

iTesla Project

Innovative Tools for Electrical System Security within Large Areas

Detailed architecture of the security assessment process

Brussels, Tuesday 14 January, 2014

Targeted solution:

Account for:

- Time horizon
- Correlations

Sliding time window
from quasi-real time to
24-48 hours ahead

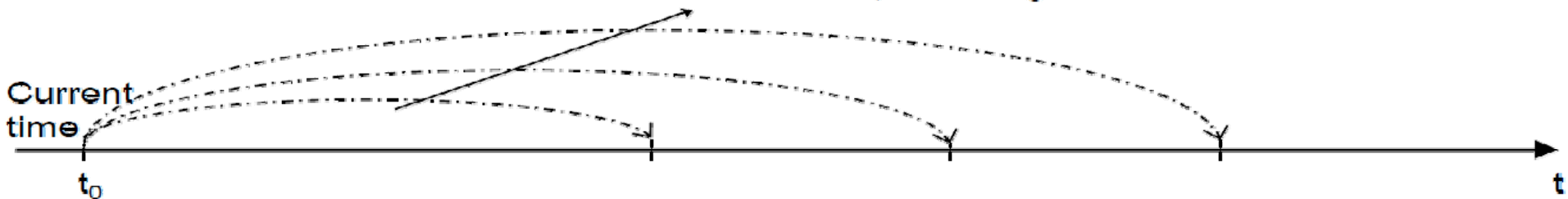
Renewabl
e &
Load
Uncertainties

Dynamics

Action
recommendation

New “online” security assessment

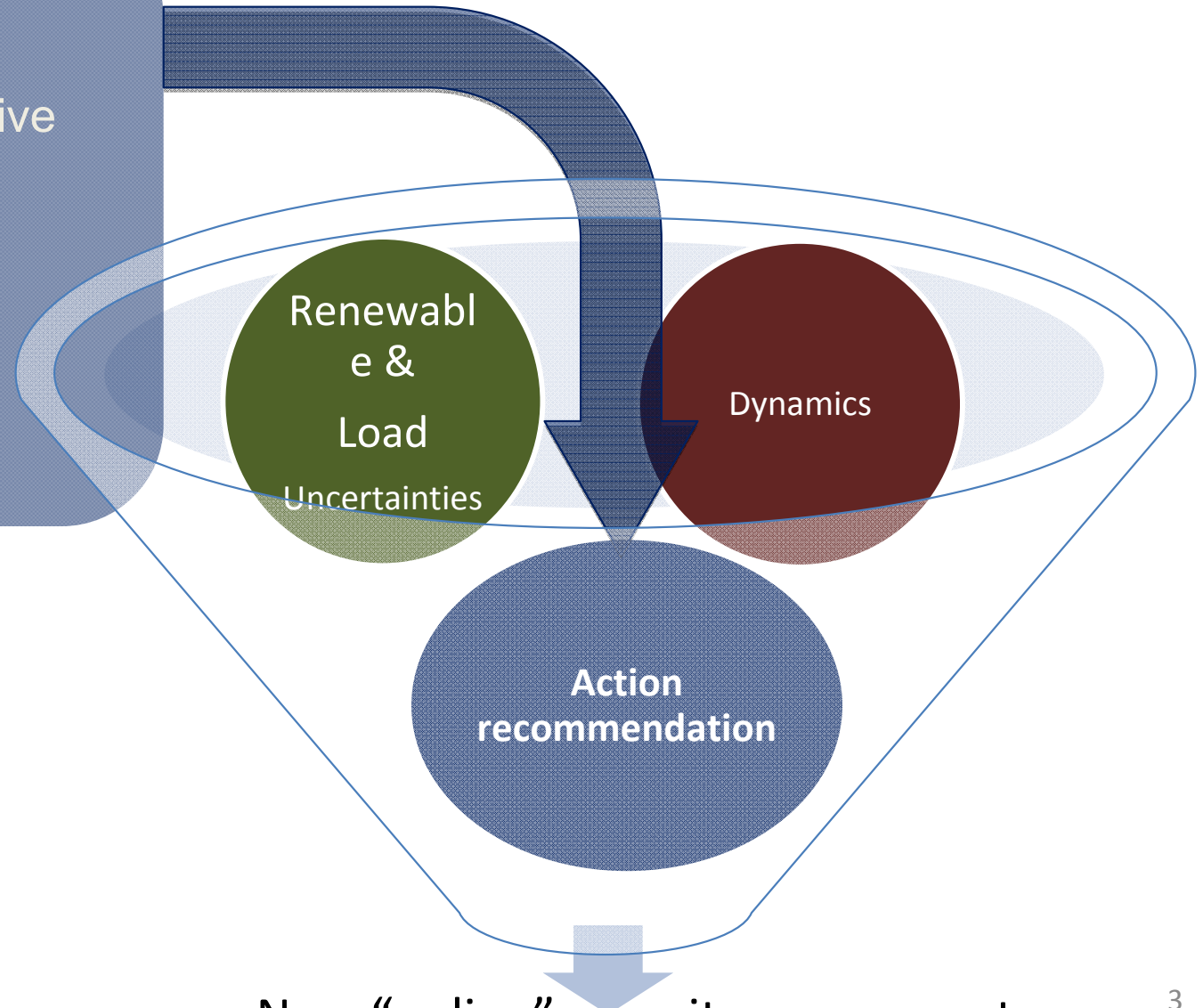
Farther time horizons, increasing uncertainties



Targeted solution:

