

Risk Management

Conflict Transformation and Peace Studies

Part 1

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Risk Analysis, Decision Science, Bayesian Networks
Artificial Intelligence, Natural Language Processing

Banking, Credit, Fraud, Anti Money Laundering, Terrorism Financing
ESG (Environmental Social and Governance)
Insurance, Supply Chain, IT, Project Management
Behavior Change, Social Care

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Ph.D student at LAMSADE

Capability approach, desision analysis, MCDA

Goals

- Introduce key concepts and issues to support decision makers in risk
- Looking at both individuals and groups as decision makers
 - Individuals. Emphasize decision analytic perspective for risk analysis
 - Groups. Collective decision making and social choice
- Emphasis on risk analysis applications

Assessment

‘Inventing’ a problem related with *Conflict transformation and peace studies*. Solving it with GeNle in four stages

- Text description of problem.
- Refined description of problem + Initial influence diagram formulation.
- Identification of relevant data sources
- Refined description and GeNle formulation + quantification.
- Final document.

Groups of 3-4 students

Class Schedule

All classes are evening classes i.e. 17:15 until 20:30.

Session Date	Topics Covered
Sep 23rd	Basic concepts and challenges in decision and risk analysis. The decision analysis cycle and its use for risk management. Structuring decision problems (Influence diagrams).
Sep 30th	Decision under risk/uncertainty. Introduction to Genie.
October 14th	Belief assessment / Coping with data. Preferences and risk attitudes. Ethical issues. Value of life. GOING FURTHER - AI in decision & risk management
November 4th	A framework for risk analysis. Multi-Criteria Decision Modelling Examples with Genie
November 18th	Project valuation. NPV. Risk and time
December 2nd	Collective decision Making and Social Choices GOING FURTHER - Thinking about adversaries. A framework for adversarial risk analysis

▶ Oct 3rd - One-page description of the decision problem

▶ Oct 17th - Refined description of problem + Initial influence diagram formulation.

▶ Nov 7th - Identification of relevant data sources

▶ Nov 21st - Refined description and GeNIe formulation + quantification.

Final report due December 12th

Resources

D. Spiegelhalter (2020) The Art of Statistics, Pelican

D. Banks, J. Ríos, D. Ríos (2015) Adversarial Risk Analysis, Taylor Francis.

Bouyssou D., Marchant Th., Pirlot M., Perny P., Tsoukiàs A., Vincke Ph., Evaluation and Decision Models: a critical perspective, Kluwer Academic, Dordrecht, 2000.

French S., Decision theory - An introduction to the mathematics of rationality, Ellis Horwood, Chichester, 1988.

Keeney R.L., Hammond J.S. and Raiffa, H., Smart Choices: A Guide to Making Better Decisions, Harvard University Press, Boston, 1999.

It's a risky life videos

<https://www.icmat.es/outreach/regular/risky-life/videos-english/>

SAPEA Strategic Crisis Management <https://sapea.info/topic/crisis-management>

[Intro to Statistical Decision Analysis \(duke.edu\)](#)

[Engineering Risk-Benefit Analysis | Engineering Systems Division | MIT OpenCourseWare](#)

Important: check for GeNIe

<https://download.bayesfusion.com/files.html?category=Academia>

Let's get to know each other

Send asap an email introducing yourselves (what did you study before, what are you doing this Master, what would you like to do in future)

Lea.deleris@bnpparibas.com

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Let's go!!!!

Check

<https://www.youtube.com/watch?v=JhYKekyC4ZQ&t=1s>

Basic concepts and challenges in decision and risk analysis.

Normative models of decision making under uncertainty

- Models for a single DM
 - Expected utility
 - Objective probability distributions
 - Subjective expected utility (SEU)
 - Subjective probability distributions
- Example: evacuation decision problem
 - One **decision** variable with two alternatives
 - What to do?
 - Evacuate the town of Nags Head
 - Do not evacuate Nags Head
 - One **uncertainty** with two possible states (simplified!!!)
 - Will hurricane Isaias pass through Nags Head
 - Yes
 - No
 - Two criteria for **consequences**
 - Comfort, No. of deaths



Subjective expected utility solution

- If DM's decision behavior consistent with some set of "rational" axioms

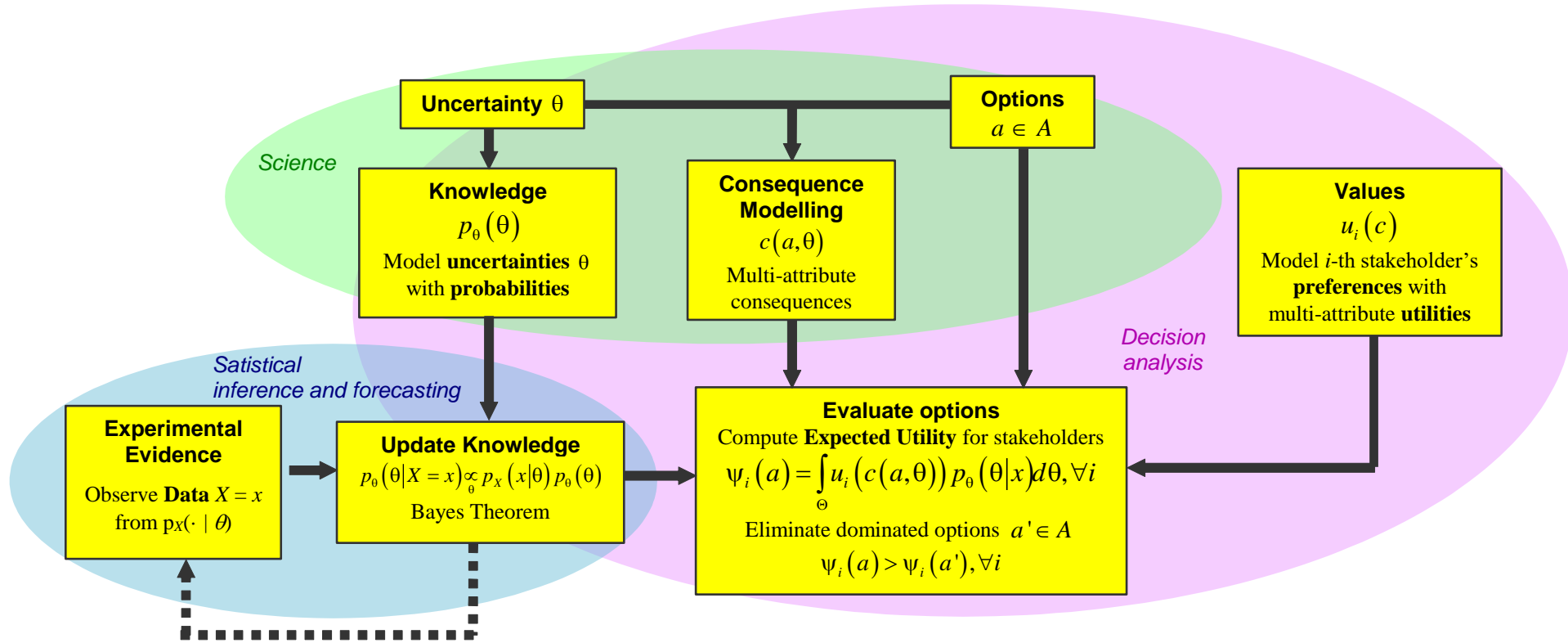
DM decides as if he has

- **probabilities** to represent his **beliefs** about the future pass of the hurricane
- "**utilities**" to represent his **preferences** and **risk attitude** towards consequences

and choose the alternative of maximum expected utility

- The subjective expected utility model balances in a "rational" manner
 - the DM's beliefs and risk attitudes
- Application requires to
 - know the DM's beliefs and "utilities"
 - Different elicitation methods
 - compute of expected utilities of each decision strategy
 - It may require approximation in non-simple problems

Ignore the 'math', focus on concepts!!



