Welcome to Risk Management - Starting elements -

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2025

ISIC-GSCP
Group of Chemical and Physical Safety

Charles Clyde Ebbets, September 29th 1932. Lunch atop the construction of Rockefeller Center

Foreword: Course examination

1 small project … deadline: June 7th, 2025: 23h59

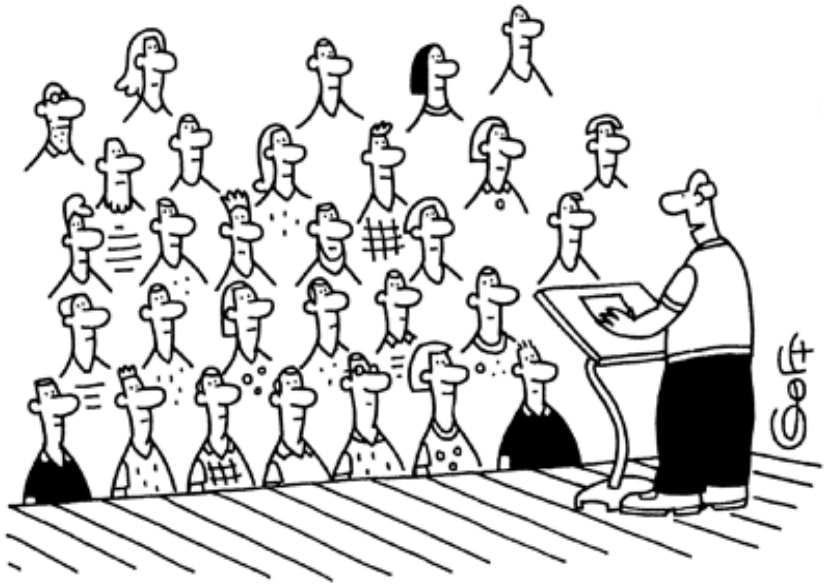
- Practical application (topic of your choice)
- Include an image or picture that illustrates the scenario (e.g., work, laboratory, home, recreation, transportation, public space, etc.).
- Target length: 5-6 pages
- Submit your project as a PDF file (including a high-resolution image) on Moodle. Name the document with your first and last name.
- The best project will be featured in the "Risk Management – Practical Application" continuing education course in October 2025.

Foreword: The project

The project – what is expected?

Refer to the document accessible on Moodle

- Include your name in the report.
- Develop a concise report, like an executive summary, focusing on key information.
- Clearly define the objectives, emphasizing content that includes images.
- Describe the hazardous situation to provide context.
- Conduct a thorough risk analysis to effectively quantify and evaluate risks.
- Suggest risk mitigation measures and discuss their potential impacts.
- Present a detailed action plan for the proposed mitigation measures.
- Add an economic analysis of these measures with accompanying discussion.
- Offer personal recommendations, reflecting on the analysis and proposed measures.
- Conclude the report thoughtfully.



"If you skipped the last safety meeting, please raise your hand, assuming you still have one."

Source: *http://www.newslettercartoons.com/catalog/browseall/1.html*

Objectives

- Risk Management Awareness
- Am I a risk or a hazard?
- Primary Approaches to Risk Analysis
- Following the course, you won't be considered risk managers!

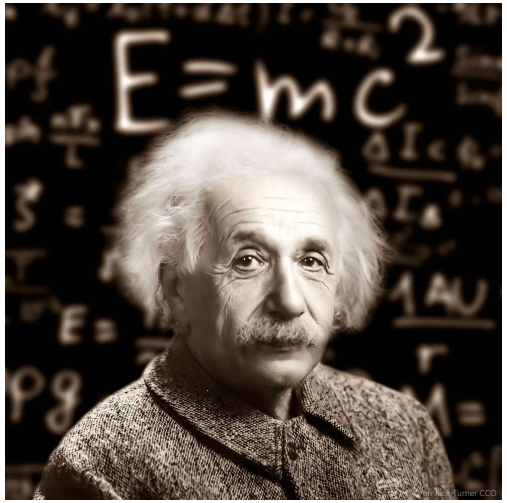
Preamble

- The future is uncertain and cannot be predicted.
- But we are all interested in the future and the consequences that our decisions will induce.
- Managing risk = managing uncertainties ?
- What does it mean to « take the risk » ?

If I had 60 minutes to solve a problem and my life depended on it, I would spend:

- 45 minutes to understand and analyze it
- 10 minutes to critically examine it
- the last 5 minutes to solve it

A. Einstein



Source: https://www.futura-sciences.com/sciences/personnalites/physique-albert-einstein-205/

Bibliography : Some supporting literature

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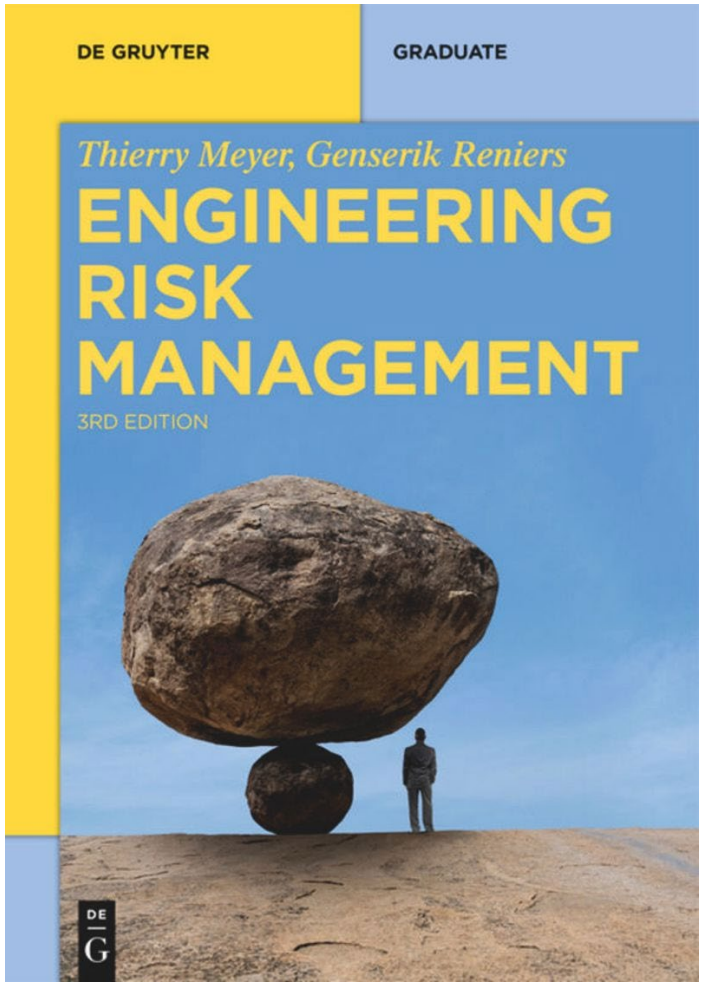
Reference



Pdf or book available at http://library.epfl.ch/en/nebis/?isbn=9783110418040

Some web sites

- https://www.suva.ch/fr-ch (Suisse: SuvaPro - Prévention des maladies et des accidents professionnels)
- http://www.cdc.gov/niosh/ (USA: The National Institute for Occupational Safety and Health)
- http://www.osha.gov/ (USA: United States Department of Labor, Occupational Safety & Health Administration)
- http://www.baua.de/ (Deutschland: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin)
- http://www.hse.gov.uk (England: Health and Safety Executive)
- http://www.iosh.co.uk (England: Institution of Occupational Safety and Health)
- http://www.inrs.fr (France: Institut National de Recherche et de Sécurité pour la prévention des accidents)
- http://www.fao.org (ONU: The Food and Agriculture Organization of the United Nations)
- http://www.who.int/occupational_health/en/ (ONU: World Health Organization)
- http://www.ekas.admin.ch (Suisse: Commission fédérale de coordination pour la sécurité au travail, CFST)
- http://www.toxinfo.ch (Suisse: Centre Suisse d'information toxicologique)
- http://www.dgah.de/ (Deutschland: Deutsche Gesellschaft für Arbeitshygiene)
- http://www.travail-et-securite.fr/ (France: INRS Travail et sécurité)
- http://www.bfu.ch (Suisse: Bureau de Prévention des Accidents)

Module 1.0

Introduction to Risk Management

Motivation Are there serious accidents happening in research and teaching institutions?

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- 2007, Taipei City (Taiwan): Blindness after a chemical experiment at University of technology.
- 2008, Delft (Netherlands): Fire due to a short circuit at the Technical University causing considerable financial losses.
- 2009, UCLA, Los Angeles (USA): Explosion (followed by a fire) in the University's chemistry building. As consequence, one dead person.
- 2010, Texas Tech University (USA). A student received severe burns and lacerations to his face and hands when a mixture of nickel hydrazine perchlorate exploded in a chemistry department laboratory.
- 2011, Yale, New Haven (USA): A student killed in a chemistry lab by being pulled into a piece of machine-shop equipment.
- 2012, Princeton, New Jersey (USA): Three people sent to hospital, 300 evacuated due to a wrong mix of nitric acid and solvents.
- 2012, Shanghai, (China): Graduate student at university opens gas cylinder and dies from inhaling of the gas
- 2013, Colorado Springs, Colorado (USA): A chemical incident in a student lab at Colorado College sent 13 people to the hospital. The group was exposed to titanium tetrachloride.
- 2013, Middleburg, Eastern Cape, South Africa (RSA): Six people died in an explosion at the Rolfe Pharmaceutical Laboratory.
- 2014, Minneapolis, Minnesota (USA): An explosion in a chemistry lab at the University of Minnesota injured a graduate student. The student was making trimethylsilyl azide.
- 2014, San Antonio, TX (USA): A lab technician at Southwest Research Institute (SwRI) was killed after a fatal accident in one of their labs (he was struck by an object from a machine he was operating).
- 2015, Tsinghua University in Beijing (China): A researcher died after a hydrogen storage cylinder unexpectedly exploded.
- 2016, Hawaii university (USA): Postdoctoral researcher lost her arm and sustained burns to her face and temporary loss of hearing due to hydrogen/oxygen explosion.
- 2017, Bristol (UK), A student at the University of Bristol unintentionally made an explosive, prompting a building evacuation
- 2017, Harare (Zimbabwe), A student at the University of Zimbabwe died from severe burns he suffered when performing an experiment.
- 2018, Nashville, Tennessee (USA), 17 people were injured when a classroom science experiment caused a flash fire.
- 2018, Beijing, (China): A chemical explosion on campus at Beijing Jiaotong University killed three students (working on a wastewater treatment experiment in a science laboratory full of flammable materials, which exploded upon contact with air).
- 2019, UCLA, Los Angeles (USA): One person was injured in an explosion involving acetone and occurring in a lab fume hood.
- 2019, Haifa, (Israel): Professor Emeritus at Technion – Israel Institute of Technology died in an explosion involving hydrogen research at his lab at the Department for Materials Science and Engineering.
- 2020, Schenectady, New York (USA): A tank used to treat avocados exploded at a lab at Innovative Test Solutions. Kapp, a former mayor, later died from his injuries.
- 2021, Gubbio, Perugia (Italy): An explosion at a Green Genetics cannabis lab killed a 52-year-old worker.
- 2021, Beijing (China): A graduate student was killed in a laboratory blast at the Institute of Chemistry of the Chinese Academy of Sciences.
- 2022, Multan (Pakistan): A lab technician died as a result of a chemical explosion at the Government Shahbaz Sharif Hospital.
- 2023, Visakhapatnam (India): A pipeline carrying ethanol exploded at GMFC Labs due to a generation of static energy, one dead, three injured.
- 2024, Chennai (India): A student has been killed in an explosion while carrying out an experiment with some chemicals.

Do we know all of them ?

In university near us? : Chemical accident

Thierry Meyer

March 26th , 2006: l'Ecole nationale supérieure de chimie, Mulhouse, France (ethylene)

- **1 death**
- **1 serious injury**
- **20 injuries**
- **250 people** followed by psychologist
- Materials damage 25 M€
- Reconstruction; 43 M€

Source: www.aria.developpement-durable.gouv.fr

Introduction: Major accidents and legislation

Major accidents

1947 Texas City (USA), Ammonium nitrate explosion (581 deaths, 8'500 injuries)

1966 Feyzin (France) Propane explosion (18 deaths, 81 injuries)

1974 Flixborough (England), Cyclohexane explosion (28 deaths, 400 injuries)

1975 Beek (Netherlands), vapour cloud explosion (14 deaths, 107 injuries)

1976 Seveso (Italy), Dioxine (200'000 long term affected)

1978 Los Alfaques (Spain), Propylene explosion (217 deaths, 300 injuries)

1984 Bhopal (India), Methyl isocyanate explosion (16'000 deaths, 200'000 injuries)

1984 Romeoville (USA) Amine explosion (17 deaths, 45 injuries)

1986 Chernobyl (URSS), Nuclear PP explosion (2 Mio affected)

1986 Schweizerhalle (Switzerland), chemical factory fire (no injuries)

1988 Piper Alpha, Oil explosion (167 deaths, 60 injuries)

1989 Pasadena (USA), ethylene explosion (23 deaths, 314 injuries)

2000 Enschede (Netherlands) Fireworks explosion (22 deaths, 947 injuries)

2001 Toulouse (France), Ammonium nitrate explosion, (31 deaths, 2500 injuries)

2003 New Dehli (India), Nitrophosphate explosion (5 deaths, 60 injuries)

2004 Springfield (USA), Vinyl chloride fire (5 deaths, 82 injuries)

2005 Buncefields (UK) Oil explosion (40 injuries)

2005 Jilin (China), Chemical explosion, benzene (5 deaths, 60 injuries)

2008 Kunming (China) H_2S leakage (6 deaths, 28 injuries)

2011 Chengdu (China), Powder explosion (3 deaths, 15 injuries)

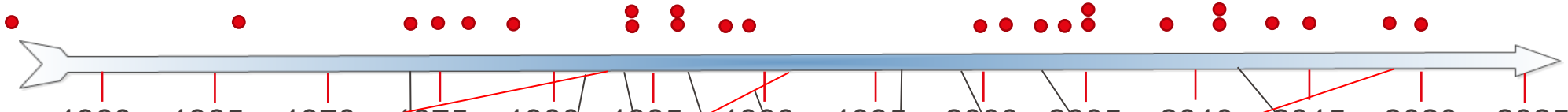
2011 Fukushima (Japan), Nuclear meltdown (no casualties)

2013 West, Texas (USA), Fertilizer explosion, ammoniumnitrate (15 deaths, 200 injuries)

2015 Tianjin (China), Storage explosion, (173 deaths, > 300 injuries)

2019 Yancheng (China), Chemical explosion, (78 deaths, 617injuries)

2020 Visakhapatnam (India), Tox gaz release, (12 deaths, 1000 injuries)



Legislation

1983
Federal Act on the Protection of the Environment (last revision 2018)

1974
Health and Safety at Work etc Act

1984
Control of Industrial Major Accident Hazards Regulations (CIMAH)

1996
Seveso II Directive 96/82/EC

2012
Seveso III

1991
Swiss Ordinance on Protection against Major Accidents

1986-1987
Seveso I amendments 87/216/EEC and 88/610/EEC

1999
Control of Major Accident Hazards Regulations (COMAH)

2019 last revision
Swiss Ordinance on Protection against Major Accidents

1982
Seveso I Directive 82/501/EEC

1989
safety and health of workers at work directive 89/391/EEC

2003
Seveso II amendments 2003/105/EC

Introduction: Realities

Source: en.wikipedia.org, December 11, 2005 explosion at the Buncefield Oil Storage Depot, GB

- Recent accidents
  - Have changed public perception and the political landscape.
  - Will result in new regulations.
- Regulatory change
  - A catastrophe serves as a catalyst for enduring changes in behaviors, standards, and performance expectations.
- Why all these new regulations ?
  - Apparently, the industry is too slow to act, either on its own or through organizations such as Responsible Care.
  - It seems that the industry by itself is insufficient to diminish the frequency of adverse events generated by industrial processes each day.

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Introduction: Risk management = old stuff ?

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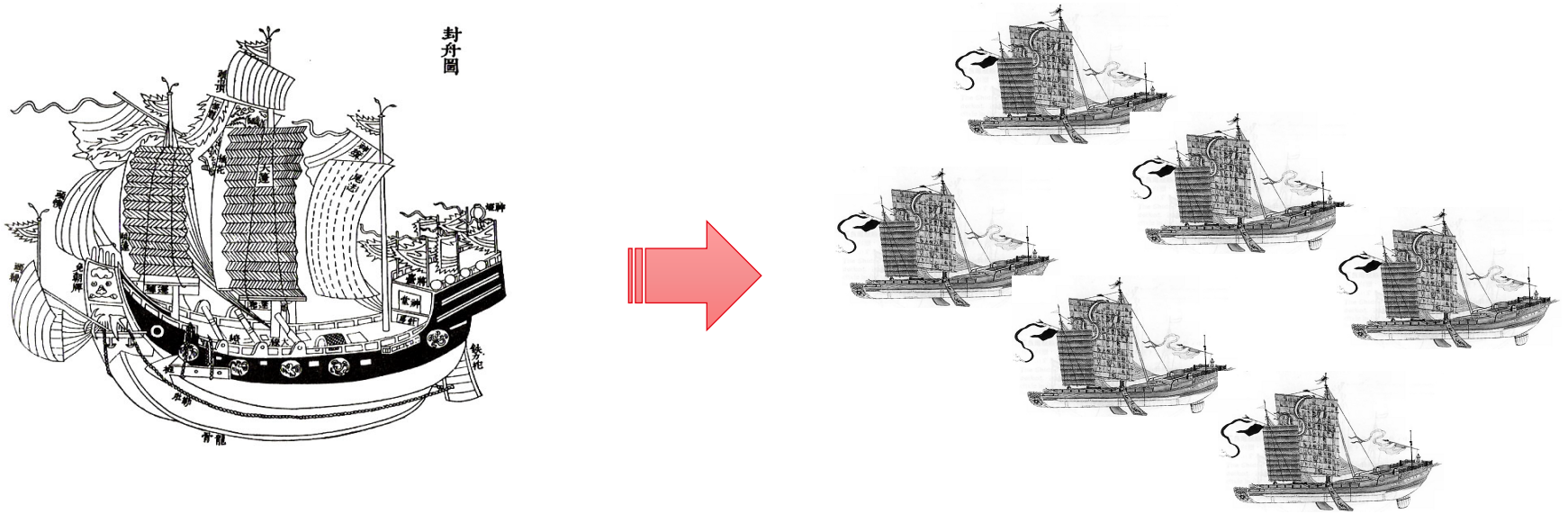
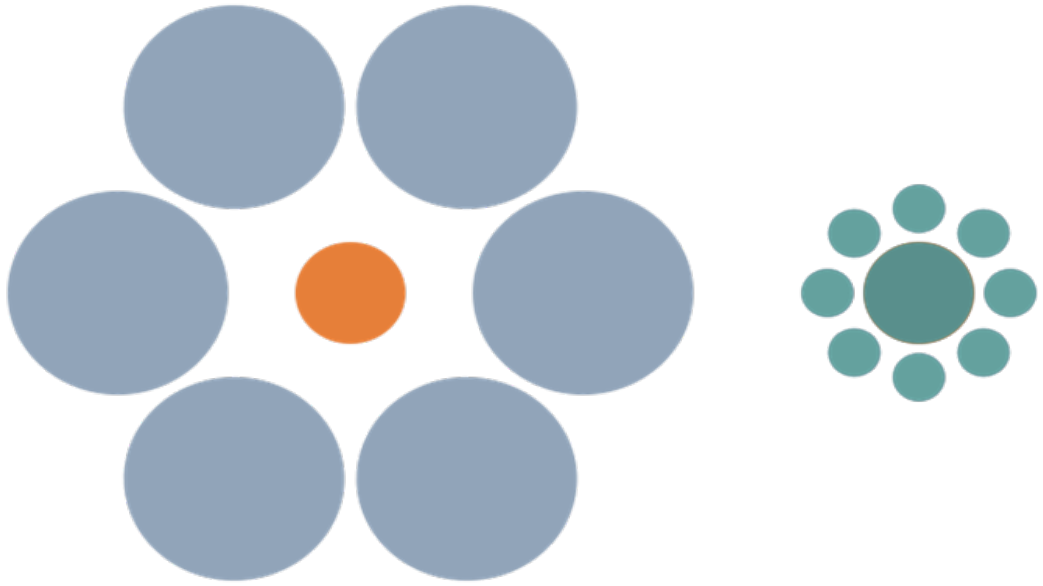
- In 2500 BC, the Chinese diversified the risk of loss by distributing one-sixth of their harvest across each of six boats.



