Systematic Risk Analysis for Safety Assessments of Road Systems

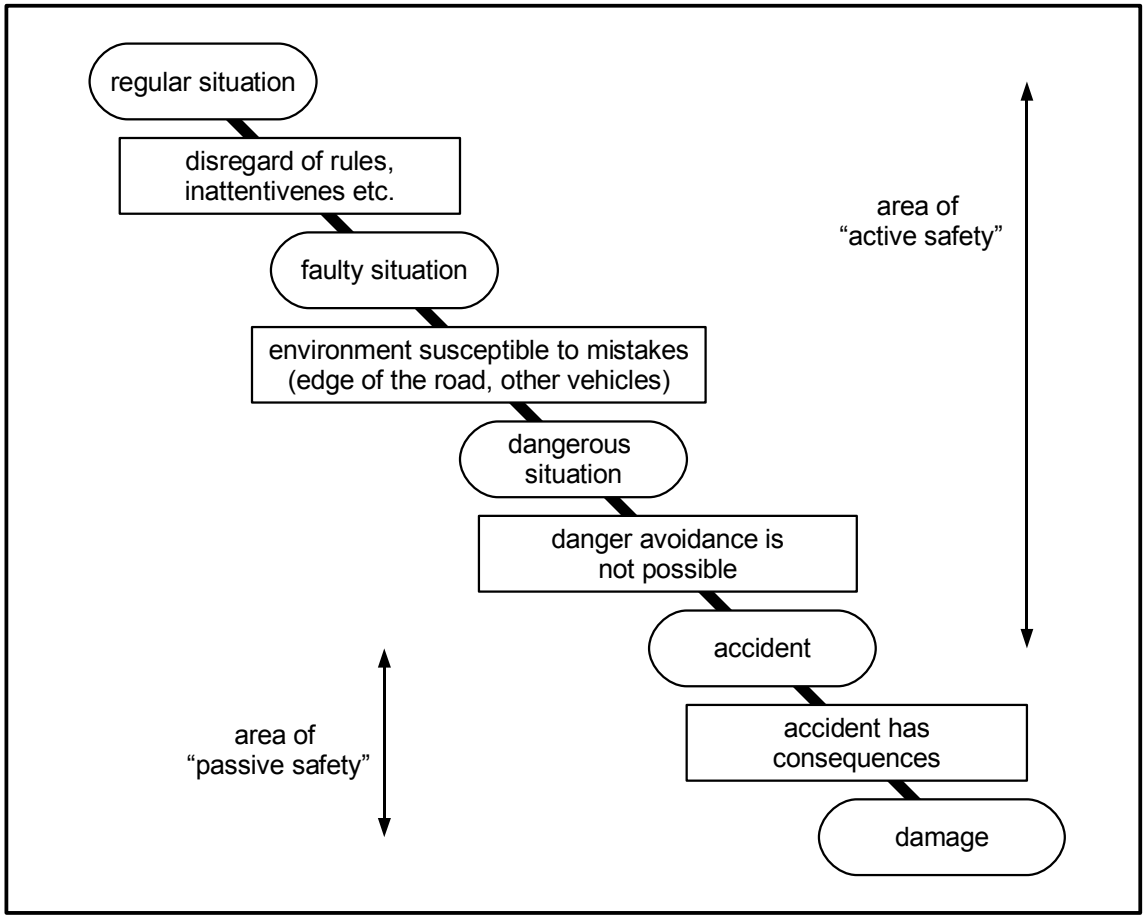
J. Stefan Bald
Katja Stumpf
Tim Wallrabenstein
Le Thu Huyen

Technische Universität Darmstadt

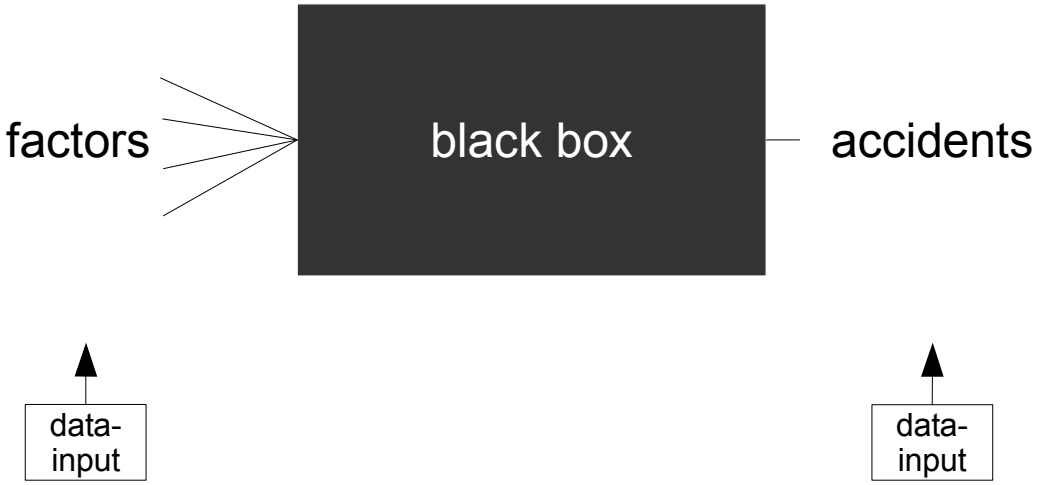
Germany

Accidents have no cause – they just happen ?!?

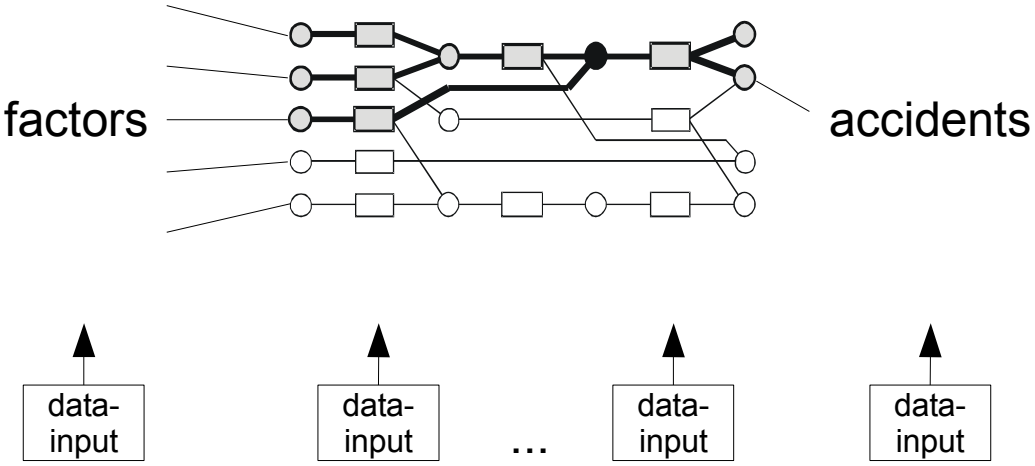
Each accidents is a result of a concatenation of unfortune events



Is the road system a black box for safety analysis?



