Application of Aramis
developed in the framework of SEVESOII directive to the Canadian Context

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- IRISK
- ARAMIS
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1 - Introduction

History is full of nightmares, some are natural, others are made by man.

Arthur C. Clarke, *3001, The Final Odyssey*

Saguenay Flood
19-21 July 1996

- Severe floods caused
  - Dam rupture
  - Damages to roads, railroads , bridges and private and public properties

Ice Storm
5-9 January 1998

- Massive damages to electrical transmission lines
  - 3 millions person without electricity some up to a month
  - Temperature drops down to -30°C

Ville La Salle – 1966

Polysterene Reactor Runaway

- 11 Fatalities
- 5 Injured

Toulouse – 2001

Ammonium Nitrate

- 30 Fatalities
- 2500 Injured
- 15000 damaged apartments

Major Industrial Accident Council of Canada

Following Bhopal, Canada chose an innovative approach, the Major Accident Council of Canada was created. (MIACC)

Major Industrial Accident Council of Canada

Safety Partners Triangle

Responsible Care

Using the same thinking that resulted in the creation of MIACC, the Canadian Chemical Producer Association (CCPA) introduced *Responsible Care*™

Responsible Care

The objectives of the Production Code of Practice are to:

- Protect people and the environment by the *Responsible Care* of hazardous substances and installations.
- Ensure that *Responsible Care Systems are in place and operational.*
- **Ensure that communities and employees know the hazards that the hazardous installation represent and that they are protected.**

SEVESO Directive

- **Faced with low results from the first Seveso Directive and difficulties in implementating Seveso II and harmonisation of practices in member states, the European Commission has supported for the last ten years, research to reduce technological and natural major risks**

European Commission Projects

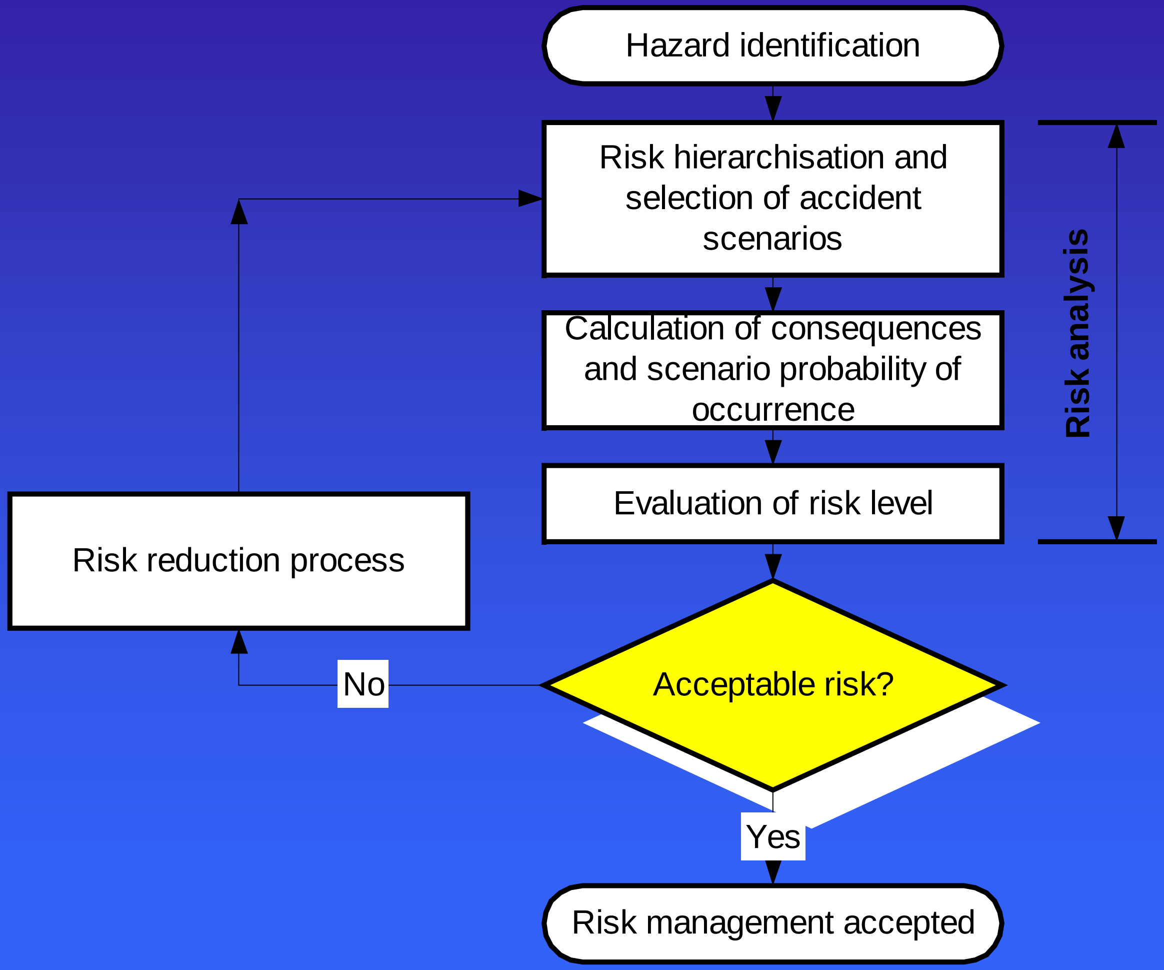
The European Commission has sponsored three projects during the last 10 years devoted to risk assessment:

- **ASSURANCE**
- **IRISK**
- **ARAMIS**

ASSURANCE

- The objective of ASSURANCE was to do a comparative analysis of the risk analysis methods and approaches to ensure safety in Europe.
- Nine independent teams participated to the test
- The study involved a large fertiliser plant using ammonia

ASSURANCE


Hazard identification
Risk hierarchisation and selection of accident scenarios
Calculation of consequences and scenario probability of occurrence
Evaluation of risk level
Risk analysis
Acceptable risk?
No
Risk reduction process
Yes
Risk management accepted

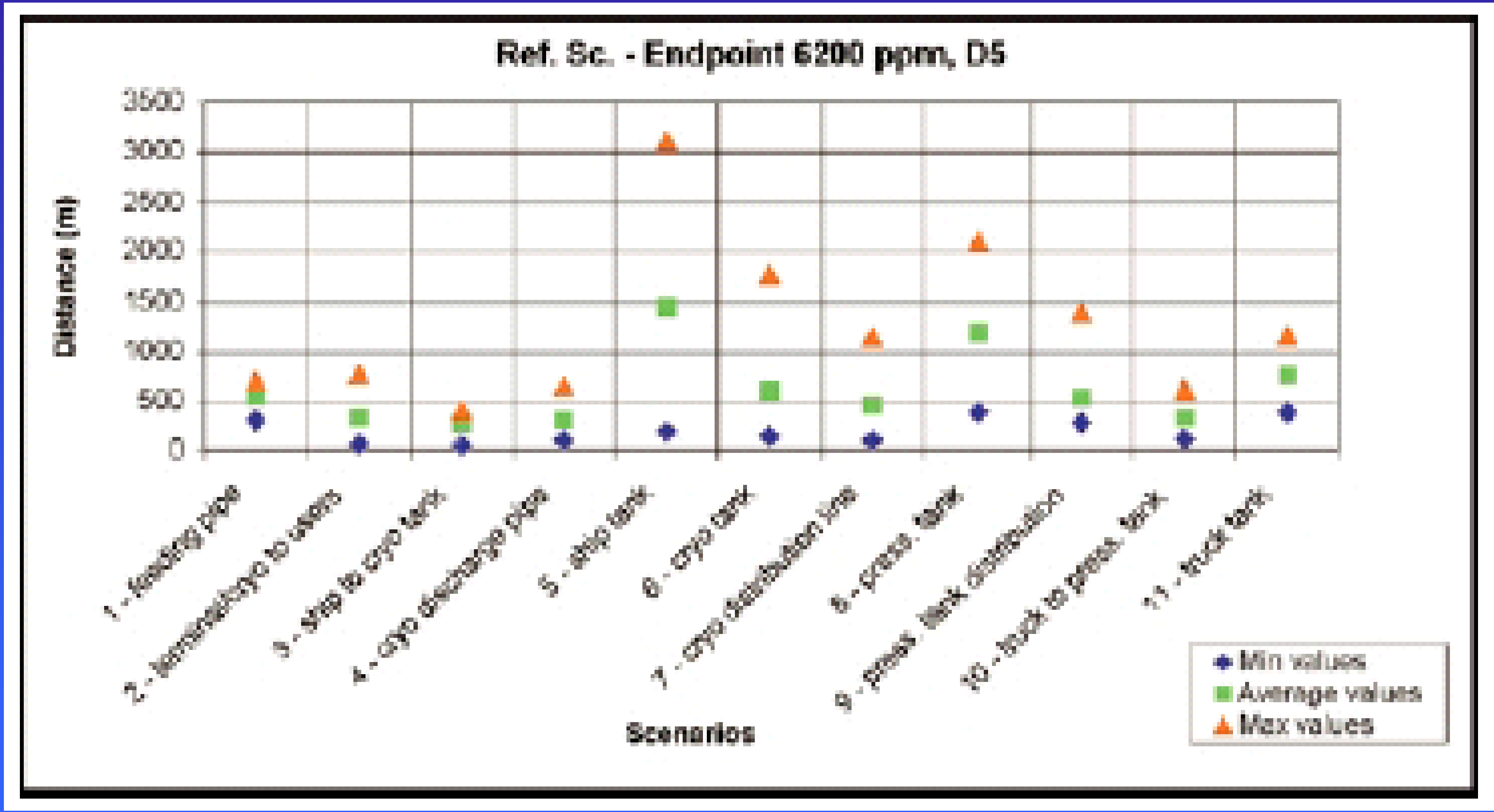
ASSURANCE

- Full bore leak on an 8 inch pipeline feeding ammonia to the site
- Full bore leak on a 4 inch line linking the cryogenic and pressurised tanks
- Rupture or uncoupling of an ship liquid phase unloading arm
- Full bore leak on the 10 inch line linking the cryogenic tank to the ship terminal
- Catastrophic rupture of a ship compartment
- Catastrophic rupture of the cryogenic tank
- Full bore leak on the 20 inch outlet line on the cryogenic tank
- Catastrophic rupture of one ammonia pressurised tank
- Full bore leak of a 4 inch ammonia distribution line to consumer units
- Rupture or uncoupling of truck unloading arm on the liquid phase
- Catastrophic rupture of a tank truck

