Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro

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A fuzzy decision system for the approval of major changes at COMAH installations

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Agenda

1. Decisions made by regulators in the field of major installations;
2. A brief review about Index Methods for risk analysis;
3. The fuzzy model for risk decision making in COMAH installations;
4. A case study application;
5. Conclusions.

Control of major accident hazards

Regulators make many decisions along the lifetime of major accident hazard installations such as…..

- in authorization phase: permits and safety report assessment;
- in operation phase: approvals of plant or process changes, authorization revisions, periodic inspections and audits, prescriptions and recommendations for preventing and reducing risks

Decisions have to be shared with employers, operators, workers and citizens

Rationale

- The basic idea of the paper is to show the potential of including the well known “safety index method” in a decision trial, based on fuzzy logic.
- The integration could provide efficient tools for addressing many issues at Seveso installations, including plant licensing and inspections planning.
- Numerical values of indexes are expressed, according to a conventional scale, in qualitative categories, which varies, typically, from “low” or “very low” risk to “high” or “very highly” risk.
- Conventional Index methods don’t manage directly level of uncertainty. For that reason, the proposed model aims to manage uncertainty in making decision in the framework of Major Accident Hazard (Seveso) legislation.

Index Methods (IM): a brief review

- IM are quite simple in their application and do not require high level of expertise.
- They are applied worldwide and, moreover, they are acknowledged in several national Major Accident Hazard legislations, including Italy;
- Judgments required for risk analysis are based on numerical values derived by check lists, often hierarchically organized;
- Numerical values of indexes are expressed, according to a conventional scale, in qualitative categories.

Indexes method has been demonstrated (for some twenty years and more) adequate to represent both the inherent risks and the safety measures

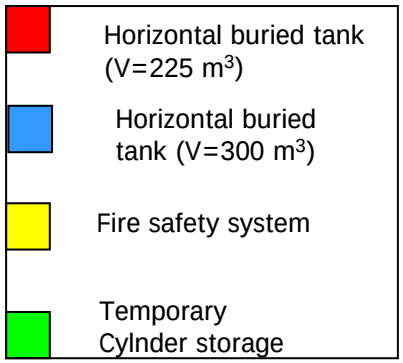
The ISPESL Index (derived from DOW and MOND)

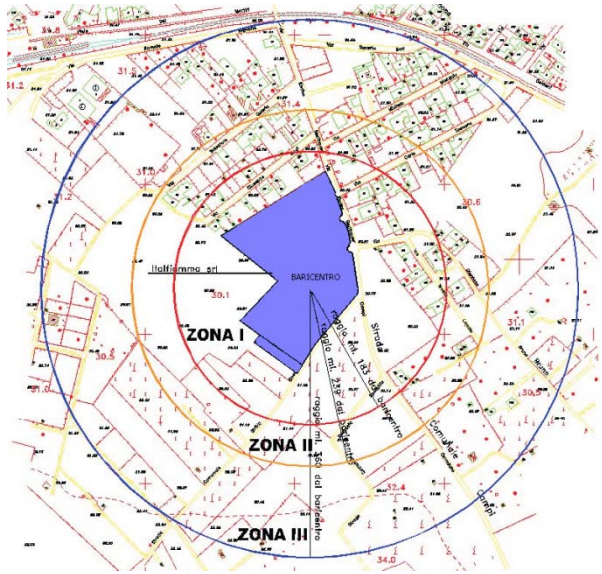
Hazard TYPE									
Fire Hazard		**Confined Explosion**		**Unconfined Explosion**		**General Hazard**		**Toxic hazard**	
0-2	Very low	0-1.5	Very low	0-10	Very low	0-20	Very low	0-5	Very low
2-5	Low	1.5-2.5	Low	10-30	Low	20-100	Low	5-10	Low
5-10	Moderate	2.5-4	Moderate	30-100	Moderate	100-500	Moderate	10-15	Moderate
10-20	High-Level 1	4-6	High	100-400	High	500-1100	High-Level 1	15-20	High
20-50	High-Level 2					1100-2500	High-Level 2		
50-100	Very high level	More than 6	Very high	400-1700	Very high	2500-12500	Very high level	More than 20	Very high
100-250	Heavy	-	-	More than 1700	Heavy	12500-65000	Heavy	-	-
More than 250	Very heavy	-	-	-	-	More than 65000	Very heavy	-	-

