

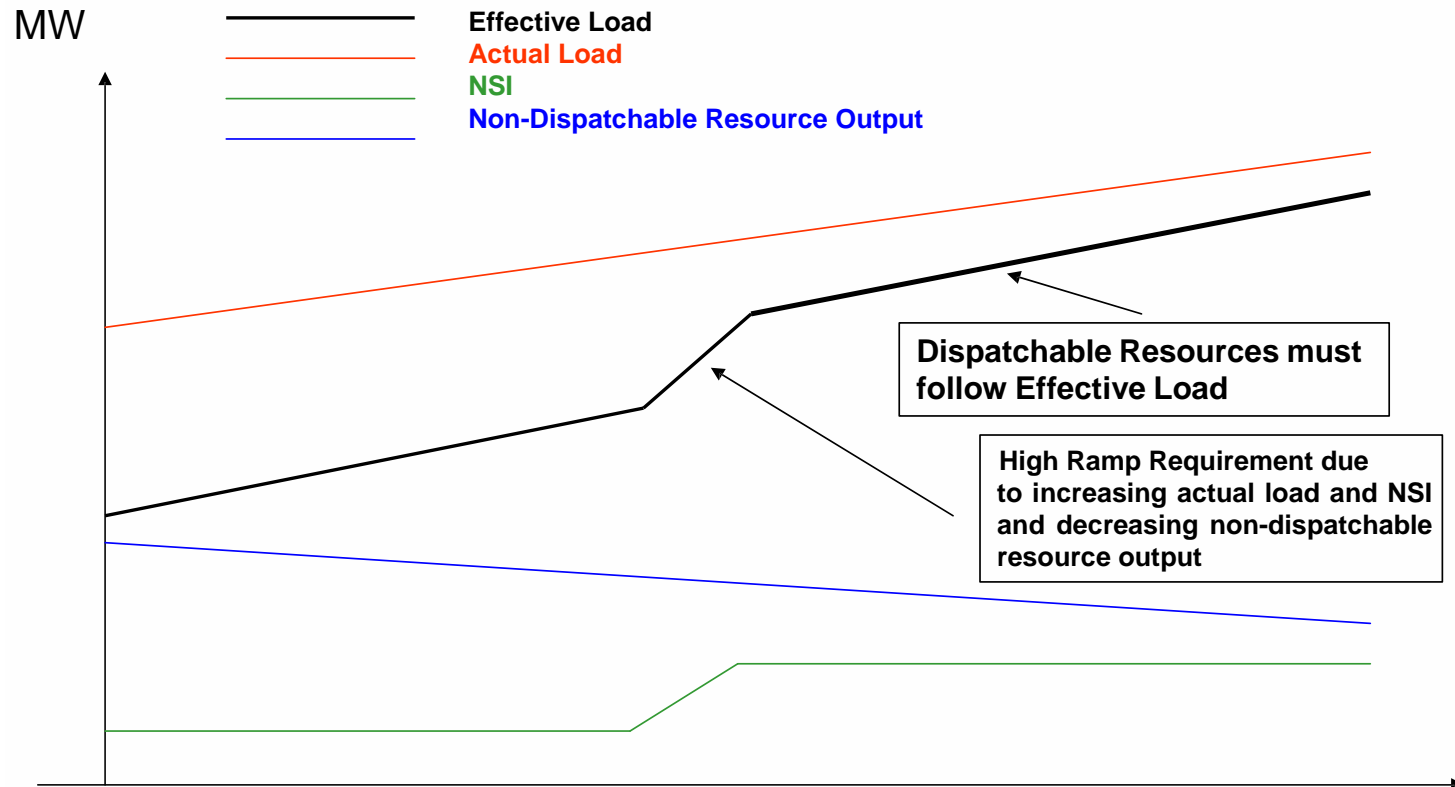
Ramp Management and Participation of Storage Resources

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Ahead Market Efficiency through Improved Software

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Illustration of Load Following Requirement