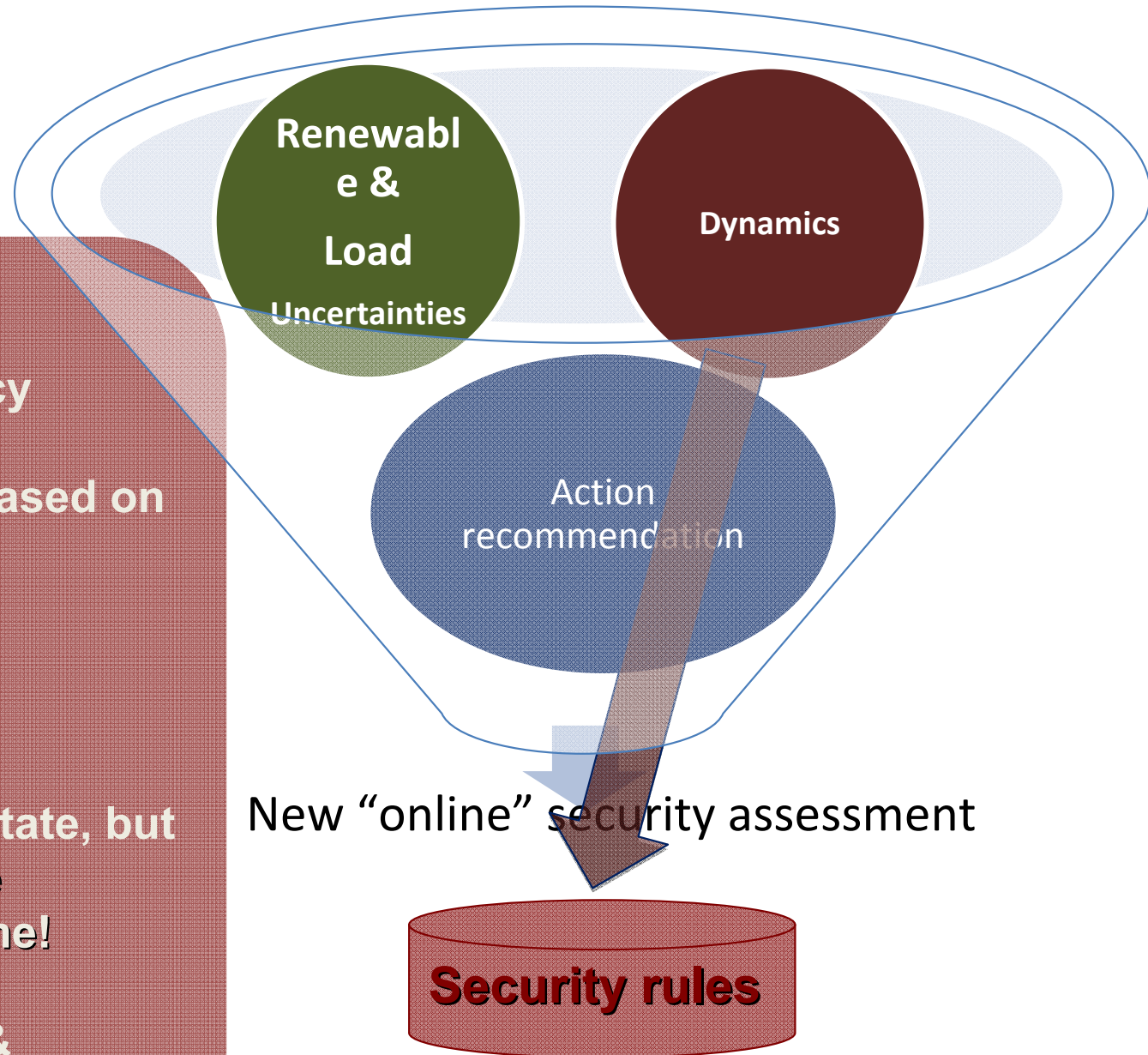
Corrective actions first
Expected costs assumed
smaller than with preventive
actions

Preventive actions
Minimal amount to
complement corrective
actions



New "online" security assessment

Targeted solution:



Security rules
Used for contingency filtering
Computed **offline**, based on
•extensive analyses
•TSO rules

“Per contingency”

Applied to the “N” state, but they account for the contingency outcome!

Encapsulate static & dynamic constraints

Rationale

Ultimate aim: assess security of next states

- Are *available corrective* resources sufficient?

- *Are any preventive actions needed?*

By when do they have to be started?

- What is the last «useful» time to trigger the actions?

