Prototyping and Testing Adaptive Transmission Rates for Dispatch

Slava Maslennikov, ISO New England
smaslennikov@iso-ne.com

Kwok Cheung, ALSTOM Grid
kwok.cheung@alstom.com

Overview

- Adaptive Transmission Rates (ATR) concept
- Prototype implementation
- ATR testing results
- Future plans

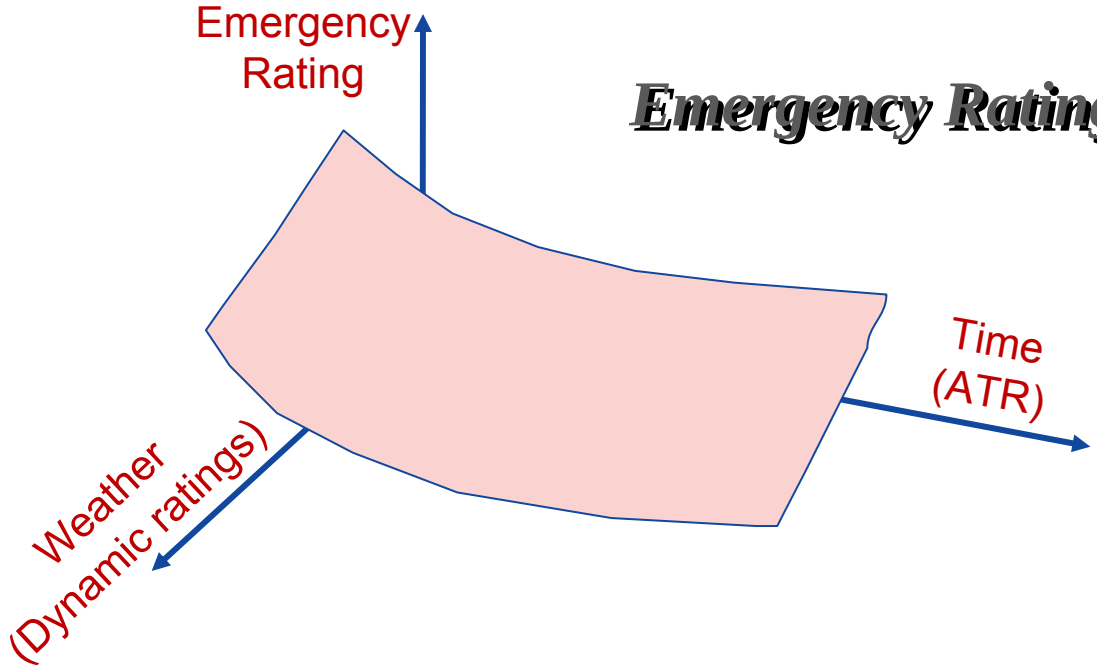
Formulation

- Post-contingency thermal transmission constraints are based on transient Emergency Ratings of lines and transformers:

$$\text{Post contingency flow} \leq \text{Emergency Rate}$$

- Emergency Rate is typically a static parameter (fixed or temperature sensitive) and equals to Long-Term Emergency (*LTE*, 4 hours) or Short-Term Emergency (*STE*, 15 min) rate
- $STE \geq LTE$ Which rate to use?
- ATR concept intends to adaptively select Emergency Ratings by accounting for the post-contingency corrective actions in the form of dispatch

