Methods of technical risk assessment in a regional context

Transportation of dangerous goods (TDG)

International research

Swiss legislation
- Transportation of dangerous goods
- Guidelines of the StFV

CARGO approach
- Basic concept
- 'Hot Spots'
- Computer tools - Results

Example: The Zurich-Affoltern Fire, March 8, 1994

SBB Cargo Train with 20 tank wagons carrying 80000 litres of benzin derailed due to a defected wheel bearing.
From a derailed wagon, benzin flowed out through a leakage, ignited and catched fire.
During the drainage of the tracks, big amounts of benzin entered the nearby canalization system.
Explosive mixture of benzin vapors and air was developed and exploded at different locations up to a radious of 7 km, causing damages to hundred meters of the canalization's pipes. A nearby rainwater purification basin was also destroyed.
Water and ground contamination due to the benzin and the polluted fire water used during the fire fighting.
Three houses burned down, three persons injured and damages of several million CHF.

What is the specific problem with TDG ?

- Moving, changing environment incl. population at risk
- Large variety of substances ; amounts vary stochastically (cargo ship - delivery van)
- Accumulations possible (shunting yards, oil depots)
- Cascading effects more probable (railway/road nearby chemical facilities)
- Risk-influencing factors (actual time table, speed control)
- General safety requirement and emergency measures

International research topics

- Routing lorries/trains transporting dangerous goods;
  trade-off between shortest/fastest route and risk issues [1];
  minimisation of the total risk of hazmat shipments [2]
- Assessing risks in transportation networks;
  calculation of societal risk due to potential accident scenarios [3], [4]
- Reduction of intervention times based on graph theory [5];
  design and location of specialised emergency response teams [6]
- Multiple use of space: individual risk and group risk in
  buildings constructed above roads and railways [7]

Transportation of dangerous goods : Regulations

International transportation regulation

- Reglement concernant le transport international ferroviaire de marchandises dangereuses (RID)
- Accord européen relatif au transport international des marchandises dangereuses par route (ADR)

Risk regulation in Switzerland

- Major accidents ordinance (StFV)
- Ordinance on the transport of dangerous goods by rail (RSD)
- Ordinance on the transport of dangerous goods by road (SDR)

SDR/ADR – Substance groups

Class 1 Explosives*
Class 2 Gases (flammable, non-flammable and poisonous)
Class 3 Flammable liquids
Class 4 Flammable solids
Class 5 Oxidizing agents and organic peroxides (liquid or solid)
Class 6 Toxic and infectious substances
Class 7 Radioactive substances*
Class 8 Corrosive substances
Class 9 Miscellaneous dangerous substances

* Not subject to the StFV

Guidelines of the StFV

Handbook III of the Major Accidents Ordinance
Guidelines for Transportation Routes [8]:

Railways and roads must be divided into segments with homogeneous characteristics

- Building structure
- Technical equipment
- Surroundings
- Security measures …

Description of the segment characteristics

- Drainage system
- Type of road
- Additional installations (e.g. petrol station, picnic area)
- Railway stations
- Number of tracks …

Guidelines of the StFV

Description of the surroundings

- Population density
- Ground water
- Surface water
- Special objects (e.g. shopping centre, camping ground, dangerous industrial facilities, etc.) …