 - Last Time To Decide



Classification of contingencies



Uncertainties
domain

- **Cluster 1**

- no action

- **Cluster 2**

- corrective actions

- **Cluster 3**

- corrective + preventive actions

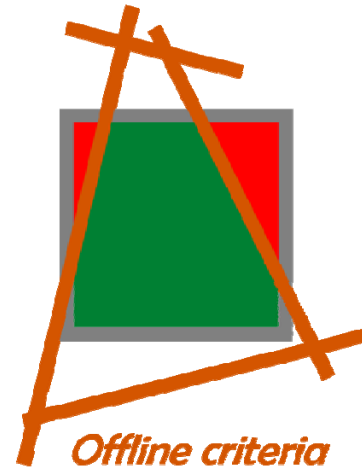
- **Cluster 4**

- «Strategic» actions needed

CLUSTER 1



CLUSTER 2 & 3 & 4



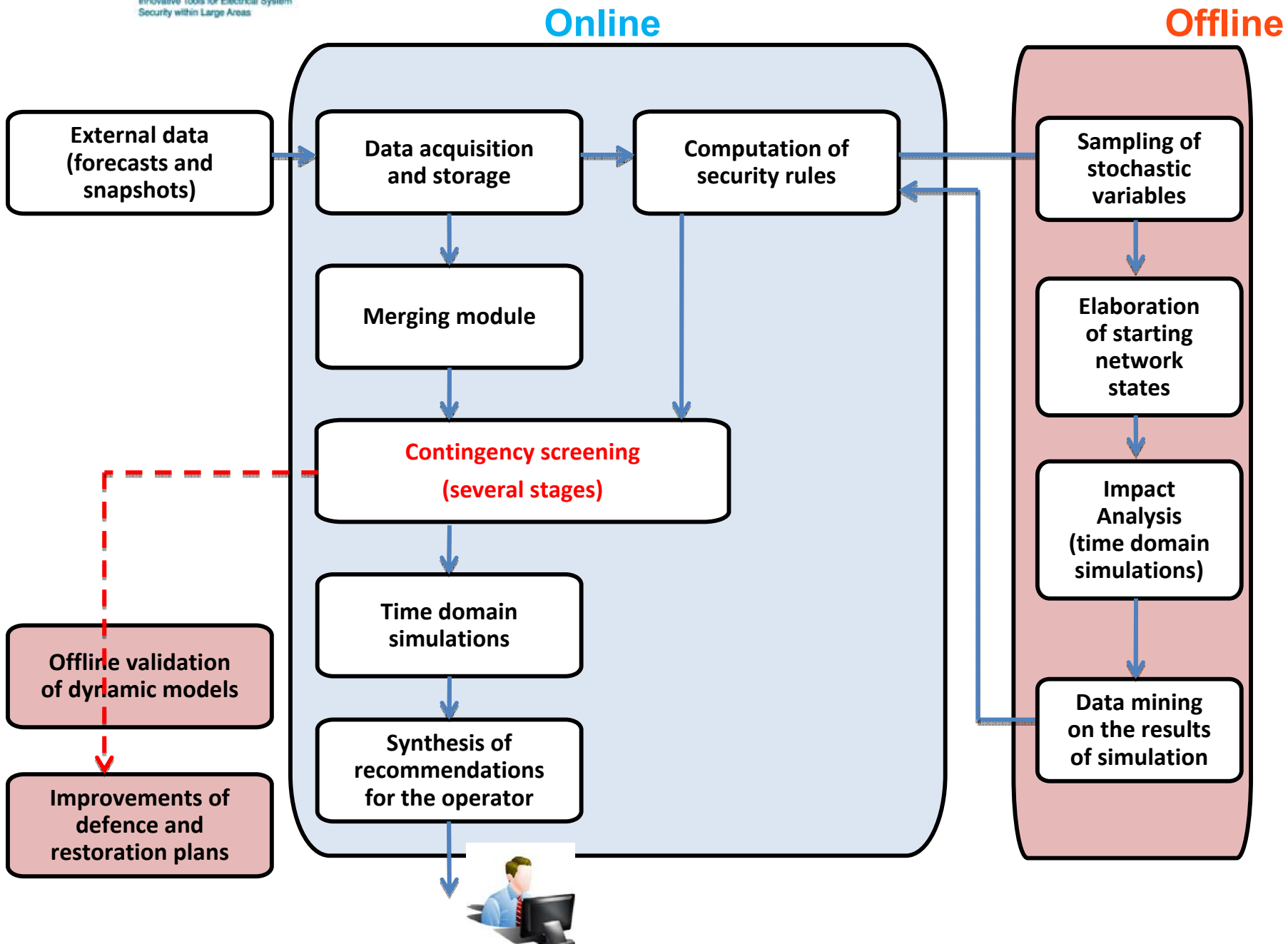
CLUSTER 2 & 3



CLUSTER 4



