GEOTEST AG

Hazard assessment and risks

Dr. Bernhard Krummenacher

Content

1. Short presentation of GEOTEST AG
2. Integrated Risk Management – Swiss Concept
3. Hazard Assessment – Modelling Landslides
4. UAV in Hazard Assessment, Processing UAV Data
5. Hazard and Risk > cost efficiency of protection measures

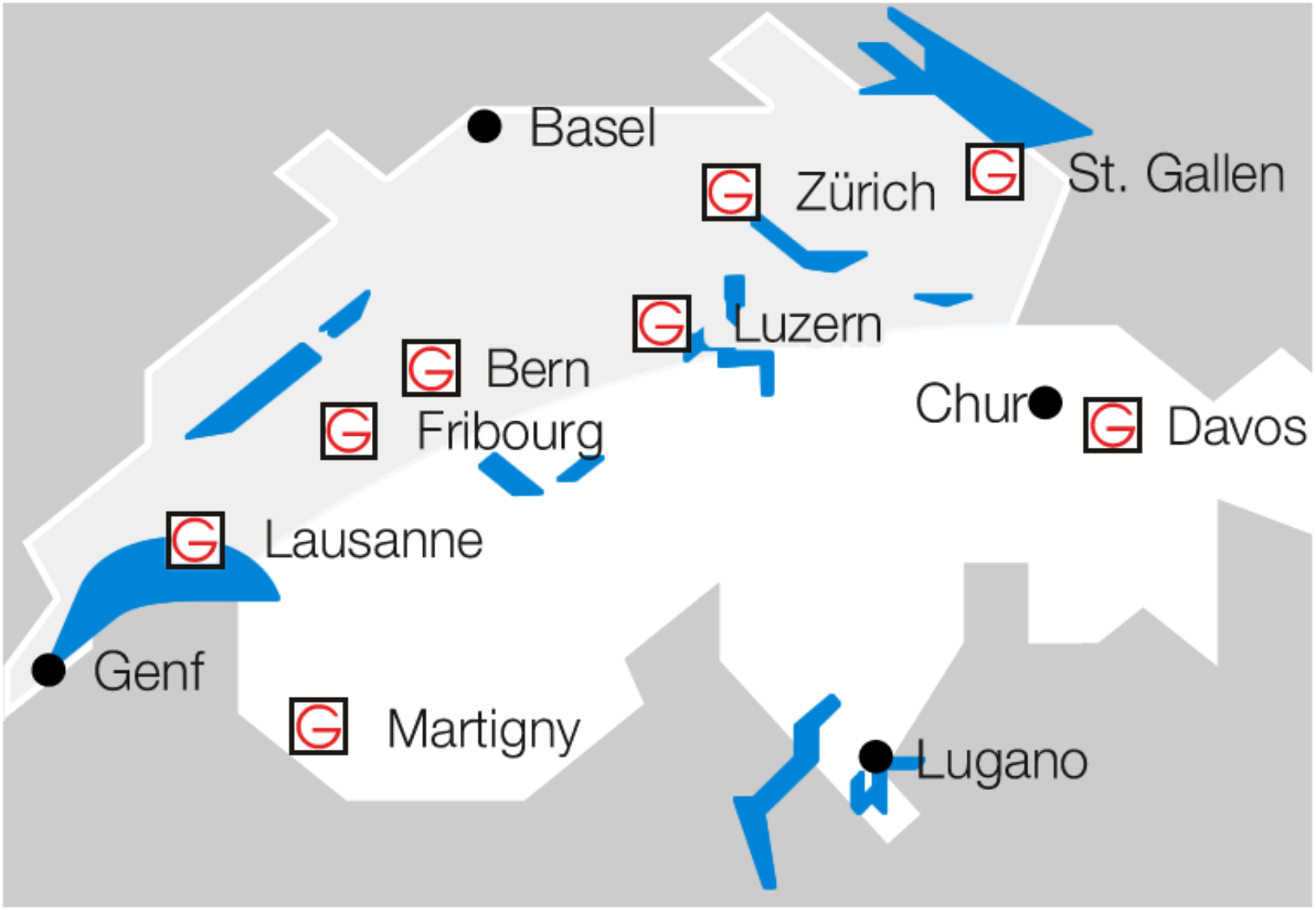
Company Profile

- GEOTEST AG was founded in 1962
- Public limited company
- Head office: Zollikofen (Bern), Switzerland

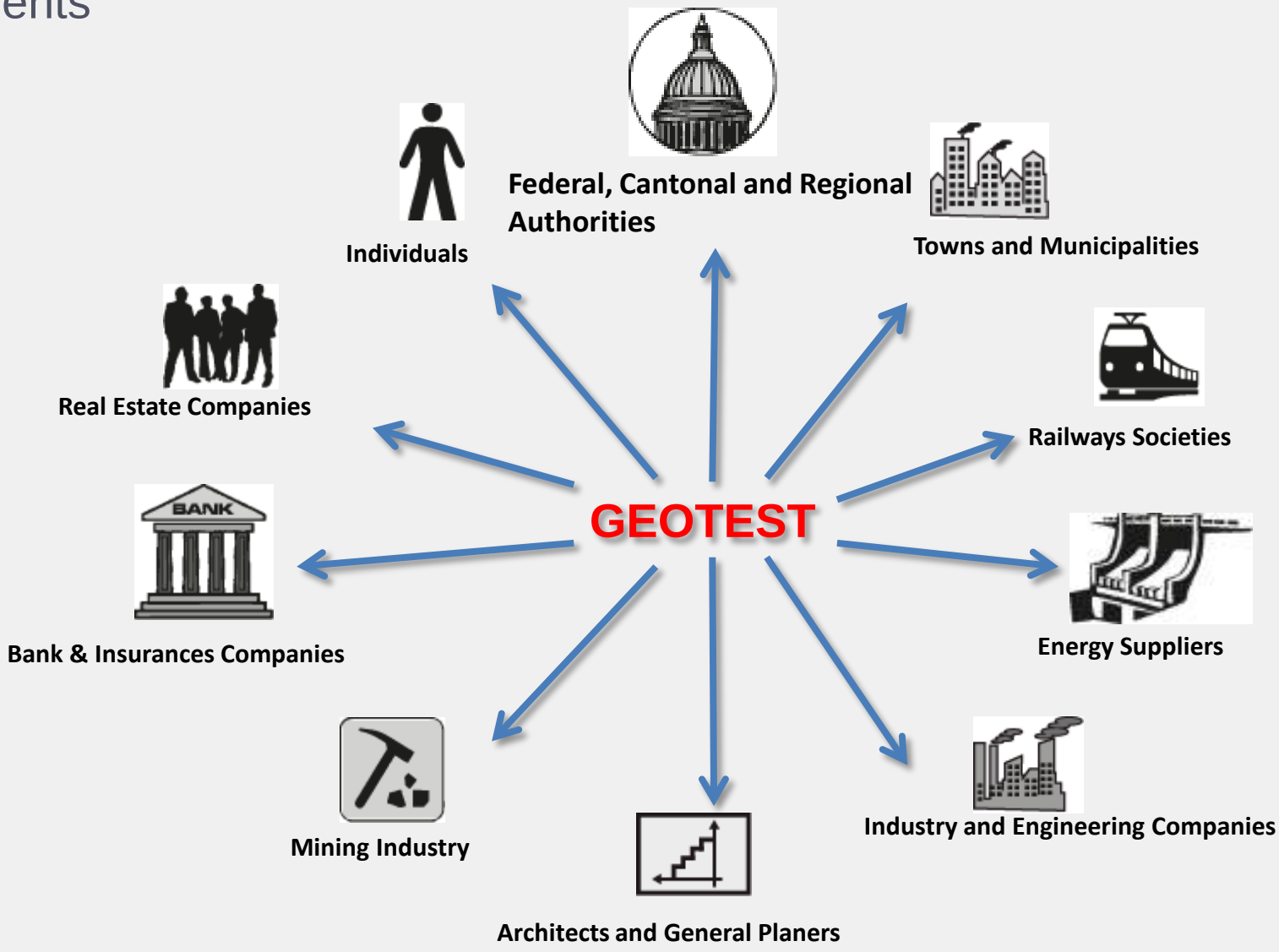
- 140 employees
  - Geologists
  - Geographers
  - Engineers
  - Geophysicists
  - Pedologists / natural scientists
  - IT specialist and software engineers
  - Specialists in geographic information systems (GIS)
  - Technicians in measurement technology

- Accredited according to SN EN ISO 9001:2000
- Accredited laboratory according to ISO/IEC 17025

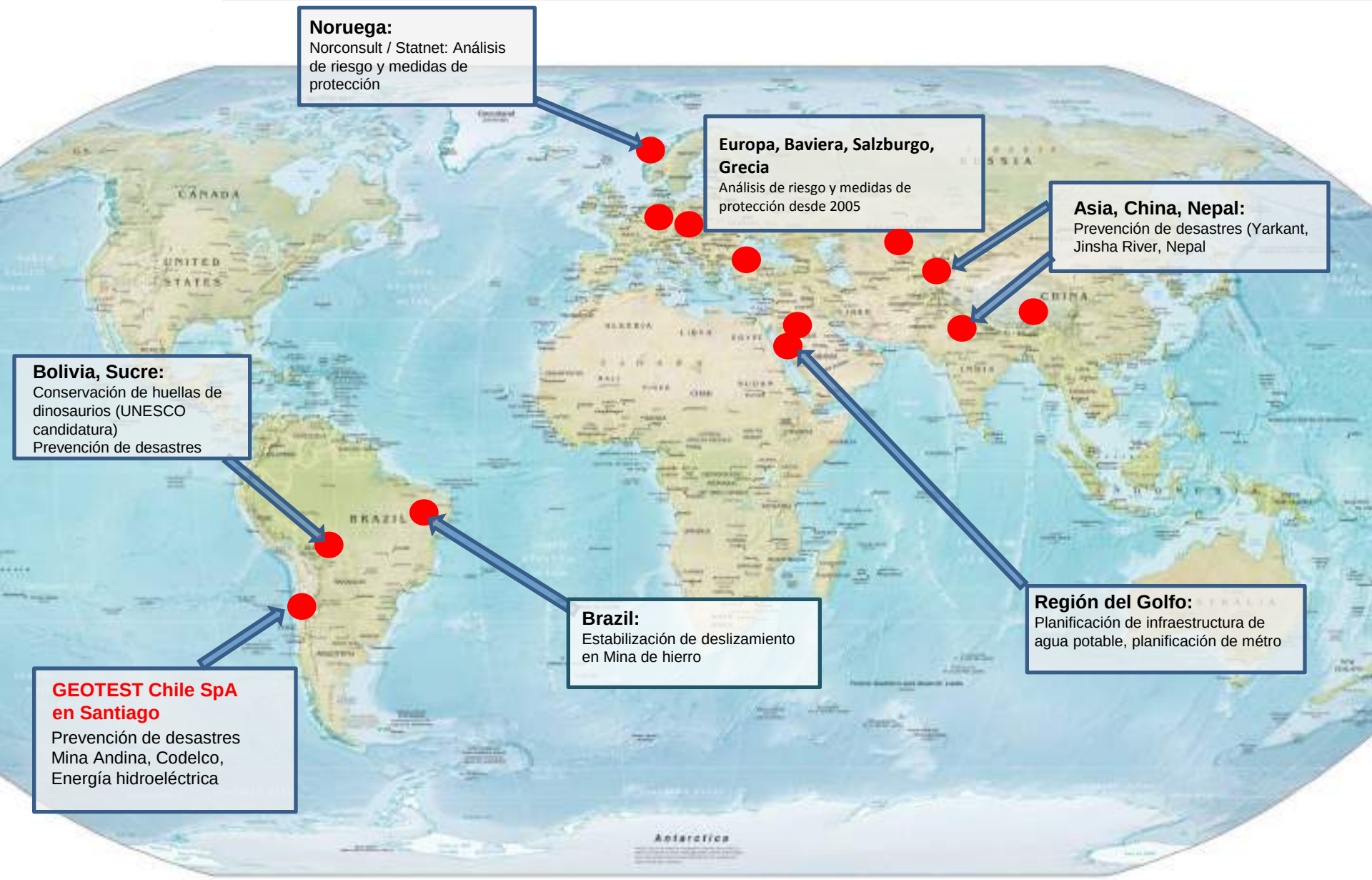
Agencies in Switzerland



Clients


Federal, Cantonal and Regional Authorities
Individuals
Towns and Municipalities
Real Estate Companies
Railways Societies
GEOTEST
Bank & Insurances Companies
Energy Suppliers
Mining Industry
Industry and Engineering Companies
Architects and General Planers