- Nowadays, do we not say: "Never put all your eggs in one basket“ ?

A priori: Take the time to think !

Which orange circle is the largest ?



Ebbinghaus illusion

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Risk: Some myths or a priori

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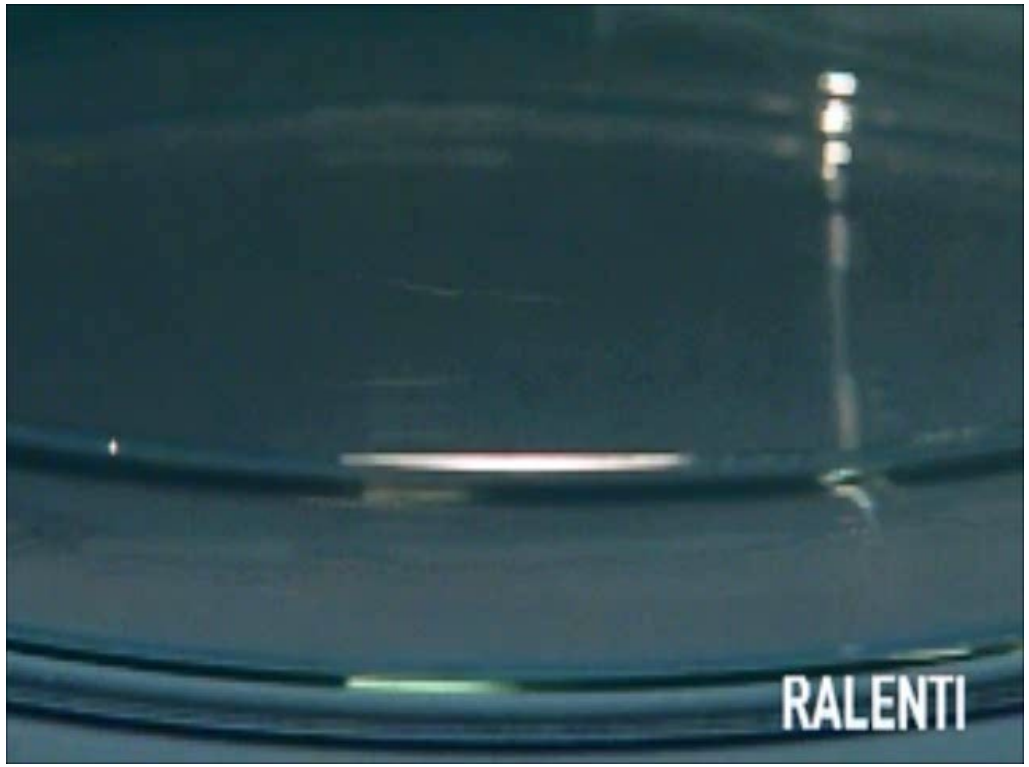
Gas release:

A gas spreads isotropically and disperses rapidly?

Time: 17 ``

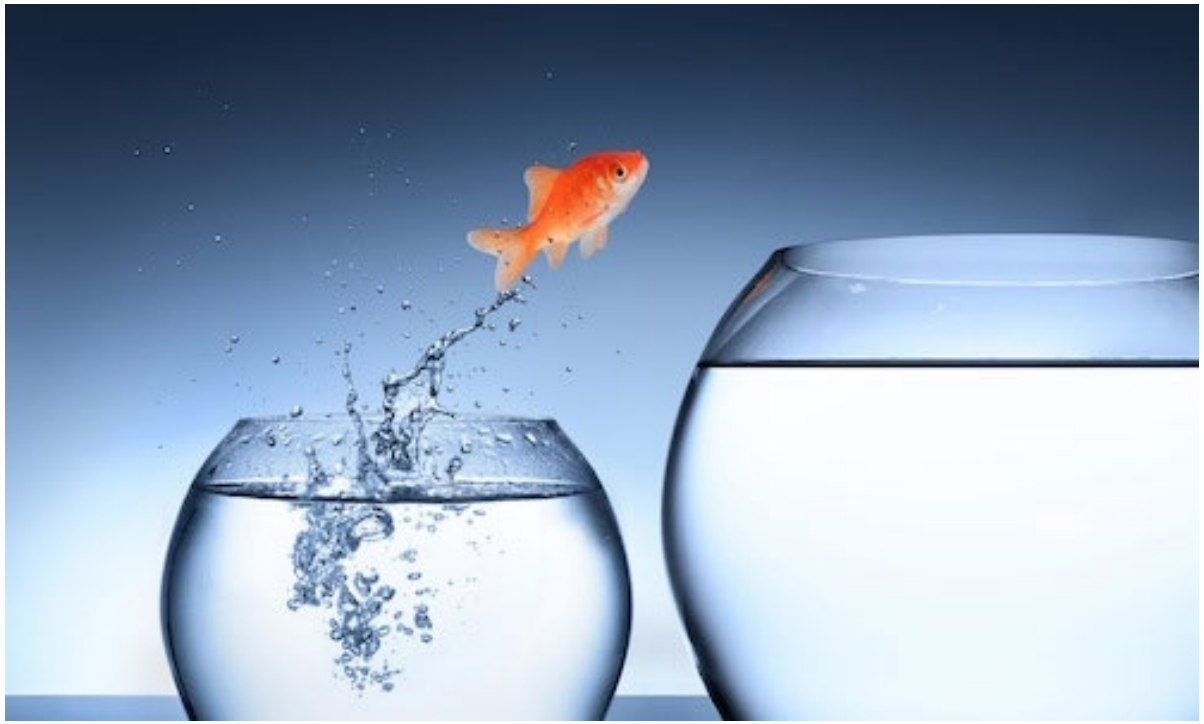
Fire triangle:

A triangle has 3 sides?



Source SUVA, time: 15 ``

Introduction: Risk Management



Source: https://www.haititechnews.com/

- Risk is present in everything we do!
- So, wouldn't it be wise to understand how to assess and evaluate these risks effectively?

Source: https://www.zurich.com/

Introduction: Accidents happen !

Consequences ?

Source: https://stringfixer.com/fr/Occupational_hazard

Module 1.1

Risk and Hazard

Hazard vs Risk: Cliff case

Bonifacio, Corse

HAZARD

VS

RISK

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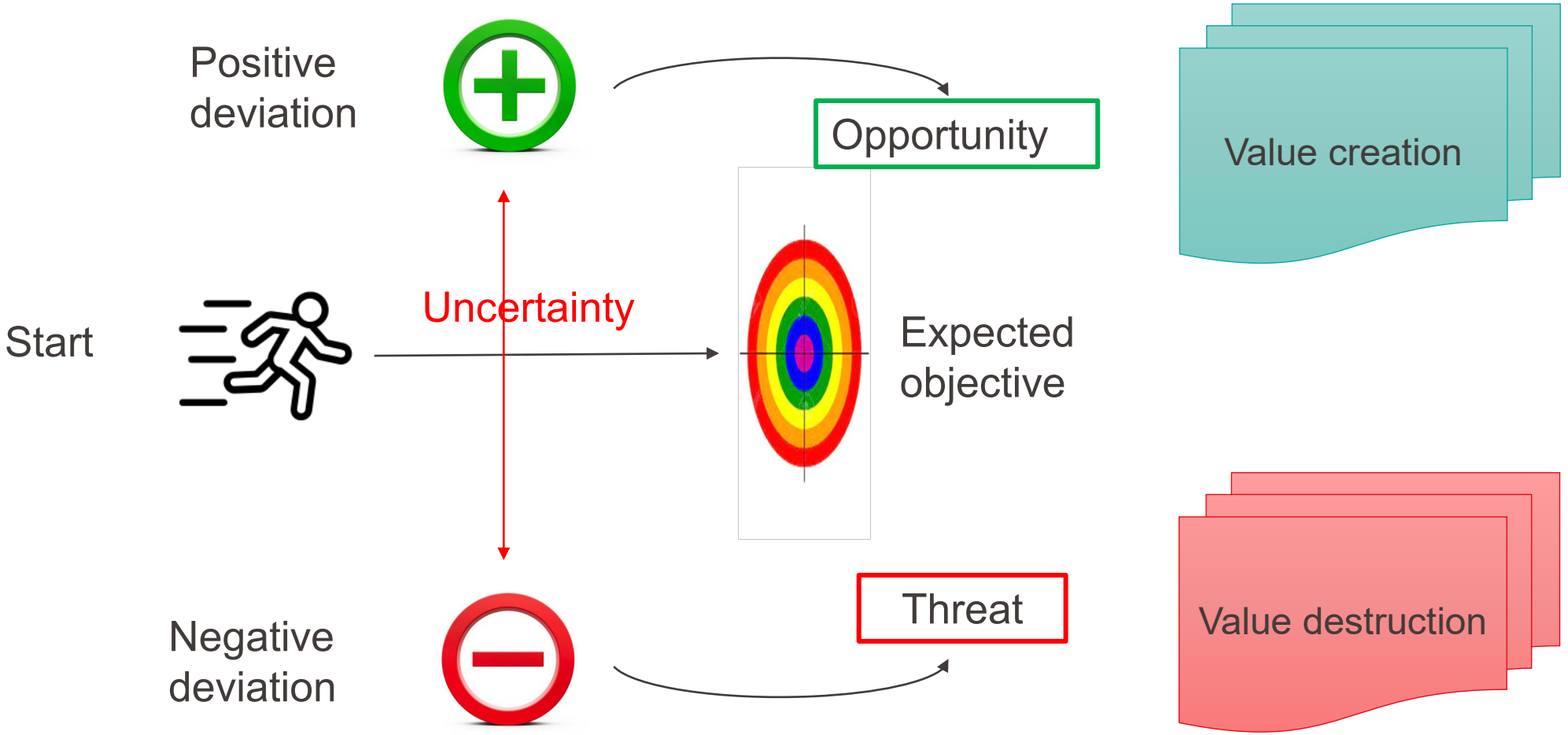
Introduction: Opportunity - Threat

Risk (effect of uncertainty on objectives) negative or positive (ISO 31000:2018)



An effect is a deviation from the expected

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Hazard vs Risk: Cliff case (2)

A cliff might be very risky and

A) A slightly dangerous if:

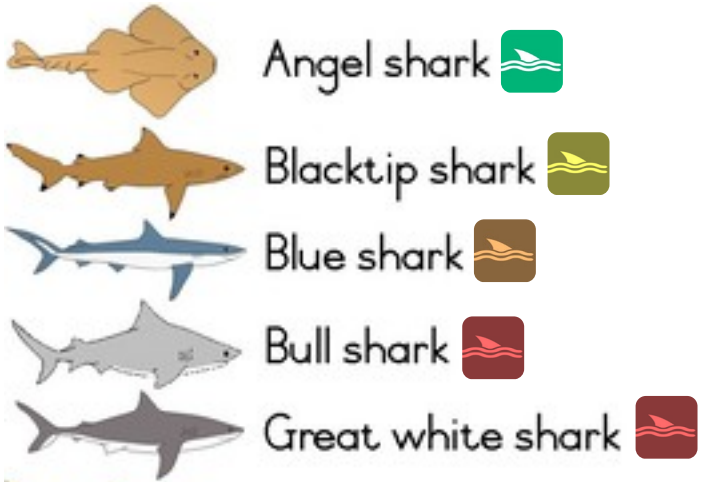
- Slippery,
- lacks guardrails,
- has a low height and
- loose soil at the bottom.

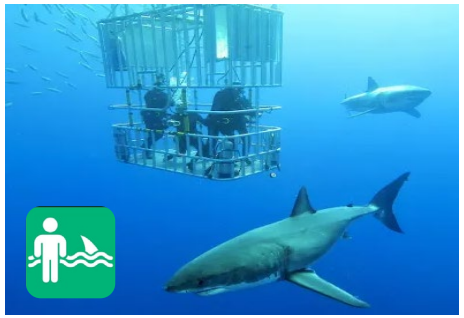
Bonifacio, Corse

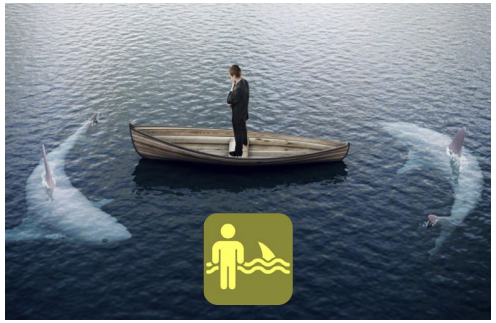
B) Very dangerous if:

- There are no guardrails or
- it has considerable height (even with warning signs) or
- if there is solid ground at the cliff's base (rocks instead of sand).

Hazard & exposure classification







Risk of injury

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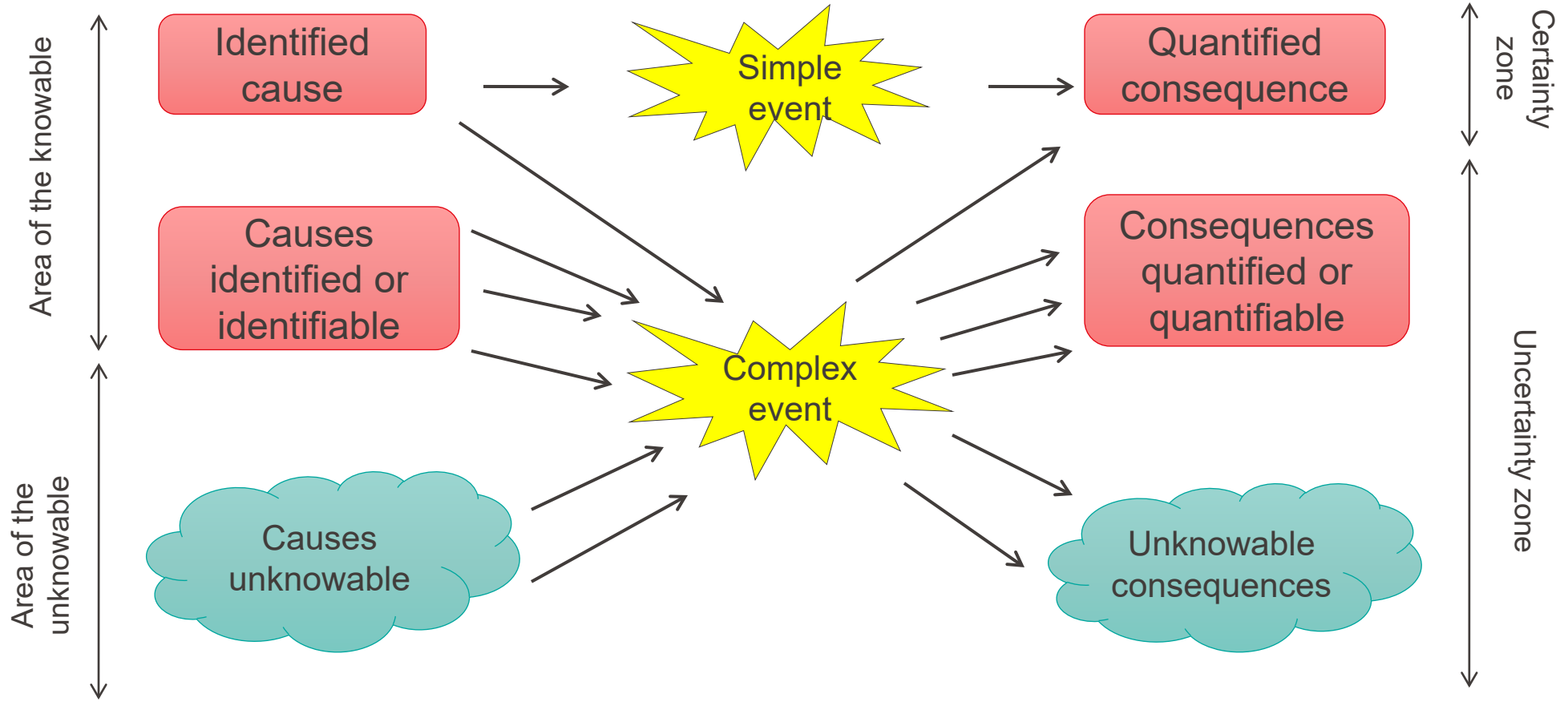
Test

Is it a hazard or a risk indicator ?