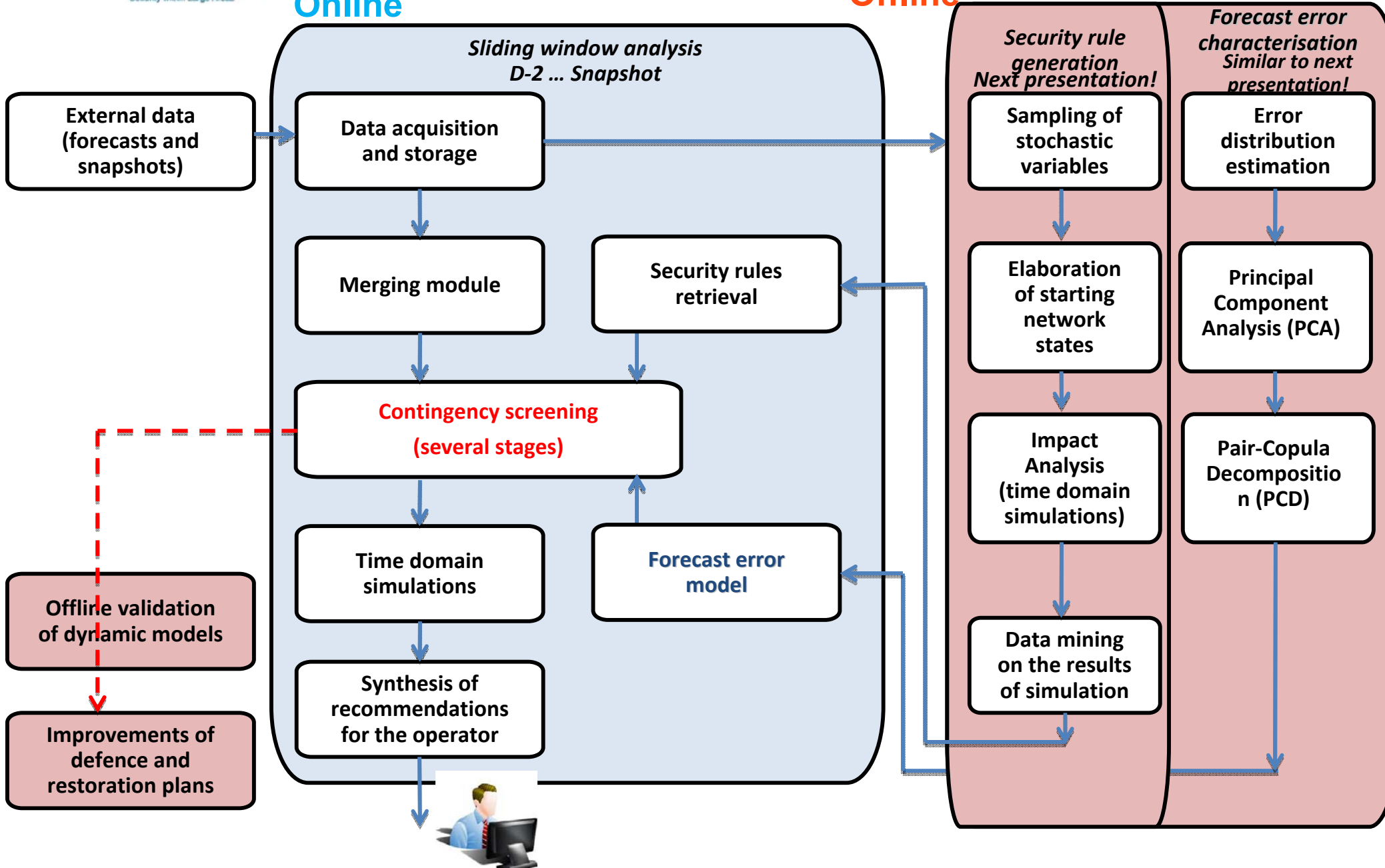
Proposed final architecture



Final architecture - *Detail*

Online

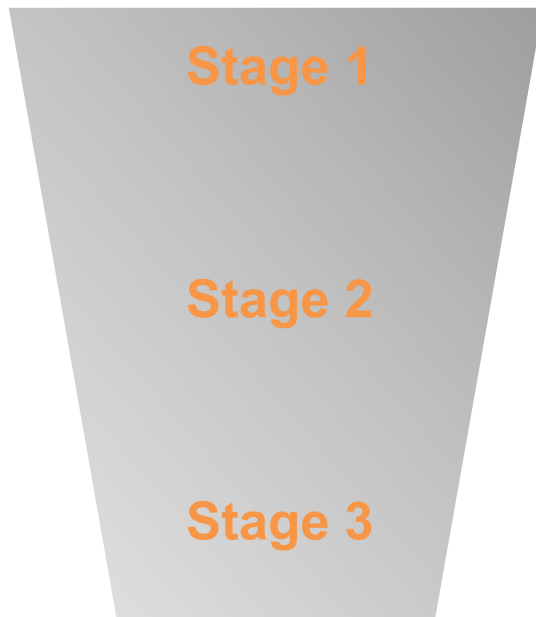
Offline



Online work flow

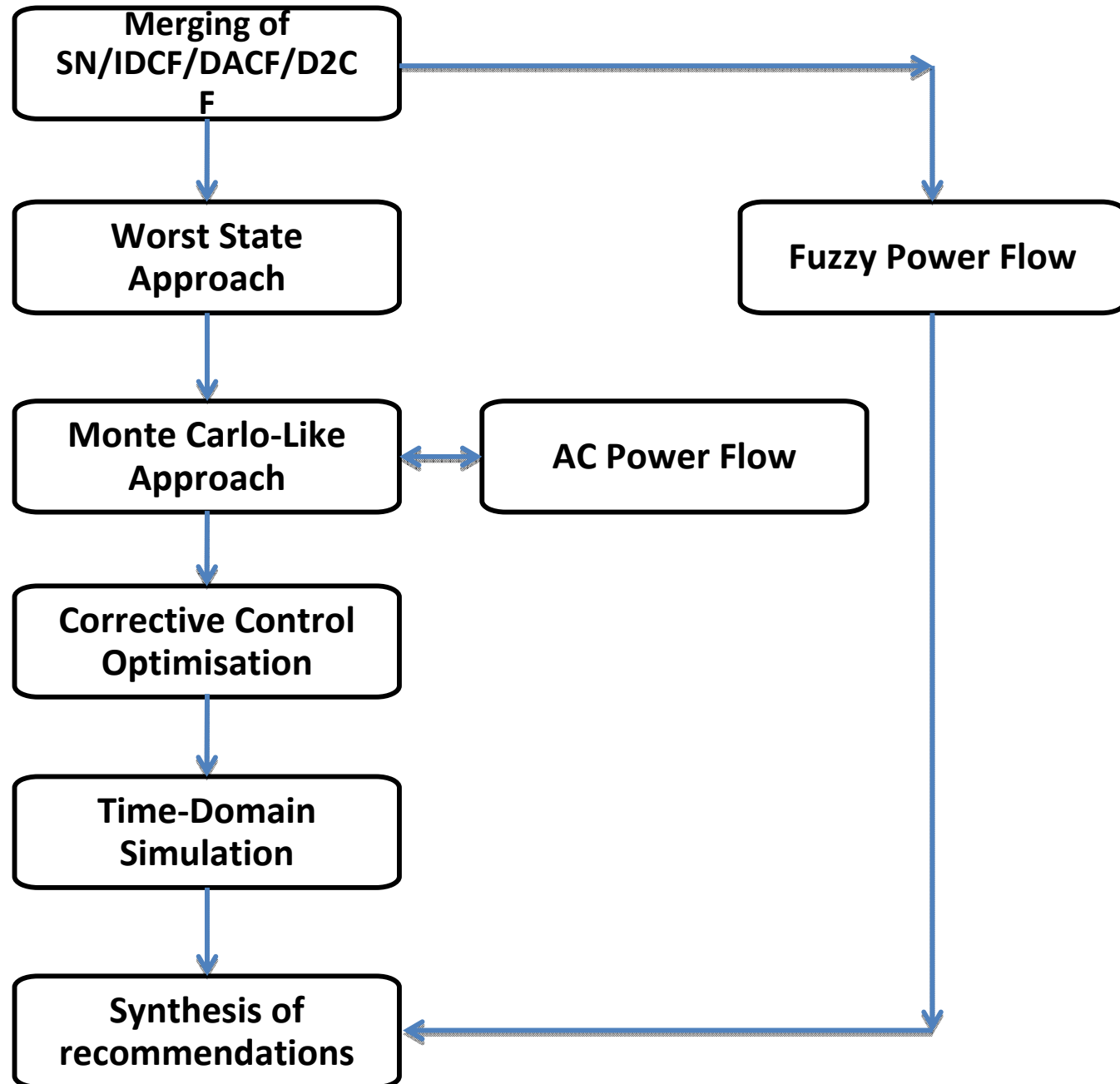
Forecast state building

Contingency Filtering



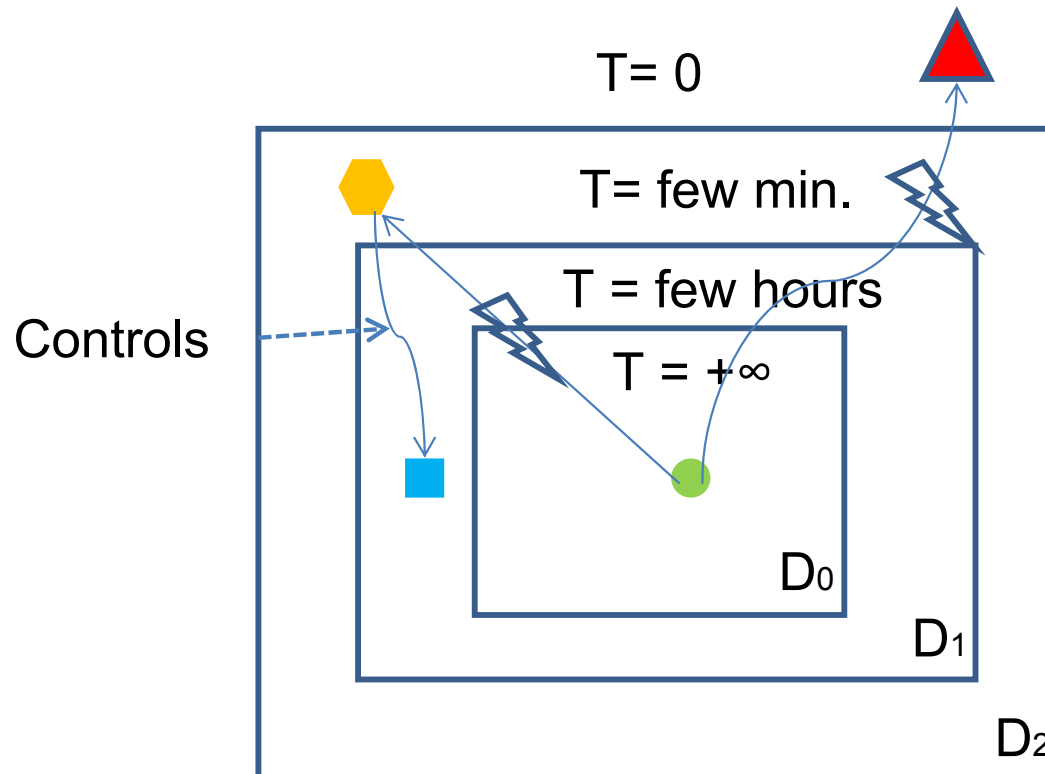
Detailed analysis

Results



Filtering (1): «Worst State»

