Universität Karlsruhe (TH)
Research University • founded 1825

EDIM

KIT
Karlsruhe Institute of Technology

Management of Critical Infrastructure Disruptions in Industrial Supply Chains




IDRC- International Disaster and Risk Conference

1st International Conference on Critical Infrastructure Protection and Resilience

Davos

August 26 - 27, 2008

Mirjam Merz and Michael Hiete
Institute for Industrial Production (IIP)
University of Karlsruhe (TH), Germany

Overview

- **Critical Infrastructure and Industrial Production**
  - Infrastructure Interdependencies
  - Vulnerability of Critical Infrastructures
  - Infrastructure Dependency of Industrial production sites
  - Cascading Effects within Industrial Supply Chains
- **Crisis Management for Critical Infrastructure Disruptions**
  - Business Recovery and Business Continuity Planning
  - Multi Criteria Decision Support for Business Continuity Planning
- **Case Study**
  - The LÜKEX Case Study
  - Exemplar Results
- **Conclusion**

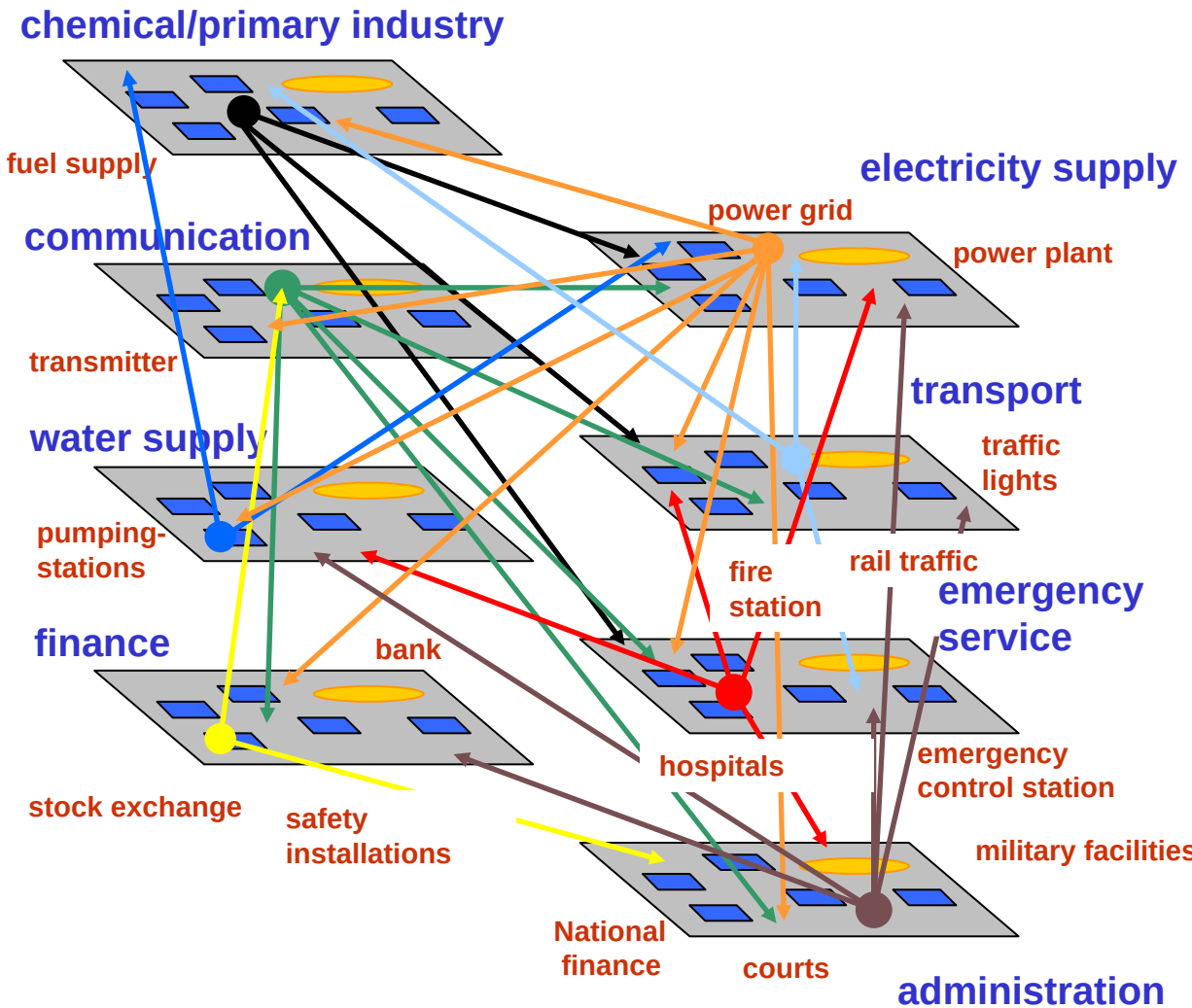
Critical Infrastructures (CI)

