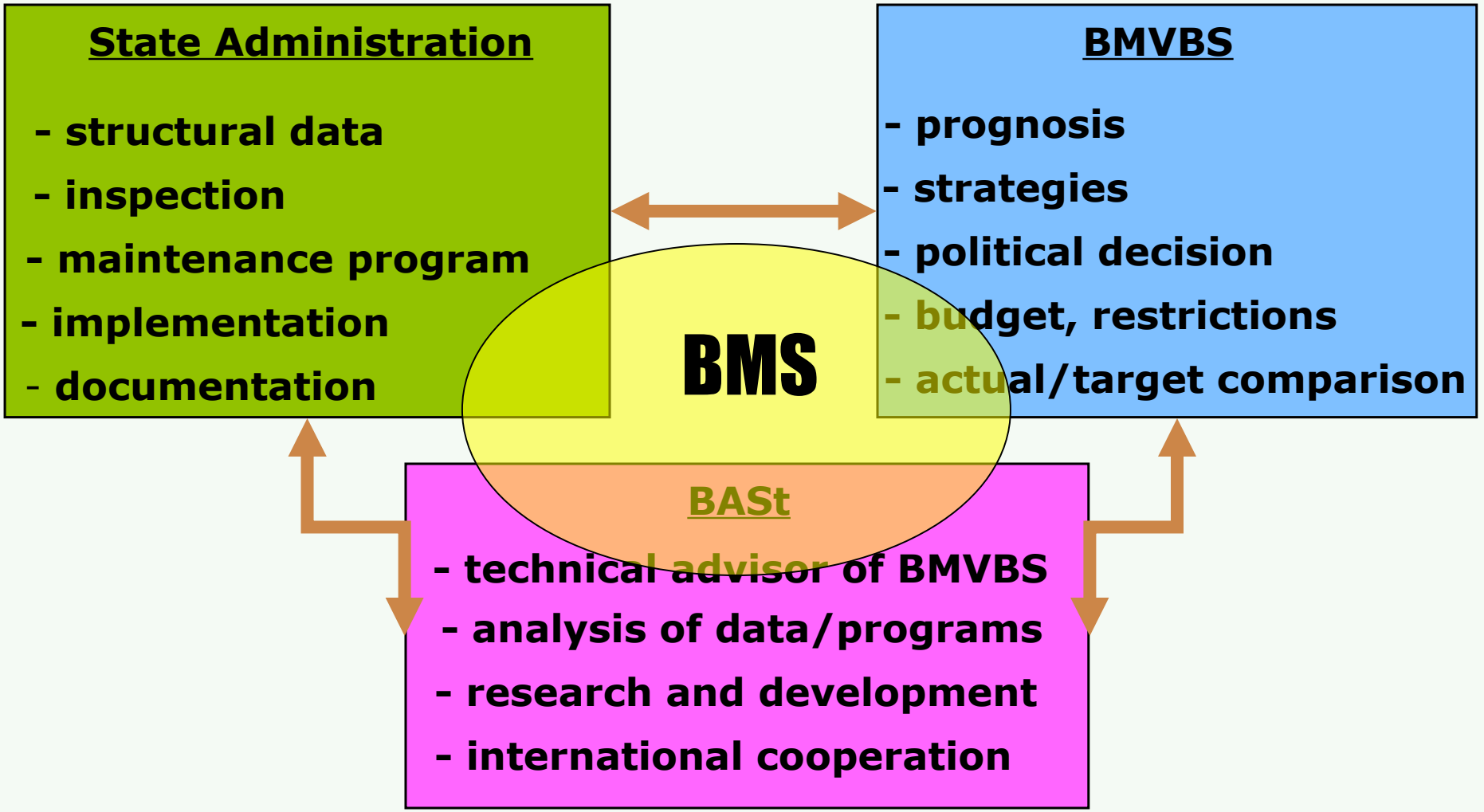
Bridge Management in Germany

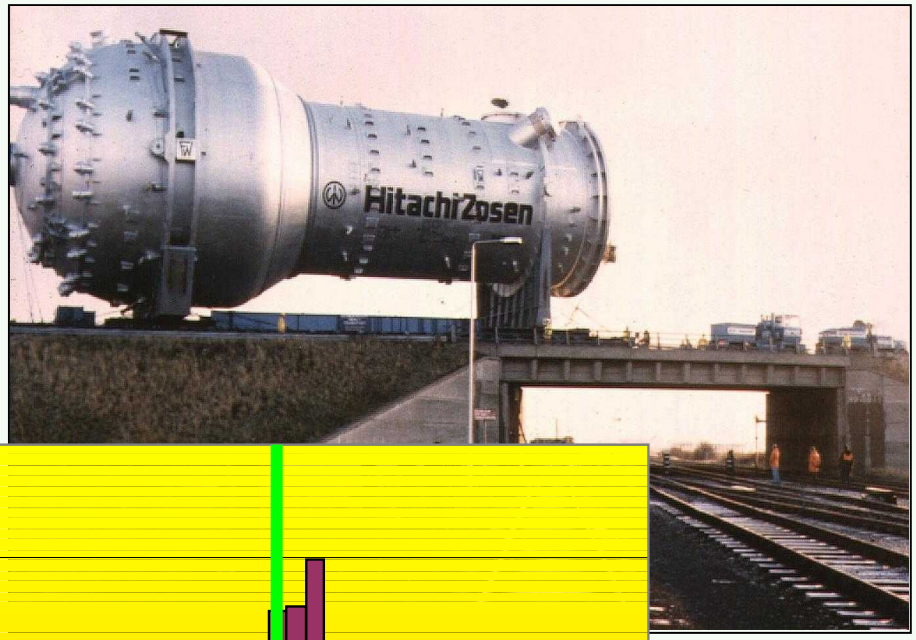
Dipl.-Ing. Ralph Holst

Bundesanstalt für Straßenwesen

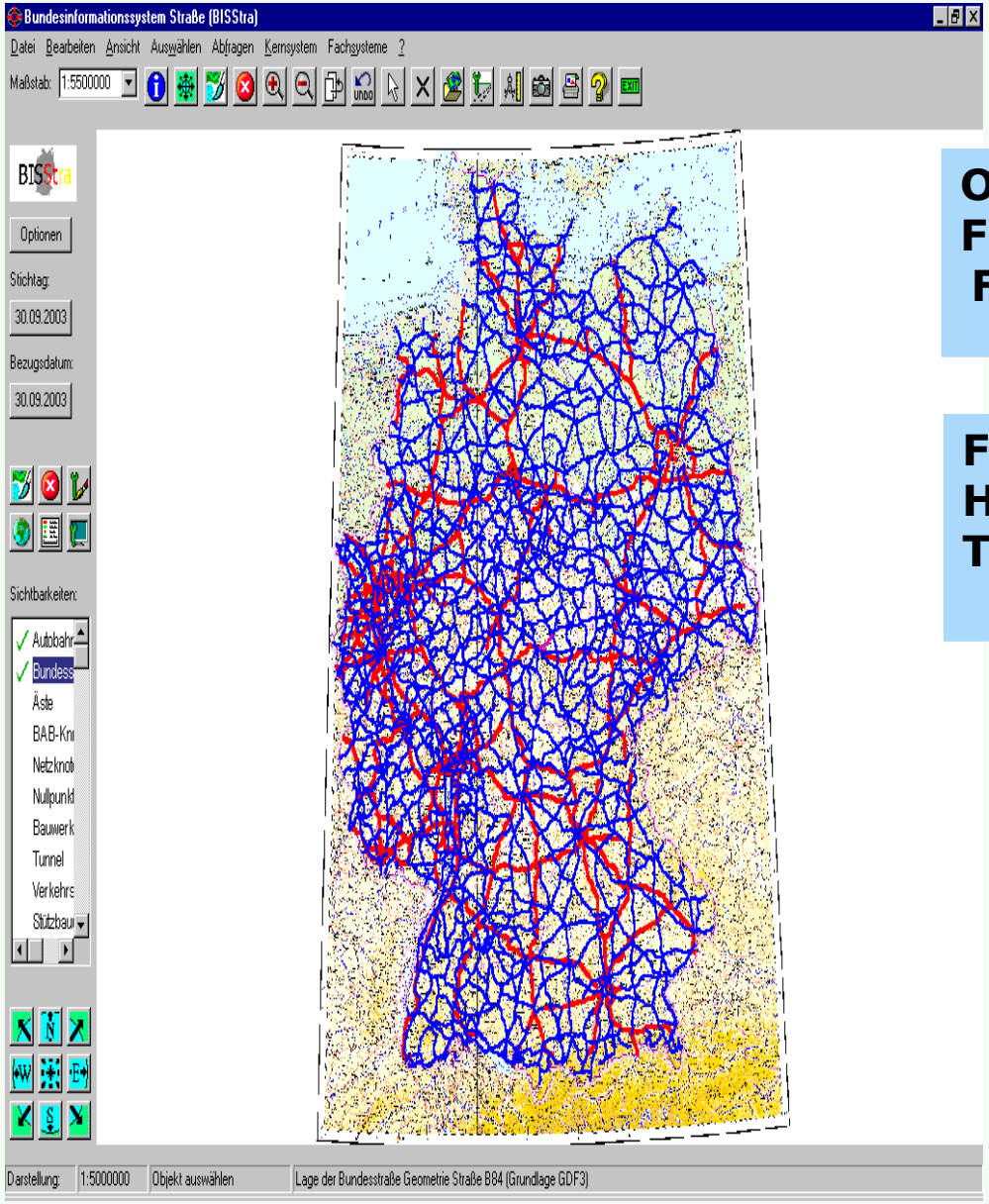
Maintenance Management



Traffic Loads



Structures



Overall road network: 688.243 km
Federal Highways: 12.718 km
Federal Trunk Roads: 40.203 km
(01.01.2010)

Federal Roads: 39.039 bridges
Highways: 17.422 bridges
Trunk Roads: 21.617 bridges
(01.03.2012)

Type of Construction

(01.03.2012)

39.039 Bridges
Bridge Deck Area = 29,95 Mio m2

Age Distribution

(01.03.2012)

