MINES ParisTech

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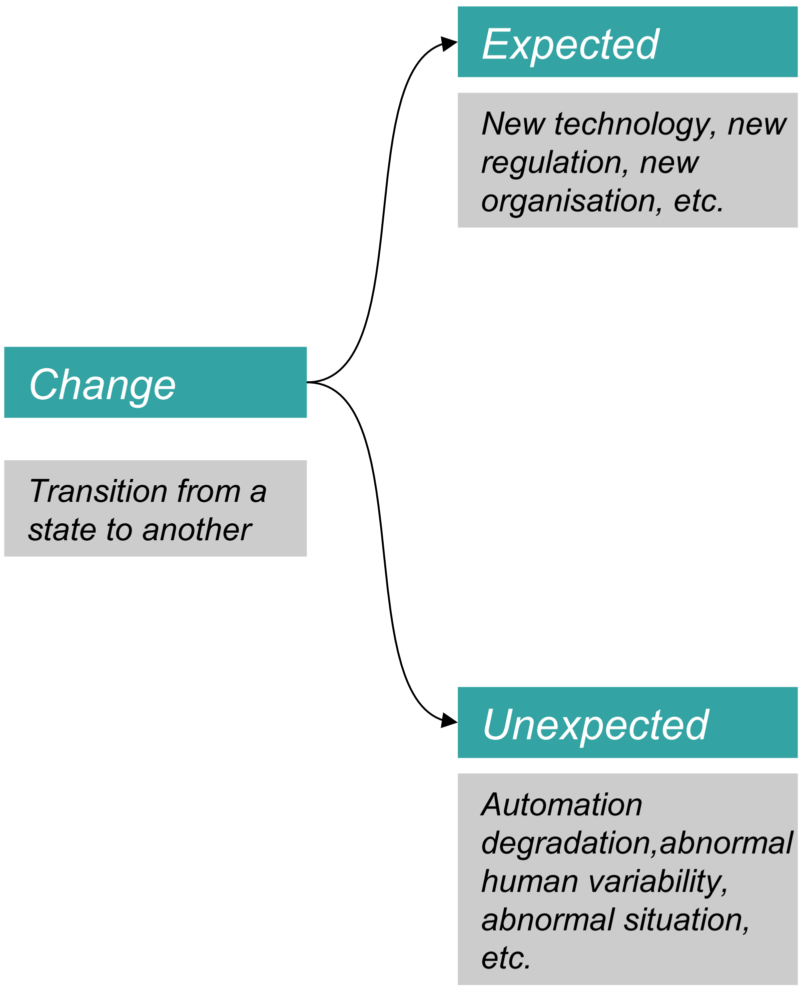
Research Centre on Risk and Crisis

24 mai 2012

FRAM for ANTICIPATION
FRAM based ecology of action simulation – application to ATM

FRAM based ecology of change simulation



FRAM based ecology of change simulation

Expected

New technology, new regulation, new organisation, etc.

Change

Transition from a state to another

Unexpected

Automation degradation,abnormal human variability, abnormal situation, etc.

Ecology of Change

Given the multiple interactions and feedbacks within the environment in which they take place, change, once started, often are beyond the control of the system, causing unexpected and sometimes even contrary effects to those expected. (adapted from morin 1990)

FRAM based ecology of change simulation

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Change

Transition from a state to another

Expected

New technology, new regulation, new organisation, etc.

Expected consequences

Unexpected consequences

Positive, negative, perverse

Ecology of Change

Given the multiple interactions and feedbacks within the environment in which they take place, change, once started, often are beyond the control of thes ystem, causing unexpected and sometimes even contrary effects to those expected. (adapted from morin 1990)

Unexpected

Automation degradation,abnormal human variability, abnormal situation, etc.

direct consequences

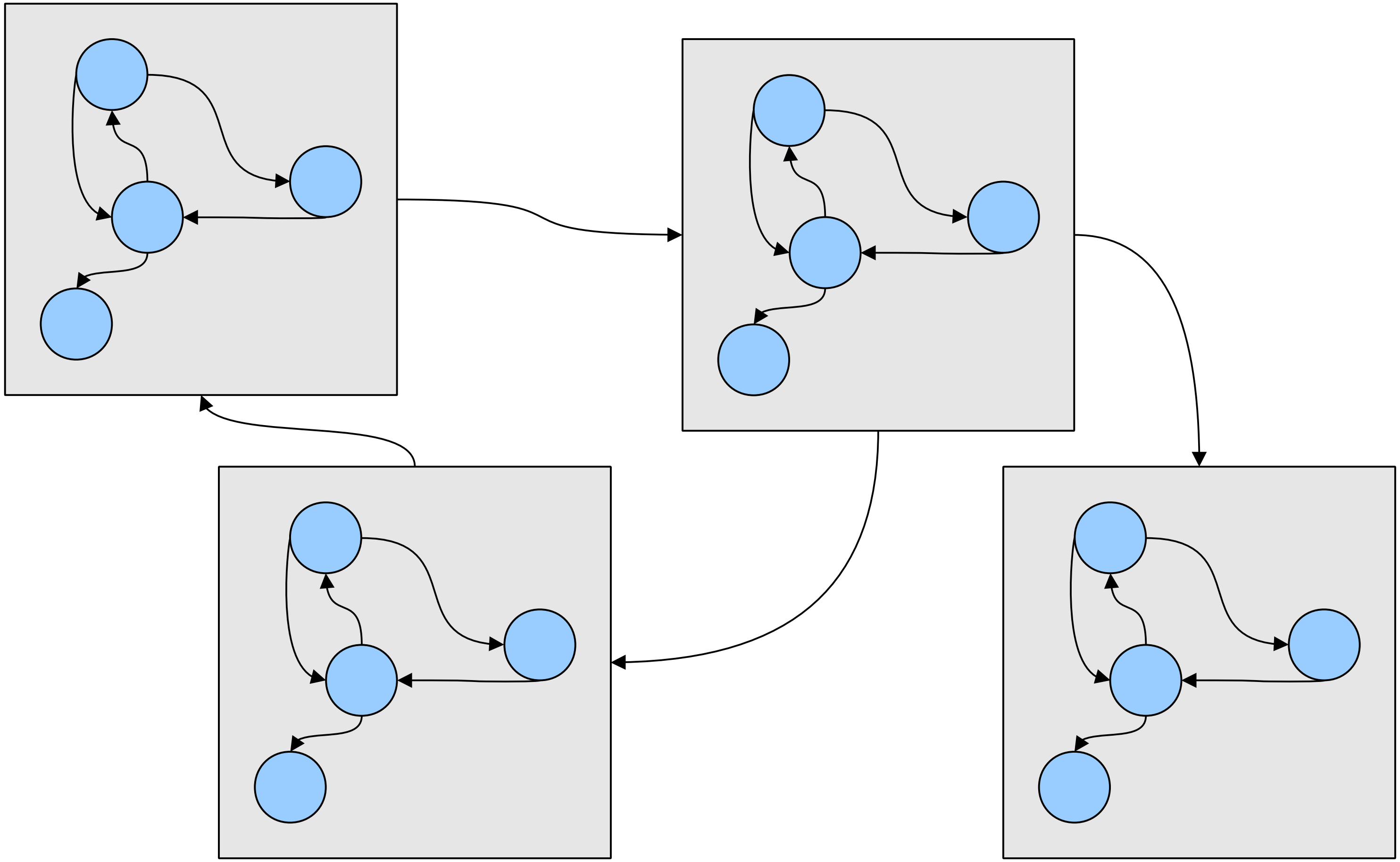
Linear causality based effects

indirect consequences (systemic)