Project locations



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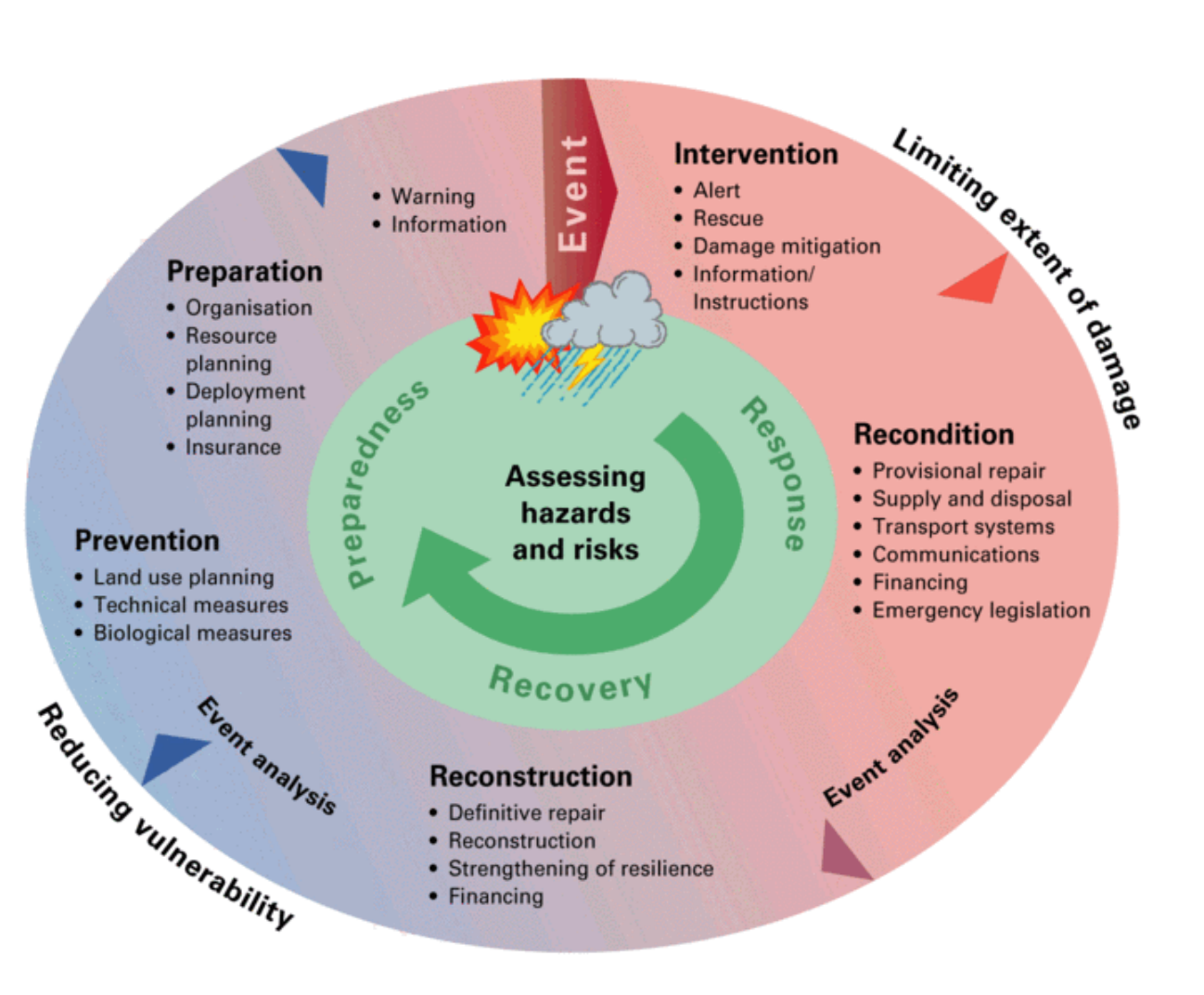
1. Short presentation of GEOTEST AG

2. Integrated Risk Management – Swiss Concept

Integrated Risk Management – Swiss Concept



Integrated Risk Management
综合风险管理

•Avoid risk 规避风险

> land-use plannning 土地使用规划

•Limit risk 控制风险

> constructive and organizational measures 建设性和组织性举措

•Manage residual risk 管理剩余风险

> self responsability and insurance 自我责任及预防措施

Be prepared when an event strikes 事先做好准备

Try to save whatever you can 尽全力挽救

Reduce the risk to an acceptable minimum 将风险降低到可接受的最小程度

Get back to normal, don't make the same mistakes twice! 恢复常态，不重复错误！

1. Integrated Risk Management – Swiss Concept

Integrated Risk Management

- Risk = probability of occurence x values at risk x vulnerability

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5. Processing UAV Data

2. Hazard Assessment – Modelling Landslides

Problem or Aim

damage potential

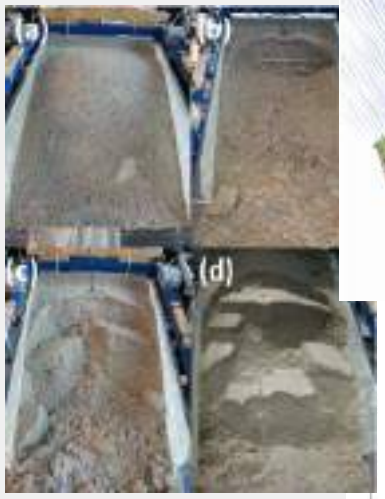
Quick identification of conflict zones between dangerous process and land use

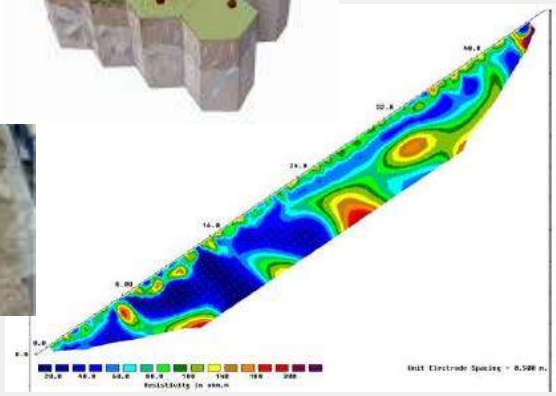
2. Hazard Assessment – Modelling Landslides

Process Understanding

2. Hazard Assessment – Modelling Landslides

Science ⟷ **Practice**



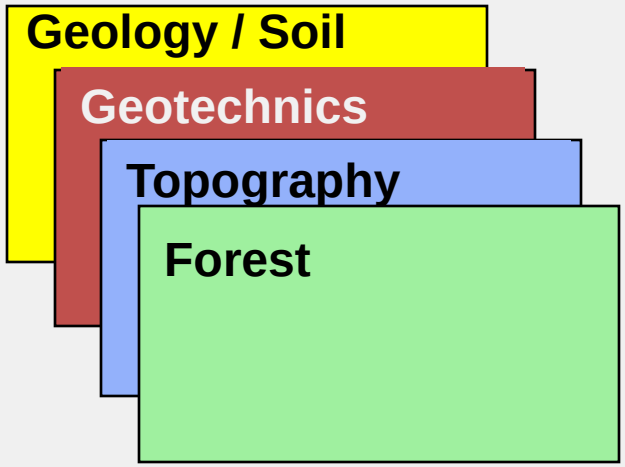


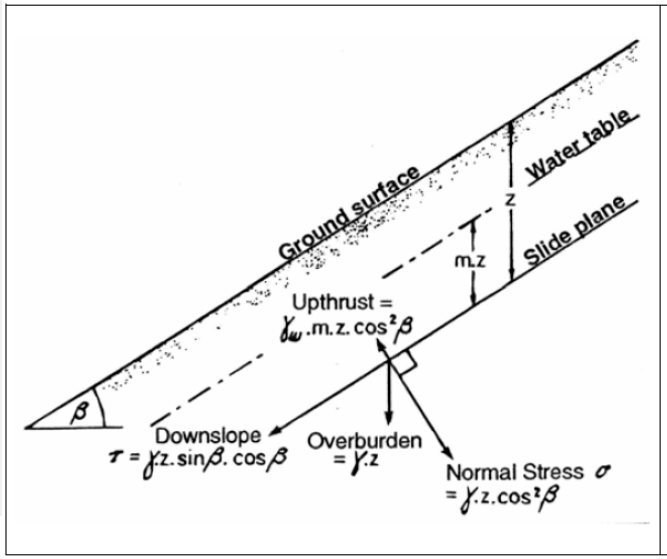
Photos: Synthesis Report TRAMM Project, 2010

2. Hazard Assessment – Modelling Landslides

Susceptibility Map - Deterministic Disposition Modell

Input - Data



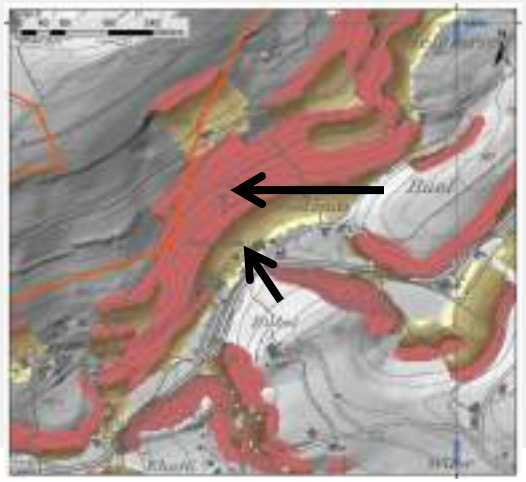


$$F = \frac{c' + (\gamma \cdot z \cdot \cos^2\beta - u) \cdot \tan\phi'}{\gamma \cdot z \cdot \sin\beta \cdot \cos\beta}$$

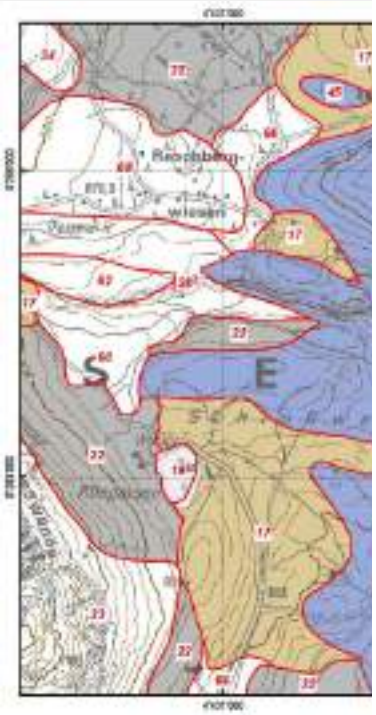
$$u = \gamma_w \cdot m \cdot z \cdot \cos^2\beta$$

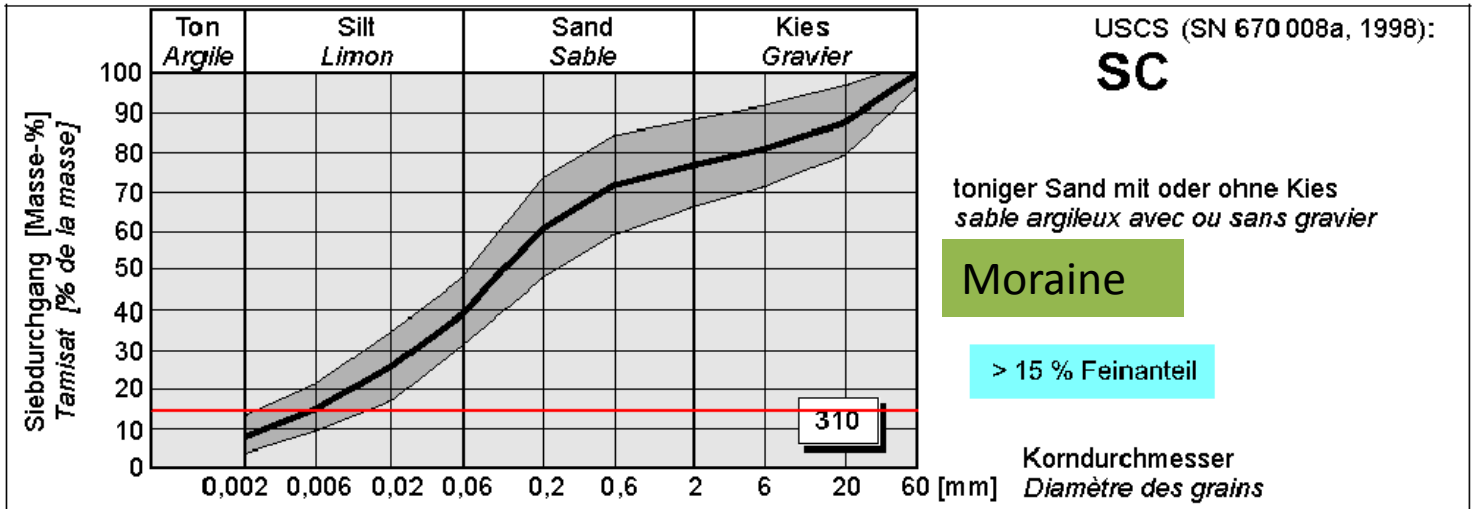
F	Sicherheitsgrad
c'	effektive Kohäsion
ϕ'	effektiver Reibungswinkel
z	Lockermaterialmächtigkeit
u	Porenwasserdruck
m	Höhe des Grundwasserspiegels
β	Hangneigung
γ	Dichte (Wichte)

Product: indication map



2. Hazard Assessment – Modelling Landslides





USCS (SN 670 008a, 1998):

SC

toniger Sand mit oder ohne Kies
sable argileux avec ou sans gravier

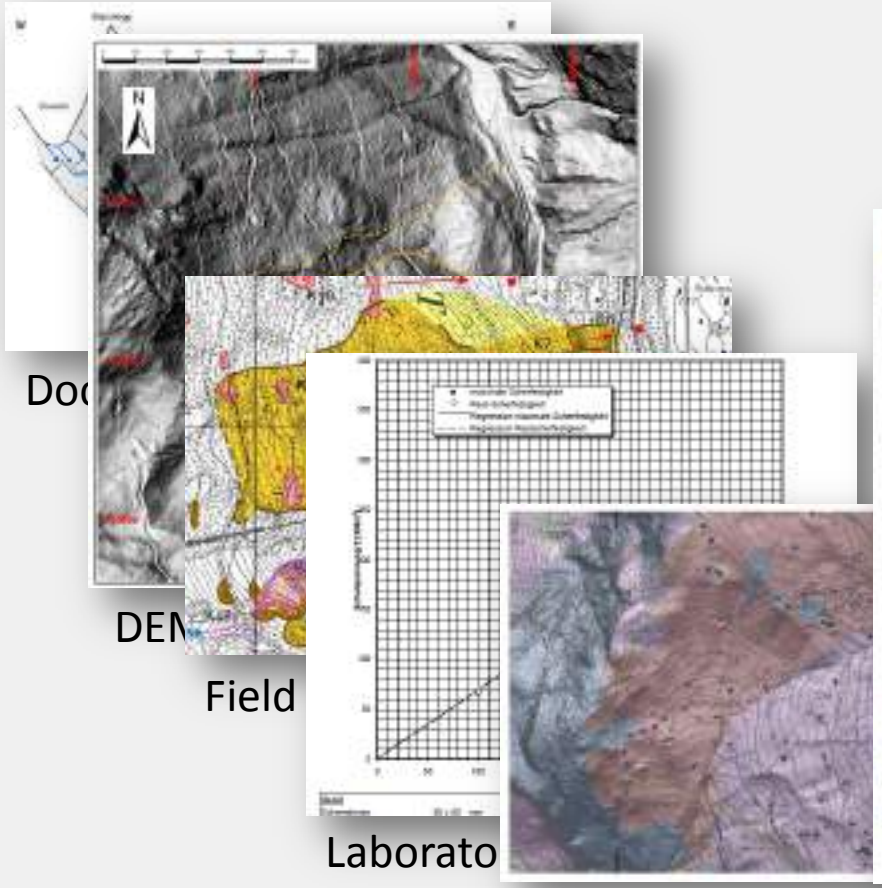
Moraine

> 15 % Feinanteil

w_L [%]	I_P [%]	ρ [t·m^{-3}]	w [%]	e_0 [-]	Φ' [°]	c' [kN·m^{-2}]	c_u [kN·m^{-2}]	C_c [-]	C_s [-]	k [m·s^{-1}]	w_{opt} [%]	$\rho_{d\,opt}$ [t·m^{-3}]
26,0 σ=7,6	11,5 σ=5,4	2,21 σ=0,17	14,8 σ=8,1	0,38 σ=0,21	34,8 σ=4,7	5,3 σ=11,6	167 σ=76	0,173 σ=0,104	0,022 σ=0,024	$1\cdot10^{-9}$ bis / à $1\cdot10^{-6}$	15 σ=3	1,85 σ=0,15