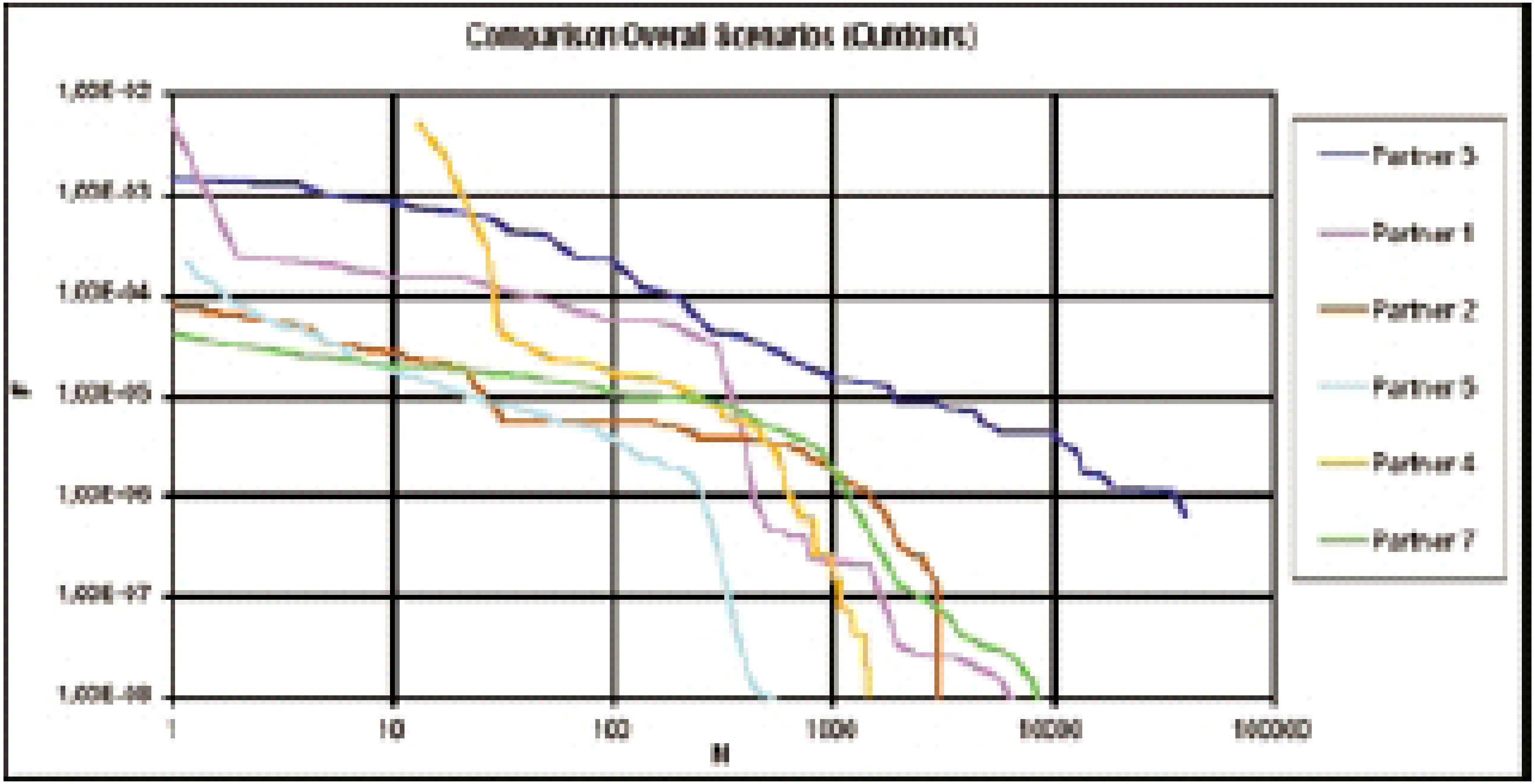
ASSURANCE
Frequencies of Occurence

Scenario	Partner 1	Partner 2	Partner 3	Partner 4	Partner 5	Partner 6	Partner 7	Variability
1	9.0×10^{-7}	1.0×10^{-6}	1.4×10^{-5}	9.0×10^{-7}	1.0×10^{-6}	-	1.8×10^{-7}	1.8×10^{-7}- 1.4×10^{-5}
2	1.0×10^{-5}	3.0×10^{-6}	1.4×10^{-5}	9.0×10^{-7}	7.3×10^{-7}	-	4.6×10^{-6}	7.3×10^{-7}- 1.4×10^{-5}
3	4.8×10^{-4}	4.8×10^{-6}	8.0×10^{-3}	5.0×10^{-3}	5.4×10^{-5}	-	1.3×10^{-5}	4.8×10^{-7}- 8.0×10^{-3}
4	1.0×10^{-6}	-	4.0×10^{-6}	9.0×10^{-7}	8.0×10^{-7}	-	1.8×10^{-6}	8.0×10^{-7}- 4.6×10^{-6}
5	2.8×10^{-7}	6.4×10^{-10}	5.7×10^{-5}	-	2.3×10^{-6}	-	4.9×10^{-6}	6.4×10^{-10}-5.7×10^{-5}