Road narrows

Risk dimension: Complex dimension of risk (1)



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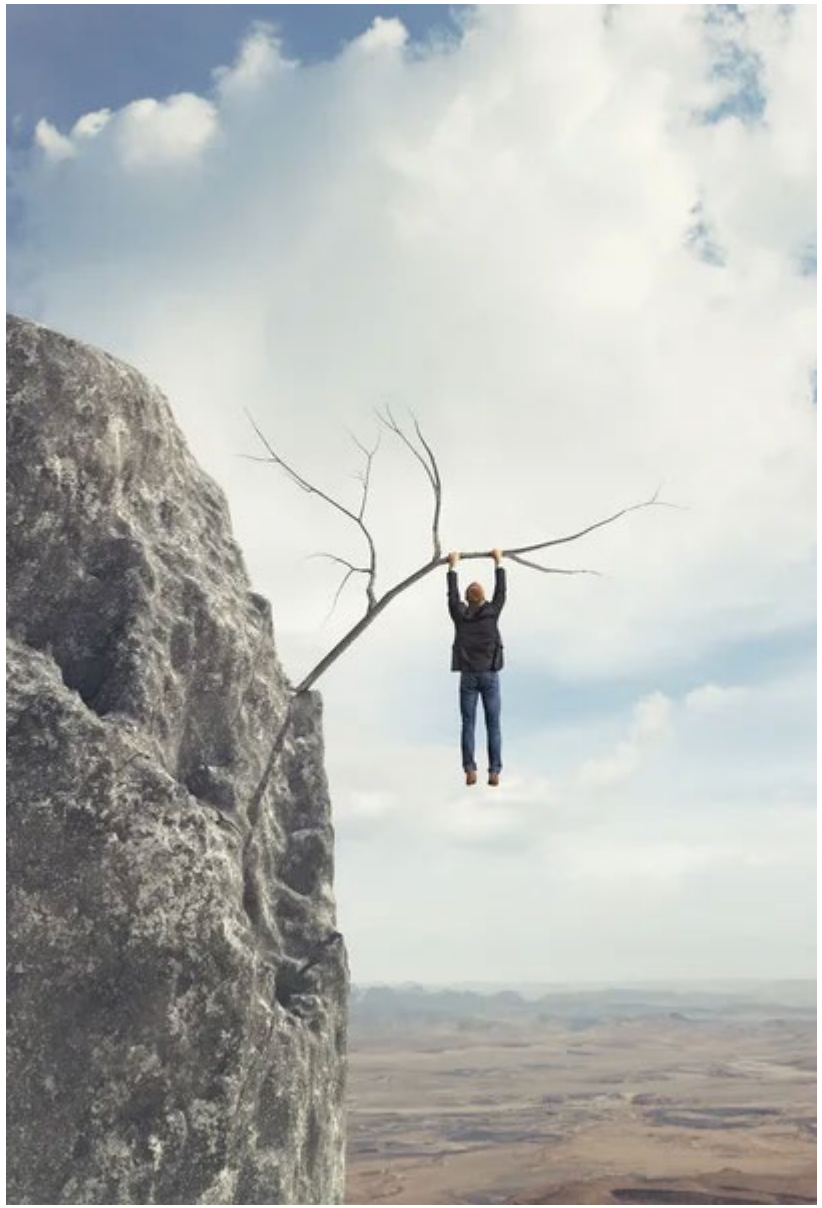
Risk dimension: Complex dimension of risk (2)



Complexity of risk

Human is behind of all → risks

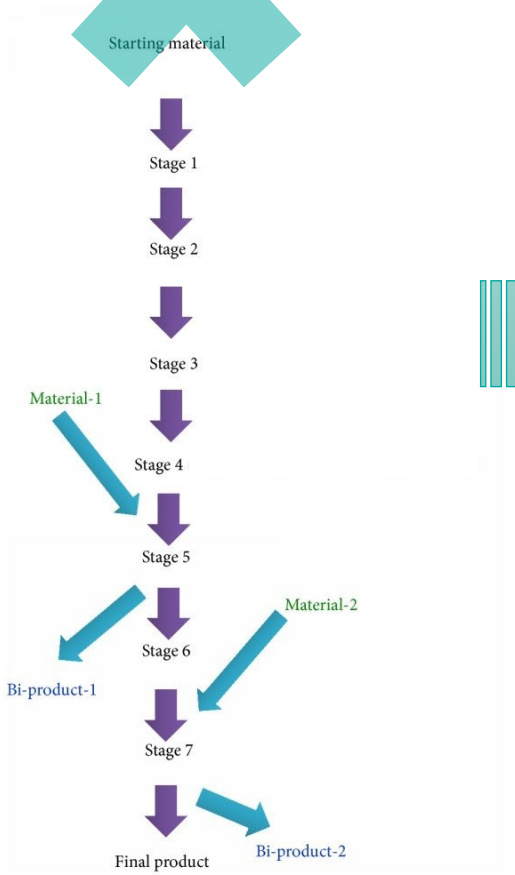
Human is behind of all → accidents

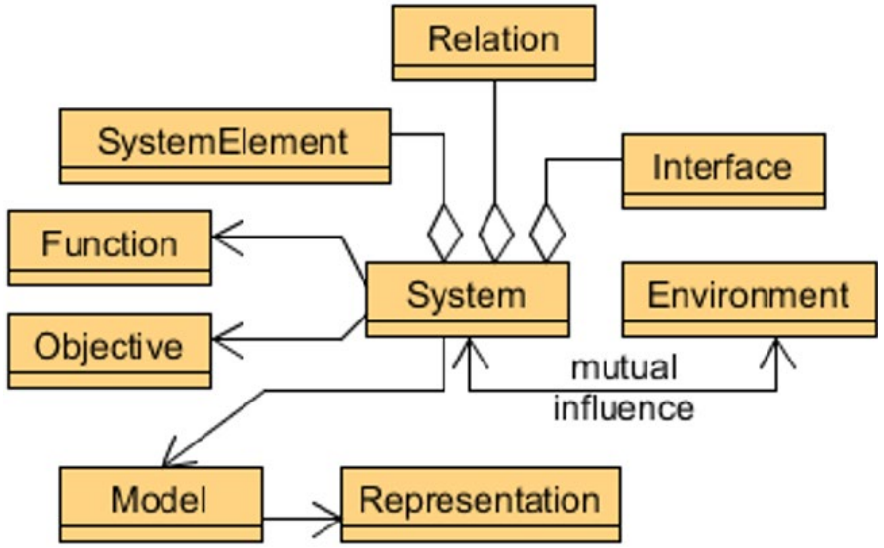
Source: https://www.everypixel.com/s/stock/man-climbs-a-mountain

Risk dimension: Complex dimension of risk (3)

Risk management involves interactions and complex relationships between causes and consequences.

Analytical approach





Systemic approach (include the analysis of the environment)

Risk dimension: Complex dimension of risk (4)

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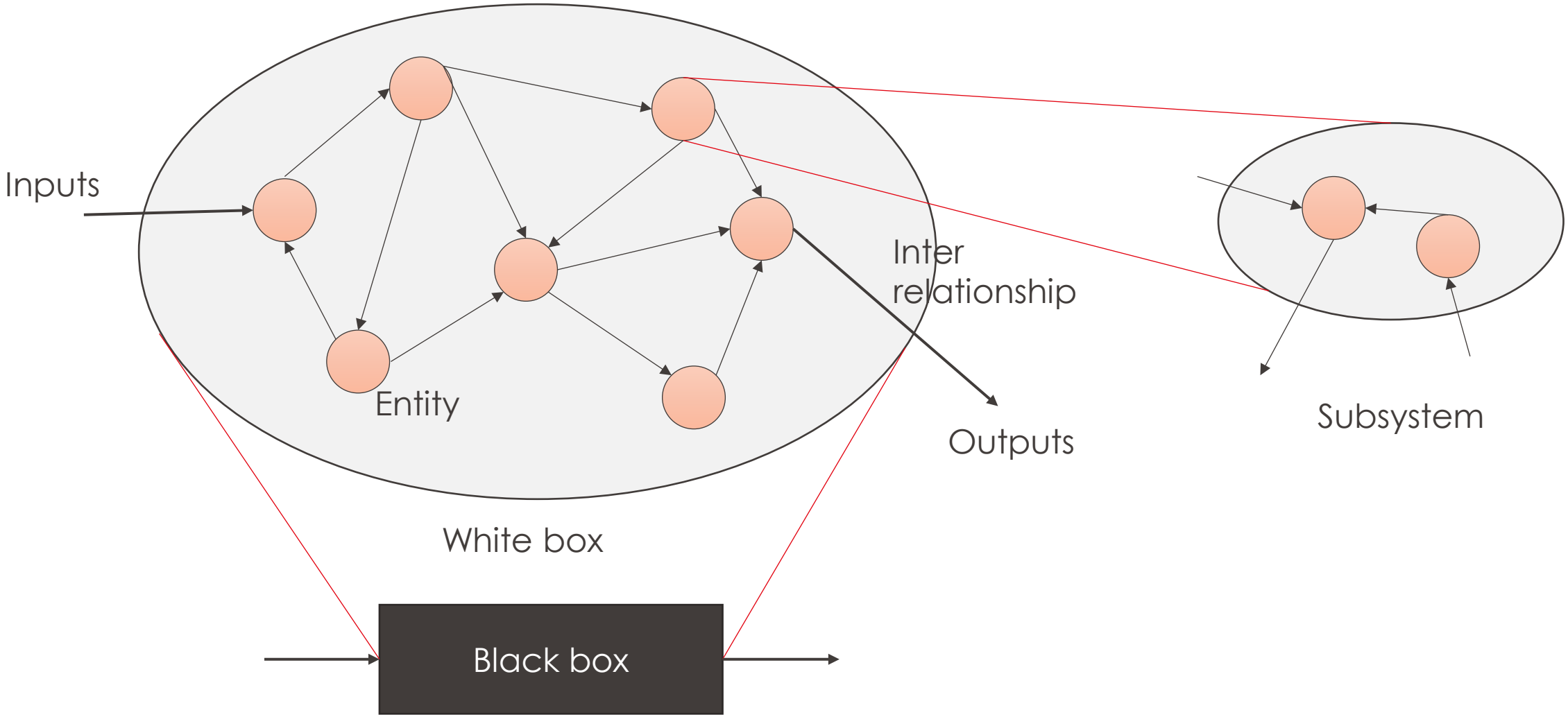
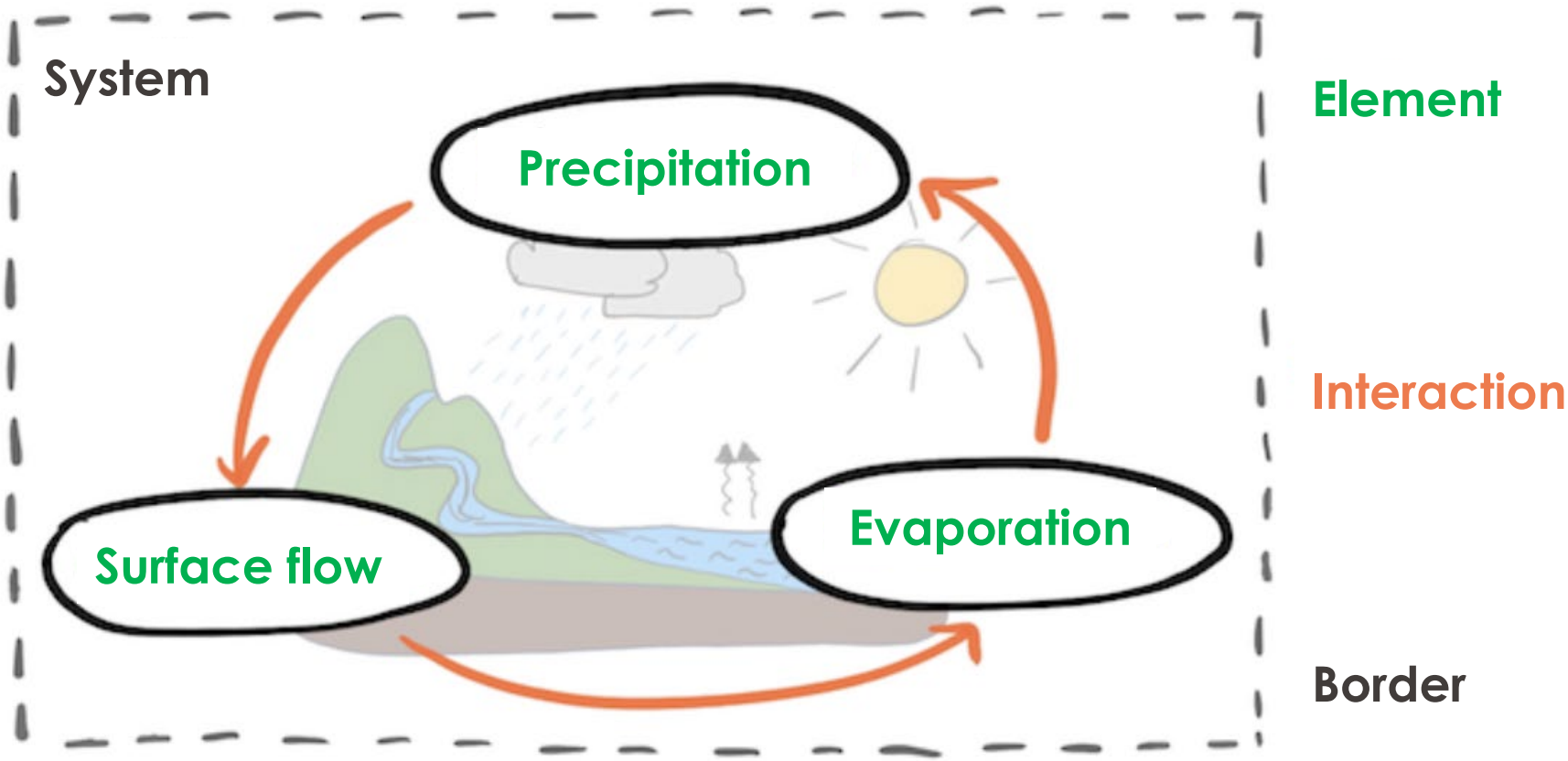
Systems approach: Basic concept



Risk dimension: Complex dimension of risk (5)

Systemic approach. What is a system ?



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Risk and Hazard: Risk perception (1)

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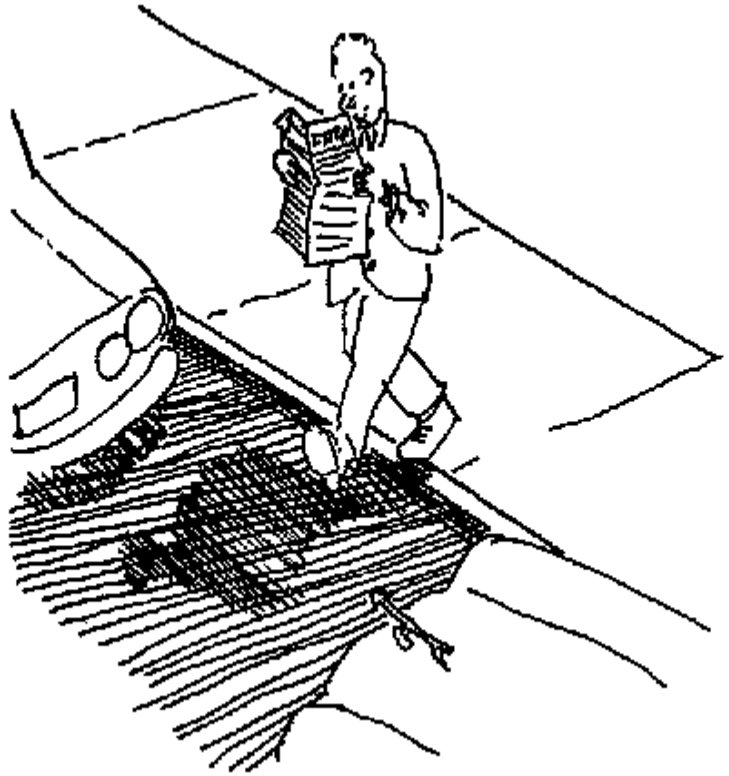
- Society's perception of risk is often subjective.
- Risk perception is shaped by factors like culture, societal norms, economic conditions, media influence, and the nature of the risk itself.
- Example: Switzerland tolerates 250 road deaths annually without major concern. However, if this same number of fatalities occurred in Swiss civil aviation - equivalent to two plane crashes per year - it would be deemed unacceptable, prompting swift action to reduce the risk

"Nothing in life is safe ...
you have to take risk"



Q. How do you define risk ?

Risk and Hazard: Risk perception (2)

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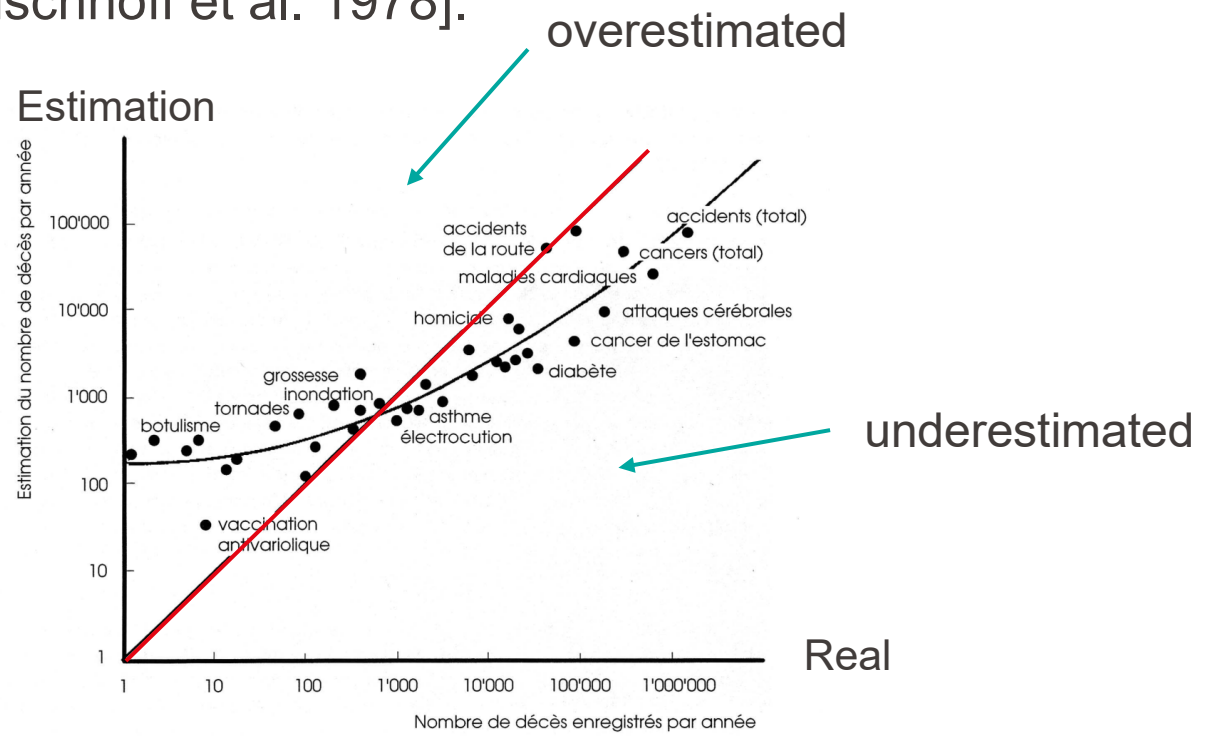
Risk perception may be defined as:

$$\text{Perceived risk} = \frac{\text{Expected severity}}{\text{Expected benefit} \times \text{hazard knowledge}}$$

Real risk vs expected risk [Fischhoff et al. 1978].



Risk and Hazard: Risk perception (3)

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Which image best represents the fear of hurricanes?

A

B

C

Source: www.wikipedia.org

Risk and Hazard: Residual risk

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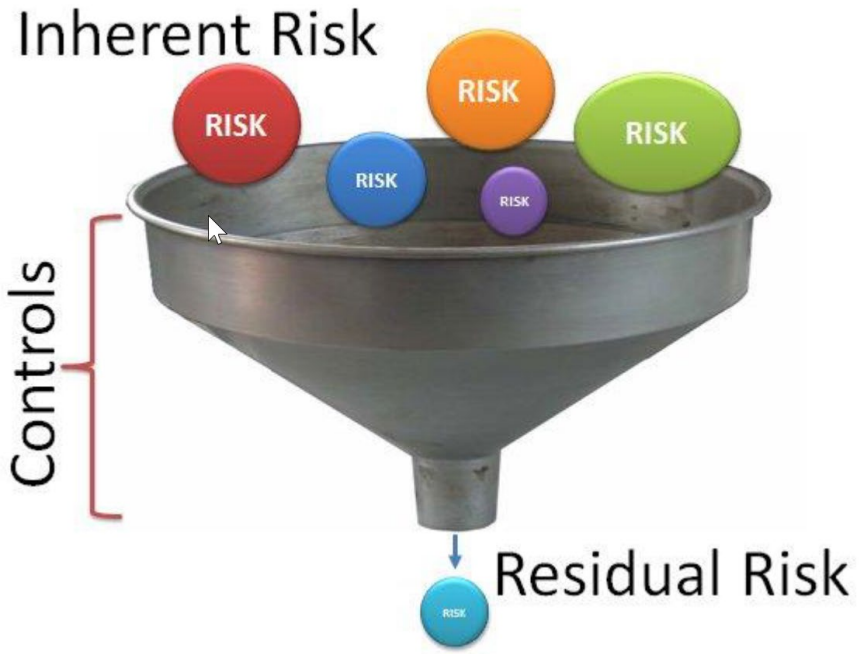

- Residual risk is the remaining risk after implementing risk reduction measures, encompassing only the identified and analyzed risks.
- Residual risk consists of three components:
  - Consciously accepted risk
  - Recognized but inadequately assessed risks
  - Risks stemming from unrecognized hazards
- The residual risk depends on the quality of the risk analysis.
- Zero-risk : it does not exist !

Risk and Hazard: Class quiz (1)

Please respond to the following questions with a "yes" or "no".

1. Is bioterrorism a significant threat to public health in your opinion?
2. Do you believe pesticides pose a substantial threat to public health?
3. In your view, are nuclear power plants a significant threat to public health?
4. Is the use of cell phones while driving, in your opinion, a substantial threat to public health?