Transient Emergency Rate

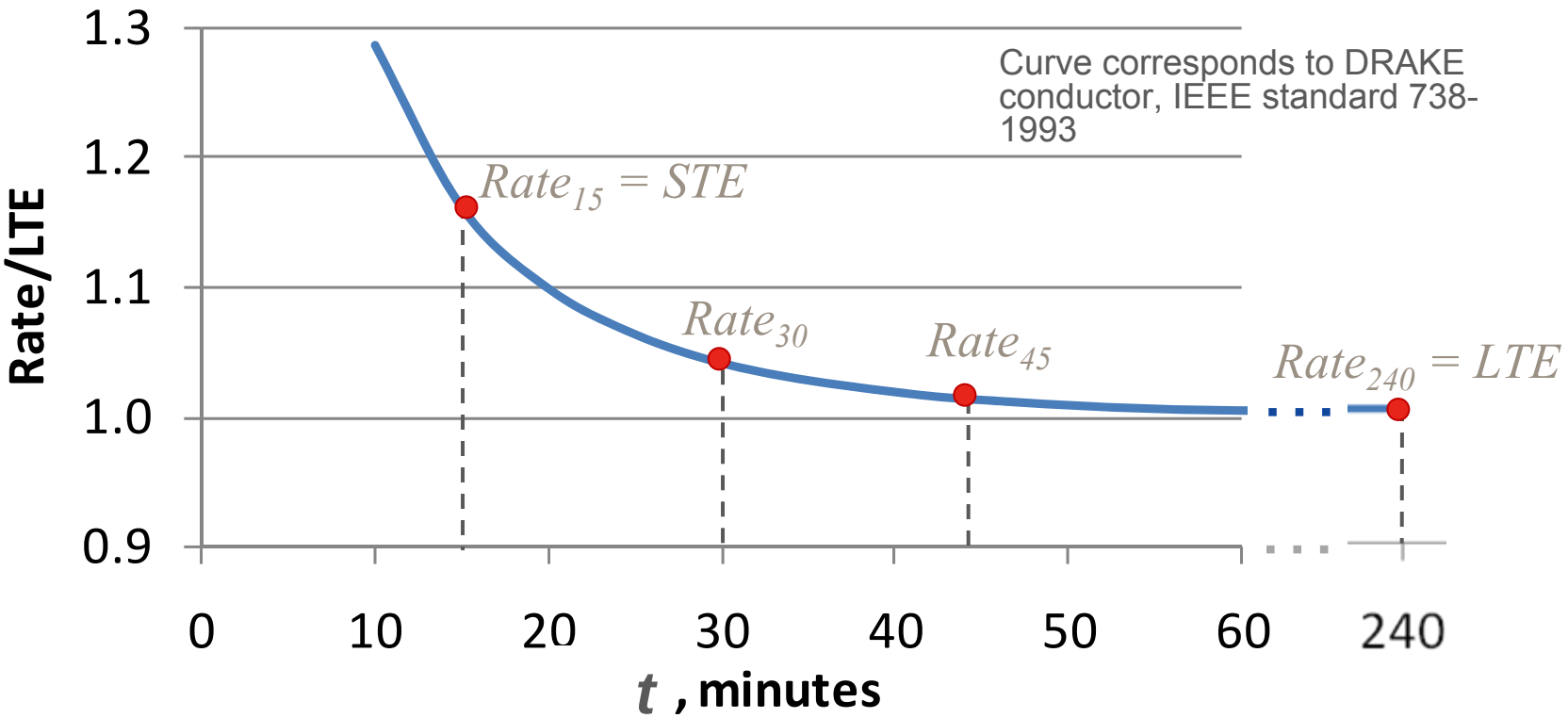


$$Emergency\ Rating \equiv f(Weather, Load, Time)$$

- "Adaptive" and "Dynamic" ratings complement each other
- They could be considered independently
- The best way is to consider them simultaneously
- Pre-contingency Load should be accounted in "Dynamic" rates

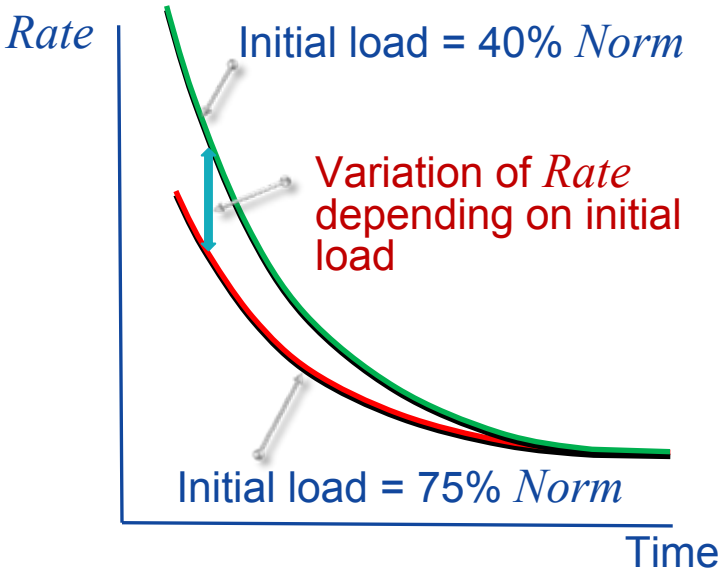
Rate(t) characteristics

- *Rate(t)* is a physical characteristics of a line. Calculation of any point uses the same method as for calculation of *STE* and *LTE*
- Any point on a curve can be used as an Emergency rate



How initial load impacts *Rate(t)*?

