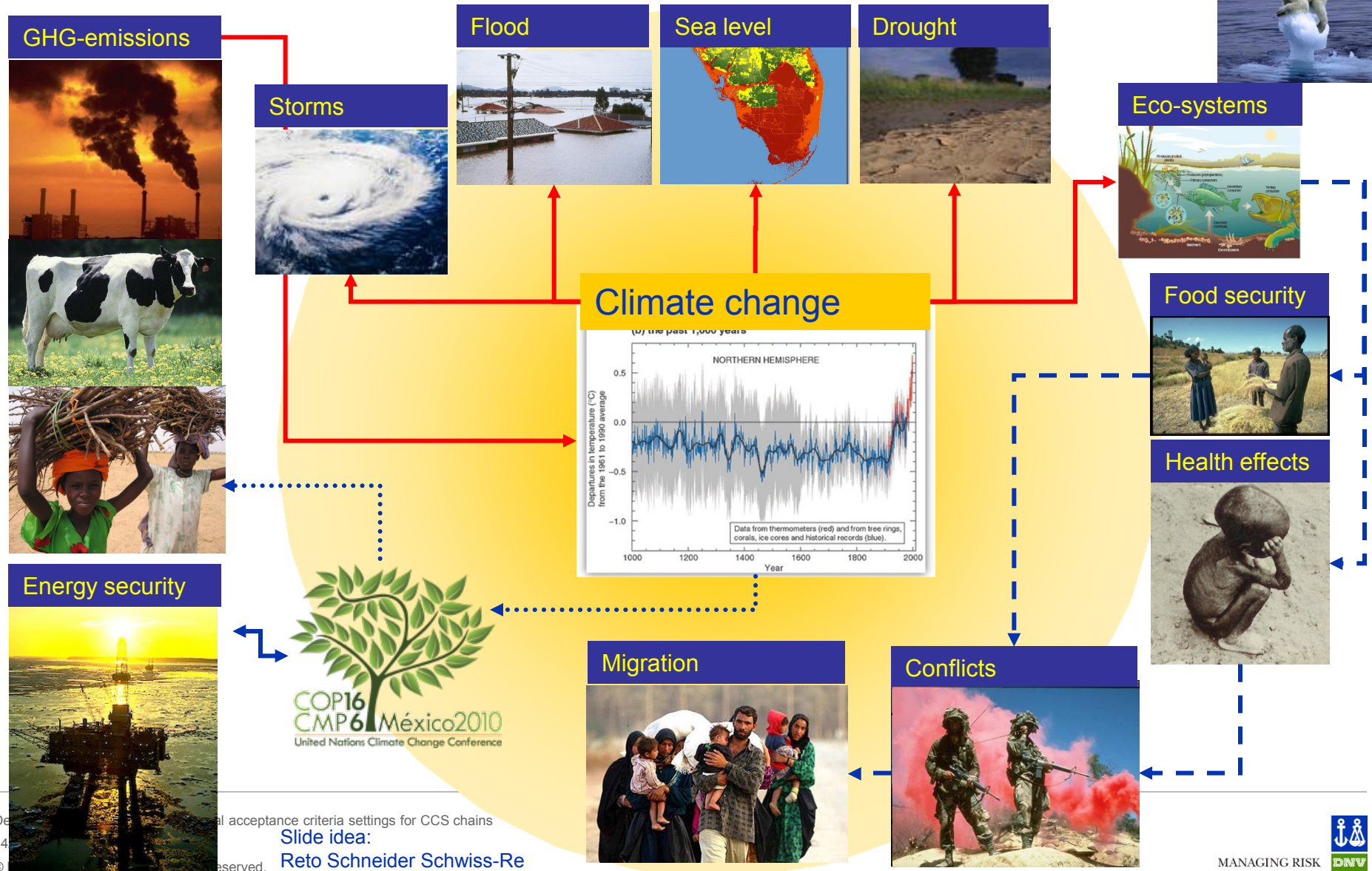# Development of guidelines for rational acceptance criteria settings for CCS chains

