KUALA LUMPUR 2012 WORLD GAS CONFERENCE

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25th world gas conference

"Gas: Sustaining Future Global Growth"

Secure gas transportation and distribution in urban areas

Safety system of gas network and urban planning

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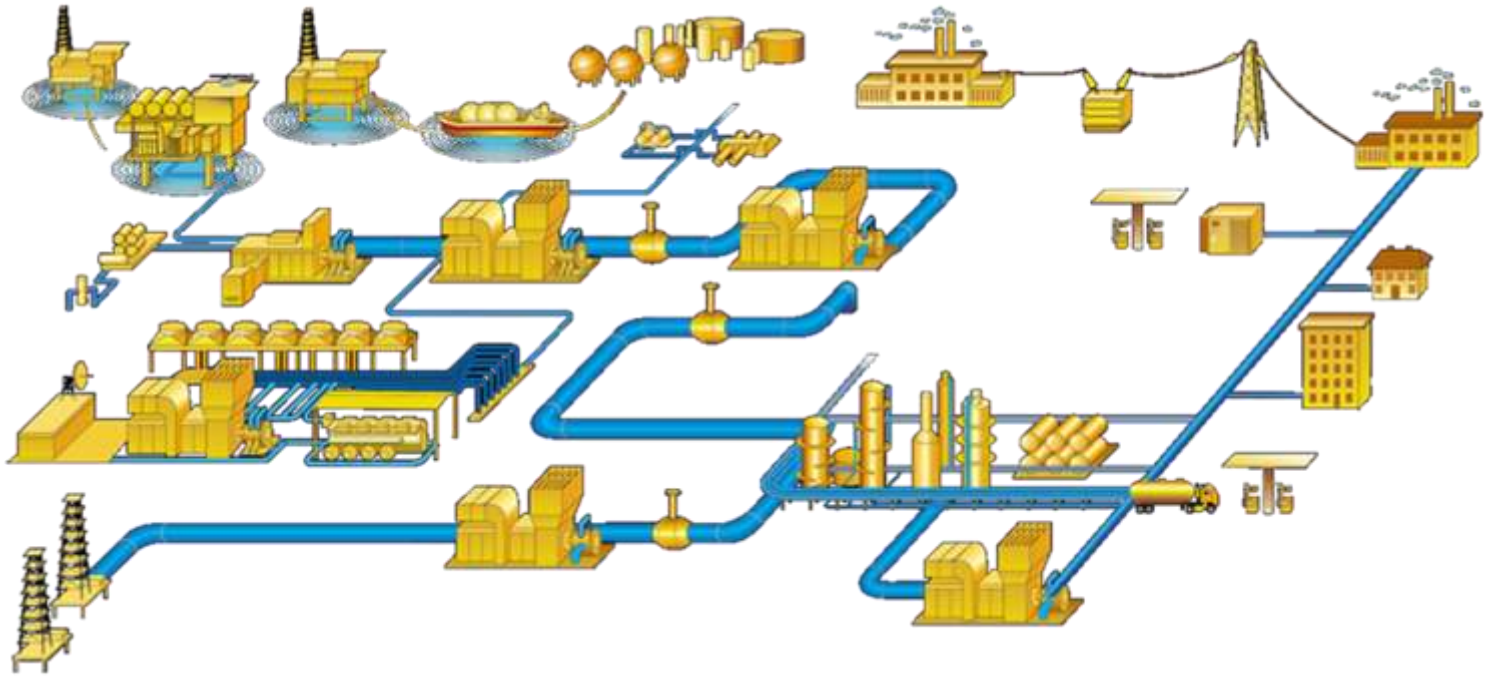
PETRONAS reimagining energy

- I- Statistical datas and feed-back experience
- II- Rules of Safety underground facilities networks
- III- Issues and perspectives
- IV- Enhancing the knowledge, improving human and mangerial process to make effective regulations



I- Statistical data and feed back experience

- **4 million km of networks in France, including:**
  - **1/3 air (1,325,000 km)**
  - **2/3 buried or underwater (2,725,000 km)**
  - **40% sensitive for security (1,630,000 km): electricity, gas, hazardous materials, rail networks, district heating**
  - **60% for non-sensitive security (2,420,000 km): electronic communications, water, sanitation, but often sensitive to the economy and for users**

- **5 to 10 millions projects per year to justify sending for each one an administrative file (a statement) to local authority (DICT)**

- **50 000 to 100 000 damage to networks occur annually when working nearby, with only 4500 on gas distribution networks**

- **Very little damage on transport networks, but a very high hazard potential**

The main gas transportation network

1 household on 3 linlked

I- Statistical data and feed back experience

Pipeline transportation of hazardous materials (France).

Networks	Lenght	% Public	Mean age	
Gas	36500 km	100%	31 years	
Oil	9800 km	75%	45 years	
Chemical	3900 km	30%	30 years	
Total	50200 km	90%	34 years	

Pipeline of gas distribution (Natural gas and LPG – 12 millions of consumers) - France

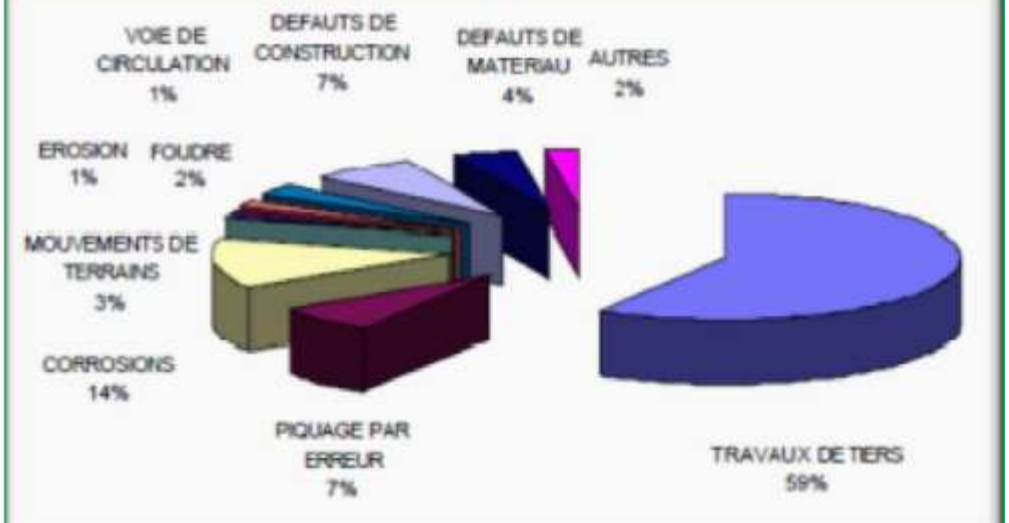
Networks	Lenght
GDF	188 000 km
Others operators	8 000 km
Total	196 000 km

Accidentology of hazardous materials and types of transportation

Type of Transportation	number of serious accidents per year (1)	Mt transported per year (2)	Ratio 1/2
Road	19	27	0,70
Rail	3,5	8,5	0,41
Sea	1,2	6,1	0,19
inland waterway	0,2	1,3	0,13
Pipeline	0,2	7,7	0,02

Source : UIC/ 2001-2004

Experience feedback



Cause of accidents-incidents (GDF, on 2006)

According to the INERIS (2002), the causes of most of the major accidents arisen in France recover essentially for:

- 70 % in the works of third party (declared or not),
- 10 % in the corrosion of pipes,
- 10 % in the movements of ground,
- 10 % of diverse origin (lightning).