Even though Index method is not fuzzy, the resulting indexes are suitable to be used for fuzzy logic applications

Decisions for Seveso Installations

As provided by Italian Legislation for petrol and gas depots





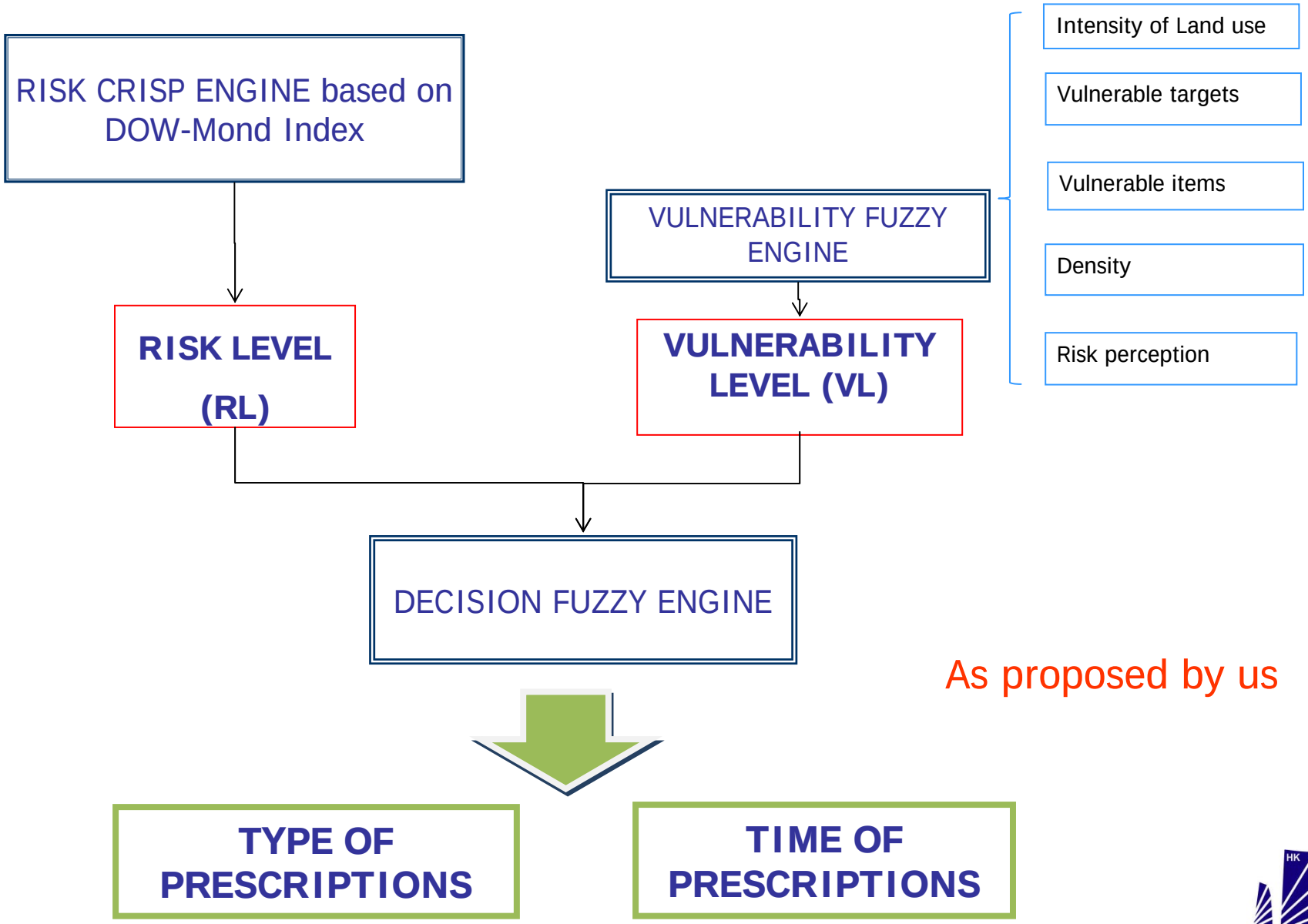
RISK LEVEL (RL)