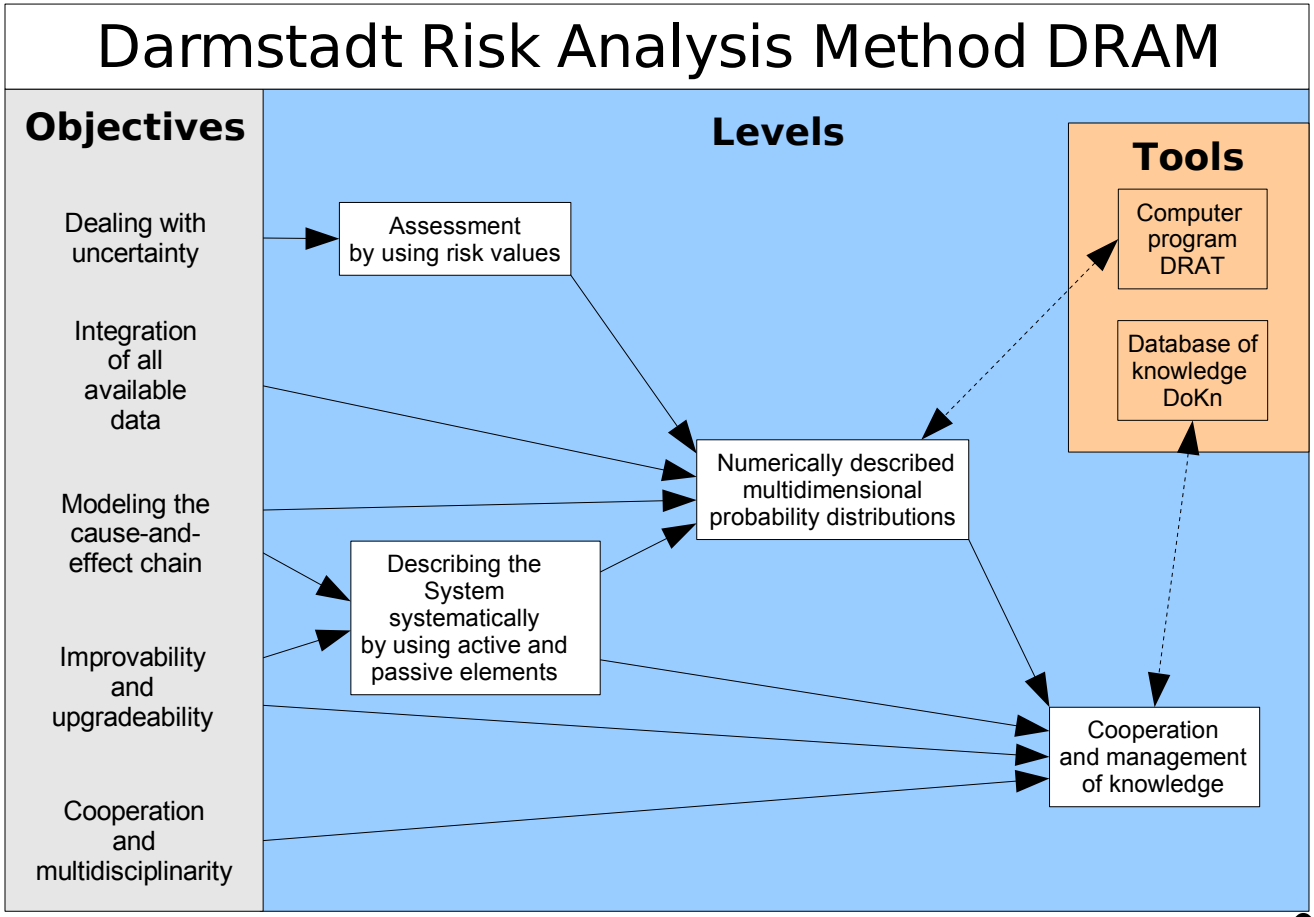
Or a well structured system, which can be described systematically?



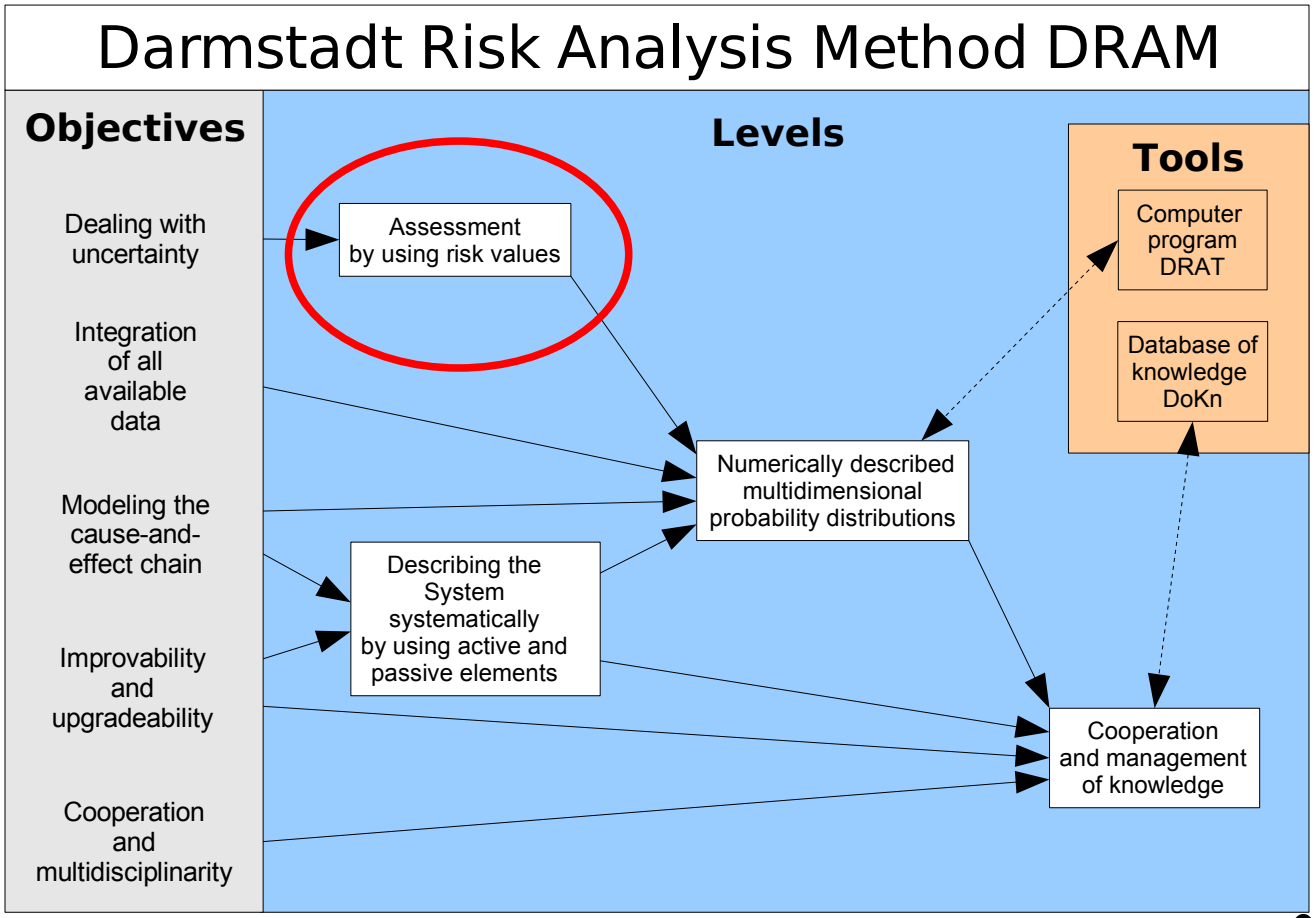
Main Objectives:

- **deal with uncertainty**;
- **include all available information;**
- get access to the **cause-and-effect chains** of the road system;
- have the possibility to **improve and upgrade** single parts (modules) of the model;
- to allow and encourage the **cooperation of different research groups,** even from different disciplines.