Risk and Hazard: Class quiz (2)

Thierry Meyer

Now the most important question.

5. Do you have all the necessary facts to make a fully informed, analytical decision on the first four questions?

Risk and Hazard: Class quiz (3)

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- Answers % according to past questionnaires (last 5 years).

Question	Yes	No
1. Bioterrorism		
2. Pesticides		
3. Nuclear power		
4. Cell phones		
5. All the facts		

- You answered 'yes' or 'no' to the initial four questions but later acknowledged that you may lack all the information needed for well-informed decisions.
- Does this suggest limitations to achieving full rationality when basing decisions solely on factual data?
- In casting your votes, you relied on the available knowledge, which, to some extent, sufficed.

Source: https://cim2019.com/tables-rondes-cim.html

Module 1.2

Introduction to Risk Management

Simplified strategies

Introduction: Risk Management, what is it ?

The aim of risk management is to reduce threats related to preselected areas.

Risk management is a structured approach managing the doubts or uncertainties associated with a hazard, a sequence of human activities that includes: risk assessment, strategies and mitigation.

Introduction: The black swan - Thinking the Unthinkable

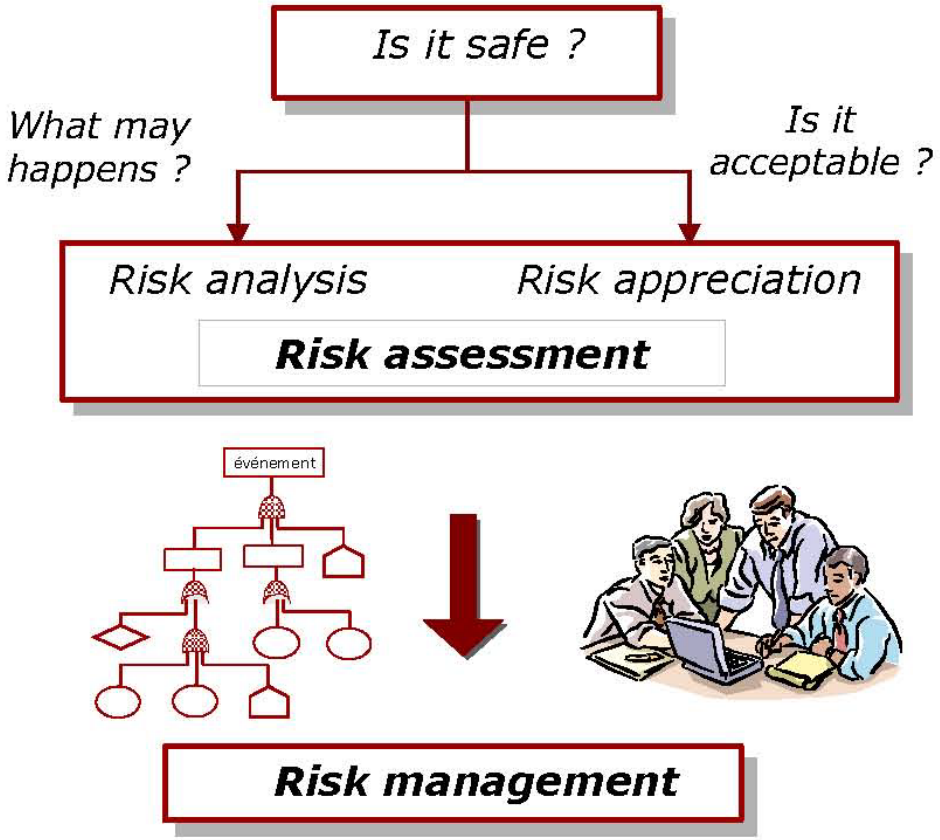
Thierry Meyer

2007, Statistician Nassim Nicholas Taleb defined "Black Swan" as an event that "is an outlier," as it lies outside the realm of regular expectations.

Four characteristics:

1. Exceeds normal expectations with unpredictability.
2. Carries potential for severe consequences.
3. Recognized in hindsight—observers feel it should have been foreseen after the fact.
4. Characterized by extreme rarity, significant impact, and a tendency to attribute the lack of prediction to hindsight.

Risk Management : General process



Internal Control System

Stages of life of the reflection

Stage 1: mission, objectives and organization	Stage 2: inventory	Stage 3: evaluation	Stage 4: treatment	Stage 5: control

Expected results

- Update of the definition of the objectives
- Update of the top 10 of the risks
- Production of a global cartography and a proposal of a final aggregation
- Realization of concrete "businesses" or "managerial" resolutions
- Focus on about fifteen anticipated controls and fifteen corrective controls

I. Mission, objectives and organization

Mission :

Understanding of the mission, the strategic and operational objectives of the organization

Tools :
1. Semi-directive interviews
2. Synthesis

II. Inventory

Identification of the most important risks and the points having an incidence on the organization

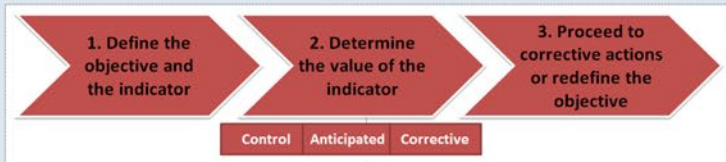
Tools :
1. Workshops
2. Synthesis

Top 10 of the risks:

V. Control

Control of the risks by means of anticipated or corrective controls

Process in 3 stage :
1. Define the objective and the indicator
2. Determine the value of the indicator
3. Proceed to the actions of treatment



Feedforward Control

Objective :
Anticipation :
Treatment :

Feedback control

Objective :
Measure :
Treatment :

"Businesses" and / or "managerial" resolutions :

Treatment of the risks

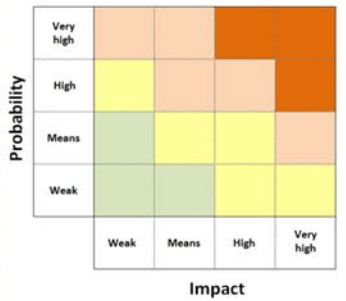
Method of approach :
1. Of prevention
2. Of acceptance
3. Of reduction
4. Of transfer

IV. Treatment

Risk assessment according to various levels of strategic objectives and / or operational

Tools :
1. Cartography
2. System of global aggregation

Risk Map :

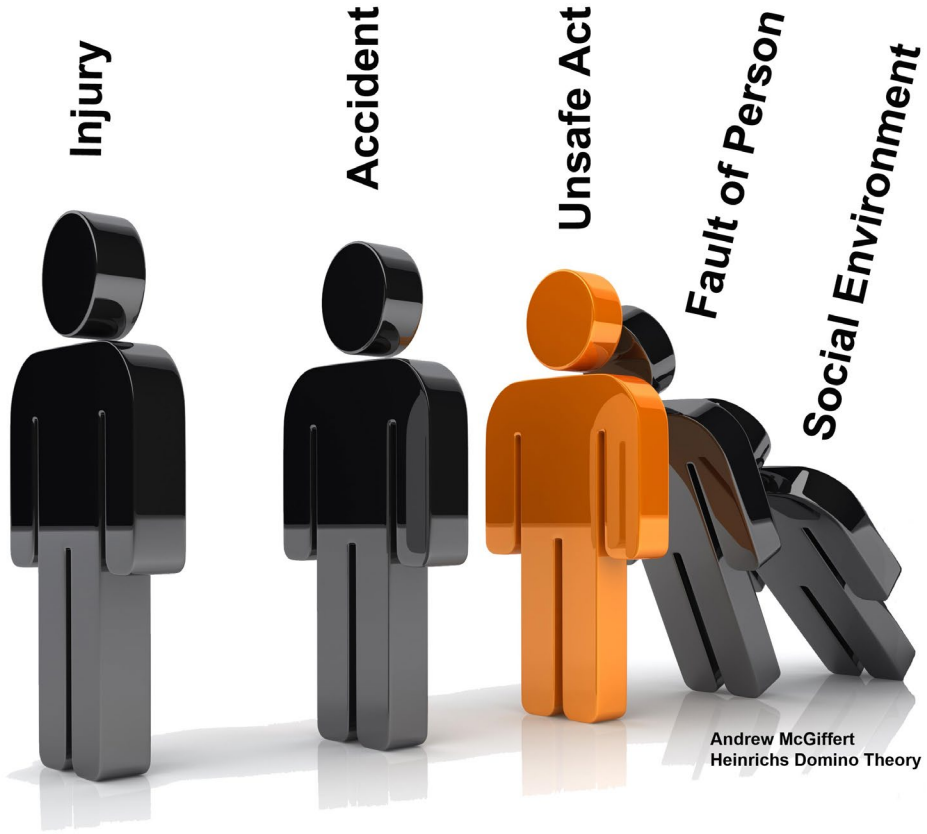


III. Evaluation

Module 1.3

Risk Modeling - Simplified

Accident theories: Some observations



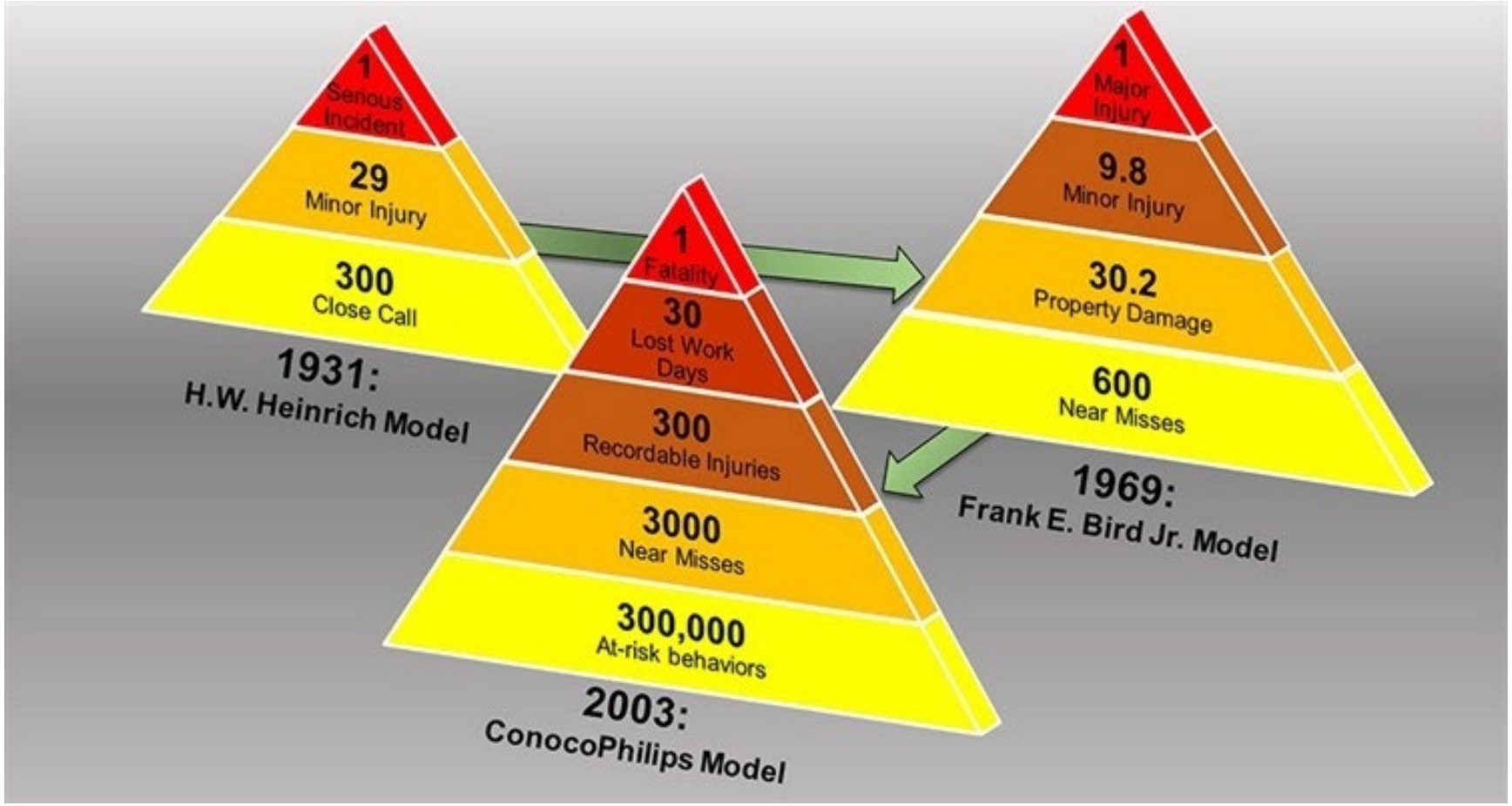
Dominos theory (Heinrich 1931)

Source: http://andrew.mcgiffert.id.au/

Is it true that every new incident has already happened before?

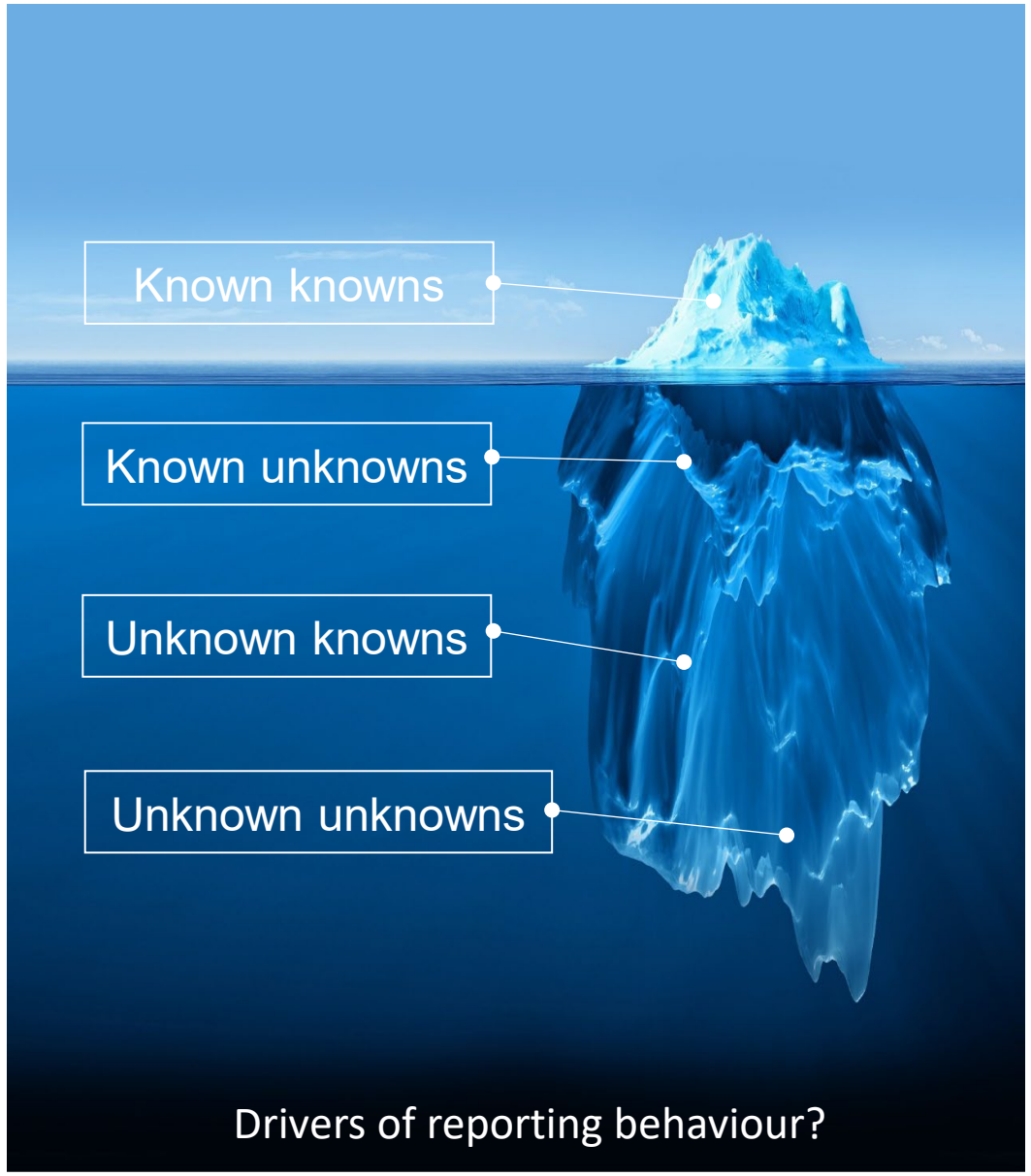
- Root cause of human errors:
  - Lack of competency
  - Procedure not followed
  - Procedure not described
  - Complacency

Accident theories: The Evolution of Workplace Safety



https://www.army.mil/article/189091/the_evolution_of_workplace_safety

Accident theories: The iceberg thinking



- performance before safety
- blame
- complacency: individual and management
- apathy

Accident theories: Operational management

80 %

of incidents are related to human errors

of human errors are related to organizational matters

of accidents are related to human behaviors

The iceberg thinking: The underwater part

Performance before safety

«Top-performing rig in the Gulf»

Deepwater Horizon, April 20, 2010

Source: www.wikipedia.org

The iceberg thinking: The underwater part

Blame and complacency

The driver was blamed immediately after the accident, but:

- The driver's alert system had been deactivated two years prior to the incident.
- A risk analyst had estimated the likelihood to be "once every six months."

Santiago de Compostela derailment, Spain, July 23, 2013

Source: www.wikipedia.org

The iceberg thinking: The underwater part

Apathy

In the first week, everyone was sympathetic. However, after a week passed:

- Leaders became occupied with other matters.
- Commitments and announcements were forgotten.
- Bureaucracy began to have adverse effects.
- Issues like corruption, humiliation, and apathy arose.
- Those affected were left to navigate a bureaucratic maze.
- Some individuals, organizations, and officials did offer support and assistance.

Mumbai bomb blast, India, July 11, 2006

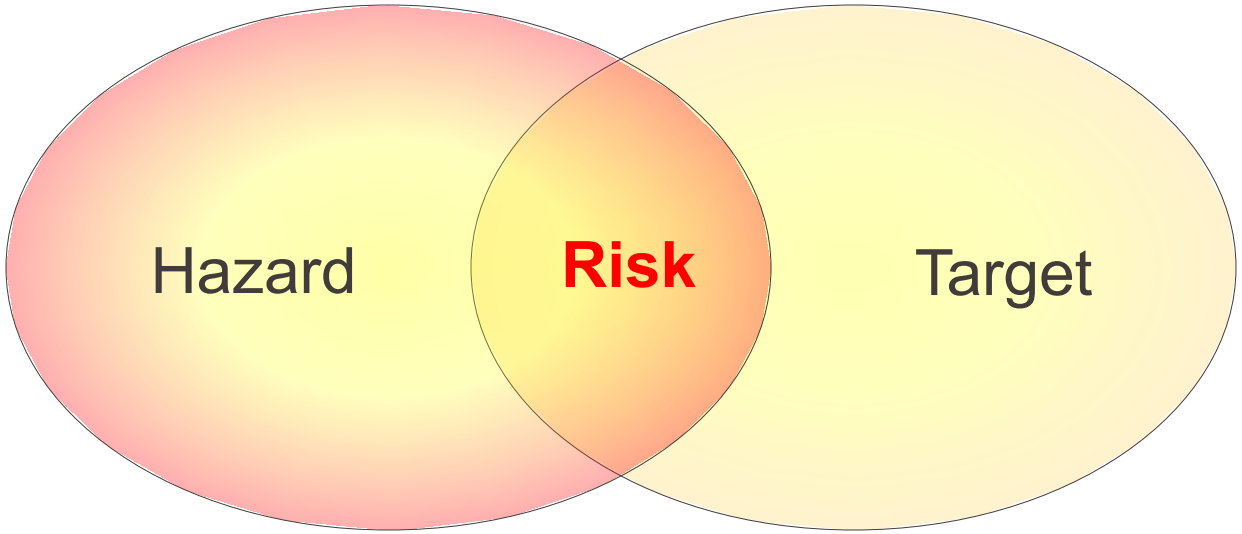
Source: www.wikipedia.org

Risk modeling: Why a risk management ?