Rate(t) adjustment per pre-contingency load by standard IEEE technique



Rate(t) adjustment can be accounted in ATR calculation but the natural way is to account that in "Dynamic" ratings

ATR calculation

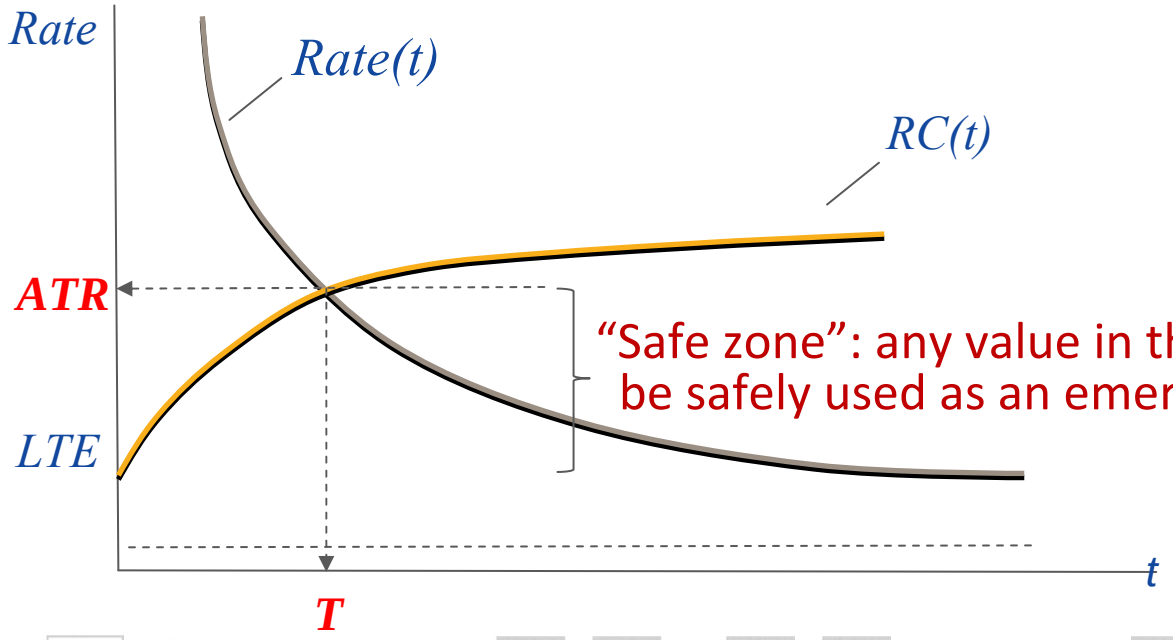
ATR is obtained as the solution of the following equation

