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Modeling of Automation Degradation: a Case Study

DEEPBLUE

The Context: Strategy of SESAR for automation

- Increase ATM efficiency and capacity to deal with traffic increase and new business challenges
- Increase of automation as one of the basic elements of all the solutions identified
- Automation intended to support, and in some long term cases even completely replace human tasks
- Different human role with more strategic and supervision activities in (from an operator-in-the-loop approach towards an operator-over-the-loop)

The Context: Problems of automation

- Automation brings a range of new challenges including those related to possible degradations.
- High levels of automation, standardization and high efficiency often imply low flexibility to deal with unplanned events and failures
- Highly automated components are usually tightly interconnected.
- Difficult to detect and isolate failures before they propagate to the whole system

The Proposal: SPAD project

- Understand, model and estimate the propagation of automation degradation in ATM
- Evaluate and estimate the consequences of degradation propagation on ATM performances
- Support an effective intervention for the containment of automation degradation

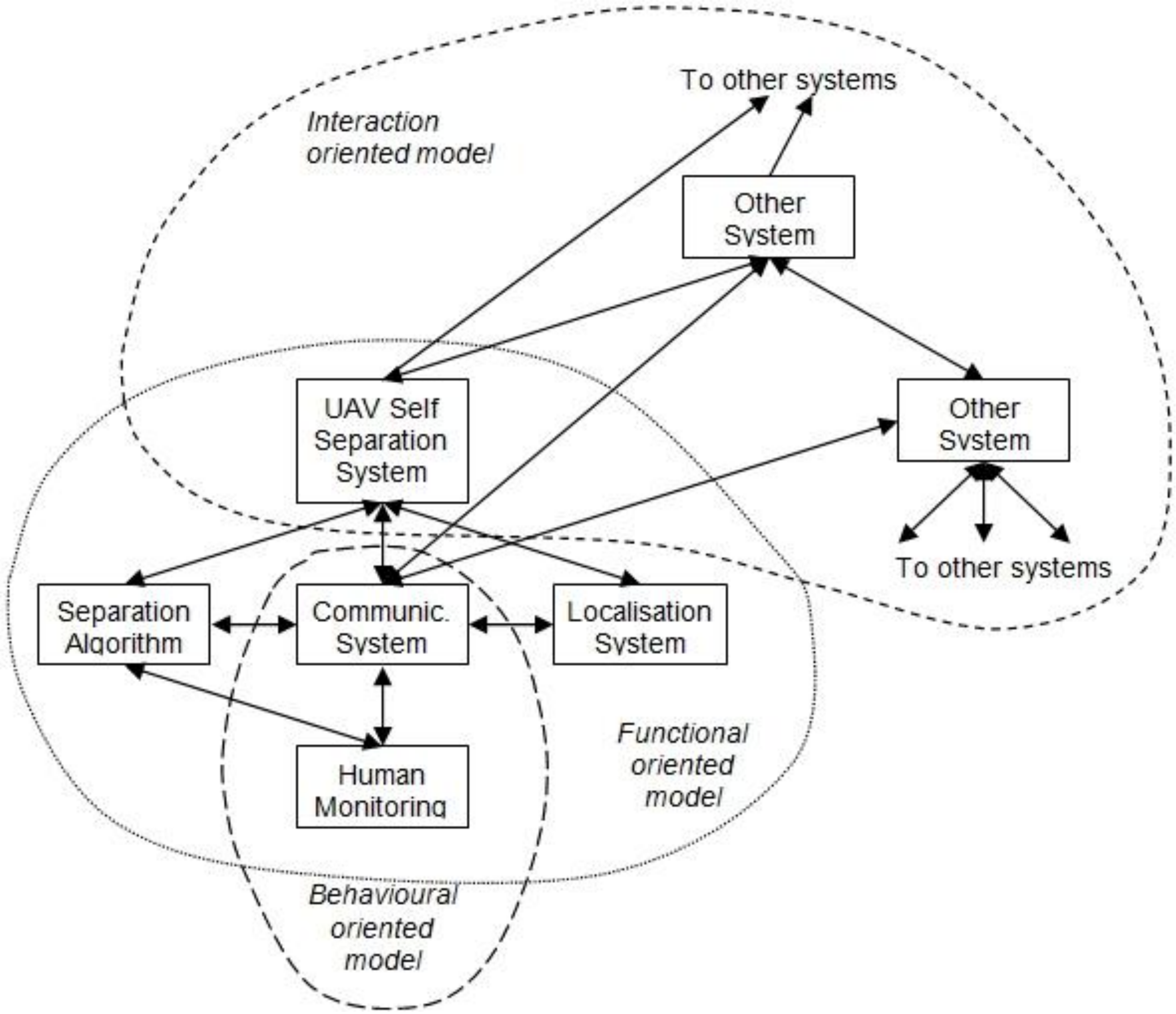
Content of (the remaining) of the presentation