- Today, these pyramids are insufficient for effective risk management.
- Systems have become increasingly complex.
- Simply assessing the severity of consequences is inadequate.
- Heinrich assumed accidents resulted directly from actions or unsafe conditions.

Risk modeling: Classical risk modeling (1)

Threat = the potential of a hazard to cause damage to the target



Risk modeling: Classical risk modeling (2)

Thierry Meyer

The classical formula

$$R = F \bullet G$$

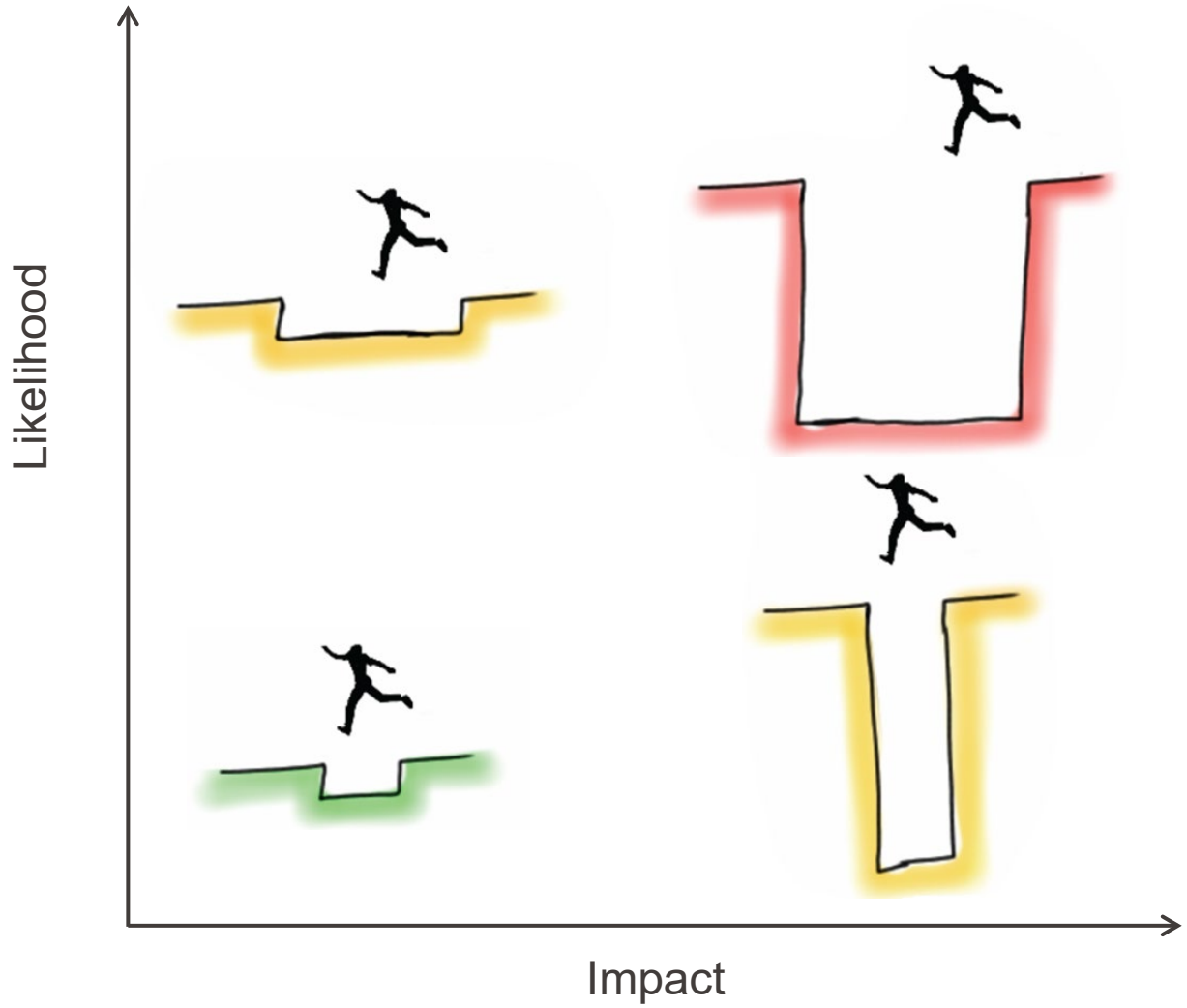
Risk = occurrence · severity

- The likelihood of occurrence depends on:
  - N: number of targets
  - T: average exposure time of each target
  - Pre: prevention implemented to reduce N or T

- Severity G is function of:
  - D: “crude” hazard of the situation
  - Pro: level of implemented protection

$$R = F \bullet G = \left(\frac{N \bullet T}{Pre} \right) \bullet \left(\frac{D}{Pro} \right)$$

Risk modeling: Risk profile illustration



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Risk modeling: Classical risk modeling (4)

Thierry Meyer

Acting on the risk …

$$R = F \bullet G = \left(\frac{N \bullet T}{Pre}\right) \bullet \left(\frac{D}{Pro}\right)$$

… is trying to answer the following questions:

- Is it possible to reduce the number of targets ?
- Is it possible to reduce the exposure time ?
- Is it possible to increase the prevention efforts ?
- Is it possible to reduce the hazard ?
- Is it possible to increase the level of protection ?

Risk modeling: Classical risk modeling (6)

Reducing risk:

- Reduce severity → reduce hazard, enhance protective measures
- Reduce the frequency → decrease exposure time, minimize the number of individuals exposed, enhance preventive measures

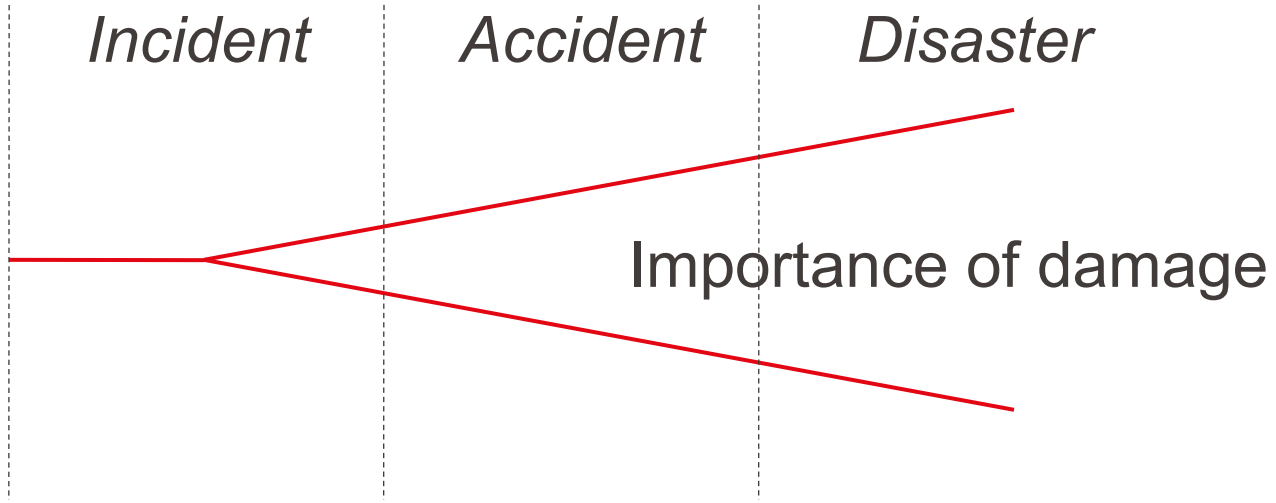
Zero risk does not exist except if:

- The hazard is nonexistent
- There is no exposure to danger

Thierry Meyer

Risk modeling: Classical risk modeling (7)

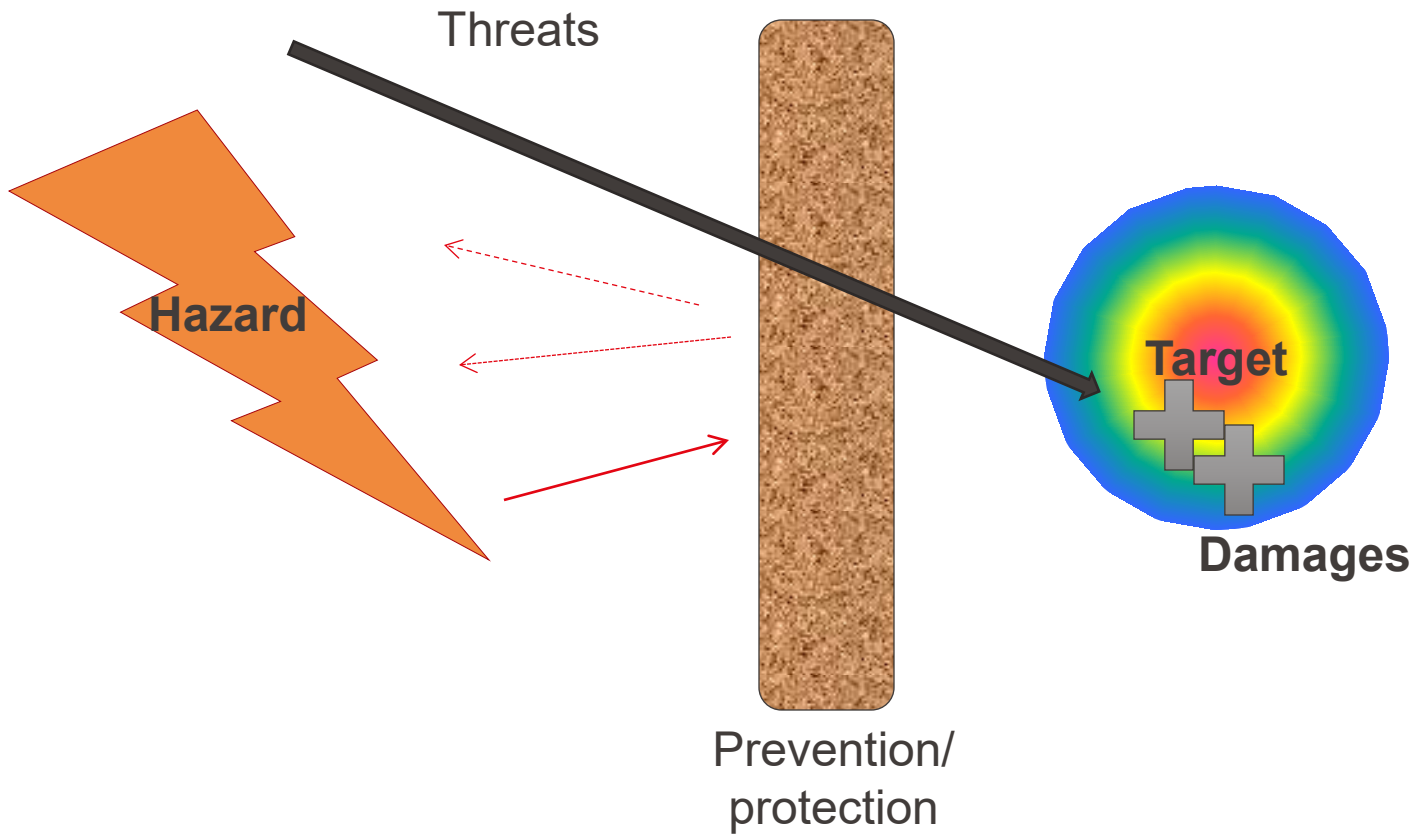
Incident, accident, and disaster are defined by the degree of damage incurred and experienced.



Risk modeling: Classical risk modeling (8)

Thierry Meyer

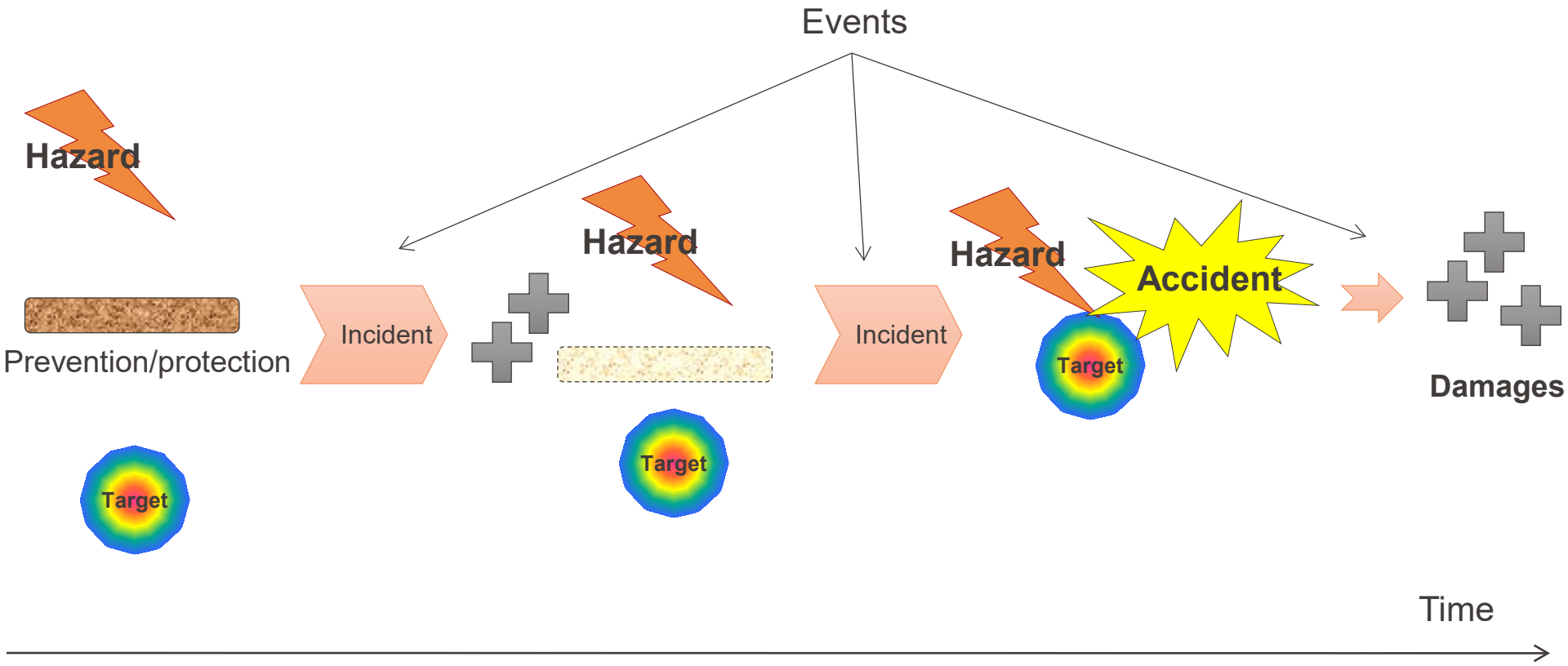
Static modeling of the incident or accident



Risk modeling: Classical risk modeling (9)

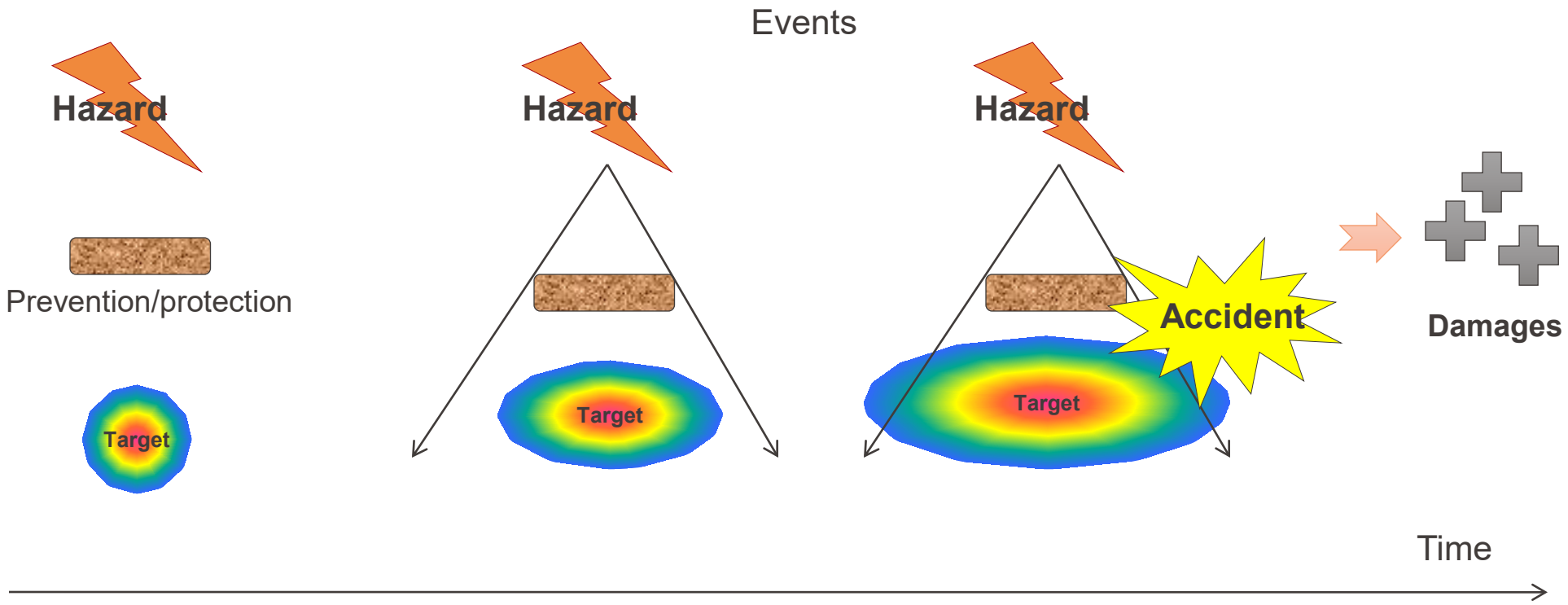
Thierry Meyer

Dynamic accident modeling: Scenario 1, sequence of events



Risk modeling: Classical risk modeling (10)

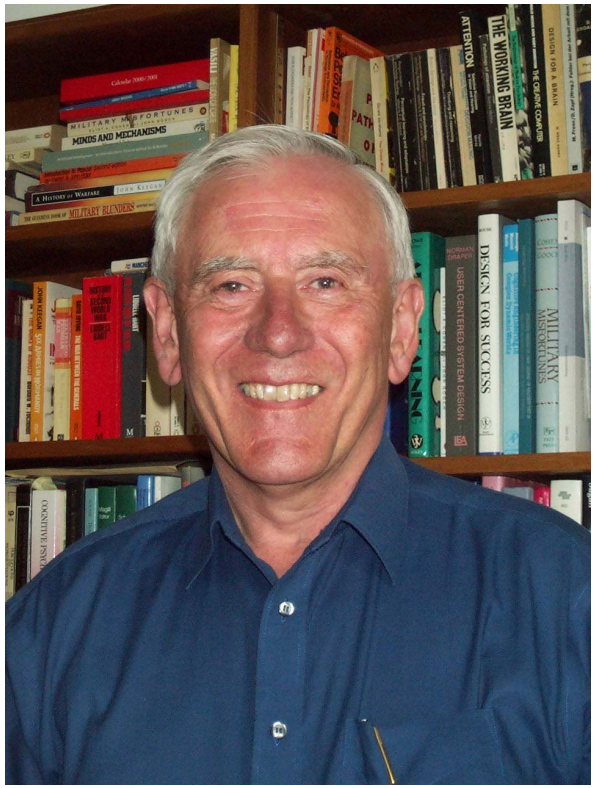
Dynamic accident modeling : Scenario 2, where the target's growth outpaces prevention/protection.