Systemic causality based effect

FRAM based ecology of change simulation

Change propagation in Large Scale Socio Technical System



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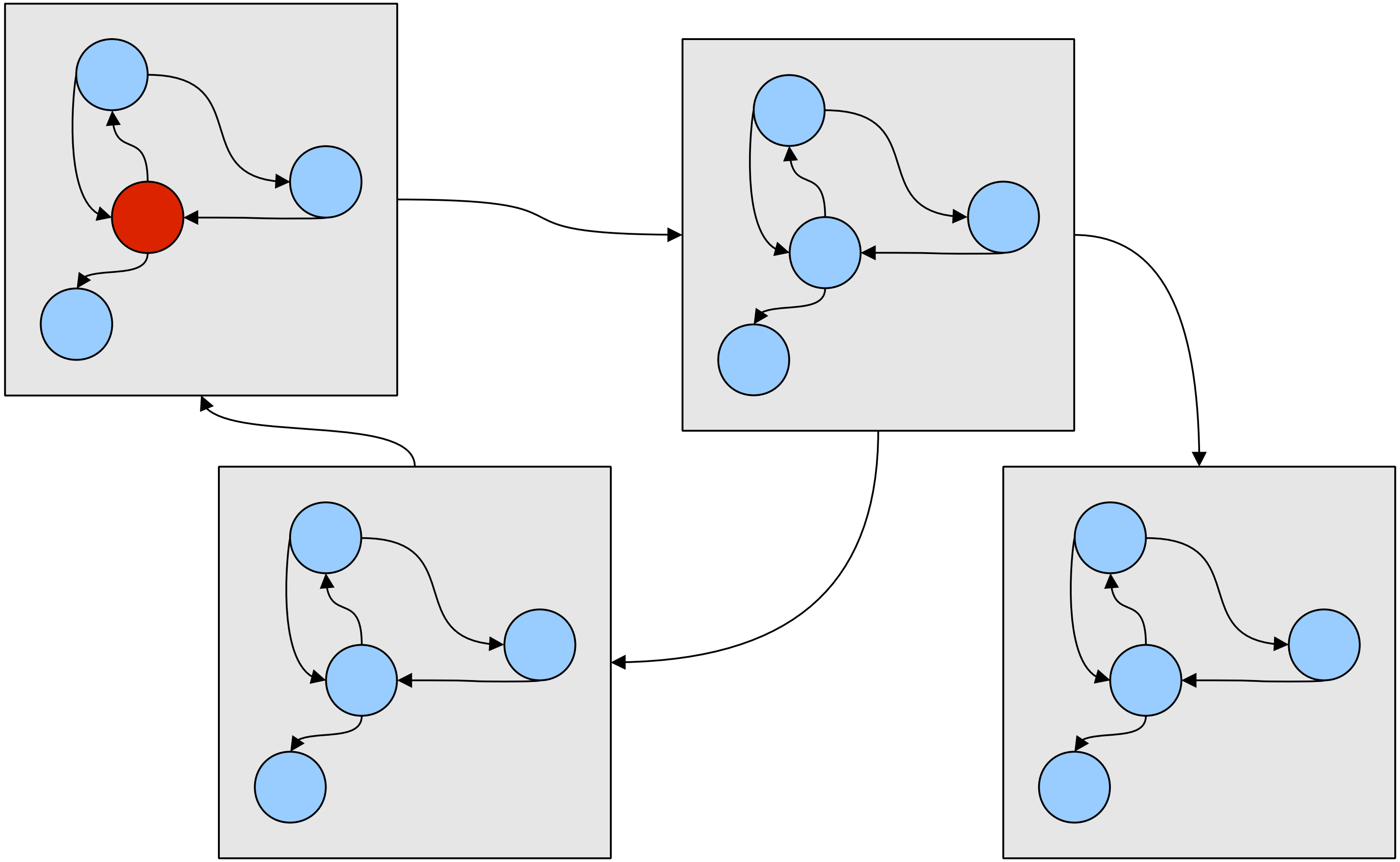