Game theory arena

- Non-cooperative games
 - More than one intelligent player
 - Interdependent consequences
- Cooperative game theory
 - Normative bargaining models
 - Joint decision making
 - Binding agreements on what to play
 - Given players preferences and solution space
Find a fair, jointly satisfying and Pareto optimal agreement/solution
 - Group decision making on a common action space (Social choice)
 - Preference aggregation
 - Voting

The ambiguous concept of risk

Risk related concepts abound in various fields :

- Statistics
- (Econ) Decision Theory
- Finance
- Insurance
- Epidemiology
- Environmental Sciences
- Political Science

The ambiguous concept of risk

There is uncertainty about the outcome and the possibility that such outcome might be undesirable

1. List of potential events
2. The probability that an adverse event occurs
3. The consequences of the adverse event

Risks

- Many types of risks: environmental, financial, political, technological,...
- Standard classifications:
 - Financial and nonfinancial risks
 - Financial: credit, operational, market,...
 - Static or dynamic risks
 - Associated with normal functioning (even if there are no changes) (loss),
Associated with changes (win or loss)
 - Fundamental and particular risks
 - Group (Earthquake) vs Individual (Burnt home)
 - Pure (loss, no loss) and speculative (win, loss) risks
 - Pure: Personal, property, liability,...

Risks: Their burden

- Some losses will actually occur: You want to avoid or reduce their impact
- The uncertainty is a burden: insure, reserve fund
- Feeling of frustration and mental unrest

- A growing number and variety of risks
 - From nature and predators, to
 - Risks associated with nuclear energy, air transportation, information technology, the legal system, terrorism, climate change,...
- With increasing severity of losses
 - Each catastrophe seems to exceed previous losses...
 - More wealth, more investment, more assets exposed to loss

Risk: challenges in a complex world

- Sao Paulo airport accident

Population has increased: facilities previously remote, now close to lots of population

- Chinese toys crisis

Use of toxic or potentially toxic materials increased

- Climate change

Public much more aware of hazards posed to humans

- Estonian hacker attack

Need to protect critical infrastructures to assure continuity of a nation.
Interconnected international infrastructures. Cold cyberwar

Risk: challenges in a complex world

- Increasing interdependencies within the world

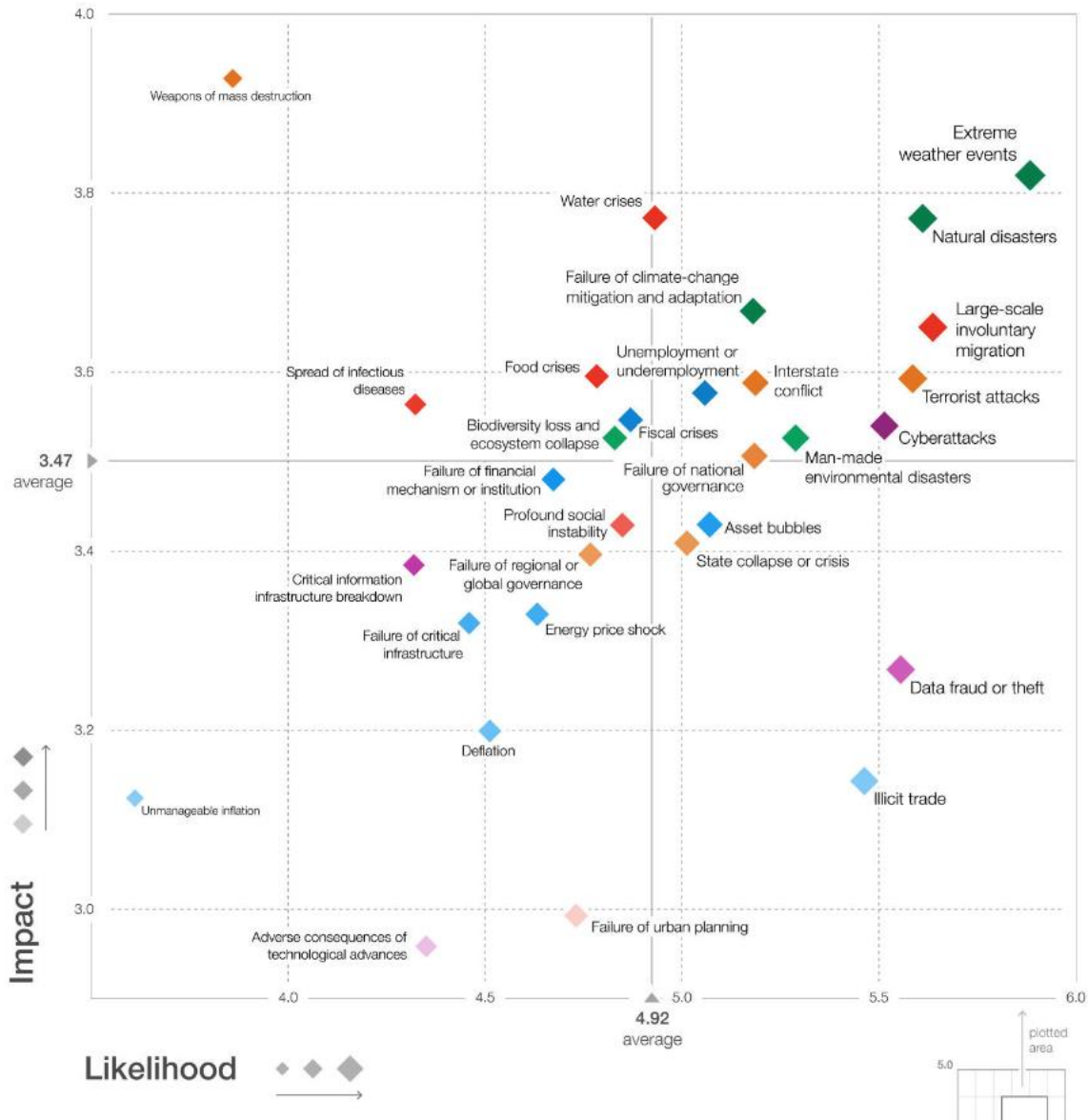
They may suffer if others do not adopt similar measures

- Katrina, Tsunami, Haiti earthquake

The 'usual' great natural disasters

- 11-September, Bataclan...