$$Rate(t) = LTE + RC(t)$$

RC(t) is the system Ramping Capability for a line post-contingency

$$RC(t) = Flow_{t=+0} - Flow_{t>0} \quad \text{[in MVA]}$$

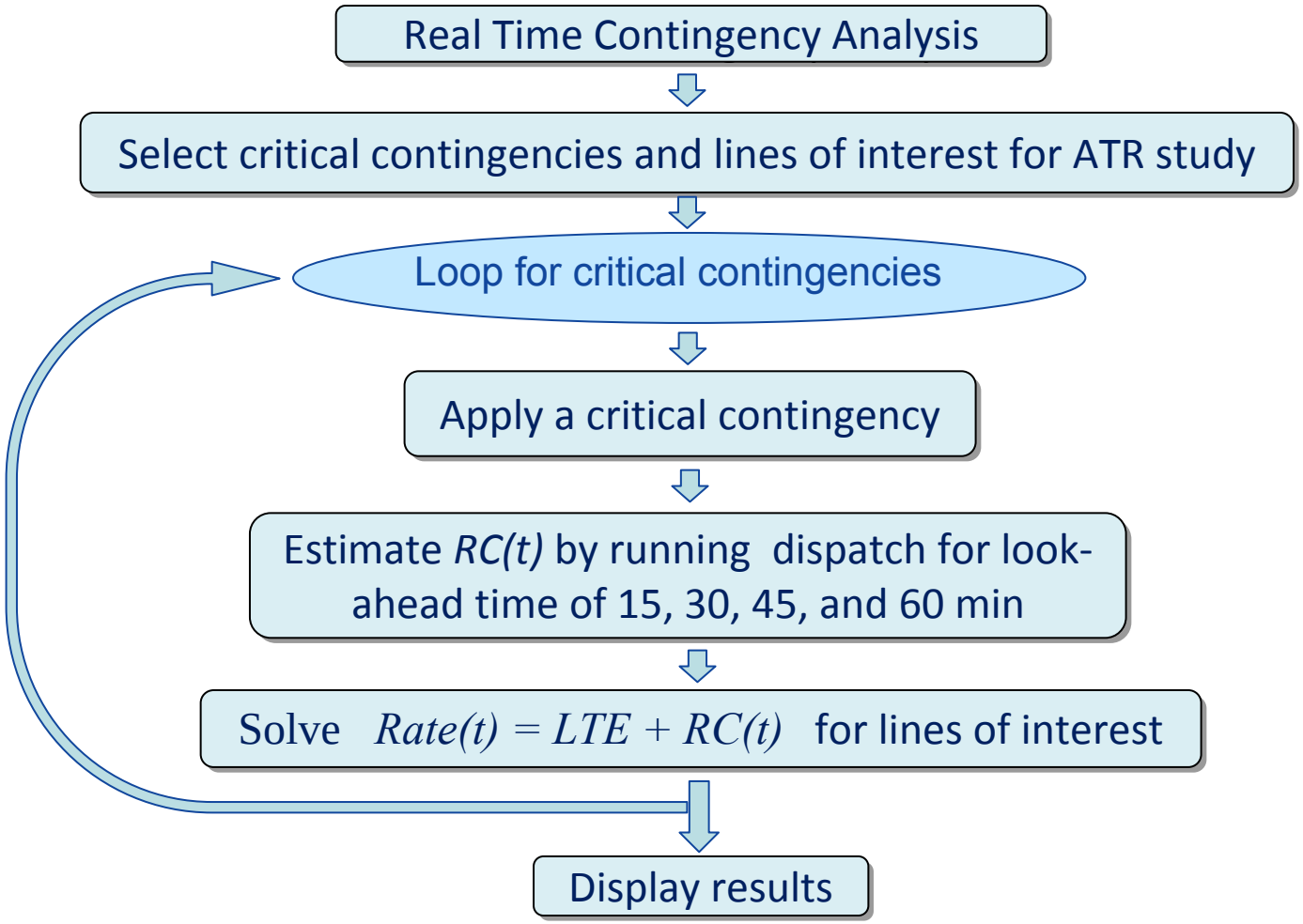
Safety cap: $LTE \leq ATR \leq STE$



Estimation of *RC(t)*

- *RC(t)* is the change in MW flow in a line of interest over time as a result of economic dispatch after contingency
- Accurate calculation of *RC(t)* requires to model post-contingency dispatch
- Use the same dispatch procedure and input data which are used for Real-Time dispatch

ATR calculation - Flow diagram



Critical contingencies

Contingencies causing post-contingency loading above threshold

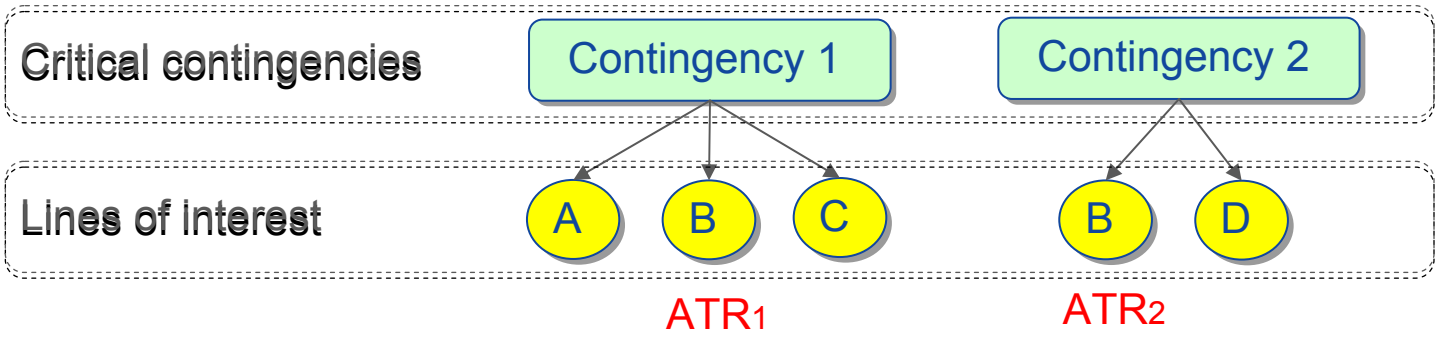
*Flow > LTE * k* *typically k=0.95*

Lines of interest satisfy the following criteria

- *Flow > LTE * k* *for a critical contingency*
- *STE/LTE > m* *typically m=1.05*
- *Rate(t) characteristics is available*

New enabling feature of ATR

- A line could be a line of interest for different contingencies
- Such line has distinctive ATR for different contingencies
- New opportunity – distinctive ATR of the same line can be used for transmission constraints related to different contingencies - reduction of redundant conservatism in today's practice when single rate is used for all contingencies.