Opportunities to improve Ramp Management

- Aid reliable operations by keeping sufficient ramp capability available for use in RT dispatch
 - Less dependency on quick start resources and other operator tools
 - Cost effective compared to managing with regulation reserves
- Create sufficient incentives such that offered ramp rates reflect physical capabilities of the generation resources
 - Profitability and competitive edge based on offered flexibility
 - Transparent market mechanism may obtain additional flexibility from the existing fleet and/or justify new investments

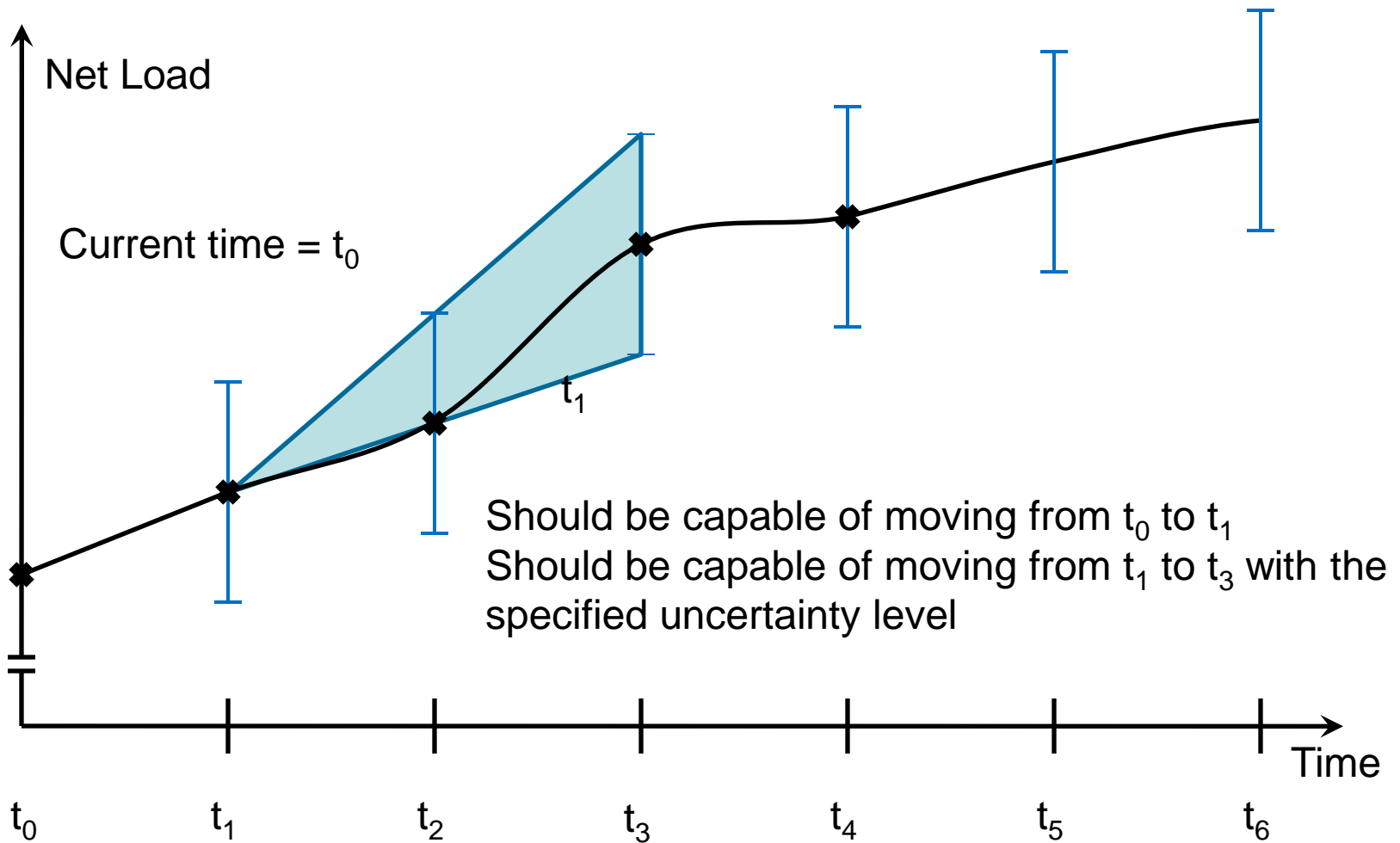
Opportunities to improve Ramp Management