P Friis-Hansen, AL Koefoed, T Myhrvold, EA Hektor, S Solomon

14/6-2011

MANAGING RISK **DNV**

The climate change effect cycle

Slide idea:
Reto Schneider Schwiss-Re

MANAGING RISK

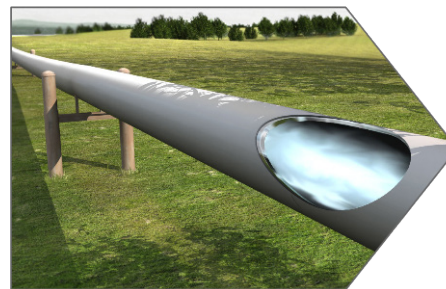# The CCS value chain

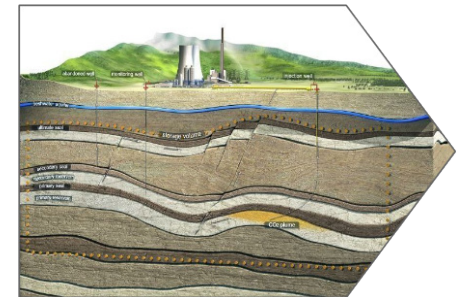CCS is one mean to mitigate the unwanted consequences of climate change
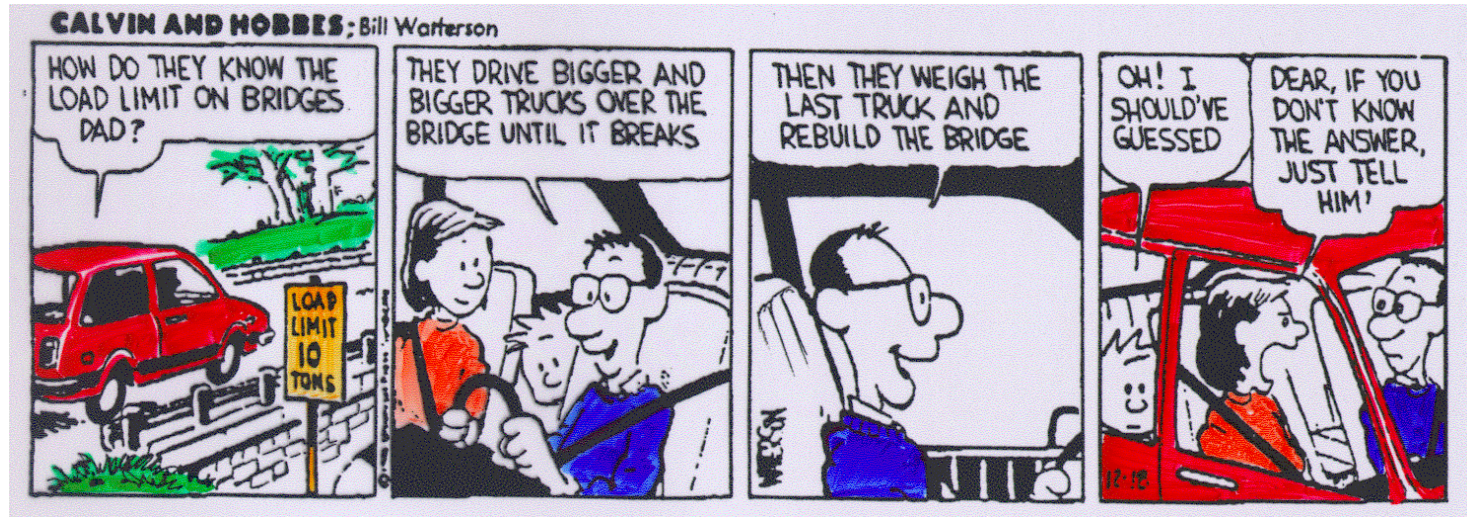

Power plant **Capture** **Transport** **Storage**

Many things may go wrong that all may have severe or catastrophic impact not only to the owner/operator but also to the surrounding society

How may we assure that the CCS value chain is sufficiently safe ?