Global terrorist and delictive organisations run as corporations

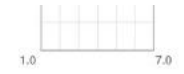


Top 10 risks in terms of **Likelihood**

- 1 Extreme weather events
- 2 Large-scale involuntary migration
- 3 Natural disasters
- 4 Terrorist attacks
- 5 Data fraud or theft
- 6 Cyberattacks
- 7 Illicit trade
- 8 Man-made environmental disasters
- 9 Interstate conflict
- 10 Failure of national governance

Top 10 risks in terms of **Impact**

- 1 Weapons of mass destruction
- 2 Extreme weather events
- 3 Water crises
- 4 Natural disasters
- 5 Failure of climate-change mitigation and adaptation
- 6 Large-scale involuntary migration
- 7 Food crises
- 8 Terrorist attacks
- 9 Interstate conflict
- 10 Unemployment or underemployment



Categories

- Economic
- Environmental
- Geopolitical
- Societal
- Technological

FIGURE C

Global risks ranked by severity over the short and long term

"Please estimate the likely impact (severity) of the following risks over a 2-year and 10-year period."

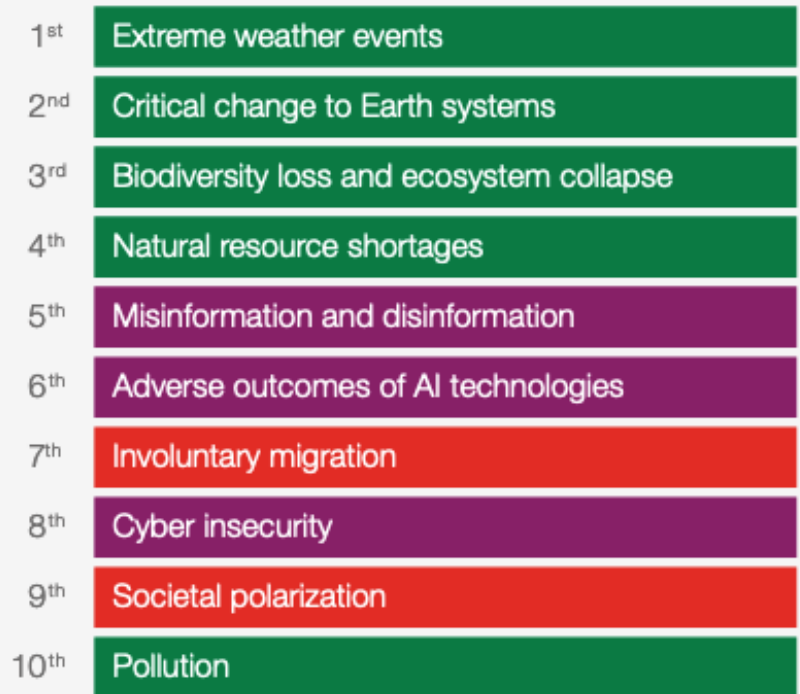
Risk categories

- Economic
- Environmental
- Geopolitical
- Societal
- Technological

2 years

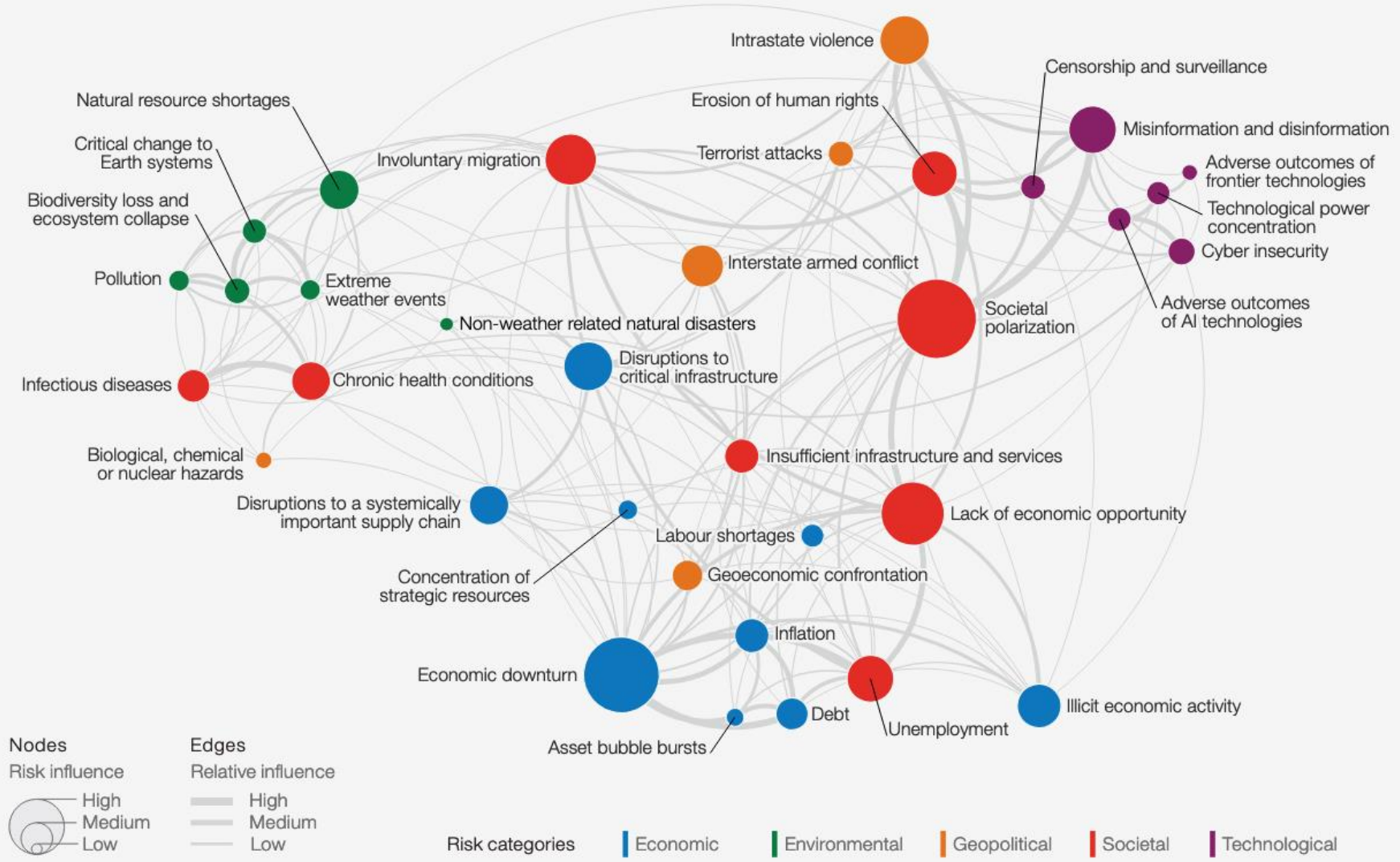


10 years



Source

World Economic Forum Global Risks Perception Survey 2023-2024.



Source
World Economic Forum Global Risks
Perception Survey 2023-2024.

Bhopal

- December 3rd 1984
- Escape of 42 ton of met-isoc
- 20 000 dead
- 600 000 affected
- Plant abandoned, U.Carbide did not respond
- 2010. 8 managers condemned to two years and 8900 euros fine!!!!



The Lubrizol Industrial Fire - Rouen, France (September 26, 2019)

A major **industrial fire** broke out at the **Lubrizol chemical plant in Rouen**. **1,000 tonnes of chemical products** were burned, releasing a **vast and toxic smoke** cloud that spread over hundreds of kilometers.

