Phd Seminar

Probabilistic Analysis

of Systems in Engineering

Snow supporting structures

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12.12.2007

[www.slf.ch/.../schutzwald/lawinenzug.jpg]

Objective of the presentation

Describing a system comprising all constituents that are important for decision making for the natural hazard process of avalanches – snow supporting structures are one subsystem out of that system.

Overview of the presentation:

Introduction to snow supporting structures

Description of the system

Constituents of system
and further characteristics as a "system"

System modeling: General overview over the modeling

Example of modeling: Probabilistic analysis of a constituent

[www.slf.ch/.../schutzwald/lawinenzug.jpg]

[www.air.droessler.at]

Introduction to snow supporting structures

Alpine regions: Every year severe damage by snow avalanches, and high costs of mitigation measures.

Measures against avalanches? Examples:

In the starting zone:
- Snow supporting structures (Grills, nets, dams, forming of the ground into terraces, forest)
- Dynamite

In the transition zone:
- Land use planning (buildings, summer/winter-tourism)
- Organizational measures

In the deposition zone:
- Land use planning
- Object protection

[Richtlinie Objektschutz gegen Naturgefahren, AWEL Kanton Zürich Baudirektion]

Introduction to snow supporting structures

Objectif: Reduce movements of snow.

Placed regularly until slope <30° or the expected remaining masses of snow are reduced to an acceptable risk.

Avalanches already ongoing can not be absorbed by these structures.
In order to handle dynamic forces: adapted arrangement of the structures.

The sides should end at natural geological lines, if not then the border structures have to be dimensioned stronger.

Two basic types:
- Nets – less vulnerable to rockfall.
- Grills – easier foundation in loose rock.

Snow supporting structures as a system?

Description of the system

What do we want to predict with the model?

Interested in damages (all types of consequences) due to avalanches, and the effect of snow supporting structures on consequences.

System definition starting from a decision problem / system comprising everything that I need to consider for decision making; it should connectable by logical relations, given by the decision problem.

Constituents of the system

Probability of an avalanche with the potential of causing consequences -
Snow energy (velocity), Snow volume

Damage potential

Resistance of snow supporting structures to the snow pressure

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Further Characteristics of "system"

Robustness

Resilience

Redundancy

Connectivity

Terms used for nervous (brain), biological (forest) systems - in the context of manmade constructs?