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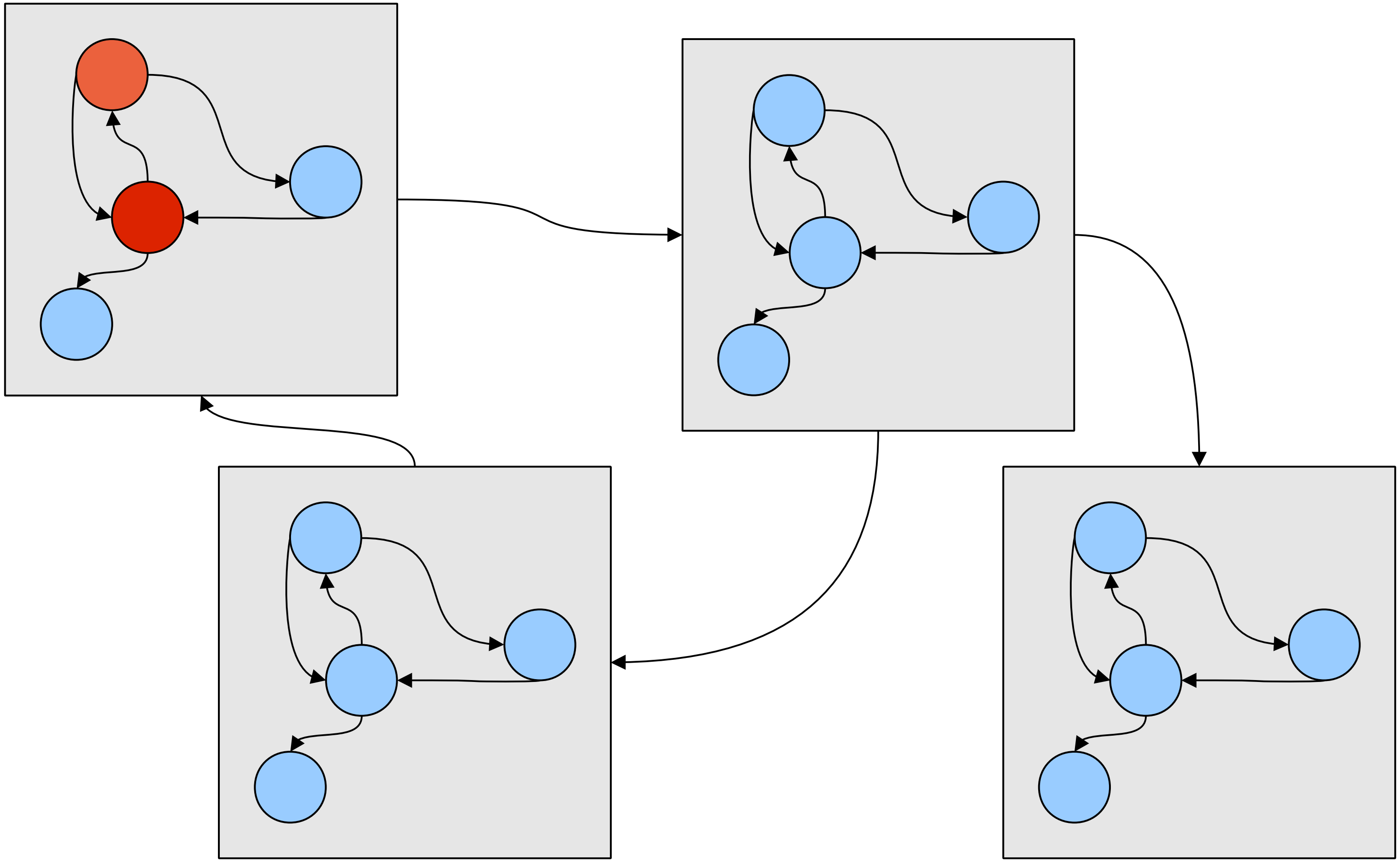

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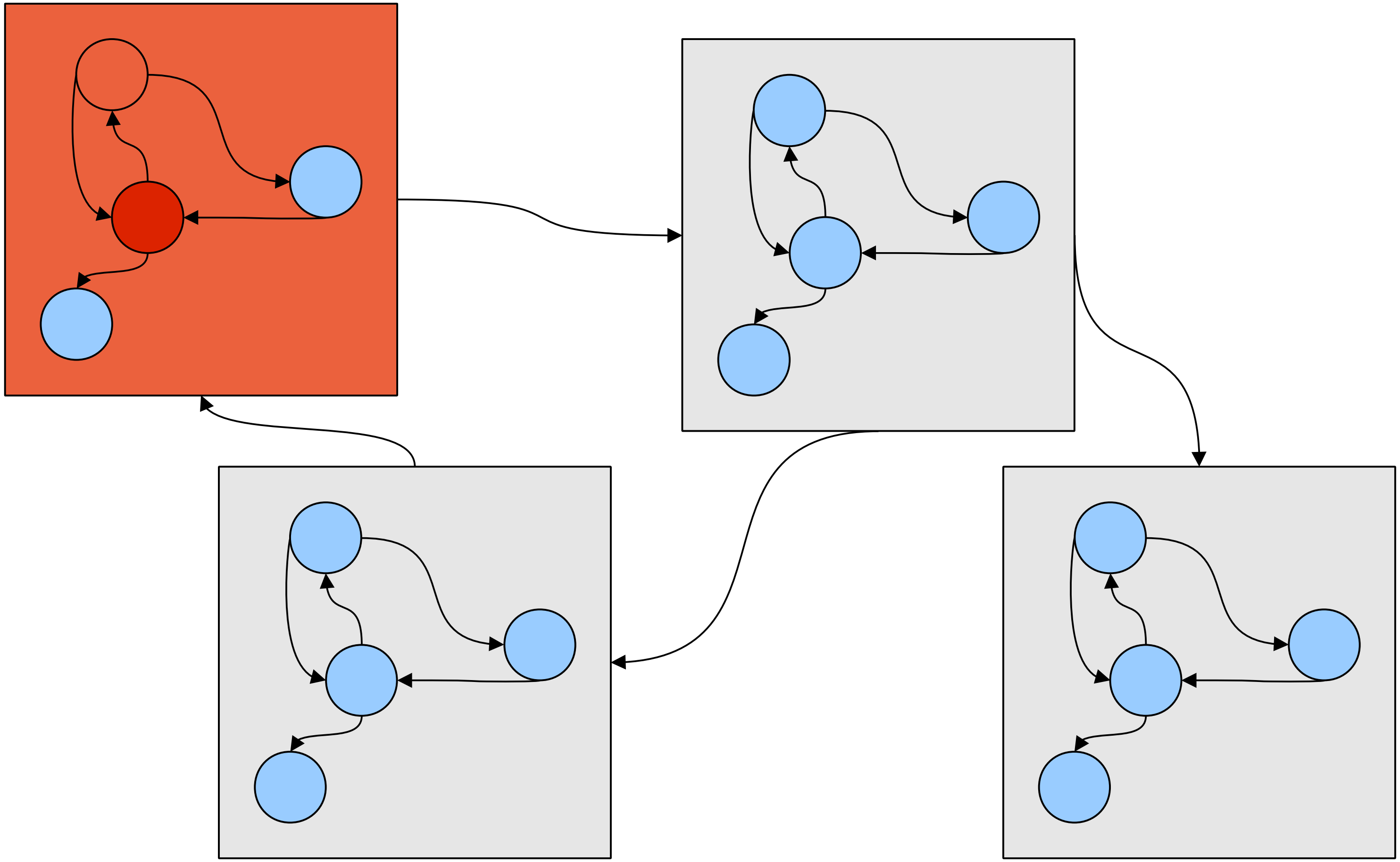
Change propagation in Large Scale Socio Technical System