- Solution adopted to achieve the project objectives
- Case Studies and tools developed
- Conclusions about applicability of the approach
- Main results from the analysis

Approach adopted in SPAD - I

- ATM seen as a system of systems that combine their resources and capabilities in order to achieve a common goal
  - Need to consider multiple levels and domains
  - Overall complexity and variety of the system elements
  - Level of uncertainty that remains in their behaviour and interactions.
- Collaboration of multiple models analysing the system from different perspectives and at various levels of granularity
- Models used within the context of a federation to facilitate integration of the analysis and of the information offered by the models

Approach adopted in SPAD - II



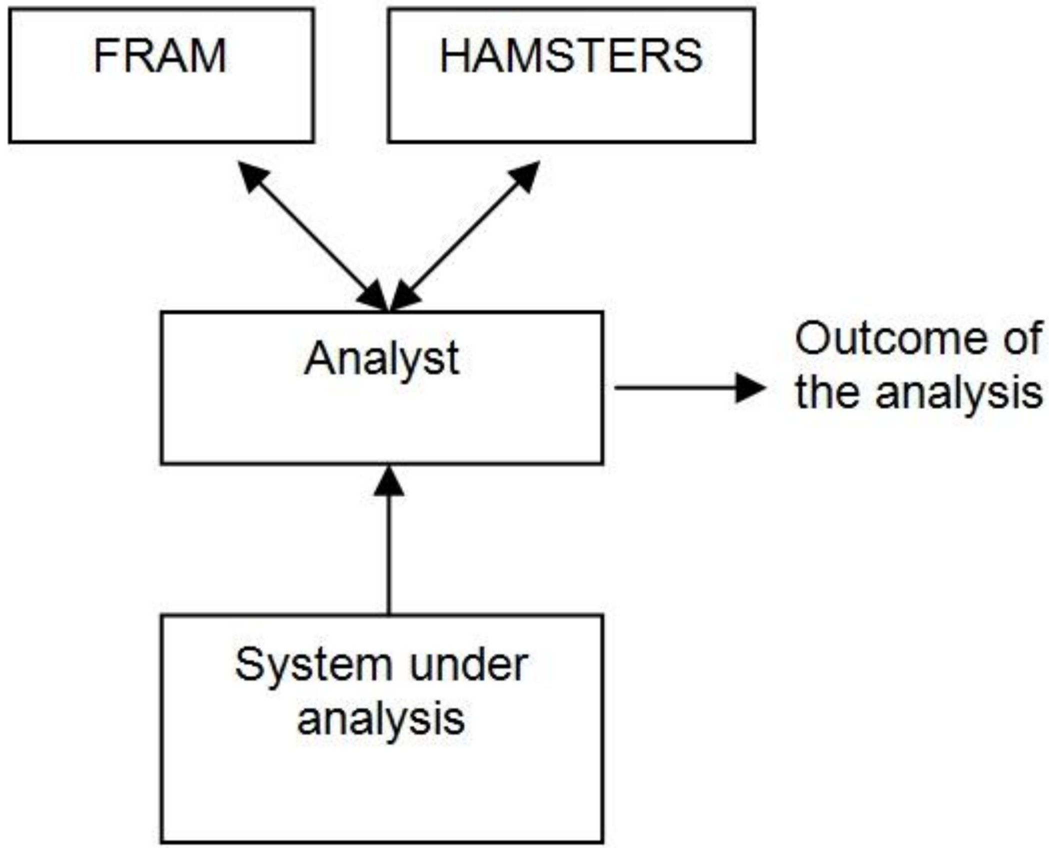
Models of the Federation

- Functional Resonance Analysis Method (FRAM) describing systems in terms of their functions and interactions between functions
- Human-centered Assessment and Modeling to Support Task Engineering for Resilient Systems (HAMSTERS) focusing on human interactions with the system and their timing properties
- ICO (limited extent) focusing on interface between systems