So, on approximately 50 000 km of pipes in France, the INERIS (2002) estimates the mortality rate in approximately 4.10-6 a year and by km.

Experience feedback in urban area

Blénod (57) -18/12/2009-rupture of a pipeline by a quagmire of death earthmover -1 dead

July 2004- Ghislenghien (Belgium): boring a pipeline DN 900 mm consecutively to work making roads (24 dead and 160 wounded)

Experience feedback in urban area

Lyon (28-02-2008) - Gas leak, explosion and fire, **1 death and 40 wounded persons**, several damaged buildings; 180 mobilized fire agents brigades.

Noisy-le-Sec (22-12-2007) - Gas leak and explosion further to works of drilling. Building HLM (social opérator) STEPHENSON destroyed by the explosion, those near very damaged (76 impacted households. 176 mobilized fire agents brigades - (Noisy-le-Sec, Paris region, France)

Experience feedback in urban area

Bondy (30-10-2007) - Perforing of a pipe and a breach(negligence) in an obligation(bond) of caution, explosion and fire, 1 deaths, 63 wounded persons among whom 10 brulés (Paris region, France)

Works of opening of trench for the pose(installation) of the pipe Medgaz (Chentouf W Temouchent (Cosider-Sonatrach, Algeria) damaging a pipe of gas-- emergency intervention.

Agricultural works to Hassi-Bounif (W. Oran, Algeria) damaging a pipe of gas in spite of the controls and the Advice of the local authority.

(Algeria), pipeline Hassi-R'mel-Arzew Mohammadia, corrosion - flight of gas explosion-fire, 78 persons hurt,damage to property - similar to a previous accident le19 in August, 2004

Experience feedback in urban area

Post control gaz close to motorways

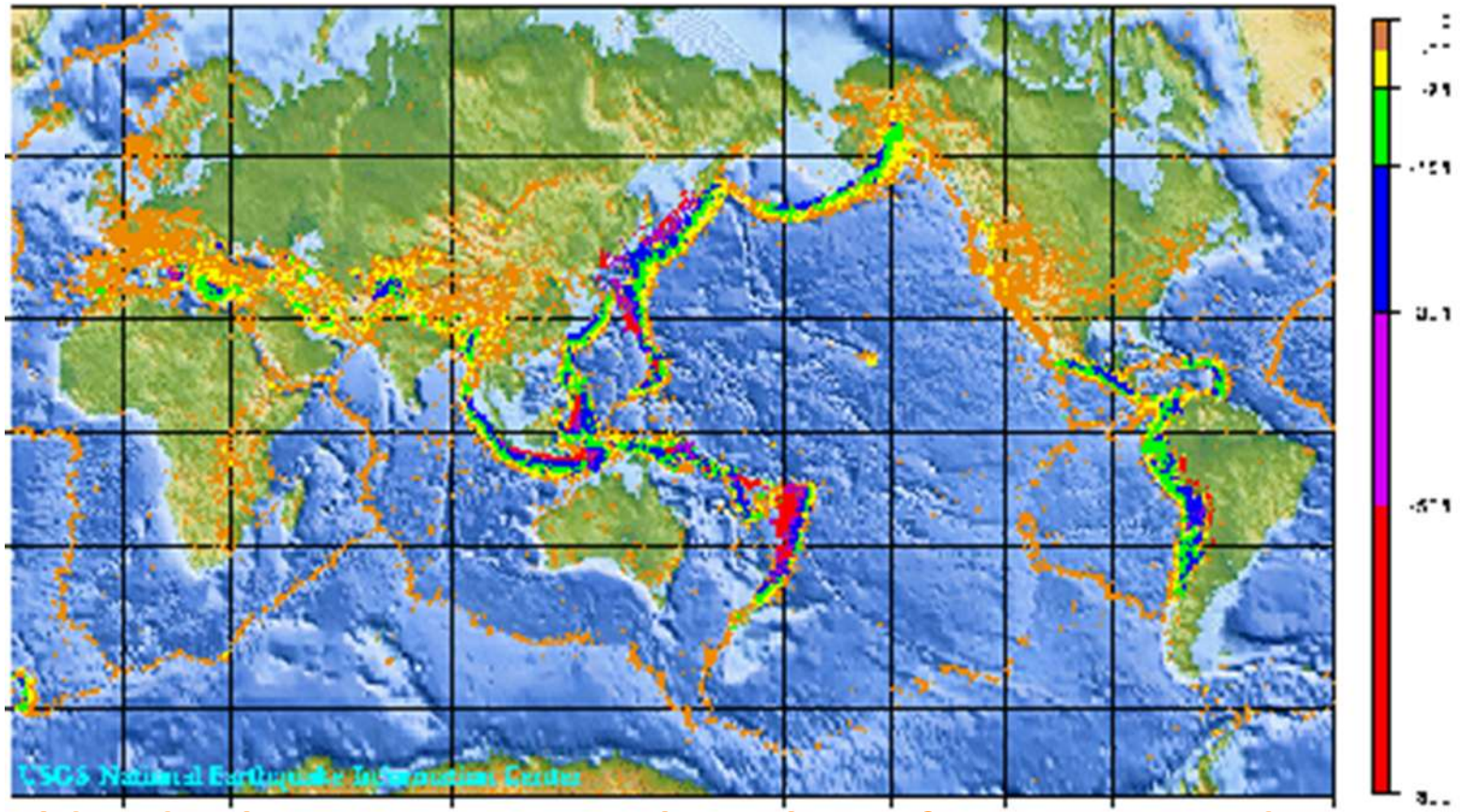
Les deux fosses à vannes du piquage DP Es-Senia et C.I COGO Es-Senia à **2 mètres** de la chaussée du 4 eme boulevard (Maitre d'ouvrage DTP Oran, Algeria)

Construction of the regional office of the employment in 10-20m of a pipe gas (GZ 014 W. Oran, Algéria) without dialogue with the operators and the authorities in charge of the

