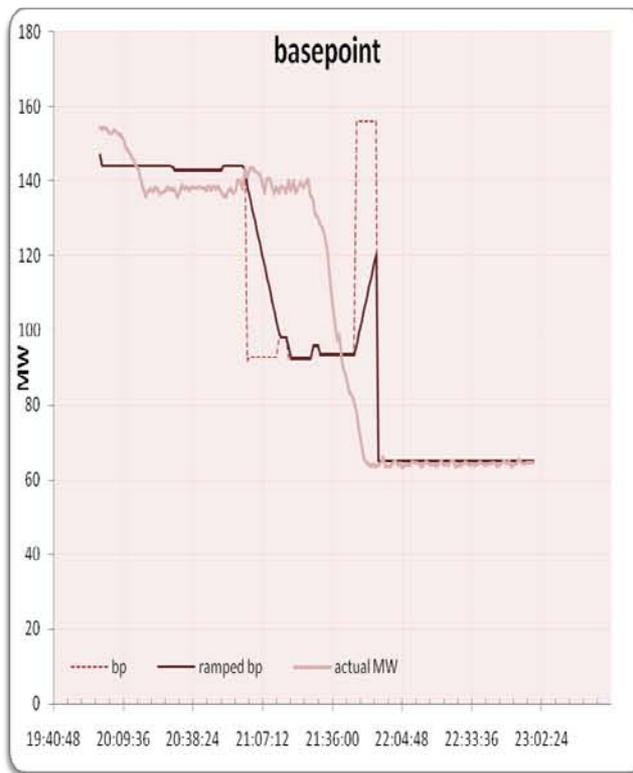
- Provide analysis to evaluate near-term line loading trends (and PV characteristics) to adapt constraint control strategy based on current conditions
- Group, rank and prioritize active transmission constraints
- Incorporate historical data to assist in anticipating and strategizing constraint control actions
- Concept.... Reduce number of “hard” limits that are introduced into the optimization phase

- RT SCED and IT SCED design
 - Introduce multi interval/multi horizon solution with flexible individual objectives
 - Employ a “time-coupled” optimization engine
- Dispatcher-focused user interface
 - Information displayed in a more relevant format
 - Many dispatcher actions can occur directly from the user interface