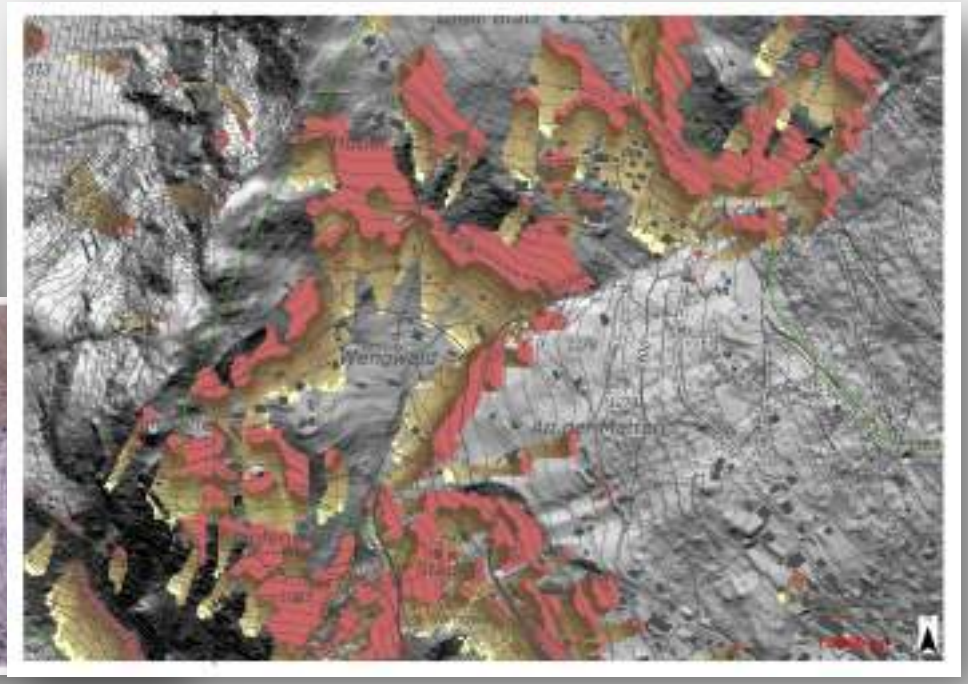
Geologie	Lithologie	Zugeteilte Codierung						USCS
		Korngrösse		Durchlässigkeit		Erodierbarkeit		
17	Fernmoräne	6	Diamiktit	4	10^{-4} bis 10^{-6} m/s	4	bindig	SC
22	Hang- / Verwitterungsschutt	6	Diamiktit	4	10^{-4} bis 10^{-6} m/s	5	-	SC – SM
45	Plattenkalke	4	Kies	5	10^{-2} bis 10^{-4} m/s	2	Feinanteil > 15%	GM

2. Hazard Assessment – Modelling Landslides (Case Study)



Soil classification

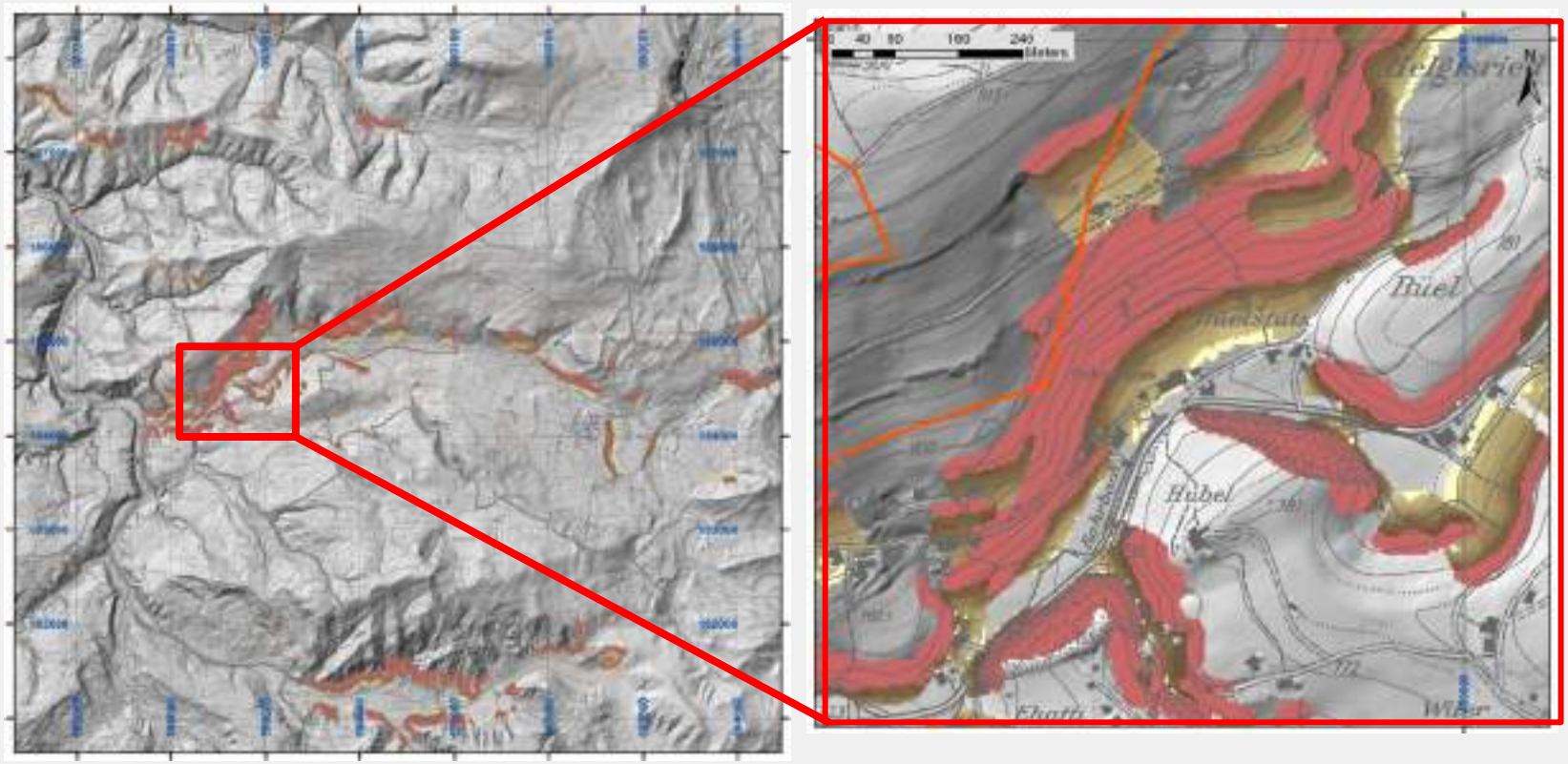
Calculation with Disposition Model
(part1 “slidisp” part2 “slidepot”)



Basis for Input-Data to model

2. Hazard Assessment – Modelling Landslides

Hazard Indication Map (large areas)



- **Spatial occurrence**
- **Conflict-zones**

-> disposition models

Conclusion Hazard Assessment – Modelling Landslides

1. Process understanding is crucial for hazard assessment

2. Modelling of landslides requires process knowledge and minimal input dataset

3. to calibrate the modelling results, an event register is required

4. Quality of input data defines quality of output

5. Step-by-step concept:
   from general hazard assessment (large areas, hazard indication maps) to detailed studies

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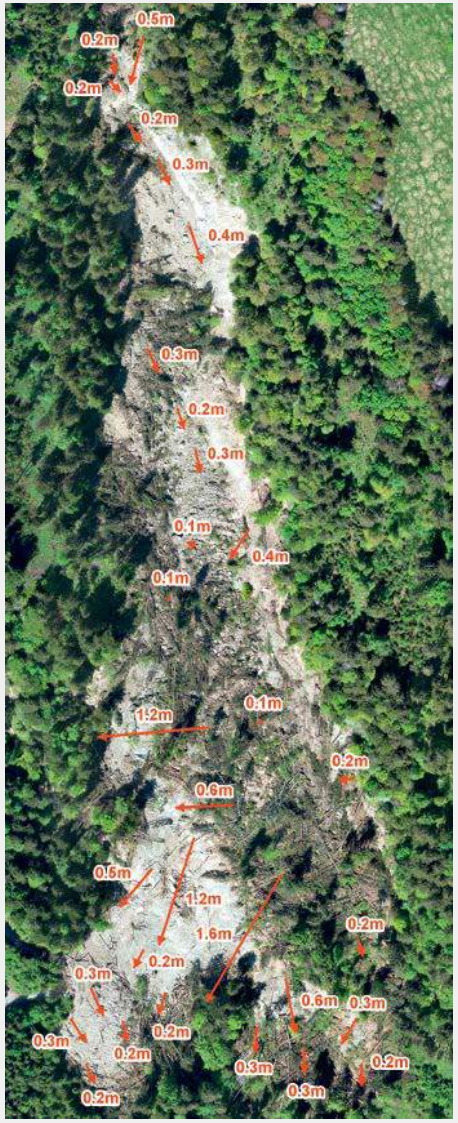
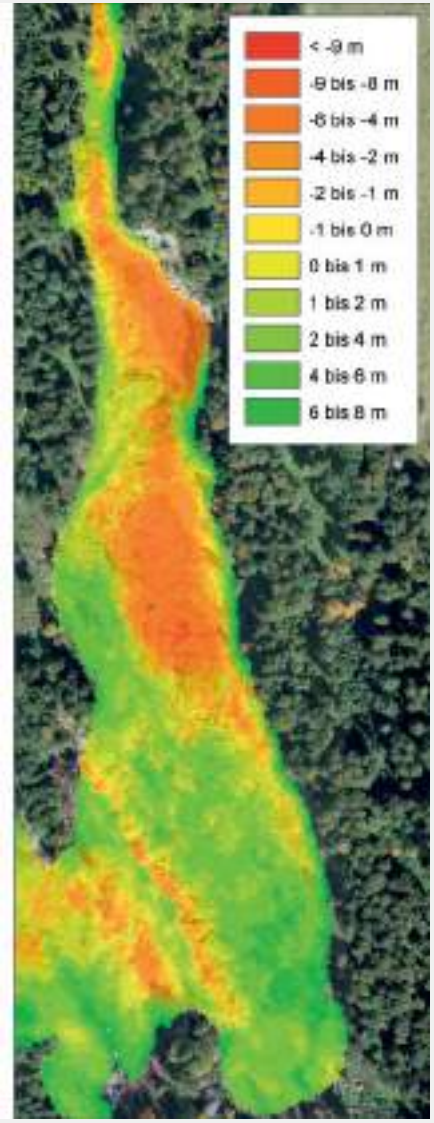
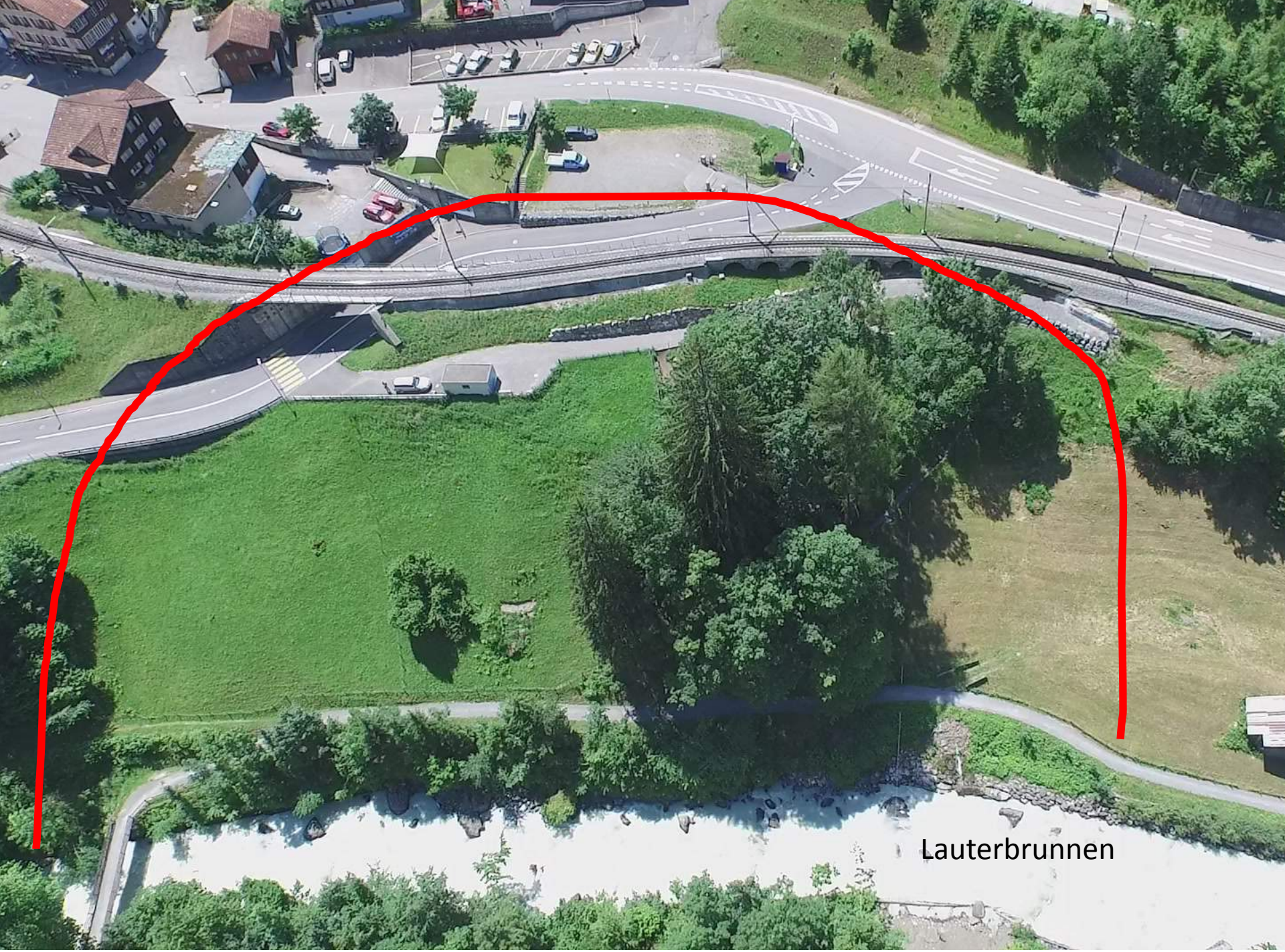
UAVs in Hazard Assessment