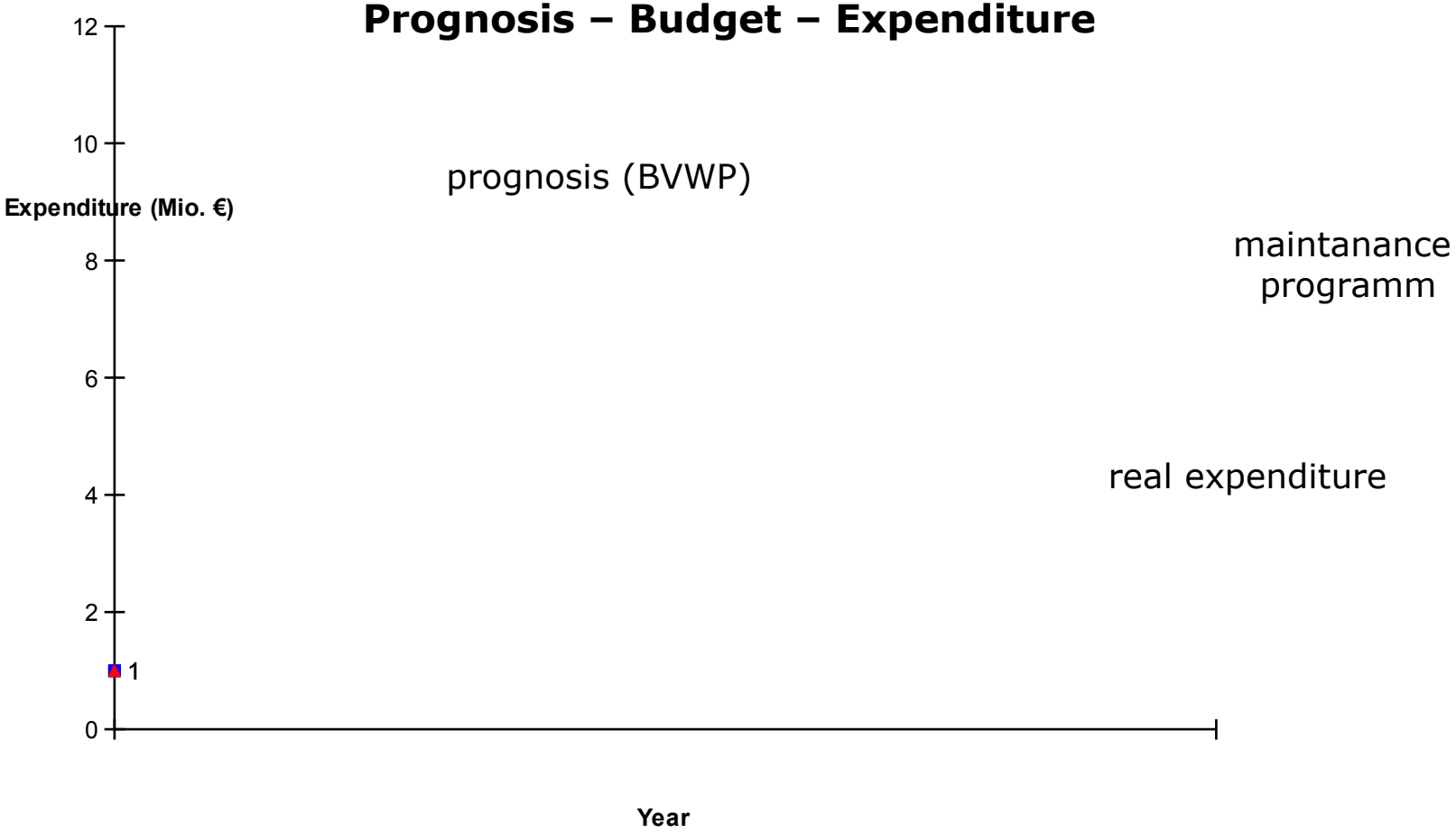
Condition

[%] of Bridge Deck Area

Condition Index

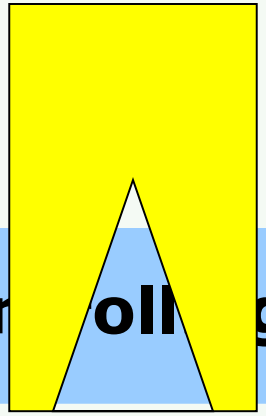
(01.03.2012)