Traditional acceptance criteria setting by normative rules – How safe is safe enough?

- Based on historic research and past experience
- Give no indications of how to update the rules

- There exist no or only limited experience for guiding the setting the acceptable level of risk for large-scale CCS projects

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NUMBY – Not Under My Back Yard!

The opposition to CCS projects has shown that there is a need to better understand local beliefs, to situate plans in the local contexts, and to understand why the public chooses to oppose or support CCS projects

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Definition of Risk, Vulnerability and Resilience

Frequency	*Probability*	*Loss types $*	*Probability*	*Loss types $*
Hazard	Barriers	Direct consequences	Barriers	Indirect/ consequential damage
	magnitude Impact		Rules	

Risk = ∑ Expected (monetary) loss of all direct and indirect events

"Vulnerability is the degree to which a system is likely to experience harm due to exposure to a hazard" (WB, 2009)

"Resilience is the ability of an organization (system) to keep, or recover quickly to, a stable state, allowing it to continue operation during and after a major mishap, or in the presence of continuous significant stresses" (Wreathall, 2006)

Clarifying the Terminology

- **_Owner_**

  - refers to the set of investors in a CCS project encompassing the whole value chain

- **_Public_**

  - refers to all parties (or stakeholders) that somehow may be affected by the CCS-chain

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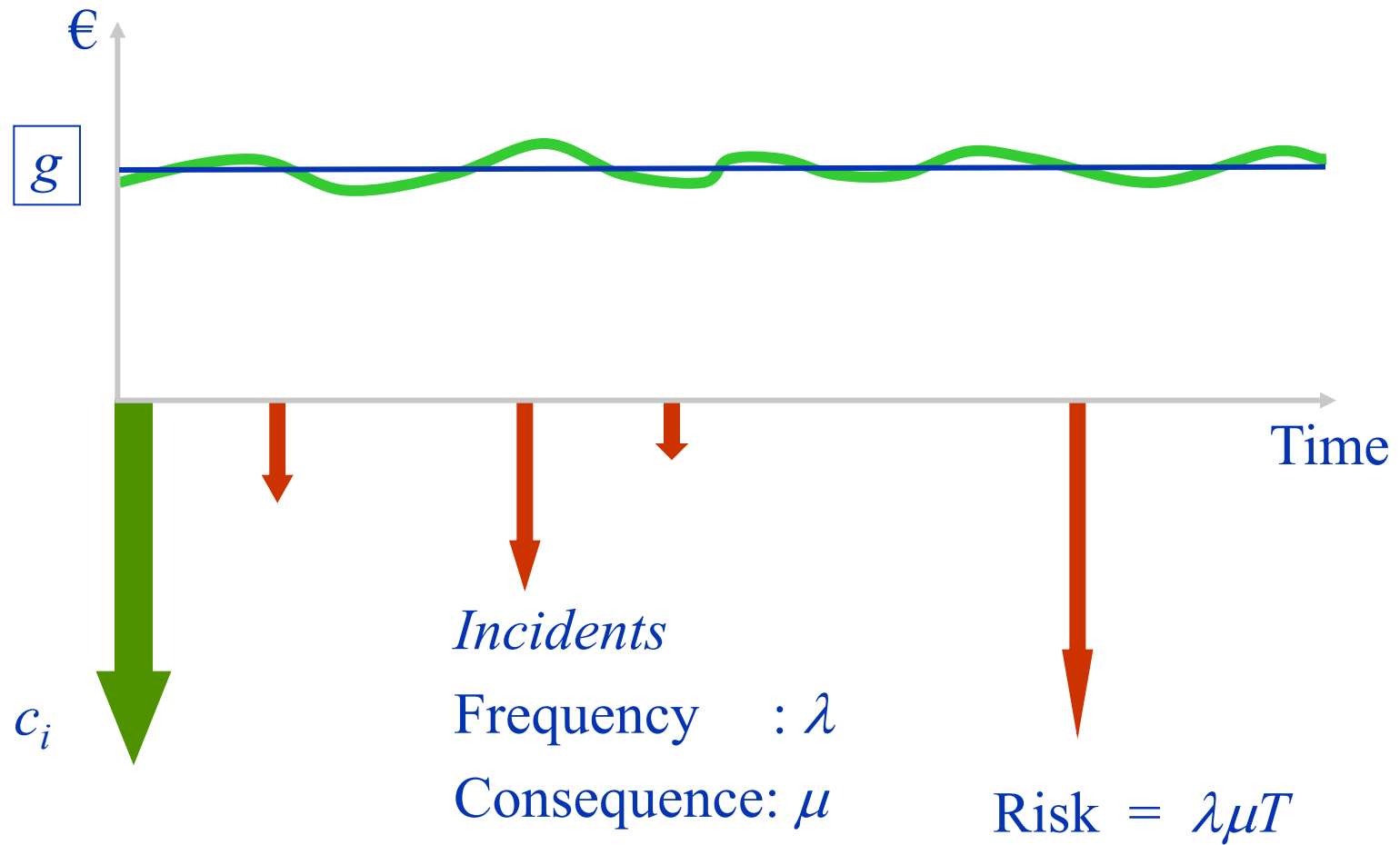
Risk-based design – questions