LAND VULNERABILITY LEVEL (VL)

TYPE OF PRESCRIPTIONS/ RECOMMENDATION

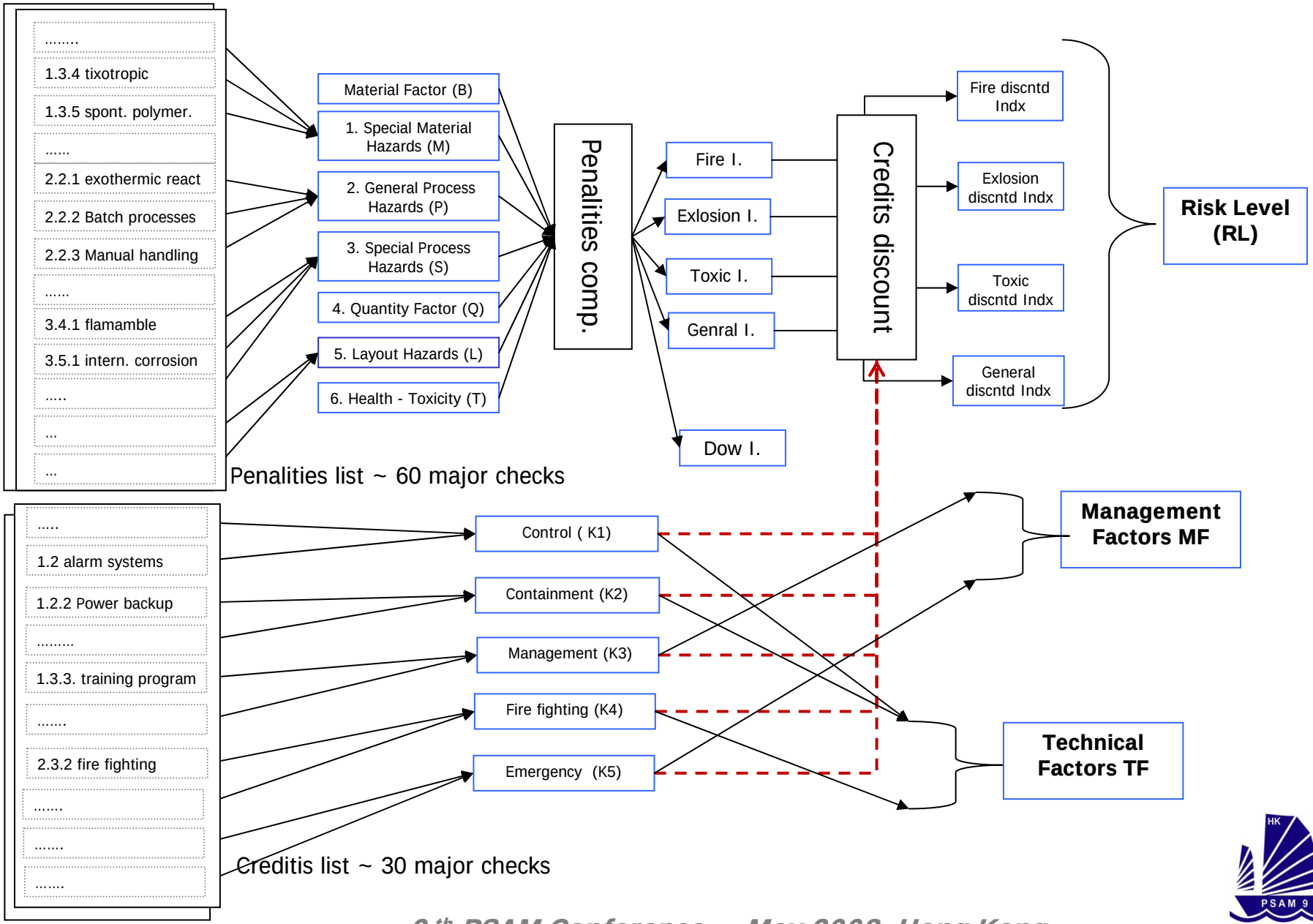
TIME FOR PRESCRIPTIONS AND INSPECTIONS

The fuzzy decision model for SEVESO installation



As proposed by us

The crisp risk engine



The vulnerability fuzzy engine

Input Parameters	Description	Parameter values	Membership Function
Intensity of Land use	Rural, industrial, infrastructural, commercial, residential, urban	0-5 (from extensive to intensive): 3 values	Triangular
Vulnerable targets (weak population)	Hospitals and primary schools (e.g. building that host vulnerable people)	0 – 1,000 (from low to high): 3 values	Triangular
Density (residential, workers, etc.)	Depends on person/ha	0 – 1,000 (from low to high): 3 values	Triangular
Vulnerable items (environmental targets)	Rivers, lakes, ponds, woods, parks, protected areas and beaches	0 – 100 (from low to high): 3 values	Triangular
Risk perception	Depends on higher population concern due to past adverse events (e.g. accidents), pollution, occupational disease, as well as a widely recognized area overload	0 – 100 (from low to high): 3 values	Triangular
Output	**Description**	**Parameter values**	**Membership Function**
Vulnerability Level	-	0 – 100 (from low to high): 3 values	Triangular

- Parameters are not independent each other;
- A deeper analysis, supplied by fuzzy logic application, is therefore needed to single out real “orthogonal parameters.
- The fuzzy model is based on 729 rules which lead to asses the vulnerability level (i.e. the output parameter) according to five input types.

The decision fuzzy engine

Input Parameters	Description	Parameter values	Membership Function
Risk Level	From Risk Crisp Engine	0-20,000 (from low to high): 4 values	Triangular
Vulnerability Level	From Vulnerability Fuzzy Engine	0 – 100 (from low to high): 3 values	Triangular
Management Factors	Safety Attitude, Emergency Measures	0 – 100 (from low to high): 3 values	Triangular
Technical Factors	Barriers, Process Control, Fire Protection, Chemicals Segregation	0 – 1,000 (from low to high): 3 values	Triangular
Output	**Description**	**Parameter values**	**Membership Function**
Decision type	Procedural or Technical Recommendation/Prescription	0 – 1: 5 values	Triangular
Decision time-schedule	Time to work out	0 – 1: 3 values	Triangular