RC(t) Estimate

- Apply critical contingency and run dispatch in look-ahead mode for 15, 30, 45 and 60 min
- Monitor power flow in lines of interest

$$RC(t) = Flow_{t=+0} - Flow_{t>0} \quad \text{[in MVA]}$$

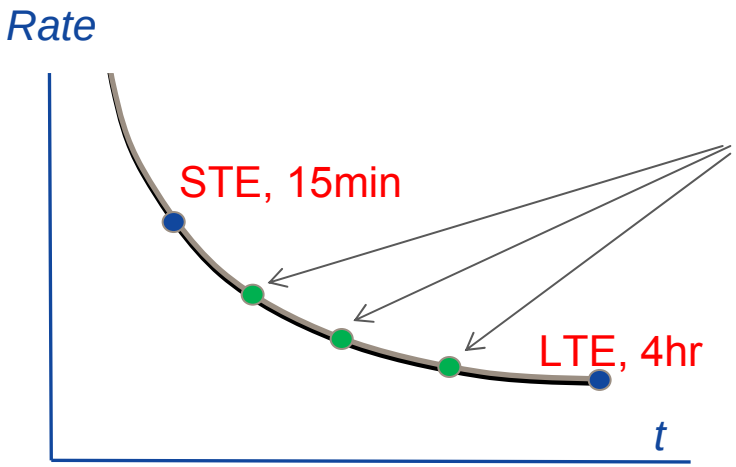
Conditions for Dispatch

- Ignore N-1 constraints and dispatch only for base case violations and load change per forecast
- Select target loading in lines of interest below LTE to reveal actual *RC(t)*

  *EnforcedRate = LTE * f f < 1.0; LTE * f > NORM*
- Restrict re-dispatch of generators having low sensitivity to power flow in lines of interest

  Do not dispatch units with Sens < s typically s=0.05
- Properly apply AC-DC bias because of DC model in dispatch and accounting of ratings in MVA

How to get *Rate(t)* characteristics?



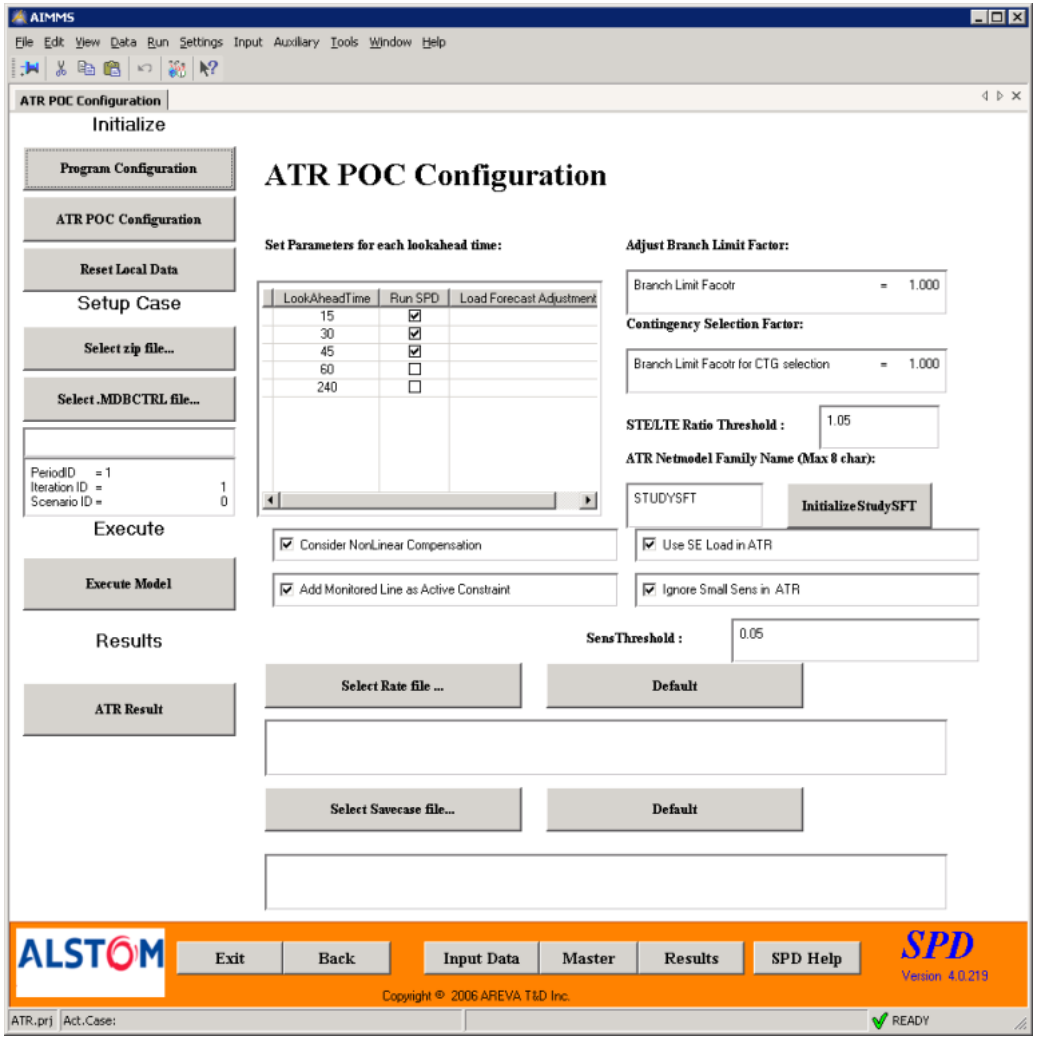
- Transmission Owners (TOs) should develop them
- Additional rates at 30, 45 and 60 min are need for creation of credible *Rate(t)* curve