Risk modeling: James Reason's Swiss cheese model (1)

Thierry Meyer

James Reason, psychologist, describes in 1990 the accident causal chain as a successive layers of defenses, barriers and safeguards.



Source: www.wikipedia.org

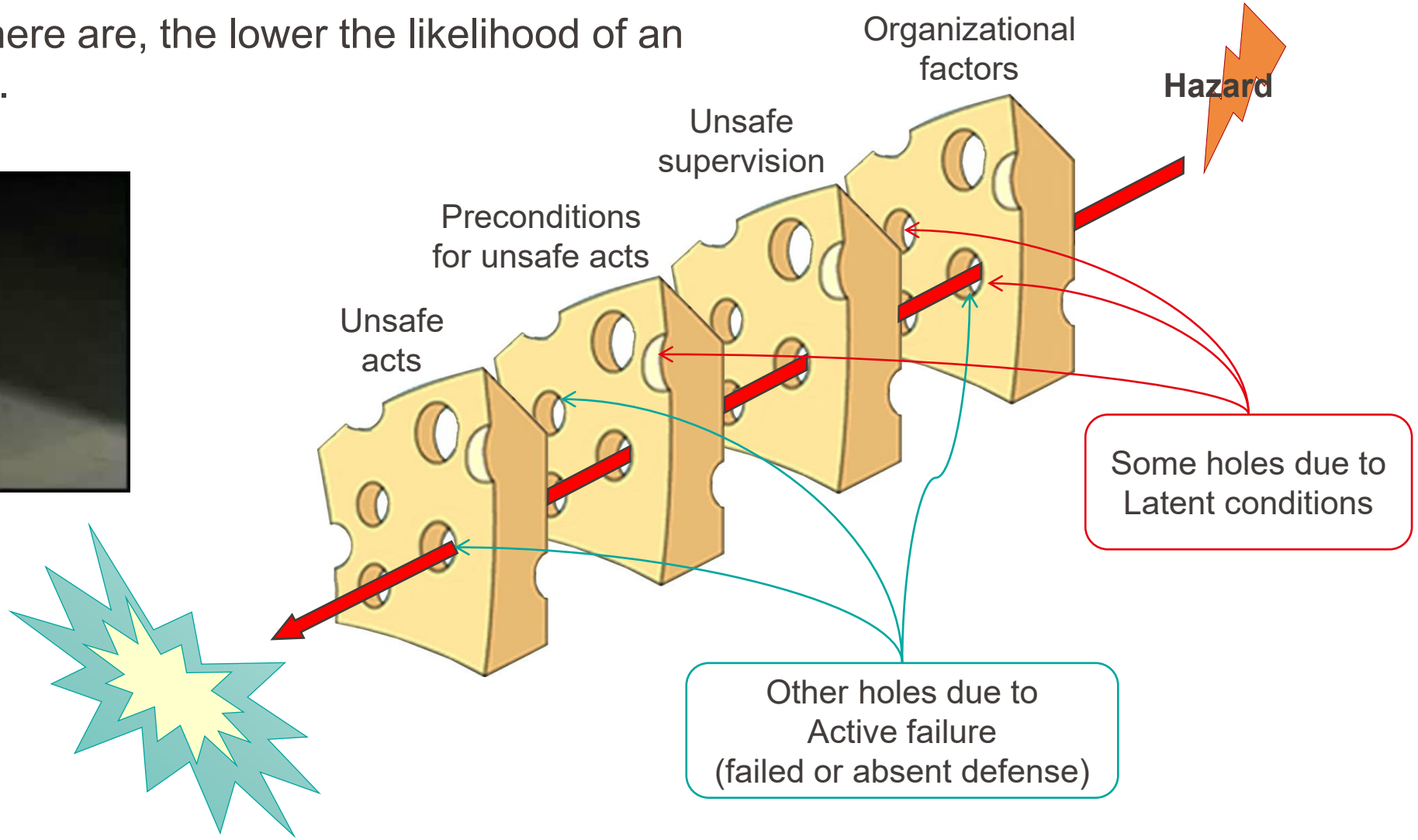
- *Defenses, barriers, and safeguards*: Their function is to protect potential victims and assets from local hazards. Mostly they do this very effectively, but there are always weaknesses.
- *Active failures* are unsafe acts committed by people who are in direct contact with the system.
- *Latent conditions* are the inevitable "resident pathogens" within a system. They are more removed from the incident itself and reflect failures in management or policies, arising from decisions made by designers, builders, procedure writers, and top-level management.

Risk modeling: James Reason's Swiss cheese model (2)

Each layer of safety is like a slice of cheese, offering a chance to intercept an error.

The more layers there are, the lower the likelihood of an accident occurring.

Time: 36 ``



Risk modeling: James Reason's Swiss cheese model (3)

Source: https://www.koreus.com/image/14-animal-insolite11.html

Why holes ?

These weaknesses, known as 'windows of opportunity,' can arise from various factors, such as mechanical or technical failures.

Unfortunately, human error remains the most common and traceable cause of many accidents.

Thierry Meyer

Why to wear a mask ?

Source: Huffingtonpost

Risk modeling: Classical risk modeling (11)

Dynamic modeling tells us that:

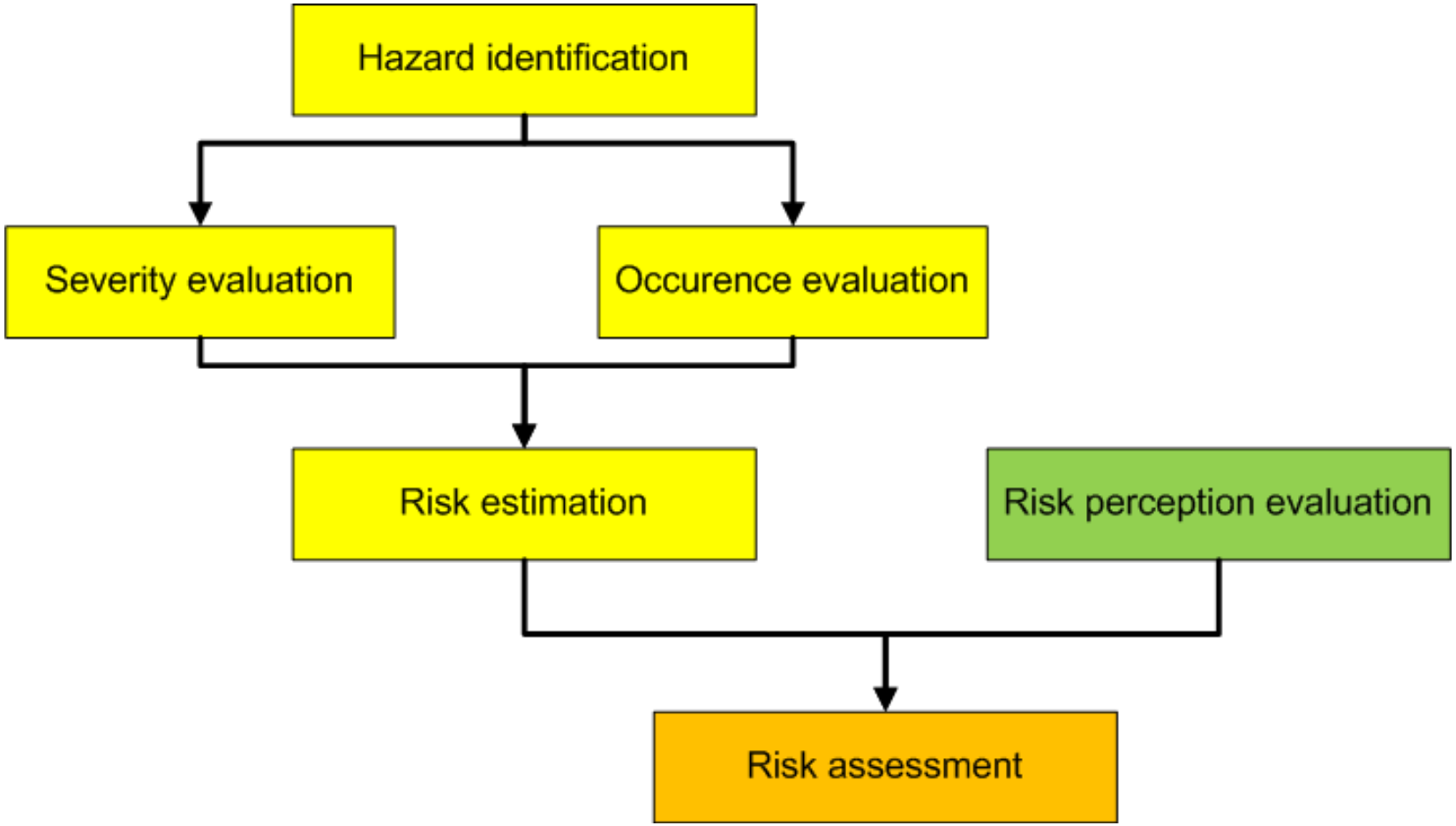
- Accidents are often the result of successive events or incidents, which may or may not result in damage. Do not trivialize the incident !
- Accidents can occur when circumstances have gradually changed without a reevaluation of the initial measures. Adjust measures to align with evolving situations !

Source: www.psychologicalscience.org

Module 1.4

Risk Evaluation

Risk evaluation: General scheme



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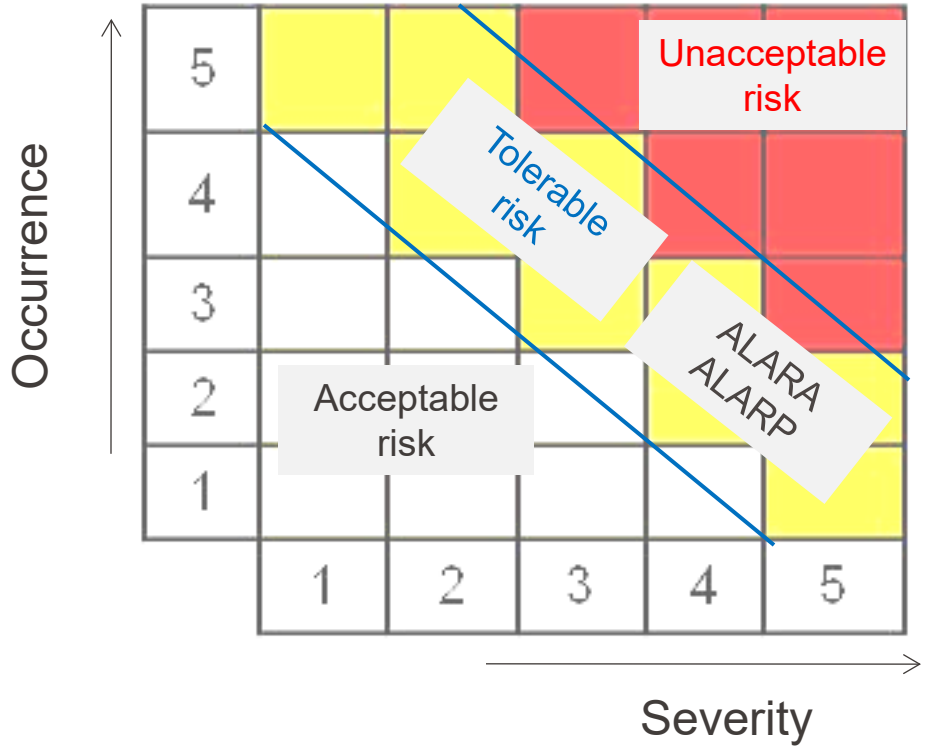
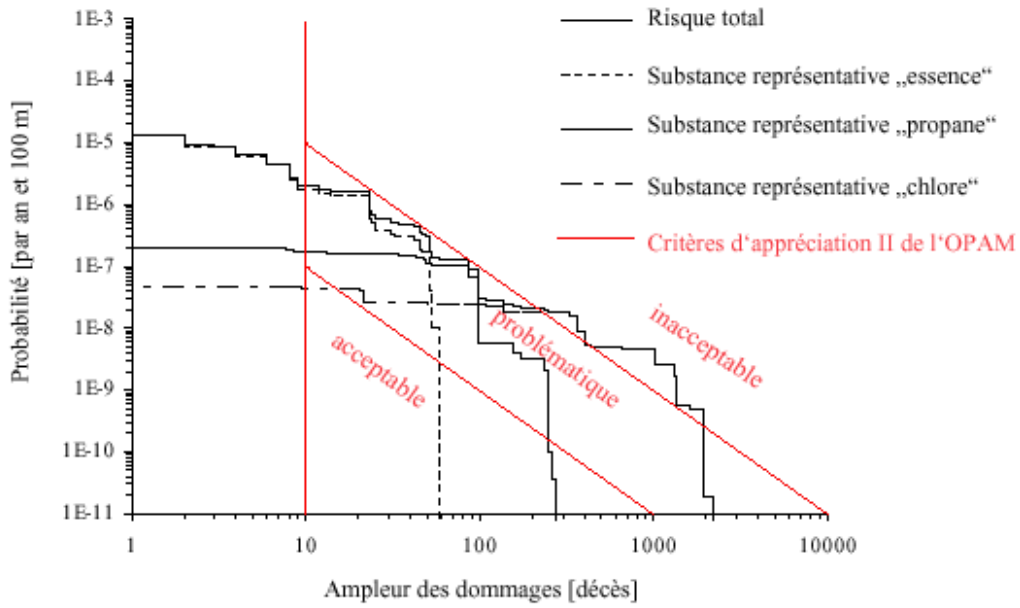
Risk evaluation: Acceptable risk

Thierry Meyer

- Risk is reduced to a tolerable level.
- Is subject to social, economic, and cultural factors.
- Concept evolves over time.
- Depends on:
  - Cultural values of our society (ethical, political, social and cultural).
  - Existing standards.
  - Scientific and technical considerations.
  - Current knowledge and the state of the art.
  - Available resources of the companies.
  - Economic factors.

Risk evaluation: Matrix of risk acceptance

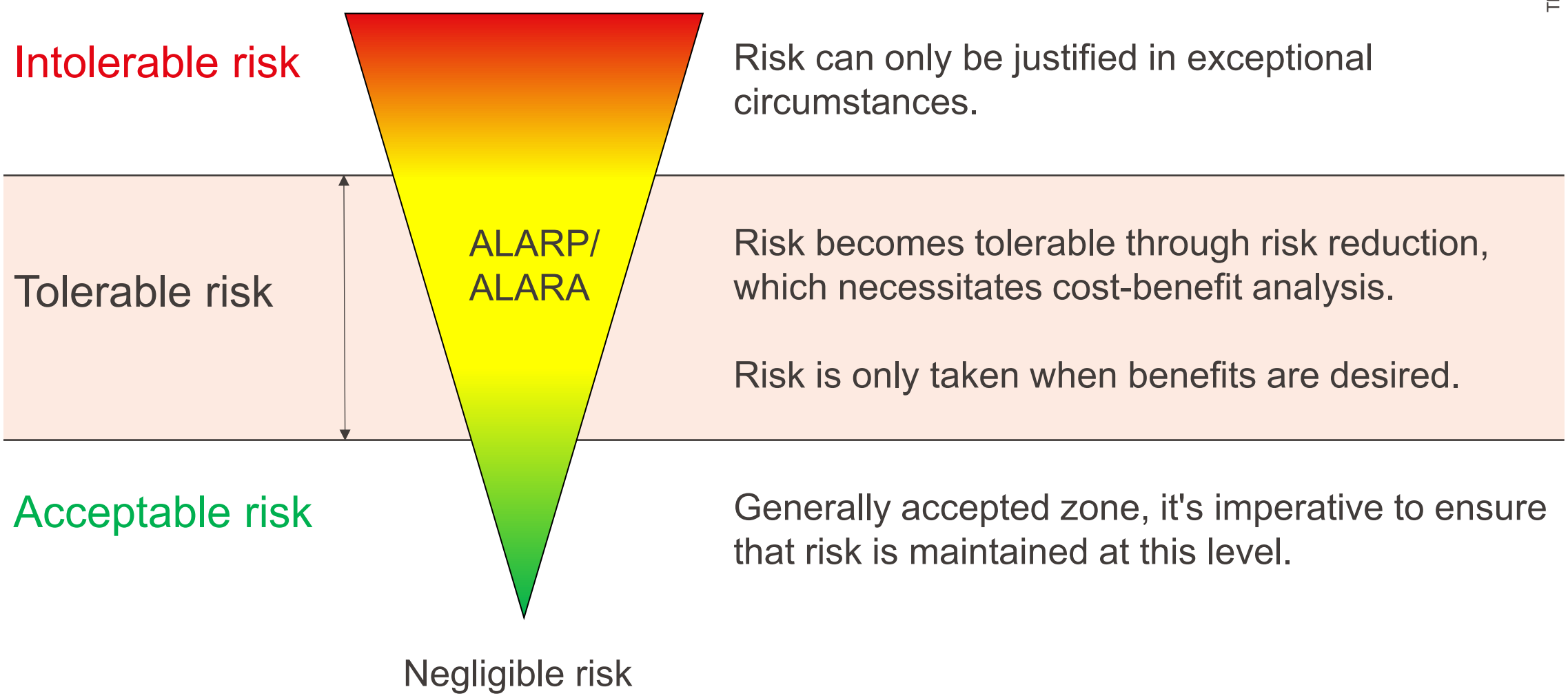




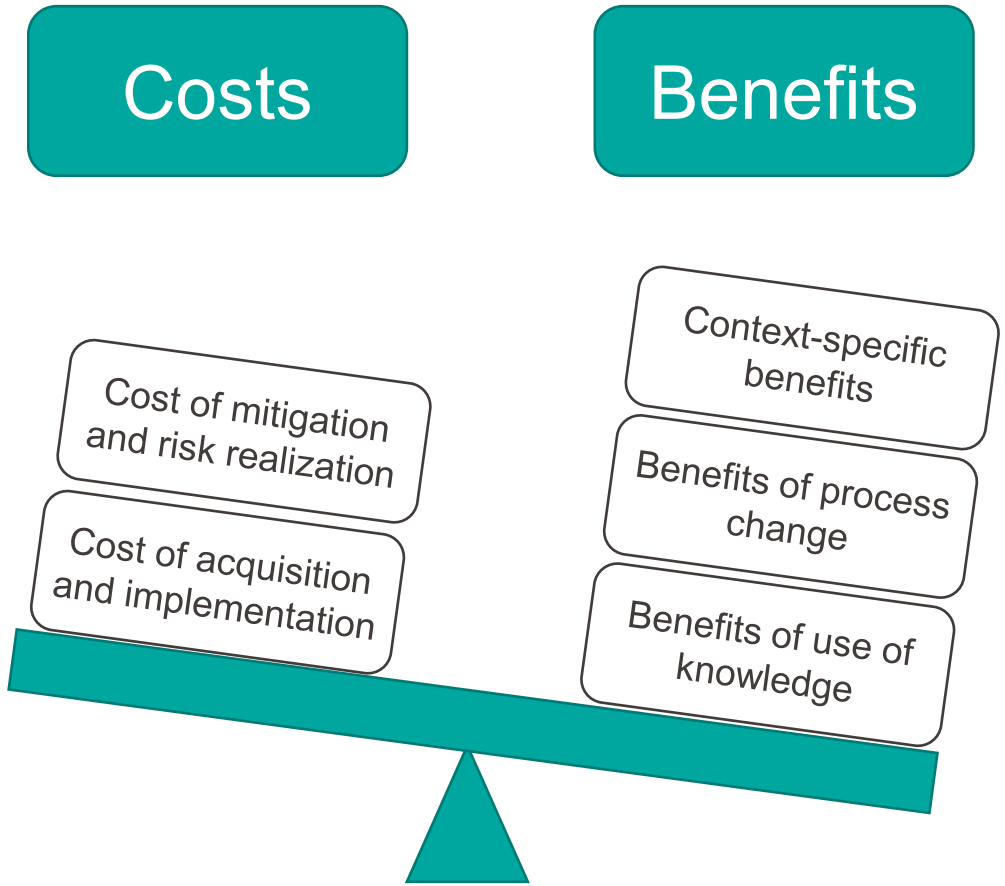
Source: Risk matrix and risk acceptance for the transport of dangerous substances. [OFEV 2010].