Financial Requirements



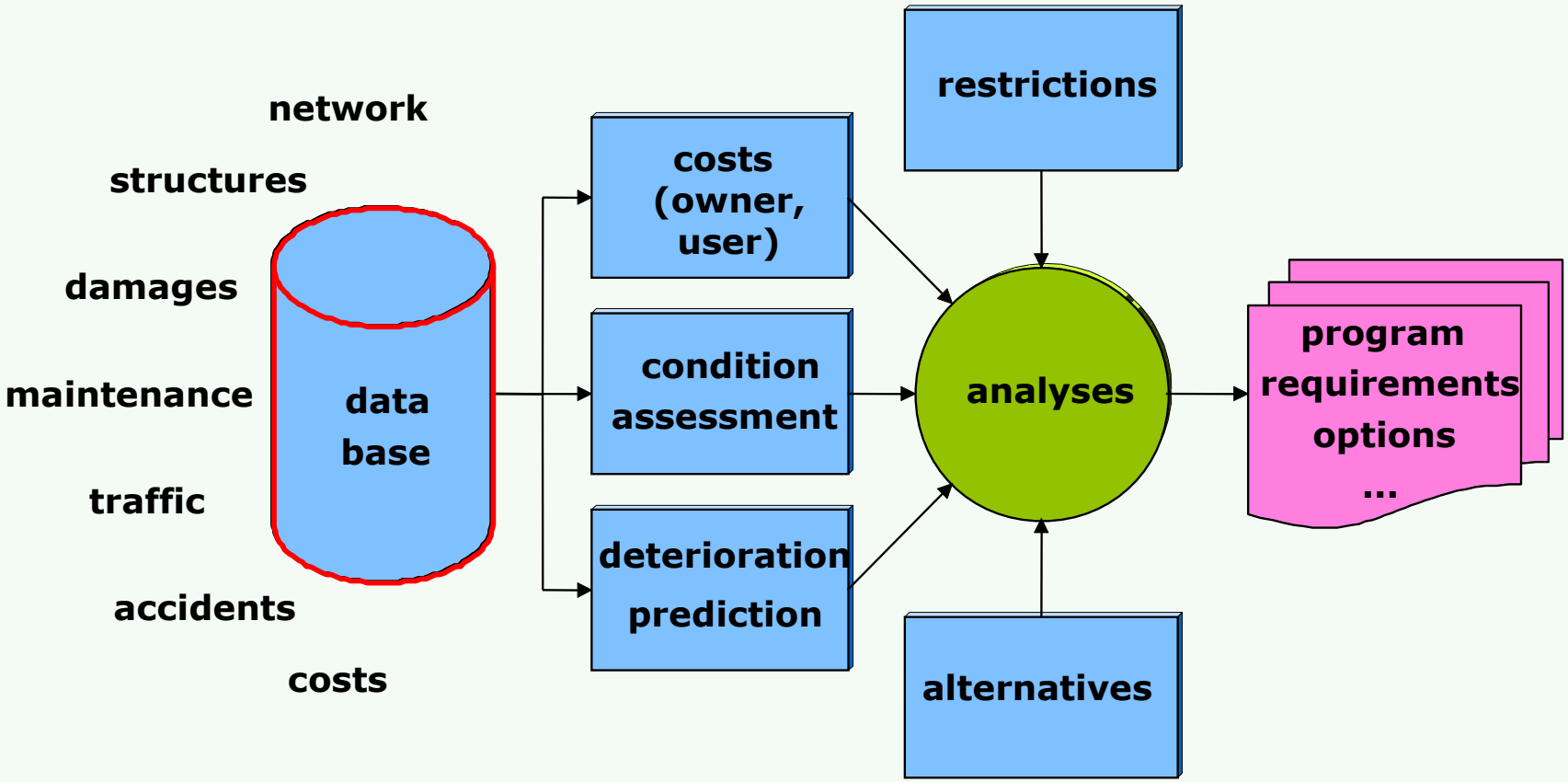
Problem

- **insufficient durability of structures**
- **growing volumes of traffic / higher weights**
- **restricted resources**
- **no standardized maintenance planning procedures**



BMS (planning, cor oll g, implementation)

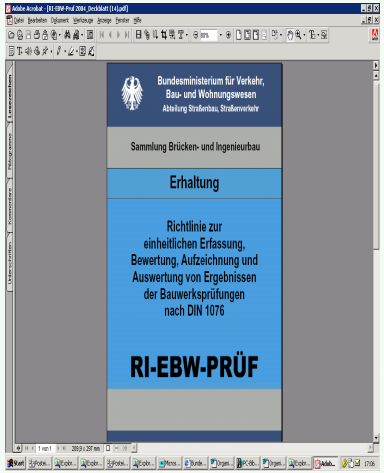
BMS - Structure



(OECD 1992)

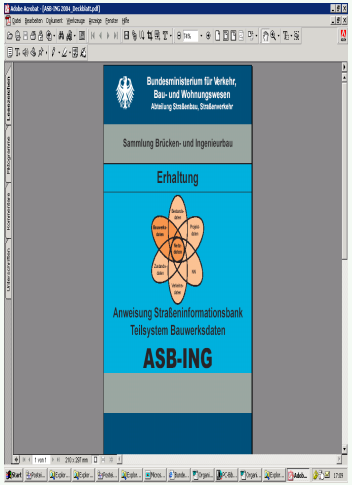
Standardized Information

DIN 1076, Engineering structures in connection with roads; inspection and test, 1999