Gas network not respected: construction of house and children's games (W. Oran, Algeria

Houses near the gas network

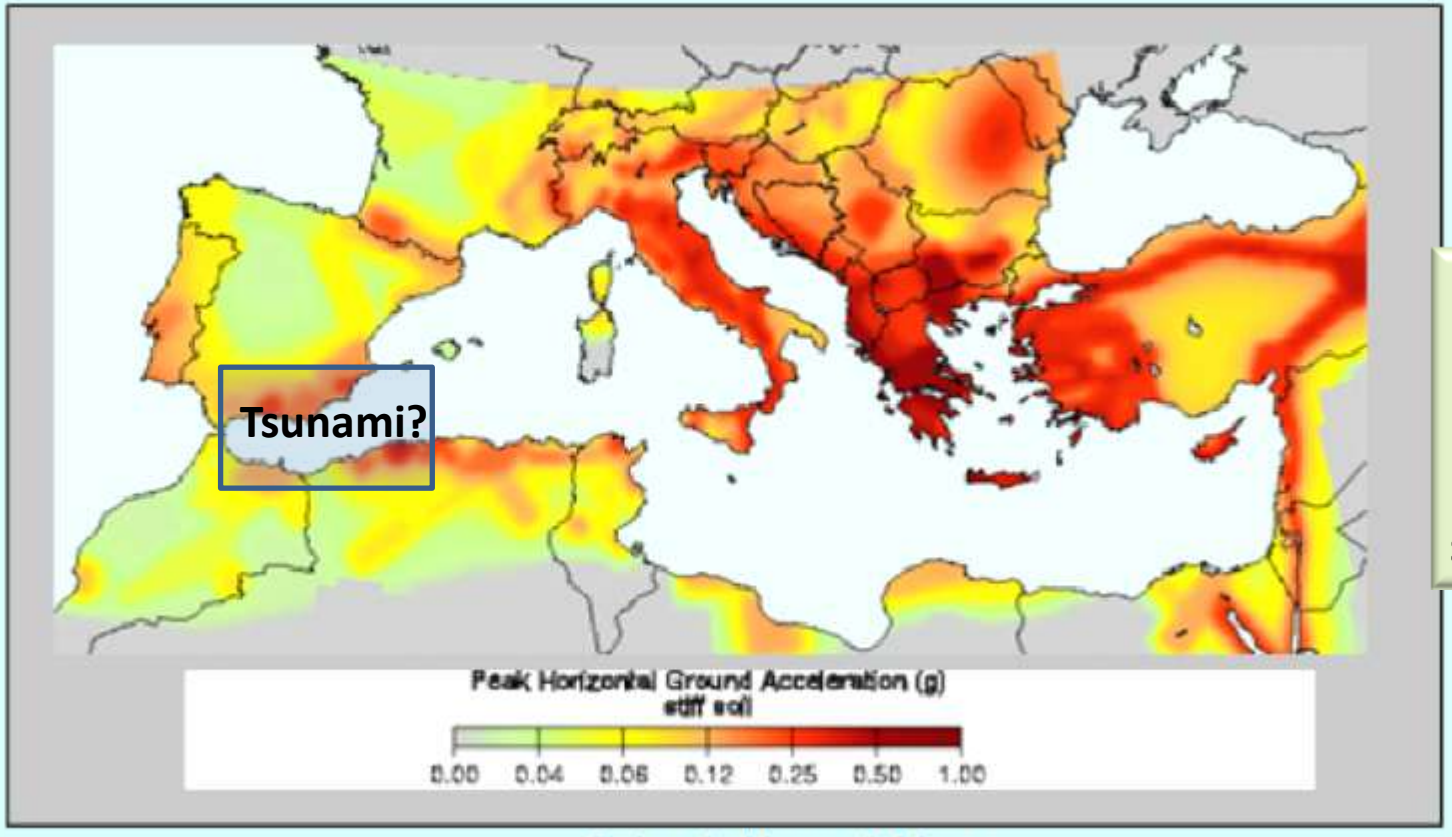
Assessing Major Risk and Preparing Earthquake and Tsunami



Worldwide there are 2-3 earthquakes of 6.5 magnitude or greater each week

Assessing Major Risk and Preparing

Potentially destructive earthquakes occur regularly in Europe
And mediterranean countries



Seismic Hazard Map

Investing urgently

Expanding seismic network

Assessing Major Risk and Preparing

Phuket, Thailand, NASA/JPL

Banda Aceh

II- Rules of safety gas transportation and distribution networks:

Dependabilty régulations and Urban planning

- **Asset and improve the construction of gas pipe and globally the underground critical facilities**
  - European Standard NF-EN 1594 "Gas supply systems. - Pipelines for maximum operating pressure over 16 bar. - Functional requirements "of May 2000 for combustible gases"
  - European Standard NF-EN 14161 entitled "Petroleum and natural gas. - Pipeline transportation systems ", June 2004;
  - Professional guides recognized

- **Both Algéria and France have generally the same technical rules and regulation references issued from european standard** *(order -arrêté 04 august 2006 "multifluide", France; decree 90-411 of December 22nd, 1990 and safety rules pipe of gas, september1991 Algeria).*

  - **Locational principle:** urban, suburban and rural zone according to criteria as : human and urban density, local urban master plan, maximum safety coefficient, distance of lethal effects.
  - **calculating tube thickness:** The minimum thickness required (to which one must add the tolerance margin construction and eventual corrosion) is, according to the *Lame equation*:
    $e = Pc.Dext/2.\tau$; τ : maximum stress function of the metal according to **the type of urban zone.**

  - **Obligation to test the pressure** under the supervision of an expert authorized by the State
  - Depth of burial of at least 1 m
  - Mandatory installation of an alarm Mesh
  - Prevention of hazards (earthquake, flood, ...)

Gas network : Rules of design and construction

- Taking into account the stresses to which the pipe will be exposed: internal pressure, load, shock, vibration
- Consideration of failure mode feared: brittle fracture, creep, plastic instability, fatigue cracking ☐
- Material Selection and calculation of the necessary thickness: definition of maximum values for the ratios maximum stress / yield stress and maximum stress / tensile strength
- Rules welding and its control: welders and welding procedures, inspection of welds
- installation precautions: quality of the coating, burial depth> 1m, warning mesh, cathodic and electrical protection...