Consequences

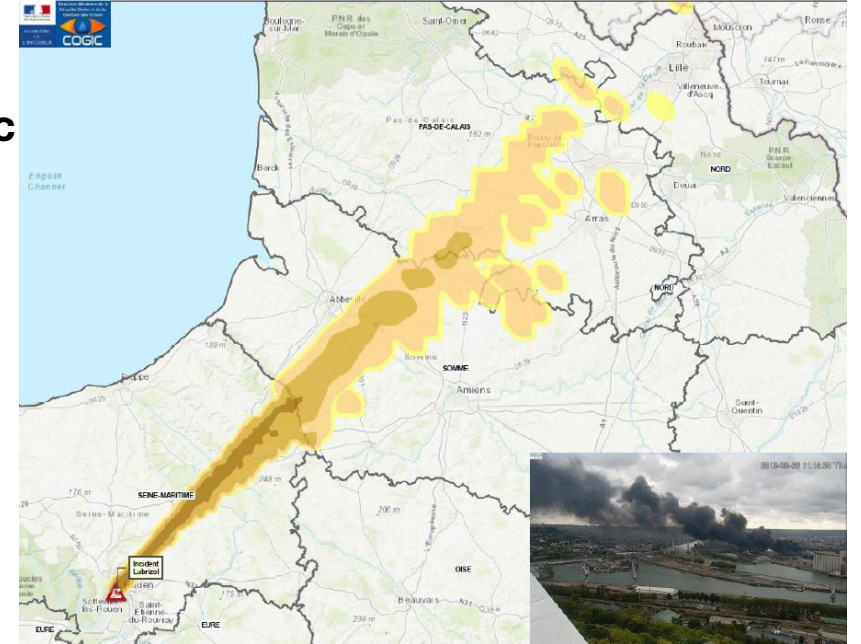
Health Issues: Thousands of residents experienced **respiratory problems** due to the smoke.

Water Access: Concerns were raised over **contaminated water supplies**.

Public Infrastructure: Public services were heavily affected, with **schools temporarily closed** for safety reasons.

Economic Consequences:

- Agriculture and tourism were hit hard by the fallout.
- Farmers reported damage to crops and livestock due to exposure to pollutants.



PLANS DE PREVENTION DES RISQUES TECHNOLOGIQUES (PPRT)

Lubrizol is a SEVESO site (EU directive identifying industrial sites that present major accident hazards).

For SEVESO sites, the **Technological Risk Prevention Plan (PPRT)** must be implemented to manage and mitigate potential hazards.

How does it work ?

<https://www.lamsade.dauphine.fr/~nfayard/PPRT.drawio.png>

Risk analysis

Systematic analytical process for assessing, managing and communicating the risk performed to understand the nature of unwanted, negative consequences to human life, health, property or the environment (so as to reduce and eliminate it)

- 1. Risk assessment.** Information on the extent and characteristics of the risk attributed to a hazard.
- 2. Risk management.** The activities undertaken to control the hazard
- 3. Risk communication.** Exchange of info and opinion concerning risk and risk-related factors among risk assessors, risk managers and other interested parties.

Risk analysis: What for??

Risk management for an existing or proposed facility

- Development of regulations
- Demonstration of compliance with regulations
- Demonstration of need for further improvement
- Litigation
- Scientific enquiry

Risk analysis: A brief history

- Predated by insurance
- The impact of decision sciences
- Systems safety (military, aerospace engineering, nuclear industry)
- Management: Having identified and evaluated the risks to which it is exposed, can plan to avoid the occurrence of certain losses and minimize the impact of others. The cost of risk can be managed and held to the lowest possible levels.
- The presence of intelligent adversaries: risk analysis+game theory
- AI predating (almost) everything

The risk management process

1. Determination of objectives
2. Identification of risks
3. Assessment of risks
4. Considering alternatives and selecting the risk treatment device
5. Implementing the decision
6. Evaluation and review

The decision analysis cycle and its use for risk management.

Decision analysis

Decision analysis involves a multi-stakeholder decision process, where at least two parties (the client and the analyst) collaborate to help the client, it must be:

- Meaningfulness for the analyst in terms of how information is manipulated.
- Usefulness of the recommendations produced for the client.
- Legitimacy of these recommendations in relation to the decision process for which the advice is sought.

Decision analysis

- Identify alternatives,
- Specify the objectives and measures to indicate the degree to which they are achieved
- Assess the likely implications of each of the alternatives in terms of the objectives
- Developing the value structure to evaluate implications
- Integrating the info to suggest desirable alternatives
- Perform sensitivity analysis
- Possibly iterate, until implementation
- Monitor once implemented

Here are some proposals sent last year
(with some elaboration to raise key features)

You need to prepare something similar like this to work on it during this course

Sketch

Welcoming refugees from Syria while ISIS was fighting

The world refugees' crisis impacted our leaders

Uncertainties

- Number of people coming (call effect)
- Structure of people coming (terrorist risk, public order issues,...)

Alternatives

- Close borders Resources made available
- Open borders (how many, under what conditions,...) Integration processes

Impacts

Violation of human rights and international law

Media impact

Public opinion

Health impact

New labor force, demographics

Terrorism risk

Public order

Political stability

Prestige as nation

Sketch

Security and safety risk management for a humanitarian organization

Security and safety for on-site team of a humanitarian organization

Uncertainties

Natural disaster, serious illness, accident, attack, burnout

Alternatives

Awareness and capacity building, security collaboration and networks, insurance, health insurance, security staff, human resources management,....

Impacts

physical (injury, death), mental (psychological trauma, mental illnesses), costs, effectiveness of team,...

Examples from previous years

- Welcoming refugees from Syria during ISIS times
- Security and safety risk management for a humanitarian organization
- The conflict in Yemen
- Terrorist risk management in Northern Mozambique
- Conflict over water and land in Northern Mali between Dogon and Fulani farmers
- Deployment of a water sanitation project in a developing country village
- Bringing back expatriates in the beginning of pandemic
- Sales of arms to Saudi Arabia
- Abandoning an area by an NGO due to local hostilities
- Flood Management in Bangladesh
- Exploring radical decisions to prevent violent acts targeting local officials in Mexico
- Accepting Kosovo in the European Union
- Resource Allocation in a Shared Water Basin
- Disembarkation of the Ocean Viking in November 2022
- Protecting the art collection from the National Museum of Damascus

For October 3rd

Identify a risk management problema.

Think about the context, the decision makers, the alternatives, the uncertainties, the impacts.

Send Lea an email with (at most) one page description (by Thursday October 3rd 23:55). Include names of team members in copy of the email !!!

If in doubt, send Lea an email.