- How does the risk analysis enter the decision process of the owner ?

- How large a risk does the owner impose on public by his activities ?

- How large benefit does public gain form the activity … and how large should the benefit be to cover the loss of public?

- How safe is safe enough … or … how much are we willing to invest in safety ?

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Owner invest c_i to obtain a gain g

€

g

c_i

Time

Incidents

Frequency : λ

Consequence: μ

Risk $= \lambda \mu T$

Owner loss: Design with respect to optimal monetary gain

Owner's optimisation

loss

Total loss

$c_i(\lambda, \mu)$=design cost

$\lambda\mu T$= risk

Best design
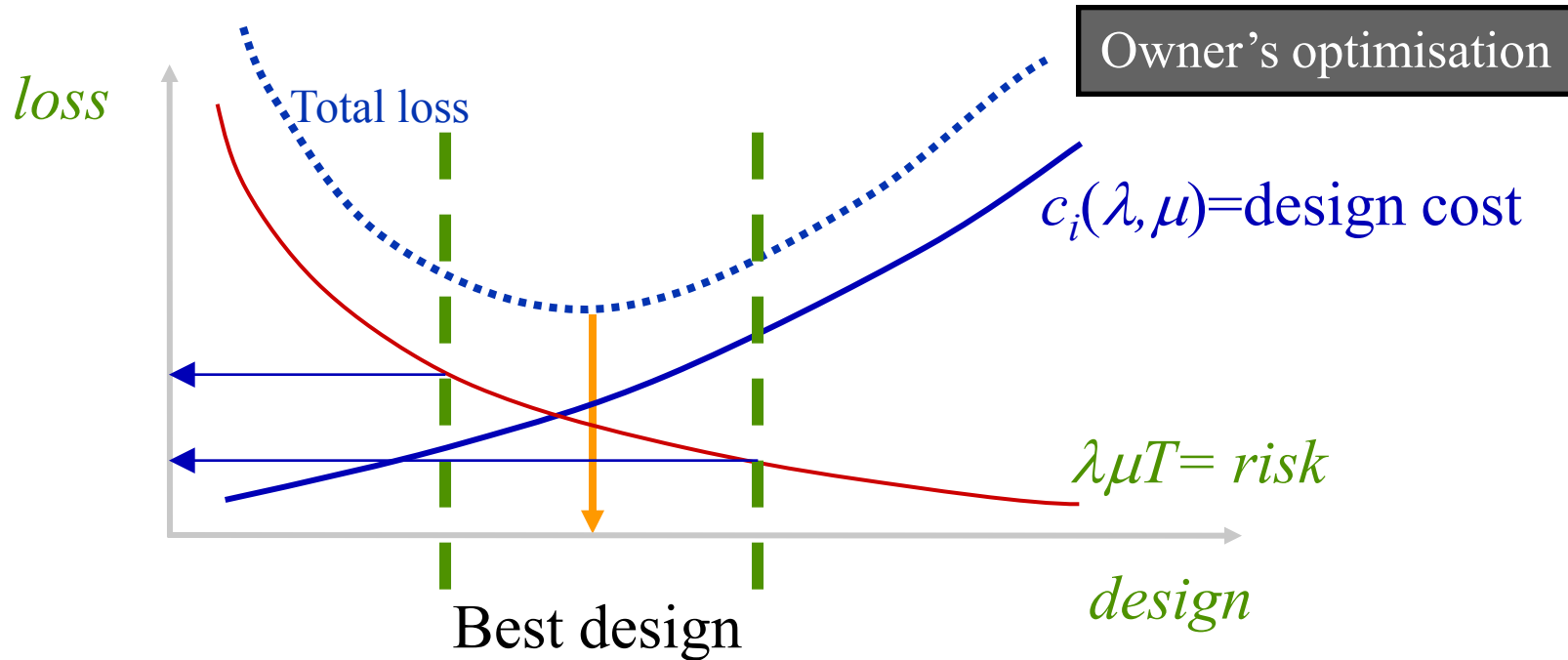
design

The more the owner invest the better the design

The better the design, the lower is the risk

Public sets restrictions to how large a risk it can accept

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Risk perception – the loss types

- **Owner losses** are typically tangible
  - loss of property
  - loss of production
  - Indemnification
  - +++

- **Public losses** are typically intangible
  - human lives, feeling of safety, welfare
  - public property
  - aesthetic values
  - culture
  - environmental qualities of nature
  - +++

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Principles for acceptance criteria setting

1. Any operation that may cause damage to a population group without counteracting benefit or compensation should not be undertaken

2. Tax paid by employees cover the expenses to maintain ordinary well fare

3. Salary taxes are generally not used to compensate damages from severe adverse events

4. The person or body that causes the damage must also compensate for the damage. The company tax yield must be sufficiently large to cover the loss of the society in excess of owners direct compensation

5. The concept of society is independent of country borders. It is not important whether tax is paid in the one or the other country

Rational risk acceptance setting

Owners net gain: $\qquad g - \lambda\mu_o > 0$

> Owner accepts only if he has a positive income

How large a risk should public be willing to accept ?

Public gain: $\qquad (g - \lambda\mu_o)\, r$

> Public gain is though taxation of owners net gain

The public gain should at least cover the public loss

$$(g - \lambda\mu_o)\, r \geq \lambda\mu_p$$

> When public increases its loss μ_p then owner must design safer

μ_p is related to the wealth of the society, i.e. GDP

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Rearranging the acceptance criteria

$$\frac{\lambda \mu_o}{g} \leq \left(1 + \frac{1}{r} \frac{\mu_p}{\mu_o} \right)^{-1}$$

What does it show ?