Gas network: Rules and regulations

- Algerian rules are not strong enough compared to the french rules.
  - **criteria** like distance of lethal effects, scenario of risk, local urban master plan…are poorly integrated. The coordination between actors is not efficient
  - **Dynamic Maintenance and safety strategy and programme** are not indicated nor legally objectified. The french order of 04 august 2006 specify a dynamic approach of dependabilty which is consist to strengthen security for existing pipe (art. 19) and in case of new environmental evolution (art. 14). But in fact in Algeria, professionnal of gas take seriously into account the topic of maintenance which interest for example « aged pipe »
  - **Recommendations and obligations** for Security study and risk analysis are specified and integrated in the package of rules and regulations in France to help gas operator to meet safety standard and to be awarness to the culture of risk. *(New order -arrêté 04 august 2006 "multifluide")*
- Algerian régulations more than french are both not enough efficiency with **human factor** and the « game of actors » to link « management process and rules procedure »: local authorities, opérators, citizens…

SYNTHESIS
Experience feedback: The lessons

- A risk of accident **extremely unlikely**, but potentially **high severity**
- Relatively **old networks**. **(**36 years on average in 2012**)**
- **Uncontrolled development of urbanization** close to the underground facilities networks of gas, electricity, water, communication…) in use
- **A high potential risk** is associated with major risks : earthquakes, tsunami, flood, wind storm, snow, lightning, works of civil engineering near transportation and distribution of gas network , if the private and public actors and operators do not respect rules and regulations…
- **The weakness of the "Method ingineering"** based on classical approch exclusively "technical"…is not enough efficiency to abord the global safety chain. Lack of Human factor, lack of strategy, lack of complexitylack of systemic approach, lack of the public awarness concerning the risk.
- in practice, for sake of clarity**, the culture of the risk** is the topic and the issue among entreprises and globaly the society.We have to built new concepts of formal logic in order to improve the risk assessment and the risk management
- **Gas Pipeline**
  - **Safe mean of conveyance and transportation .**
  - **Reductor of** atmospheric concentrations of anthropogenic greenhouse gases emitted **(carbon dioxide -CO2)**

Synthesis
Objective of the rules and regulations : built human and territorial resilience

- **Land use planning**: To Secure and to optimize the land use, the location and the setting-up of underground “critical facilities” , urban, economic and environmental utilities, buildings, equipments and housing.
- **Retrofitting:** Adopt civil engineering techniques more efficient and resistant :(building, pipe, underground, road composition)…to reduce risk (by integrating the risk component)
- **Contingency planning:** based on coping capacity of actors and organization to identify, assess, forecast, mitigate and manage locational human activities and their functionalities on regards to their constraints and their advantages integrating and taking into account the disaster risk component
- **Prevent accidents** when planning and carrying out public works (civil engineering)

Synthesis
Complex system : City and its networks

the city and its complex and critical facilities networks. The daily of the operators

III- Issues and perspectives

- The potential risks of industrial and technological accidents is usually located at the interface of activities. In our case the interaction between the urban, industrial and environmental land uses raises issues of urban planning and risk management, particularly the case of critical network facilities.
  - How to well allocate and locate in the urban space the “complex uses” consisting of “critical facilities”, “publics utilities”, “housing”, activities and services, equipment, park and recreational space…taking into account the issue of risk?
  - How to ensure the dependability of gas transportation and distribution networks against unplanned urbanization defying the rules and the regulations of urban planning and its master plan locating and securing perimeters of public utility easements as gas networks?
  - How to ensure safety, quality service and continuous access to the critical facilities (water, energy, communication…) to customers and citizens?
- Improving the competitiveness and the performance of distribution and use of gas by targeting efficiency and safety in managing this energy as close as to the others urban uses. In this sense it is an absolute mission of protection and prevention through the control of urban planning and strengthening gas network security.

III- Issues and perspectives

- Both in Algeria and France this topic raise as a major public policy of prevention and protection of citizens, environment and goods. It requires the establishment of a providing system engineering to enable human resilience, to assess and manage risk,

- We try, in the light of experience feedback related to gas distribution and transportation networks easements, capitalized on Algeria and France, to develop a method engineering of risk assessment and management on regard to urban planning.

IV- Enhancing and sharing the knowledge, improving human and managerial processes to make effective regulations

- **A first step called technical regulations reform in France** *(New order- arrêté 04 august 2006 "multifluide")*

  - The principle: a maximum period of 10 years, examination of all sections of the pipe, using the tools and methods appropriate
  - techniques: periodic "re-test", internal inspection by instrumented scrapers (electromagnetic, acoustic or ultrasonic), thickness measurement by external visual examinations
  - The feedback experience: the program (content and frequency) are adapted to the experience, with systematic record of incidents
  - The repositories of good practice: a professional guide lists the methods of monitoring and proposes methods of maintenance and repair adapted to different situations
  - The time: emergency lines reported for pipe with a maturity of retesting reached

A first step called technical regulations reform in France *(New order- arrêté 04 august 2006 "multifluide")*

- **Risk assessment : deterministic approach with an upper bound scenario**

RISK = Probability x Severity : classical formula but synthetic and operationnal

Nature des effets		Seuils de dangers		
		Dangers significatifs pour la vie humaine *effets irréversibles*	**Dangers graves** pour la vie humaine *premiers effets létaux*	**Dangers très graves** pour la vie humaine *effets létaux significatifs*
Effets toxiques	Valeurs **MEDD**	SEI	SEL CL 1%	**SEL CL 5%**
	Valeurs **GESIP**	SES	**CL 1%**	-
Effets de surpression	Valeurs **MEDD**	50 hPa	140 hPa	**200 hPa**
	Valeurs **GESIP**	50 hPa	**170 hPa et 700 hPa**	-
Effets thermiques	Valeurs **MEDD**	3 kW/m² ou 600 ([kW/m²]$^{4/3}$).s	5 kW/m² ou 1000 ([kW/m²]$^{4/3}$).s	**8 kW/m² ou 1800 ([kW/m²]$^{4/3}$).s**
	Valeurs **GESIP**	9,5 kW/m² $^{(1)}$ ou 400 ([kW/m²]$^{4/3}$).s	**13 kW/m² ou 1800 ([kW/m²]$^{4/3}$).s**	-

MEDD order 29-09-2005

- SES: threshold of significant effects
- SEL : threshold of lethal effects
- SEI : threshold of irreversible effects
- CL : threshold of lethal concentration

Upper bound scenario : complete rupture of pipe

IV- Enhancing and sharing the knowledge, improving human and managerial processes to make effective regulations

Example of detour(deviation) of plan with compensatory measures and pose(installation) of paving stones of mechanical protection (France)

Plans of pipes with safety zones (distances of effect irreversible and lethal) (France)

IV- Enhancing and sharing the knowledge, improving human and managerial processes to make effective regulations

❑**The next steps: improving system engineering more global**

to establish integrative method based on actors network, systemic approach : The **Cindynics**