Estimation of undesired event frequency

Accident scenarios

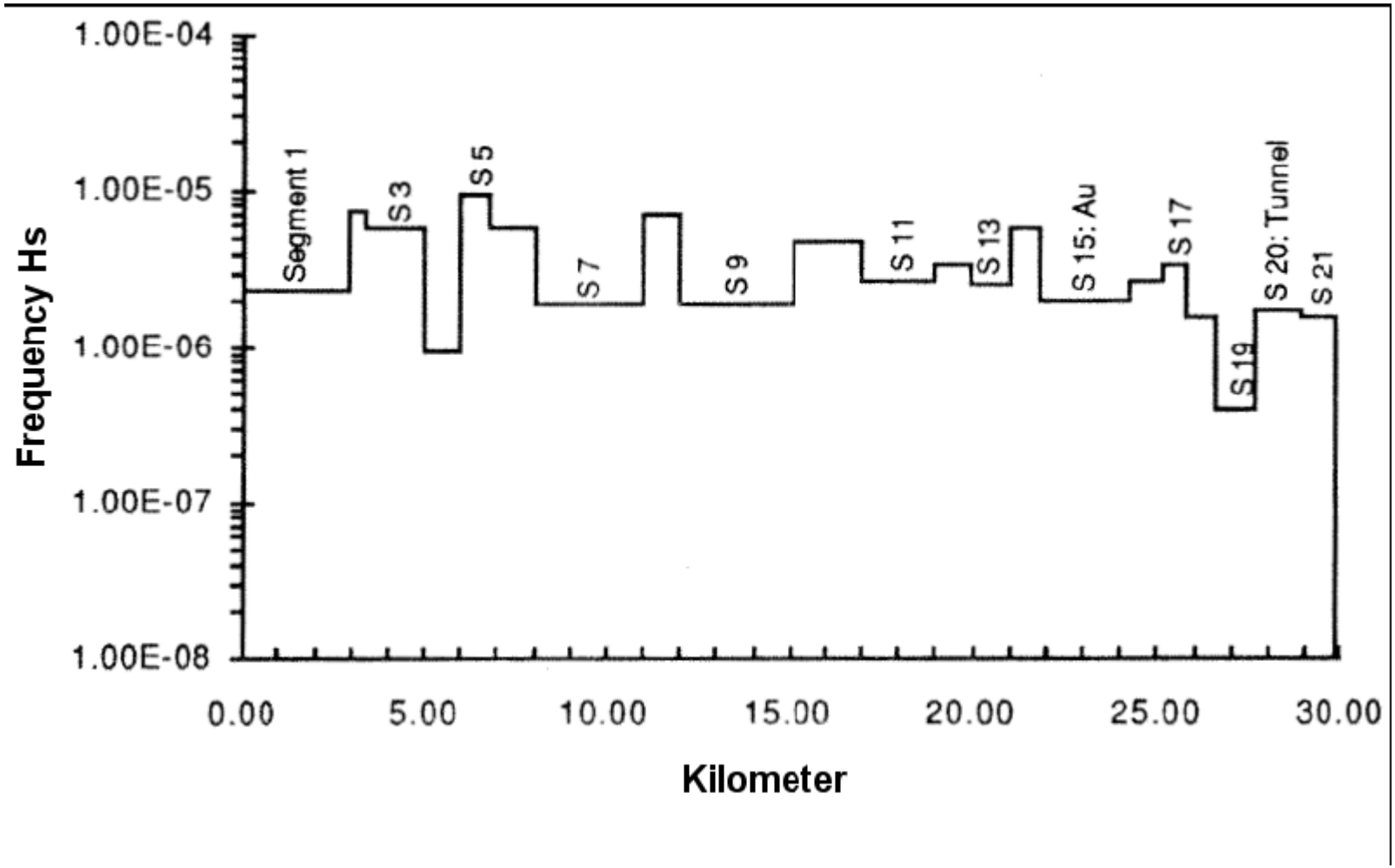
- Fire
- Explosion
- Toxic gas release
- Release of water endangering substances
- Release of mineral oil products

Road – Release frequency calculation

$$H_S = DTV \cdot 365 \cdot ASV \cdot UR \cdot AGS \cdot ASK \cdot ARS \cdot RFZ \cdot ASS$$

H_S: Frequency of a representative release scenario which causes heavy damage [$km^{-1}\ a^{-1}$]
DTV: Daily mean traffic is calculated to yearly traffic [vehicles/a]
ASV: Share of heavy vehicle traffic on the DTV [-]
UR: Accident rate [$vehicle^{-1}\ km^{-1}$]
AGS: Share of dangerous goods transports on the heavy vehicle traffic [-]
ASK: Share of the decisive SDR-classes on the representative accident scenario [-]
ARS: Share of the relevant substances on the decisive SDR-classes for the representative accident scenario [-]
RFZ: Rate for relevant releases and (in case of fire and explosion) a following ignition [-]
ASS: Number of representative accident scenarios which cause heavy damage [-]

