

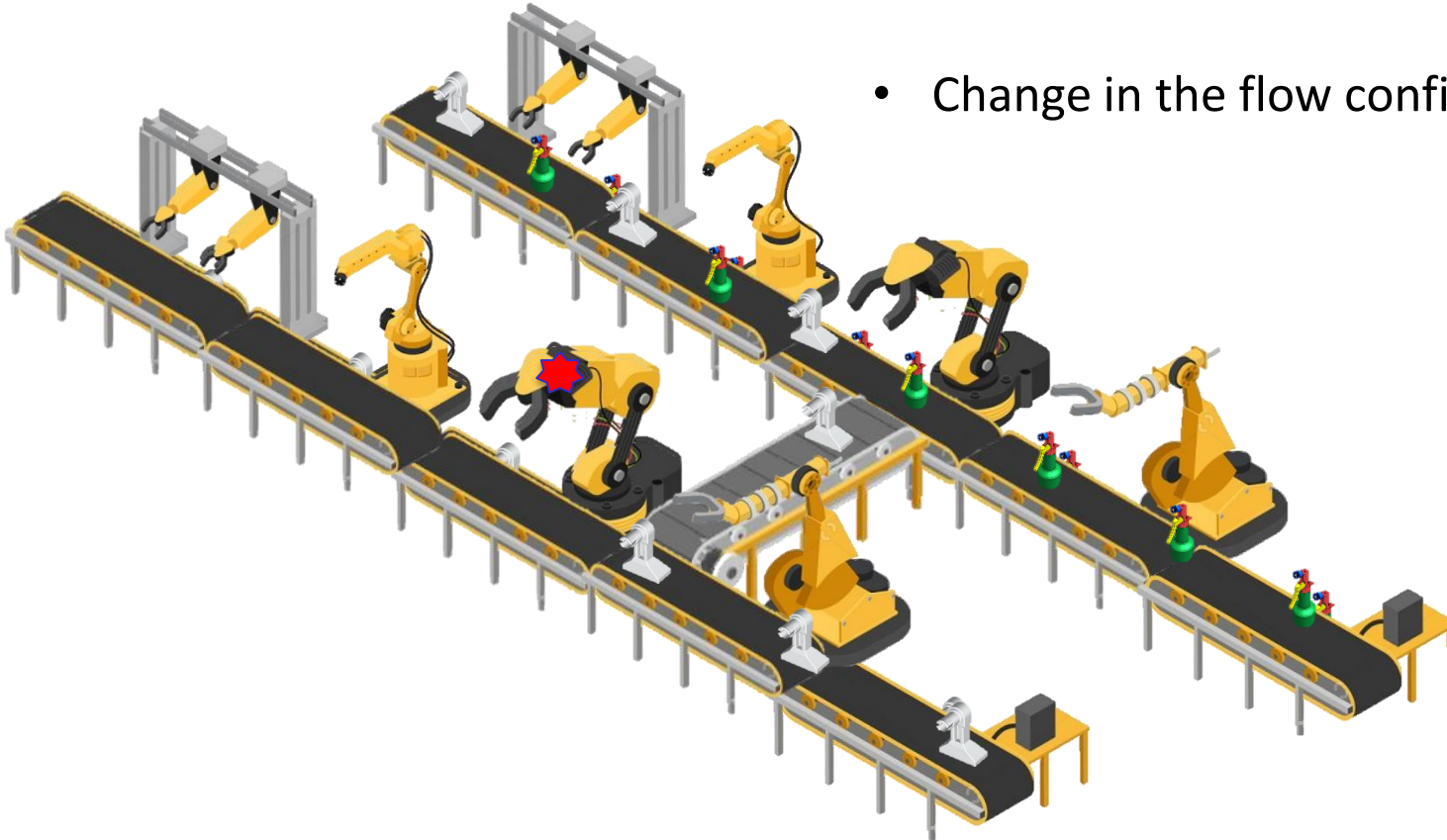
# *A Simulation Tool to Assess the Performance of Production Systems in Degraded Mode*

*M. Di Mascolo, J.M. Flaus, K. Negrichi*

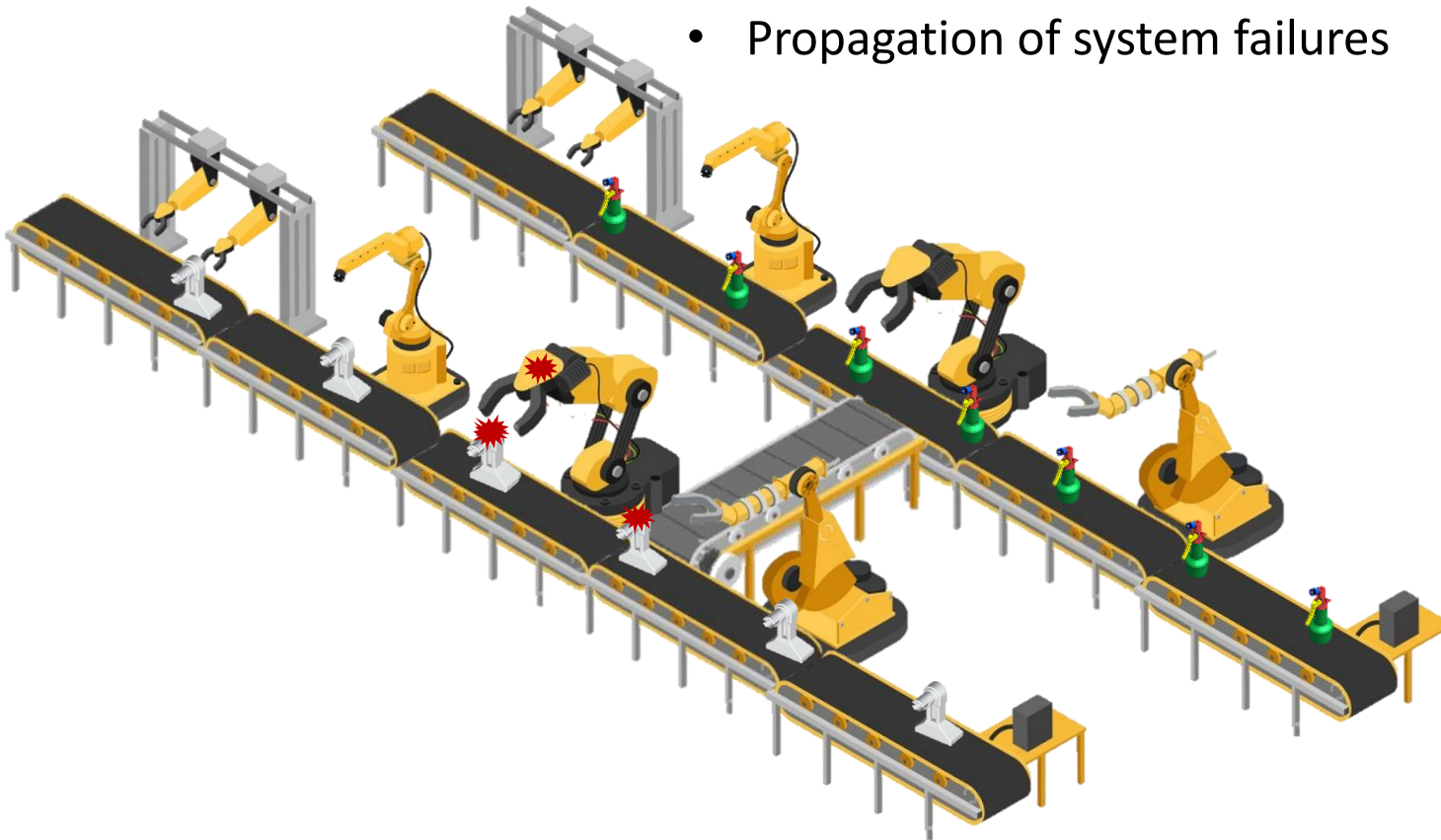
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*G-SCOP, Univ. Grenoble Alpes, CNRS, Grenoble INP*

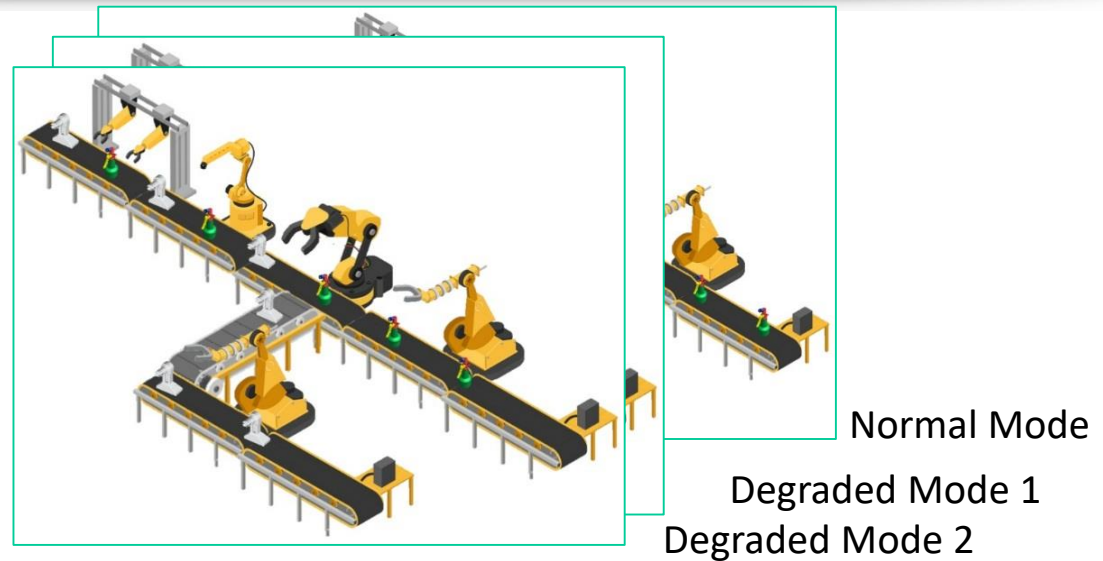
- Degradation of the system performance
- Change in the flow configuration