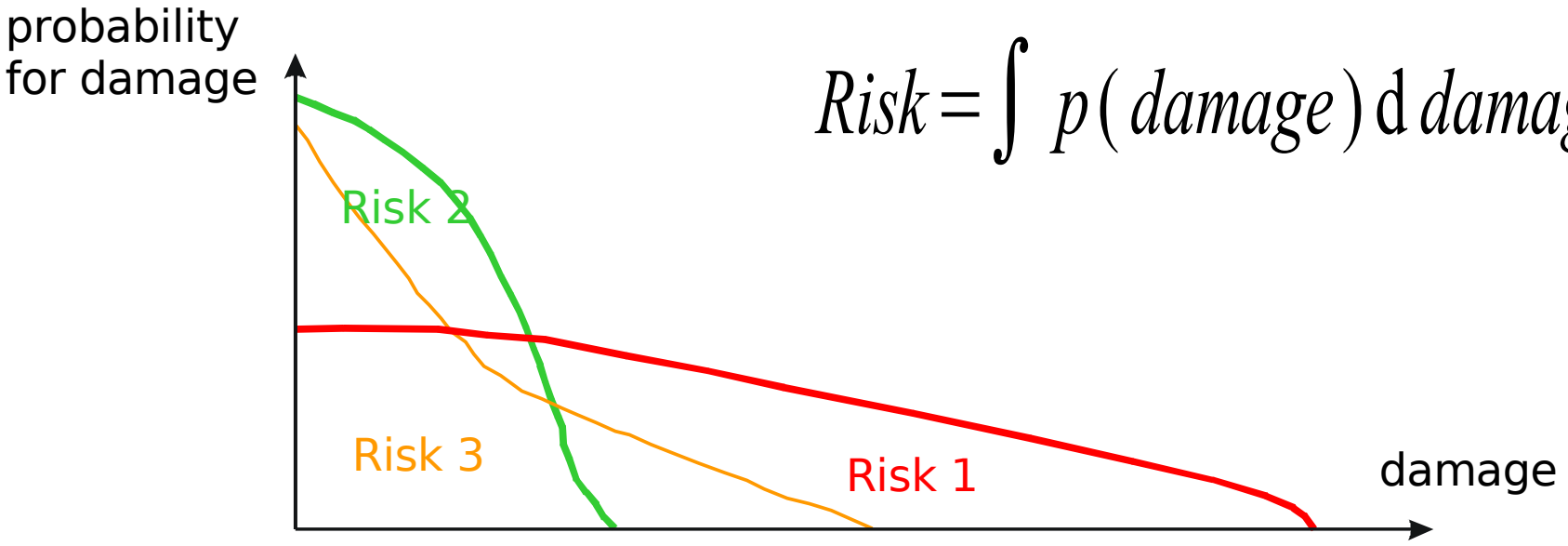
Overview


Darmstadt Risk Analysis Method DRAM
Objectives
Dealing with uncertainty
Integration of all available data
Modeling the cause-and-effect chain
Improvability and upgradeability
Cooperation and multidisciplinarity
Levels
Assessment by using risk values
Numerically described multidimensional probability distributions
Describing the System systematically by using active and passive elements
Cooperation and management of knowledge
Tools
Computer program DRAT
Database of knowledge DoKn

Overview

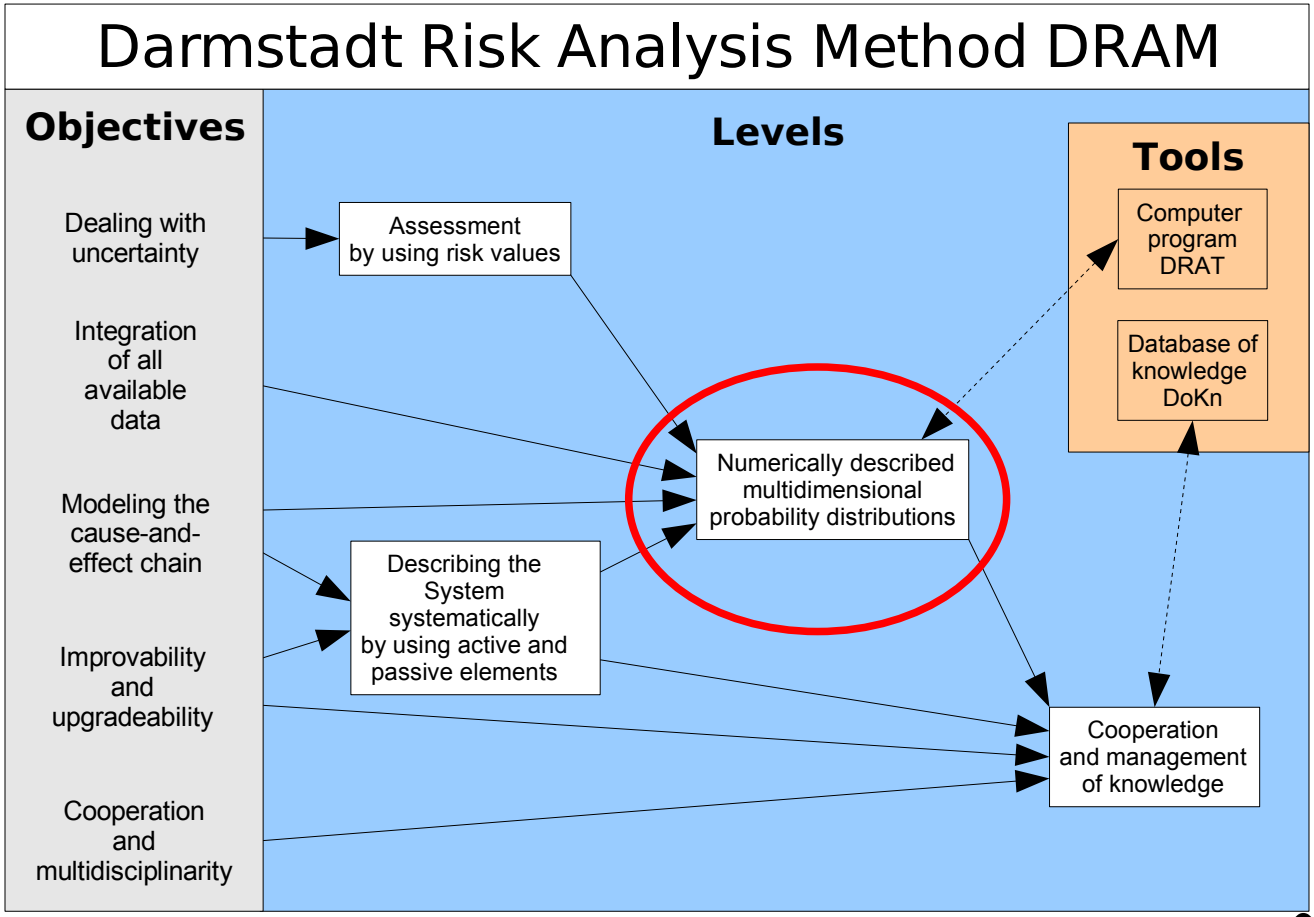

Darmstadt Risk Analysis Method DRAM
Objectives
Dealing with uncertainty
Integration of all available data
Modeling the cause-and-effect chain
Improvability and upgradeability
Cooperation and multidisciplinarity
Levels
Assessment by using risk values
Numerically described multidimensional probability distributions
Describing the System systematically by using active and passive elements
Cooperation and management of knowledge
Tools
Computer program DRAT
Database of knowledge DoKn