How the models collaborate

- Two layers based on FRAM Models
  - First layer to represent and model what happens at the level of the single system (e.g. an ACC)
  - Second layer to consider the influence of propagation to a large portion of the ATM System (nearby ACC, airports and related traffic) and consider the effect of propagation down to system level
- HAMSTERS in support of FRAM application at the high granularity layer
  - To support the analysis of the functions outcome with a more quantitative and rigorous analysis and when humans are involved

Analyst at the center of the federation



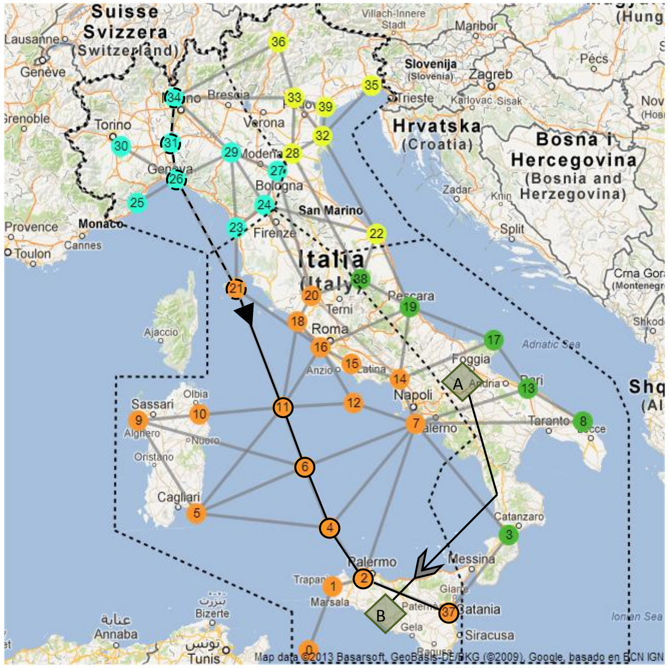
Information provided by the federation

- Possible interactions between the different system functions and consequences that may affect system performance adversely
- Identification of the functions that are potentially more influenced and possible effect of mitigation solutions (e.g. introducing indicators and barriers, modifying the design or the procedures, etc.)
- Information provided for all the ATM system, at different levels of granularity

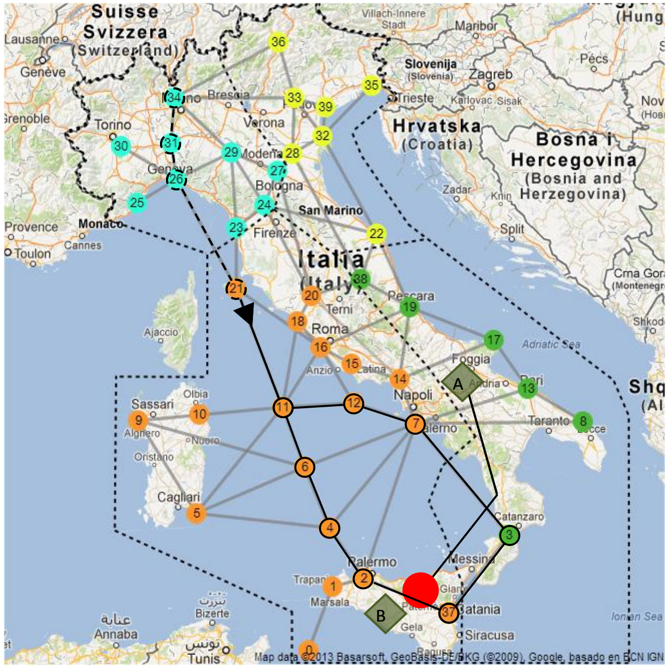
How the federation was tuned and validated