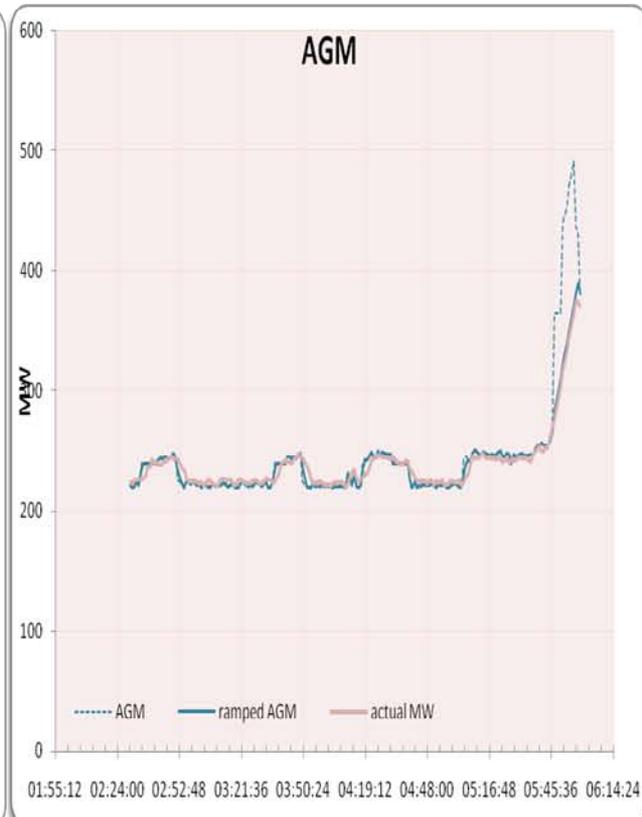
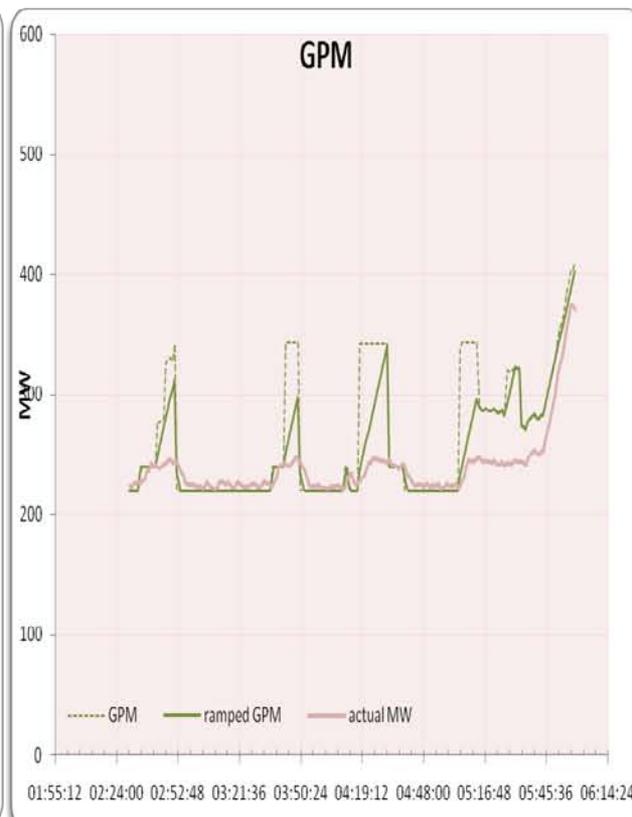
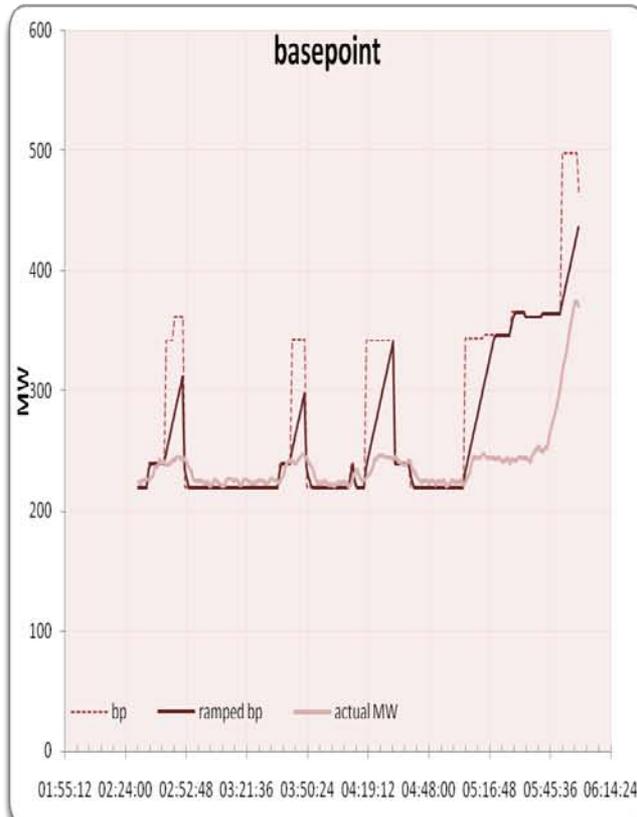
Data	Update rate
Load Forecast	5 minutes
External Transaction Data	5 minutes
Generator MW output	2 minutes
Transmission Constraints	2 minutes
eMkt – Unit Hourly Updates	1 minute
GPM and AGM	1 minute
Unit bid, schedule, ramp rate, etc.	Available for each case execution from daily input file.
Regulation and Spinning status	Available for each case execution upon becoming effective

- AREVA RT-SCED and IT-SCED design
 - Implement modern platform that will reduce maintenance and enhancement cost & time
 - Introduce multi interval/multi horizon solution with flexible individual objectives
 - Employ a “time-coupled” optimization engines
- Dispatcher-focused user interface
 - Information displayed in a more relevant format
 - Many dispatcher actions can occur directly from the user interface