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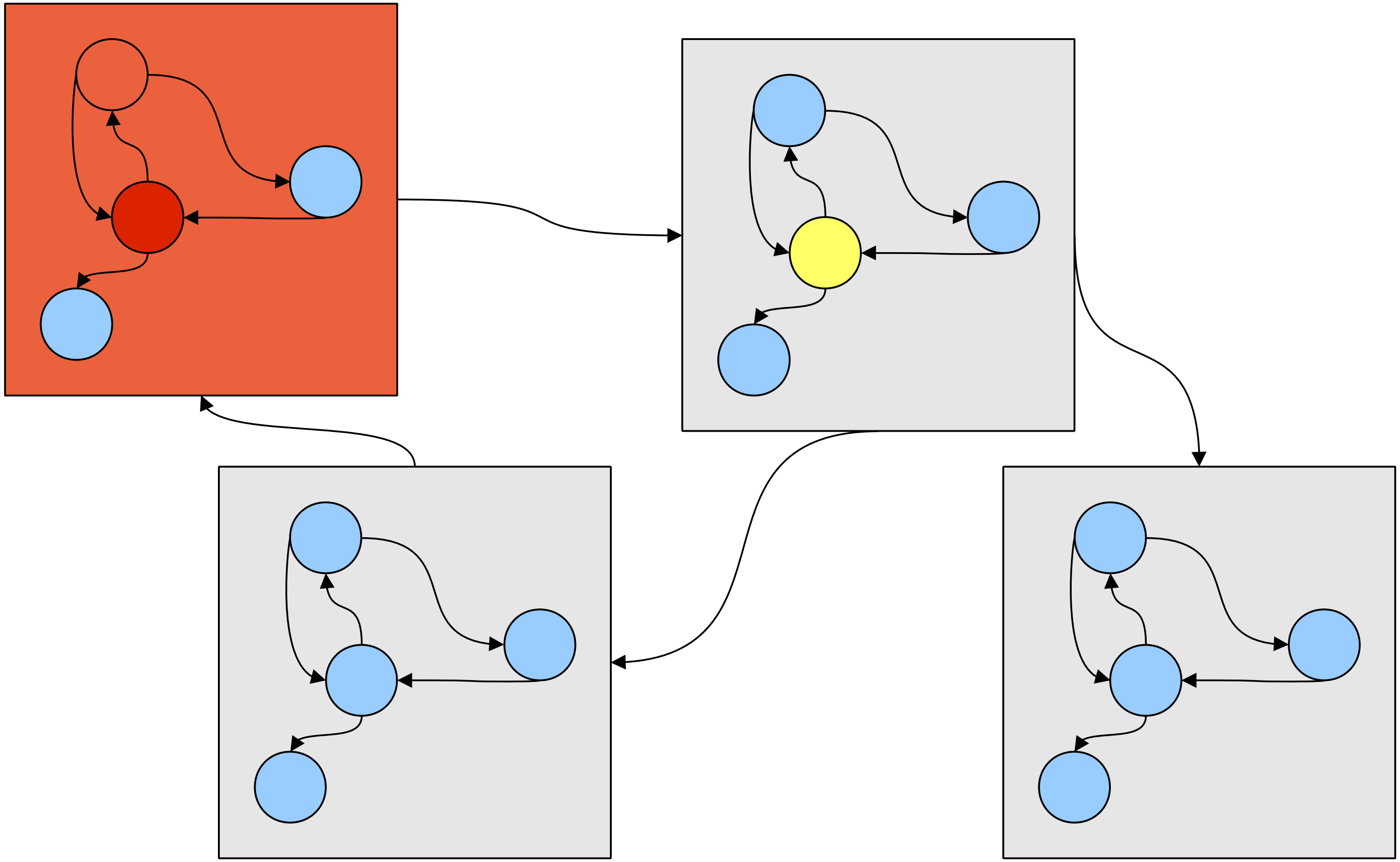