Rate(t) curve can be estimated by using available *STE* and *LTE* and typical *Rate(t)* dependence for overhead lines and cables. Needs to be agreed with TOs.

ATR Proof Of Concept (ATR POC)

- Joint R&D project between ISO-NE and Alstom Grid
- ATR POC is a standalone application which can use real-time EMS and Market data
- AIMMS based project and includes two components:
  - Scheduling Pricing and Dispatch (SPD)
  - Simultaneously Feasibility Test (SFT)
  - New control flow and data processing logic for ATR

ATR POC – main menu



Input data

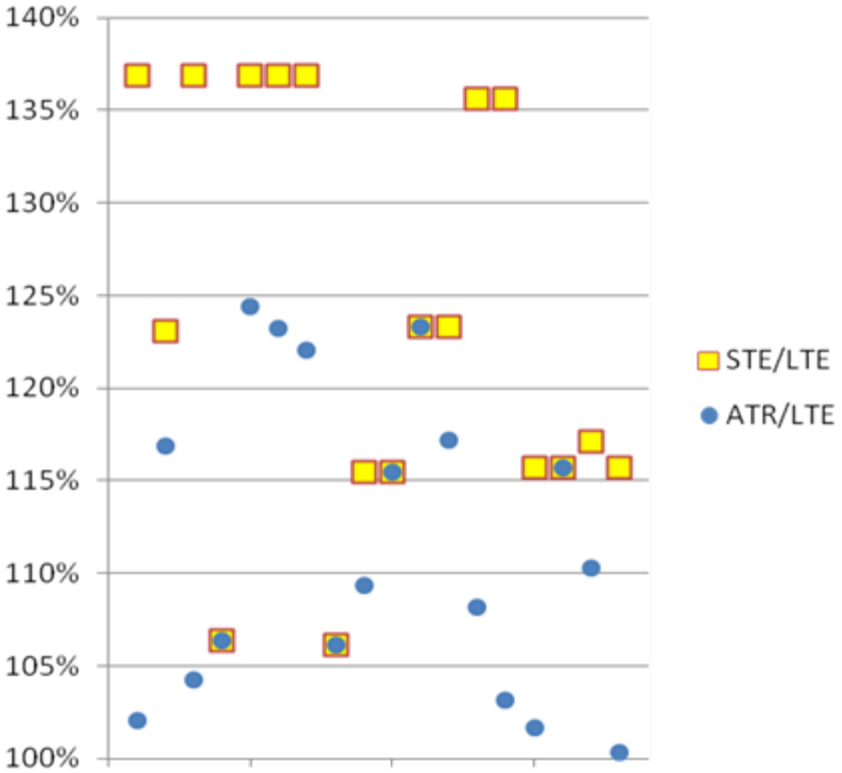
- State Estimator solution
- Real Time CA results
- Real Time Market data
- Static line ratings