- Propagation of system failures



Different behavior modes  
Failure propagation



## Performance Evaluation?

Risk analysis

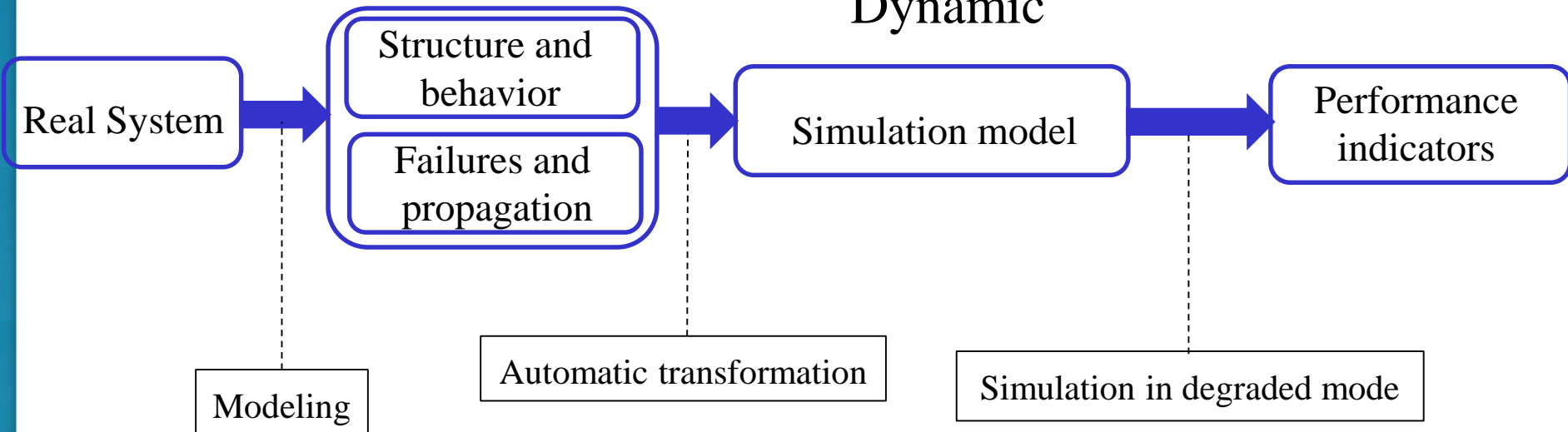


Performance evaluation

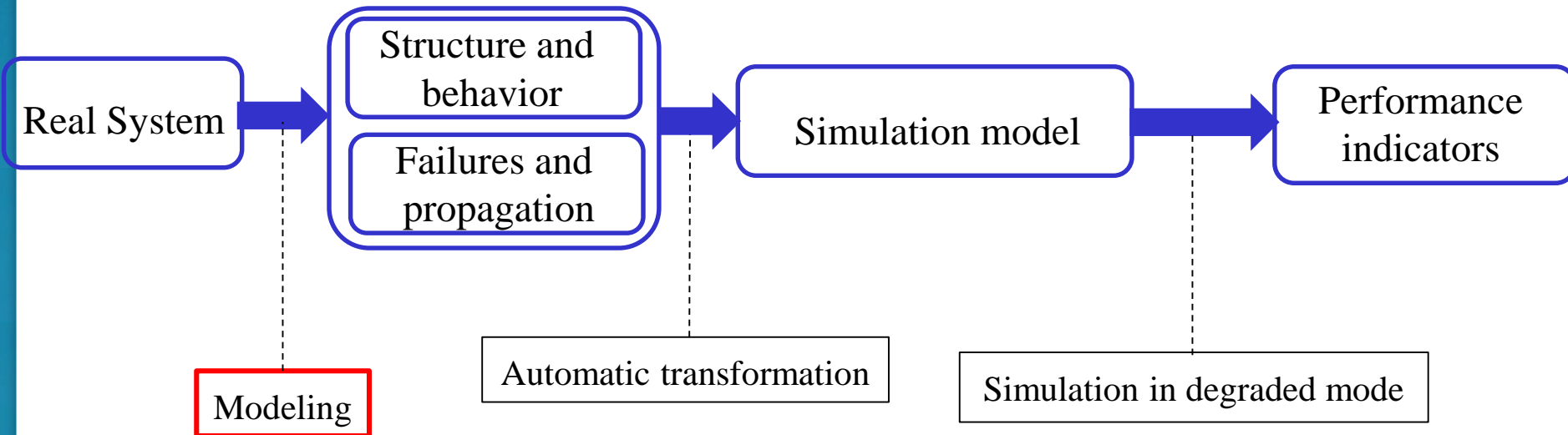
Evaluate the performance of a production system in degraded mode (considering the information related to risks).

## Descriptive, Static Risk Model

## Dynamic



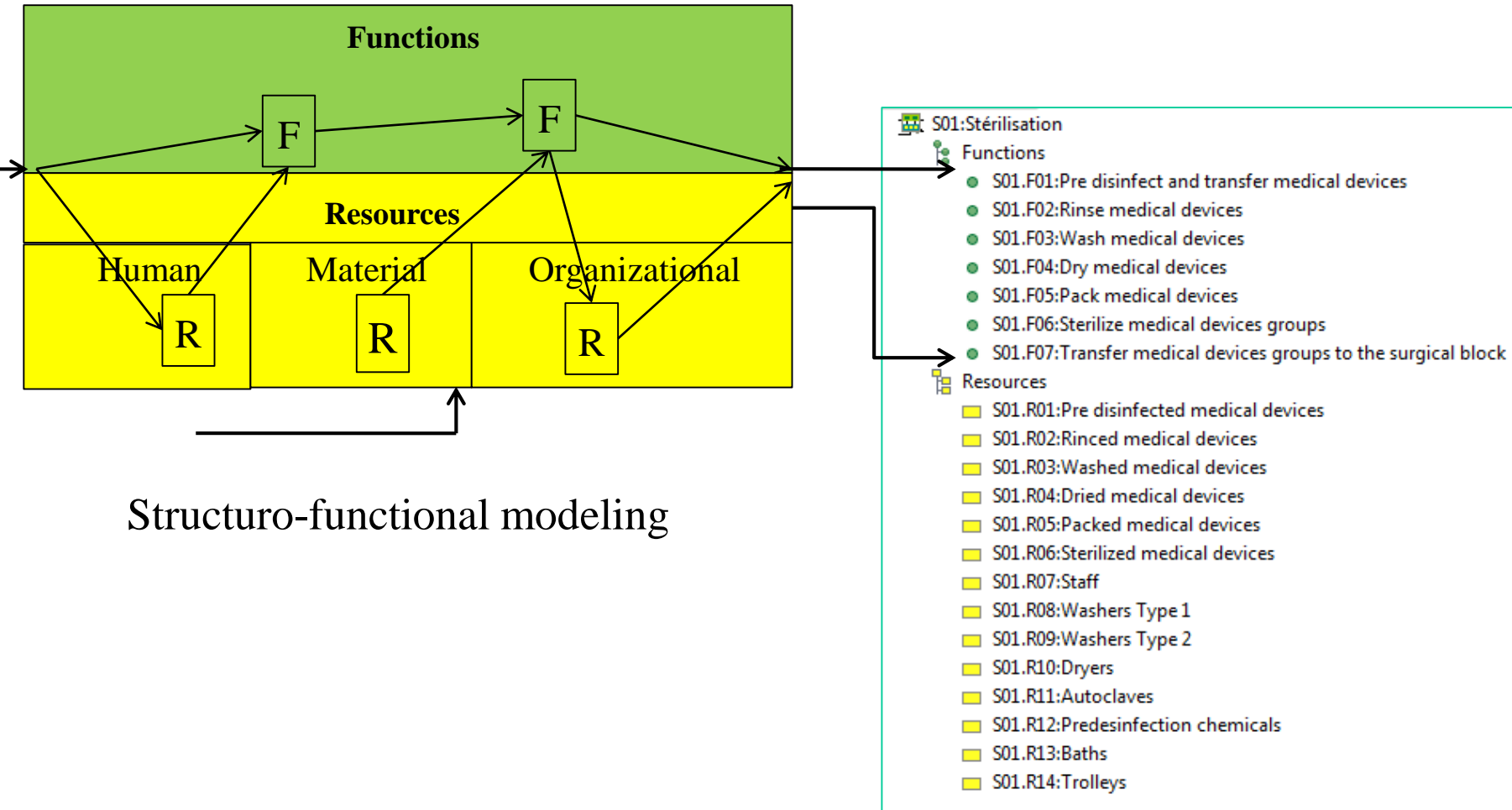
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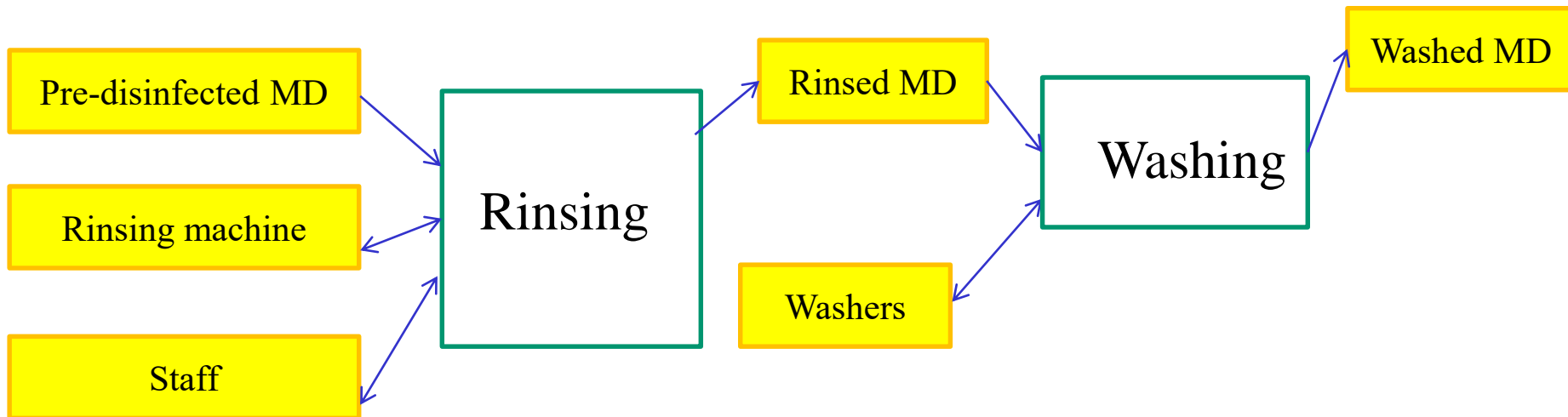