6	5.0×10^{-7}	1.0×10^{-8}	4.0×10^{-8}	-	5.0×10^{-8}	-	5.0×10^{-7}	1.0×10^{-8}- 5.0×10^{-7}
7	6.0×10^{-6}	1.0×10^{-6}	5.0×10^{-6}	9.0×10^{-7}	4.0×10^{-7}	-	4.0×10^{-7}	4.0×10^{-7}- 6.0×10^{-6}
8	1.0×10^{-6}	5.0×10^{-7}	1.0×10^{-6}	4.5×10^{-7}	1.3×10^{-5}	-	4.0×10^{-7}	4.5×10^{-7}- 1.3×10^{-3}
9	3.0×10^{-6}	3.4×10^{-7}	1.5×10^{-5}	9.0×10^{-7}	2.2×10^{-6}	-	8.0×10^{-7}	13.4×10^{-7}- 1.5×10^{-5}
10	2.4×10^{-6}	1.5×10^{-7}	2.1×10^{-3}	2.7×10^{-6}	6.0×10^{-6}	-	5.0×10^{-7}	1.5×10^{-7}- 2.1×10^{-3}
11	5.5×10^{-9}	1.5×10^{-9}	1.2×10^{-7}	1.2×10^{-7}	4.7×10^{-6}	-	1.4×10^{-8}	1.5×10^{-9}- 4.7×10^{-6}