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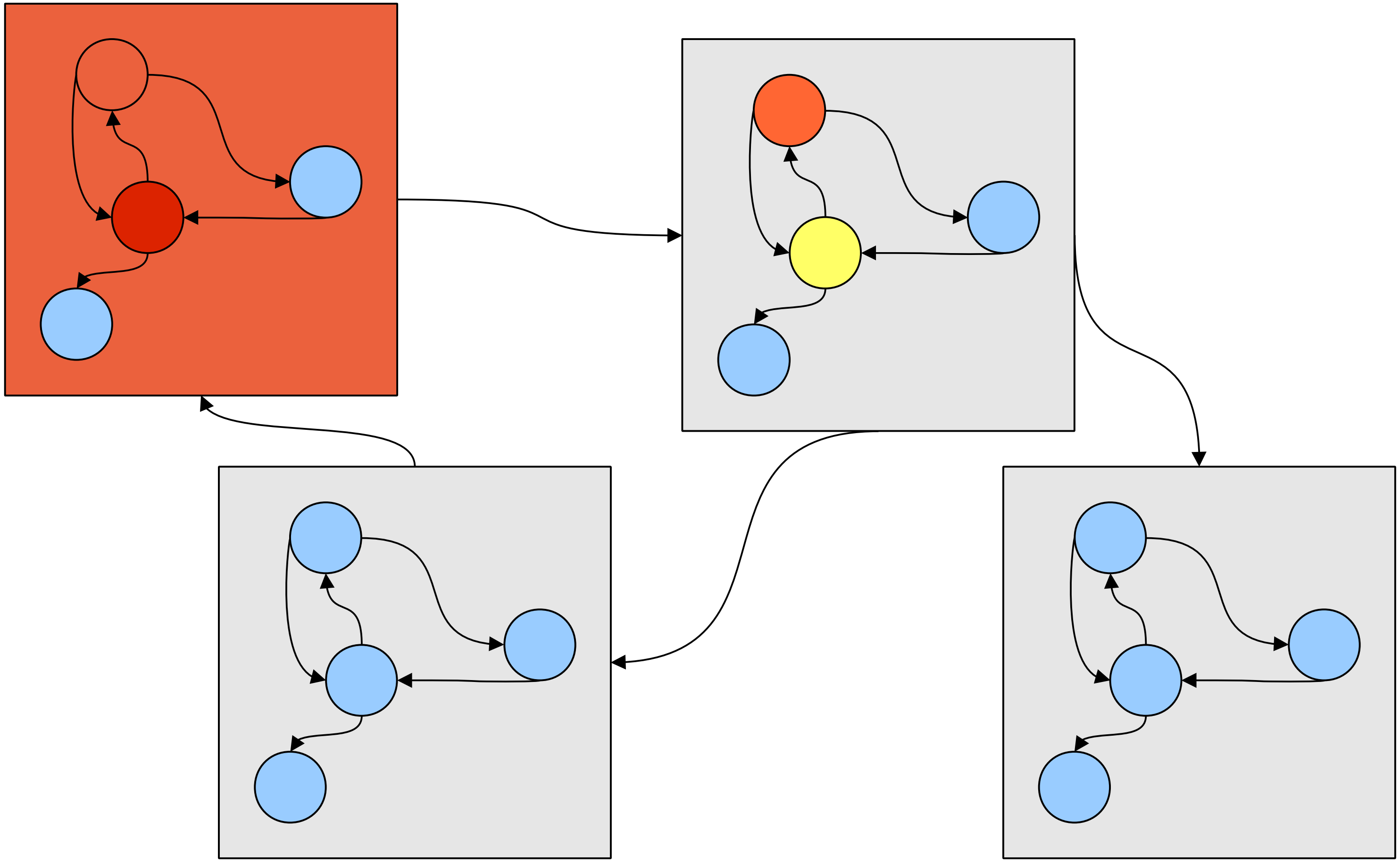
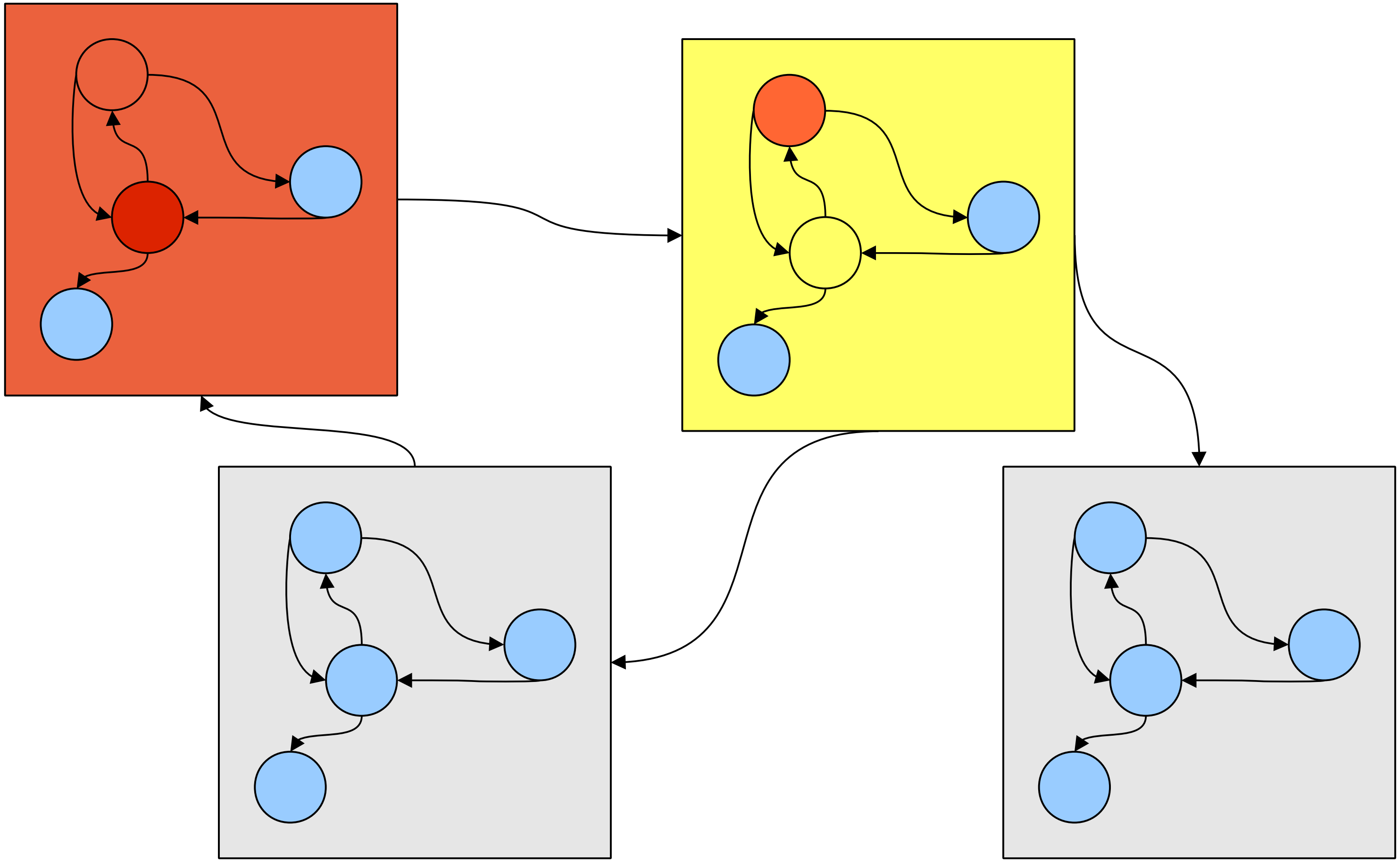
Change propagation in Large Scale Socio Technical System



FRAM based ecology of change simulation

Change propagation in Large Scale Socio Technical System



FRAM based ecology of change simulation

Research questions

- Model LSSTS in a perspective of assessing consequences of change impact (performances affected, intensity, propagation)
- Model change consequences and propagation

FRAM based ecology of change simulation

Model change consequences and propagation

Context	AMAN degradation impacts on ATM performances
Model	TMA resilience performance
Tool	FRAM consequence of event analysis

FRAM based ecology of change simulation

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Model change consequences and propagation