To deal with various possibilities interacting actors through their visions and points of view in order to co-built an efficiency risk managment based on « good governance, ethics, sharing knowledges»: New science of danger and hazardous: **the cindynics**

❑ **Integrating a complex vision of the risk**

From the simple formula : **Risk = ProbabilityX Severity** (Technial point of view)

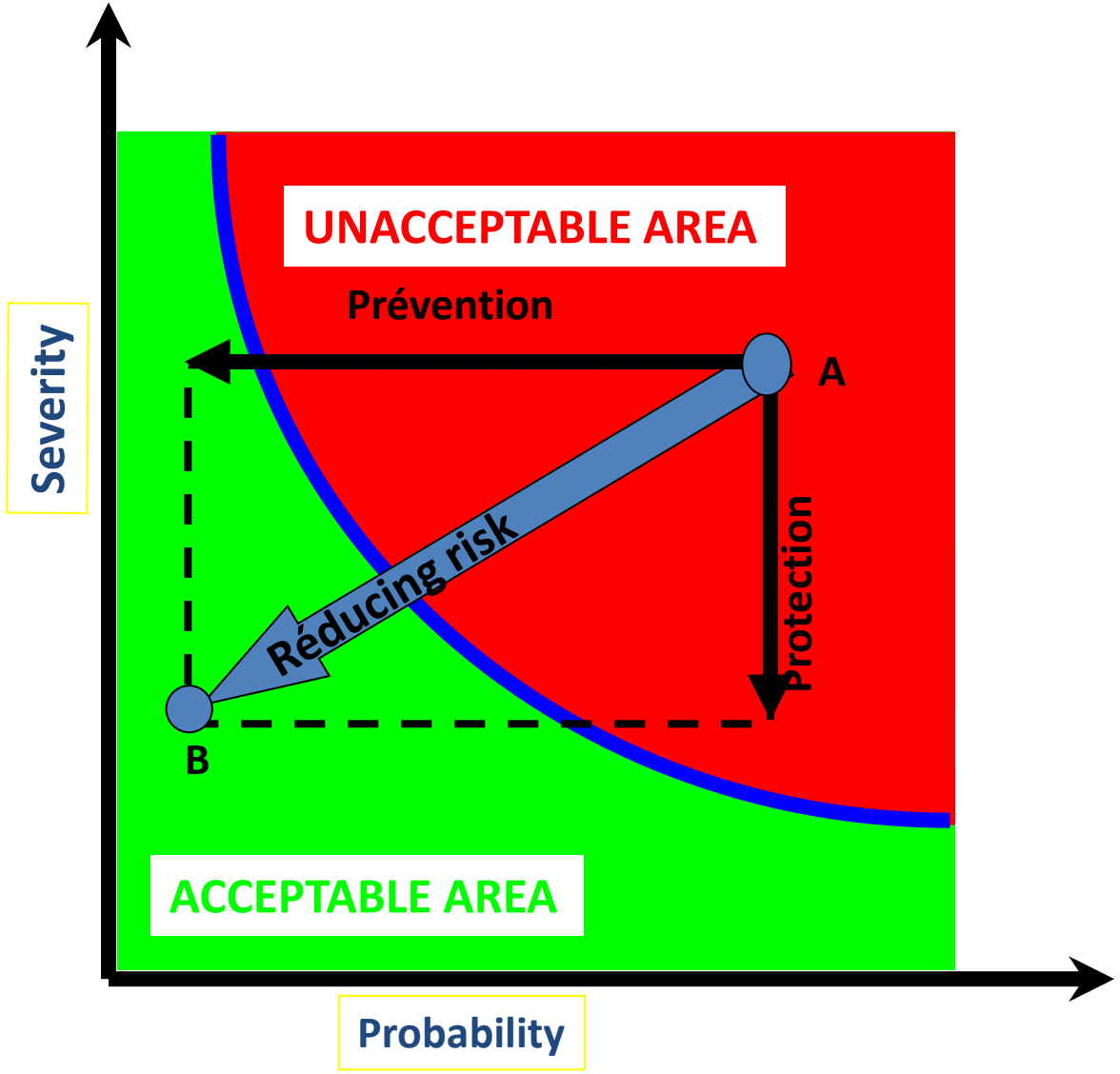
to **Risk = (S x V x D) / P**

- **S:** severity depending on the product (gas) and industrial process (condition of transport…)
- **V:** urban, human, organisational, envirnemental, technical vulnerability of the gas network
- **D:** potential of danger : a complex of natural, climatic, technological, human hazardous
- **P:** performance level of the operator to control risks, manager to enhance and improve the capacity of the installation, polittical actors to develop an integrated vision of resilience

With more and various actors, not only specialists and technical or scientifical expert