Describe the production system, its structure, its behavior and its failures and propagation  
 FIS model (Function, Interaction, Structure)

(1).FLAUS. J-M. A model-based approach for systematic risk analysis. *Journal of risk and reliability*. 2008

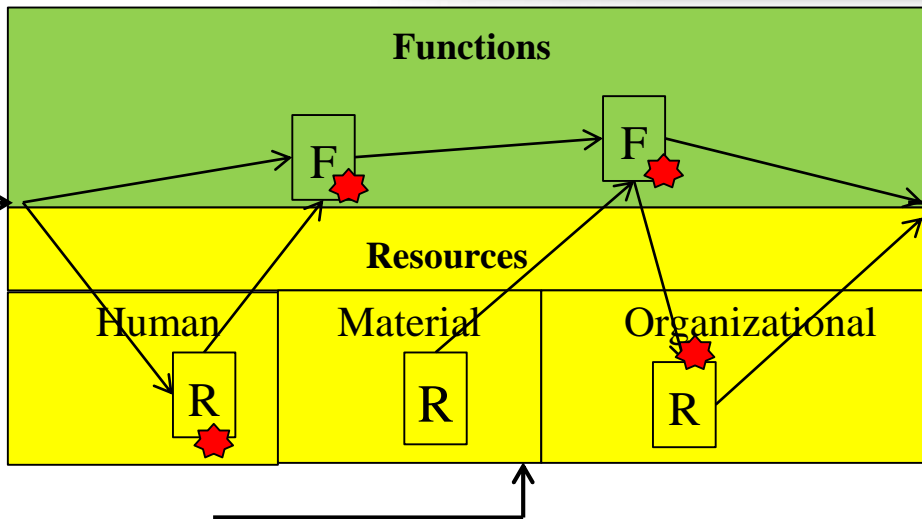
# G-SCOP FIS Modeling – Structure and Behavior





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Dysfunctional modeling

**S01.F03:Wash medical devices**

in [S01:Stérilisation](#)

[Edition de l'ID](#) / [Edition du nom](#) / [Edition de la Description](#)

**Fail modes**

[S01.F03.FM01](#):Degradation of the function performance

[S01.F03.FM02](#):Function loss

[Ajoute](#) / [Supprime](#) / [Trie](#) failmode

**S01.R10:Dryers**

in [S01:Stérilisation](#)

[Edition de l'ID](#) / [Edition du nom](#) / [Edition de la Description](#)

**Fail modes**

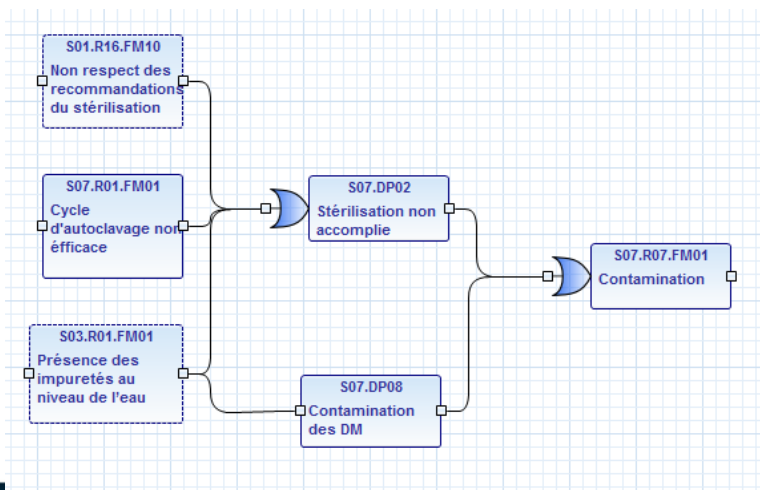
[S01.R10.FM01](#):Electrical fault

[S01.R10.FM02](#):Heat loss

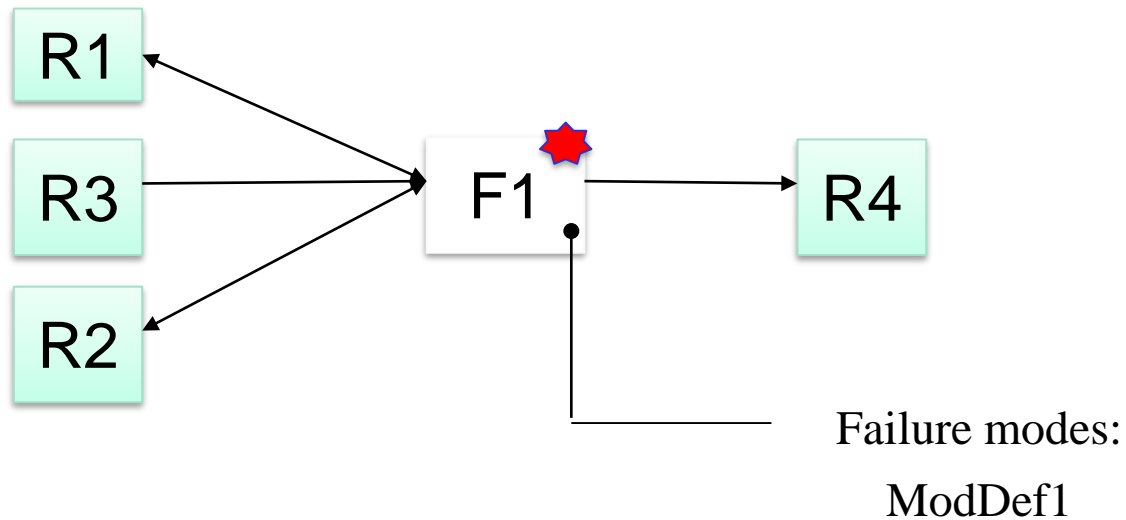
[S01.R10.FM03](#):Inadequate drying program