Definition:

Organisations, facilities, networks, services and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of a country or the effective functioning of the government.

German Federal Office for Information Security (BSI) (2004)

- High degree of interdependency between the CI-sectors
- Exceptional role of the electricity supply sector



addapted from Foster et al. 2004

Infrastructure Dependency of Industrial Production Sites

Critical Infrastructures are essential for the **continuity** of Production Processes

Critical Infrastructure	Relevance for Industrial Production	Criticality
Electricity Supply	Production processes Process controll Measuring systems Administration/Management Service installations	**high** sector specific
Transport	Supply of raw materials Supply of vendor parts Ditribution of products Waste disposal	**high**
Water Supply	Process water Cooling water Auxiliary material Cleaning Sanitary equipment	sector specific
IT and Communication	Data management General administration Process control Internal and external Communication Sales Ordering	**medium - high** sector specific
Primary Industry	Raw materials Energy sources	sector specific
Administration	Licences Surveillance	**medium**
Finance	Payments	**medium**
Emergency Services	Medical care for employees	**low - medium**

Exceptional role due to:

- direct dependency of production processes
- dependency of almost all auxiliary services
- dependency of all other sectors of critical infrastructures

Sector specific Power Dependency

Sector Specific Power Dependency of energy intensive Sectors:

Sector	Power Intensity [MJ/€]	Power Criticality (ATC-25)
Primary Metall Production	9,6	0,9
Paper & Pulp	8	1
Petrol. Refining	5,9	1
Chemical & Drug	4,1	0,9
Glass Stone Clay	3,3	1
Food &Tobacco	1,7	0,9
Vehicle Construction	1	1
Machine Construction	0,5	0,9

Power disruptions resulting in industrial / economic losses :

- 2008 South Africa: Interruption of gold and platinum mines
- 2007 Korea: Samsung chip production – losses: US $ 60 Mio.
- 2005 Germany: Large area blackout, SME - losses: > € 100 Mio.
- 2003 USA: Petroleum refineries and chemical industry – losses: US $ 2 billion
- 1999 Turkey: Automotive supplier and chemical industry

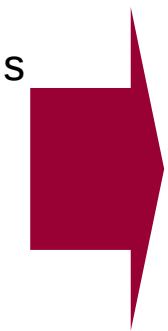
Industrial Impacts of Power Disruptions

Typical Impacts of Power Disruptions:

- production downtimes
- damage of sensitive manufacturing facilities
- loss of raw materials, finished products and products in stock
- secondary hazards