Assessment by Using Risk Values

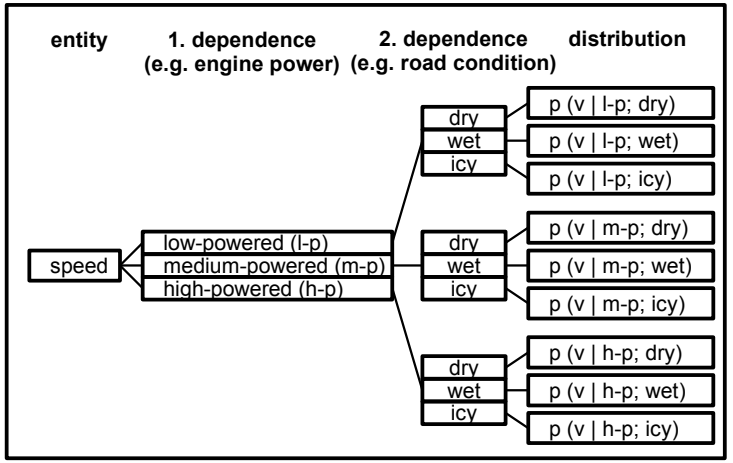


$$Risk = \int p(damage)\,\mathrm{d}\,damage$$

Overview


Darmstadt Risk Analysis Method DRAM
Objectives
Dealing with uncertainty
Integration of all available data
Modeling the cause-and-effect chain
Improvability and upgradeability
Cooperation and multidisciplinarity
Levels
Assessment by using risk values
Numerically described multidimensional probability distributions
Describing the System systematically by using active and passive elements
Cooperation and management of knowledge
Tools
Computer program DRAT
Database of knowledge DoKn

Numerically described multidimensional probability distributions (NDMPD)