Structuring decision problems (Influence diagrams)

Three problem structuring tools

- Decision Tables
- Decision Trees
- Influence Diagrams

- Nags Head decision problem
 - One **decision** variable with two alternatives
 - To evacuate or not?
 - One **uncertainty** with two possible states
 - Isaias will touch Nags Head or not
 - One evaluation criteria for **consequences**
 - Costs from decision

Decision Table

	Touch	Not touch
Evacuate	5M	5M
Not evacuate	25M	0M

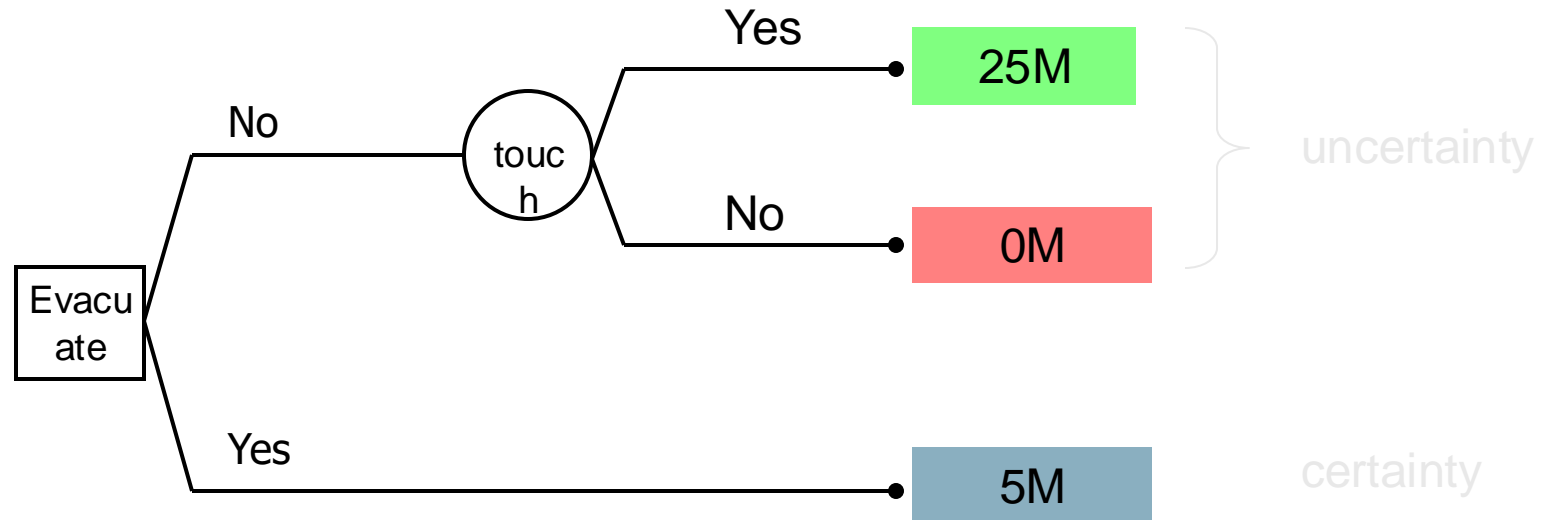
- DM chooses a row without knowing which column will occur
- Choice depends on the relative likelihood of Touch or not touch?
 - If DM is sure that Isaias will touch, best choice is to evacuate
 - If DM is sure that Isaias will not touch, best choice is to not evacuate

Elicit the DM's beliefs about which column will occur

- Choice depends on the value of money
 - Expected return not a good measure of decision preferences

Elicit risk attitude of the DM

Decision tree representation



- What does the choice depends upon?
 - relative likelihood of Yes vs No
 - strength of preferences for money

Influence Diagrams

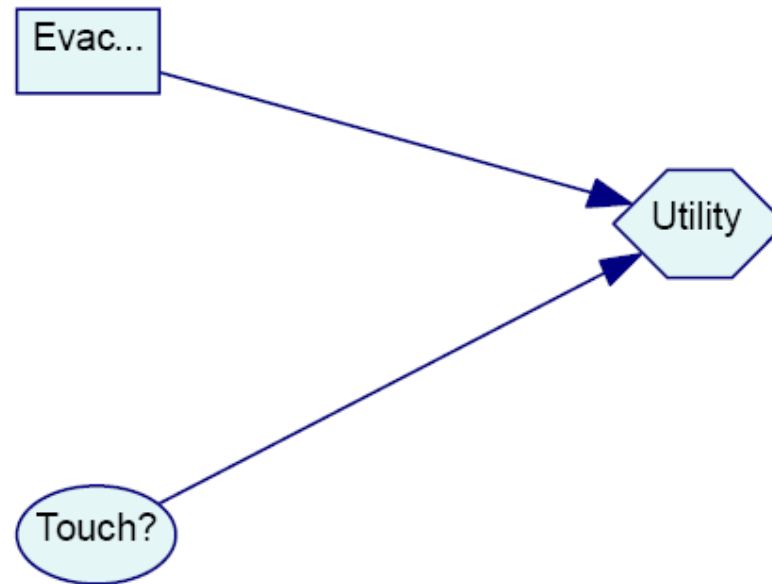
- Tool to structure (and solve) decision making problems
- Graph with nodes and arcs. No cycles
- Three main types of nodes.
 - Chance. Circle
 - Decision. Square
 - Value. Hexagon, Diamond
- Two types of arcs
 - Arcs into decision nodes
 - Arcs into chance and value nodes

Influence Diagrams. Interpretation?



Suppose you're Nags Head mayor. There is a hurricane threat.
Would you issue an evacuation order?