UAVs in Hazard Assessment

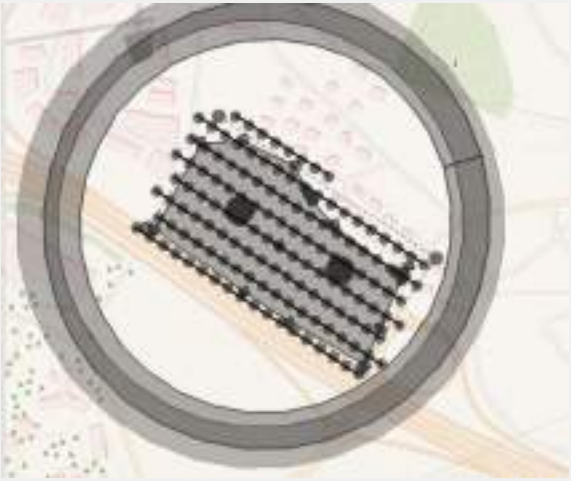




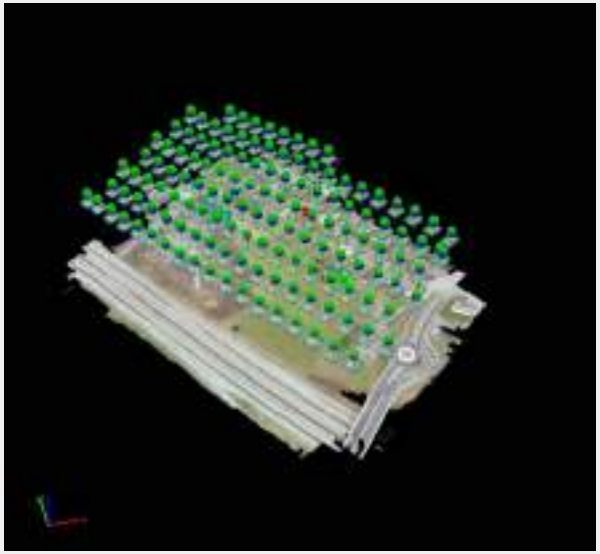

Lauterbrunnen

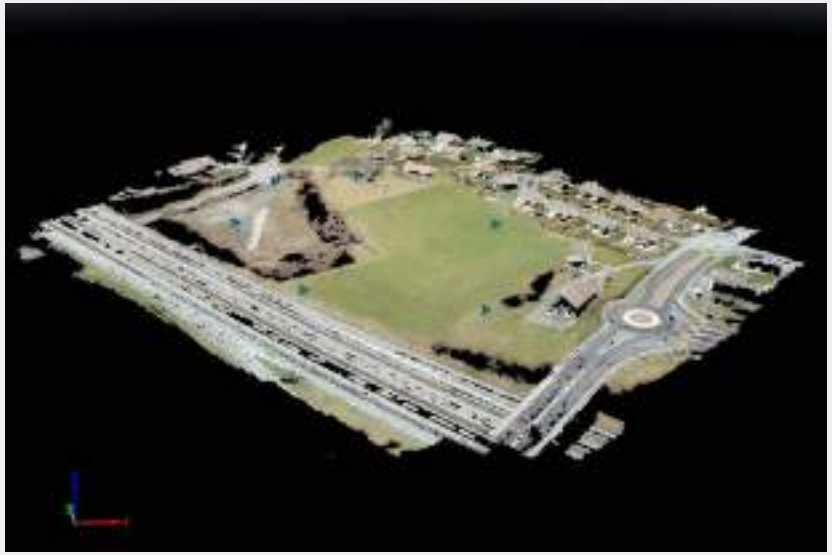
Grindelwald

UAV in Hazard Assessment – Preparation of Field Work



St. Légier (VD)





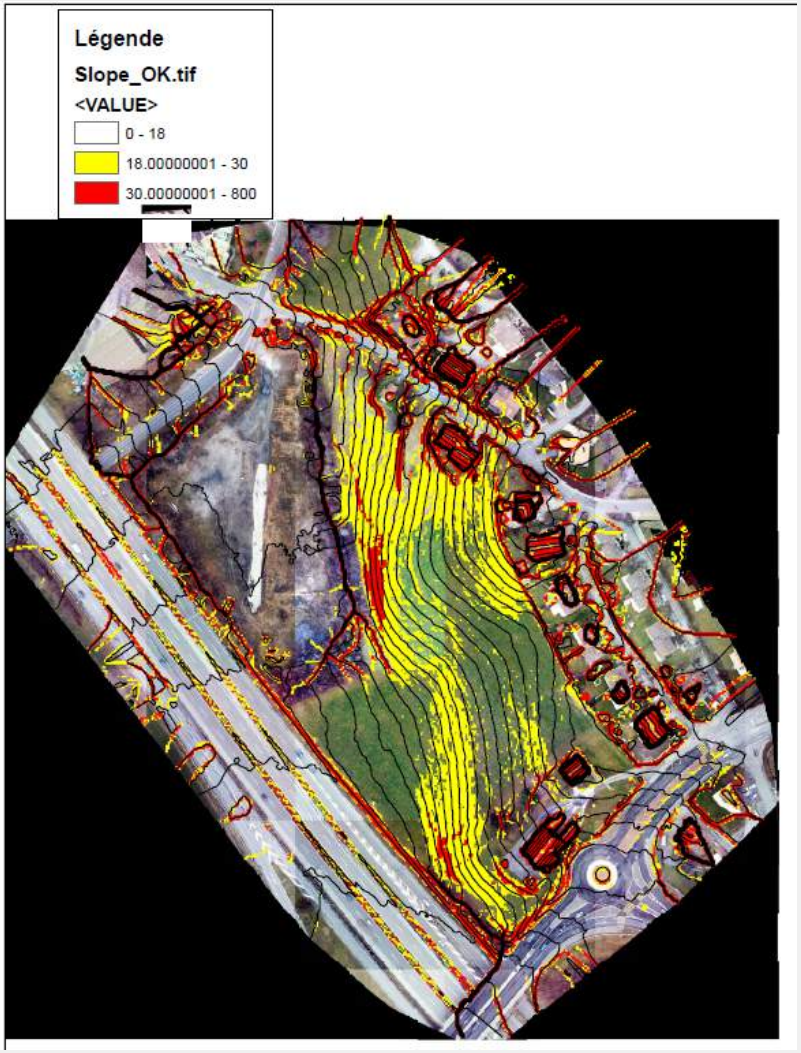
UAV in Hazard Assessment – Preparation of Field Work

- Differential GPS
- tape or meter-marks

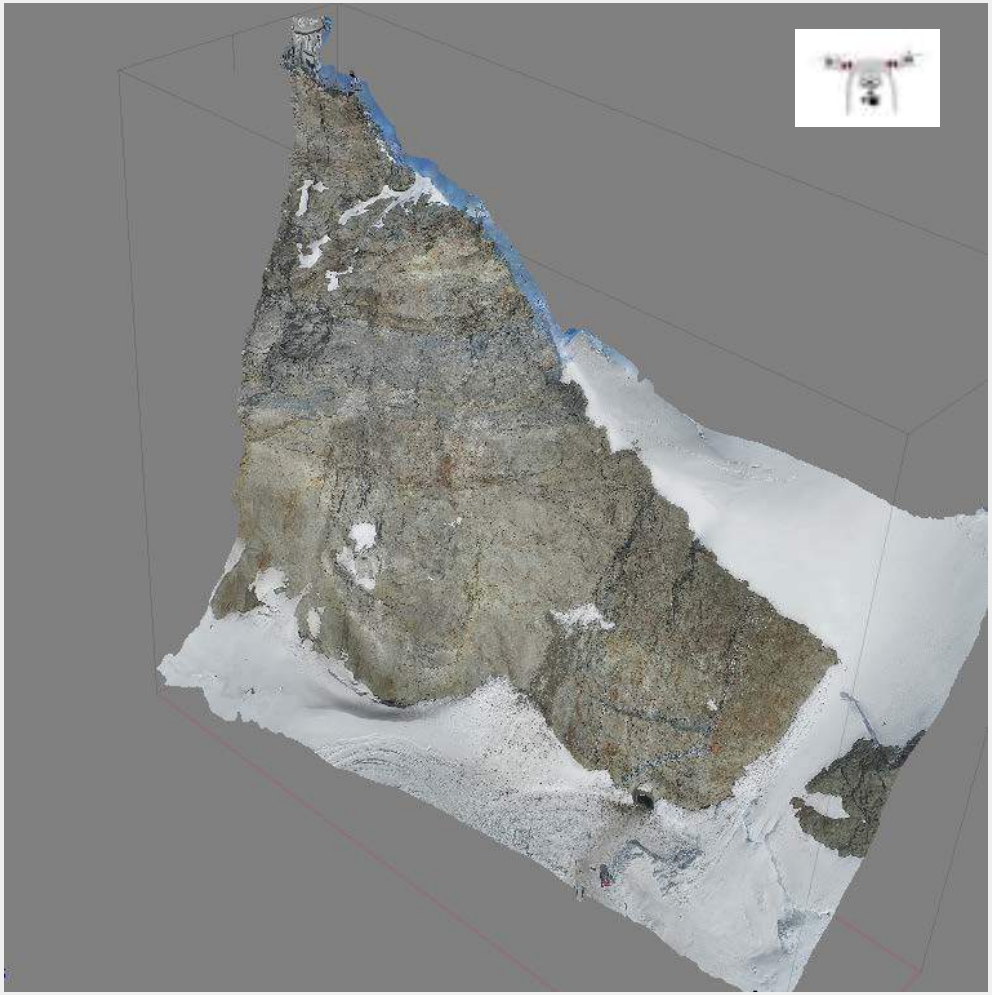
UAVs in Hazard Assessment – Flight

Processing UAV Data

Slope indication model
as important base in landslide
hazard assessment and modelling