Guideline RI-EBW-PRÜF, 2007

Recording and assessment of damages, condition assessment



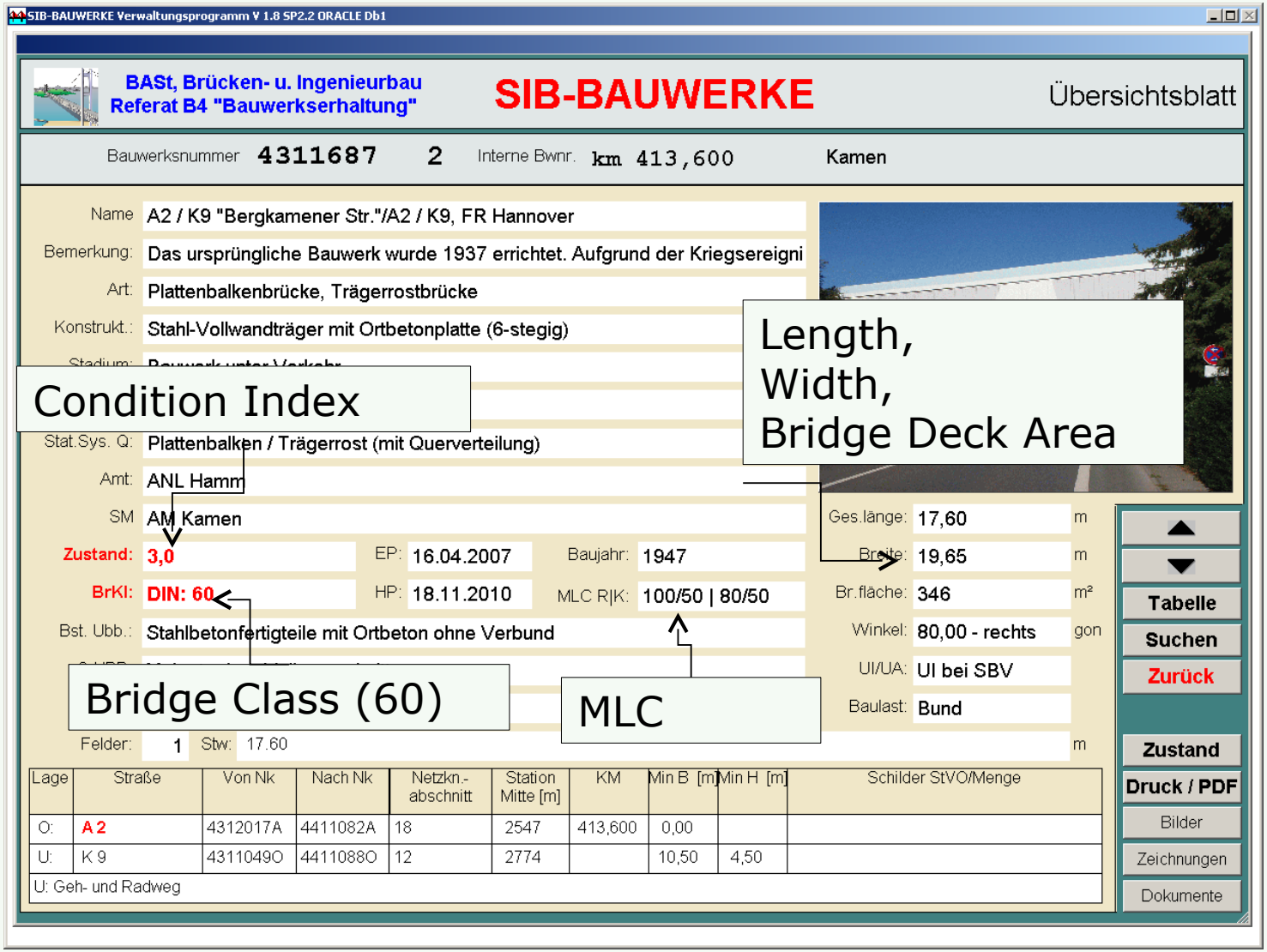
ASB Structures Inventory instructions, 2008

Extent and structure of data

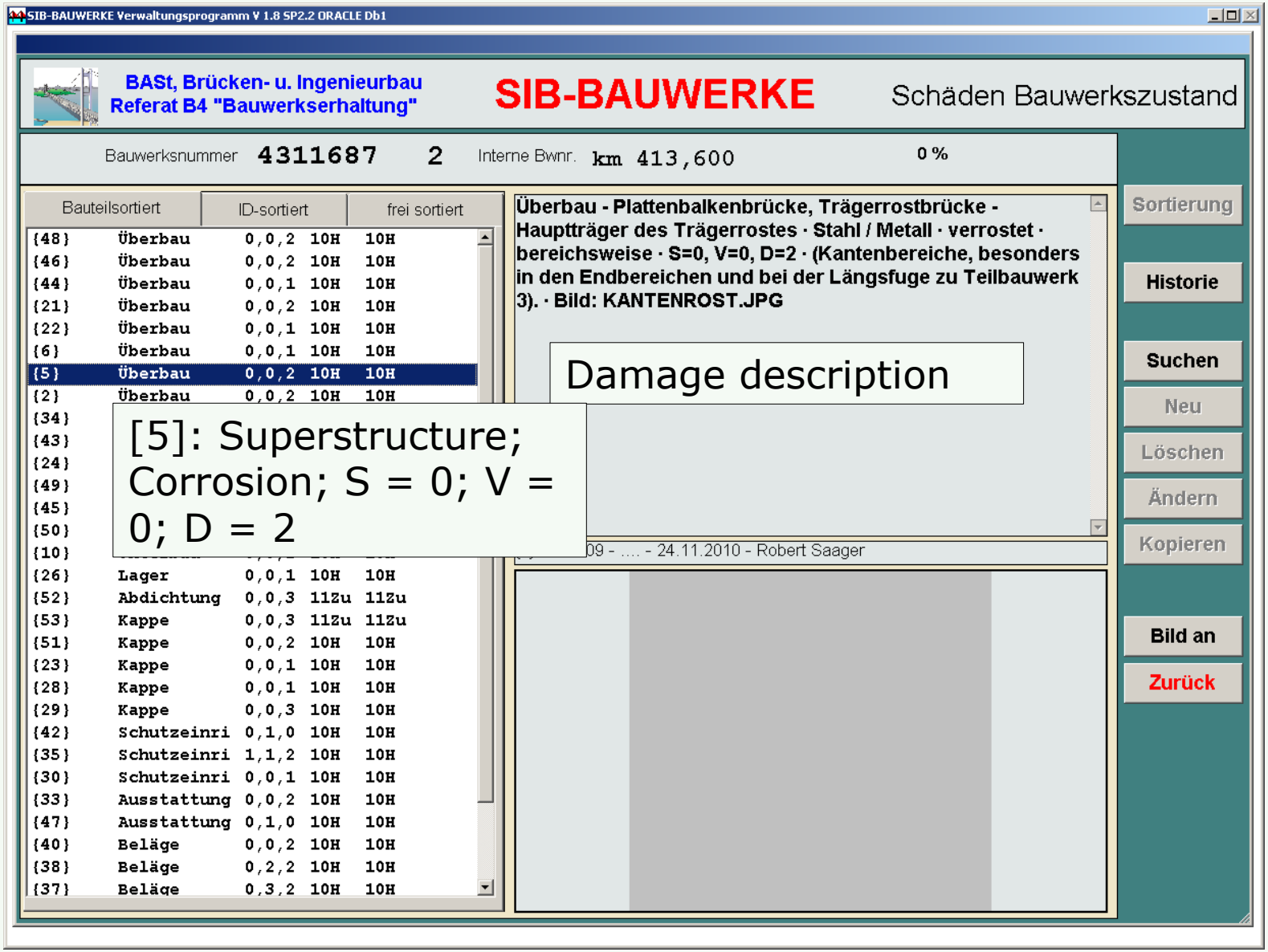
Software SIB-Bauwerke, Version 1.8, 2008