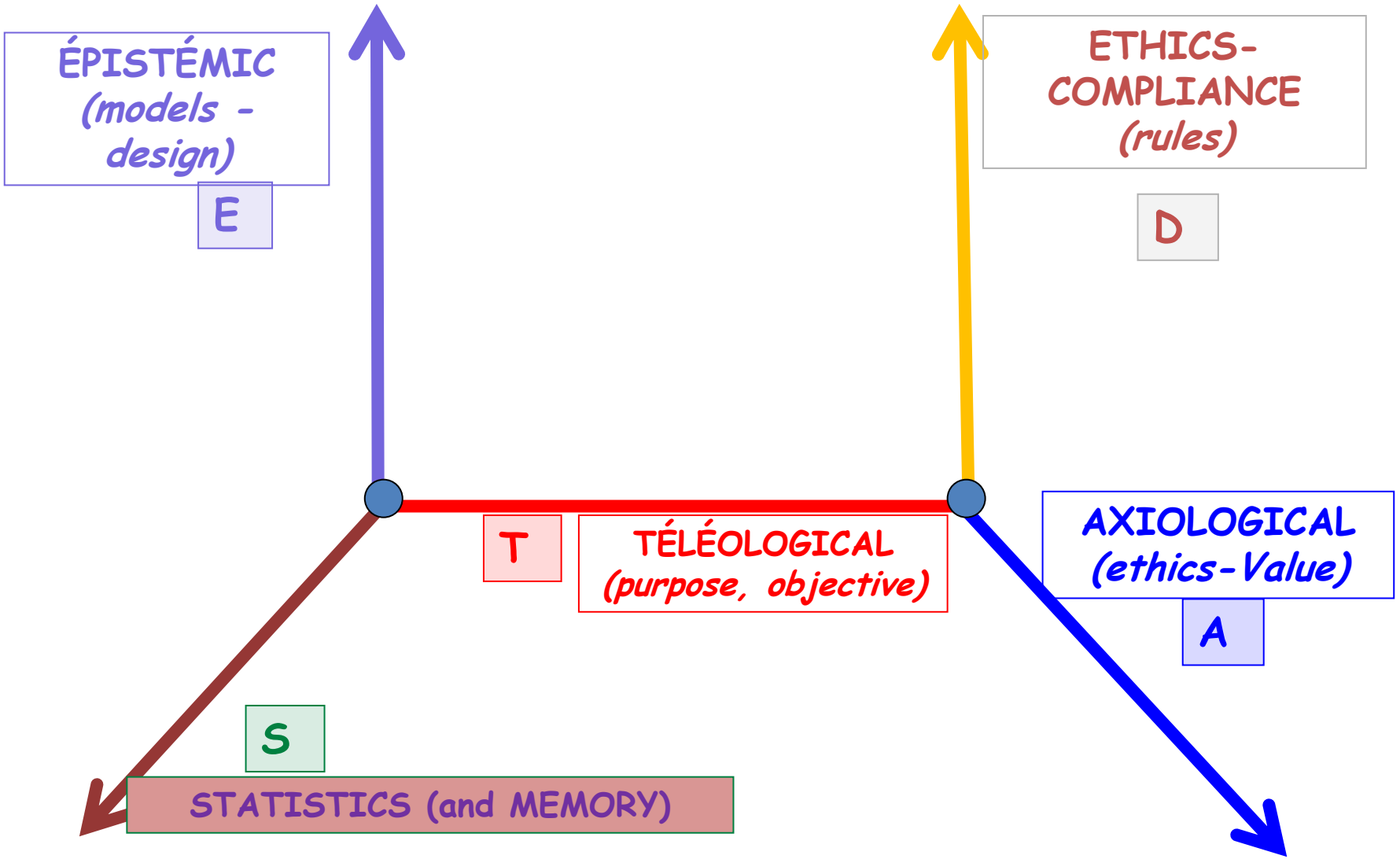
CINDYNICS

FROM SPACE OF DANGER WITH 2 COMPONENTS



CINDYNICS

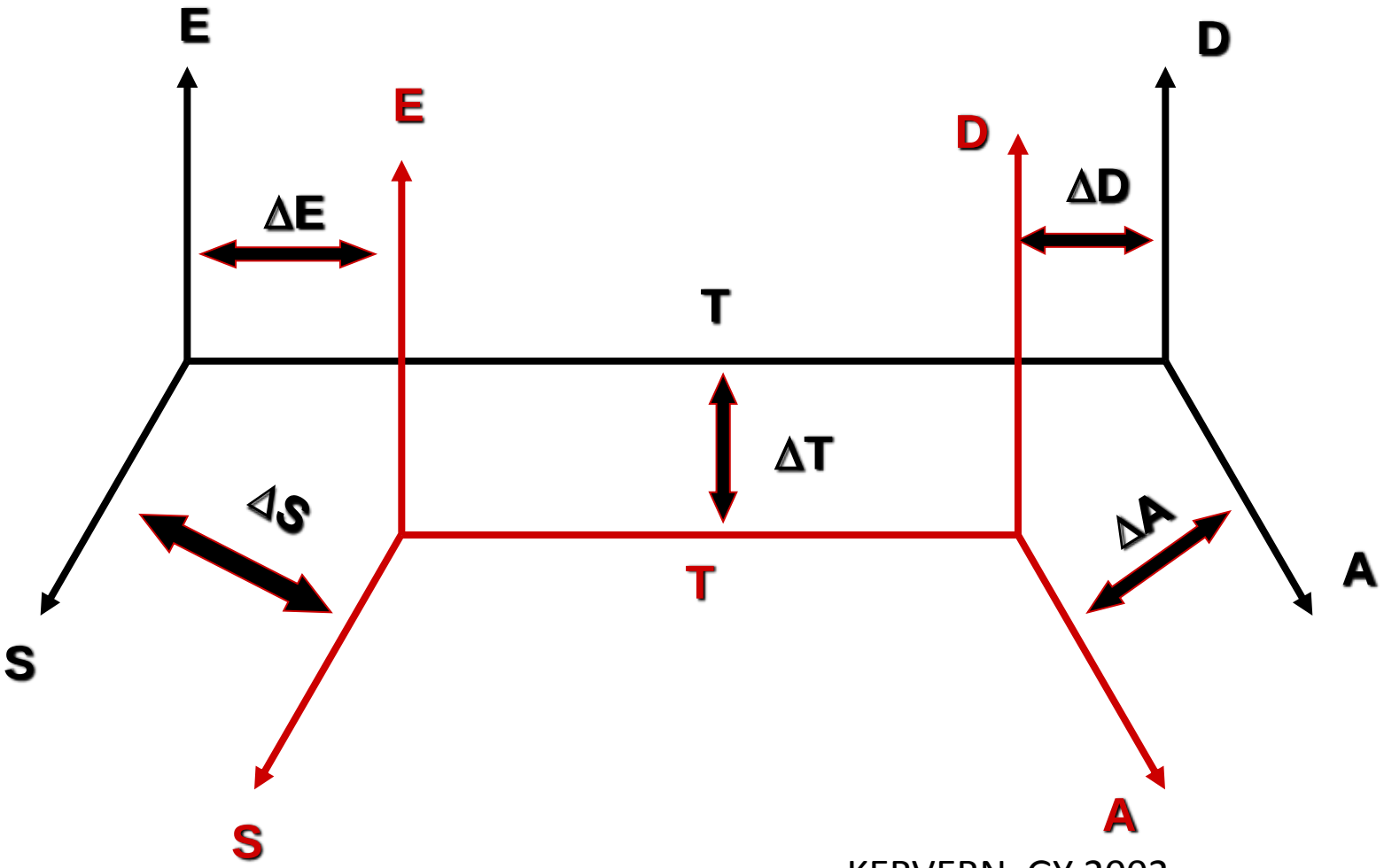
TO HYPER-SPACE OF DANGER (hazard) WITH 5 COMPONENTS