More advanced methods: Frequency of harm to the population



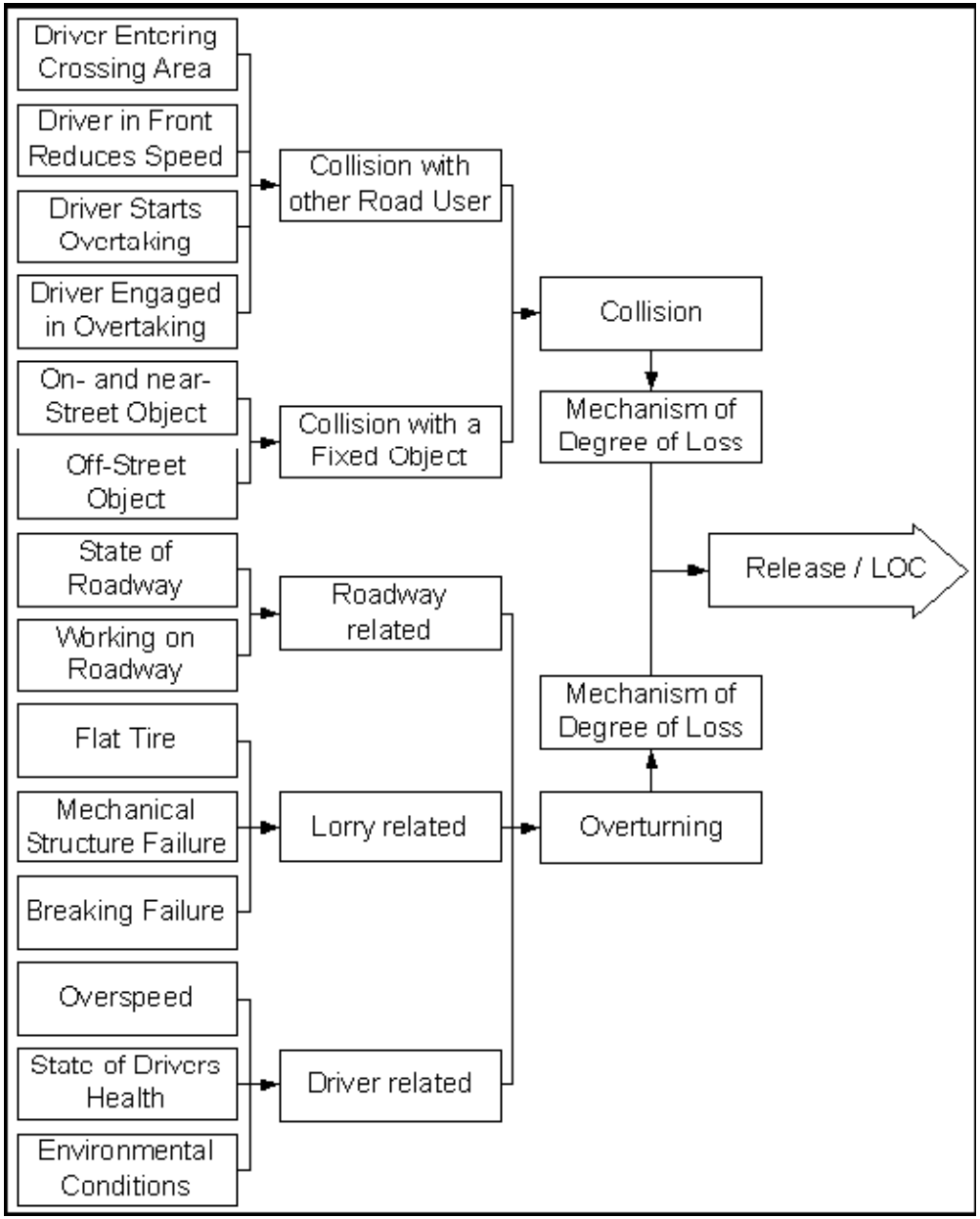
Basic concept

Loss of containment frequency

- Frequencies of transportations
- Basic event probabilities
- Human behaviour
- Segment parameters / characteristics