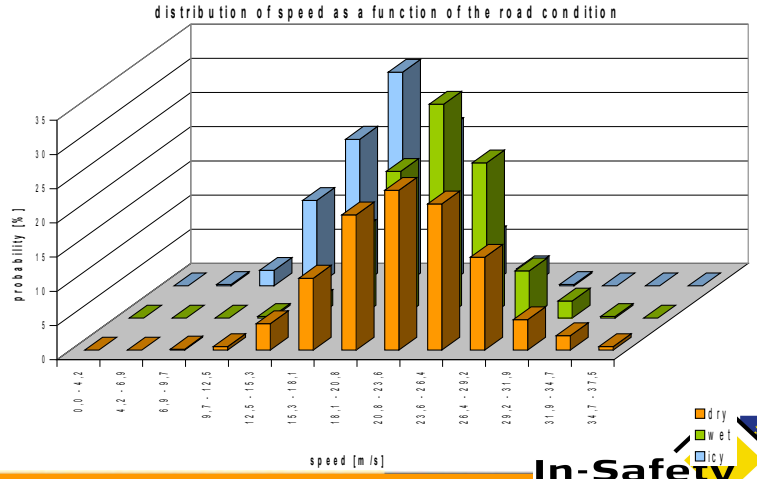


– Data is numerically described with probability distributions

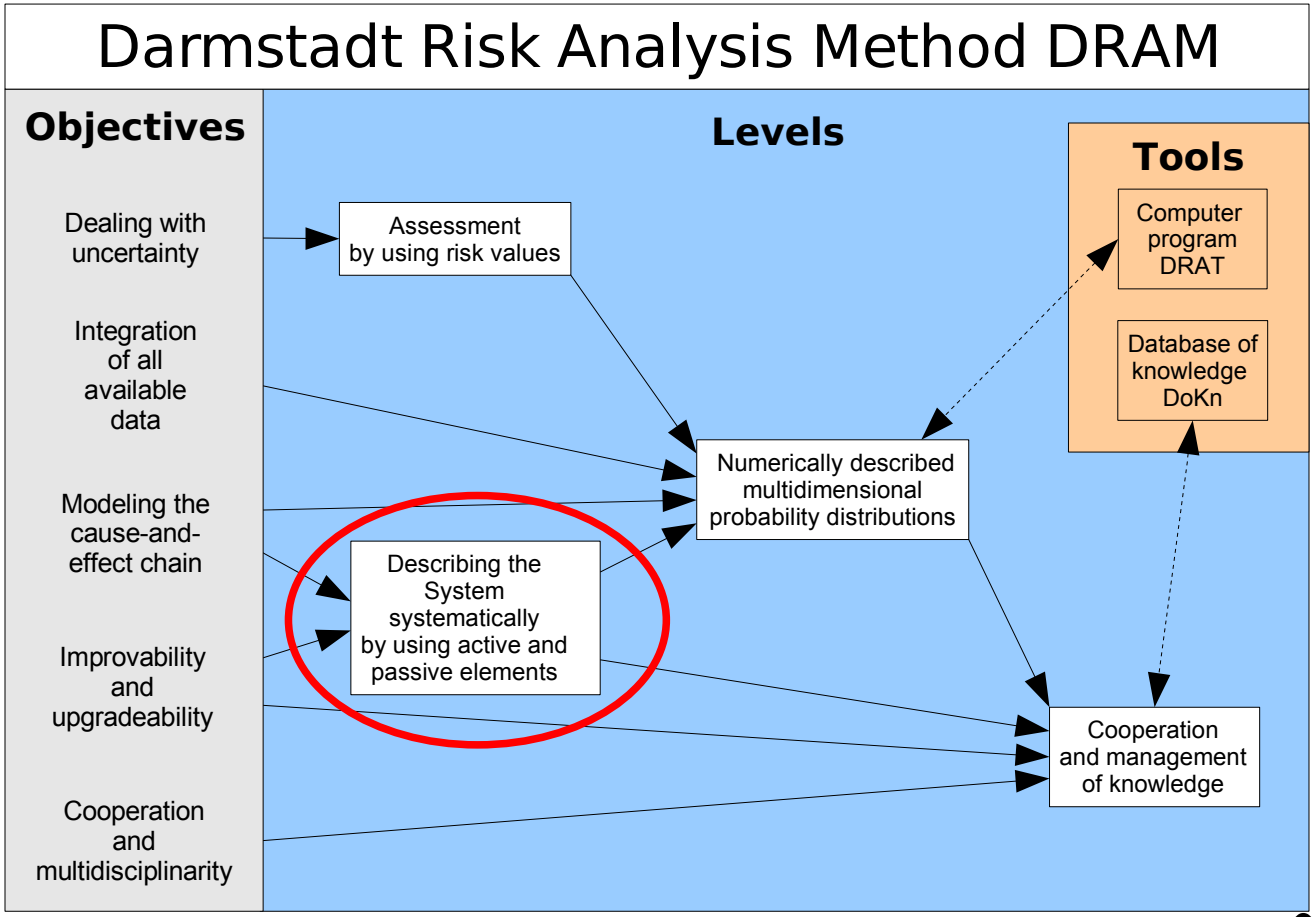
– Numerical description

– Multidimensionality

– The user describes the relations between variables as he is used to do



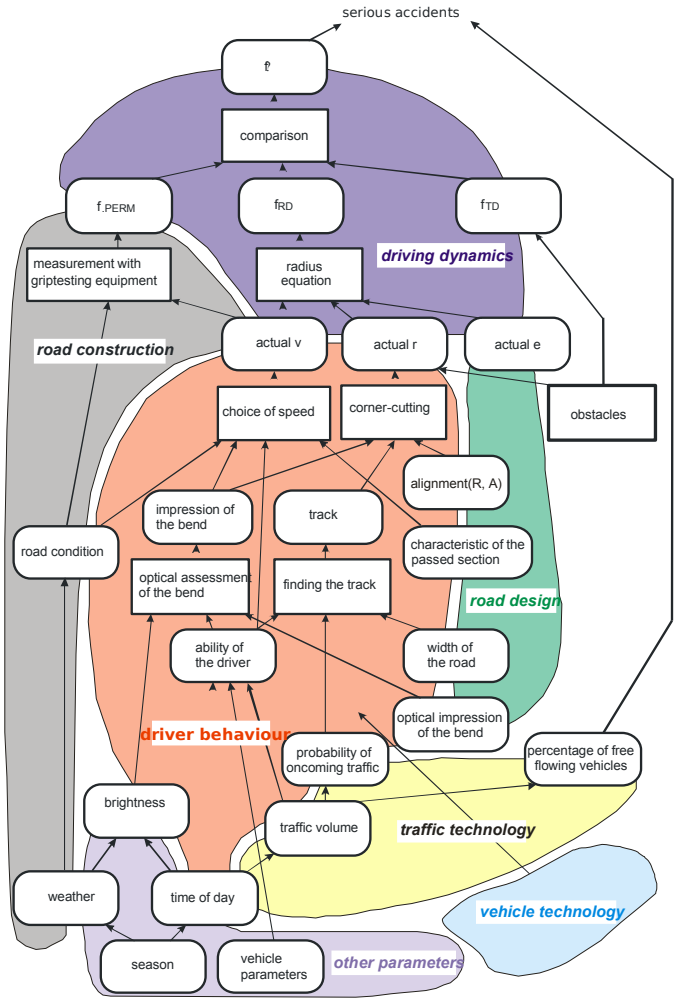
Overview


Darmstadt Risk Analysis Method DRAM
Objectives
Dealing with uncertainty
Integration of all available data
Modeling the cause-and-effect chain
Improvability and upgradeability
Cooperation and multidisciplinarity
Levels
Assessment by using risk values
Numerically described multidimensional probability distributions
Describing the System systematically by using active and passive elements
Cooperation and management of knowledge
Tools
Computer program DRAT
Database of knowledge DoKn

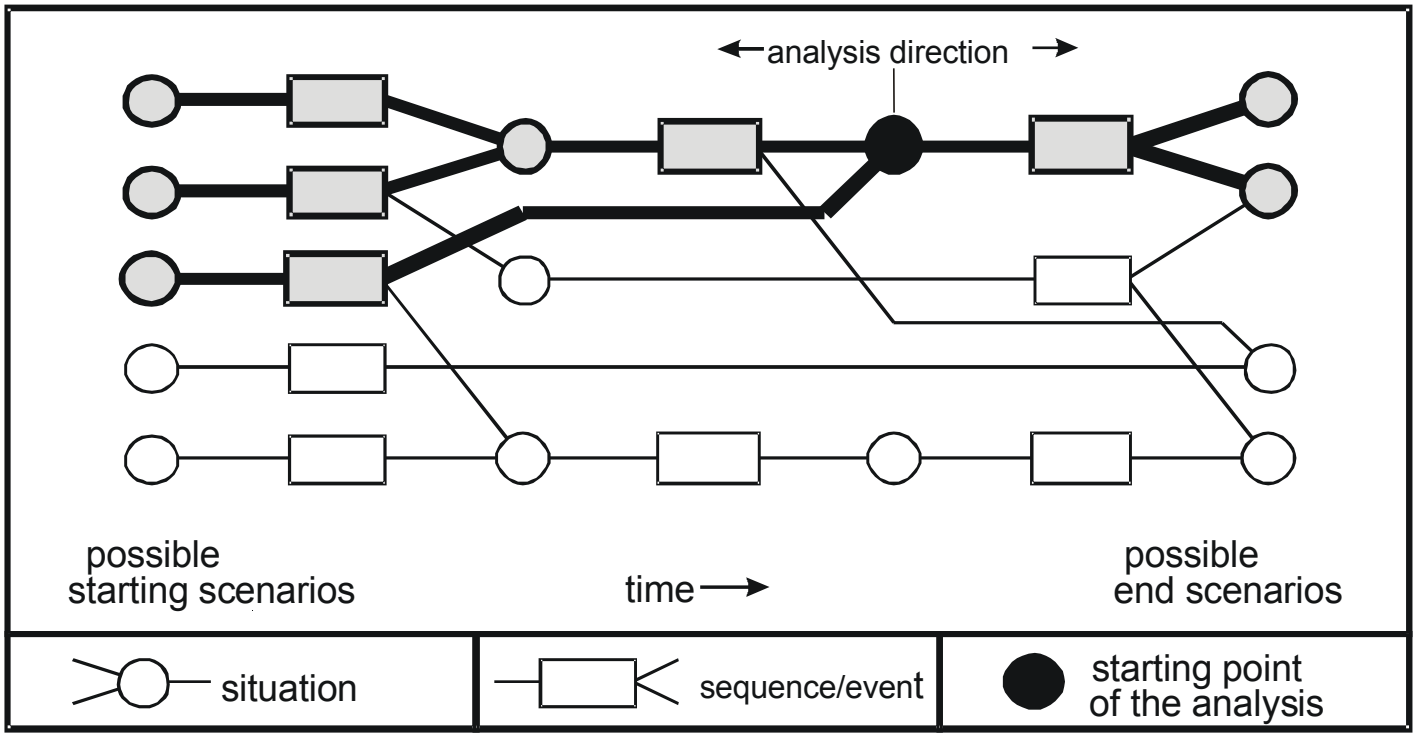
Describing the System systematically

The aim of DRAM is to modularily describe the cause-and-effect chain of a system with active and passive elements

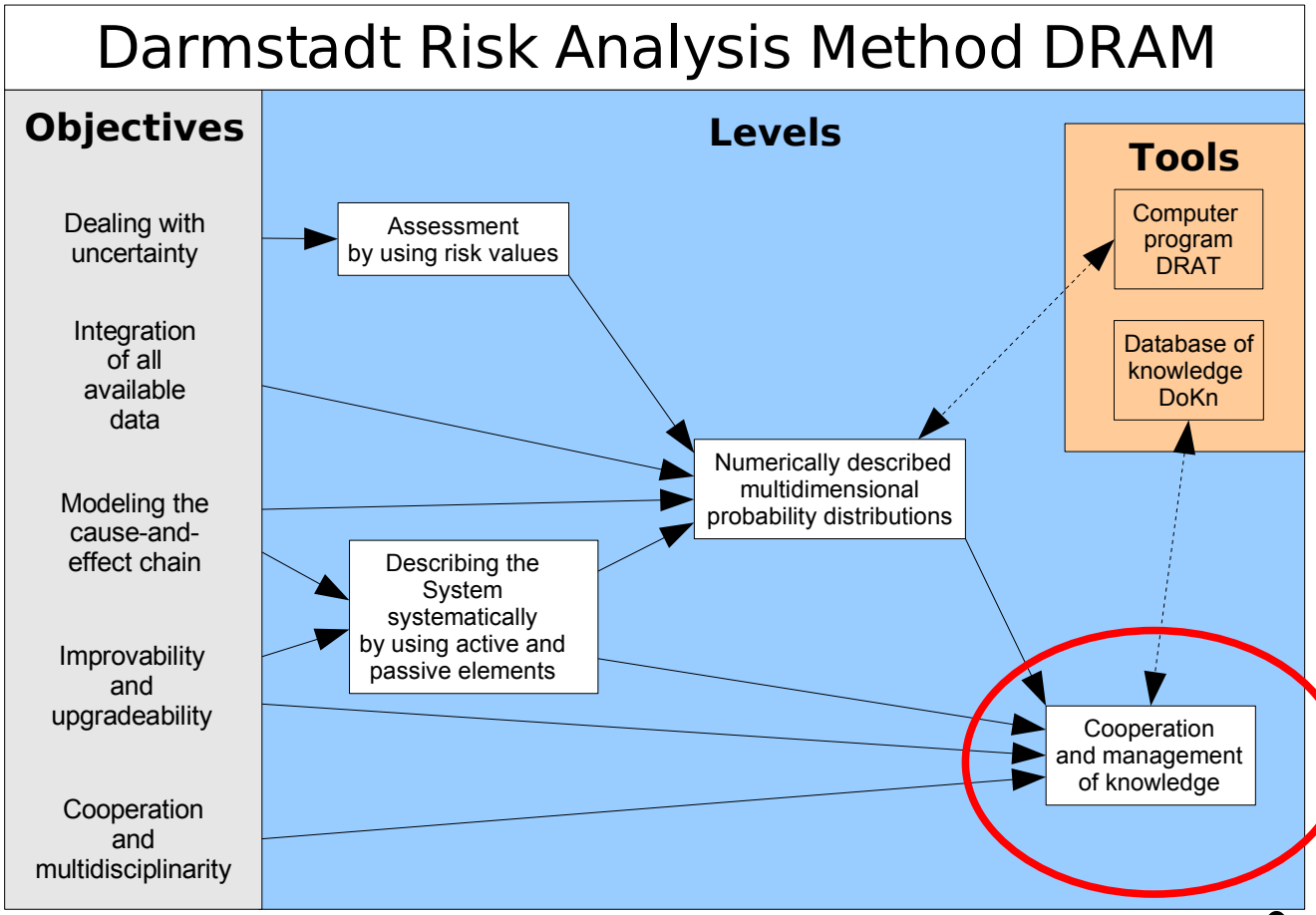
The modelling process may build on (reasonable) assumptions