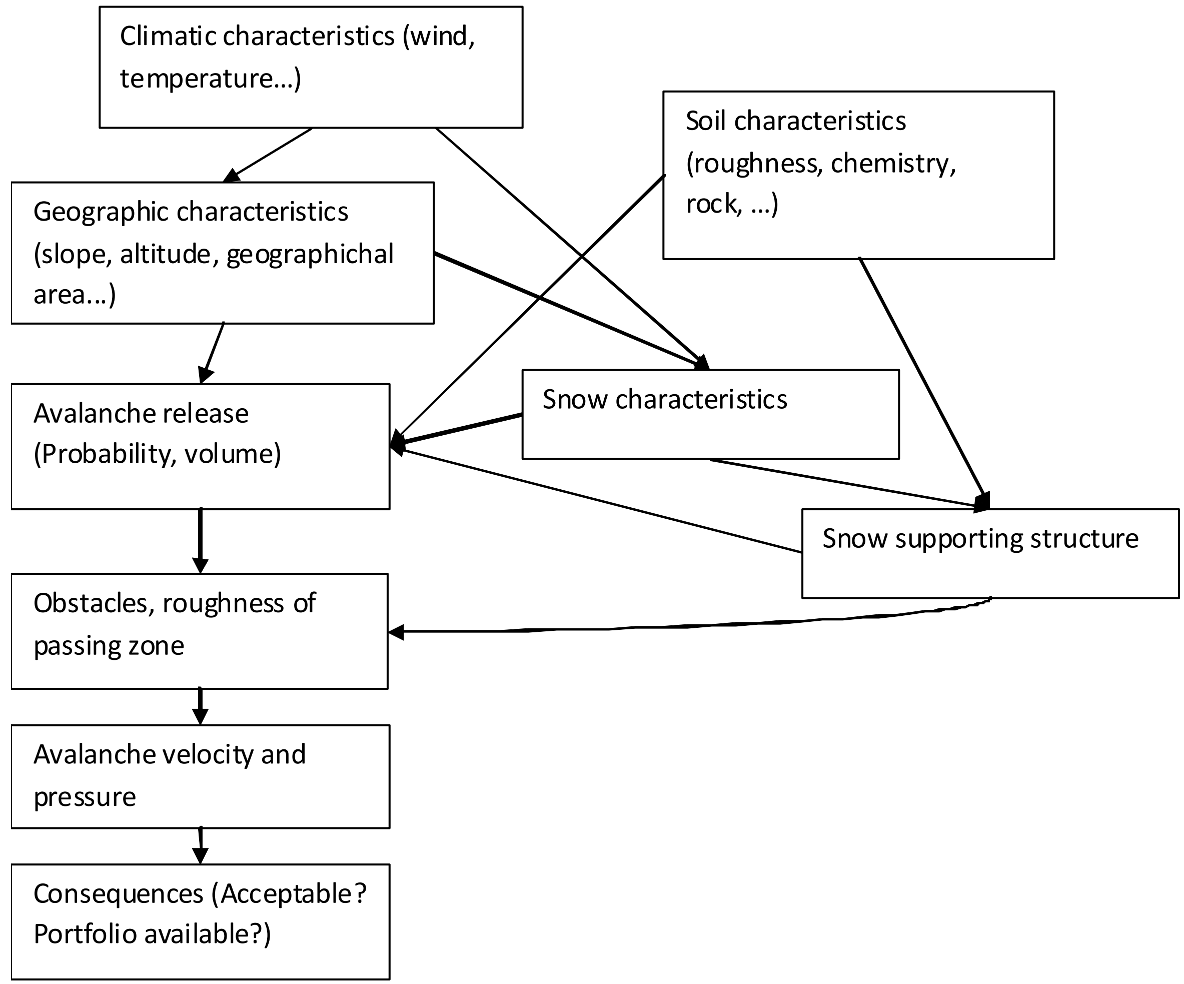
System modeling: General overview over the modeling

1. Physical understanding

2. Represent the relevant experience

3. Represent the available data at different hierarchical Levels

[M. Sandomeer, intern presentation Phd Seminar on Probabilistic Analysis of Engineering Systems, SS 2007]



Example of modeling

[A. Grêt-Regamey and D. Straub (2006): Spatially explicit avalanche risk assessment linking Bayesian networks to a GIS. Nat. Hazards Earth Syst. Sci., 6, 911–926, 2006]

Assessment of the uncertainties in the modelling of the avalanche – important for the proper assessment of the avalanche runout zones and estimation of the damage potential!

$$R = \mathrm{E}_{O,F,K}[C_T] = \int_O \int_F \int_K P(k|o,f)P(f|o)P(o) \cdot C_T(o,f,k)\,dk\,df\,do$$

System exposure O – Probability of occurrence of avalanche hazard event to the considered system

System resistance F – Intermediate processes and elements modifying the exposures in the system; e.g. avalanche defence structures