Test conditions

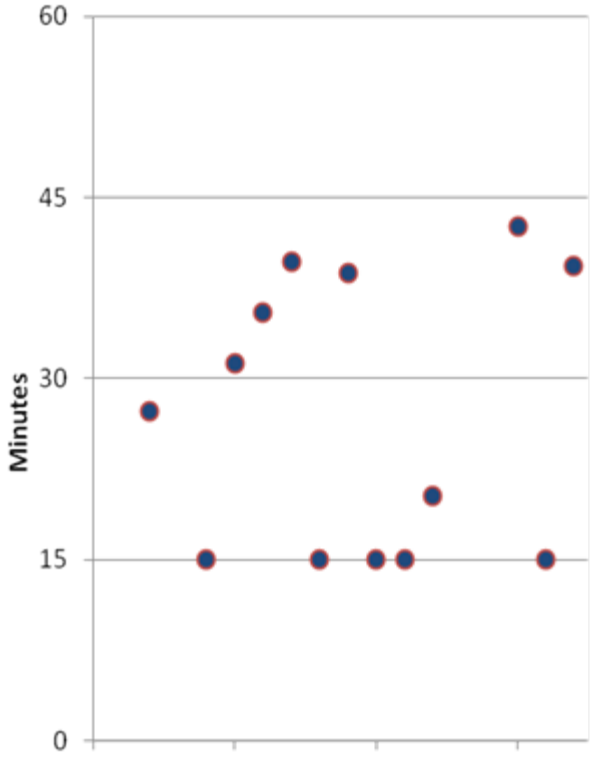
- ATR POC was applied off-line for all instances of Real-Time (RT) binding constraints caused by transmission lines applicable for ATR
- Study period June – November 2011
- Re-run all RT market cases with binding constraints but enforce ATR values
- Rate(t) characteristics were estimated based on typical profiles for overhead lines and cables