- Unit A – 9/16/09
 - Unloading of the unit with basepoint reversal



- Unit B – 9/8/09
 - Volatile basepoint moves through non-operating band

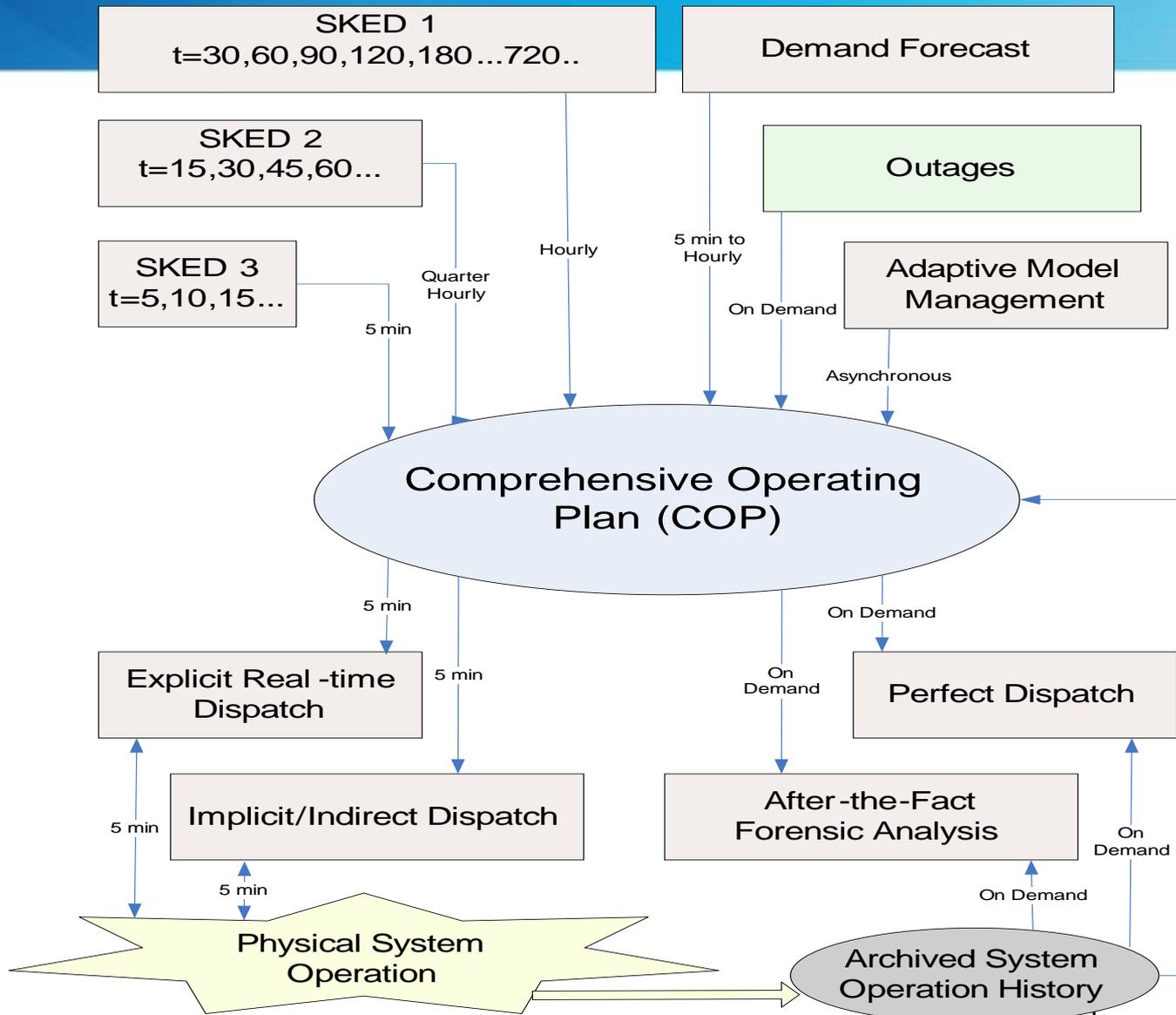


- IT-SCED 2 in “parallel” mode since July 2009
 - Time coupled solution intervals of 15, 30, 75 and 120 minutes ahead
- RT-SCED 3 in parallel model since November 2009
 - Time coupled solution intervals of 10 and 20 minutes ahead
- Integrated system was put into production in May 2010
 - Comparisons to past dispatch results show improvement
 - Dispatch staff endorsed the switch to production