- Different acceptable domains for the system states are generally used in the operation of transmission grids. Limits related to overloads of power lines depend on the duration of violation of these limits (thermal problem)



Filtering (1): «Worst State»

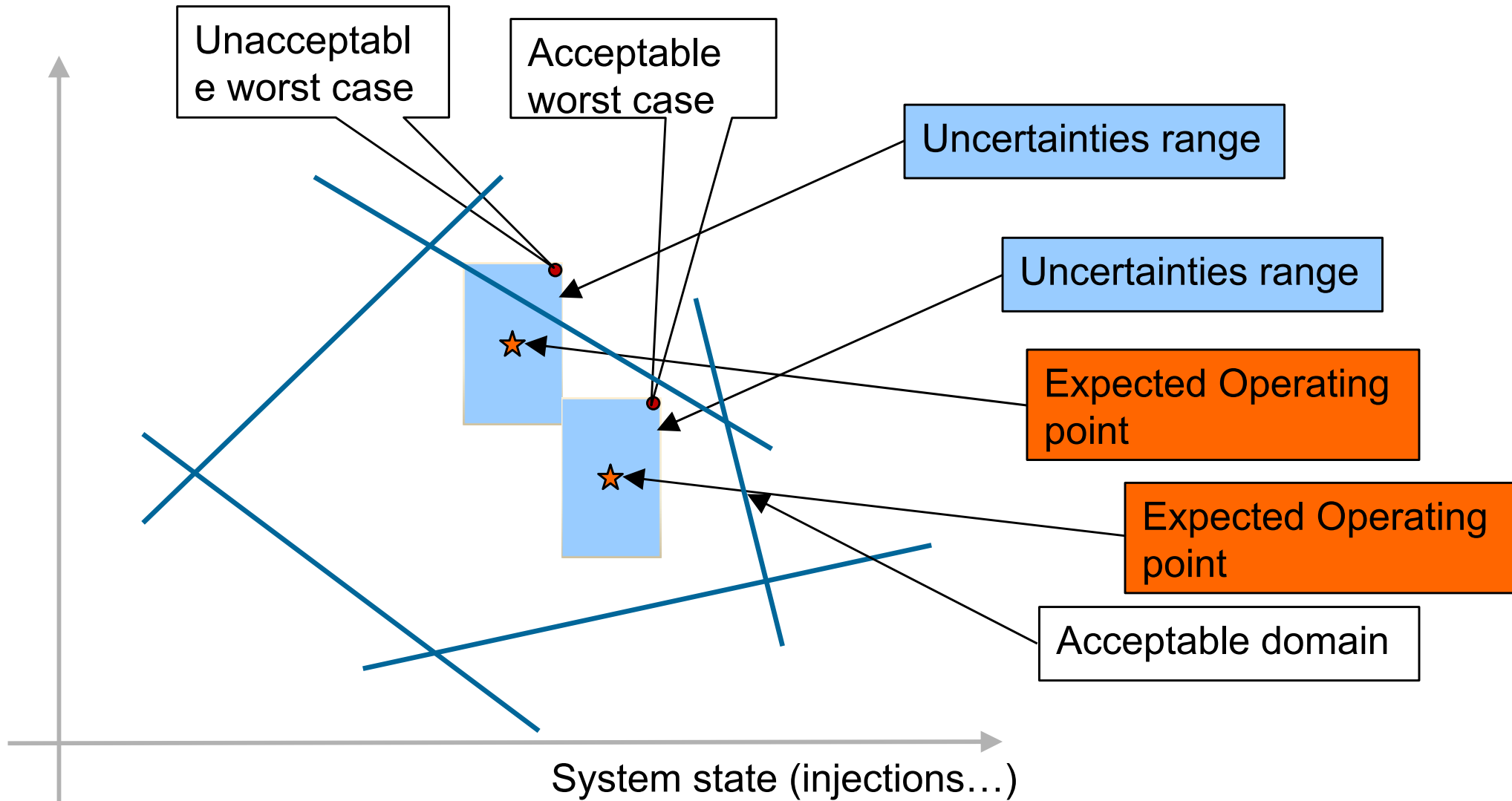
- **Preliminary filtering**
- Offline security rules based on active power
- DC model
- Corrective actions
- Static optimisation
- Very conservative