Describing the System systematically



Overview


Darmstadt Risk Analysis Method DRAM
Objectives
Dealing with uncertainty
Integration of all available data
Modeling the cause-and-effect chain
Improvability and upgradeability
Cooperation and multidisciplinarity
Levels
Assessment by using risk values
Numerically described multidimensional probability distributions
Describing the System systematically by using active and passive elements
Cooperation and management of knowledge
Tools
Computer program DRAT
Database of knowledge DoKn

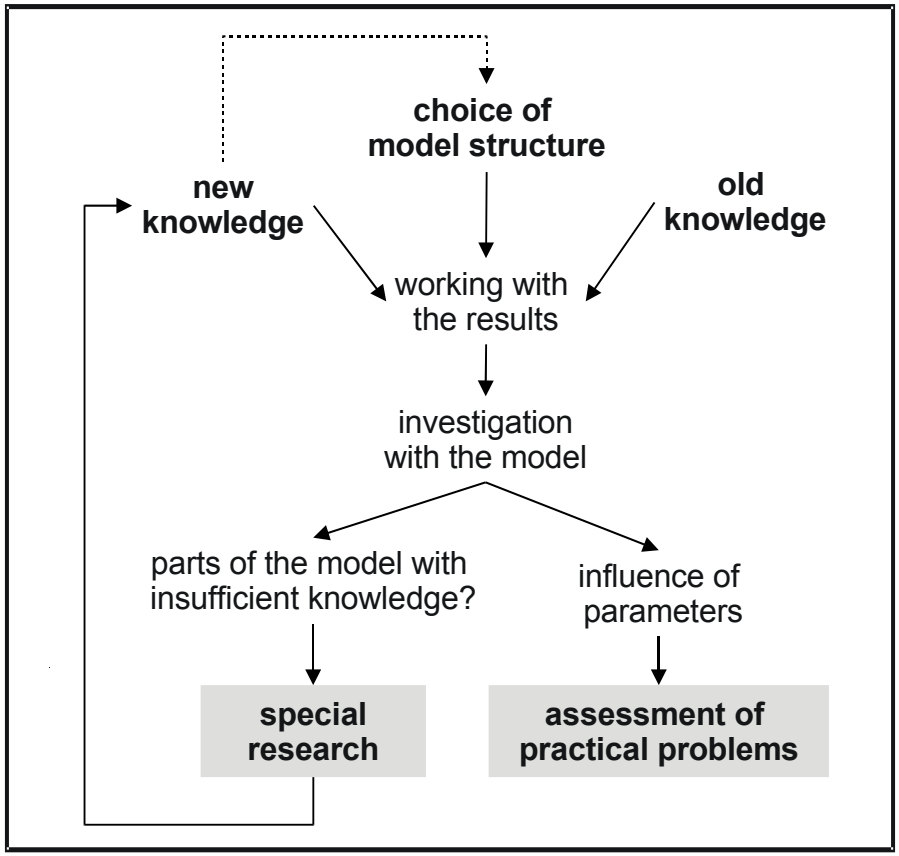
Cooperation and Management of Knowledge

To enable, encourage and promote cooperation

- we propose to establish a Database of Knowledge (DoKn) as a sort of repository of modules
- we propose a set of „rules“ how researchers and practicianers may anounce their needs and their findings and how they can find partners
- NDMPD are an ideal way to store and exchange risk (safety) related information

Proposed Approach

- First model, in which existing knowledge will be integrated
- Identify problematic parts (sensitivity analysis)
- Refine and enhance model with specific research, possibly also with reasonable assumptions
- Use the model for general and detailled investigations



Our vision is cooperation

- We are convinced that a breakthrough in safety research is only possible, if many specialists work together
- We developed a method, which allows, needs and promotes cooperation
- We ecourage to build up such a community
- It is up to you to use the method (with us; with others)

Actual Work

- Motivate knowledge holders to cooperate
- Start qualitative analysis
- Collect data and building the Database of Knowledge (DoKn)
- Refine quantitative analysis
- Start to enhance the tools

Thank You!