Based on 108 rules

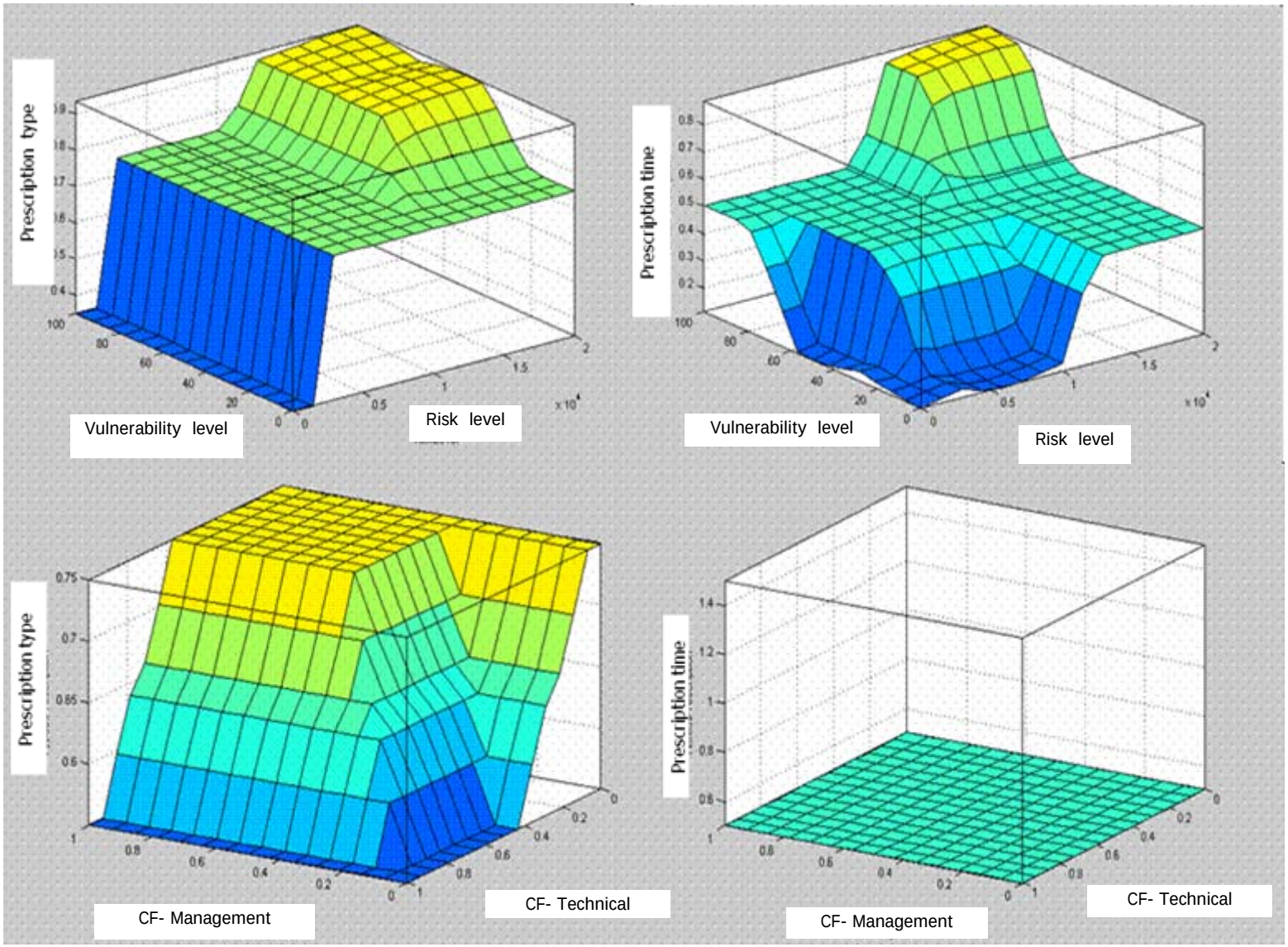
Five outputs for decision type

- General Recommendations (GR): management or technical recommendation;
- General Prescription (GP): management or technical prescription;
- Major Prescription (MP)

Three outputs for time of decision

- First Option: “to be immediate verified”;
- Second Option: “to be verified in after a time”;
- Third Option: “to be verified during peridodic inspections”

The Decision Fuzzy Engine



Conclusions

- Decision made by regulators in the field of Major Accident Hazard cannot be driven by rigid and deterministic criteria; usually several qualitative issues about both installations and land vulnerability have be considered.
- On the other hand, judgments cannot be subjective, since they have to be shared with all stakeholders, including owners, employers, operators, workers and citizens.
- The paper propose a model which allow to integrate efficiency of index methods with fuzzy logic which could supply more efficiency and flexibility in risk analysis.
- The proposed model aims to achieve two main goals :

1. a more precautionary protection for workers, people and environment
2. a decision trial that may be demonstrated to all stakeholders, in a open and transparent way.

Thank you for your attention!