ASSURANCE


Ref. Sc. - Endpoint 6200 ppm, D5
Distance (m)
3500
3000
2500
2000
1500
1000
500
0
1 - feeding pipe
3 - ship to cryo tank
4 - cryo discharge pipe
5 - ship tank
6 - cryo tank
7 - cryo distribution line
8 - press. tank
9 - press. tank distribution
10 - truck to press. tank
11 - truck tank
Scenarios
Min values
Average values
Max values

ASSURANCE



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ASSURANCE

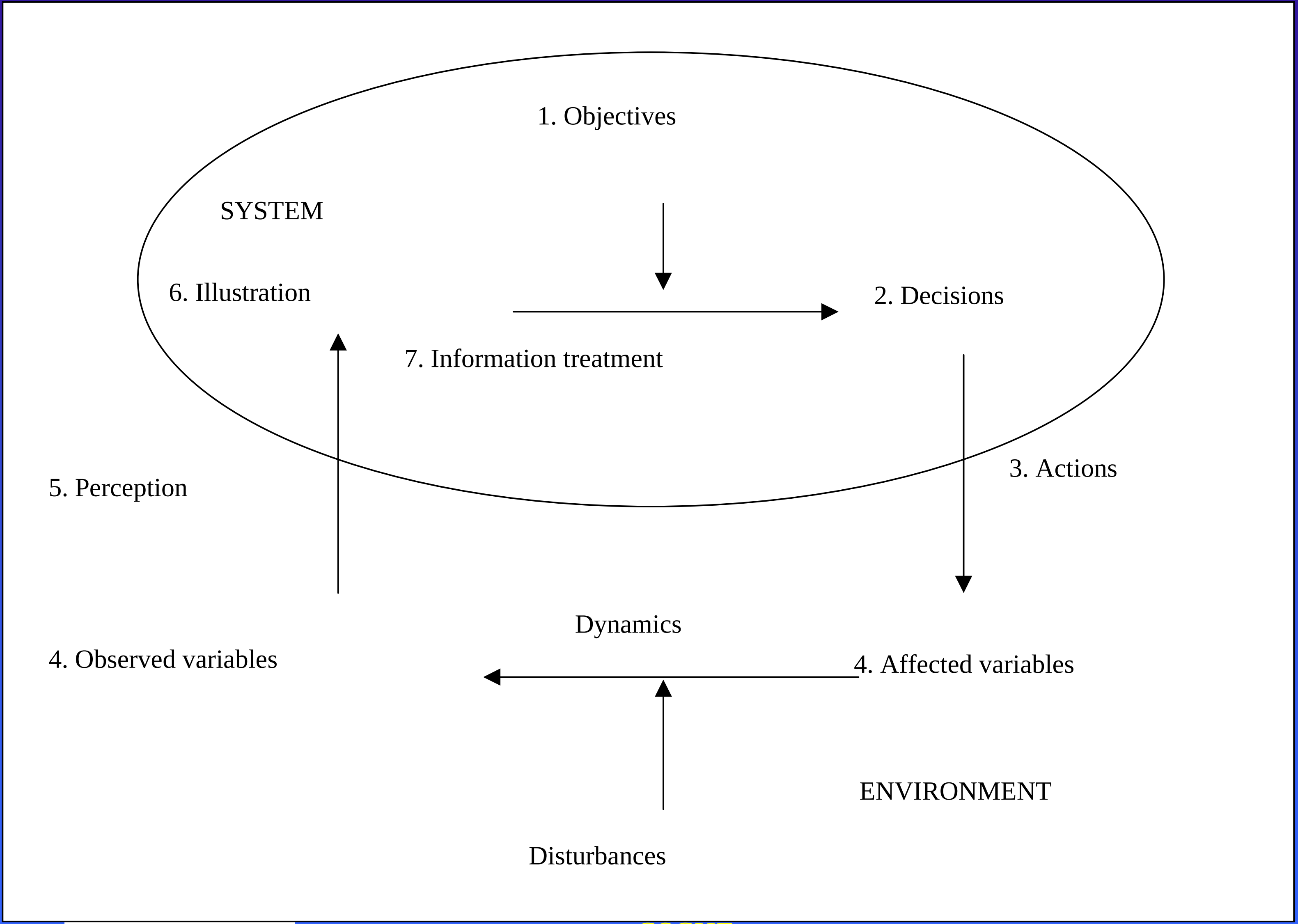
Reasons for discrepancies

- Choice of scenarios
- Choice of initiating causes which affect probabilities
- Type and sophistication of models
- Choice of hypothesis affecting source terms
- Level of conservatism applied by expert

IRISK

- The objective of IRISK was to produce a method for an integrated evaluation of the risks of major industrial accidents involving hazardous substances.
- Integration of the risk evaluation disciplines is a recurring theme in the evaluation of major technological risks
- Interdisciplinitarity should permit a better understanding of phenomena that are perceived to be complex.