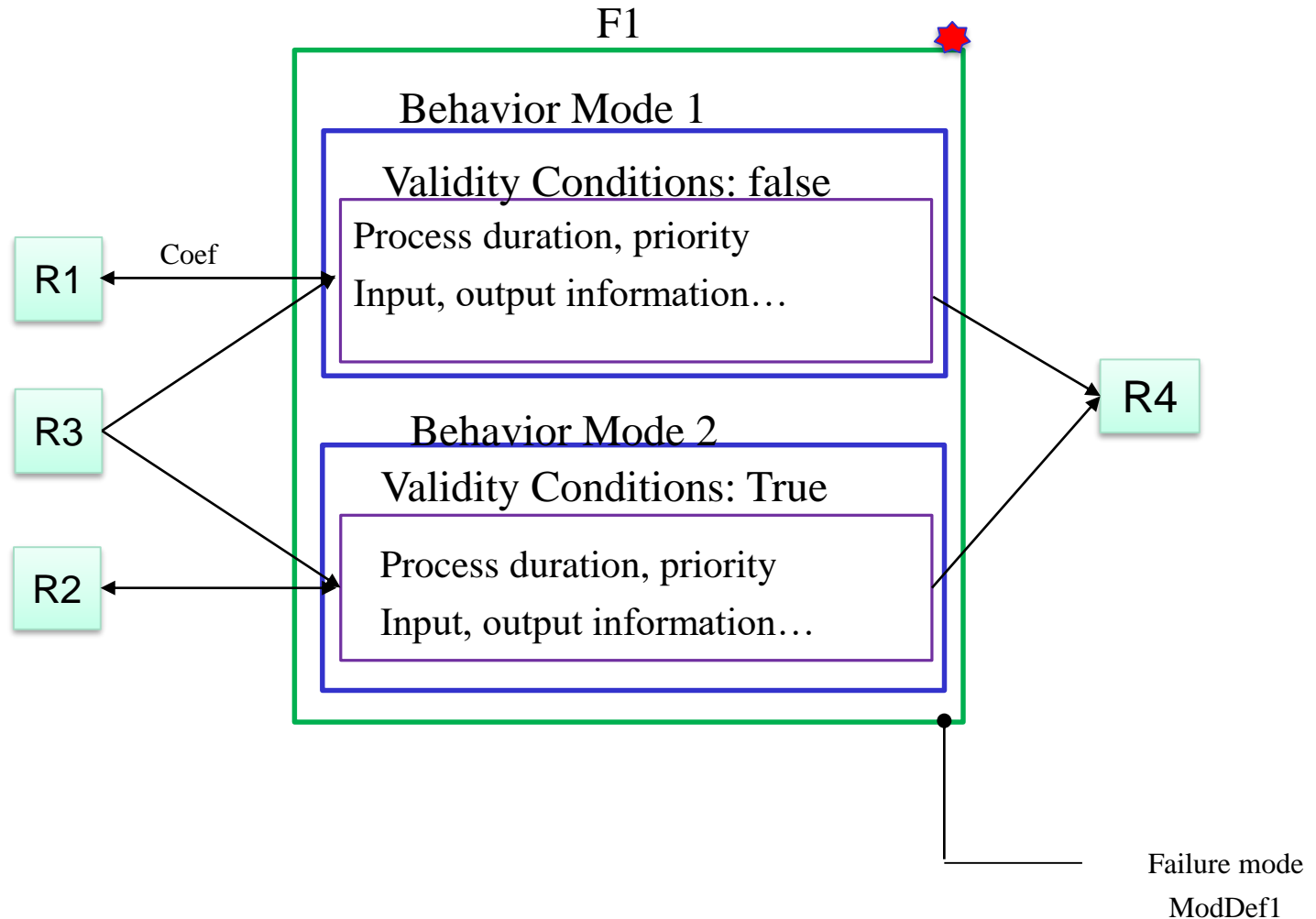
[S01.R10.FM04](#):Presence of warm part

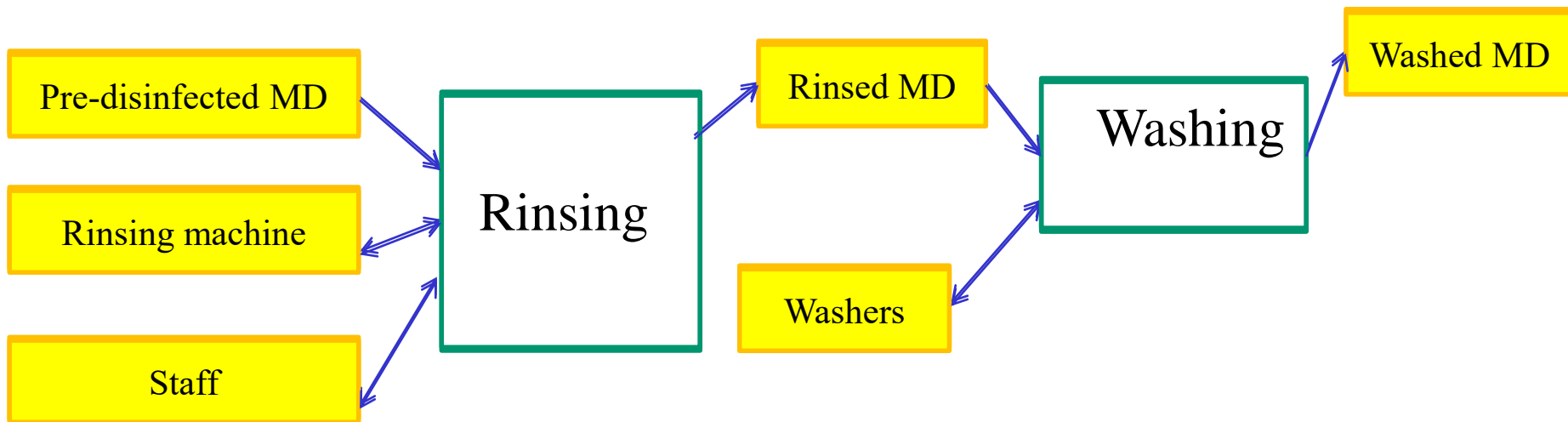
[Ajoute](#) / [Supprime](#) / [Trie](#) failmode