- Federation refined and validated in two case studies from the ATM world.
  - Arrival Manager (AMAN) used to support identification of the optimal aircraft approach sequence (level of automation between 2 and 3)
  - Remotely Piloted Aircraft System (RPAS), where Remotely Piloted Aircraft (RPA) are able to self-separate from each other and from the surrounding commercial traffic (level between 7 and 10)
- Three possible degradation events of growing levels of severity per case study
- Data about second case study generated with the support of a simulator

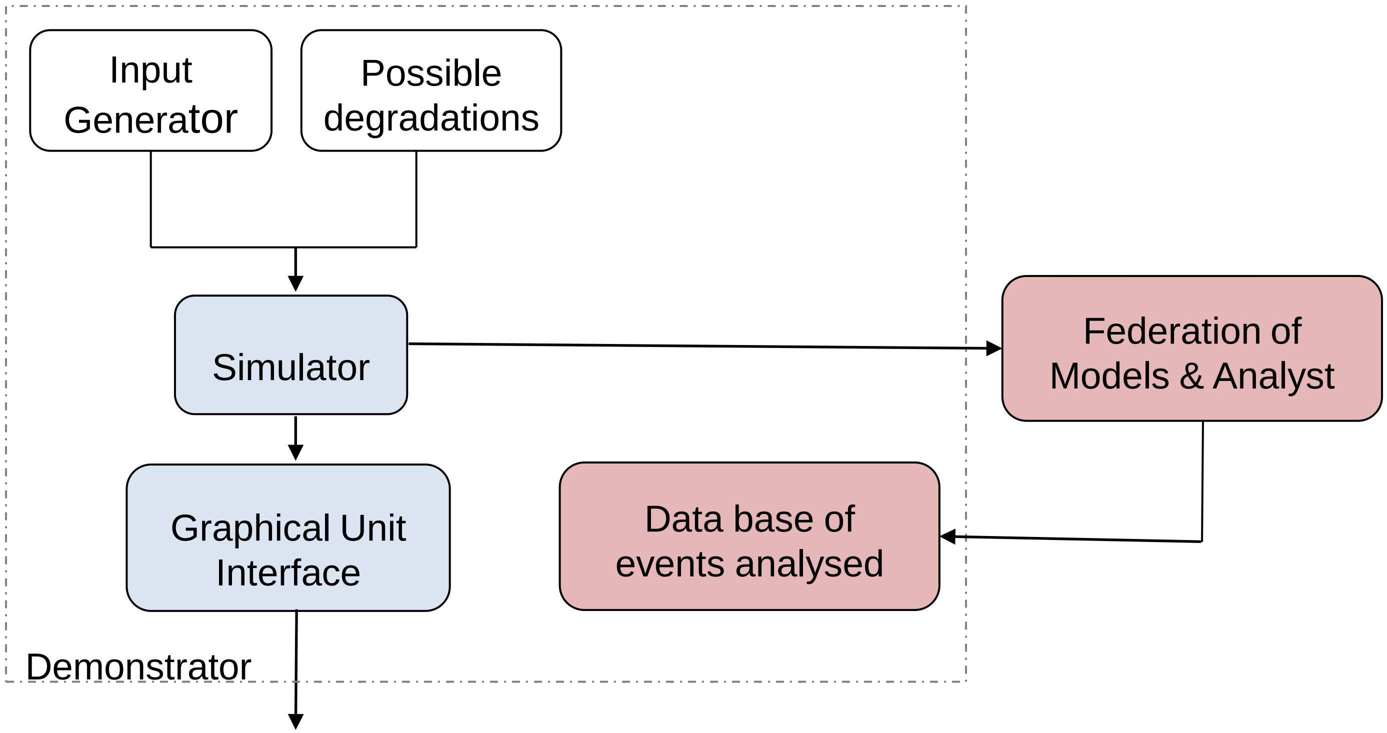
SPAD Simulator - I



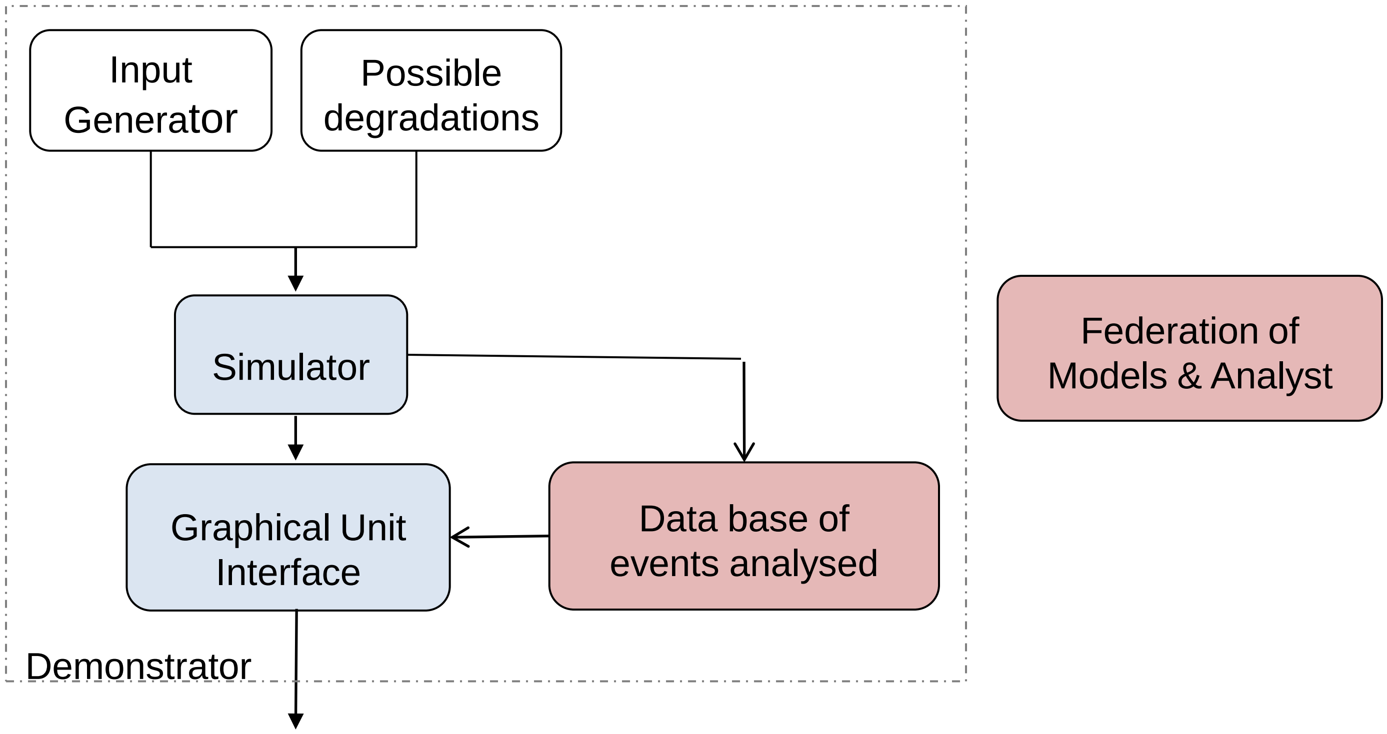
SPAD Simulator - II



Organisation of the simulation - I



Organisation of the simulation - II



SPAD Demonstrator

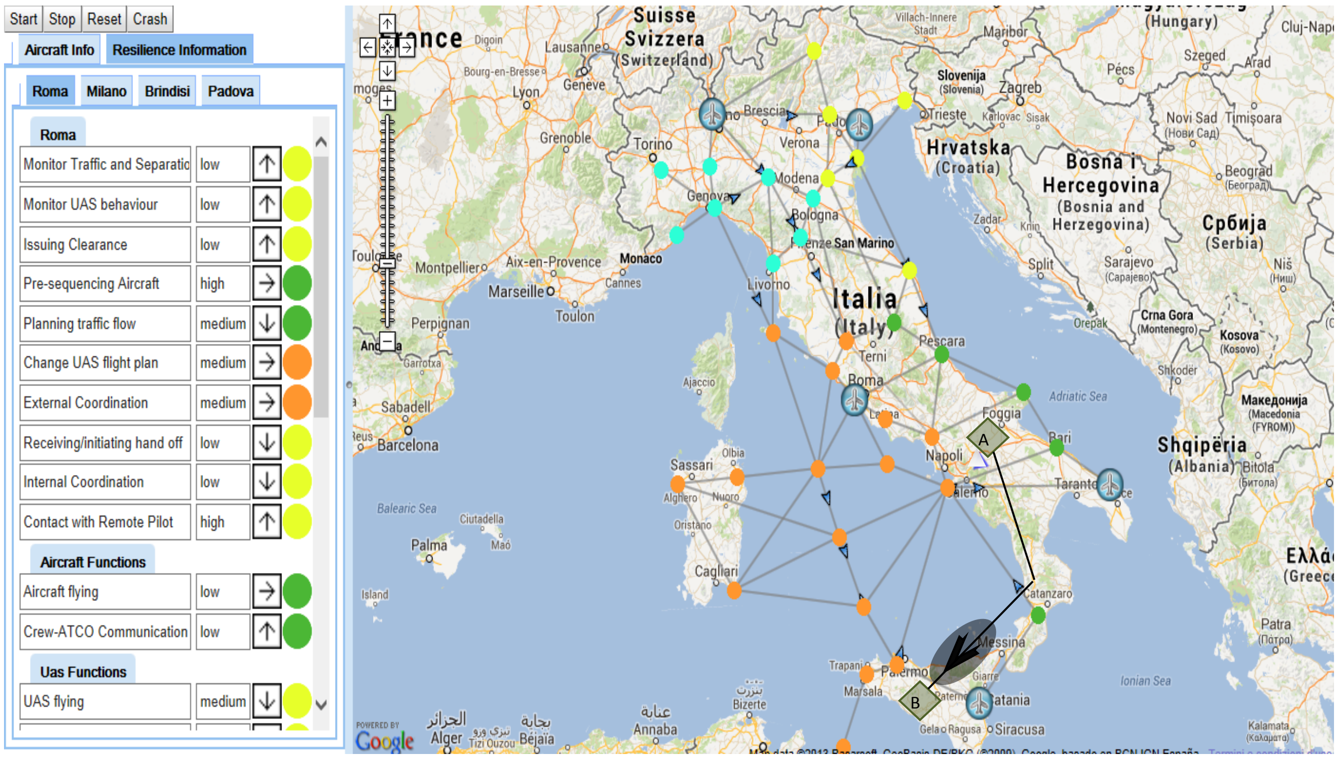
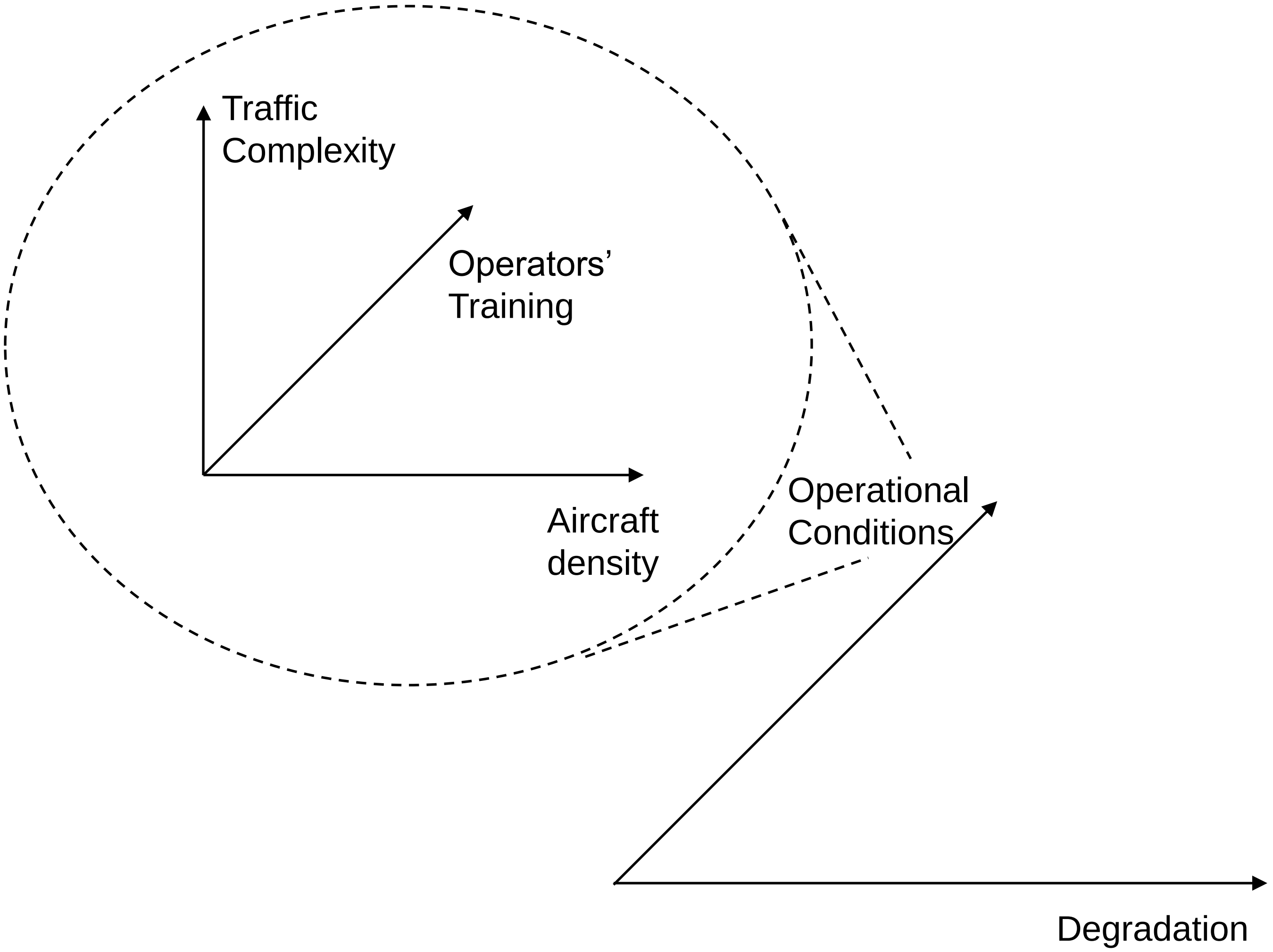