IRISK


1. Objectives
SYSTEM
6. Illustration
2. Decisions
7. Information treatment
3. Actions
5. Perception
Dynamics
4. Observed variables
4. Affected variables
ENVIRONMENT
Disturbances

IRISK

IRISK has shown the complexity of the phenomena to be studied:

- technical analysis and
- systemic organisation modeling

Conclusions were developed that will be used in the ARAMIS project

ARAMIS

- ARAMIS objective is to develop a new risk assessment methodology for major accidents that integrates the strength of the various approaches existing at the European level, i.e. deterministic and probabilistic cultures.
- It is based on the management principle that “all what is not measured cannot be managed”
- ARAMIS must also be used as a tool to promote safety in the chemical industry and with the competent authorities, to contribute to harmonisation of the European practices in matters of risk assessment and promote the implementation of Seveso II directive in member states.

ARAMIS

ARAMIS will allow to characterize an integrated risk index composed itself of three distinct and independent indexes

- **Index S** is to assess the consequence severity of reference scenarios
- **Index M** is to evaluate prevention management effectiveness
- **Index V** is to estimate the environment vulnerability

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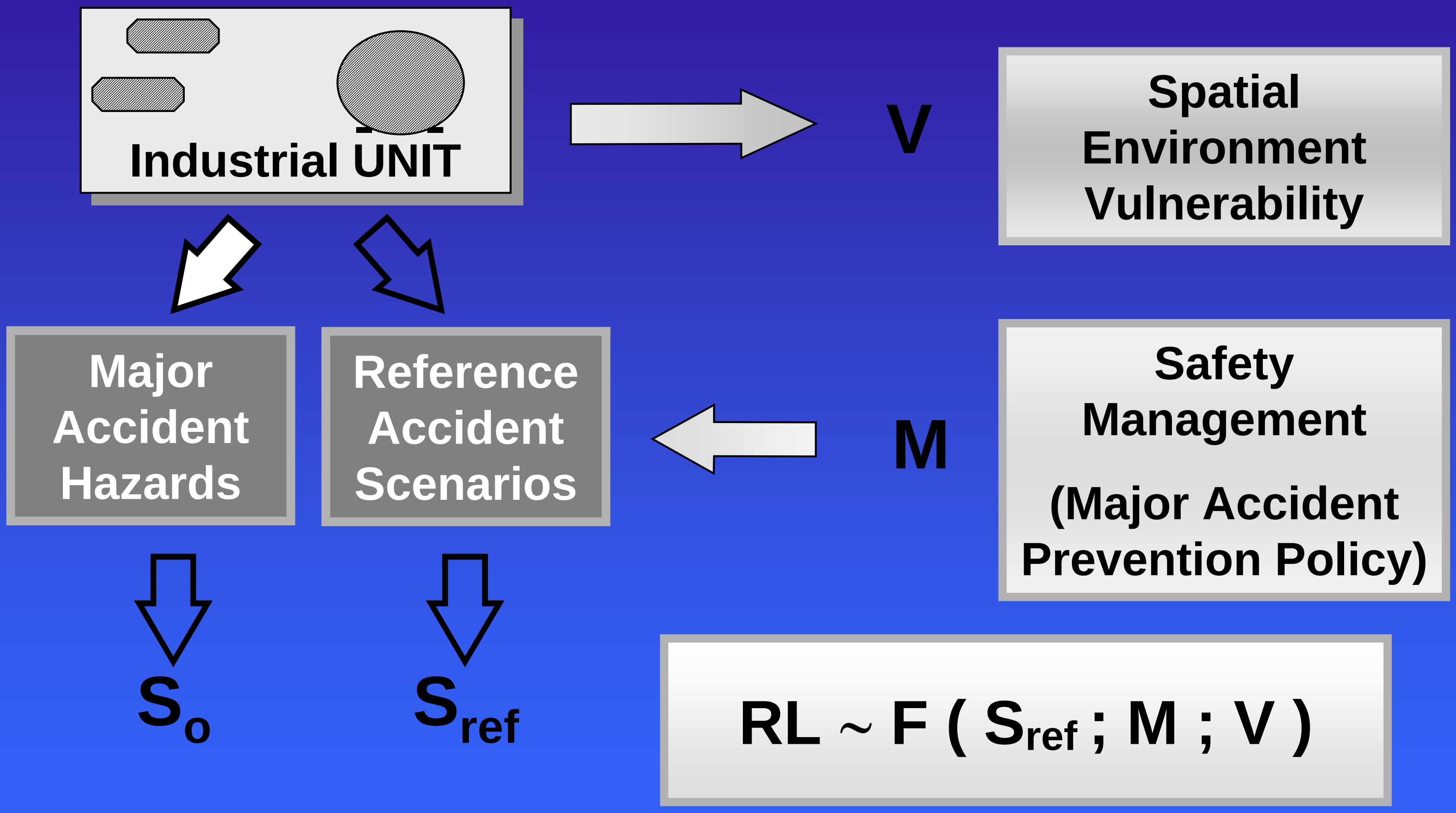
ARAMIS