- Ensure price volatility in RT is less impacted by transitory ramp shortages
 - Price signals are inefficient when market players are unable to react before corrective measures are administered
- Ensure reliable and economical operation in the presence of renewable resources and the impacts associated with the EPA mandates
 - Fuel prices making flexible resources less expensive and more heavily loaded can erode available responsiveness
 - Increasing penetration of renewable resources and interchange flexibility require additional ramp capability to ensure reliability

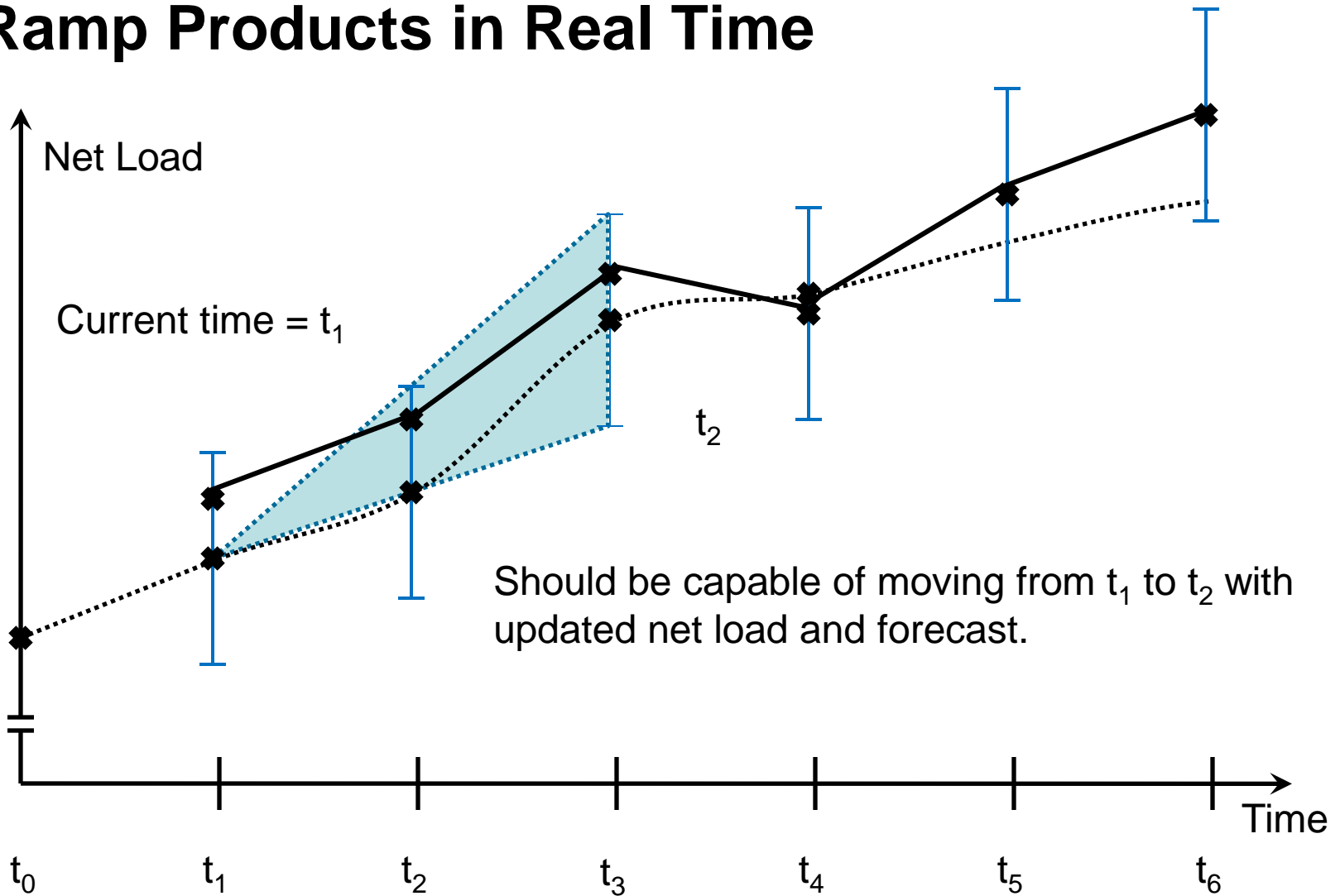
What are the proposed Ramp Products?