Owner risk is measured relative to owner gain

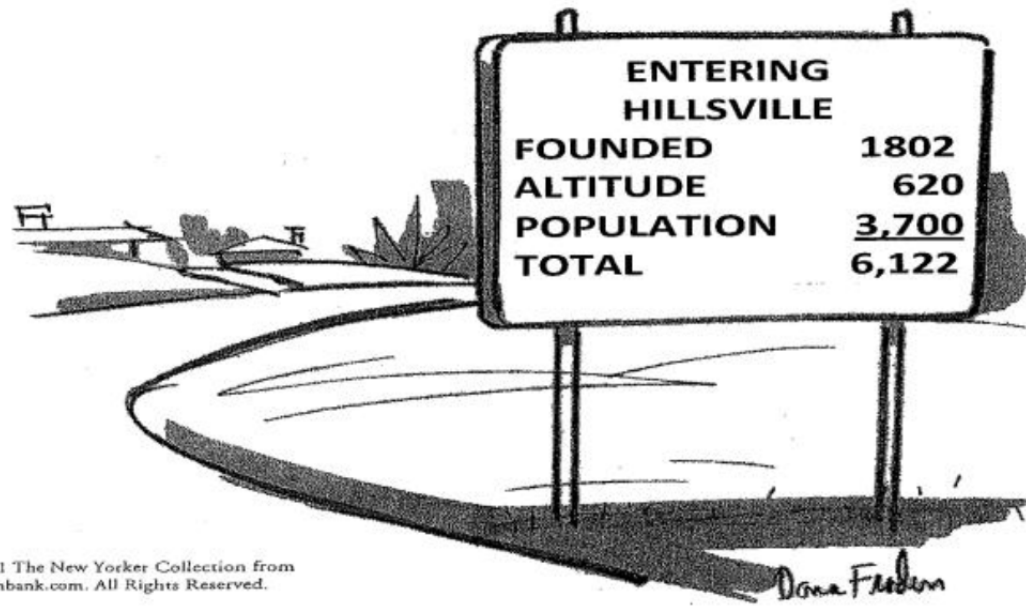$$\frac{\lambda \mu_o}{g} \leq \left(1 + \frac{1}{r}\frac{\mu_p}{\mu_o}\right)^{-1} = 0.03$$

Restriction is defined by the ratio between public loss and owner loss

Example:
$\mu_p / \mu_o = 100$
$r = 1/3$

Guideline for rational acceptance criteria setting

- Step 1: Agreeing on the fundament for acceptance

- Step 2: Identification of consequence spectra *for the owner and for the public*, including setting the monetary equivalent of the consequences

- Step 3: Validation of constructed (transparent) risk models to assure that these display how all relevant adverse events are envisaged to materialize

ENTERING
HILLSVILLE
FOUNDED   1802
ALTITUDE   620
POPULATION   3,700
TOTAL   6,122

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Transparent multi-criteria decision making

Label		None	Negligible	Significant	Serious	Critical	Catastrophic
Consequence Class	Abbreviation	3	4	5	6	7	8
First and second party	PD	Bruises and minor damages that do not require hospital treatment	1 injury requiring hospital treatment	Several incidents requiring hospital treatment	Several incidents requiring hospital treatment. 1 disabled	1-10 killed	More than 10 killed
Third party	ND	Uncomfortable, insecurity	Bruises and minor damages that do not require hospital treatment	1 injury requiring hospital treatment	Several incidents requiring hospital treatment	Several incidents requiring hospital treatment. 1 disabled	1 or more killed
Production	PR	Short production stop	2 hours production stop	1 day production stop	1 week production stop	1 month production stop	1 year production stop
Material	MK	Minor repairs that can be done immediately by own crew	Repairs that takes several days to carry out	Damages that takes weeks to repair and will affect the system	Damages that takes months to repair and cause serious consequences	Very large material damages	Significant parts of the system destroyed
Environment	EM	None/negligible	Minor environmental damages. Restored within days	Serious environmental damages. Restored within weeks	Serious environmental damages. Restored within months	Critical environmental damages. Takes 1-2 years to restore	Catastrophic environmental damages. Takes several years to restore
Monetary value (€)		1.000	10.000	100.000	1.000.000	10.000.000	100.000.000
Acceptability per year		Negligible	Tolerable	Unwanted	Unacceptable	Unacceptable	Unacceptable

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