Context	AMAN degradation impacts on ATM performances
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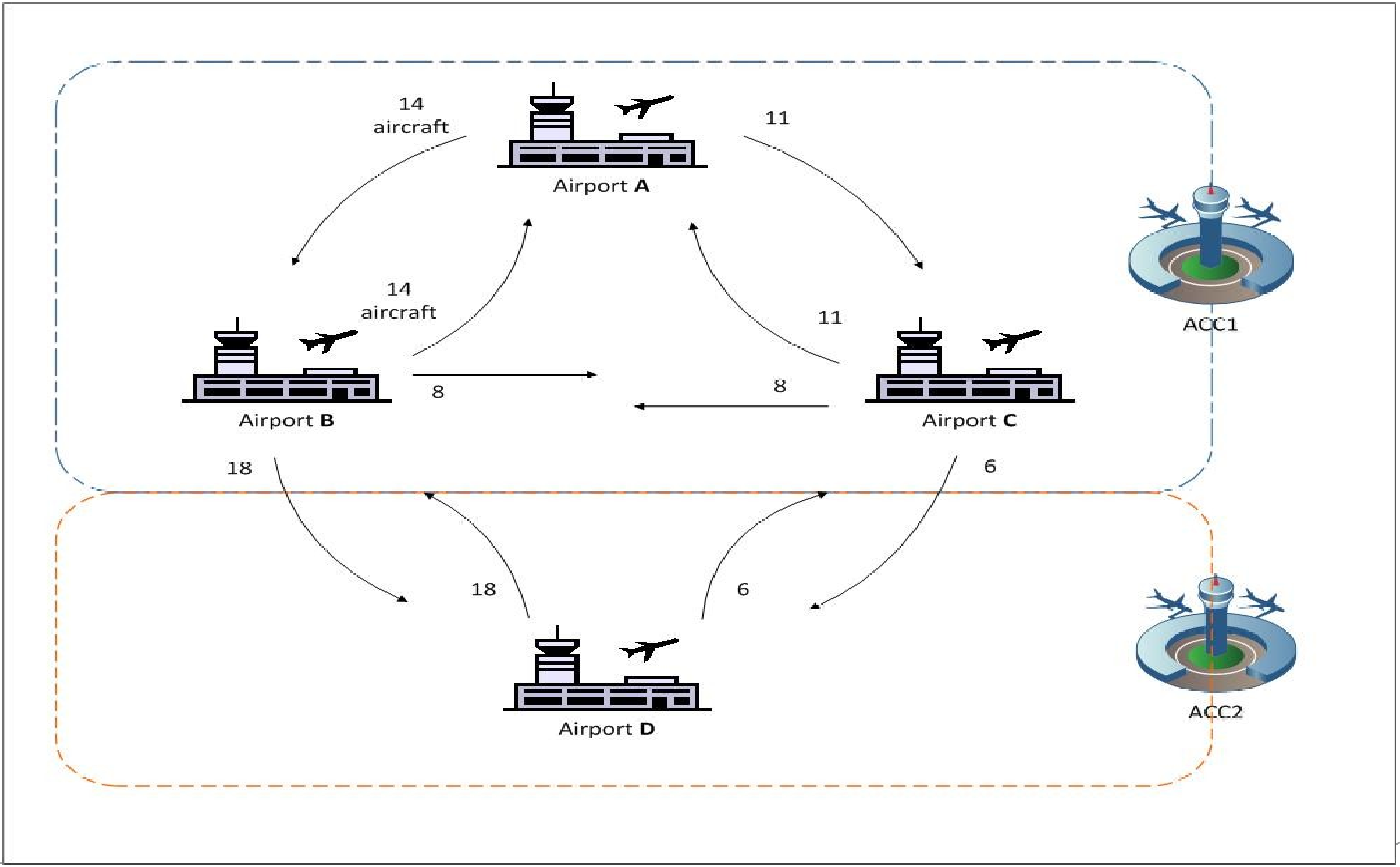
FRAM based ecology of change simulation

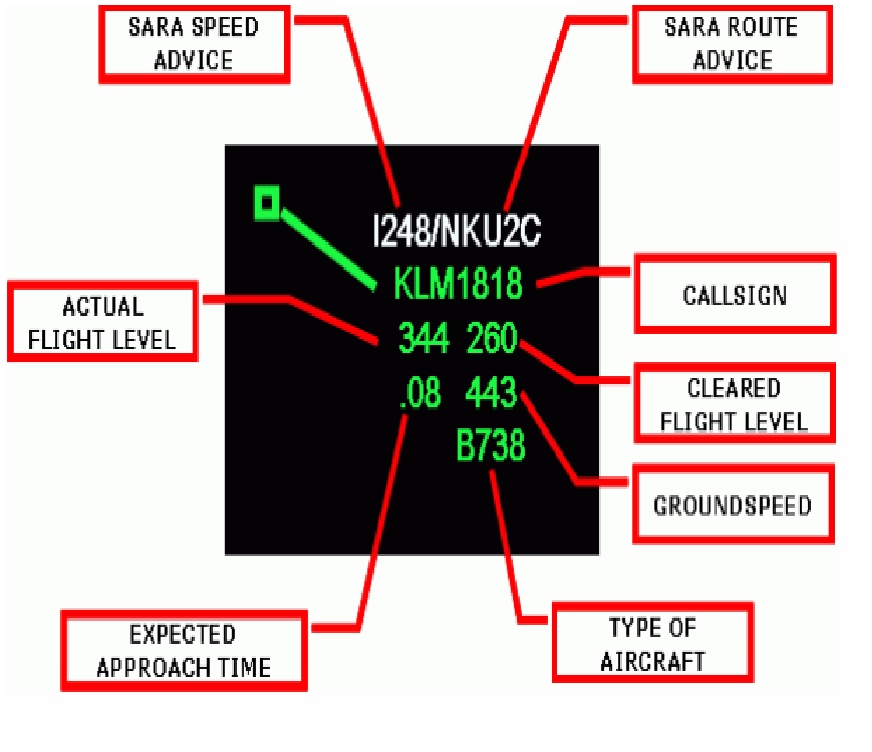
Context

AMAN degradation impacts on ATM performances



FRAM based ecology of change simulation

Context | AMAN degradation impacts on ATM performances



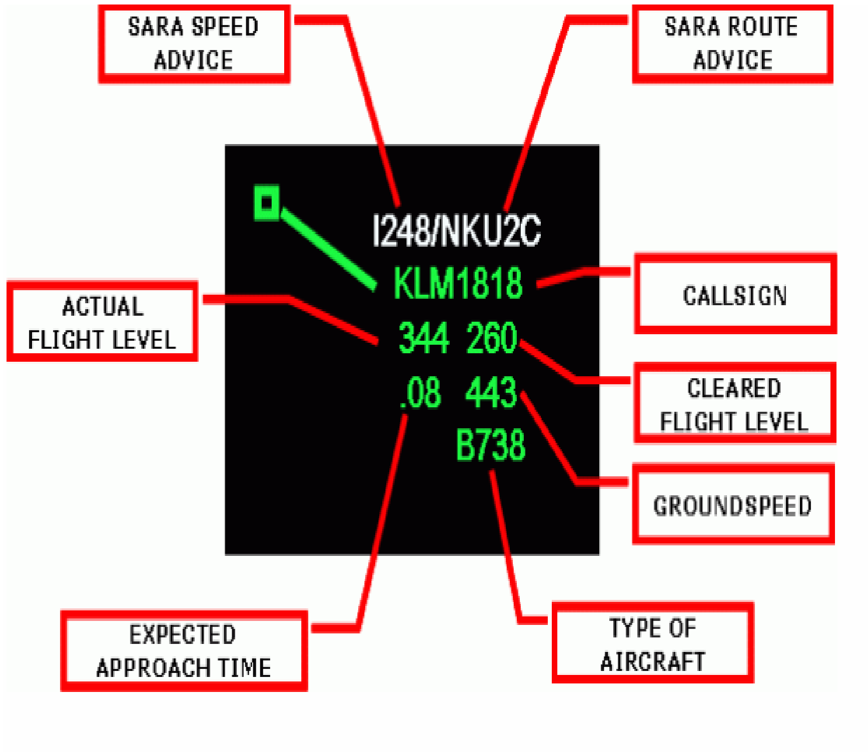
Calculate optimum aircraft arrival sequences and times for flights approaching to defined constraint points

Presente the planned inbound traffic flow at the controller working positions together with suitably generated advisories in order to meet the planned arrival sequence and time schedules.