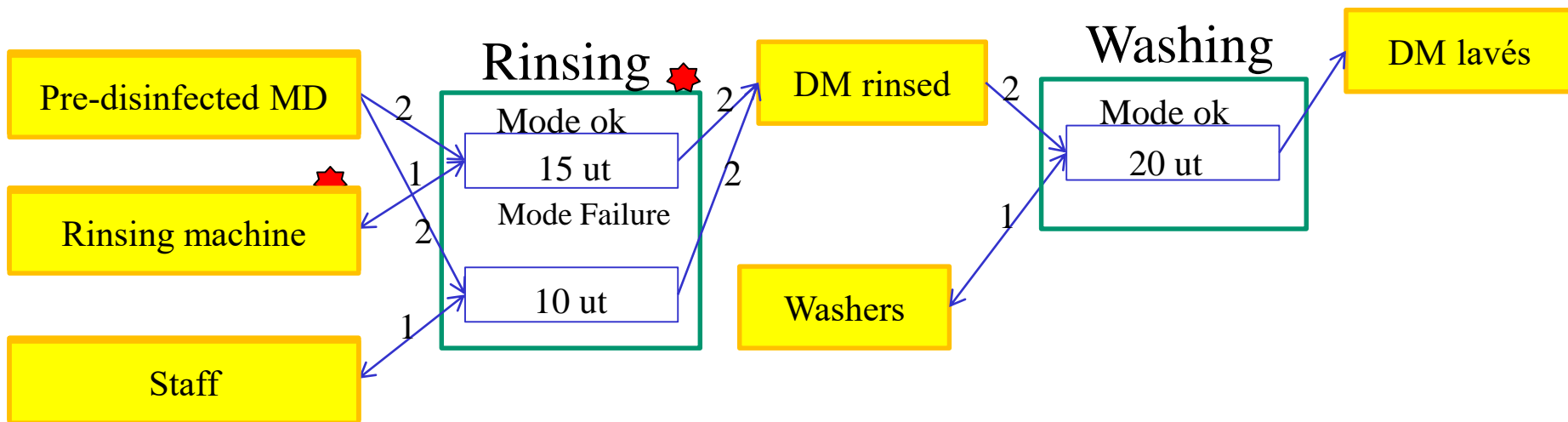


# FIS – Modeling of flows

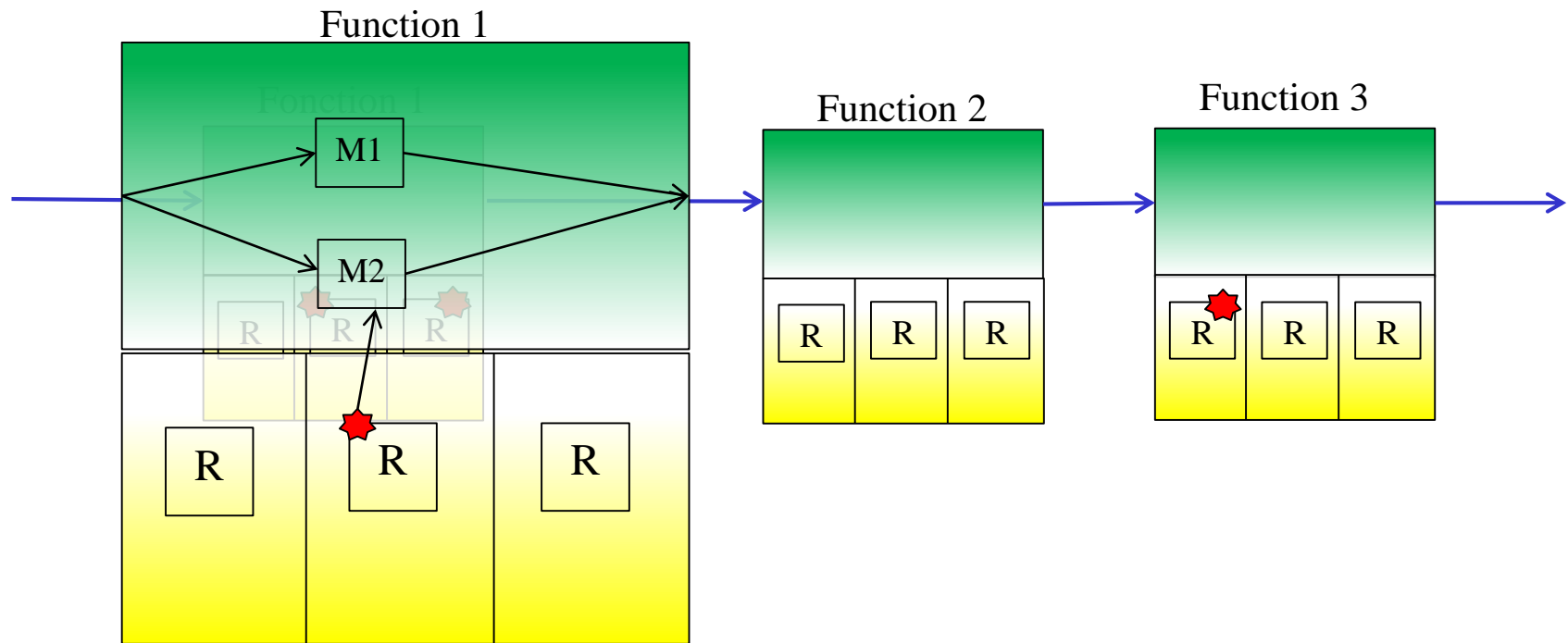


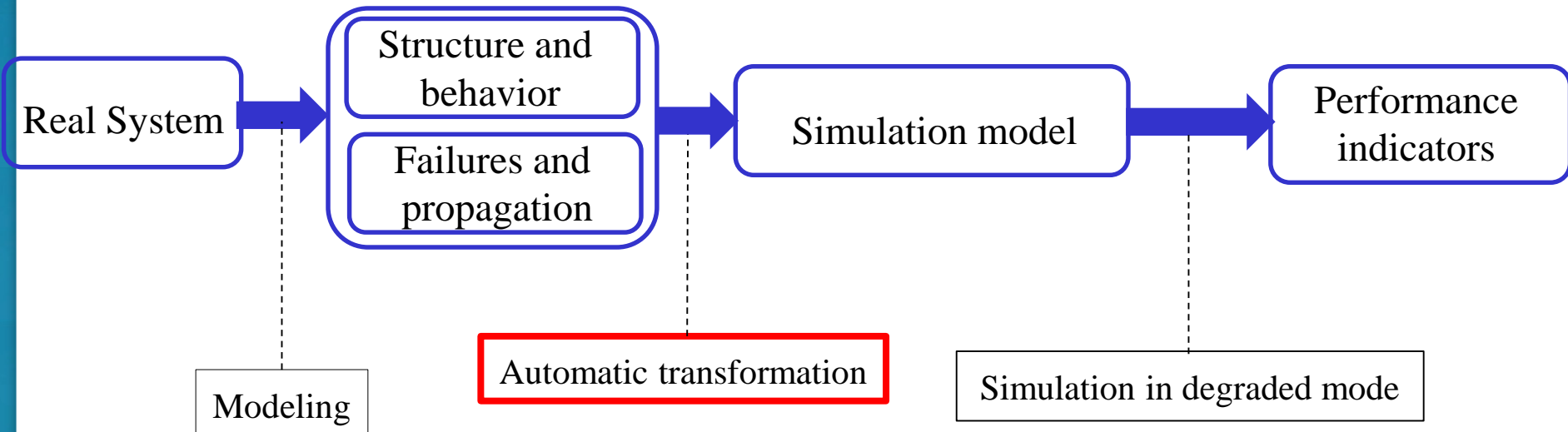
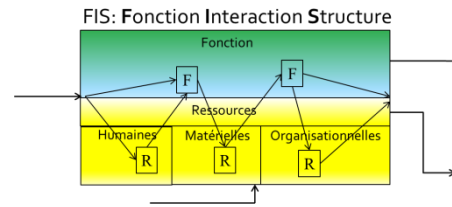






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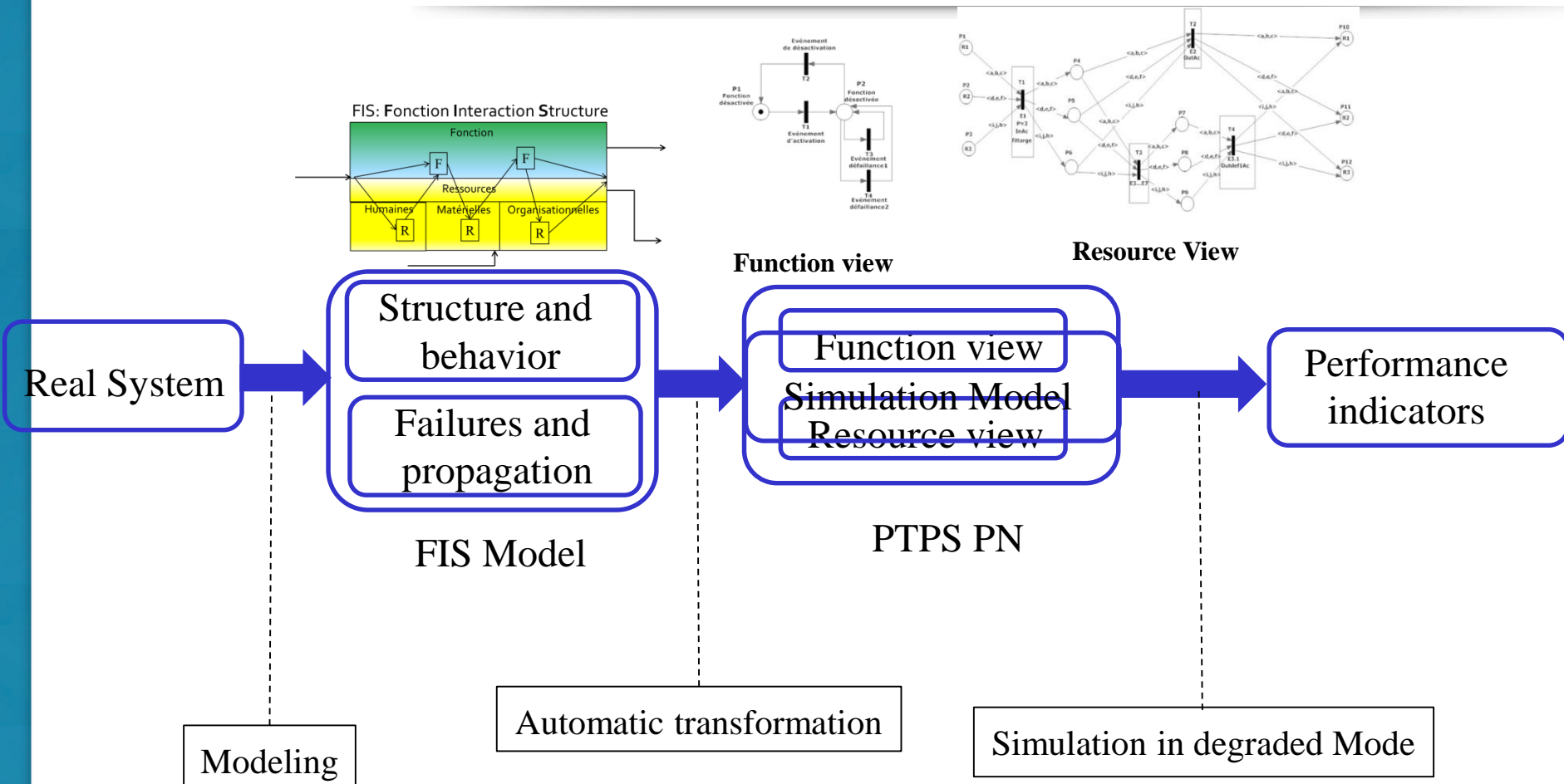