- Up Ramp Capability and Down Ramp Capability products to explicitly manage the ramp available from the controllable generation through market incentives
 - Reserve a specified level of resource ramp capability to meet RT dispatch variability
 - Requirements vary to support different operating conditions, forecasts, uncertainties, time of day, seasons, etc.
- Integrated within the commitment and dispatch functions in DA and RT markets
 - Modelled in the objective formulation as constraints with demand curve based penalty values
 - Co-optimized with Energy and Ancillary Service products
 - Prices determined by the resource opportunity cost

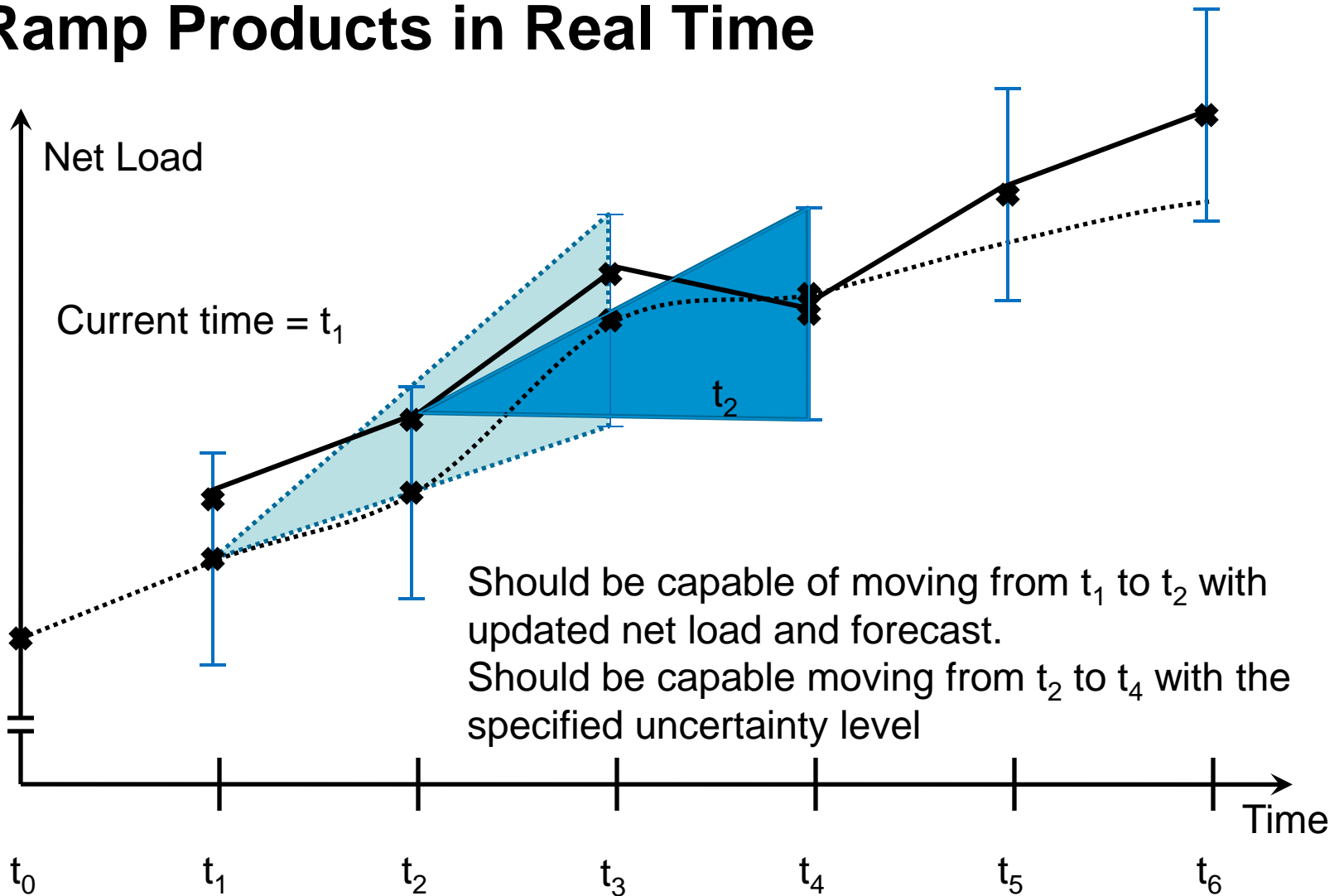
Ramp Products in Real Time



Ramp Products in Real Time



Ramp Products in Real Time



Long-Term Benefits

- Price volatility reflect true market economics and allow predictable market outcomes for generation and load
- Improved market transparency will reflect true cost of service
- Smoother dispatch signals potentially reducing wear and tear of generation resources
- Cost savings for load through reduction of shortage conditions and avoiding commitment of expensive quick start resources
- Sets the stage for more efficient usage of dispatchable resources including DRR and long-term storage

Opportunities for Long-Term Stored Energy Resources in MISO markets

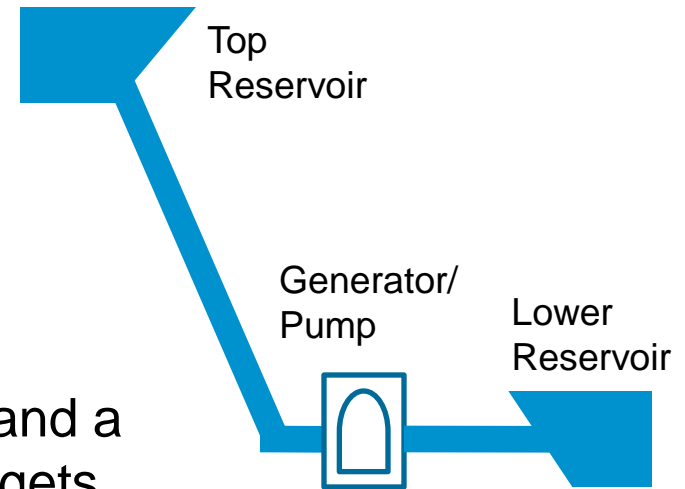
- System and resource efficiency can be improved if the market models and clearing process allow determination of generation and charging schedules
 - Considering coupling effect on the storage reservoir, weekly operational cycle and economics across multiple intervals
 - Current business rules puts the onus on the Market Participant to determine energy constraints based on storage targets, schedules and bids and offers