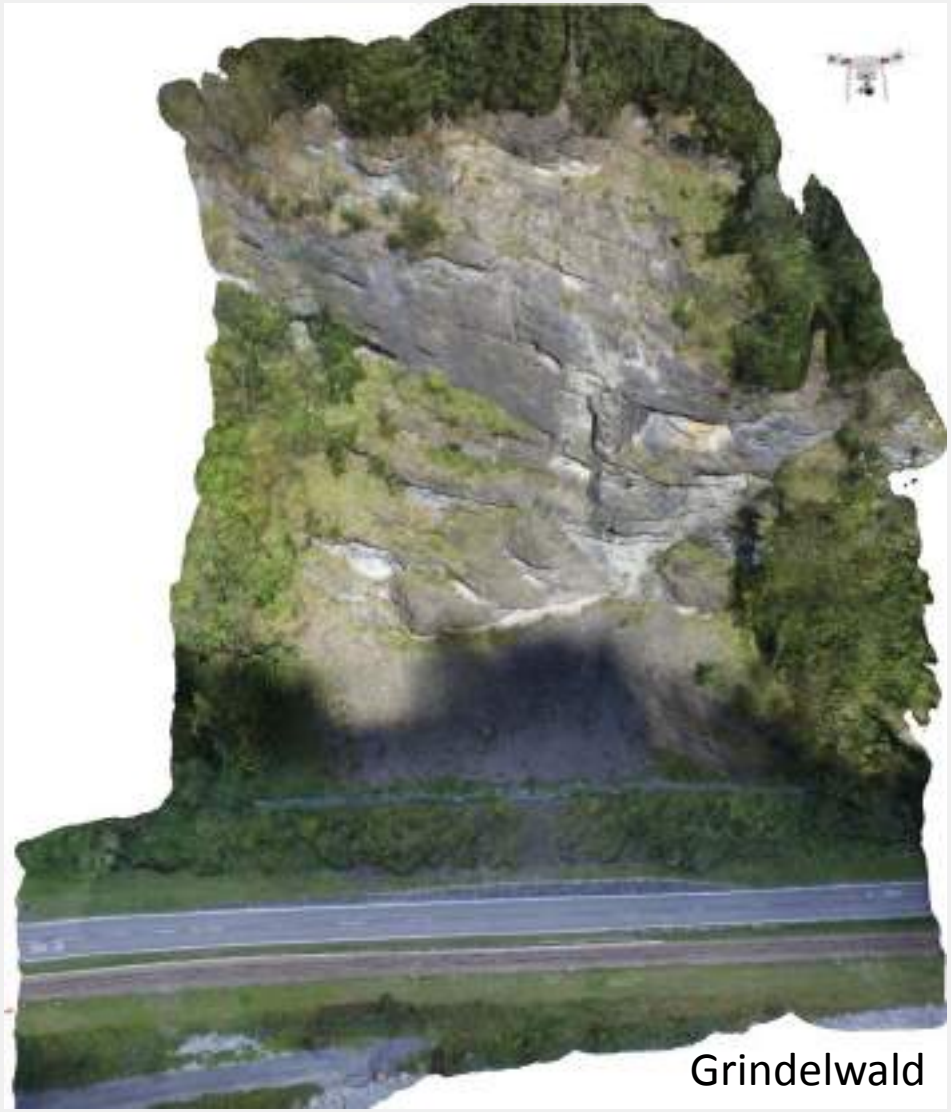


Processing UAV Data

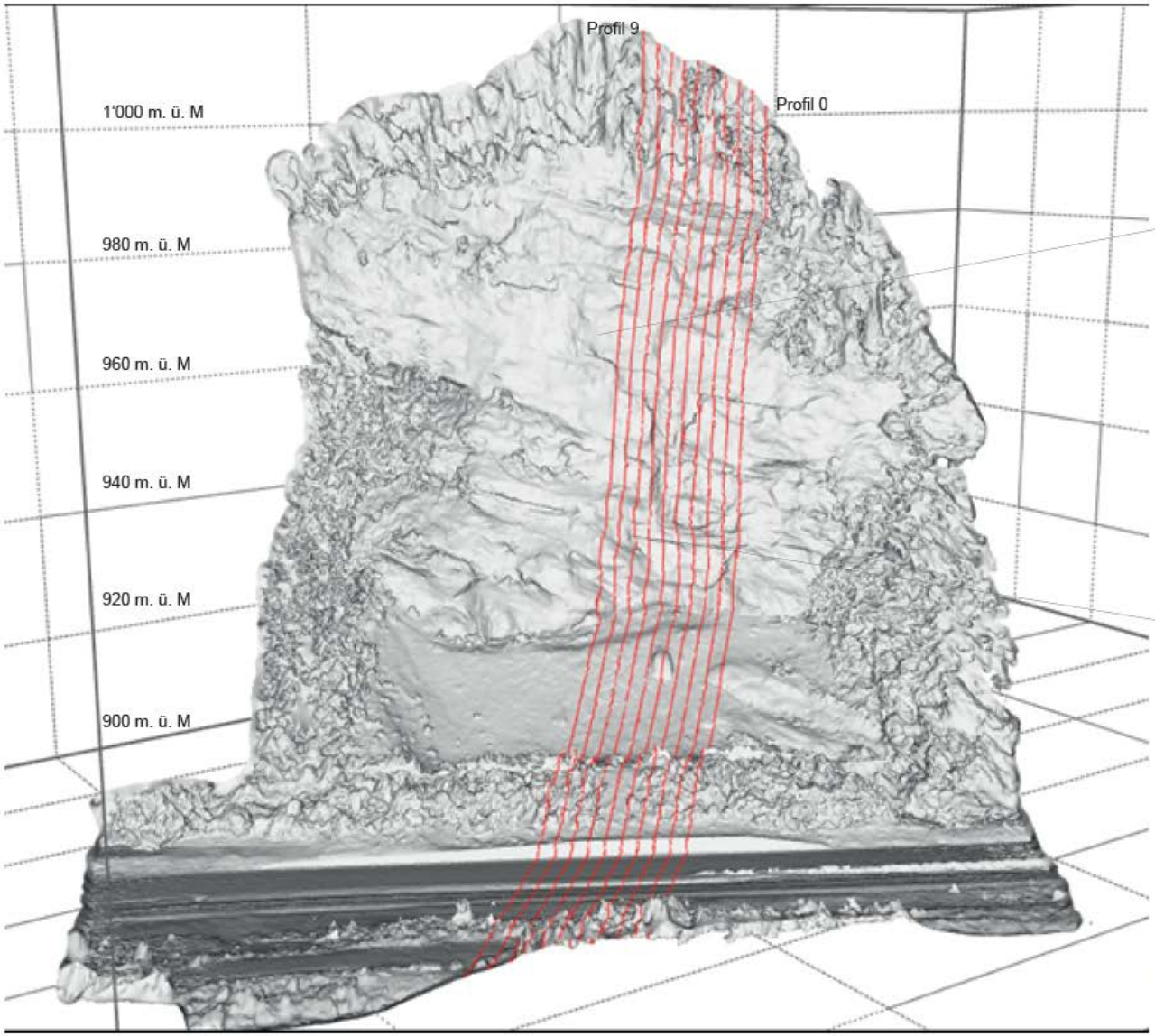


Digital terrain model Jungraujoch

Processing UAV Data



Processing UAV Data



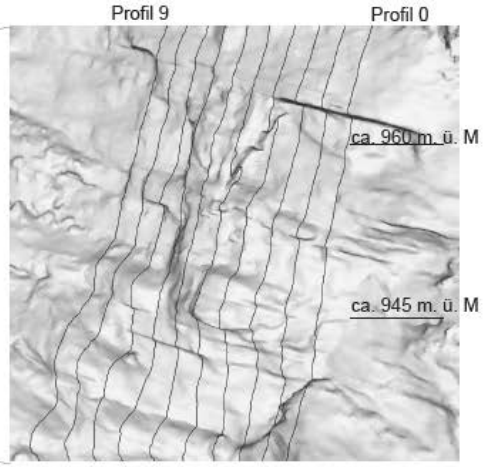
GEOTEST GEOLOGEN / INGENIEURE / GEOPHYSIKER / UMWELTFACHLEUTE

Auftrag: Grindelwald, Felsstabilität Haltischwand Nr. 1415145.1

Koord. ca. 642 600 / 165 000

Ansicht
Lage der Profile

Grindelwald



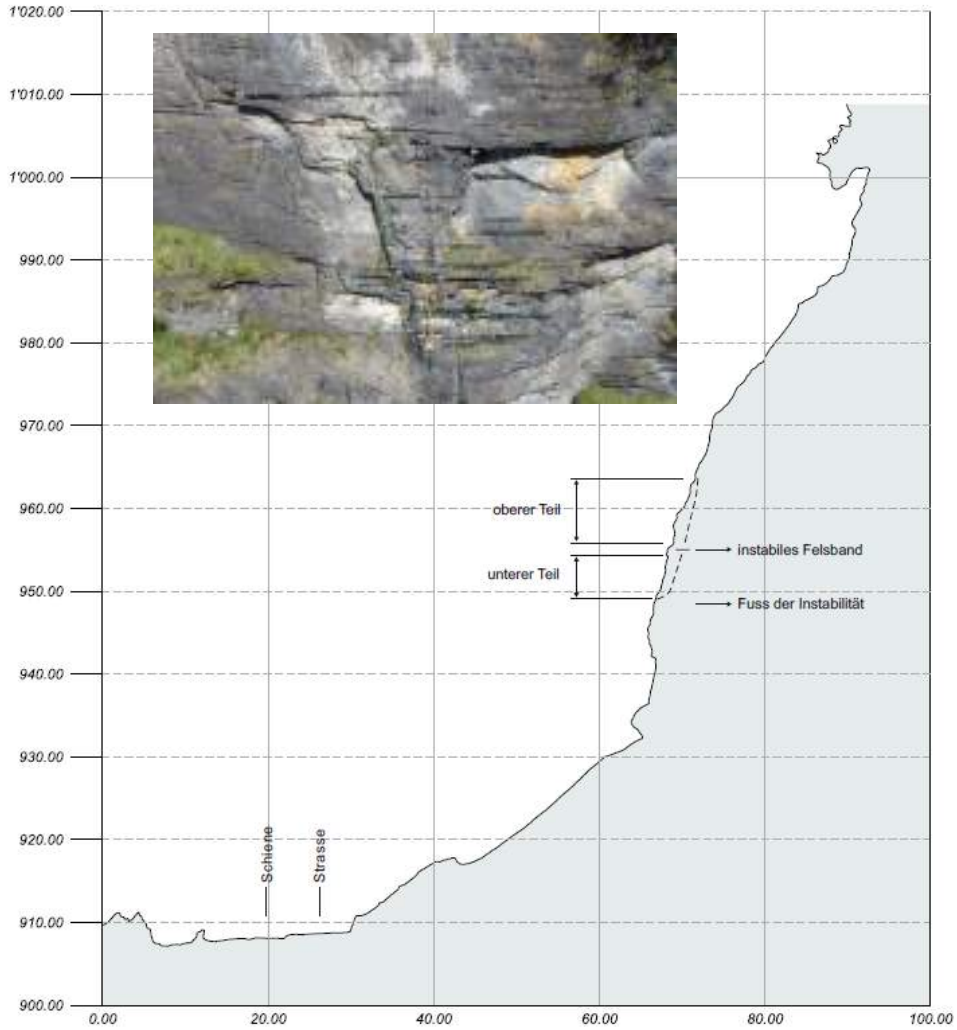
Detailausschnitt Lage der Profile im Bereich des instabilen Felsturmes, Ansicht aus E

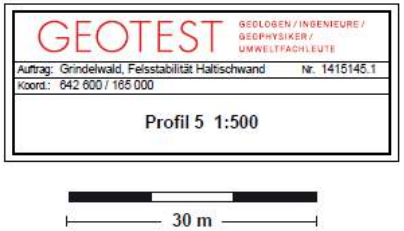
Luftausfnahme des instabilen Felsturmes, Ansicht aus W

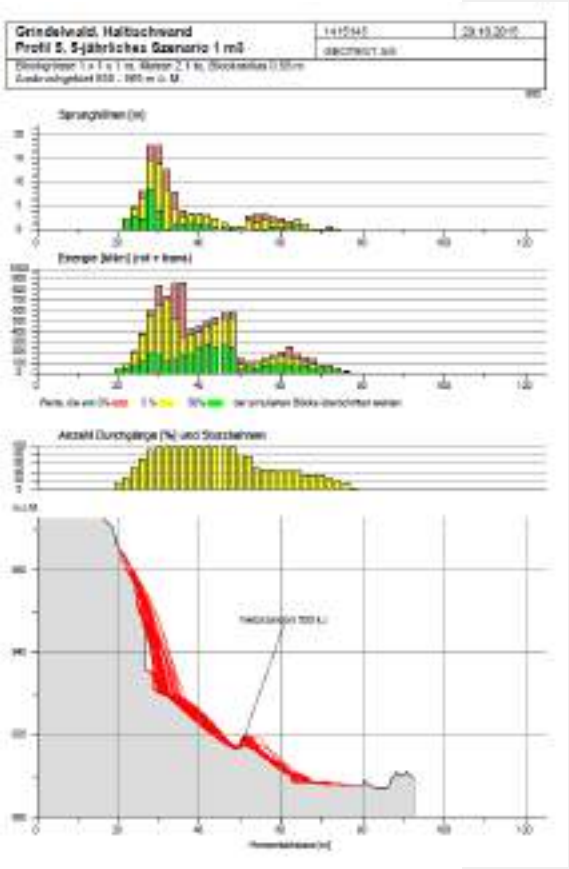
1415145.1_AH03_Ansicht.al /20.10.2015_RmMas

Anhang 3

Processing UAV Data







Grindelwald

Processing UAV Data - Conclusion

Field of Applications:

- Depending on type of UAV
- Efficient tool in natural hazard assessment (picture and video)
- Calculation of DEMs
- Documentation of progress on construction sites
- rapid deployment for initial site assessment

Products:

- Digital pictures (12 to 25 MP)
- HD video

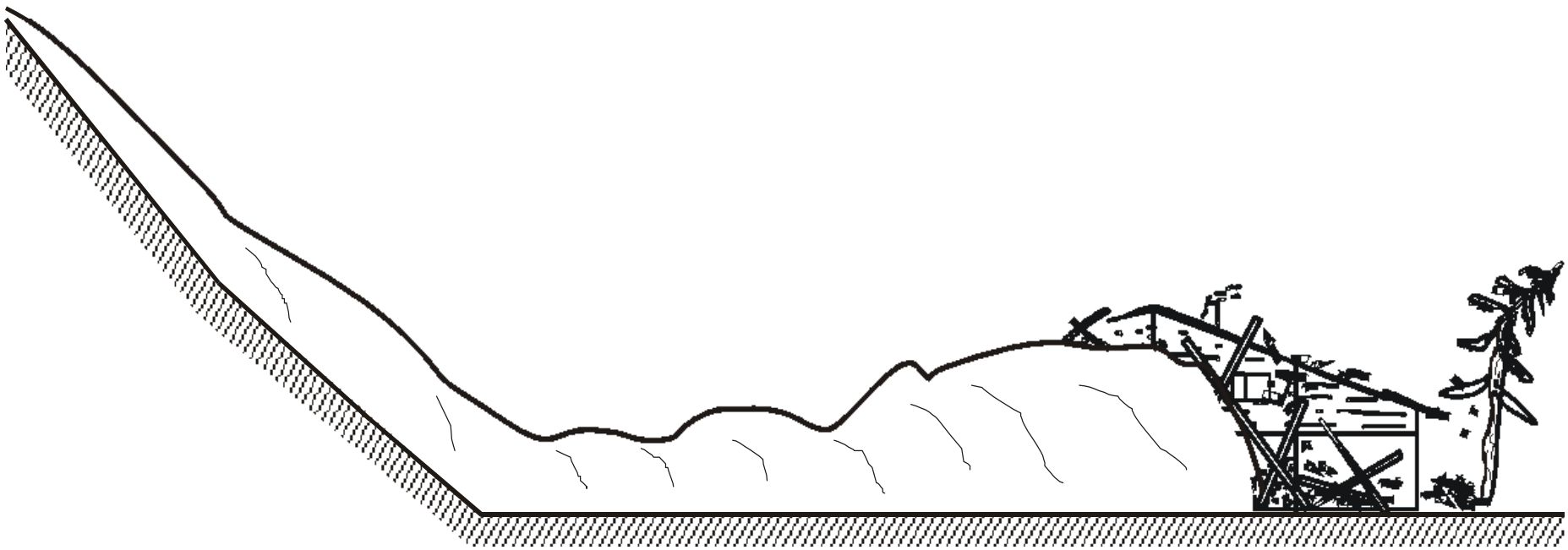
Results (for CAD input-data)

- Georefered elevation models
- 3D-models
- ortophotos
- Terrain profiles, volumes, etc.