Represent the dynamic behavior of production systems

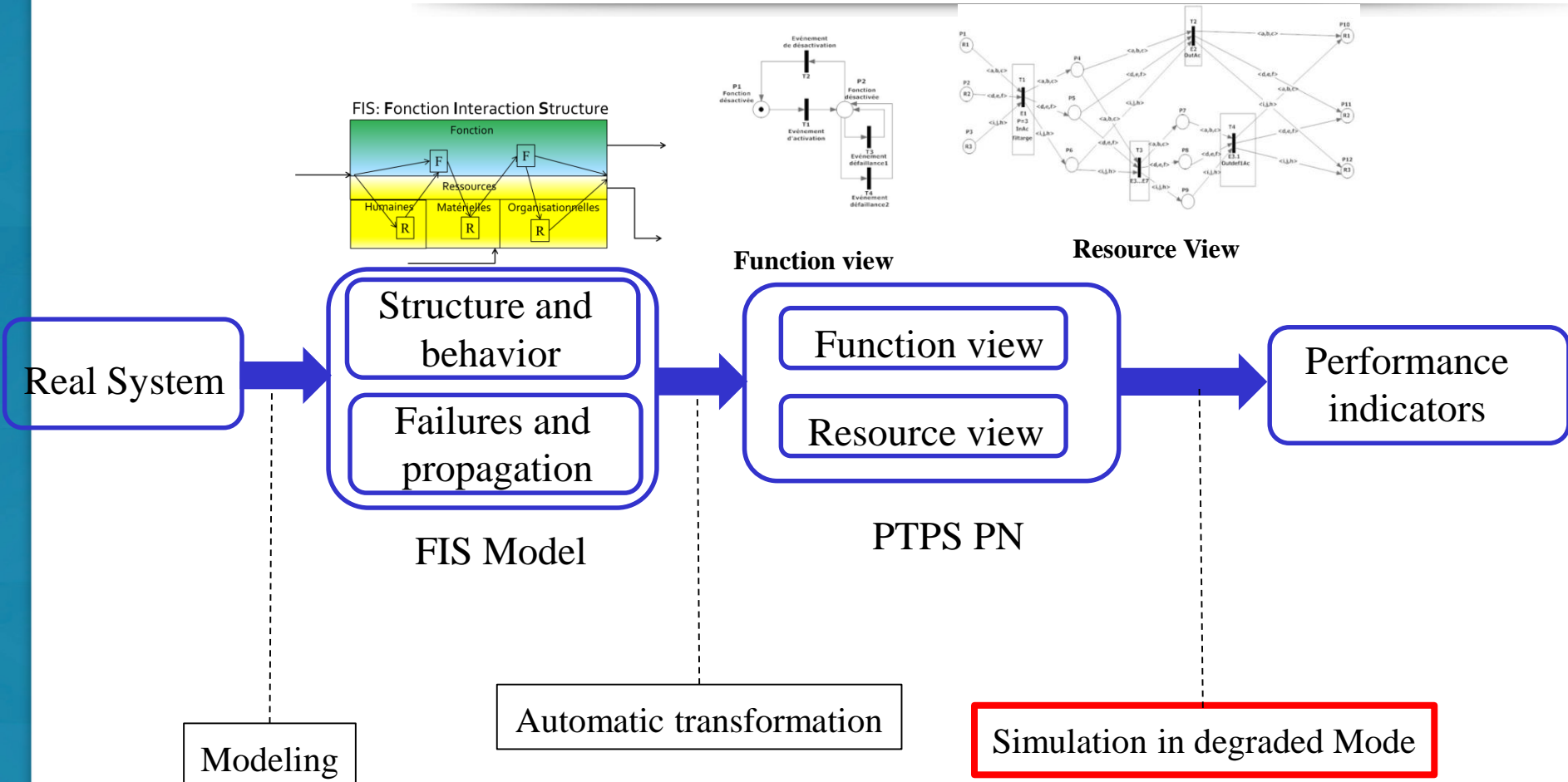
PTPS (Predicate-Transition, Prioritised, Synchronous Petri Nets

(capable of satisfying all the requirements of FIS Model)

Set of conversion algorithms

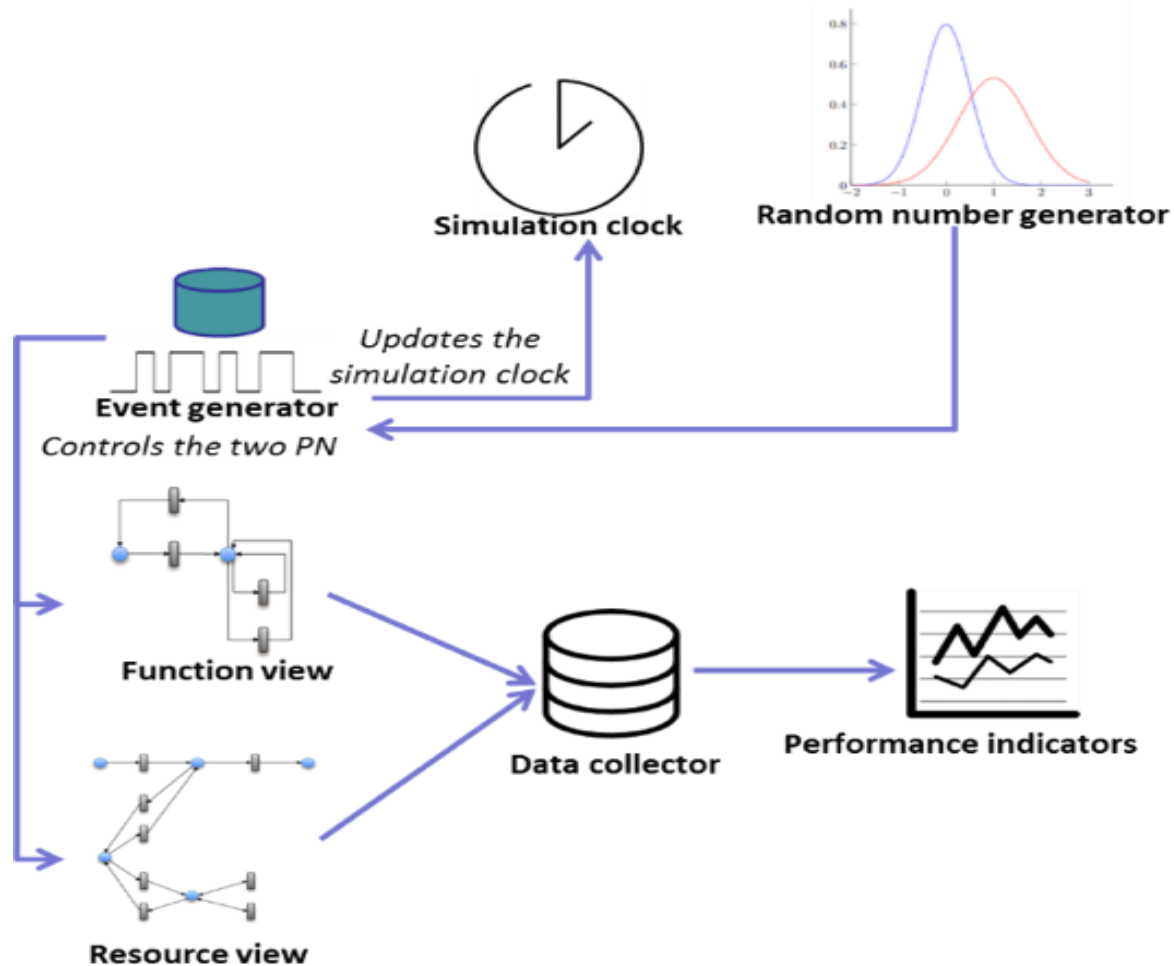






Tool for the dynamic simulation and definition of the performance indicators enabling to quantify the performance degradation when a risk occurs

# Composition of the simulation tool

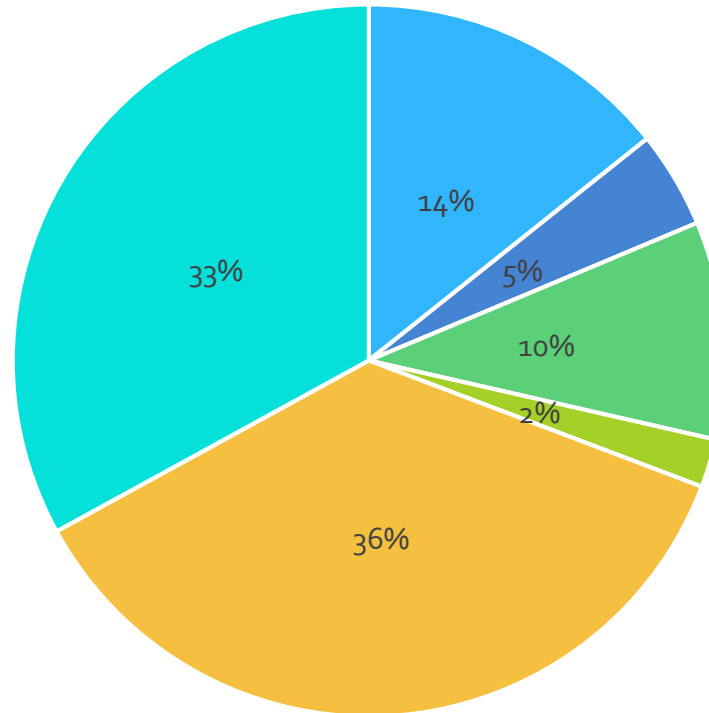




- Identify the functions and resources of the sterilization service
- Identify the dangerous phenomena and the failure modes that can occur in the sterilization service
- Decompose the identified resources into behavioral modes