Cyndinics approach

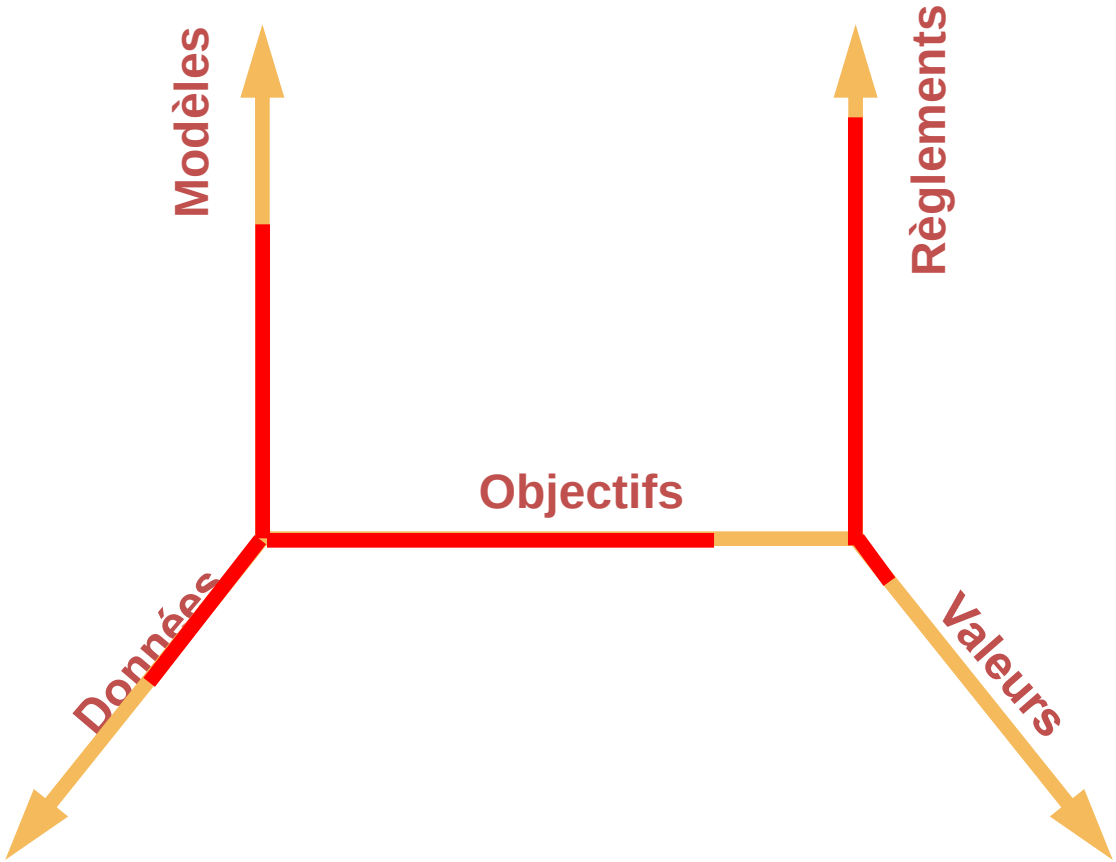
- **Confrontation** between networks of actors and hazardous situations;
- Structuring the actors **visions** (the **“way of looking”** the situation) into cyndinics hyperspace;
- Identifying **deficits** that affect cyndinics hyperspace;
- Identifying inconsistencies and dysfunctional; between actors among the organization: **dissonance**

Dissonance



KERVERN GY 2002

DEFICIT



The concept of point of view (MADS model)

Source system	Target system	Point of view
Installation (Plant, gas network transportation,distribution)	**Installation**	Dependability management
Installation	**Operator**	Ergonomy, work safety, work conditions
Opérateur	**plant**	Human reliability, malicious act (malevolence),
Installation	**Population**	Hygiene and Public health, hygiene and environmental safety, technological risk
Population	**Installation**	External malevolance
Installation	**ecosystem**	Hygiene and environmental safety, ecology, sanitary engineering, technological risk
ecosystem	**Installation**	Natural risk, climatic risk, human risk, urban planning,

System engineering, Method engineering,

Security Model through deterministic and technical approach	Systemic Model integrating actors networks and complexity
Attempt to approach the « absolute security » Deterministic approach	Risk Management Result of global regulation in a set of constant recombination
Research trend additive	Iterative and interactive approach
Normative model	The systemic model incorporates the best psycho-sociological approach to risk.
Multidisciplinary approach	transdisciplinary approach
Economic feasibility: cost acceptable or not; envelopes available	Profitability overall socio-economic Balance by actors Negotiating transfers between actors
Approach in relation to decision-makers: « blackmail for disaster » Strenght position of techno-specialists	Approach in relation to decision-makers: Control of urban vulnerability Negotiation and risk sharing contractual approachAnnuler les modifications

Meta Urban Planning : actors game in the heart of complexity

Classical approach (technical)	Systemic approach
Urban Planning	Strategic Urban Management
Stringent safety rules	Understanding process improving rules
Spatial specializations.	Management of spatial complexity
Opposition between actors	Integrating actors
General interest declared	« Co-build » the General interest
Town local government	Urban governance

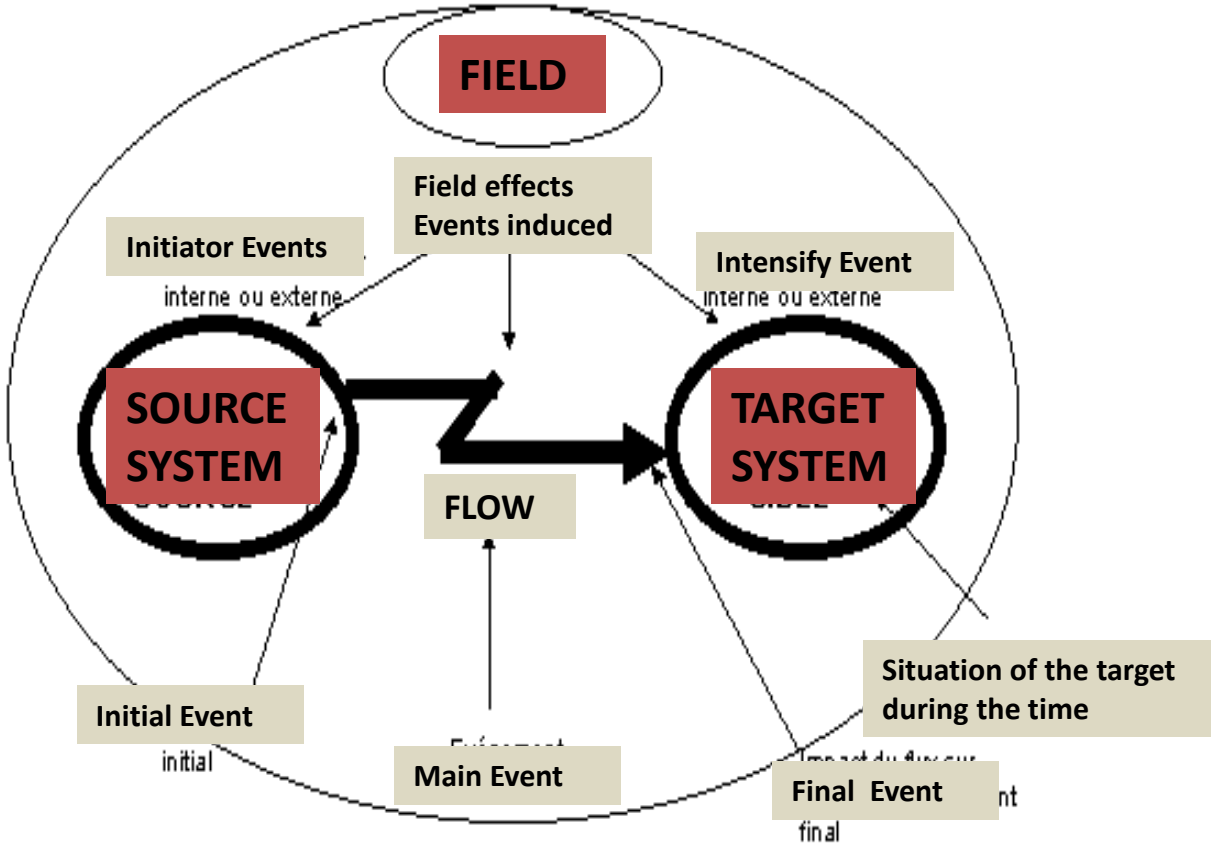
- ***Understanding and sharing - Science, Risk, Probabilities & Resilience, complexity, stratégies, actors games, ethics***
- ***Preparing - Warnings, Education, Development***