Risk evaluation: ALARA / ALARP (1)

Thierry Meyer



Risk evaluation: ALARA / ALARP (2)



ALARP= As Low As Reasonably Practicable

ALARA= As Low As Reasonably Achievable

- These principles suggest that the residual risk should be minimized to the greatest extent reasonably possible.
- It represents a best common practice that involves the judgment of the trade-off between risk and societal benefits.

Risk evaluation: Severity scale

	Insignificant 1 or E	Moderate 2 or D	Important 3 or C	Severe 4 or B	Critical 5 or A
Health	Minor injury without work stoppage	Injury with work stoppage	Reversible injury	Permanent injury	1 or more death
Environnement	No significant effects	Causing damage to the operation of the waste water treatment plant	Environmental damage inside the company	Environmental damage outside the company	Environmental damage like SEVESO type
Company properties	Incident without consequences	Damage was limited to the production unit	Damage with severe consequences in business	Damage with serious consequences outside the company	Explosion, major fire
Production	Short-term interruption of production	At least one week production stop	Interruption of production resulting in an inability to deliver during several days	Interruption of production resulting in an inability to deliver during several weeks	Interruption of production resulting in an inability to deliver during several months
Brand image	Awareness only at the local	Awareness level of a building unit	Awareness within the entire company	Awareness outside the company	Claim against the company
Media impact	No reaction	Local press Regional rumor	Regional TV and press National rumor	National press and TV	International press and TV
Financial consequences	< 20 kCHF	> 20 kCHF	> 200 kCHF	> 2 Mio CHF	> 10 Mio CHF

Risk evaluation: Likelihood of occurrence scale (1)

Probability classes	Exceptional 1 or E	Very rare 2 or D	Rare 3 or C	Recurrent 4 or B	Regularly 5 or A
Qualitative meaning	event possible but extremely unlikely	very unlikely event	unlikely event	probable event	frequent event
Explanation	is not impossible for the current knowledge, but have not been encountered in the world over a very large number of years	has already occurred in this area but has been considerably reduced by adequate measures	a similar event already met in the industry or in such organizations throughout the world, without any correction being made since the guarantee to significantly reduce its probability	has occurred and/or may occur during the life of the facility	has occurred on this site and/or may occur several times during the life of the facility, despite possible remedies
Occurrence	1x / 50 years	1x / 10 years	1x/ year	several times a year	several times a month
Quantitative scale (probability per unit and year)	$< 10^{-5}$	between 10^{-4} and 10^{-5}	between 10^{-3} and 10^{-4}	between 10^{-2} and 10^{-3}	$> 10^{-2}$

Thierry Meyer

Risk evaluation: Likelihood of occurrence scale (2) with daily exposure

Occurrence					
every day throughout the year	4	5	5	5	5
a few days/week or months/year	3	3	4	4	4
few days/month or weeks/year	2	3	3	3	3
few days / semestre	2	2	2	3	3
few days / year	1	1	1	2	2
	20	40	60	80	100

→ % of daily hours of work

Thierry Meyer

Source: www.urbanresilienceresearch.net

Module 1.5

Risk Resilience

Risk resilience: Definition

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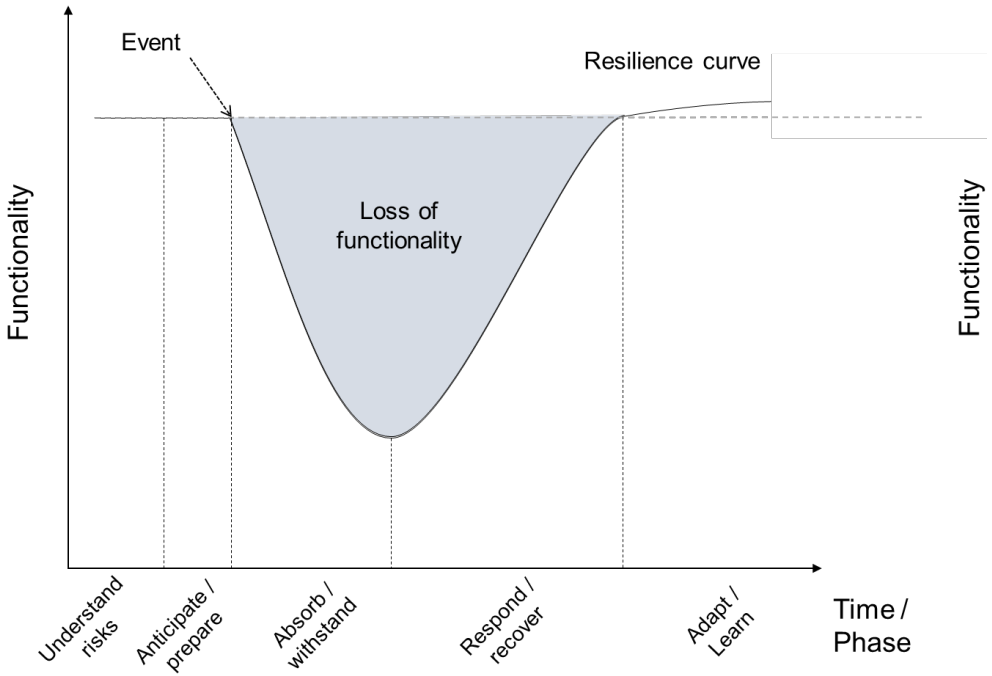
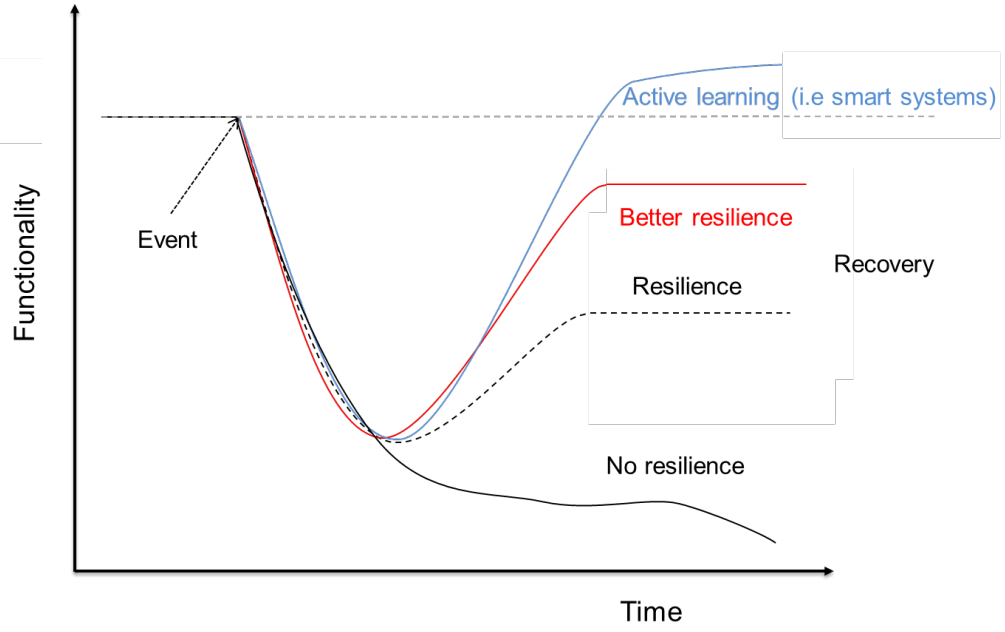
Resilience is the capacity to recover (quickly) and adapt effectively to adversity, challenges, or disruptions (shocks).





Risk resilience: Expectation

Source: https://listaka.com/

A resilient system possesses four key attributes:

1) **Capacity**: The ability to withstand threats.
2) **Flexibility**: The capability to adapt and respond to changing conditions.
3) **Tolerance:** The capacity to gracefully degrade when facing a threat.
4) **Cohesion**: The ability to operate seamlessly before, during, and after encountering a threat.

Thierry Meyer

Risk resilience: Resilience analysis grid

Following Erik Hollnagel's framework, there are four system categories:

1) Systems of the first kind: Reacts passively, always surprised, not truly resilient.
2) Systems of the second kind: Manages events as they happen and learns from them to adapt.
3) Systems of the third kind: Proactively analyzes and prepares for developments, excelling in all aspects of resilience.
4) Systems of the fourth kind: Achieves the highest level of resilience management by considering recursive anticipation of how changes affect the system and the world's responses.

Hollnagel, E. (2011) Resilience Engineering in Practice, UK, Ashgate.

Risk resilience: Conclusion (1)

- Systems should prioritize resilience over merely having a low probability of failure.
- Resilience engineering is a dynamic process.
- It will reveal safety margins and trends, and better understand abnormal process states.

Risk resilience: Conclusion (2)

Is the system resilient ?

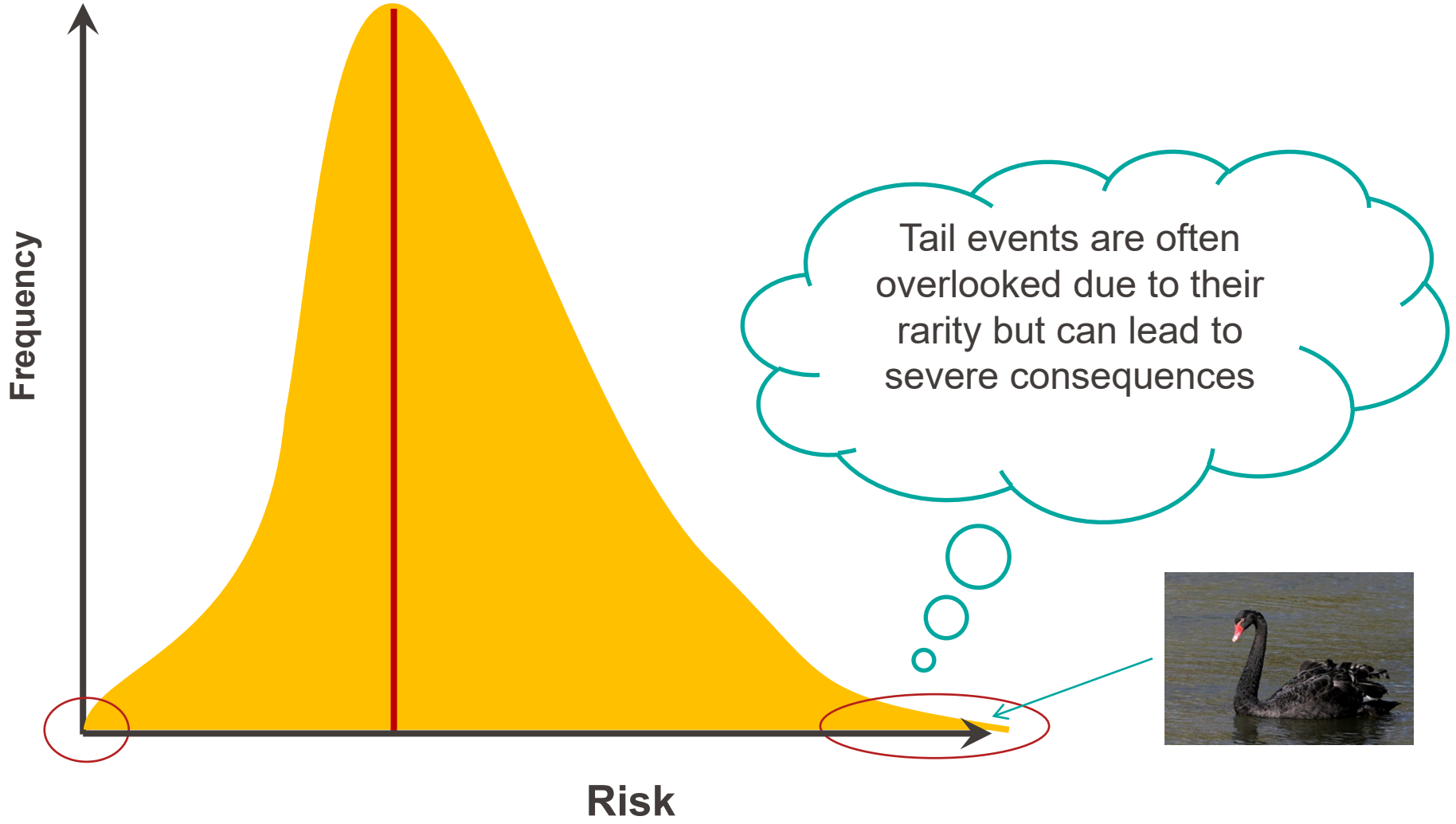
Time 1’13’’

Source: https://www.imdb.com , Tacoma bridge collapse on November 7, 1940; The failure of the bridge occurred when a never-seen-before twisting mode occurred (aeroelastic fluttering=resonance), from winds at a mild 40 miles per hour (64 km/h).

Module 1.6

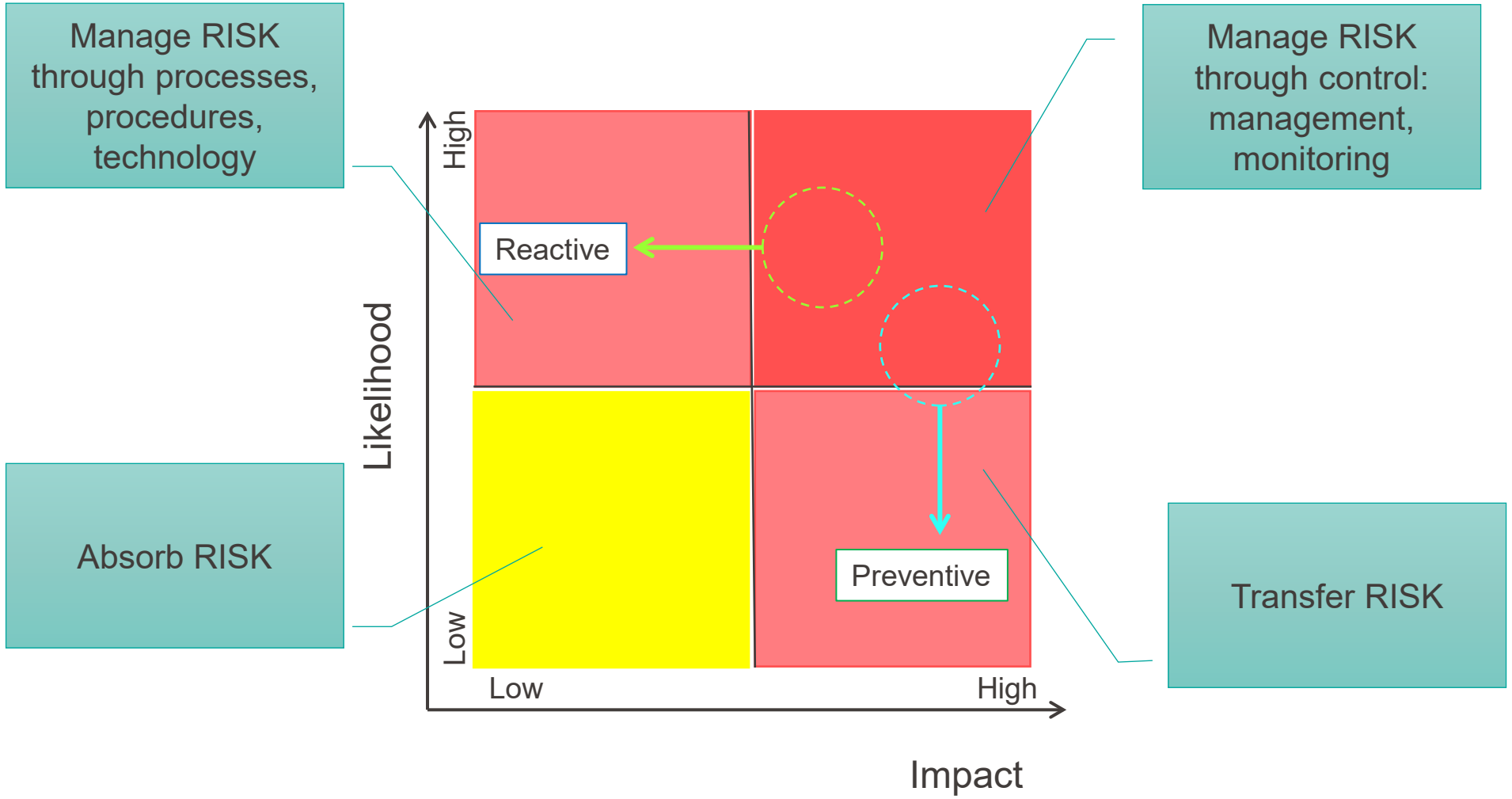
Risk management as a strategic tool

Risk distribution: Tails and mean value

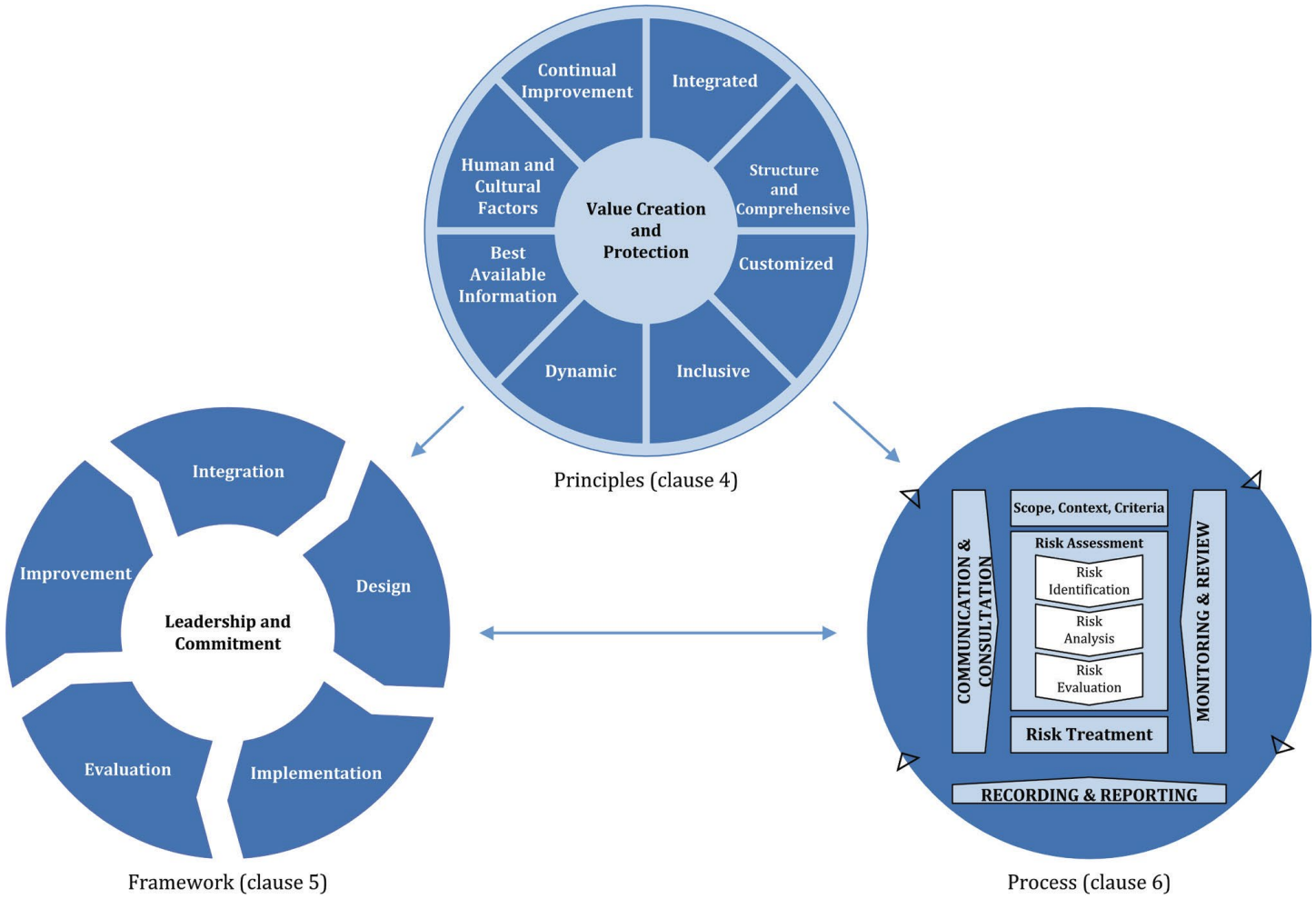


Risk identification : Consideration of likelihood and impact

Thierry Meyer



Risk management : Process



According to ISO 31000:2018, provides principles, a framework and a process for managing risk

Risk management: Why a risk portfolio ?