# Case study: sterilization service from Grenoble Hospital

177 dangerous phenomena



■ Pré-désinfecter et transférer les DM

■ Rincer les DM

■ Laver les DM

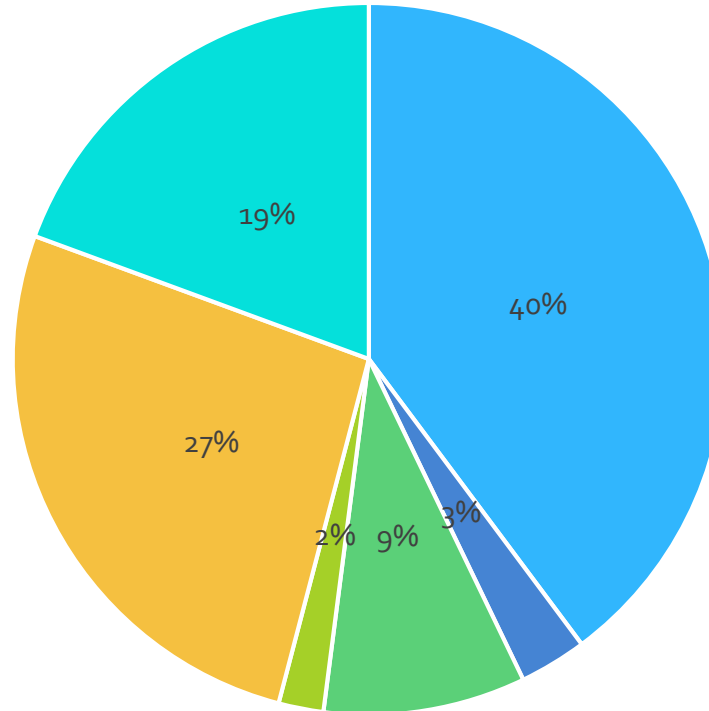
■ Sécher les DM

■ Vérifier et Conditionner les DM

■ Stériliser les DMs

# Case study: sterilization service from Grenoble Hospital

536 Failure modes



■ Pré-désinfecter et transférer les DM

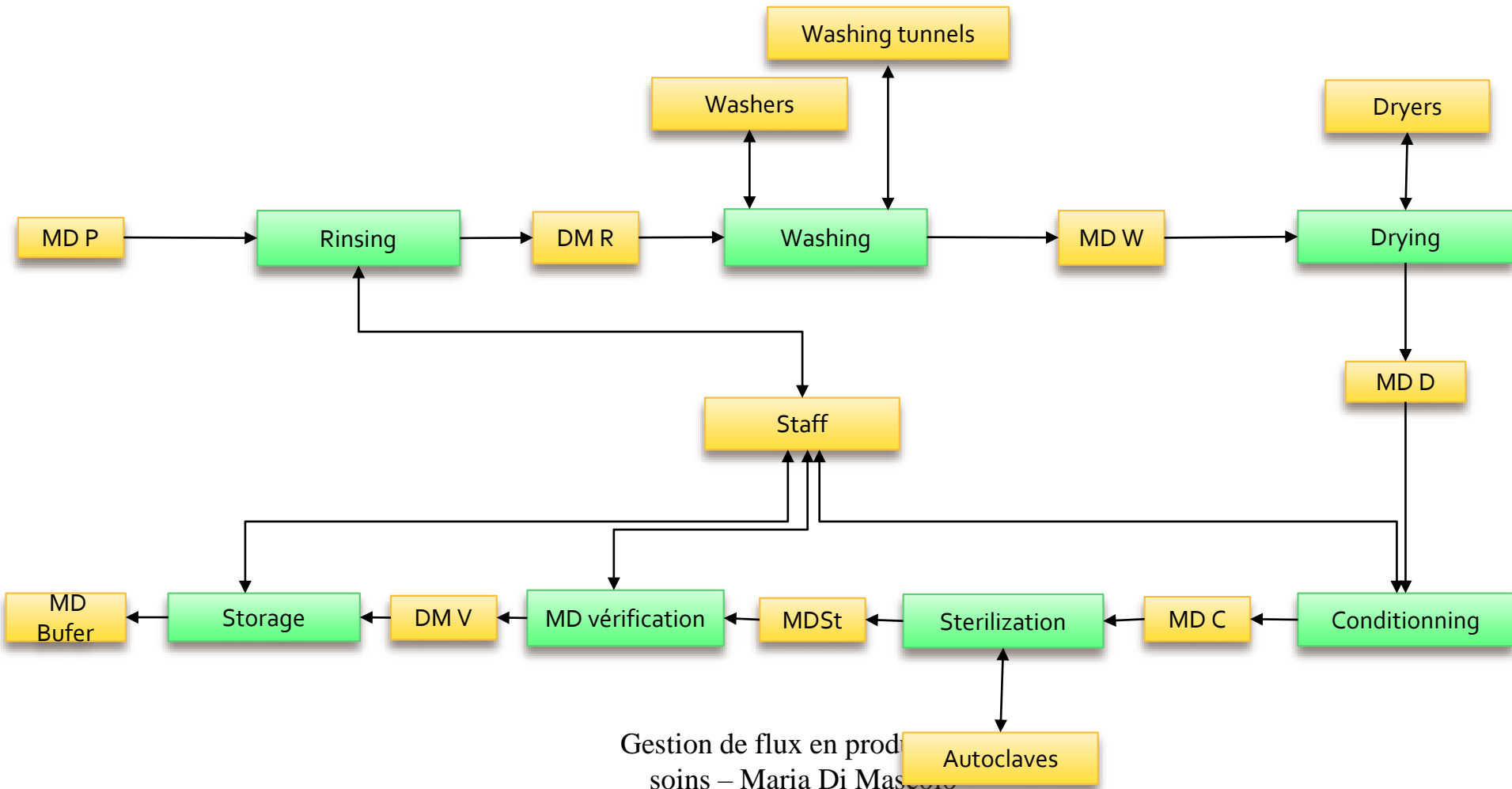
■ Rincer les DM

■ Laver les DM

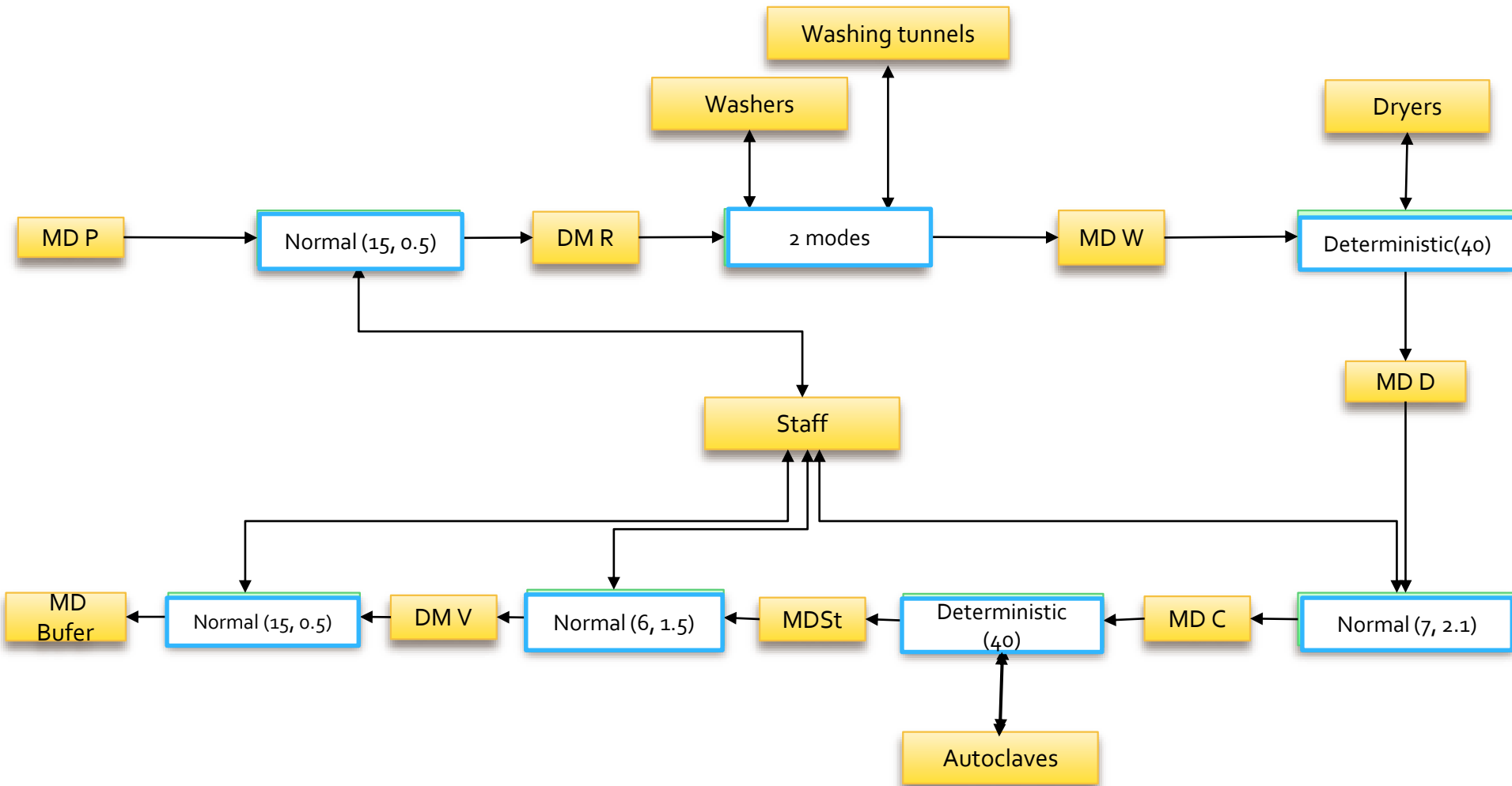
■ Sécher les DM

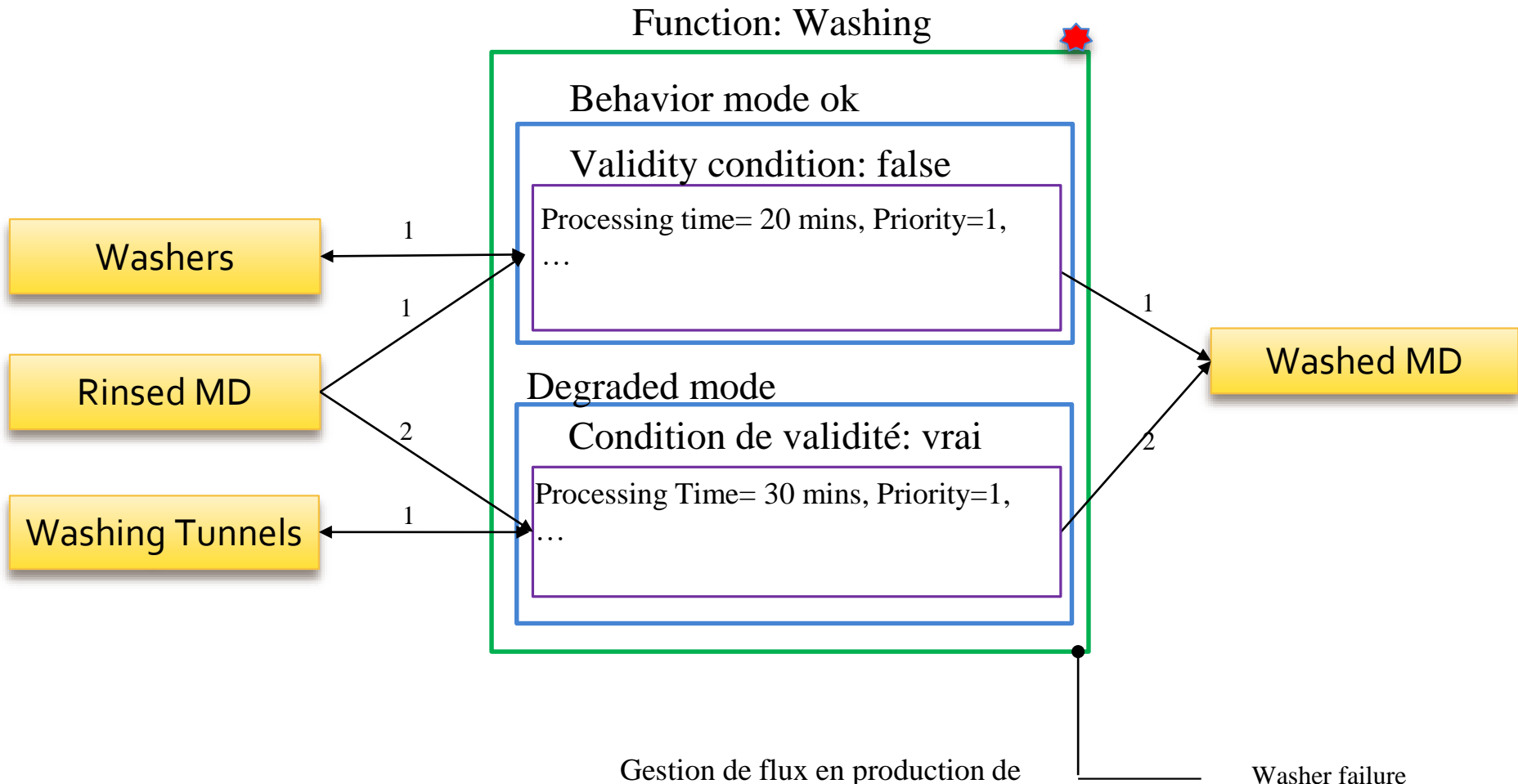
■ Vérifier et Conditionner les DM

■ Stériliser les DMs

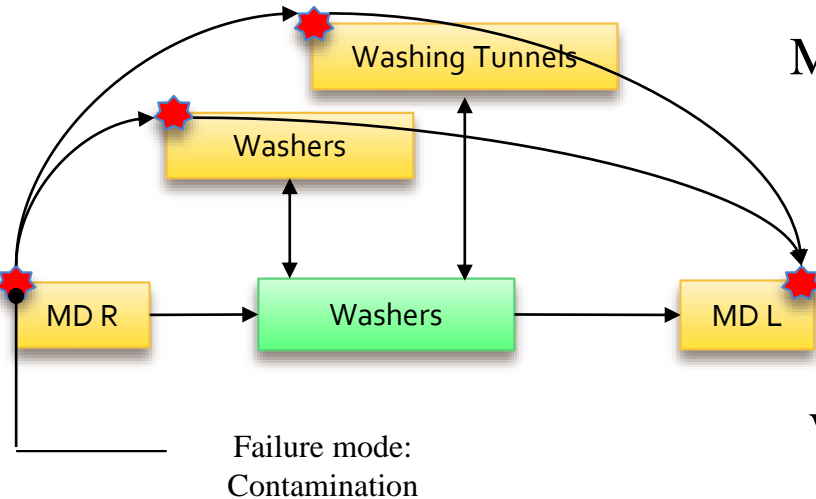


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## MD creation

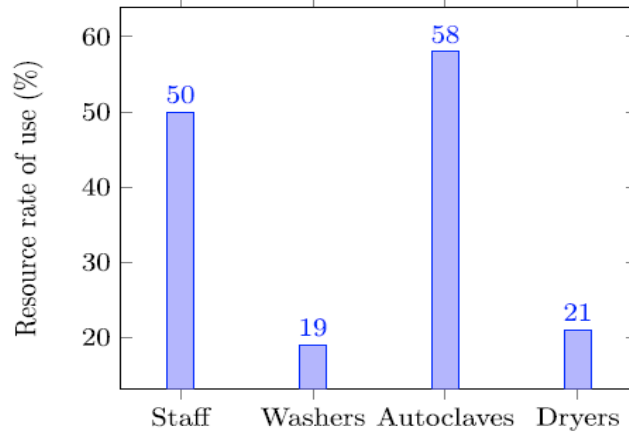
Arrival distribution: Triangular (18, 20, 27)  
120 MD (2 Contaminated by CJD)

## Washer failures

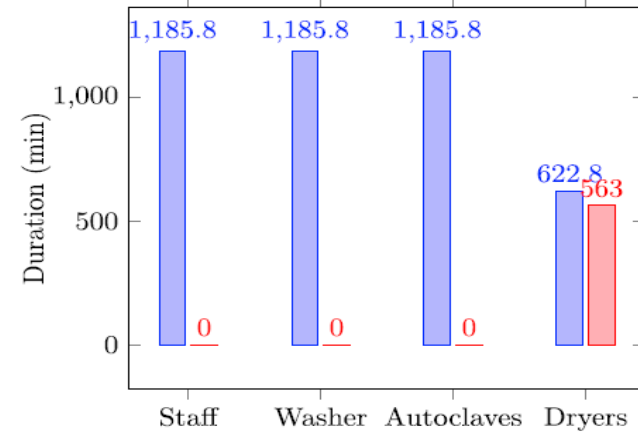