Results for RT binding constraints

ATR value

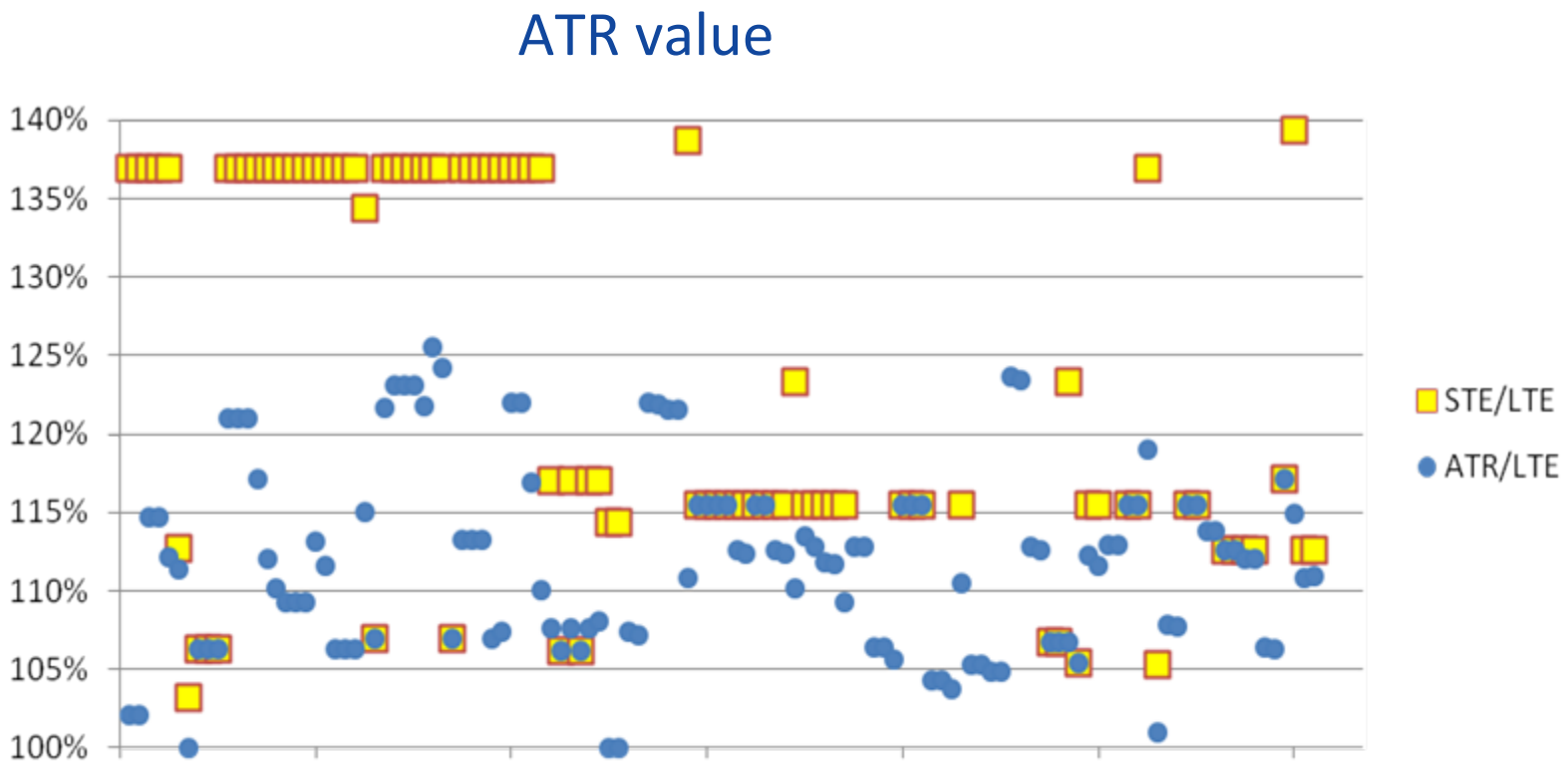


ATR time



Average increase in capacity over LTE is 11.7%

Results for RT active constraints



Average increase in capacity over LTE is 11.9%

Results – specific situations

- Dispatch case has two binding constraints simultaneously for distinct lines and distinct contingencies

Dispatch case	1		2	
Contingency	1	2	3	4
Line	A	B	C	D
ATR/LTE	106.3%	124.4%	115.7%	110.3%

- The same line is overloaded by four contingencies

Contingency	1	2	3	4
ATR/LTE	121.0%	117.1%	112.0%	110.2%

- The same contingency overloads two lines

Line	1	2
ATR/LTE	107.0%	121.6%

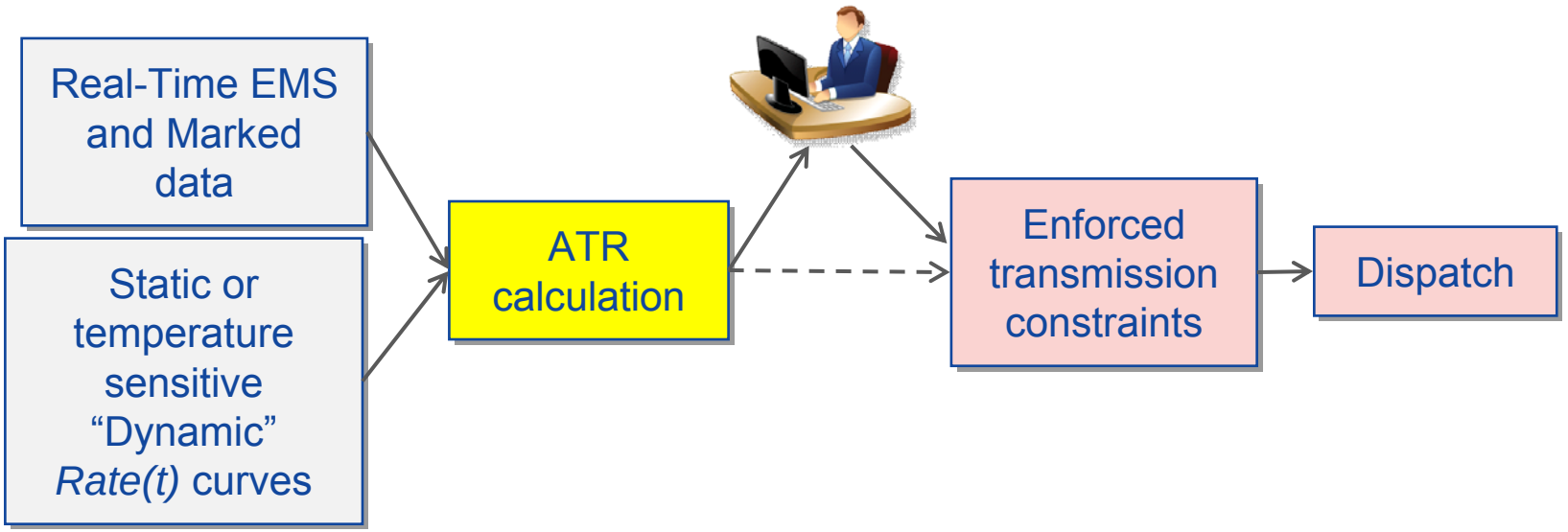
Economic Impact

Re-run all RT dispatch cases with binding constraints but use ATR instead of actually enforced in RT ratings

- Production cost reduction per case $501 - $22,324 with average $5,869
- Binding constraints in 44% of cases were relaxed
- Average shadow price was reduced from $457/MW to $190/MW

Use of ATR in RT dispatch

- ATRs are supplied to Operator in advisory mode
- Automatic use of ATR in dispatch (optional)



Future plans

- ATR technology has recommended by ISO New England for implementation in production ALSTOM system
- Implementation features
  - ✓ ATR values will be supplied in advisory mode
  - ✓ Use of multi-period Market Clearing Engine (MCE) instead of single-period SPD
  - ✓ Parallel computing to enhance performance

Questions