- Adaptive Models enhance performance of dispatch engines
- Experience indicates adaptive generation models must be 're-trained' every 3 to 4 months
- Trend visualization well received by dispatchers
- Reduction in dispatch base point volatility

AREVA Material

Smart Dispatch Overview

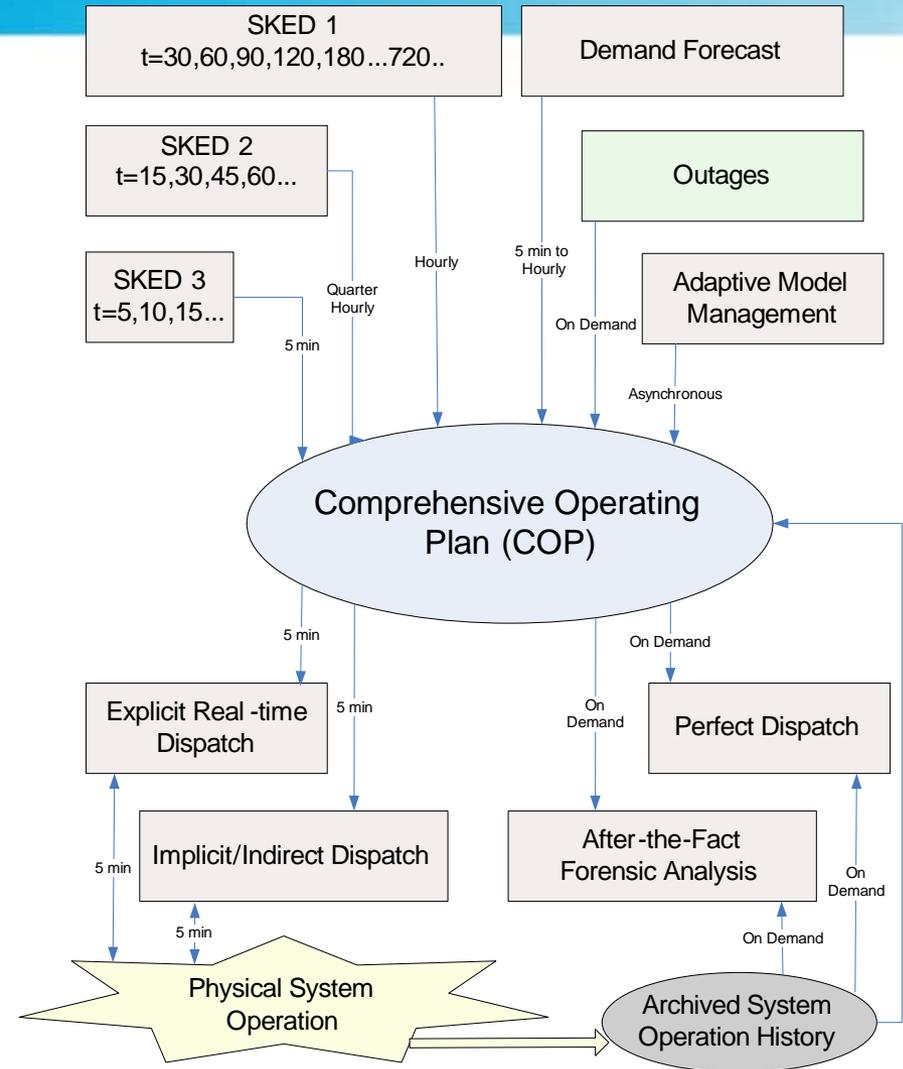


GRID

ALSTOM

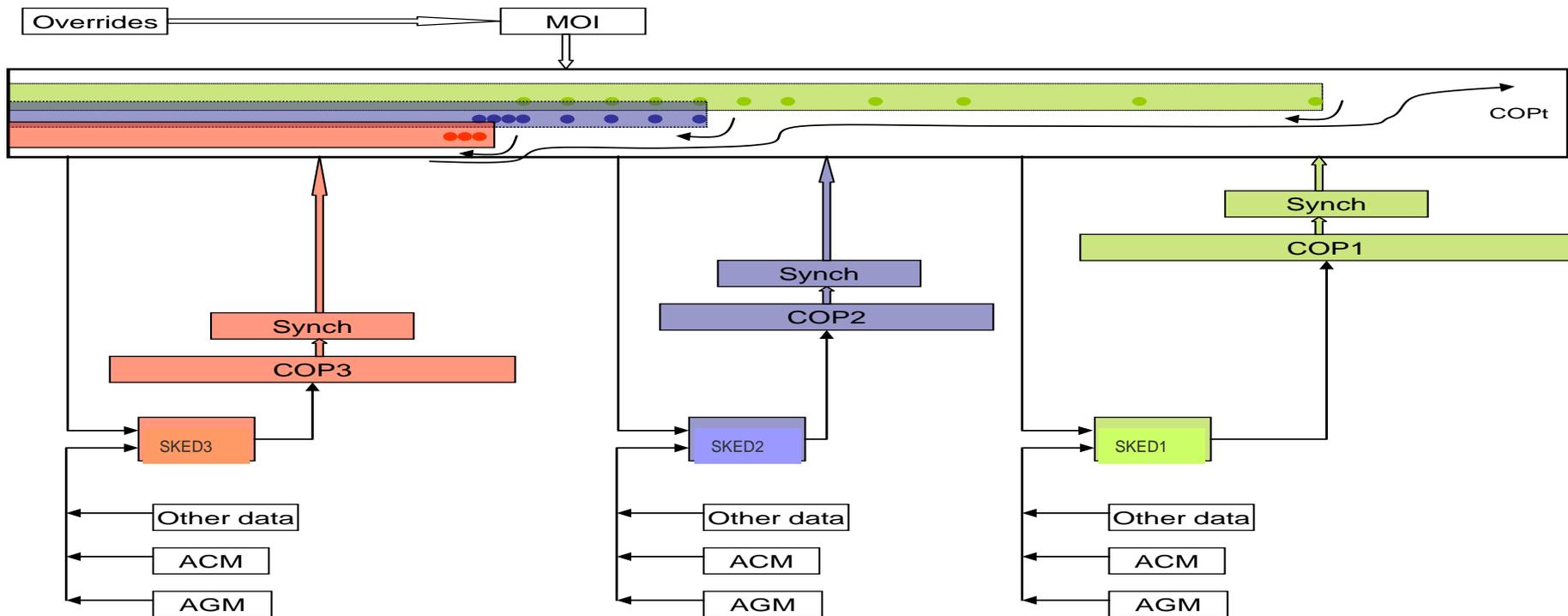
SKED 1, 2 & 3

- ▶ **Look-Ahead Scheduling Functions (SKED1, 2 & 3):** security constrained unit commitment and economic dispatch sequences with different look-ahead periods (e.g. 6 hours, 2 hours and 20 minutes) used to update the Comprehensive Operating Plan (COP), considering the “reality” (from State Estimator) as well as more updated forecasts of the future.
- ▶ For SKED1 and SKED2, the studies shall be time-coupled.
- ▶ Due to the concern of pricing, SKED3 shall have the flexibility of being configured as either time coupled or not coupled. When running in a decoupled mode, for each SKED3 interval, the latest available SE shall be the initial status, and each SKED3 interval shall consider the envelope provided by the Comprehensive Operating Plan (COP).