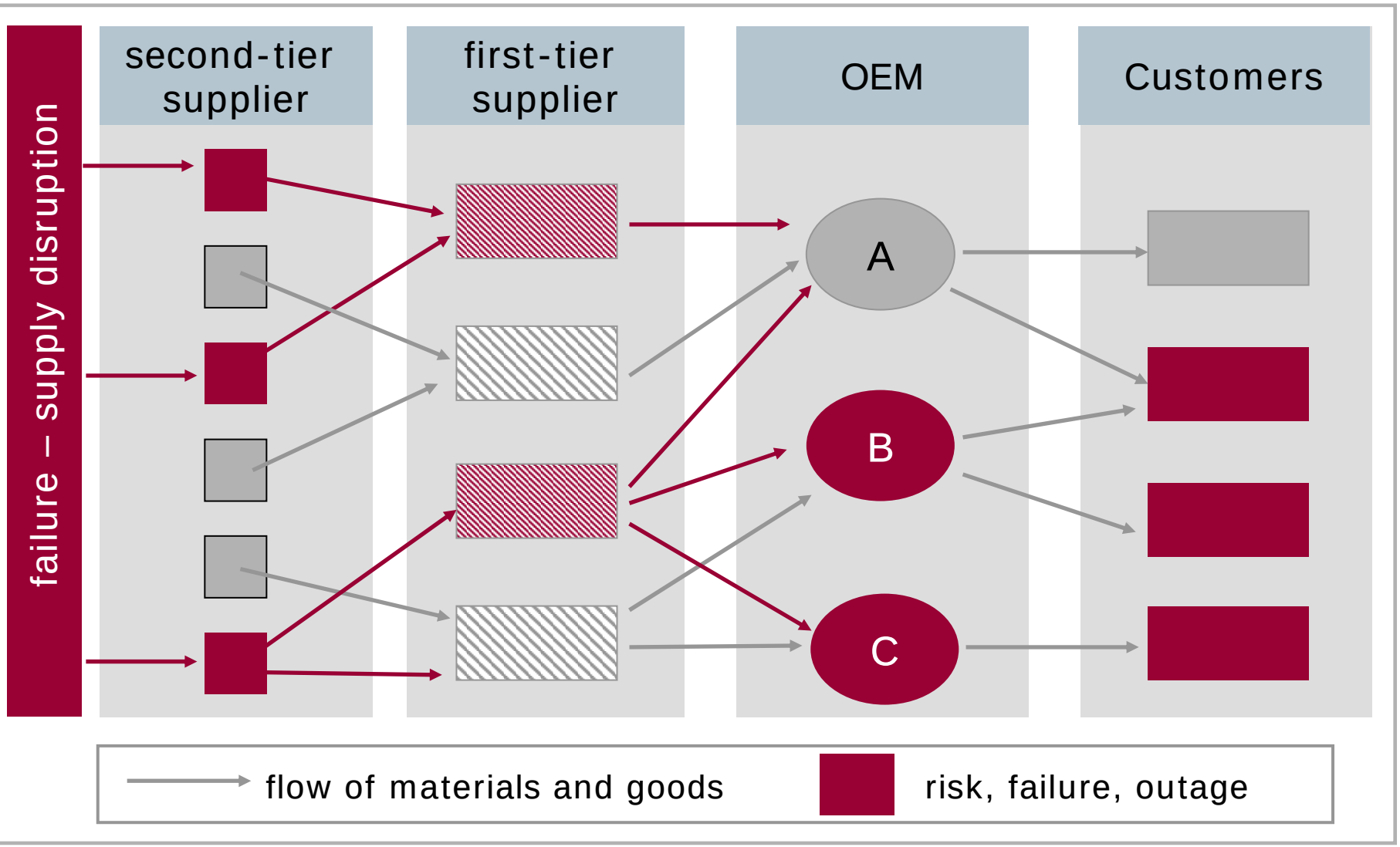
Example: Chemical Industry

- breakdown of measure and control installations
- interruption of mixing and cooling equipments
- malfunction of valves and pumps
- sudden onset of power supply



domino accidental events
chain reactions
release of HazMat
gas leakages, explosions

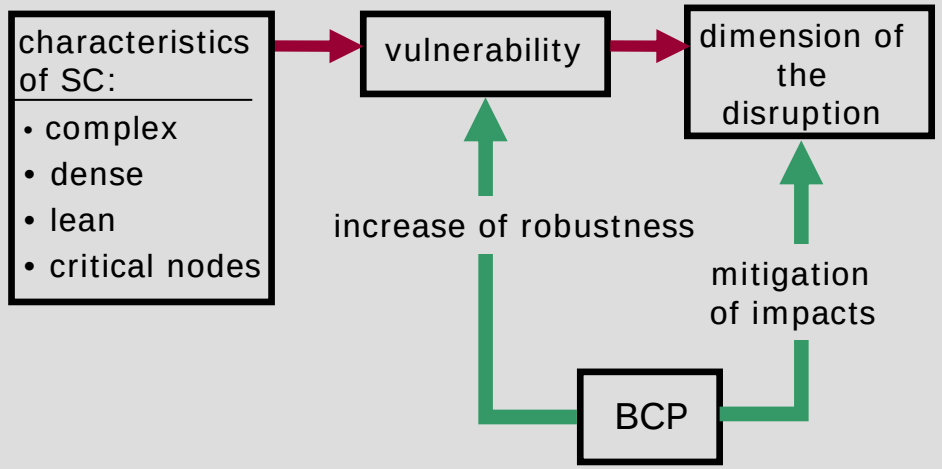
Cascading Effects within Industrial Supply Chains