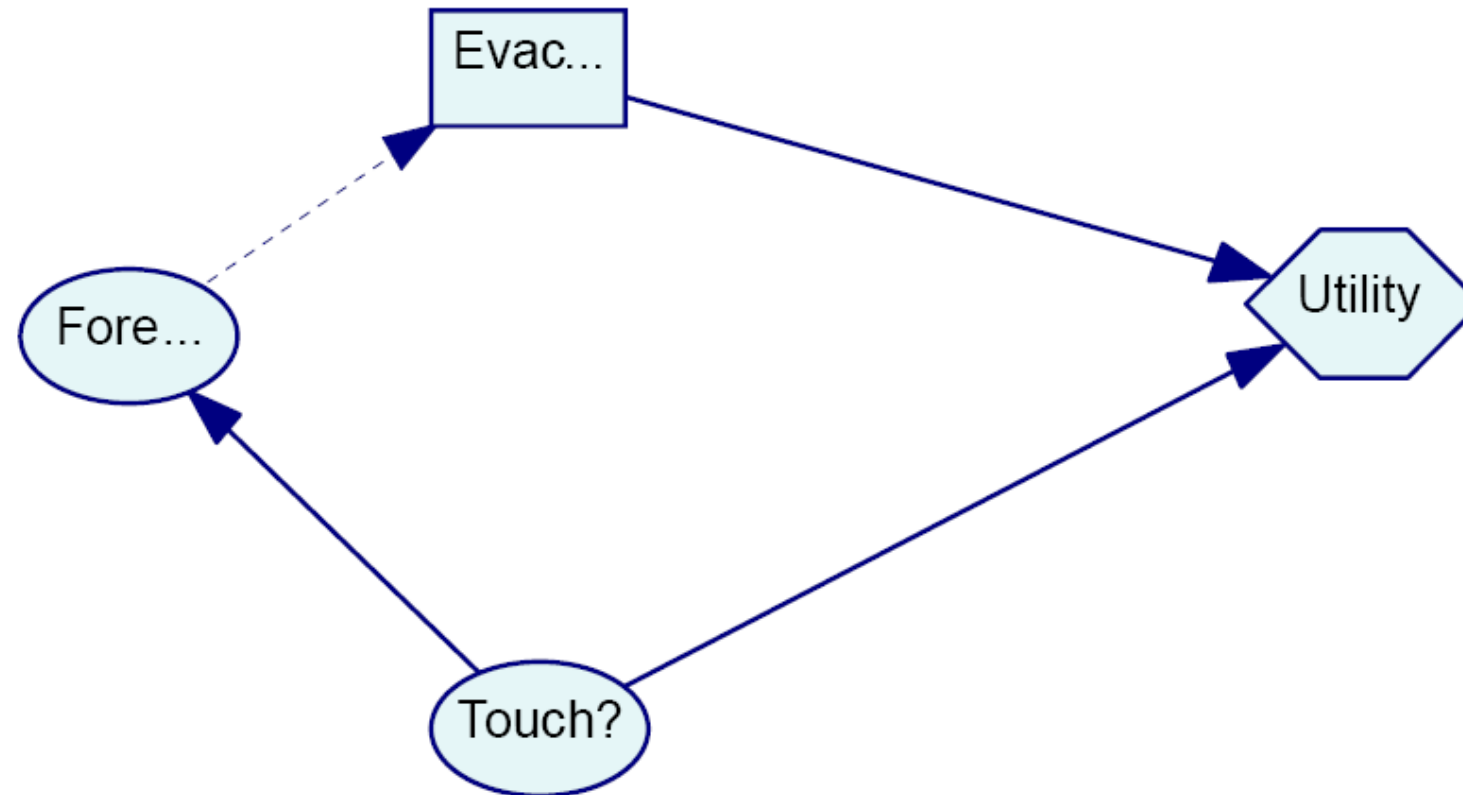
Decision under risk



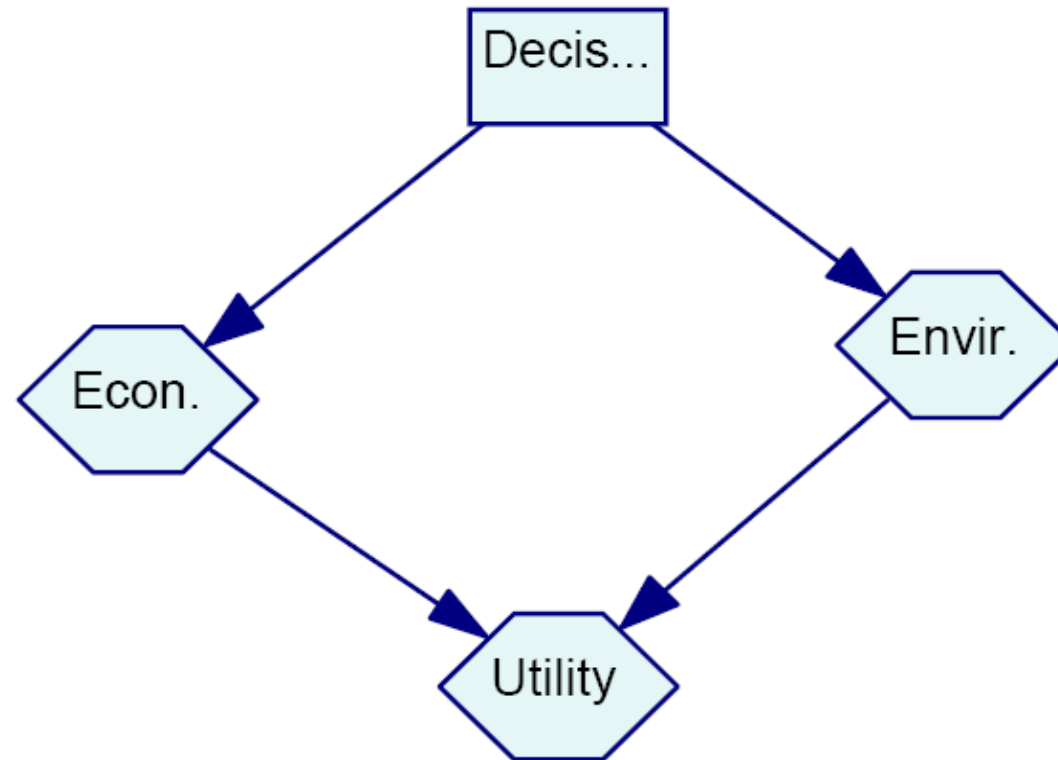
Suppose you're Nags Head mayor. There is a hurricane threat.
Would you issue an evacuation order?

Use the forecast. But the forecast is not perfect...