distribution: Binomial (50, 0,7)  
Preemption

	Number of non-contaminated MD	Number of contaminated MD
Input	118	2
Output	42	78

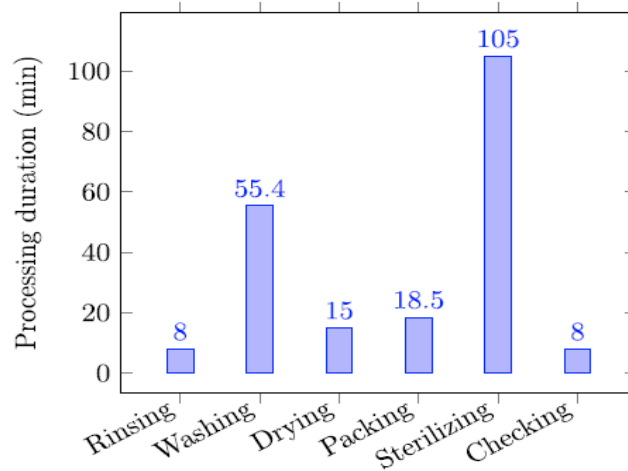
# Some simulation results generated by SIM-RISK



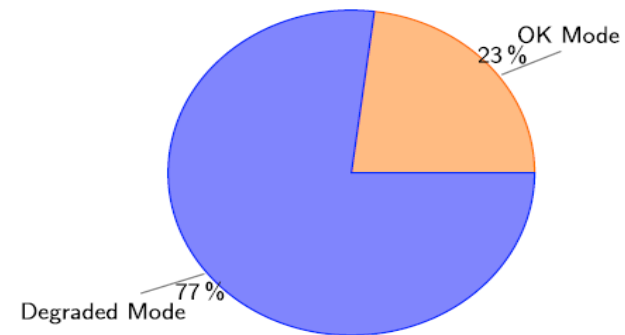
(a) Resource rate of use



(b) Resource MTBF (blue) and MTTR (red)



(c) Mean time spent by medical devices in each function



(d) Percentage of time spent in each mode of behavior of the washing function

- Conclusions
  - Tool enabling to evaluate the performance of a production system, by taking into account the risks, their effects and their propagation
  - Application on a simplified sterilization service
- Future work
  - Improve the usability of the tool
  - Include the detection of failures
  - Include other features, as optimizing performance in degraded mode.

# Thank you!

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