Pre-fault

Post-fault

Post-fault corrective actions

Security assessment under uncertainty: Worst State approach pictorial examples

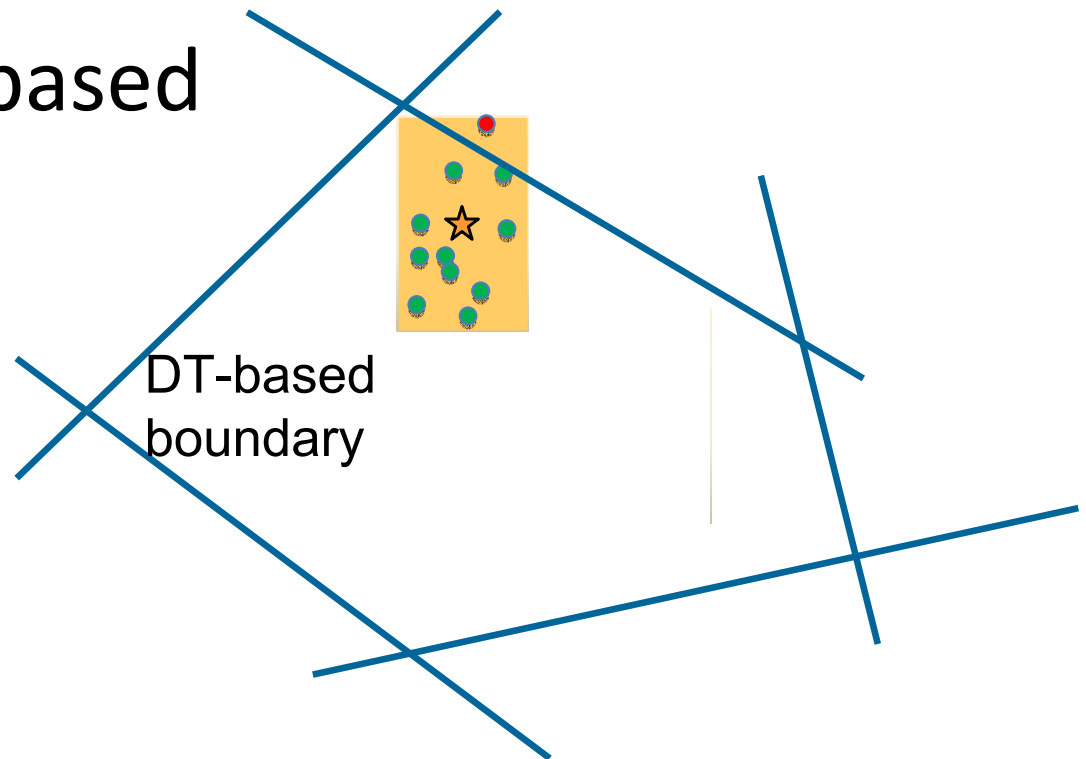




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Filtering (2): «Monte Carlo-Like» Approach

- Samples of operating states within the **uncertainty cloud**
- **Correlations** of forecast errors
- Offline security rules based on AC quantities
- Decision Tree (DT) -based security rules
- Samples deemed **unsecure** go to next stage

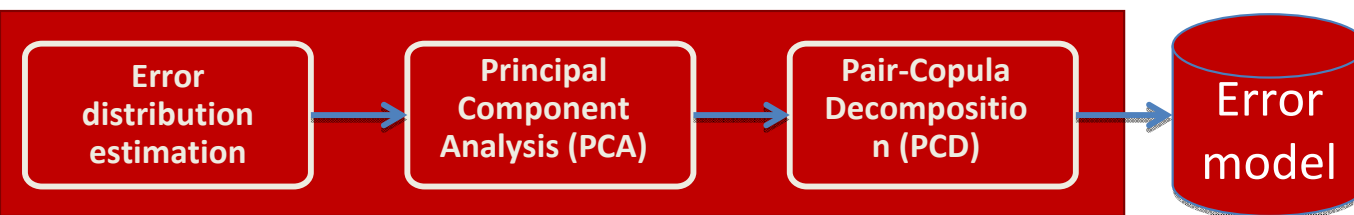


Filtering (2): «Monte Carlo-Like» Approach

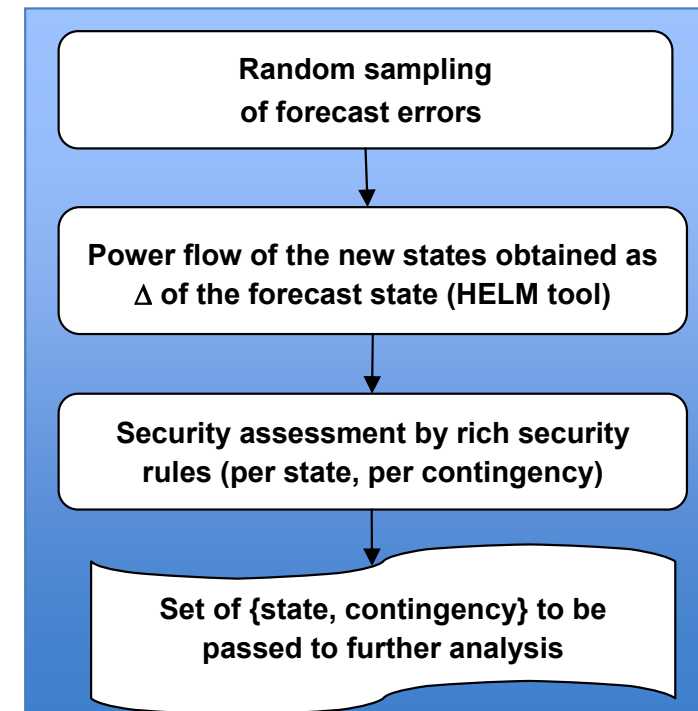
- Sampling of **forecast errors**
 - **Accounting for correlations**
 - Formally, same process as to create «generic» plausible states for *security rule* generation (see next presentation)