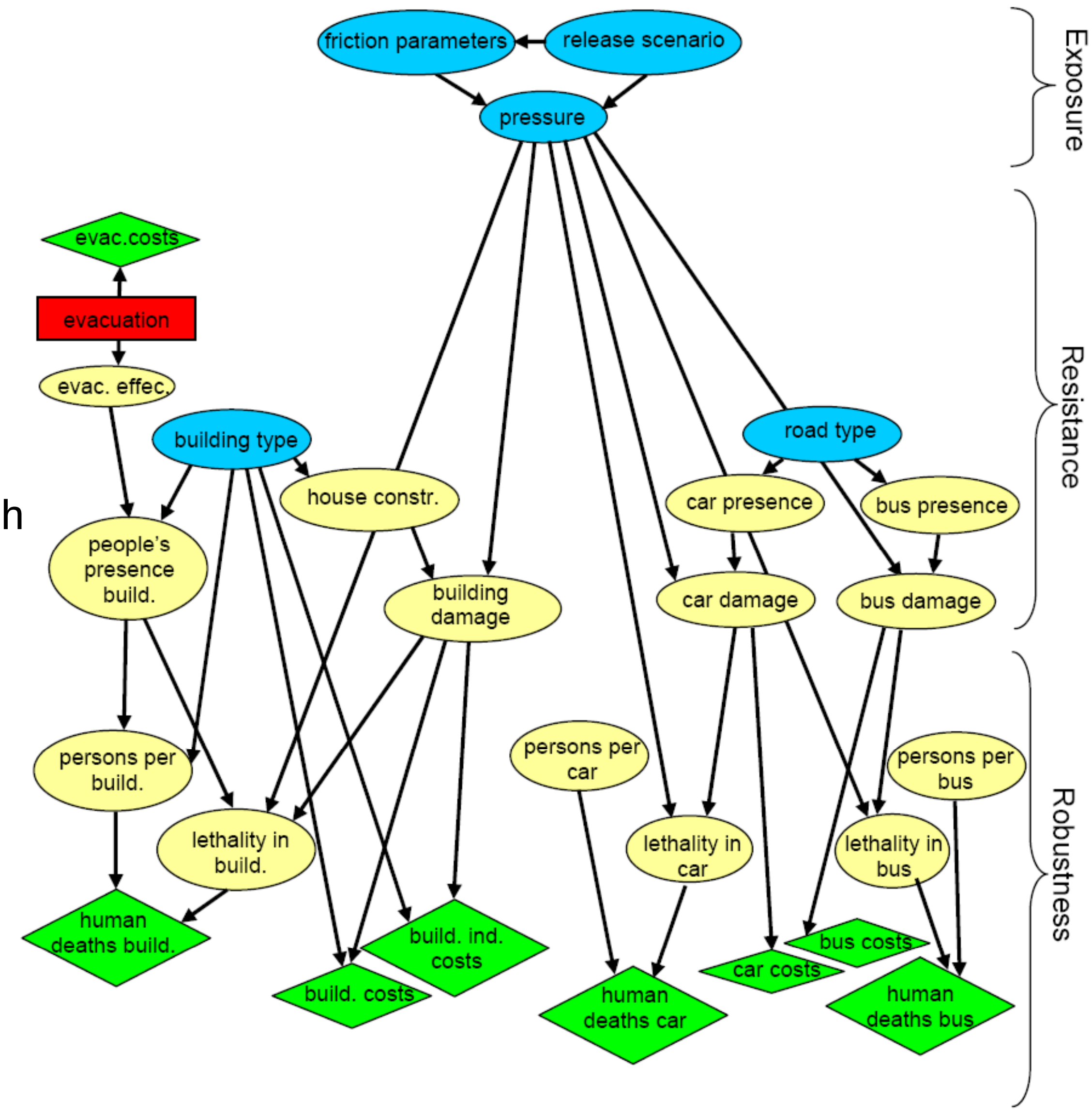
System robustness K – Reaction of the system to damaging events

Example of modeling

A. Grêt-Regamey and D. Straub

Fig.: Decision graph (BN extended with decision nodes and utility nodes)

→Complete probabilistic model of P, in combination with the joint probabilistic model of the friction parameters and the release scenarios.



Example of modeling

A. Grêt-Regamey and D. Straub

Comparison to the “traditional approach”, calculating with deterministic values:

Risk computed from expected value of each random variable (no probability distribution of variables, no joint probability distribution)

For a given avalanche release scenario,
- calculate separately the risk for each building, road type
- replacing all probability distributions by the mean probabilities.