Industrial UNIT
V
Spatial Environment Vulnerability
Major Accident Hazards
Reference Accident Scenarios
M
Safety Management
(Major Accident Prevention Policy)
S_o
S_{ref}
$RL \sim F\ (S_{ref}\ ;\ M\ ;\ V\ )$

ARAMIS

- Identification of the possible accident scenarios is a key-point in risk assessment.
- However, especially in a deterministic approach, worst case scenarios are considered, often without taking into account existing safety devices and implemented safety policy.
- This approach can lead to an overestimation of the risk level and <u>does not promote the implementation of safety systems.</u>

ARAMIS

- The aim is first to identify major accidents without considering safety systems.
- A second step is then to study in depth safety device effectiveness and safety management efficiency, which will allow assessing -qualitative- probabilities, in order to identify finally Reference Accident Scenarios taking into account some of the implemented safety systems.

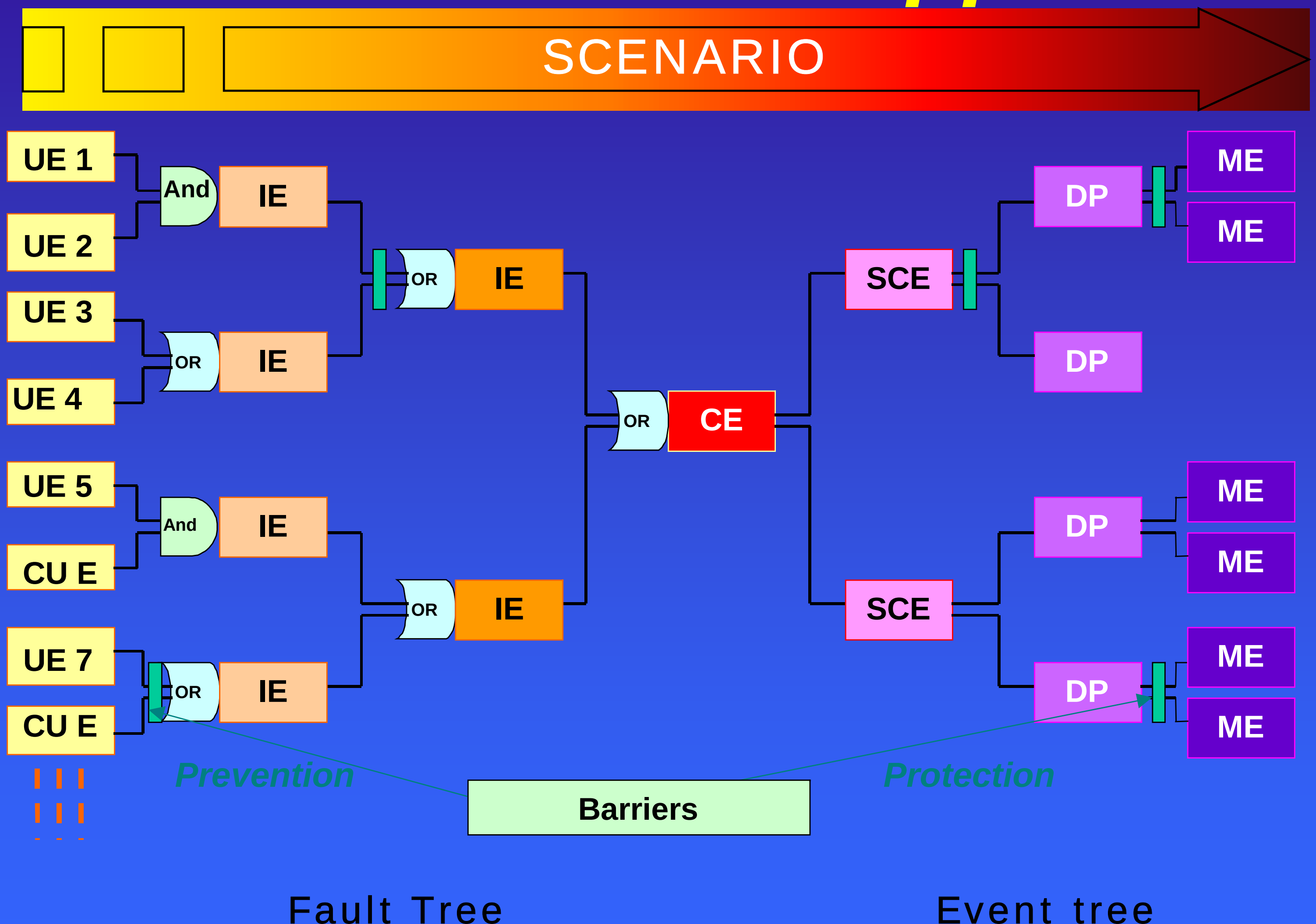
ARAMIS

- Thirteen types of dangerous phenomena and four types of major events are considered

ARAMIS

Dangerous Phenomena		Major Events			
		ME1 Thermal radiation	ME2 Overpressure	ME3 Missiles	ME4 Toxic effects
Pool fire	DP1	X			
Tank fire	DP2	X			
Jet fire	DP3	X			
VCE	DP4	X	X	X	
Flash fire	DP5	X			
Toxic cloud	DP6				X
Fire	DP7	X			
Missiles ejection	DP8			X	
Overpressure generation	DP9		X		
Fireball	DP10	X			
Environmental damage	DP11				X
Dust explosion	DP12		X	X	
Boilover and resulting pool fire	DP13	X			

ARAMIS
Bow Tie Approach



ARAMIS

Index S : Severity of the consequences

- The effect area concerned with the phenomenon, e.g. a disc in case of an explosion, a plume surface for gas dispersion ;
- The kinetic of the phenomenon: rapid for an explosion, much slower for a fire ;
- The potential of generating domino effect: fragment emission, delayed phenomena triggered off.

ARAMIS

Index M : Prevention management effectiveness

- The methodology is based on the identification of initiating events and direct causes of the accident scenarios (bow-tie approach).