- Systematically list all hazards within your organization to fully understand the situation.
- Prioritize the management of various hazards.
- Identify scenarios that require a risk assessment.

Overview of potential hazards → management

Risk management: Risk portfolio - Objectives

Thierry Meyer

- Inventory of hazards and / or risks = KNOWLEDGE
- Map hazards and / or risks = EVALUATE
- Prioritize actions and resources = ACT
- Implement = CONTROL
- Reassess the situation = ITERATE

Risk management: Hazard mapping example

Source: National Geographic https://www.nationalgeographic.com

Module 1.7

Emerging Risks

Emerging risks: Definition

Source: http://www.itchronicles.com

Emerging risks may be characterized as follows:

- Uncertainty: New or novel.
- High Potential Impact: These risks can have significant and far-reaching consequences.
- Evolving Nature: Tend to change over time, influenced by factors like technological advancements, regulatory shifts, and societal changes.
- New environment: A previously known risk in a new or unfamiliar setting or amid new circumstances (re-emerging).

Some examples:

- Space commercialization and debris
- Climate change impacts
- Ageing population
- Antimicrobial resistance
- New viruses
- Social media and misinformation

Emerging risks: Characteristics - IRGC

Three types of emerging risks:

- Uncertain Impacts: Uncertainty resulting from advancing science and technological innovation

  Lack of knowledge and experience about consequences that could result from deploying new technology, in the form of new processes and products.

- Systemic Impacts: Technological systems with multiple interactions and systemic dependencies

  Loss of safety margins, one or more systems → systems interconnections increasing → higher levels of stress → systems may become more vulnerable to disruption and failure.

- Unexpected Impacts: Established technologies in evolving environments or contexts

  These risks emerge, not from new technology or complex systems, but as surprises in established areas of technology and human activity where it was presumed.

IRGC (2015), International Risk Governance Council

Emerging risks: According to SwissRe

Demographic and social environment

- Shifting demographics and global aging
- Growing middle class in high growth markets
- Longevity & radical medical innovation
- Prevalence of mental health issues
- Mass migration & urbanisation
- Changing workplace and talent gaps
- Rising social inequality & unrest

Political and economic environment

- Macroeconomic fragility
- Challenged globalisation
- Geopolitical & economic instability
- Rising interest rates and risk of persistent inflation
- Infrastructure funding needs

Technological and natural environment

- Addressing physical climate change risks
- Rising importance of biodiversity and ecosystem services
- Transition to a low carbon economy
- Expansion of digital & cyber risk
- Data as an asset
- Impact of generative AI
- Digital products and processes
- Disruptive digital technologies
- Autonomous transportation & robotics

Competitive and business environment

- Re/insurance value chain disaggregation and rise of alternative re/insurance providers
- Consolidation of platforms as a business model through strategic partnerships
- Regional champions going global
- Increasing digital customer interaction
- Increasingly litigious environment
- Rising importance of Environmental, Social and Governance (ESG)

SwissRe Institute (2024) Swiss Re SONAR: New emerging risk insights

The biggest risk ? Not taking one.

Source: https://www.universityofcalifornia.edu/news/risk-tolerance-your-dna

Module 1.8

Conclusion

Conclusion: Observation

Thierry Meyer

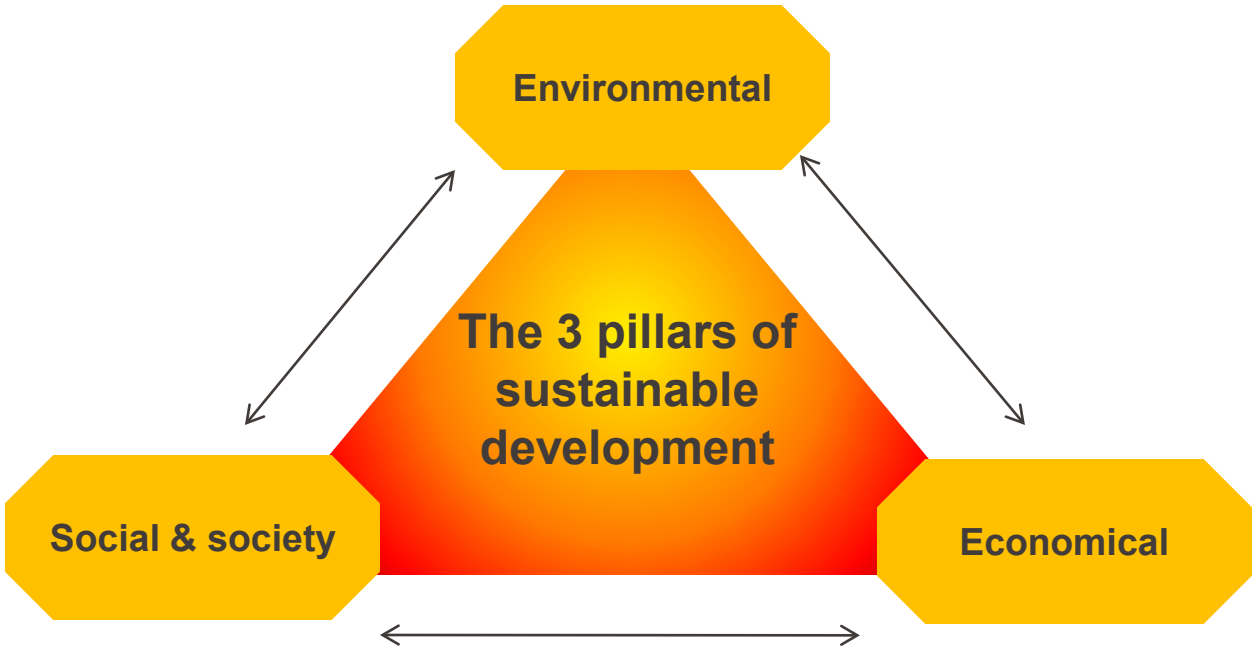
To fulfill its protective role effectively, risk management must be dynamic, proactive, and responsive, based on vigilant and continuous monitoring of precarious situations.

- Estimating probability can be challenging and often depends on indirect indicators.
- Risk must include an element of uncertainty as well as an associated cost.

Conclusion: Sustainability

Risk management supports sustainable development by:

- preserving resources,
- mastering risks,
- reducing disruptions,
- and engaging stakeholders in organizational efforts.



Conclusion: Statements

- Safety is not just for safety specialists.
- Engineers should identify and communicate safety issues to communities.
- Engineers must improve communication on risk with all societal segments.

Source: https://delfinanicora.cumbresblogs.com

Conclusion: Risk appetite (1)

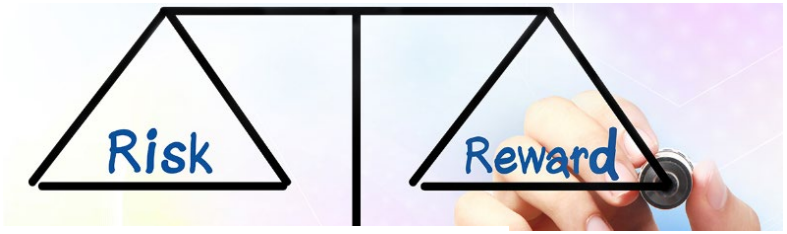
- Risk appetite is the level and type of risk an organization is willing to accept to achieve its strategic objectives.

- While risk appetite reflects a proactive approach to taking risks, risk tolerance indicates the level of risk an organization can realistically withstand, balancing willingness and capacity.

- A dynamic company embraces risk, shows courage, and raises its risk tolerance level?

→ Risk ownership !

Conclusion: Risk appetite (2)



Risk appetite vs. risk tolerance

If risk appetite represents the official speed limit of 80, risk tolerance is how much faster you can go before likely getting a fine.

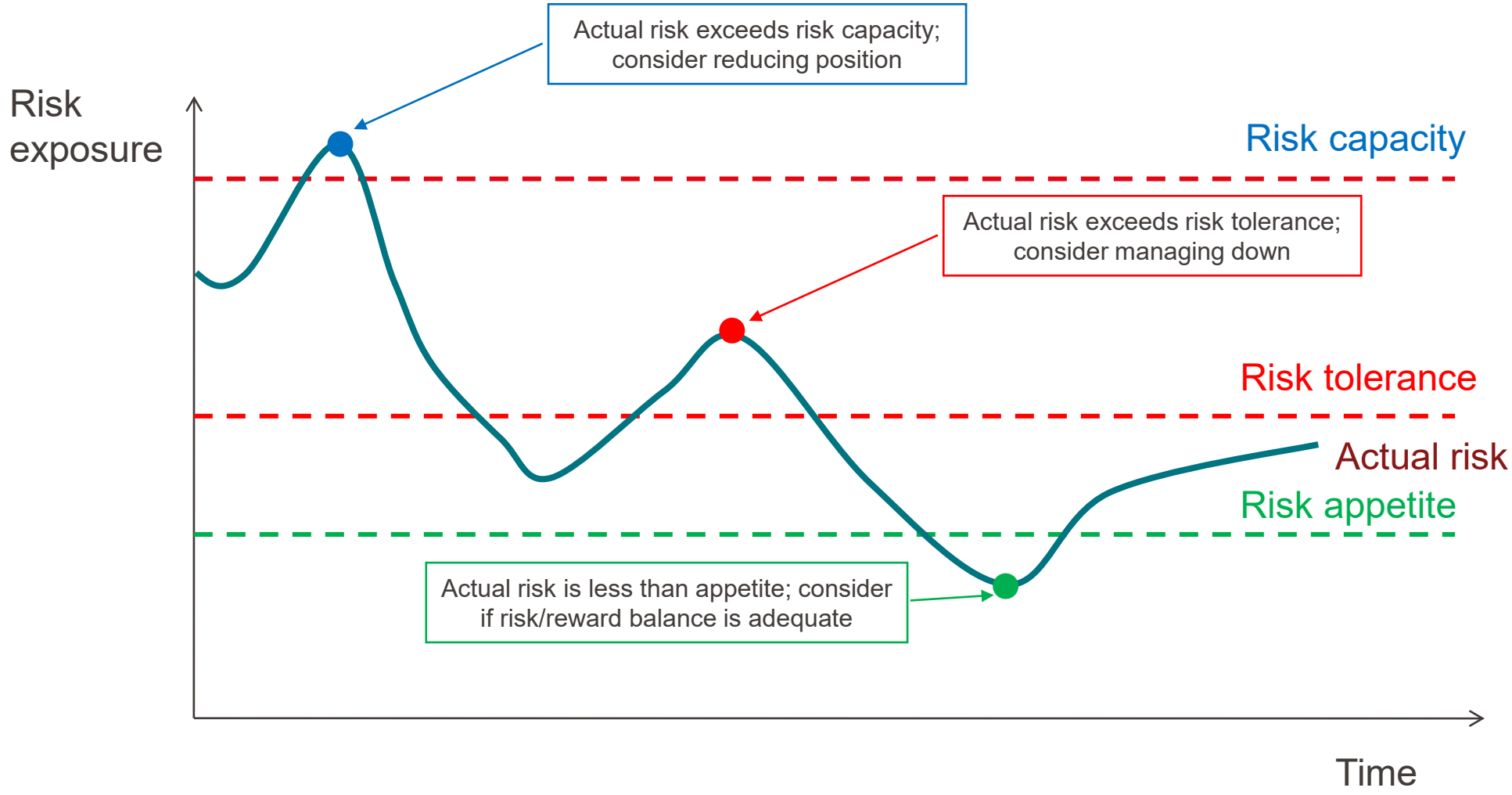
Risk appetite
(ranges from 0-80 km/h):
The amount of risk an organization is willing to accept to achieve its objectives

Risk tolerance
(ranges from 80-90 km/h):
The acceptable deviation from the organization risk appetite

Unacceptable risk
(90 km/h and above):

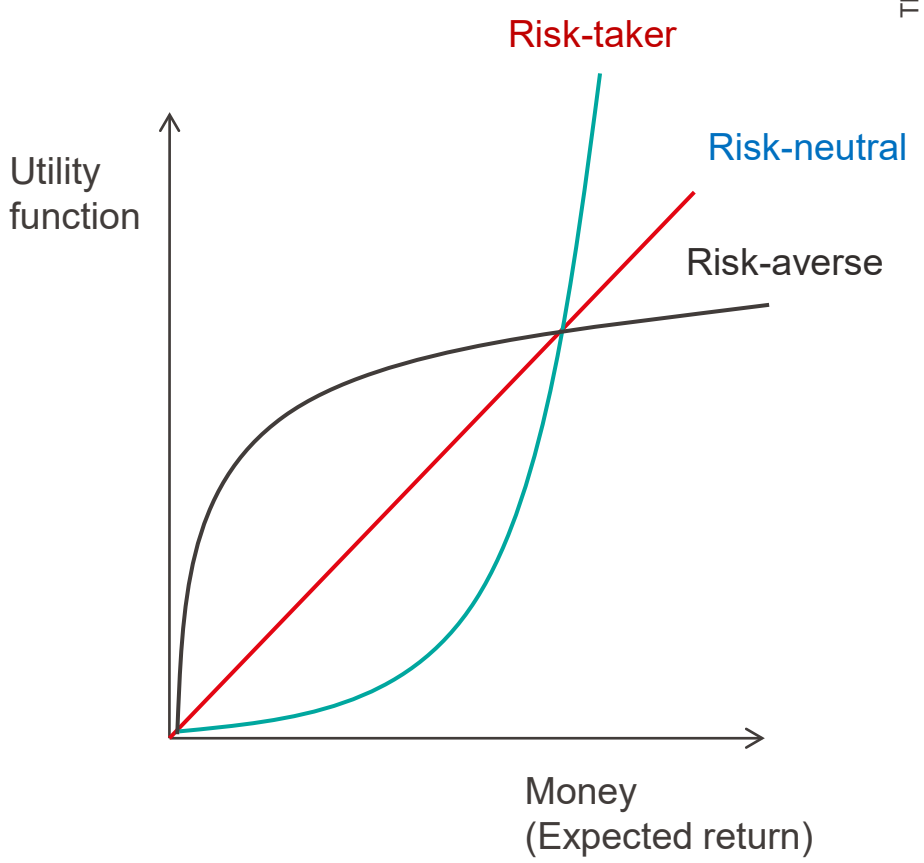
Conclusion: Risk appetite (3)

How are risk capacity, risk tolerance, and risk appetite related?



Conclusion: Risk appetite (4)

- You are risk-averse when you prioritize safety and certainty over the potential for higher rewards that come with greater risk.
- You are risk-neutral when you focus only on potential returns, without preference for or against risk.
- You are a risk-taker or risk-lover when you embrace uncertainty and potential loss, seeking higher rewards despite the associated risks.



Conclusion: Reality is surprising !

Time 36``

Should I take the risk ?

Source: https://www.istockphoto.com/de/fotos/cat-chasing-mouse

Module 1.9

Too fast to conclude ?

Too fast ?: Hotel logo

What are you currently reading?

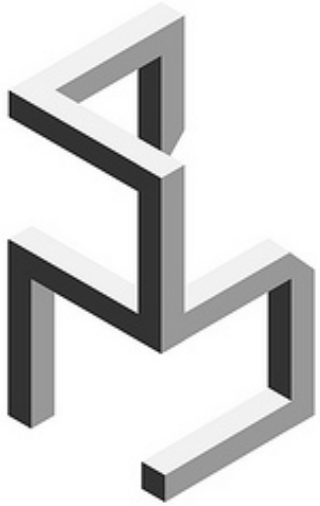
Too fast ?: Dices

How to pile dices?

Source: https://www.futura-sciences.com

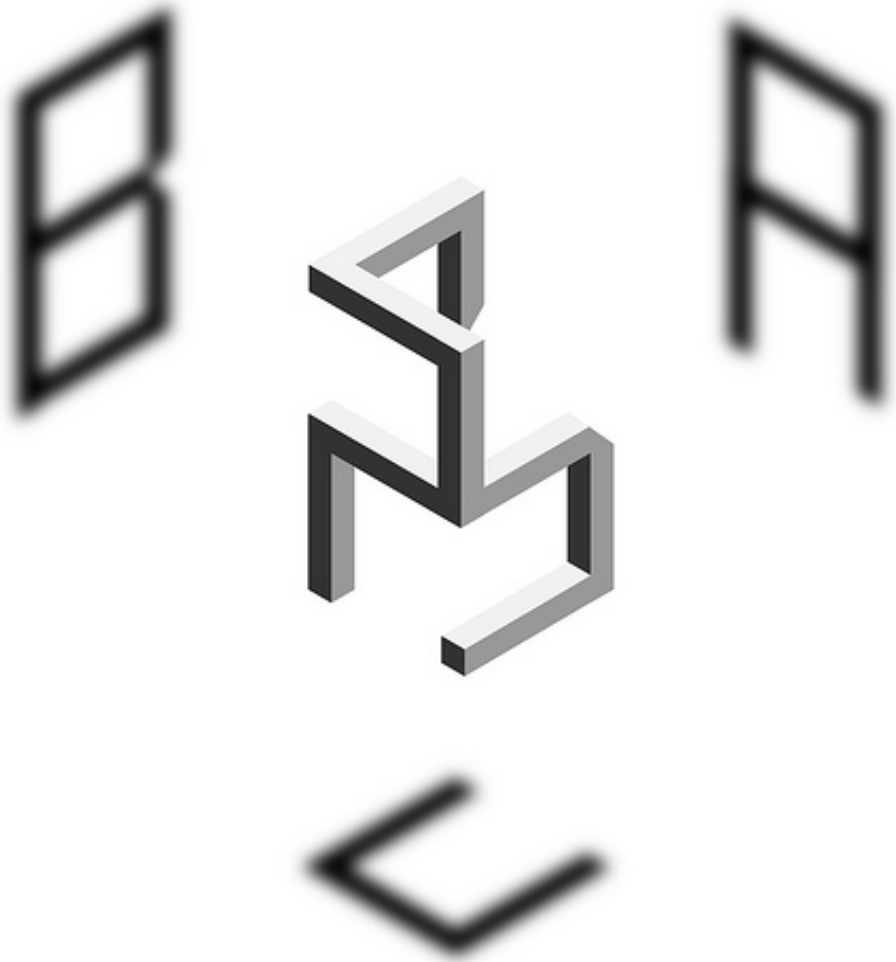
Too fast ?: Can you read ?

What do you see?



Source: https://commons.wikimedia.org/

Too fast ?: Can you read ?



Ambigram

Thierry Meyer