Meta-Model MADS - MOSAR,

Logical frame to define the methodological process of risk assessment

- MADS: Methodology of analysis unfonctionnalities in systems (Méthodologie d'Analyse des Dysfonctionnements dans les Systèmes)
- MOSAR: Organized systemic method of risk analysis (Méthode Organisée Systémique d'Analyse des Risques)
- Global method of knowledge and action to assess risk (Méthode générale de connaissance et d'action) :
  - Identifying an unexpected and indesirable events / ENS (Evènements Non Souhaités)
  - Analysing ENS
  - Controling ENS
  - Managing ENS

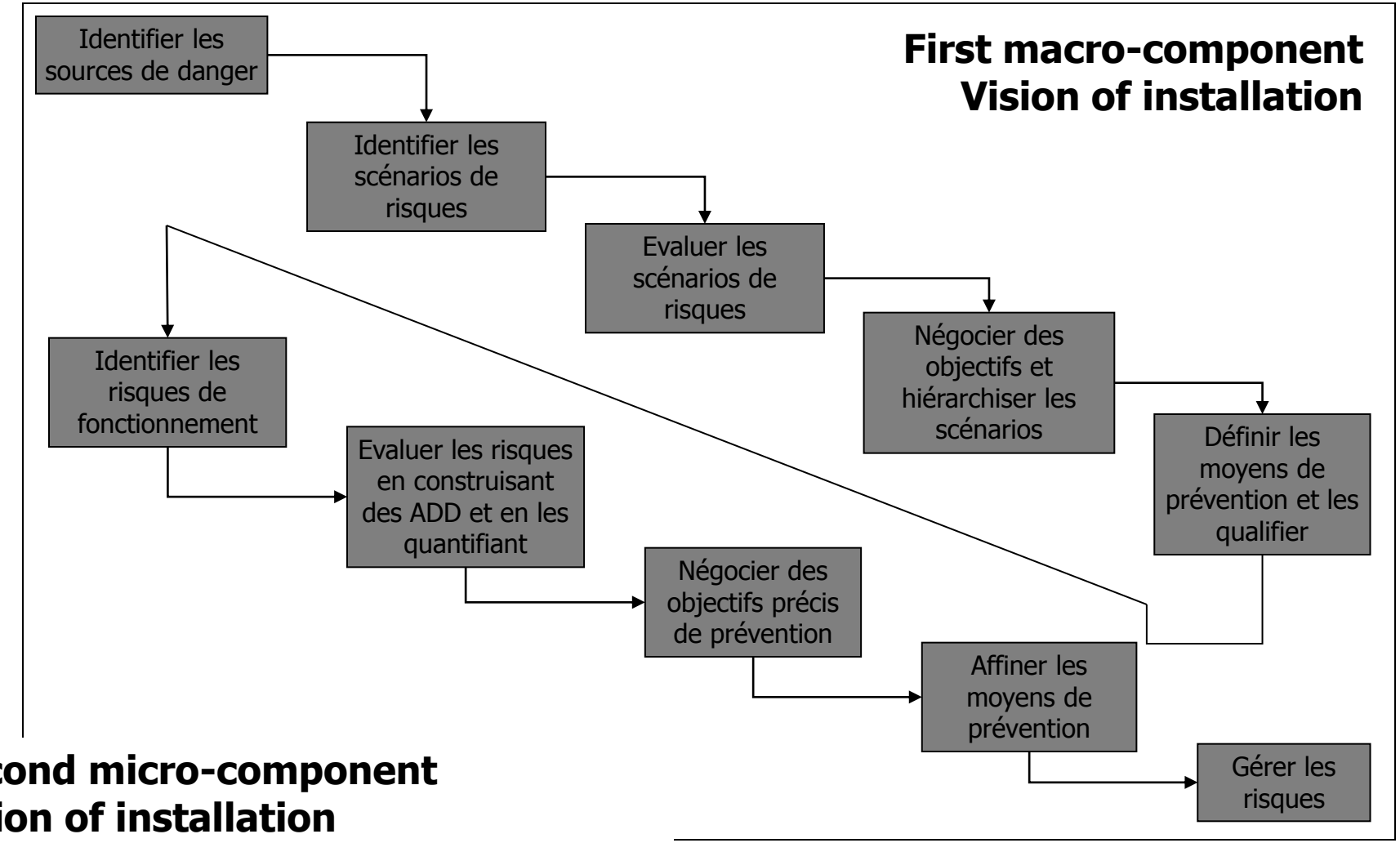
PROCESS OF DANGER
MADS-MOSAR MODEL AMONG CINDYNICS



EVENEMENT NON SOUHAITE = ENCHAINEMENT D'EVENEMENTS

MADS AS A TOPOLOGICAL MODEL

MOSAR, Principles (used to assess nuclear risk)



CONCLUSION

- Successfull development of the system and the method ingineering based on systemic approach with « cindynics, MADS-MOSAR… » may open new oppotunities to risk assessment integrating « complexity ».
- The safety Gas network transportation and distribution will not well managed if we don't take into account the global comprehension and analysis of the system of gas network with different point of view
- Education, Professionnal and conventionnal training, consulting, benchmarking are the way to lead issues and topics of method ingineering based on « complexity, systemic approach and resilience » is the real way of human development purchasing: quality, reliability, availability, continuity and security of critical facilities and public utilities as gaz .
- Gas network among the Urban space raises all these issues because ir's the projection on the land of human activities.