- Once adequately enabled, additional flexibility can be extracted from these resources to participate in products such as Ramp Capability

Specific Elements of Efficiency Gain

- Multi-day operational cycle can be better reflected in the daily market processes
- Proactive scheduling of limited energy generation using forward looking processes instead of reactive assessment by resource owner
- Daily energy constraints can be softened to strike a trade-off between value of energy to the system versus future value of retaining the storage
- Economic scheduling of charging of the storage instead of a fixed load schedule

Reservoir Storage Model and Participant Offers

- Reservoir model is coupled with the associated generation and pumping
 - Minimum and maximum storage limits are specified
 - Supports daily/hourly storage targets and a cost function for deviation from the targets
- Offered for Energy and Operating Reserves
 - Energy targets are replaced with reservoir limits and targets
 - Pumping is scheduled when economical to charge the storage to offset generation
 - Reservoir Target Price Curve reflecting the \$/MWh price for deviation from the target reservoir storage is also specified



Market Clearing (similar for DA and RT)

- Time-coupled multi-interval commitment analysis determines hourly storage targets
- Reservoir Target Price Curve will act as soft limit on the use of stored energy
- Hourly storage targets and value of storage are fed into the single interval dispatch for setting energy targets/trajectory and penalty values
- Violations are rolled into future intervals so attempt is made to restore to the energy trajectory if it is economic
- The resource will clear for Energy, Ancillary Services and Ramp Capability

Questions?

Website

<http://www.midwestiso.org> > What We Do > Strategic Initiatives > Ramp Management

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