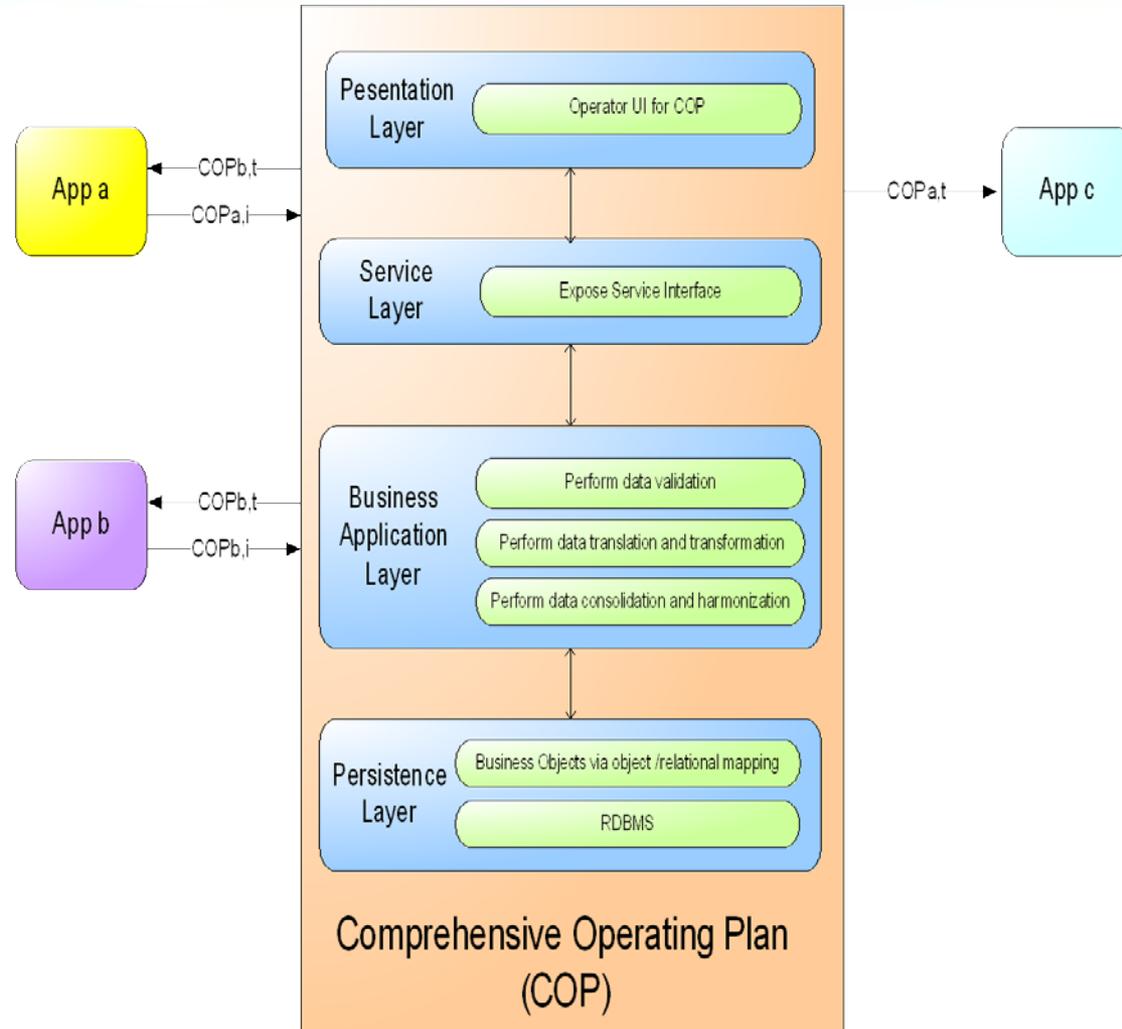
Comprehensive Operating Plan (COP)

- ▶ COP is an application to coordinate scheduling data to and from a certain class of power system applications and present a comprehensive, synchronized and more harmonized view of scheduling data to applications, to system operators or other stakeholders for the purpose of power system operations.