Disaster Recovery and Business Continuity Planning (BCP)

BCP - process:

- **analysis** of disruption **risks**,
- **Impact assessment**,
- Identification of adequate **emergency- and recovery measures**



Adapted from Craighead, 2007

Objective of BCP:

- Increase of the **reactivity during crisis** and after failures
- Increase of the **robustness** of supply chains
- Reduction of **down time and down time costs**

Motivation for BCP**:**

- **Legal regulation**
  - Seveso II Directive (96/82/EG)
  - Basel II (2006/48/EG; 2006/49/EG)
  - Sarbans Oxlay Act
- **Standards**
  - ISO 17799
  - PAS 56
  - BCI Good Practice Guide

BCP- Process Steps

Phase I	Impact Assessment	
Phase II	Risk Analysis	
Phase III	Plan design	• Design of emergency and continuity plans • Identification of emergency and remediation strategies • Determination of responsibilities • Determination of crisis communication strategies • Capability planning
Phase IV	Plan Audit	

Source: Chapman, 2002

Methods for BCP

- Risk analysis: quantitative (e.g. hazard modelling, statistical analysis, and qualitative methods, fault tree analysis)
- Impact assessment: qualitative methods (e.g. scenario-based workshops, interviews)
- Plan design: mainly qualitative, descriptive approaches, developed by practitioners
- No quantitative methods for plan design and optimisation
- Involvement of different stakeholders and expert groups in the development of continuity plans (risk management, environmental management, employment protection, human resources, research & development...).
- Development of structured emergency, recovery and continuity plans necessary
- Transparency and traceability important for risk awareness and acceptance of BCPs

Multi Criteria Decision Support for business continuity plan design

Multi Criteria Decision Support - MAVT

- evaluation of continuity and emergency measures wit regard to
  - economic,
  - technical,
  - ecological,
  - and social criteria.
- applicable methode: Multi Attribute Value Theory (MAVT)
- main steps of MAVT:

- facilitates group decisions and brings together knowledge from different disciplines

Case Study – LÜKEX 2004 Evaluation

- *LÜKEX*: „Länderübergreifende Krisenmanagement Exercise“
  Scenario: large-area power blackout due to extreme weather events

- *Project Partners*:
  - Power supply company
  - Ministry of the Interior and Ministry of Economics, Baden-Württemberg
  - Federal Office of Civil Protection and Disaster Assistance (BBK)

- *Objective:* Development of a **crisis management handbook for power disruptions**:
  - exemplar BCP (descriptions and data sheets of recovery measures)
  - checklists
  - decision trees

- *Workshops*:
  - Time dependent impact analyses
  - Identification of BCP-measures for exemplar BCPs
  - Characterisation and evaluation of the BCP-measures

MAVT – Problem Structuring

Problem Structuring:

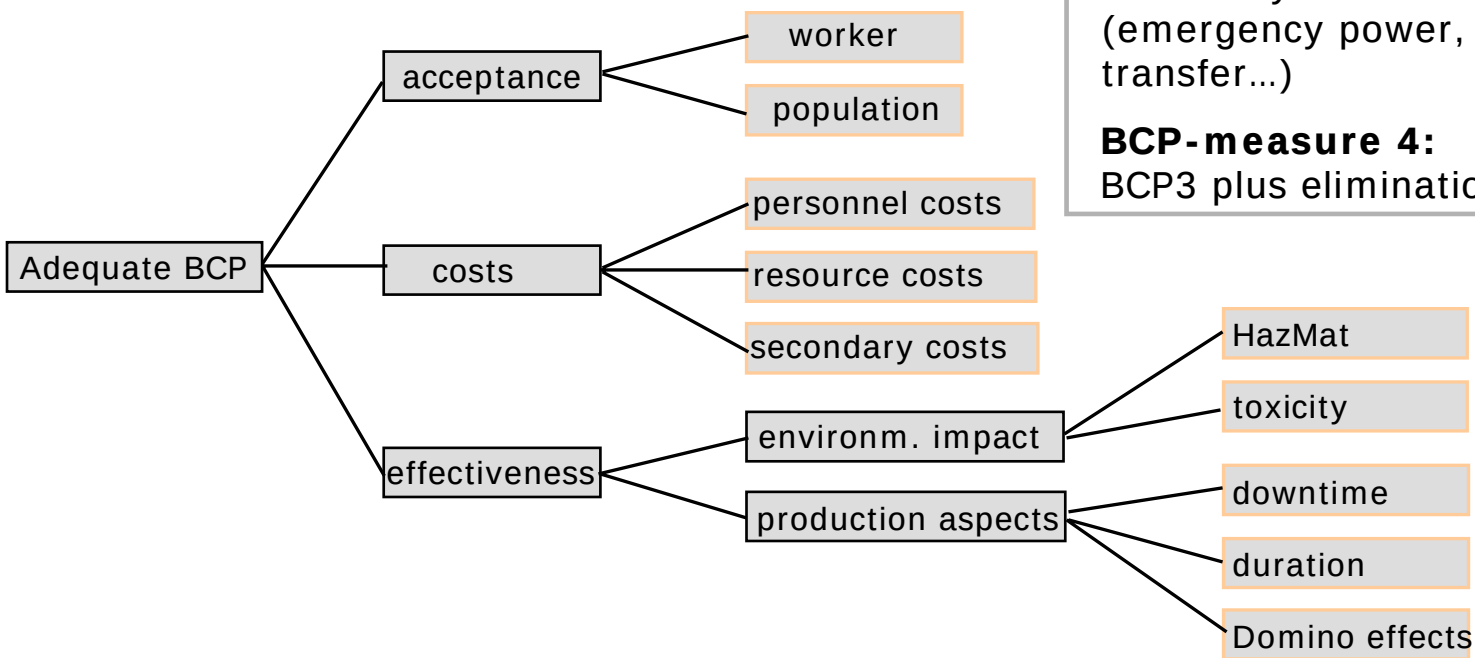
- hierarchical attribute tree
- Identification of potential Alternatives
- Example: Chemical Industry

BCP-measure 1:
no action in case of a blackout

BCP-measure 2:
Safe shut down of processes, no continuity measures

BCP-measure 3:
Continuity and safety measures (emergency power, reactor transfer…)

BCP-measure 4:
BCP3 plus elimination of causes



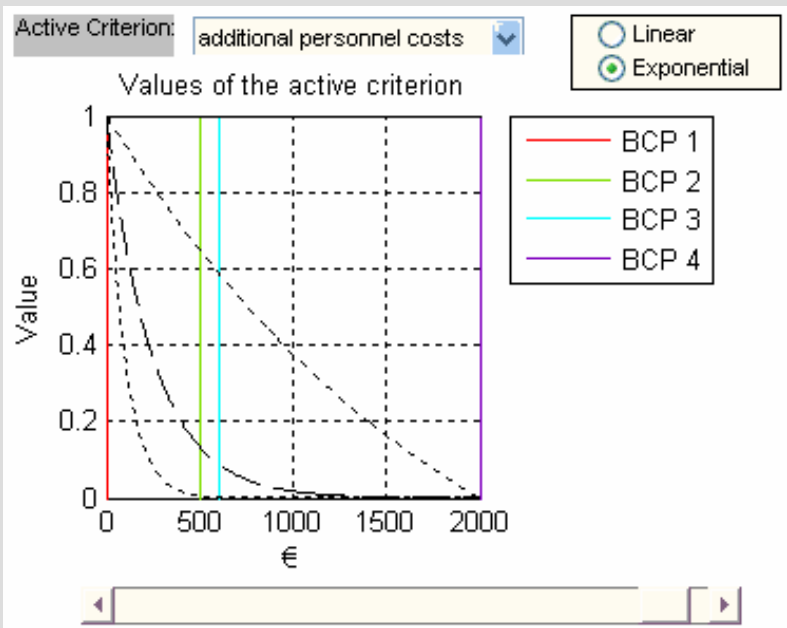
MAVT – Preference Elicitation

Preference elicitation:

modelling of:

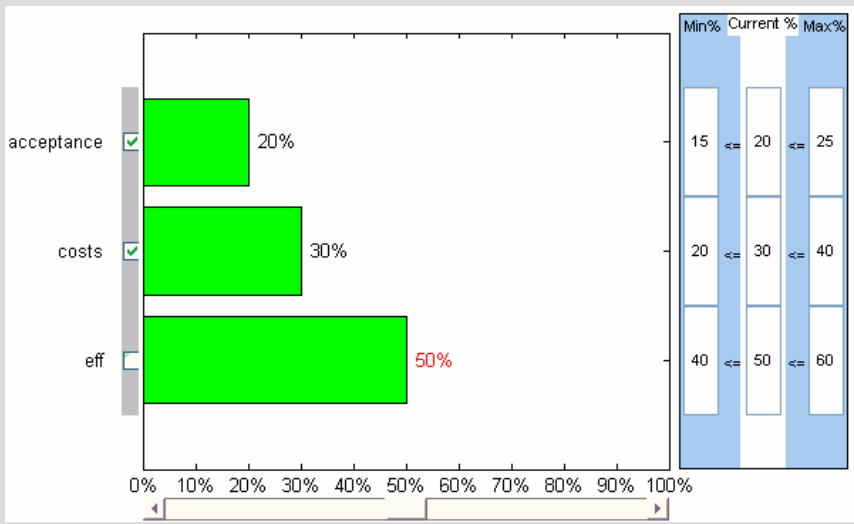
- **performance scores** (value) of each alternative with respect to each measurable attribute value (1)
- **relative importance** amongst the different criteria have to be modelled (2)

(1)



$$v_i : \begin{cases} \mathrm{R} & \to [0,1] \\ s_i(a) & \mapsto v_i(s_i(a)). \end{cases}$$

(2)

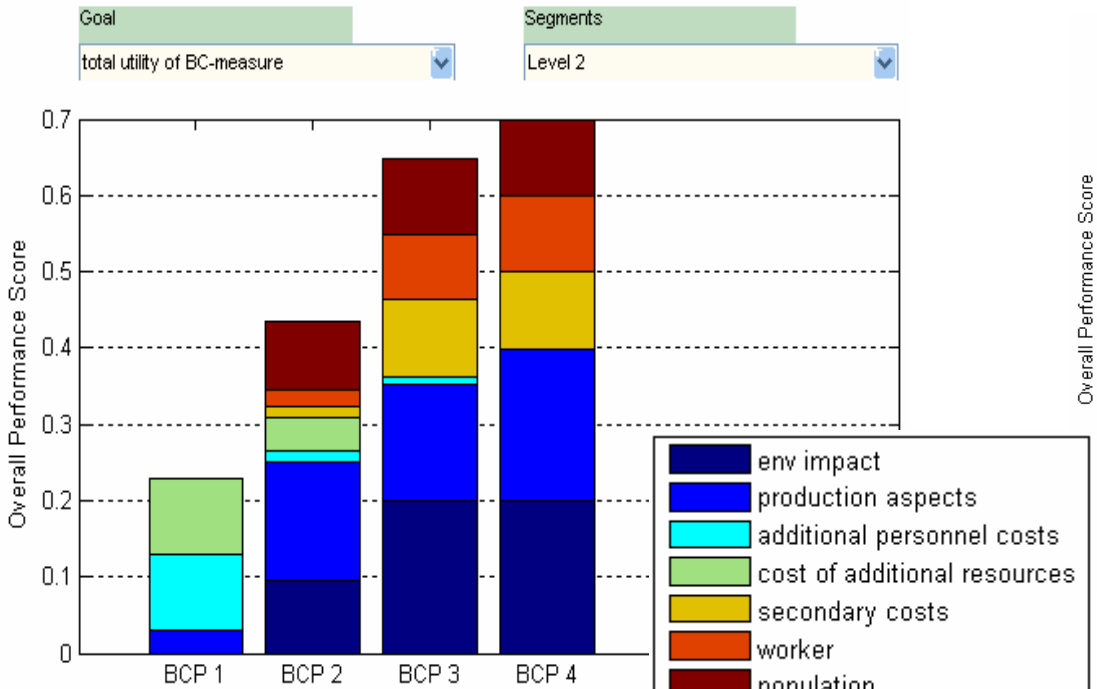


$$w_j \in [0,1], \quad \sum_{j=1}^{n} w_j = 1$$

MAVT – Aggregation and Sensitivity Analysis

Aggregation:

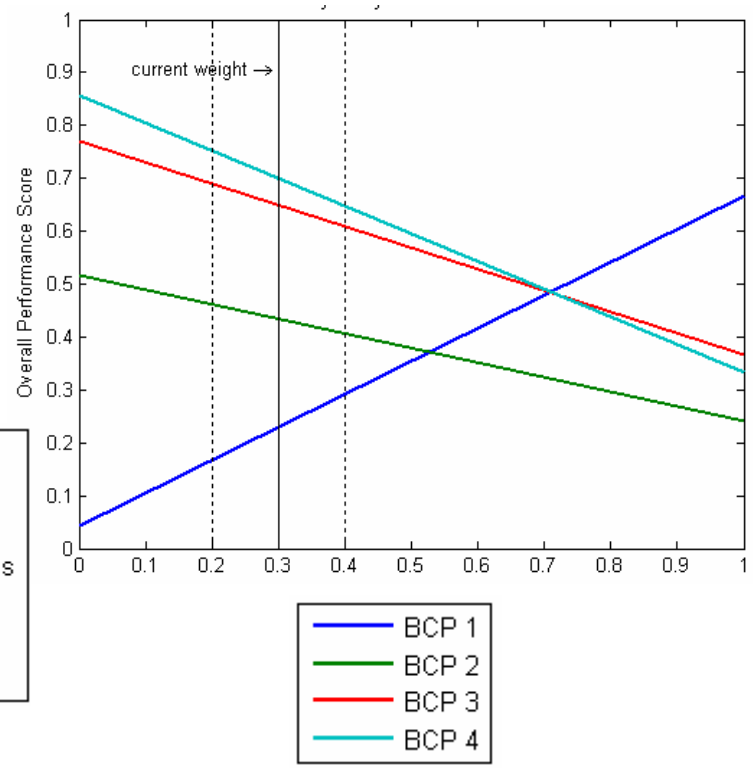
- **overall performance scores** illustrate the results of the analysis and the contributions of the different criteria to the overall results



$$V(a) = \sum_{j=1}^{m} w_j v_j\left(s_j(a)\right)$$

Sensitivity Analysis:

- **Sensitivity analyses** show the effect of changing the weight of an objective and give an overall assessment of the decision parameters an the robustness of a decision



Conclusion

- The continuous availability of Critical Infrastructures (CI) is important for the continuity and safety of production processes.
- Due to the high degree of power dependency of modern production processes on and interdependencies with other CI-sectors, the electricity supply takes an exceptional position and crisis management in the event of power blackouts constitute a special challenge .
- Within industrial production sites power disruptions may cause production down times, equipment damages and secondary hazards.
- The negative impacts caused by power disruptions can be propagated via cascading effects through globally interlaced supply chains .
- In order to reduce the down time of industrial production and to minimise monetary losses, an efficient and transparent business continuity planning (BCP) is needed.
- At present no quantitative methods for BCP-design exist.
- Multi Criteria Decision Support methods can be used to facilitate a transparent and structured plan development.

Thank you very much for your attention!

Mirjam Merz and Dr. Michael Hiete

Institute for Industrial Production (IIP)
Center for Disaster Management and Risk Reduction Technology (CEDIM)
University of Karlsruhe (TH), Germany

E-mail: mirjam.merz@kit.edu

Backup

Risk of CI-Failure

Hazard	x	Vulnerability	x	Exposure
▪ technical failure ▪ human failure ▪ natural hazards ▪ terrorism ▪ sabotage		▪ technical elements ▪ human elements ▪ information systems ▪ access to information ▪ organisation ▪ incident management		▪ location ▪ spatial concentration of CI- objects

Risk of CI-failure

Exceptional Role of Electricity Supply