FRAM based ecology of change simulation

Context

AMAN degradation impacts on ATM performances



Temporary malfunctionning

Provide misleading information

Permanent malfunction

FRAM based ecology of change simulation

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Model change consequences and propagation

Context	AMAN degradation impacts on ATM performances
Model	TMA resilience performance
Tool	FRAM consequence of change analysis

TMA resilience performance

Intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions (Hollnagel 2011).

Respond to regular and irregular conditions in an effective, flexible manner

Learn from past events, understand correctly what happened and why

Monitor short-term developments and threats; revise risk models

Anticipate long-term threats and opportunities

TMA resilience performance

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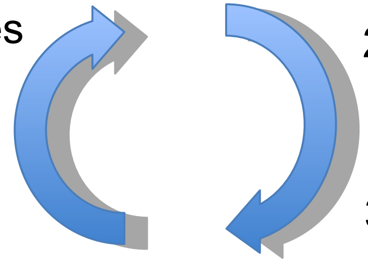
Respond to regular and irregular conditions in an effective, flexible manner

1 - Detect situation

5 – Mobilize resources to respond



2 – Identify situation

4 – Plan response

3 – Evaluate situation

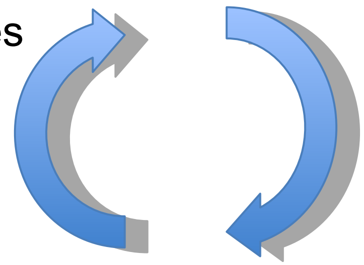
TMA resilience performance

Respond to regular and irregular conditions in an effective, flexible manner

1 - Detect situation

5 – Mobilize resources to respond

2 – Identify situation



4 – Plan response

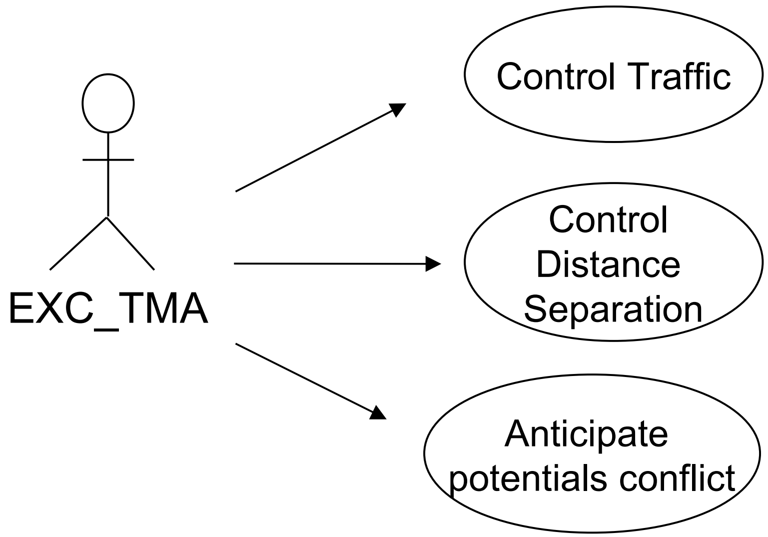
3 – Evaluate situation

Control Mode

Strategic	In the strategic control mode correspond, system as a time horizon and can look ahead at higher level goals.
Tactical	The tactical control mode corresponds to situations where performance more or less follows a known procedure or a rule
Opportunistic	In the opportunistic control mode, the salient features of the current context determine the next action
Scrambled	In the scrambled control mode, the choice of next action is basically random

Define TMA resilience performances

TMA regular control process



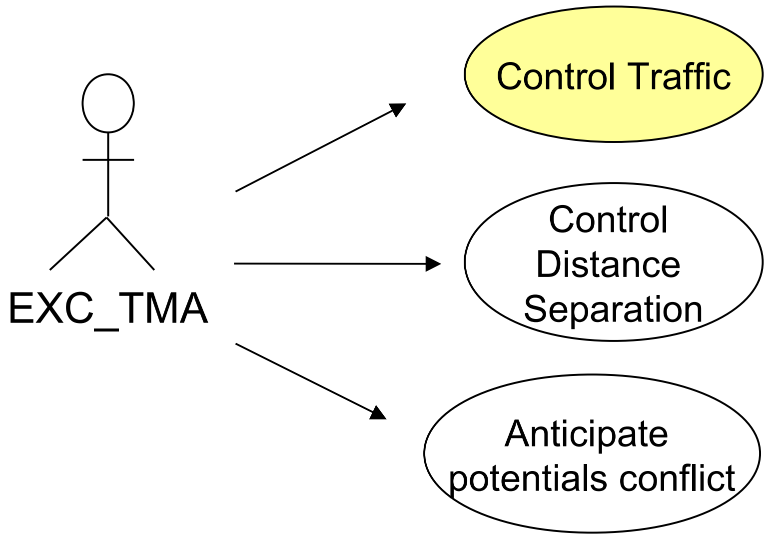
Control flight position and speed and clear pilot in order that it follows planed arrival sequence.

Control distance between aircrafts and clear pilots if minimum distance between aircraft is not satisfied

Control flight position and evolution in order to avoid potential conflict

Define TMA resilience performances

TMA regular control process



Control flight position and speed and clear pilot in order that it follows planed arrival sequence.