Recording and evaluation of data; inspection software

Construction-data



Damage-data


SIB-BAUWERKE Verwaltungsprogramm V 1.8 SP2.2 ORACLE Db1
BASt, Brücken- u. Ingenieurbau
Referat B4 "Bauwerkserhaltung"
SIB-BAUWERKE
Schäden Bauwerkszustand
Bauwerksnummer 4311687 2
Interne Bwnr. km 413,600
0 %
Bauteilsortiert
ID-sortiert
frei sortiert
{48} Überbau 0,0,2 10H 10H
{46} Überbau 0,0,2 10H 10H
{44} Überbau 0,0,1 10H 10H
{21} Überbau 0,0,2 10H 10H
{22} Überbau 0,0,1 10H 10H
{6} Überbau 0,0,1 10H 10H
{5} Überbau 0,0,2 10H 10H
{2} Überbau 0,0,2 10H 10H
{34}
{43}
{24}
{49}
{45}
{50}
{10}
{26} Lager 0,0,1 10H 10H
{52} Abdichtung 0,0,3 11Zu 11Zu
{53} Kappe 0,0,3 11Zu 11Zu
{51} Kappe 0,0,2 10H 10H
{23} Kappe 0,0,1 10H 10H
{28} Kappe 0,0,1 10H 10H
{29} Kappe 0,0,3 10H 10H
{42} Schutzeinri 0,1,0 10H 10H
{35} Schutzeinri 1,1,2 10H 10H
{30} Schutzeinri 0,0,1 10H 10H
{33} Ausstattung 0,0,2 10H 10H
{47} Ausstattung 0,1,0 10H 10H
{40} Beläge 0,0,2 10H 10H
{38} Beläge 0,2,2 10H 10H
{37} Beläge 0,3,2 10H 10H
Überbau - Plattenbalkenbrücke, Trägerrostbrücke - Hauptträger des Trägerrostes · Stahl / Metall · verrostet · bereichsweise · S=0, V=0, D=2 · (Kantenbereiche, besonders in den Endbereichen und bei der Längsfuge zu Teilbauwerk 3). · Bild: KANTENROST.JPG
Damage description
[5]: Superstructure; Corrosion; S = 0; V = 0; D = 2
09 - .... - 24.11.2010 - Robert Saager
Sortierung
Historie
Suchen
Neu
Löschen
Ändern
Kopieren
Bild an
Zurück