Consequence calculations

- Substance characteristics
- Amount transported



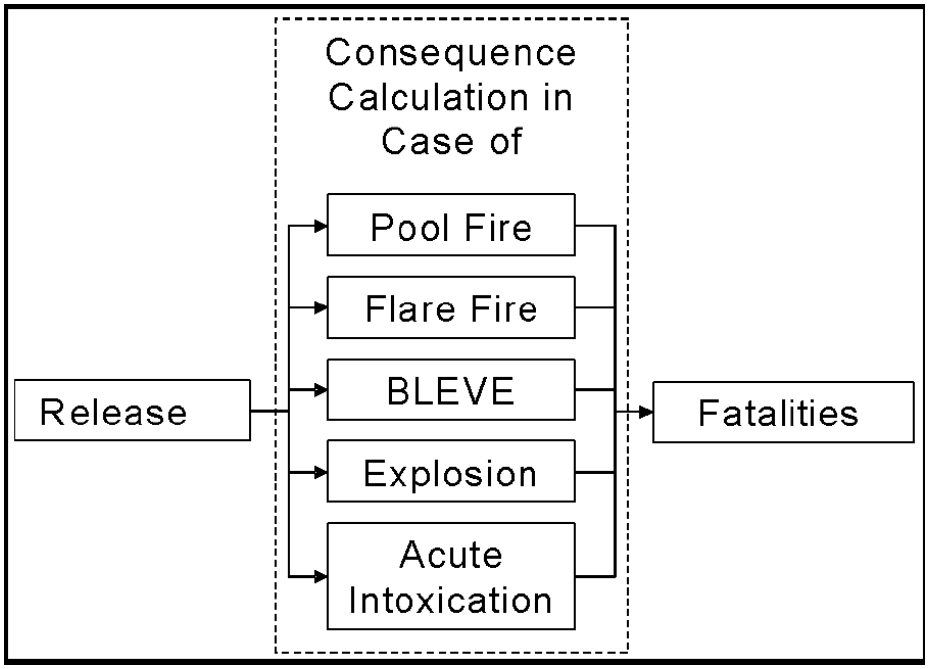
Basic concept

Loss of containment frequency

- Frequencies of transportations
- Basic event probabilities
- Human behaviour
- Segment parameters / characteristics

Consequence calculations

- Substance characteristics
- Amount transported
- Impact scenarios



Hot Spots

The concept of Hot Spots:

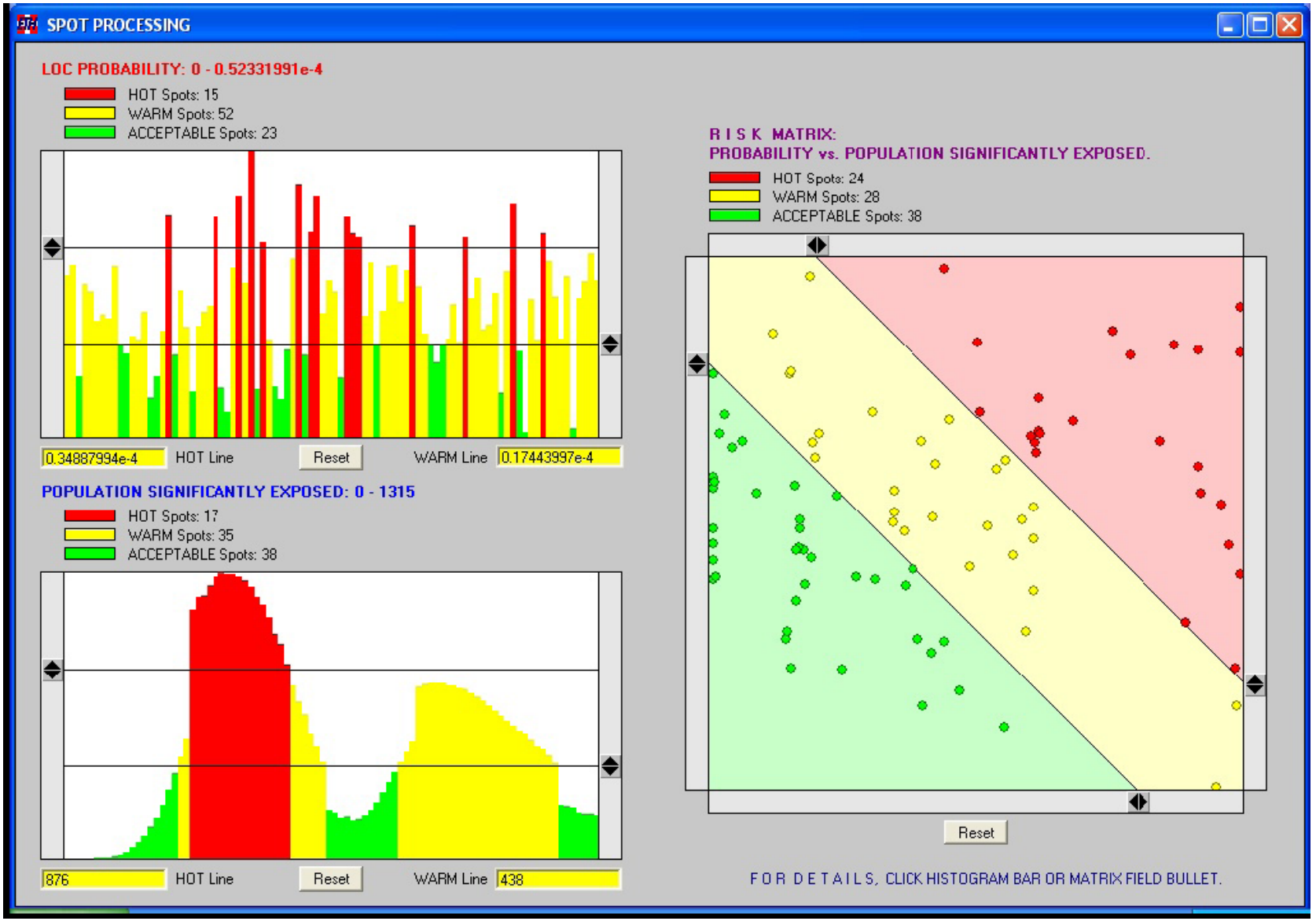
> *"A hot spot is defined by the existence of at least one infrastructural sensitive object in the vicinity of the actual location, and/or by the fact that the location has a high population density irrespective of the existence of an object." [3]*