J. Stefan Bald, Katja Stumpf, Tim Wallrabenstein, Le Thu Huyen

Road and Pavement Engineering,
Technische Universität Darmstadt

Petersenstraße 30, 64287 Darmstadt, Germany

fon +49 6151 16-2686
fax +49 6151 16-3386

strassenwesen@verkehr.tu-darmstadt.de

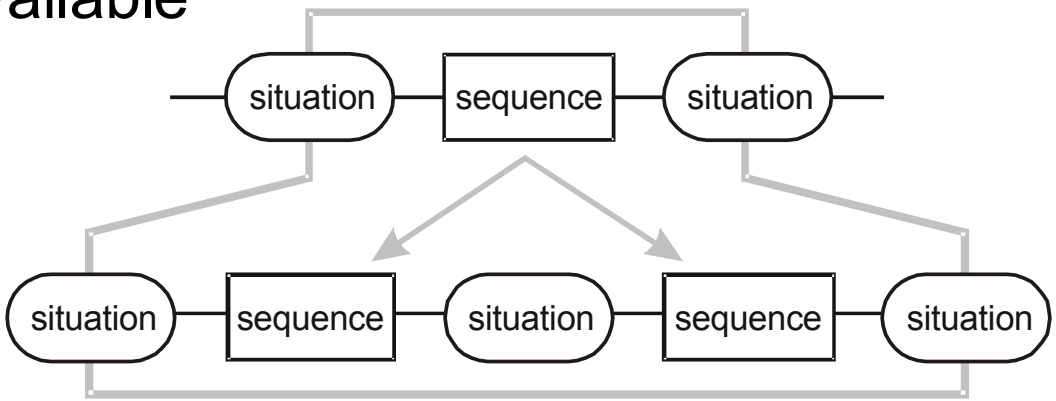
www.tu-darmstadt.de/verkehr

Summary of Advantages

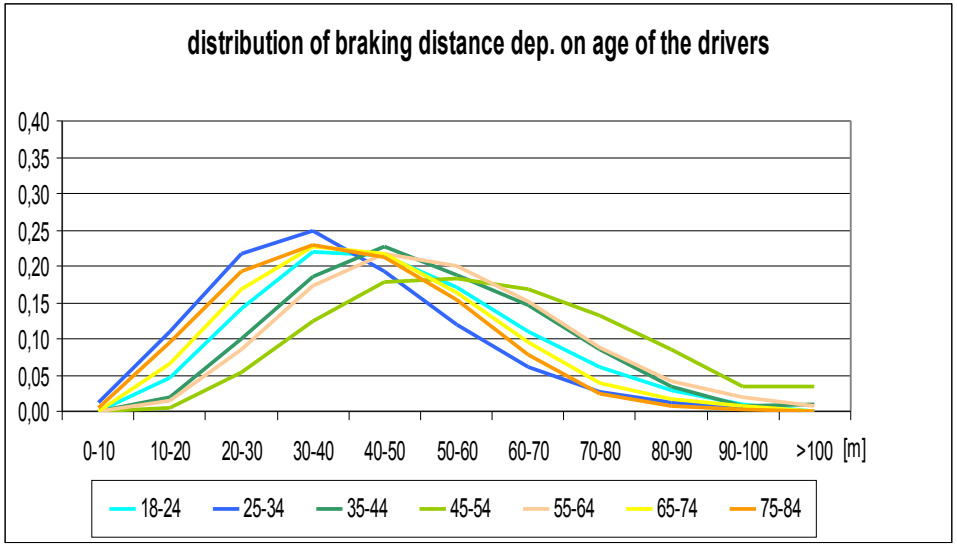
- Modelling the cause-and-effect chains gives new insights into the system, especially if you are looking for
  - the reasons for failures
  - the probable extent of damage
  - the effect of possible measures
- An overall covering structured model allows
  - to work in many working groups, even from different disciplines
  - integrating not only the (statistically „rare“) accident events, but many more (also behavioural) data
  - upgrading and refining the model in certain areas without redesigning the whole structure

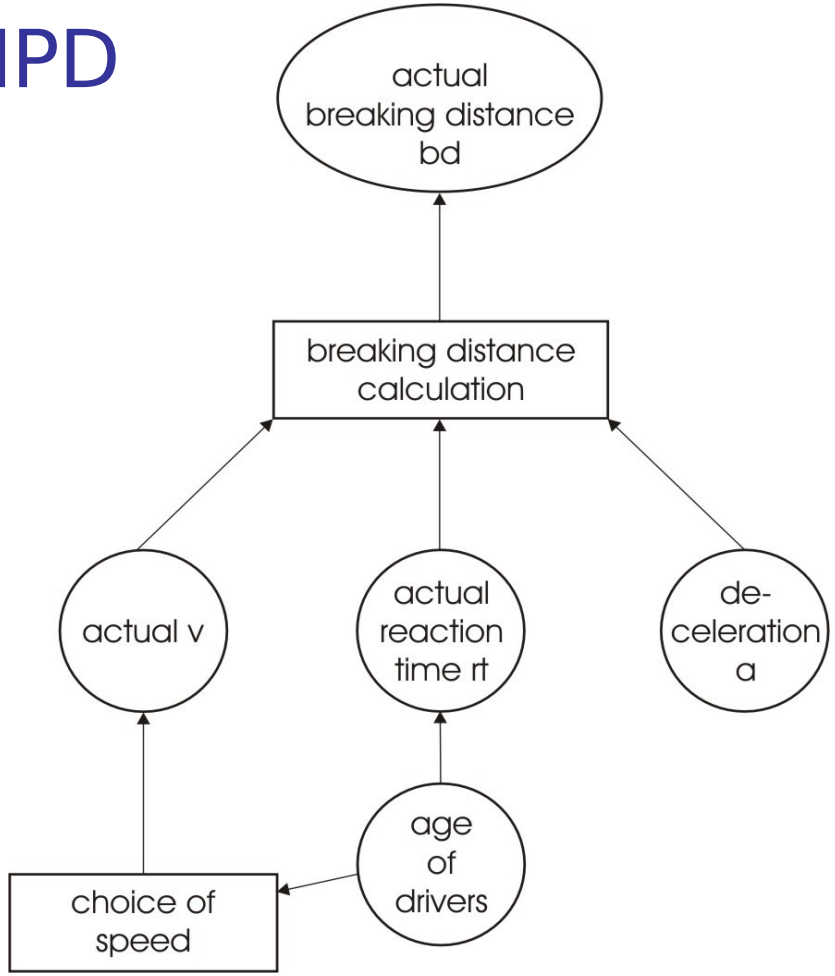
Modularity

–allows to selectively refine (parts of) the model according to the needs and the available knowledge