$$P_{\text{sample}} = P_{\text{forecast}} + \Delta P_{\text{error}}$$

Offline, computed periodically



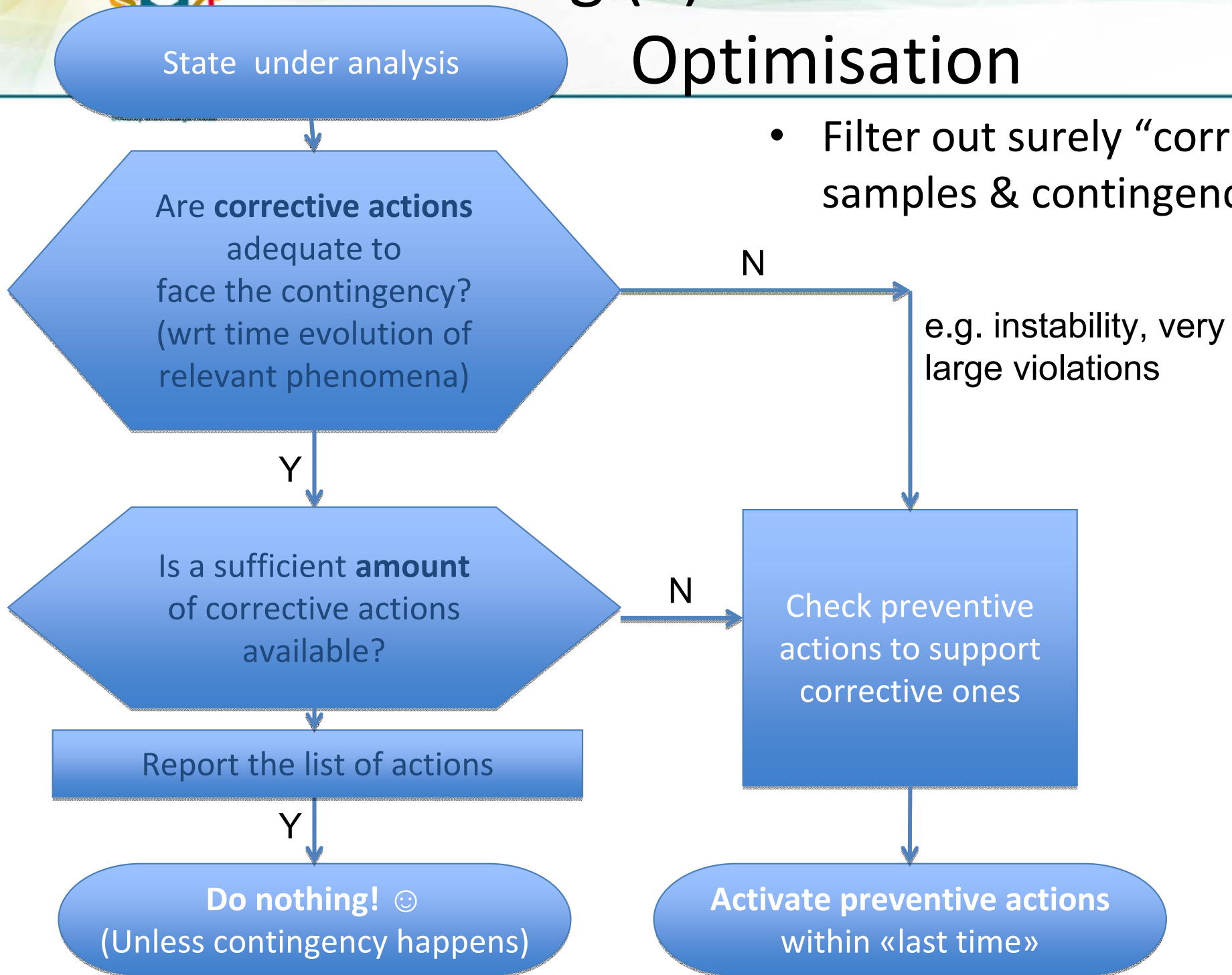
Online





Filtering (3): Corrective Control Optimisation

- Filter out surely “correctable” samples & contingencies

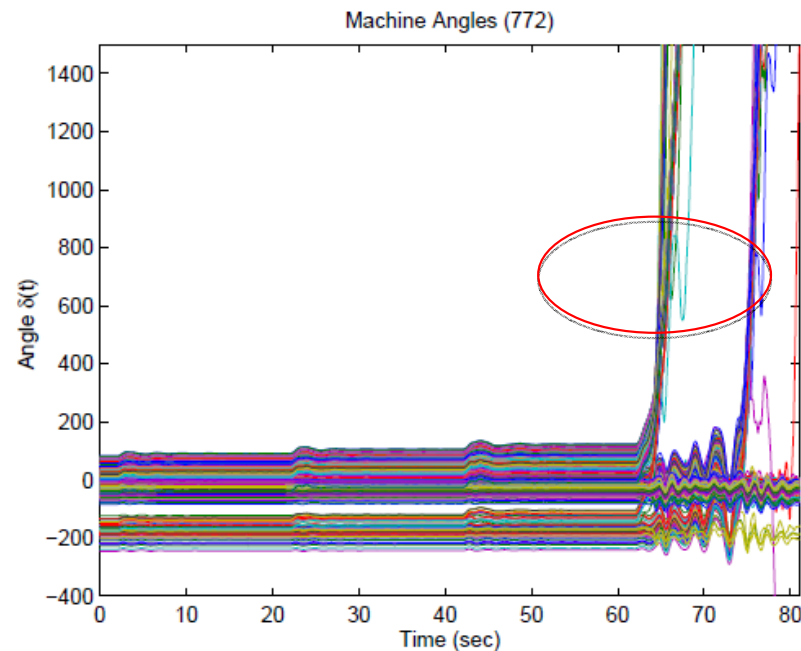




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Time-Domain Simulation

- Perform detailed analysis of the set of state & contingency identified as possibly dangerous
- Check preventive and corrective control actions
- Exploits algorithms to detect instabilities and violations from swing curves