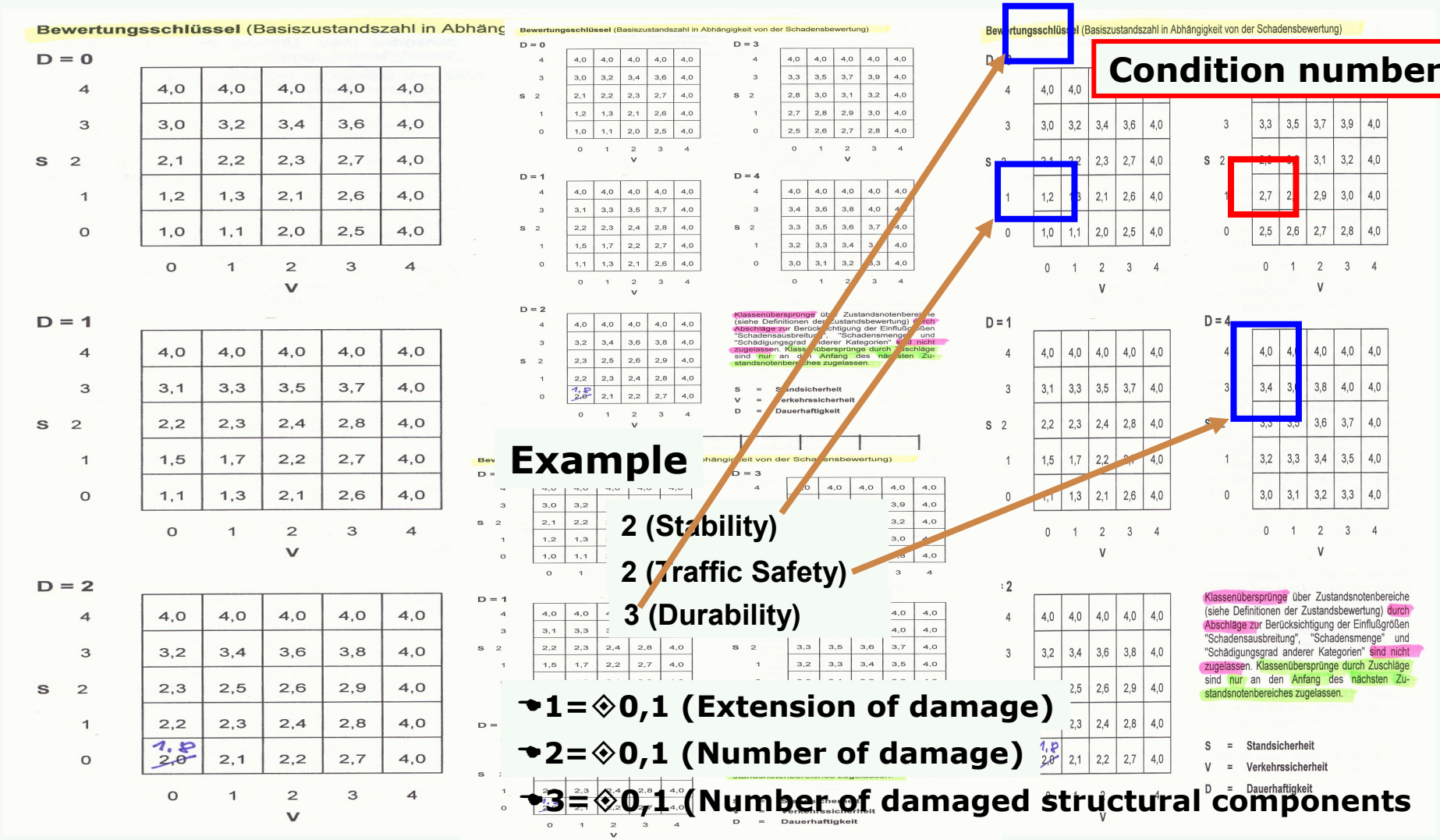
Equipment

Inspection Device

Damage Assessment -Stability

Damage Assessment "Structural Stability"	
Assessment	Description
0	The defect/damage has **no effect on the structural stability** of the structural element/structure.
1	The defect/damage **negatively affects the structural stability of the structural element;** however, it has **no effect on the structural stability of the structure.** With respect to the as-planned utilization**, individually occurring, small deviations** in the condition of the structural element, the quality of the construction material or the element's dimensions are **still clearly within the scope of the admissible tolerances.** Repairs to be carried out within the scope of **regular maintenance.**
2	The defect/damage **negatively affects the structural stability of the structural element;** however, it has **little effect on the structural stability of the structure.** The **deviations** in the condition of the structural element, the quality of the construction material or regarding the dimensions or the as-planned stresses resulting from the utilization of the structure are **still within the scope of the permissible tolerances.** In individual cases, the admissible tolerances of the structural element may be exceeded. **Repairs must be undertaken within the medium term.**
3	The defect/damage **does affect the structural stability of the structural element negatively. the deviations** with respect to the condition of the structural element, the quality of the construction material or regarding the dimensions or the as-planned stresses resulting from the utilization of the structure **exceed the permissible tolerances.** The required restrictions on the use are not in place or are ineffective. **The damage must be repaired at short notice. Restrictions regarding utilization must be put in place immediately.**
4	The **structural stability of the structural element and the structure no longer exists.** **Immediate measures must be taken during the inspection of the structure. Restrictions regarding the utilization must be put into place immediately. The repair or renovation must be initiated.**

Calculation of Condition Index



Condition Index

Grade	Description
1.0-1.4	**Very good structural condition**
	The **structural stability, traffic safety and durability** of the structure are given. **Continuous maintenance** is required.
1.5-1.9	**Good structural condition**
	The **structural stability and traffic safety and durability** of the structure are given In the long term, the **durability** of the structure **may** be negatively **affected to a small degree. Continuous maintenance** is required.
2.0-2.4	**Satisfactory structural condition**
	It is possible that, in the long term, the **durability** of the structure **may** be negatively **affected. An expansion of the damage** or **consequential damages** which, in the **long term, would lead to** considerable deterioration of the structural stability and/or traffic safety and increased wear and tear. **Continuous maintenance** is required. **Maintenance** is required **in the medium term.** **Measures to eliminate the damage or warning signs to maintain traffic safety** might be necessary **at the short notice.**
2,5-2,9	**Unsatisfactory structural condition**
	The **structural stability** of the structure is **given.** **Traffic safety might be negatively affected.** The **durability** of the structure **may** be negatively **affected** quite a bit. **An expansion of the damage** or **consequential damages** which, in the **medium term, would lead to** considerable deterioration of the structural stability and/or traffic safety and increased wear and tear is to be expected. **Continuous maintenance** is required. **Maintenance at short notice** is required. **Measures to eliminate the damage or warning signs to maintain traffic safety** might be necessary **at short notice.**