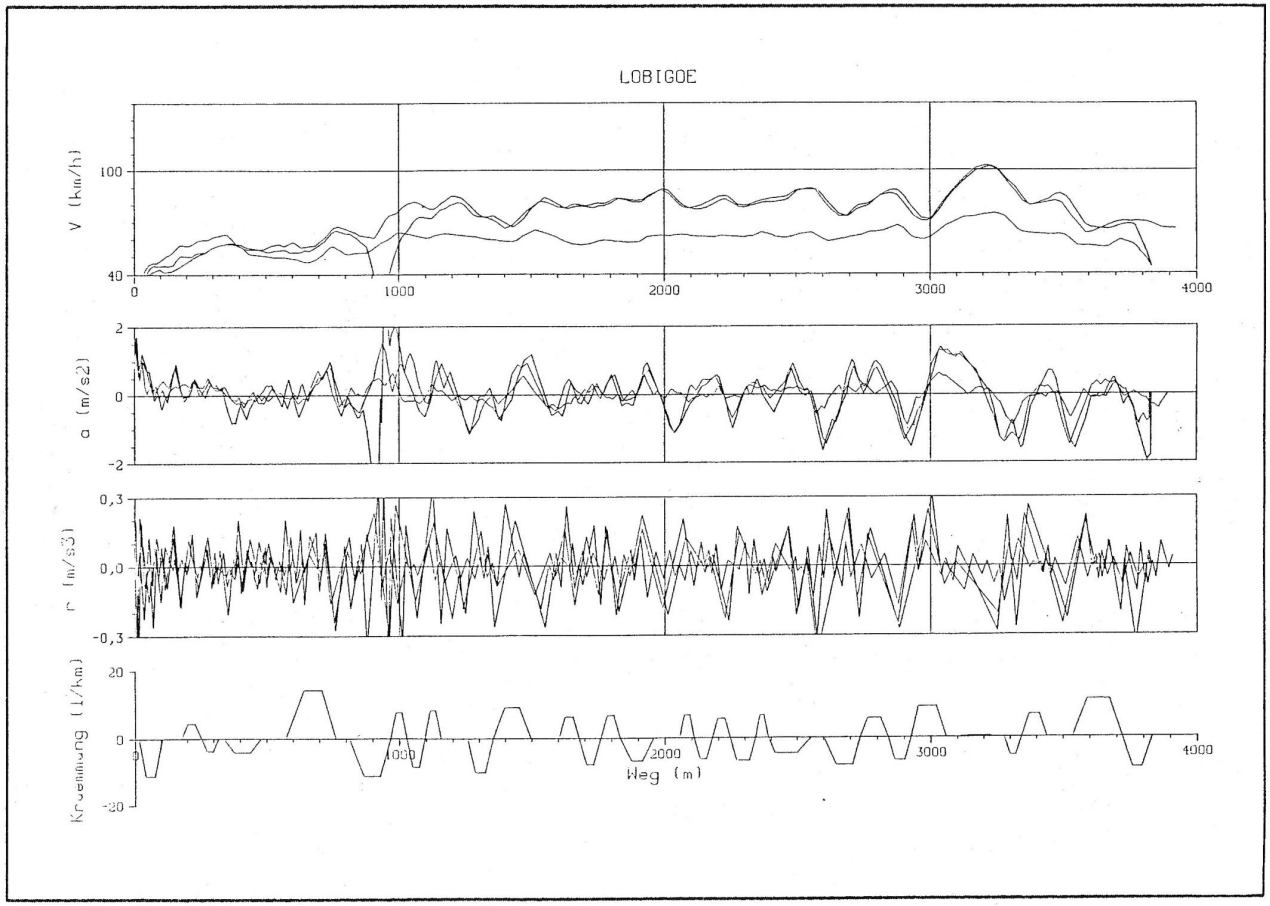


Very simple example for calculating with NDMPD



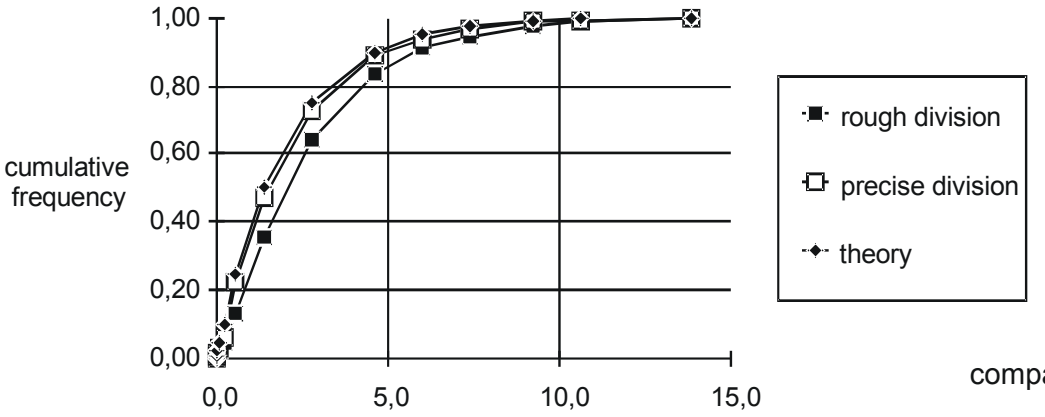


Driver behaviour is reproducable

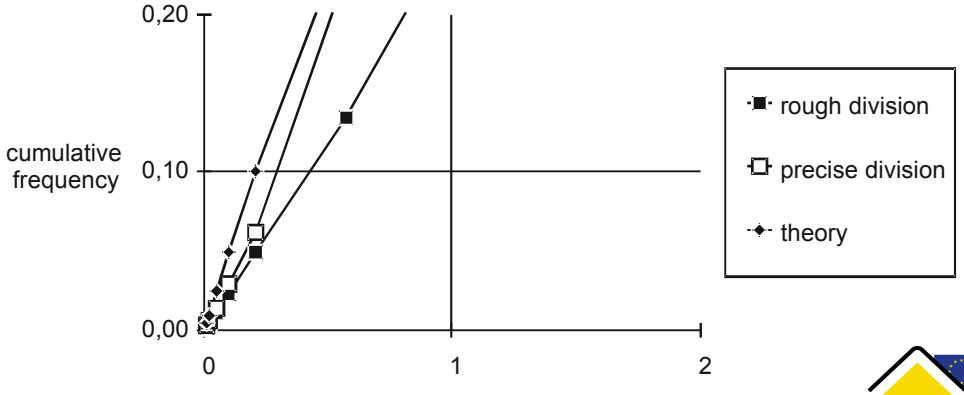


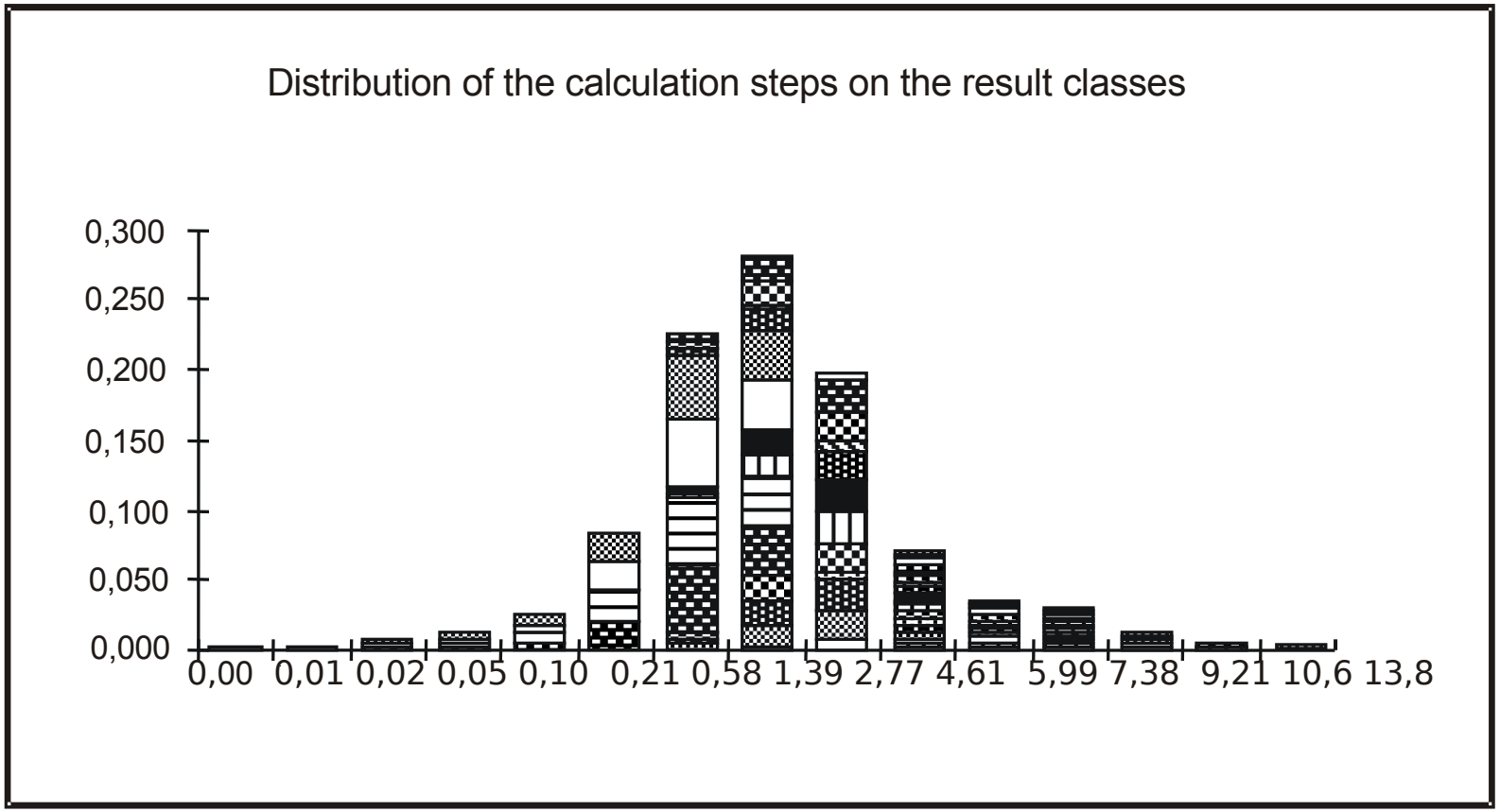
Numerical description allows appropriate accuracy

comparison of the computation accuracy



comparison of the computation accuracy (enlargement)




Distribution of the calculation steps on the result classes
0,300
0,250
0,200
0,150
0,100
0,050
0,000
0,00 0,01 0,02 0,05 0,10 0,21 0,58 1,39 2,77 4,61 5,99 7,38 9,21 10,6 13,8