Integrated Risk Management

- Risk = probability of occurence x values at risk x vulnerability

Damage



Dangerous Process

Intensity and
probability of occurrence

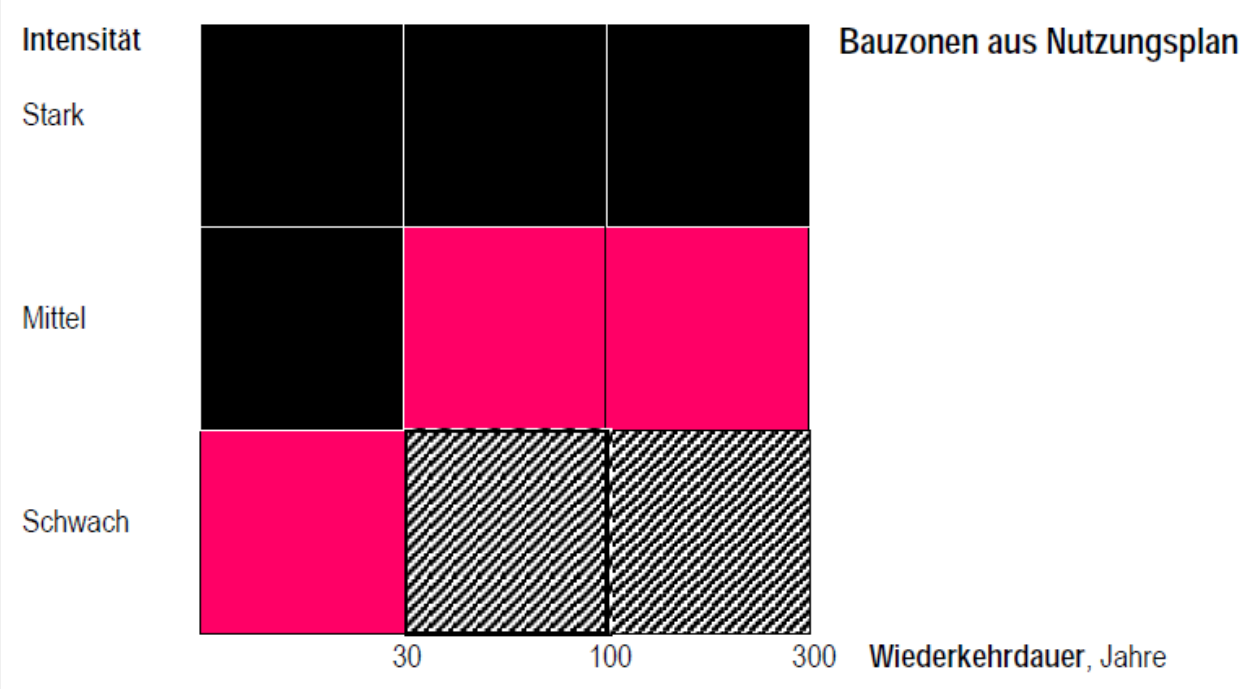
Value, Vulnerability,
Probability of presence

Integrated Risk Management

- Risk = probability of occurence x values at risk x vulnerability

Schutzziele Bauzonen

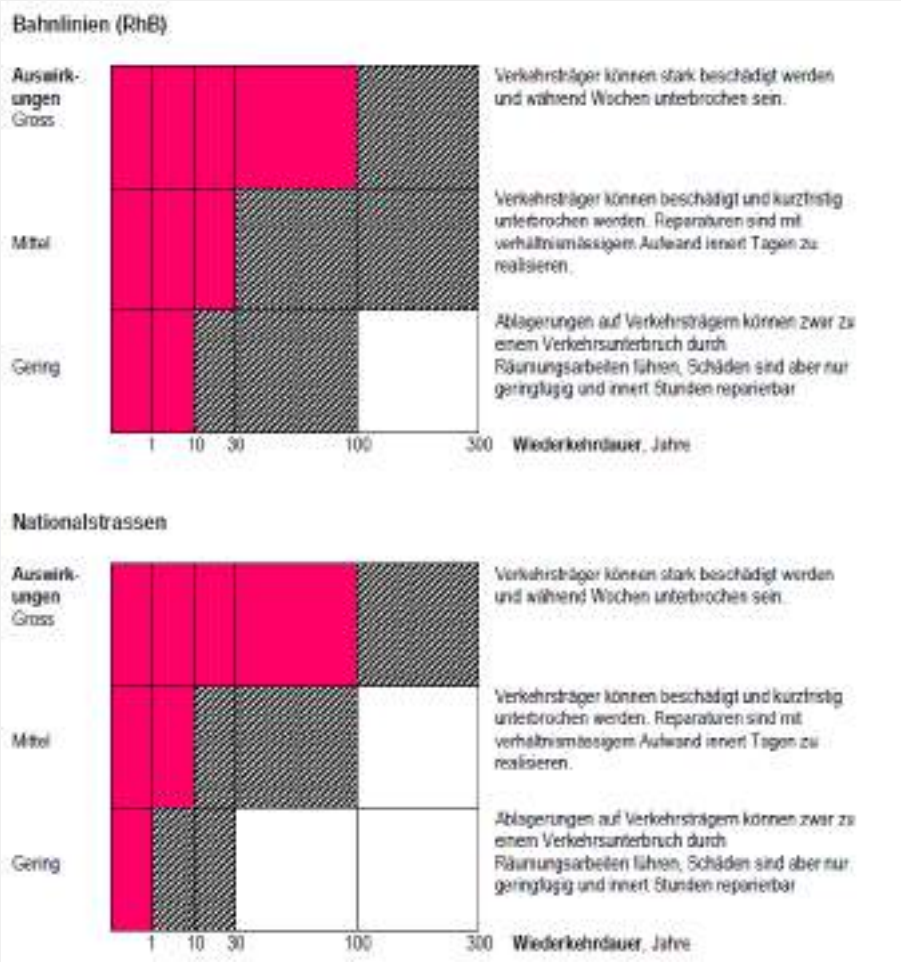
AWN GR (2006)

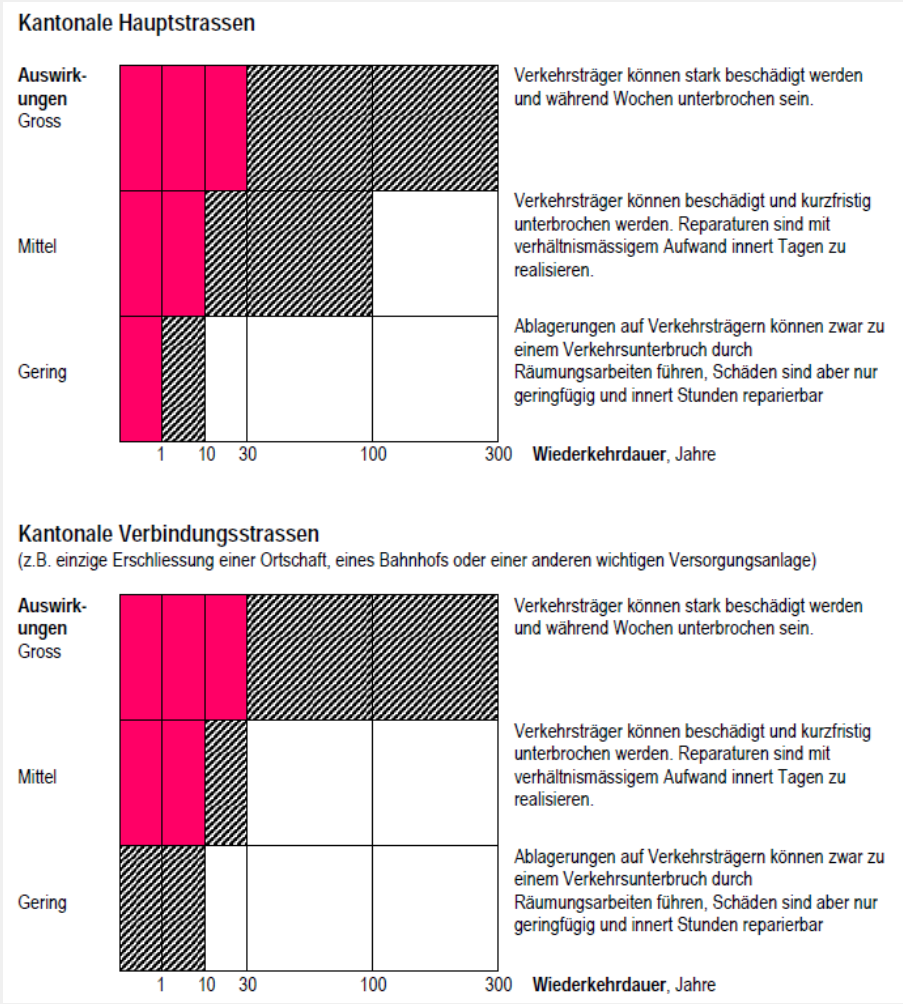


- Unzulässig (Raumplanerische Massnahmen)
- Schützen (Risikoanalyse zur Abklärung der Art der Massnahmen)
- Überprüfen (Risikoanalyse zur Abklärung der Notwendigkeit von Massnahmen)
- Tolerieren (im Allgemeinen keine Massnahmen notwendig)

Schutzziele Verkehrswege

AWN GR (2006)

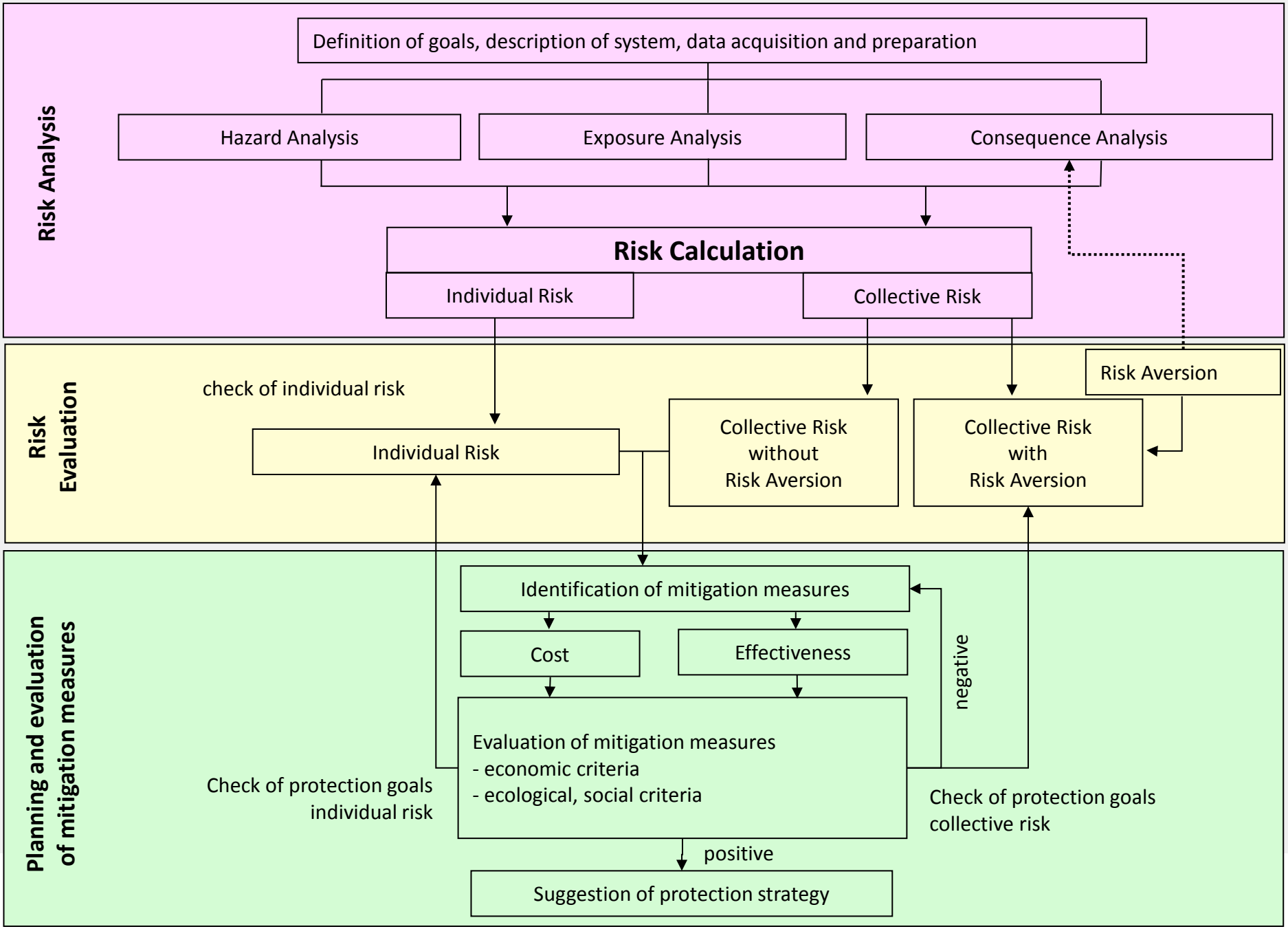




Schützen (Risikoanalyse zur Abklärung der Art der Massnahmen)

Überprüfen (Risikoanalyse zur Abklärung der Notwendigkeit der Massnahmen)

Tolerieren (im Allgemeinen keine Massnahmen nötig)


Risk Analysis
Definition of goals, description of system, data acquisition and preparation
Hazard Analysis
Exposure Analysis
Consequence Analysis
Risk Calculation
Individual Risk
Collective Risk
Risk Evaluation
Risk Aversion
check of individual risk
Individual Risk
Collective Risk without Risk Aversion
Collective Risk with Risk Aversion
Planning and evaluation of mitigation measures
Identification of mitigation measures
Cost
Effectiveness
negative
Evaluation of mitigation measures
- economic criteria
- ecological, social criteria
Check of protection goals individual risk
Check of protection goals collective risk
positive
Suggestion of protection strategy

Definition risk

Risk is …

Risk = probability of occurrence
x
values at risk
x
vulnerability

Factors for calculation of damage

Value of object *W*, Number of persons N_p

Object vulnerability *SE*

Factor of object protection ε

Lethality λ

Probability of death for an exposed person (outside, in house or in car) affected by a certain process intensity.