CARGO

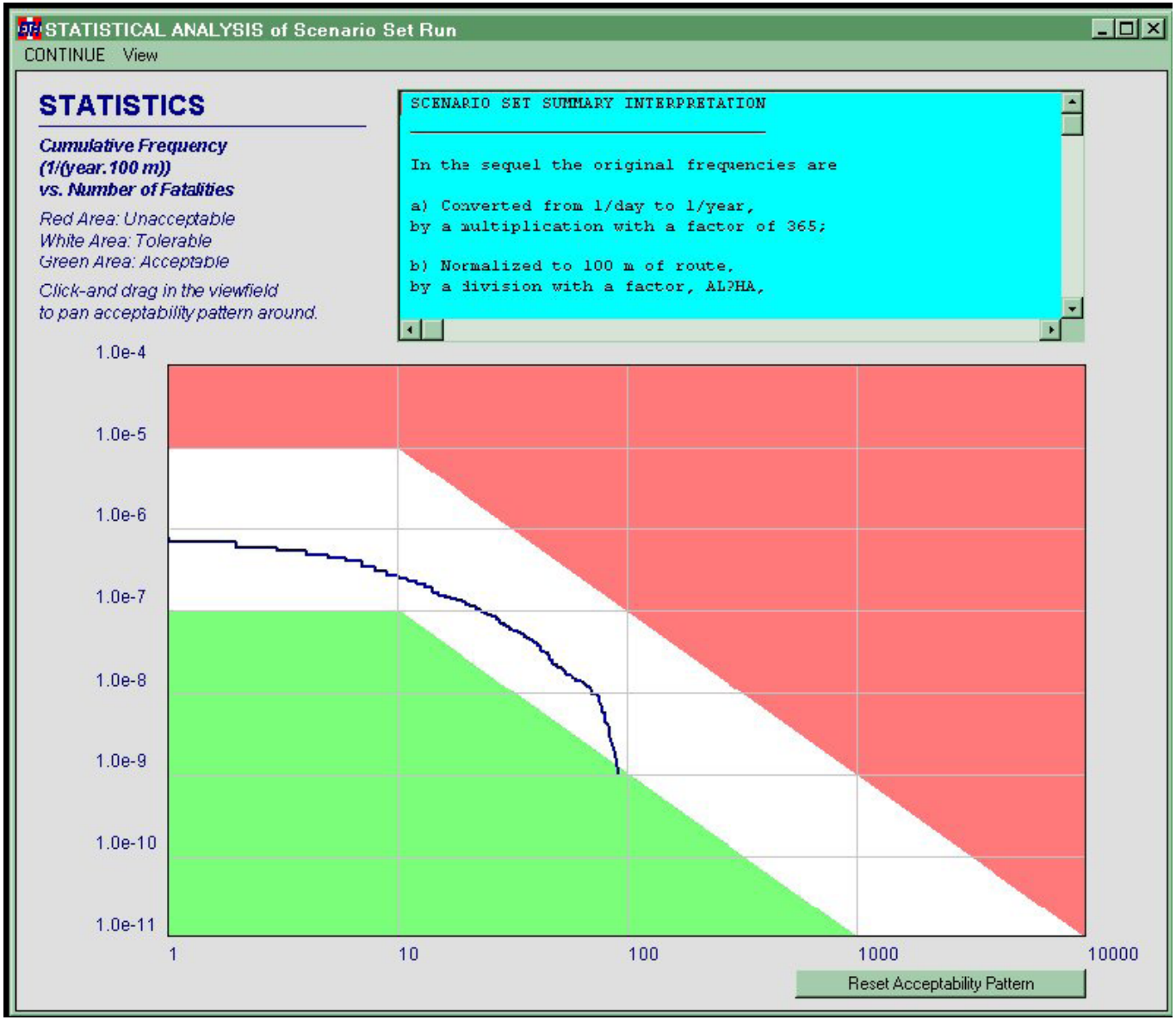
Implementation of the models and the concepts into the software tool CARGO.

- Societal risk along transportation routes
- Detection of "Hot Spots"
- Generation of a "Risk profile"

CARGO – Hot spots regarding societal risks



CARGO – Societal risk profile



References

[1] William C. Frank, Jean-Claude Thill, and Rajan Batta. *Spatial decision support system for hazardous material truck routing.* Transportation Research Part C: Emerging Technologies, 8(1-6):337–359, 2000.

[2] Stefano Giordani, Pasquale Carotenuto, and Salvatore Riccardelli. *Finding minimum and equitable risk routes for hazmat shipments.* Computers & Operations Research, 34:1304–1327, 2007.

[3] Adrian V. Gheorghe, Jürg Birchmeier, Dan Vamanu, Ionnis Papazoglou, and Wolfgang Kröger. *Comprehensive Risk Assessment for Rail Transportation of Dangerous Goods: A Validated Platform for Desicion Support.* Reliability Engineering & System Safety, 88(3):247–272, June 2005.

[4] John Hodgson, Jianjun Zhang, and Erhan Erkut. *Using GIS to assess the risks of hazardous materials transport in networks.* European Journal of Operational Research, 121:316–329, 2000.

[5] B. Fabiano, F. Currò, A.P. Reverberi, and R. Pastorino. *Dangerous good transportation by road: from risk analysis to emergency planning.* Journal of Loss Prevention in the Process Industries, 18:403–413, 2005.

[6] Vedat Verter, Oded Berman, and Bahar Y. Kara. *Designing emergency response networks for hazardous materials transportation.* Computers & Operations Research, 34:1374–1388, 2007.

[7] Ben Ale and Shahid Suddle. *The third spatial dimension risk approach for individual risk and group risk in multiple use of space.* Journal of Hazardous Materials, A123:35–53, 2005.

[8] BUWAL. *Handbuch III zur Störfallverordnung StFV (Richtlinien für Verkehrswege).* Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Dezember 1992.