Figure 9: Status of the ATM functions as presented by the simulator

Space of the Simulator



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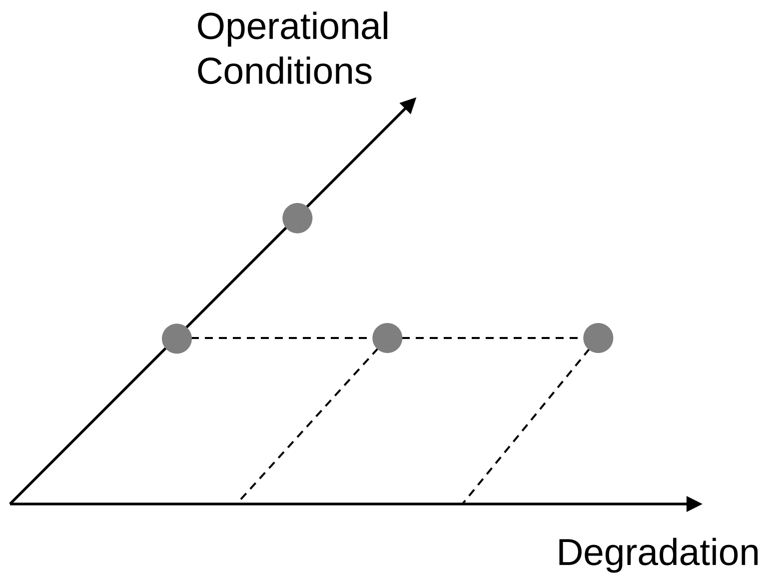