Spatial probability of process p_{rA}

Probability of presence of persons p_{pr}

Risikoanalyse, Methodik

Risiko = Eintretenswahrscheinlichkeit x Schadenausmass

(f)

- Szenarien Phase 1 (10y, 30y,100y)
- r. Auftretenswahrscheinlichkeit (P_{rA})

Expositionsanalyse:

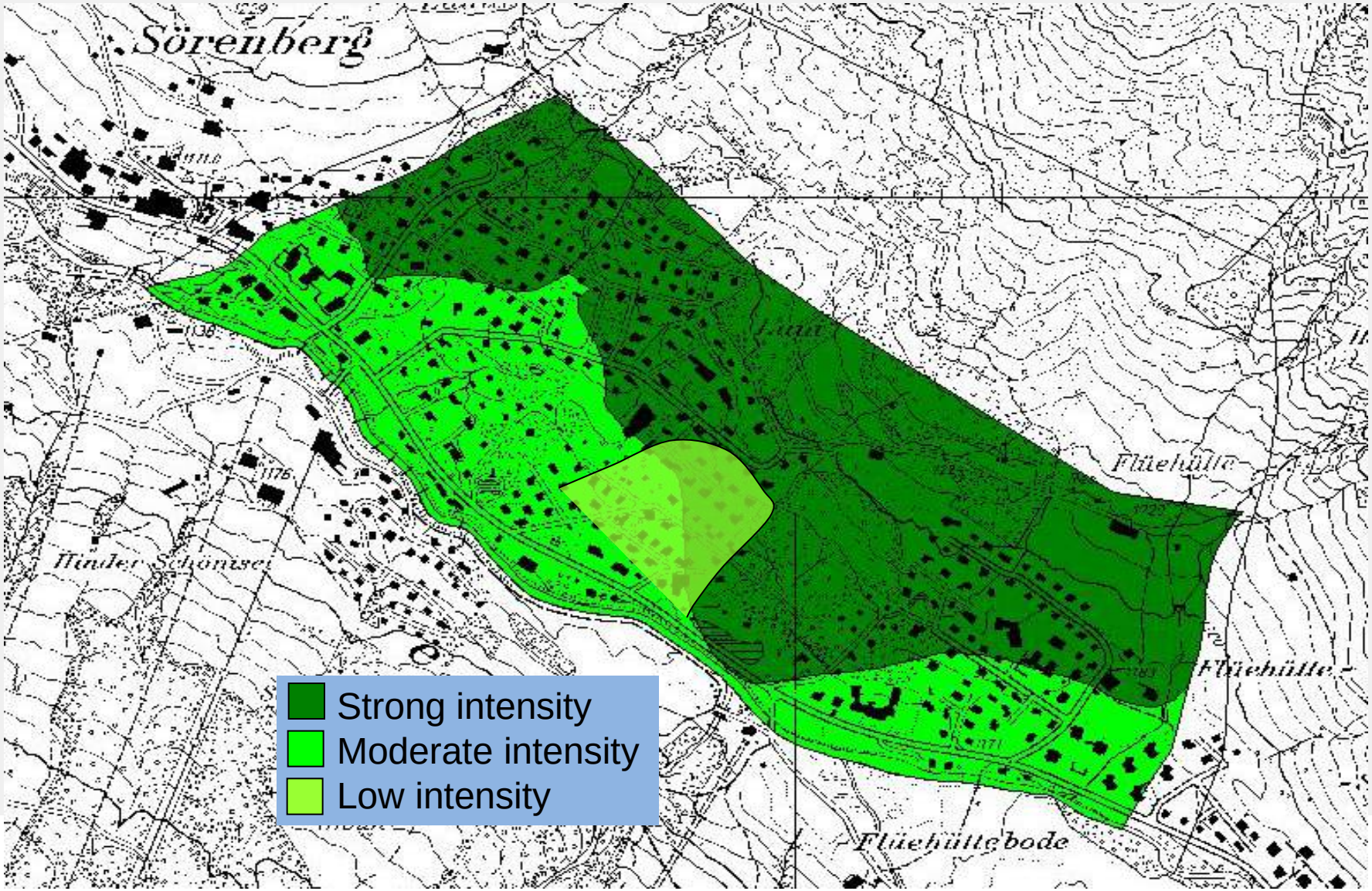
- Sperrwahrscheinlichkeit
- Vorsorgliche Sperrung
- Sperrung infolge gleichzeitiger Ereignisse
- Auffahrwahrscheinlichkeit
- Direkttreffer

(f)

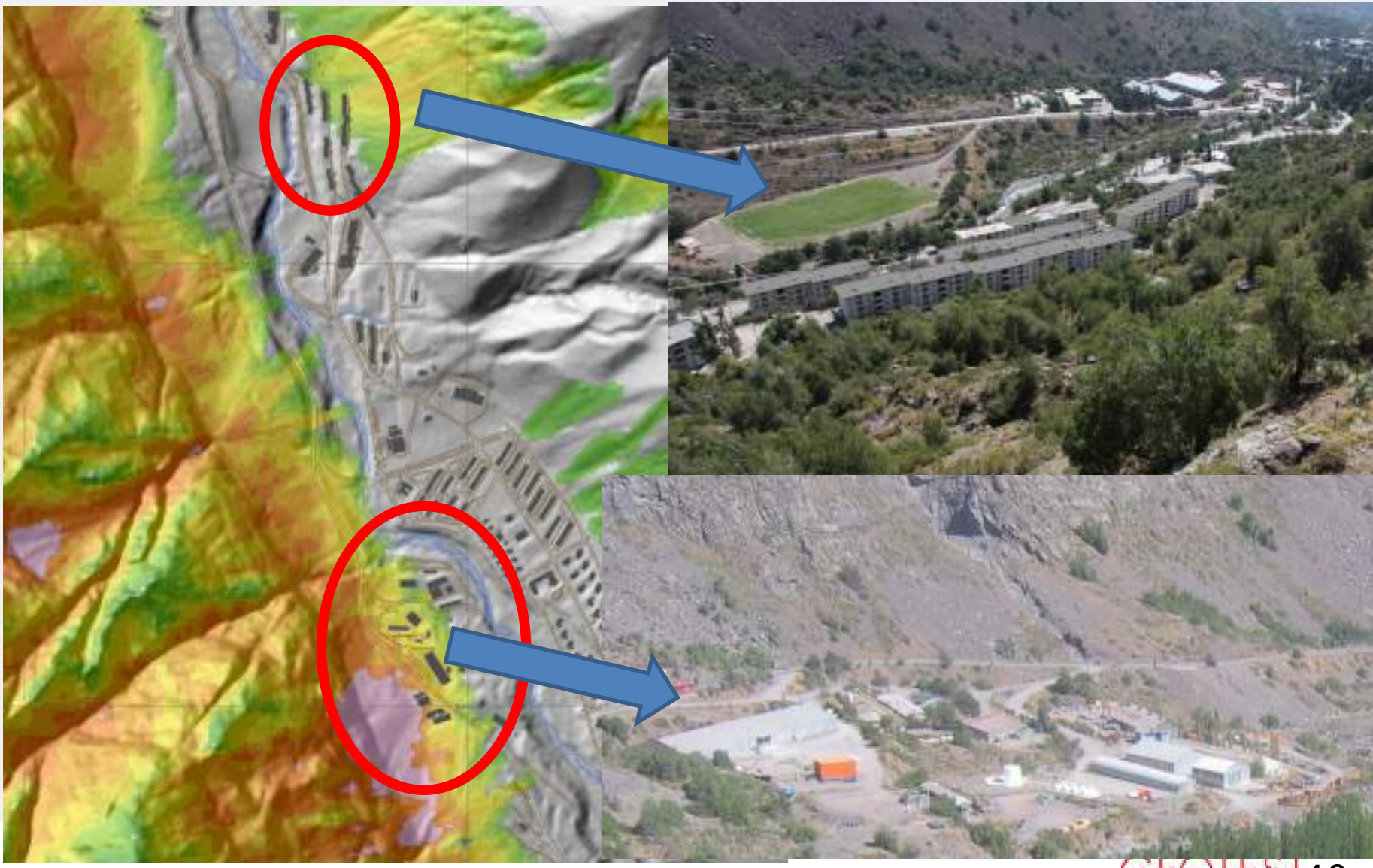
- Intensität > Schadenempfindlichkeit
- Schadenerwartungswert Basiswerte für Streckenobjekte (Galerien, Strasse, Brücken, Tunnel)
- DTV
- Fahrgeschwindigkeit
- Personenbelegung
- Verfügbarkeit nach Ereignis
- Verfügbarkeit vorsorgliche Sperrung
- Verschüttung mit Räumungskosten und Wiederherstellung)

Intensity-map

Debris flows 100-year event



Consequence Analysis (2)