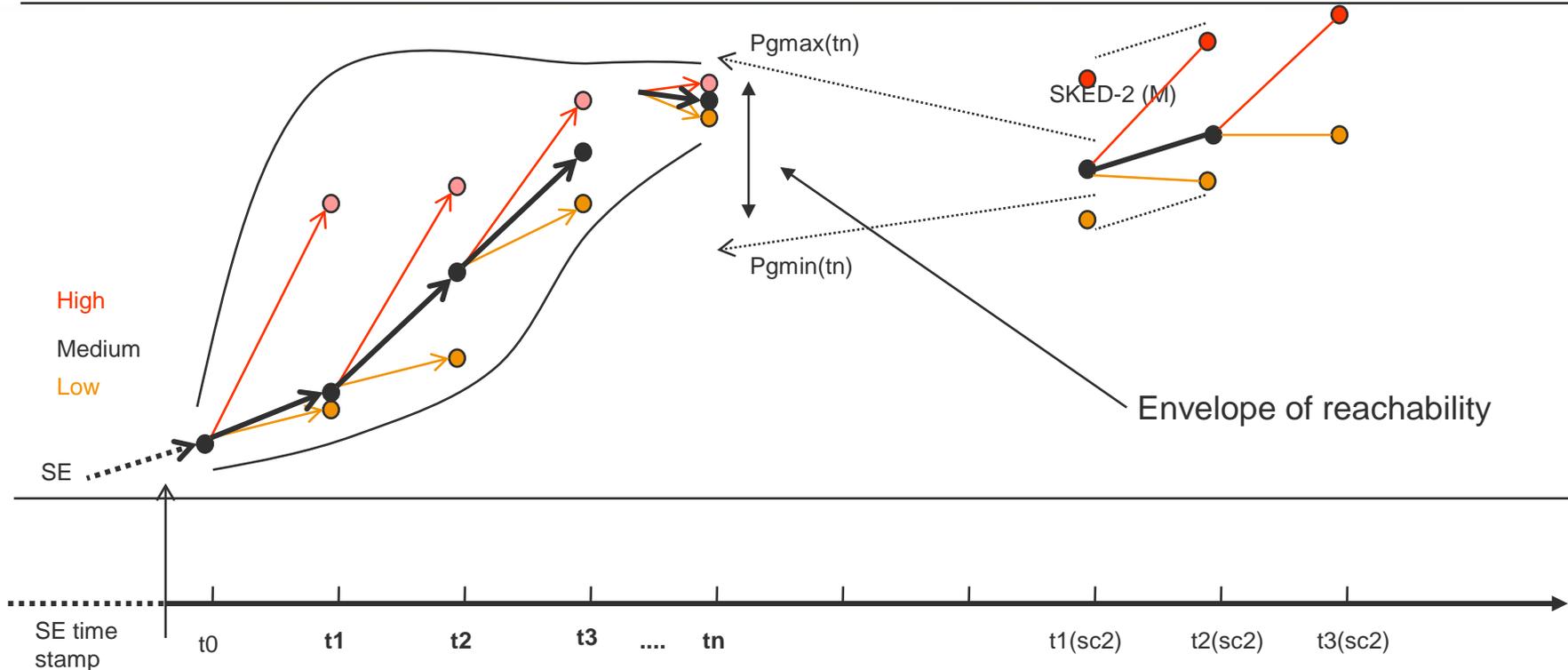


Comprehensive Operating Plan (COP) – Cont'd

- ▶ COP has a presentation layer or a set of Operator UI of its own to support system operator decision making. However, it does not intend to replace but supplement UIs of individual scheduling applications.
- ▶ COP has a service layer to provide a set of APIs to interact with external power system applications or data sources.
- ▶ COP has a business application layer that performs validation, translation, transformation, consolidation and harmonization of various asynchronized scheduling data.
- ▶ COP has a persistence data layer (most likely relational) for some key scheduling data.



COP Coordination - Reachability



- ▶ Coupling between SKED2 and SKED3 to ensure that SKED3 solution gets into the envelope of SKED2.

www.alstom.com

ALSTOM