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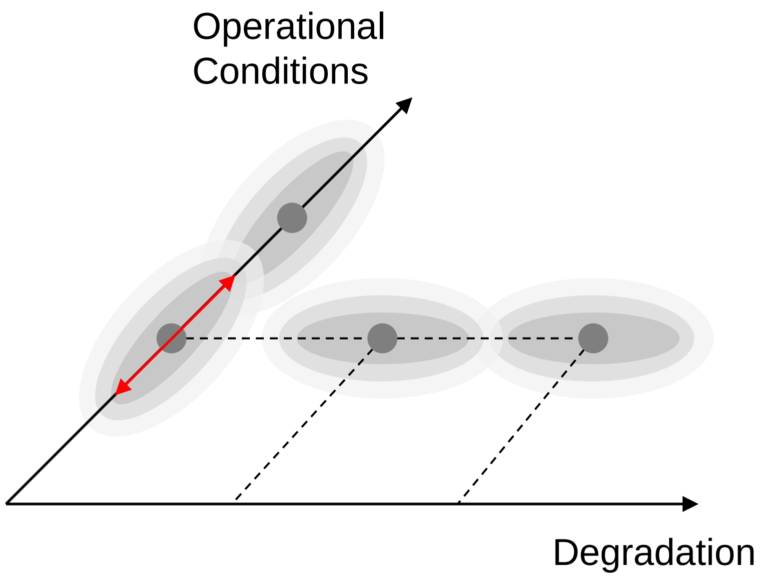

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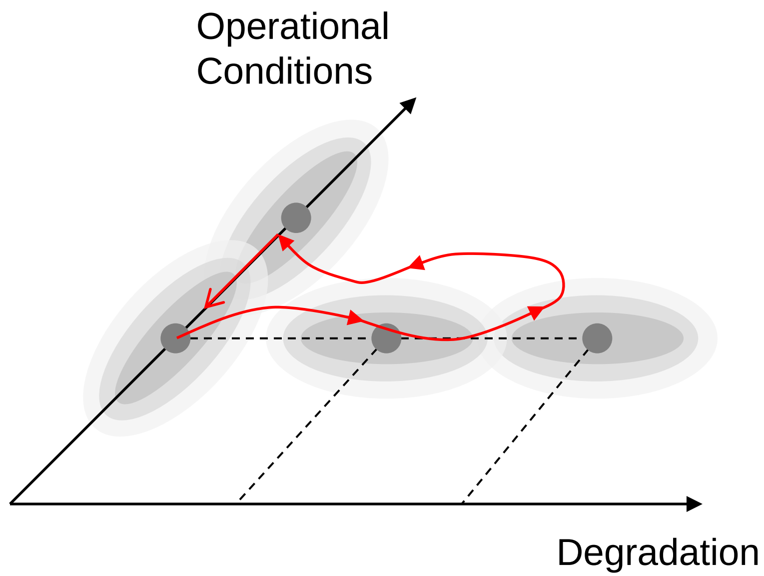

Conclusions about applicability of the approach - I

- Support the understanding modeling and estimation of automation degradation and its consequences in ATM
- Application of the results for real-time monitoring of ATM system is difficult and time consuming because of the significant human contribution required
- Approach used in SPAD was an off line use of the federation to explore in advance a limited number of possible future events (effective but still expensive in terms of application effort)

Conclusions about applicability of the approach - II

- Use to support the analysis of systems (e.g. support to safety assessment and safety analysis) more efficient
- Possible use of the Federation to support the interaction between the analyst and the operational experts
- Application effort can still be high because of the different instantiations and because of the grow with complexity
- Need to focus the analysis on the most relevant parts of the system and choose the right levels of granularity for its parts
- Simulator created different possible realistic cases for the federation offering the opportunity to test and improve it on the basis of realistic usage

Insights from the analysis (to be taken with caution)

- Humans (and especially air traffic controllers) are the elements more capable of absorbing the consequences of failures and avoid propagation
- Perturbations are significantly higher if systems are optimised and with the capacity close to the theoretical limits