Decision under risk with imperfect information



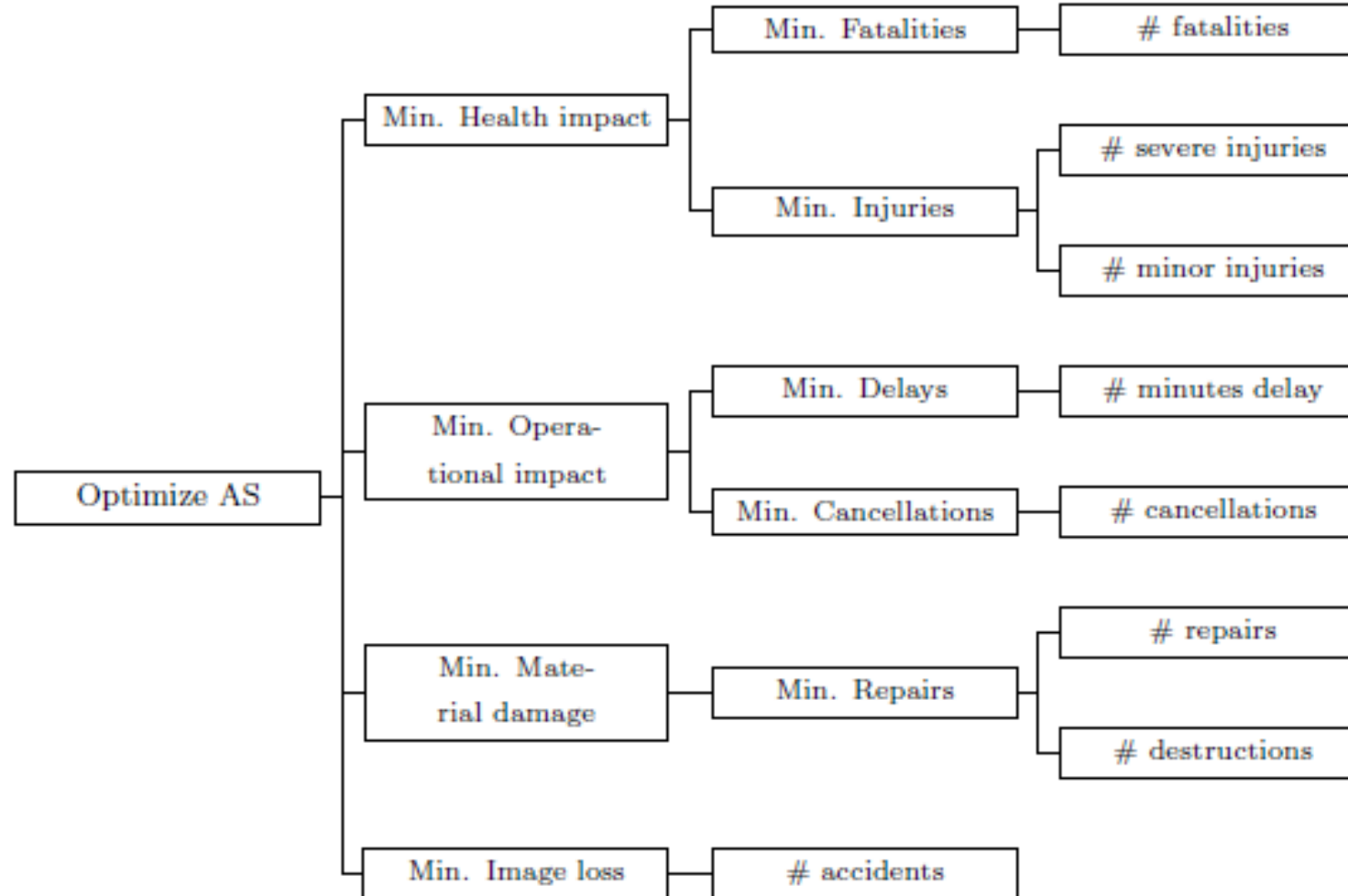
Influence diagrams: Multiple objectives



Multiple objectives

- Hierarchy
- From top level generic objective
- To more precise subobjectives
- Until low subobjectives determined.
 - Relevant
 - Non redundant
 - Measurable
- Natural, Constructed, Proxy

Multiple objectives in aviation safety. AESA



Multiple objectives in cybersecurity



Handling uncertainty

We shall deal with issues in relation with modelling uncertainty. We focus on topics relevant for Risk Analysis

A light intro is in

Uncertainty

<https://www.youtube.com/watch?v=x81lfoN1Ryc&t=1s>

Probability concepts

<https://www.youtube.com/watch?v=vAFelYbhZjY&t=1s>

Bayes formula

<https://www.youtube.com/watch?v=z0FNY35BW7c&t=1s>

Uncertainty

Uncertainty is the lack of knowledge of what is or will happen. It is almost ubiquitous in our lives. Consider these statements:

- Smoking will cause me a cancer
- Madrid will organise the Olympic Games in 2044
- Mexico became independent in 1826
- I am taller than 1m85

Probabilistic diagrams

- As basic tools for qualitative modelling of uncertainty use probabilistic influence diagrams a.k.a. causal networks, Bayesian networks, Belief networks,.... See the excellent

http://en.wikipedia.org/wiki/Bayesian_network

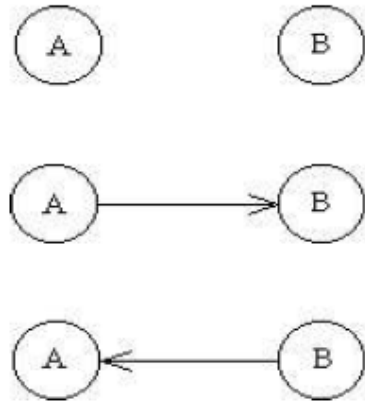
They are **influence diagrams** with chance nodes only. Qualitatively they describe a probabilistic model through

$$P(A_1, A_2, \dots, A_n) = P(A_1 \mid \text{ant}(A_1)) \dots P(A_n \mid \text{ant}(A_n))$$

where $\text{ant}(A_i)$ are the antecessors of node A_i .

In what follows we see several probabilistic diagrams and we need to indicate the entailed probabilistic model

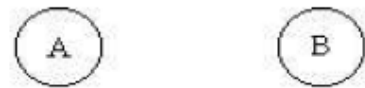
Probabilistic diagrams with two nodes



Before moving forward, write the entailed probabilistic model

Probabilistic diagrams with two nodes

Model for $P(A,B)$



$$P(A)P(B)$$



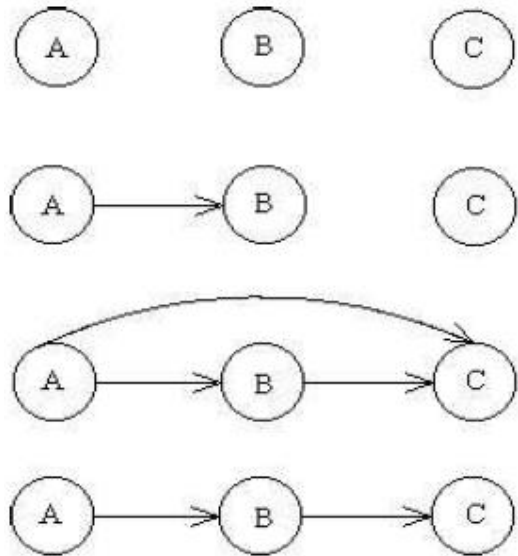
$$P(A) P(B|A)$$



$$P(B) P(A|B)$$

First case, A and B are independent. We move from second to third, and viceversa, via Bayes formula

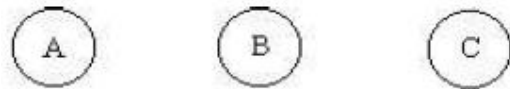
Probabilistic diagrams with three nodes



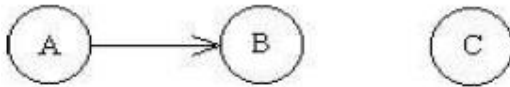
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Probabilistic diagrams with three nodes

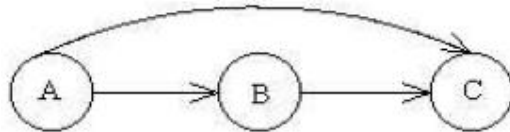
Model $P(A, B, C)$



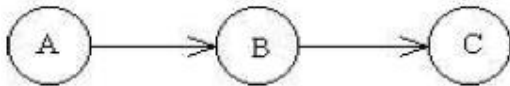
$P(A)P(B)P(C)$



$P(A) P(B|A) P(C)$



$P(A)P(B|A)P(C|A,B)$



$P(A)P(B|A)P(C|B)$

First case, independence. Fourth case, A and C are conditionally independent given B.

Read http://en.wikipedia.org/wiki/Conditional_independence

Probabilistic diagrams.