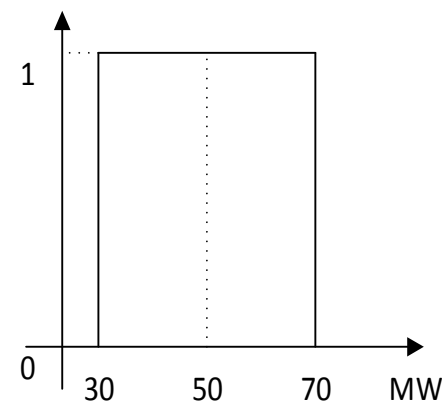
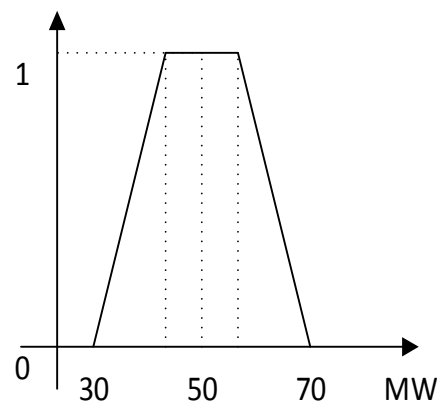
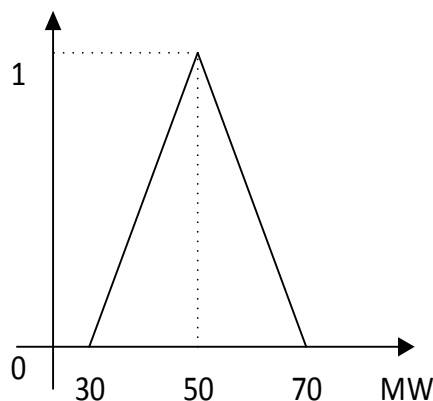




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Fuzzy Power Flow

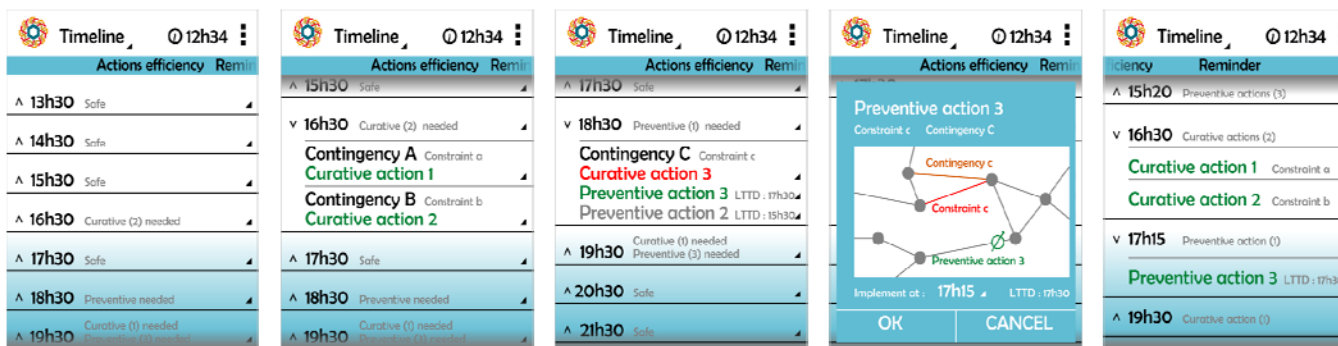
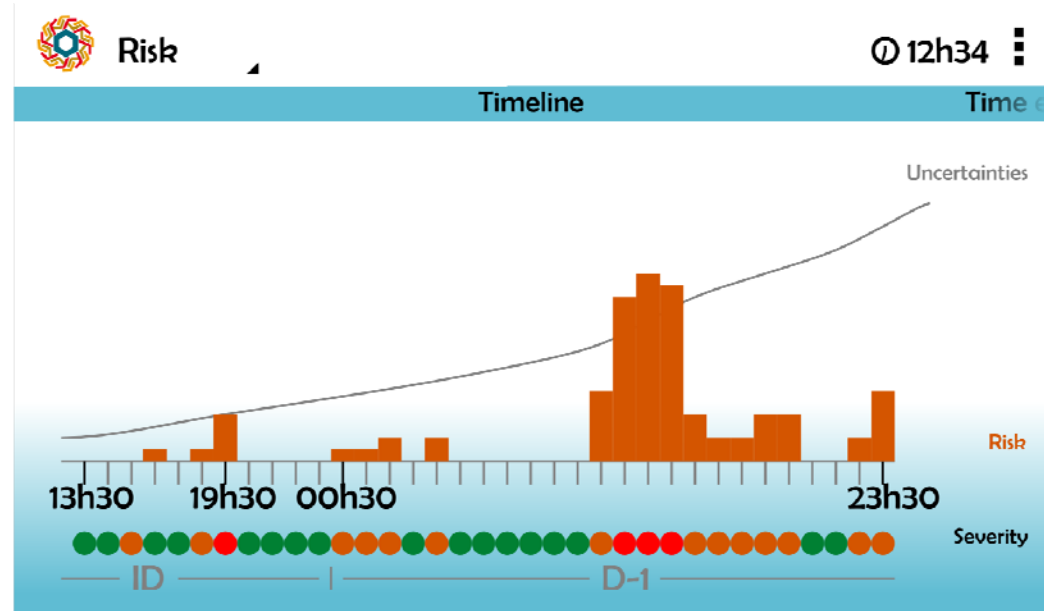
- Meant as parallel to the main online workflow:
 - Allow independent validation of the filtering
 - Show integrability features of iTESLA
- Uncertainties evaluated in a qualitative way
- Static tool, used for contingency analysis



Synthesis of the results

Results interface

- Steady-state constraints per contingency
- Transient stability info
- List of recommended preventive actions and simulated curative actions



- Synthesis of **recommendations** for the operator