Calculation of risk

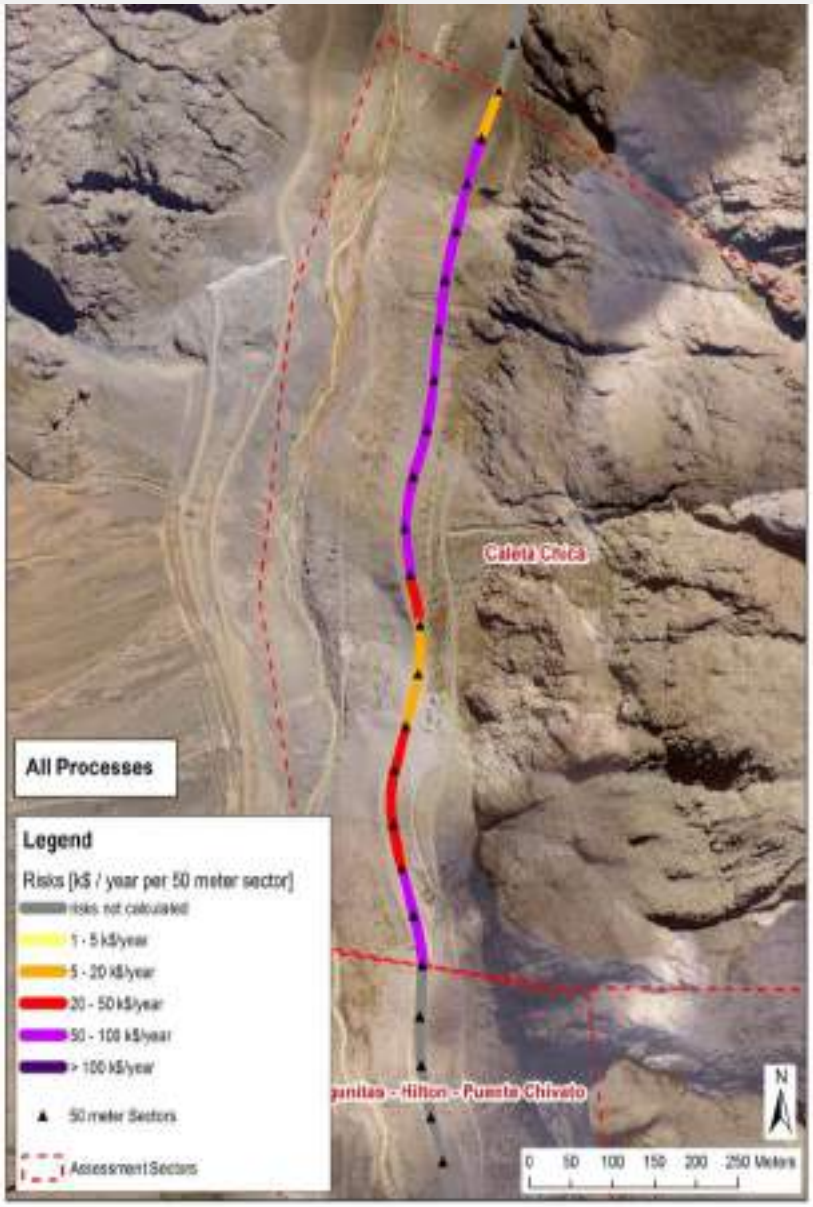
http://risk.geotest

Result: > Risk maps

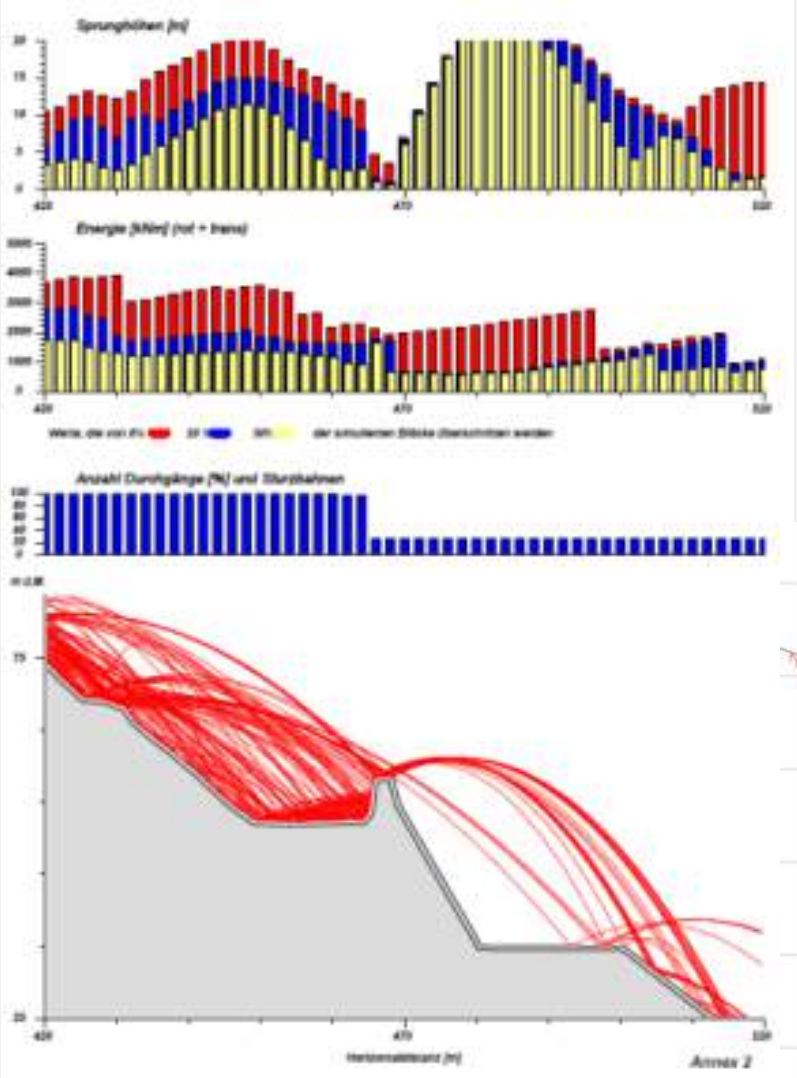
avalanchas

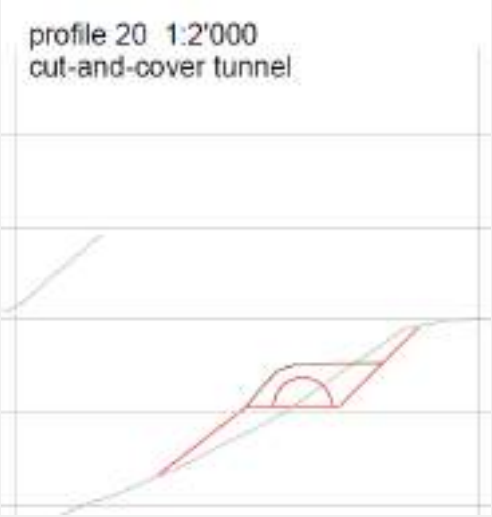
Debris Flow

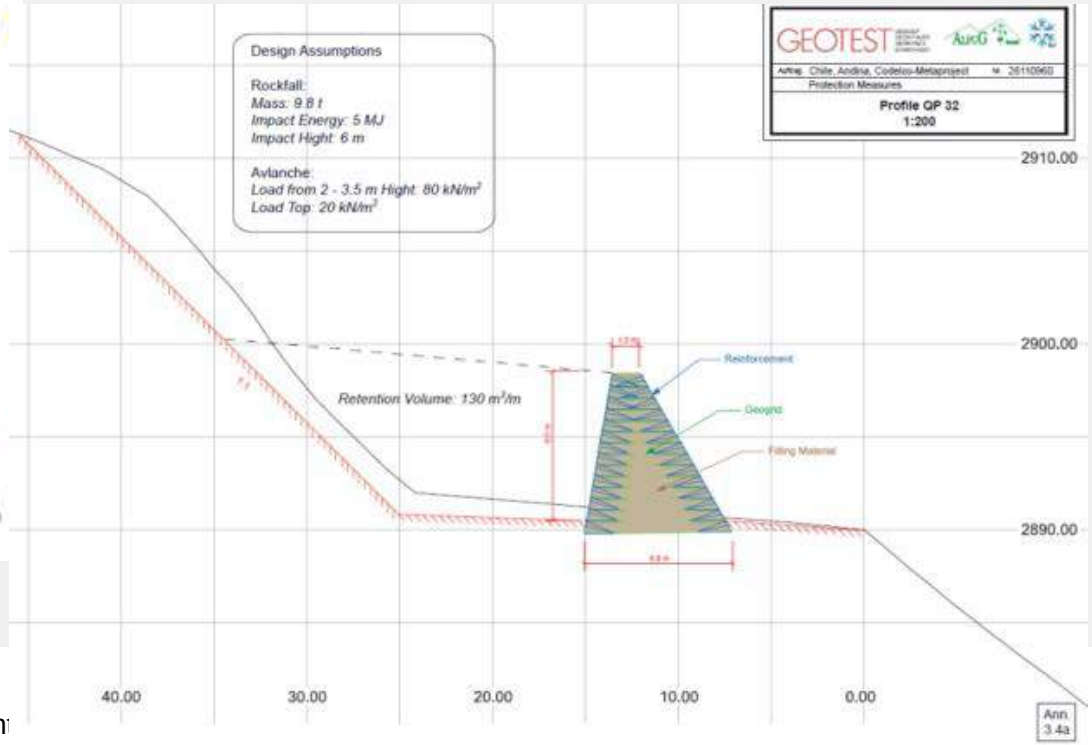
Caída de bloques



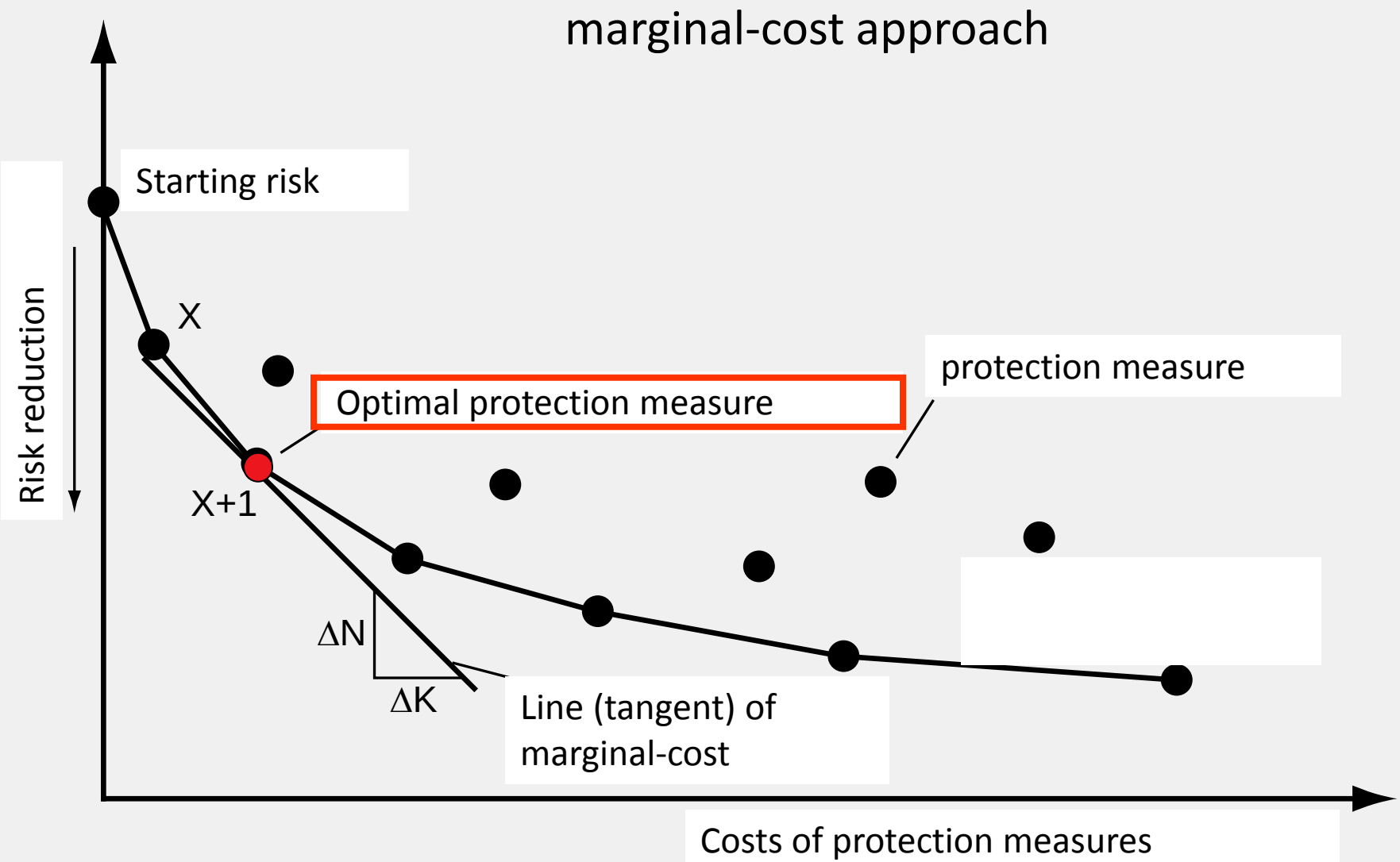
Planning of protection measures



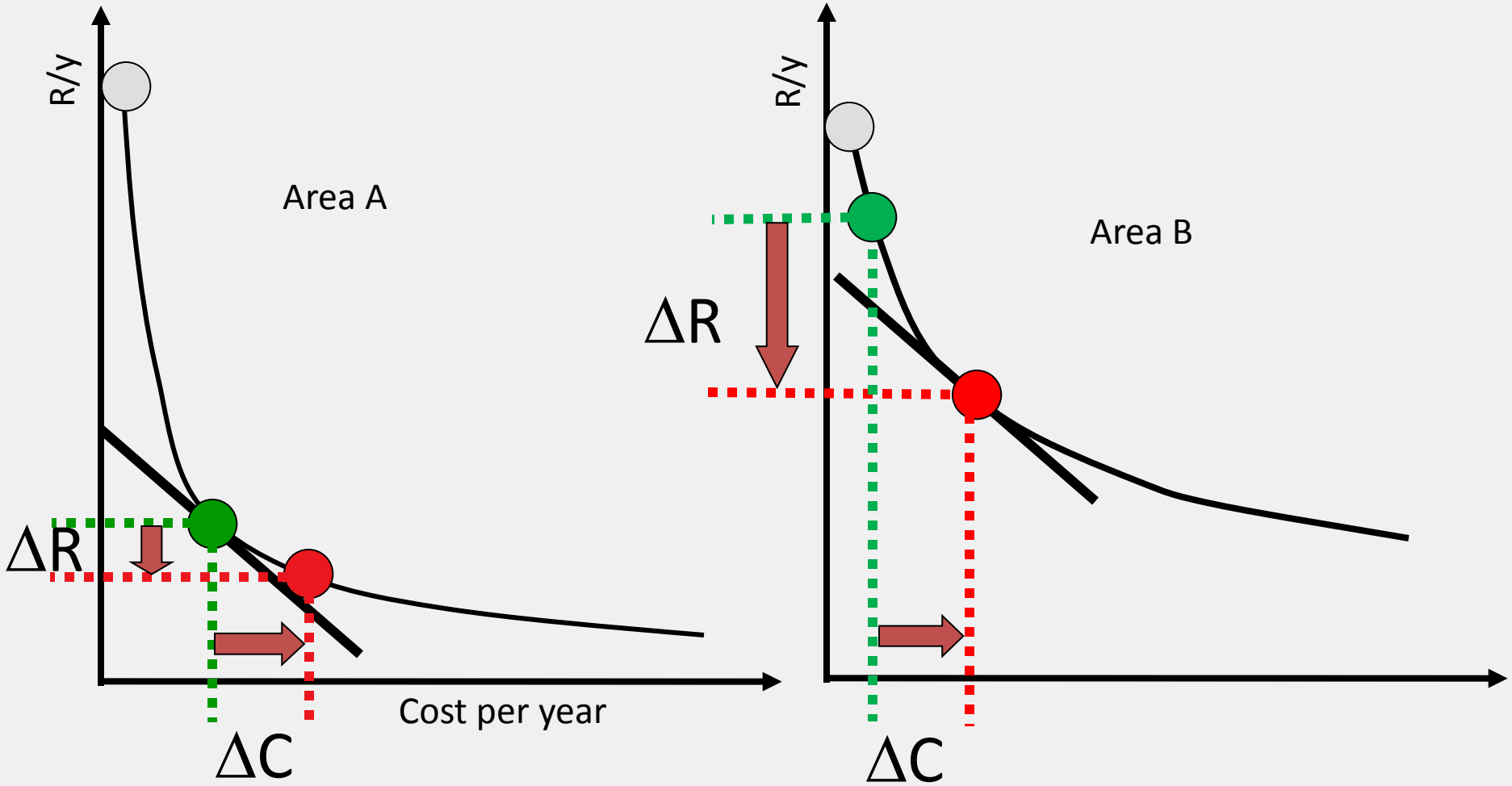




Optimisation of measure



Why marginal-cost approach?



Active of protection measures

Passive protection measures

Absolute safety does not exist

Avoid endagered areas

Reduce vulnerability (construction codes)

Be prepared for an event (Emergency plan)

Conclusion

To achieve a high level of safety, in endangered areas protection measures are essential.

To invest the money at the right place risk based decisions are required.

Based on the risk calculation the cost – effectiveness shows the «hot spots» for investigations in protection measures

Suche nach der optimalen Gefahrenbeurteilung und Massnahmenplanung

falsche, zu optimistische Modelle

falsche, zu pessimistische Modelle

fahrlässig

übervorsichtig

falsche Gefahren-beurteilung

richtige Erfassung der Gefahrensituation

falsche Gefahren-beurteilung

Zu kleine Gefahrenzonen
zu wenig Schutzmassnahmen
zu wenig Frühwarndienst

Weniger Aufwendungen aber Gefährdung von Menschen und Sachwerten

zu grosse Gefahrenzonen
zu viel Schutzmassnahmen
zu viel Frühwarndienst

Vermögensschäden
teure Investitionen
hohe Betriebskosten

Thank you
for your
attention