An example referring to lung diseases:

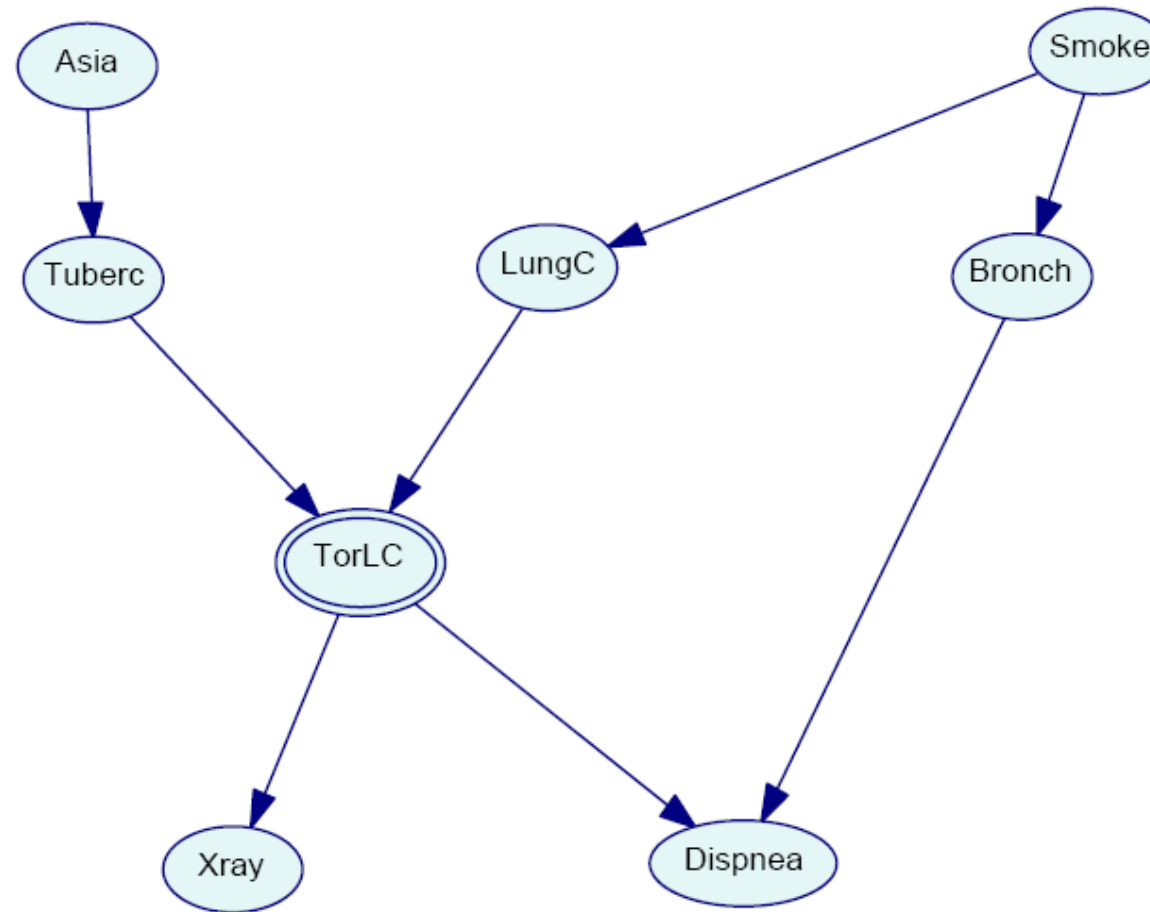
Une difficulté respiratoire (dyspnée) peut être due à la tuberculose, au cancer du poumon ou à la bronchite, ou bien à aucune de ces maladies, ou plusieurs d'entre elles à la fois. Une visite récente en Asie augmente les chances de tuberculose, tandis que le tabagisme est un facteur de risque pour le cancer du poumon et la bronchite. Les résultats d'une radiographie peuvent ne pas faire la distinction entre le cancer et la tuberculose, de même que la présence ou l'absence de dyspnée.

Probabilistic diagrams

An example referring to lung diseases:

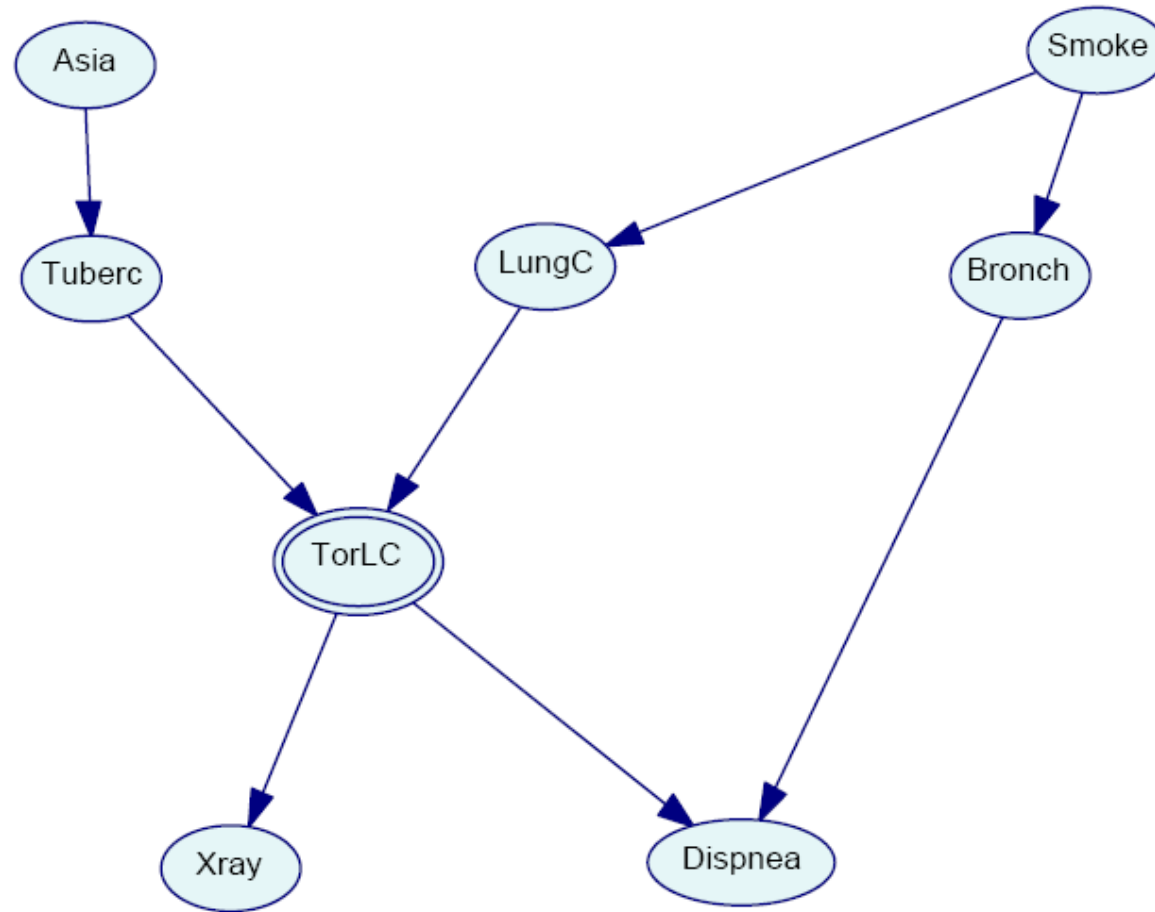
Une difficulté respiratoire (dyspnée) **peut être** due à la tuberculose, au cancer du poumon ou à la bronchite, ou bien à aucune de ces maladies, ou plusieurs d'entre elles à la fois. Une visite récente en Asie **augmente les chances** de tuberculose, tandis que le tabagisme est un **facteur de risque** pour le cancer du poumon et la bronchite. Les résultats d'une radiographie **ne peuvent pas** faire la distinction entre le cancer et la tuberculose, de même que la présence ou l'absence de dyspnée.

Probabilistic diagrams



Provide the model

Probabilistic diagrams



$$P(A,T,S,L,B,O,X,D) = P(A)P(T|A)P(S)P(L|S)P(B|S)P(O|T,L)P(X|O)P(D|O,B)$$

Model for oil prices