If all relations among the variables were linear, then the BN and the “traditional” approach would lead to the same results.
(E.g. if letality/mortality in buildings was a linear func of the building damage.)

	30-year avalanche release scenario		
	Traditional approach [CHF/yr]	Bayesian Network approach [CHF/yr]	% difference
multiple family house	1 392 502	996 266	28
one-family house	620 871	485 565	22
hospital and clinic	0	0	0
hotel	70 850	51 279	28

Example of modeling

A. Grêt-Regamey and D. Straub

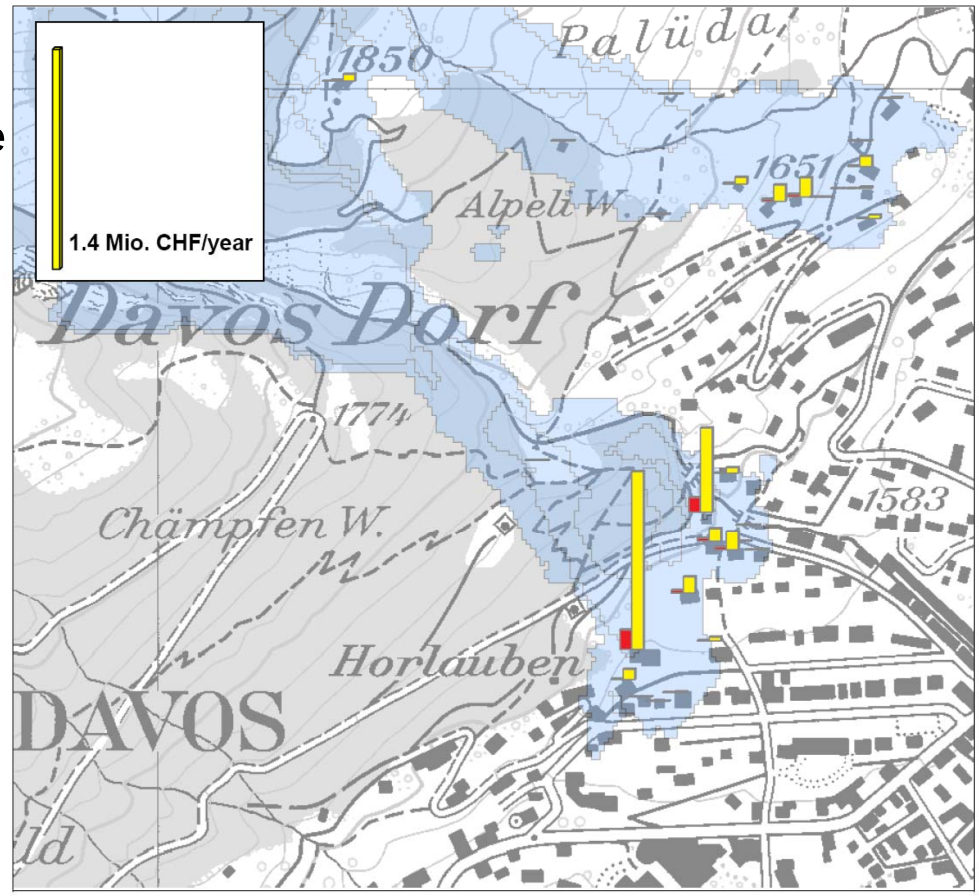
Representation of the uncertainty in a map: Expected costs (red) and upper bound of a 95%- interval (yellow).

→Uncertainties are large at the border of the avalanche run-out areas – visible due to uncertainty modelling.

Knowing uncertainty, and knowing its influence on the risk (sensitivity analysis), allows specifying the data to Precise and allows updating the probabilities.

Variables identified with the largest impact on the outcome:

- •Uncertainties in Pressure
- •House construction
- •People present



Thanks for your attention