

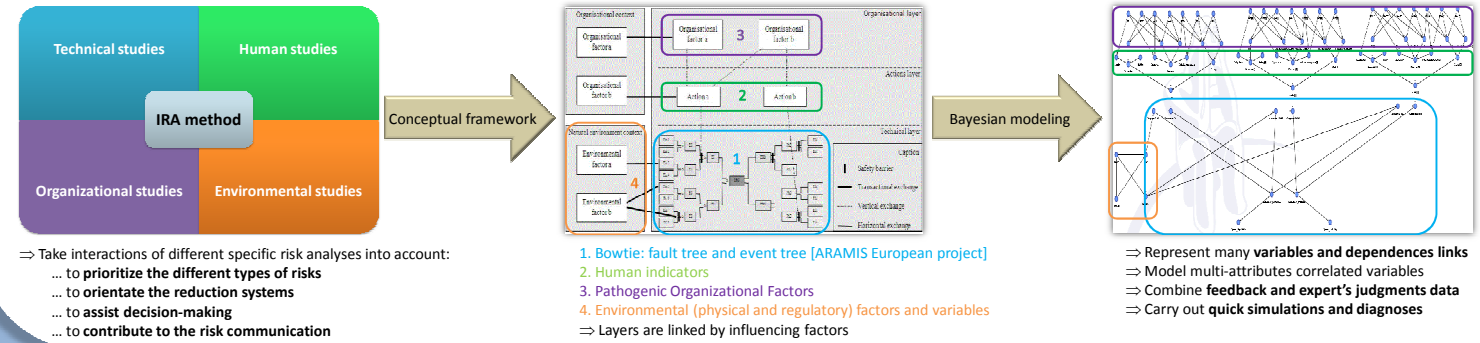
PROBLEM STATEMENT

GENERAL CONTEXT OF RISK ANALYSIS

1. Presence of several sources and types of uncertainties
2. Need to be able to assess at best different issues of industrial systems (safety, availability ...)
3. Necessity to take uncertainties into account in global risk models
4. Lack of tools for applying Evidence Theory on large-size systems (several hundred of nodes)



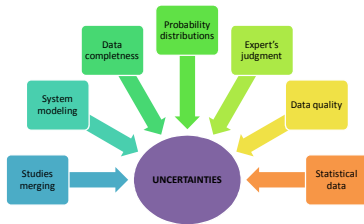
« INTEGRATED RISKS ANALYSIS » METHOD



TREATMENT OF UNCERTAINTIES

SOURCES OF UNCERTAINTIES IN IRA

- ⇒ Very precise estimations for technical and environmental (statistics on experimental feedback)
- ⇒ Qualitative estimations for human and organizational (expert's judgment)



GOALS TO BE TARGETED

1. Modeling and propagating both aleatory and epistemic uncertainties in the same risk model
2. How to take into account epistemic uncertainty in Bayesian Networks?

THE EVIDENCE THEORY

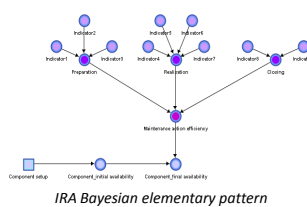
State hypothesis for variable X : H_i Frame of discernment: $\Omega = \{H_1, \dots, H_n\}$

Focal sets: $A_i \in 2^\Omega = \{A_i = \{H_1\}, \dots, A_i = \{H_n\}, A_{i,j} = \{H_1, H_2\}, \dots, A_{i,n-1} = \{H_1, \dots, H_{n-1}\}\}$

uncertainty modelling

FROM BAYESIAN NETWORKS TO EVIDENTIAL NETWORKS

⇒ Encoding Evidence Theory (ET) into Bayesian Networks used for IRA studies



Leaning on ET bases for uncertainty characterization

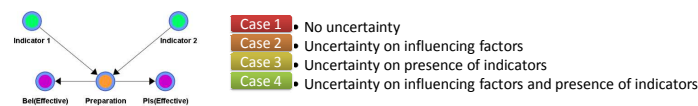
Adapting semantics (modalities/focal sets)

Combining ET with the Bayesian inference

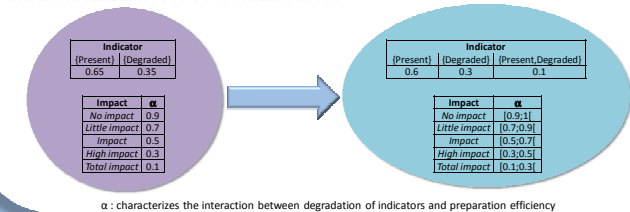
$$Bel(A_i) = \sum_{A_j \subseteq A_i} m(A_j) \quad Pls(A_i) = \sum_{A_j \supseteq A_i} m(A_j)$$

IMPLEMENTATION IN A RISK MODEL

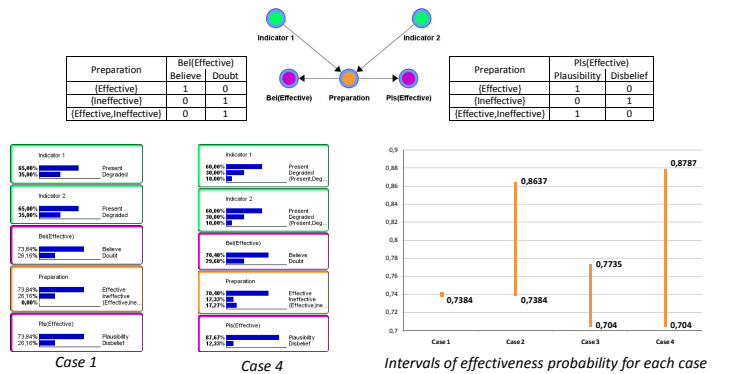
PROPAGATION TEST ON THE PREPARATION PHASE



CHARACTERIZATION OF UNCERTAINTY



INFERENCES AND RESULTS



ANALYSIS & CONCLUSION

CONTRIBUTION OF UNCERTAINTIES

- ⇒ Largest uncertainty contribution related to influencing factors (case 2)
- ⇒ Inferior Bel value and large interval around reference value in case 3 and 4 ... optimistic reference value
- ... IRA need to be conservative in order to ensure safety criteria
- ⇒ Role that uncertainties play in the basic blocks of integrated risk models

USE OF EVIDENTIAL NETWORKS FOR IRA

- ⇒ Possibility to transform the Bayesian Networks used for IRA to Evidential Networks
- ⇒ Feasibility of characterization and propagation of both variability and epistemic uncertainties in IRA

CONCLUSION

- ⇒ Capacity of Evidential Networks to prioritize the contributions of uncertainties
- ⇒ Estimation of influencing factors is critical to reduce uncertainties
- ⇒ Possibility to quickly simulate and diagnose systems with Evidential Networks

PERSPECTIVES

1. Develop these works on a whole IRA network
2. Reduce initial uncertainties ... by guiding the assessment of influencing factors and studying the sensitivity ... by using previous works on expert's judgment
3. Decision-making methods with uncertain assessment for IRA problems