- Safety barriers are then related to generic fault and event trees representing all possible accident scenarios leading to critical events.
- The safety organization includes both the adequacy and completeness of technical and managerial barriers (lines of defence) that are implemented to prevent these accidents and the management system that ensures that these barriers are maintained and adjusted properly.

ARAMIS

Index M : Prevention management effectiveness

- Currently, the focus is on developing instruments to measure the set of dimensions, using a combination of audit, questionnaire, interview and observation techniques.
- The combination of measurements ensures that not only the implementation of functions, but also its conditions and outcome (e.g. good safety commitment of the employees) are taken into account.

ARAMIS

Index V: Environment Vulnerability

- An accident is only “catastrophic” if there are vulnerable targets that could be affected. The notion of risk makes sense only when it refers to targets that could be affected by this risk.
- To achieve this, it is first required to characterise the environment against a typology of targets (population, natural environment, and property) and potential effects, and to evaluate the impact that could generate these effects on the targets.

ARAMIS

Conclusions

- The original feature of ARAMIS is the integration of the three indexes, S, M, and S to characterize the level of risk in a site. It is a hybrid between the deterministic and probabilistic approaches used in risk management.
- The bow tie approach and the typology of scenarios that are generated could be particularly useful for the development of credible worst case and alternate cases scenarios required in the Environmental Emergency Regulation under section 200 of the Canadian Environmental Protection Act.
- The concept of a Management index is appropriate and could support the Site Self-Assessment Tool developed by the Major Industrial Accident Council of Canada (MIACC) under the Partnership Toward Safer Communities.