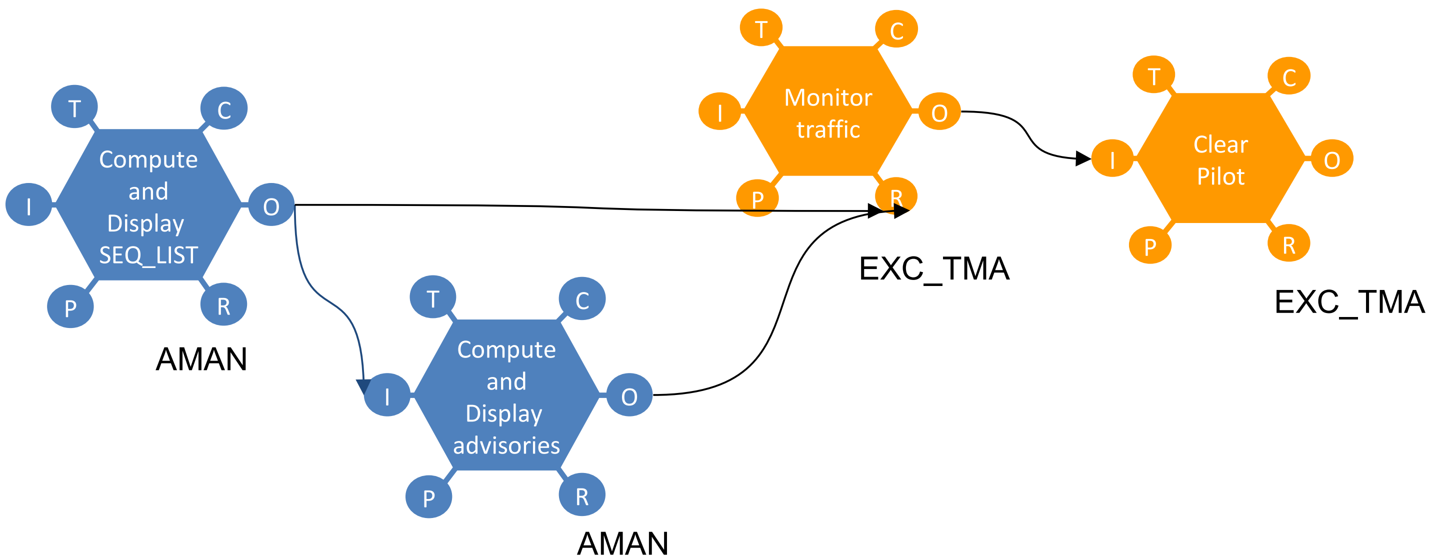
Control distance between aircrafts and clear pilots if minimum distance between aircraft is not satisfied

Control flight position and evolution in order to avoid potential conflict

Define TMA resilience performances

Control traffic simple model

Hypothesis 1.
Control traffic performance is model with EXC_TMA *Monitor traffic* function and *Clear Pilot* and AMAN functions *Compute and Display SEQ_LIST* and *Compute and Display advisories*.



Define TMA resilience performances

Control traffic simple model

Factors that affect Monitor traffic function can affect **available time** to monitor traffic and clear pilot and others can affect **time required** by EXC_TMA to achieve functions.

Endogenous factors

EXC_TMA variability factors (workload, stress, experience in monitoring traffic, experience with AMAN) will affect EXC_TMA time to proceed

EXC_TMA focus of attention impact time available (if EXC_TMA focus on monitoring traffic he's got more time than if he focus both on monitoring traffic, distance separation and emergence situations)

Exogenous factors

Complexity of traffic and amount of traffic affects available time because of the frequency of occurrence of new AMAN advisories.

Working conditions impacts both available time and time required to perform

Coupling factors

Availability of AMAN impacts available time. If AMAN is available control functions *Detect, Identify, Evaluate* and *Plan* are "negligible" because of the automation. If AMAN is not available those function have to be done manually and then impact *time available*.

Define TMA resilience performances

Control traffic variability hypothesis

Strategic

In strategic control mode time required to perform functions is much superior to available time :

EXC_TMA variability factors are optimum
EXC_TMA is focusing half of it's activity on *Monitor traffic function*
AMAN is available
Complexity of traffic and amount of traffic is low

Tactical

In tactical control mode time required to perform functions is just superior to available time :

EXC_TMA variability factors are not optimum
OR
EXC_TMA is focusing less than half of it's activity on *Monitor traffic function*
OR
Complexity of traffic and amount of traffic is medium
AND
AMAN is available

Define TMA resilience performances

Control traffic variability hypothesis

Opportunistic

In to opportunistic control mode time required to perform functions is inferior to available time :

AMAN is not available and other conditions are optimum or average
AMAN is available and others conditions are negative

Scrambled

In to scrambled control mode time required to perform functions is much inferior to available time :

AMAN is not available and other conditions are negative

Define TMA resilience performances

Control traffic variability model

Endogenous factors of variability	
Habit to AMAN	[High(10), Medium (5), Low (0)]
Training	[High(10), Medium (5), Low (0)]
Workload	[High(10), Medium (5), Low (0)]
Stress	[High(10), Medium (5), Low (0)]
Focus of attention	[High(10), Medium (5), Low (0)]
Number of tasks	[High(10), Medium (5), Low (0)]

Endogenous variability V*en* evaluation

If 10 >= (Σ factors / 6) > 7 then V*en* = Optimum

If 7 >= (Σ factors / 6) > 3 then V*en* = Average

If 3 >= (Σ factors / 6) > 0 then V*en* = Bad

Define TMA resilience performances

Control traffic variability model

Exogenous factors of variability	
Working conditions	[High(10), Medium (5), Low (0)]
Complexity of traffic	[High(10), Medium (5), Low (0)]
Amount of traffic	[High(10), Medium (5), Low (0)]

Exogenous variability V*ex* evaluation

If 10 >= (Σ factors /3) > 7 then V*ex* = Optimum

If 7 >= (Σ factors / 3) > 3 then V*ex* = Average

If 3 >= (Σ factors / 3) > 0 then V*ex* = Bad

Define TMA resilience performances

Control traffic variability model

Coupling factors of variability	
AMAN available	[Yes, No]

Coupling variability V*co* evaluation
If Yes V*co* = Optimum
If No V*co* = bad

Define TMA resilience performances

Control traffic variability model

Control traffic variability model control mode calculation rules

IF (V*en* == Optimum) AND (V*ex* == Optimum) AND (V*co* == Optimum) THEN Control Mode = Strategic

IF (V*en* == Average) OR (V*ex* == Average) AND (V*co* == Optimum) THEN Control Mode = Tactical

IF ((V*co* == Optimum) AND ((V*en* == bad) AND (V*ex* == bad)) OR
((Vco == bad) AND ((V*en* != bad) AND (V*ex* != bad))
THEN Control Mode = Opportunistic

IF ((Vco == bad) AND ((V*en* == bad) OR (V*ex* == bad))
THEN Control Mode = Scrambled

Define TMA resilience performances

Control traffic variability model

Consequences of variability of control mode on EXC_TMA endogenous variability and on *monitor traffic* function.

1. If control mode is strategic, there is no influence on EXC_TMA variability and on the performance of the function, time to perform and precision are optimum
2. If control mode is tactical EXC_TMA stress is affected to medium and time to perform and precision are average
3. If control mode is opportunistic EXC_TMA stress and workload are affected to medium and time to perform and precision are average
4. If control mode is scrambled EXC_TMA stress and workload are affected to high and time to perform and precision are bad

Conclusion

Next steps :

Modeling and couping all TMA control activities
Modeling of global varibaility of TMA
Modeling and coupling varibaility of TWR and ACC to TMA variability

Link FRAM based model with Lindemayer System based model
Develop prototype of simulation tool

Generalyse methodology