Condition Index

Grade	Description
1.0-1.4	**Very good structural condition** The **structural stability, traffic safety and durability** of the structure are given. **Continuous maintenance** is required.
1.5-1.9	**Good structural condition** The **structural stability and traffic safety and durability** of the structure are given In the long term, the **durability** of the structure **may** be negatively **affected to a small degree. Continuous maintenance** is required.
2.0-2.4	**Satisfactory structural condition** It is possible that, in the long term, the **durability** of the structure **may** be negatively **affected. An expansion of the damage** or **consequential damages** which, in the **long term, would lead to** considerable deterioration of the structural **Continuous maintenance** is required. **Maintenance** is required **in the medium t** **Measures to eliminate the damage or w** **the short notice.**
2,5-2,9	**Unsatisfactory structural condition** The **structural stability** of the structure is **Traffic safety might be negatively affect** The **durability** of the structure **may** be neg **consequential damages** which, in the **me** structural stability and/or traffic safety and **Continuous maintenance** is required. **Maintenance at short notice** is required. **Measures to eliminate the damage or w** **short notice.**

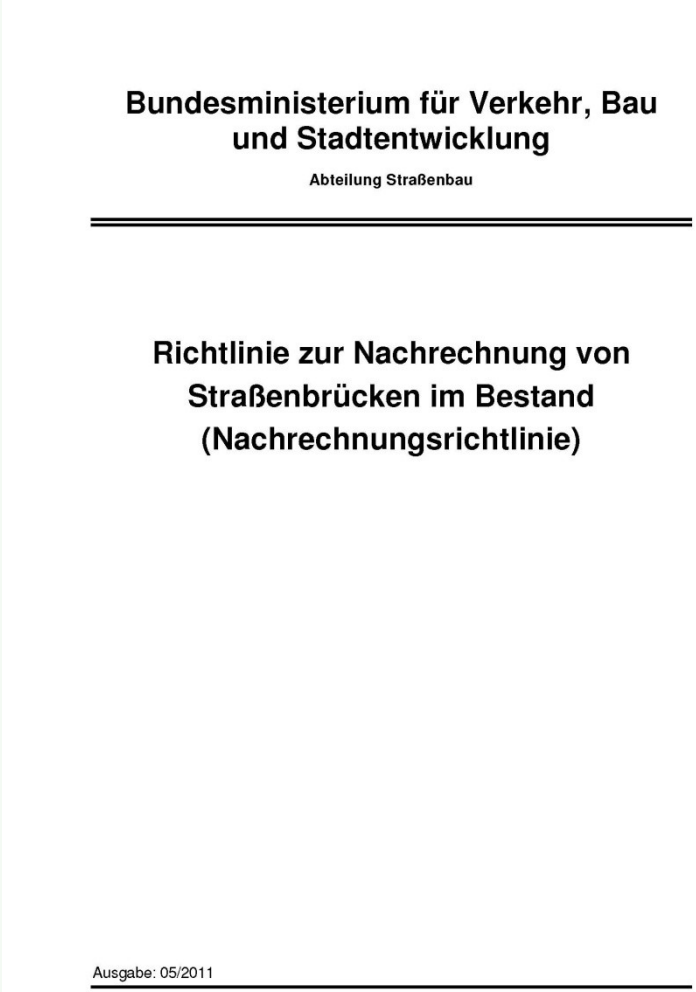
Grade	Description
3.0-3.4	**Critical structural condition** The **structural stability and/or traffic safety** of the structure **are negatively affected.** Possibly, **durability** of the structure is **no longer given. An expansion of the damage** or **consequential damages** may, in the **short term,** lead to the fact that structural stability and traffic safety are no longer given. **Continuous maintenance** is required. **Immediate repairs** are required. **Measures to eliminate the damage or warning signs to maintain traffic safety** or restrictions in its use might be required as soon as possible.
3.5-4.0	**Inadequate structural condition** The **structural stability and/or traffic safety are negatively affected quite a bit or is no longer given.** Possibly, **durability** of the structure is **no longer given. An expansion of the damage or consequential damages** may, in the **short term,** lead to the fact that structural stability and traffic safety are no longer given and that it will result in an irreparable deterioration of the structure. **Continuous maintenance** is required. **Immediate repairs** or **renovations** are required. **Measures to eliminate the damage or warning signs to maintain traffic safety** or **restrictions in its use** might be required **immediately**.

Guideline for Recalculation

4 Recalculation Levels

- Level 1:German „Fachbericht“ or DIN EN 1992 – 1994, 1996,
- Level 2: supplementary regulations,
- Level 3: Results from measurements (e.g. Monitoring)
- Level 4: scientific methods (reliability based Methods)

Goal:
- realistic Assessment of Bridge Condition (structural stability and usability)



Bundesministerium für Verkehr, Bau und Stadtentwicklung

Abteilung Straßenbau

Richtlinie zur Nachrechnung von Straßenbrücken im Bestand (Nachrechnungsrichtlinie)

Ausgabe: 05/2011

Results from BRIME-Project (I)

Important Topics for a BMS (BRIME (BRIdge Management in Europe (1998-99))

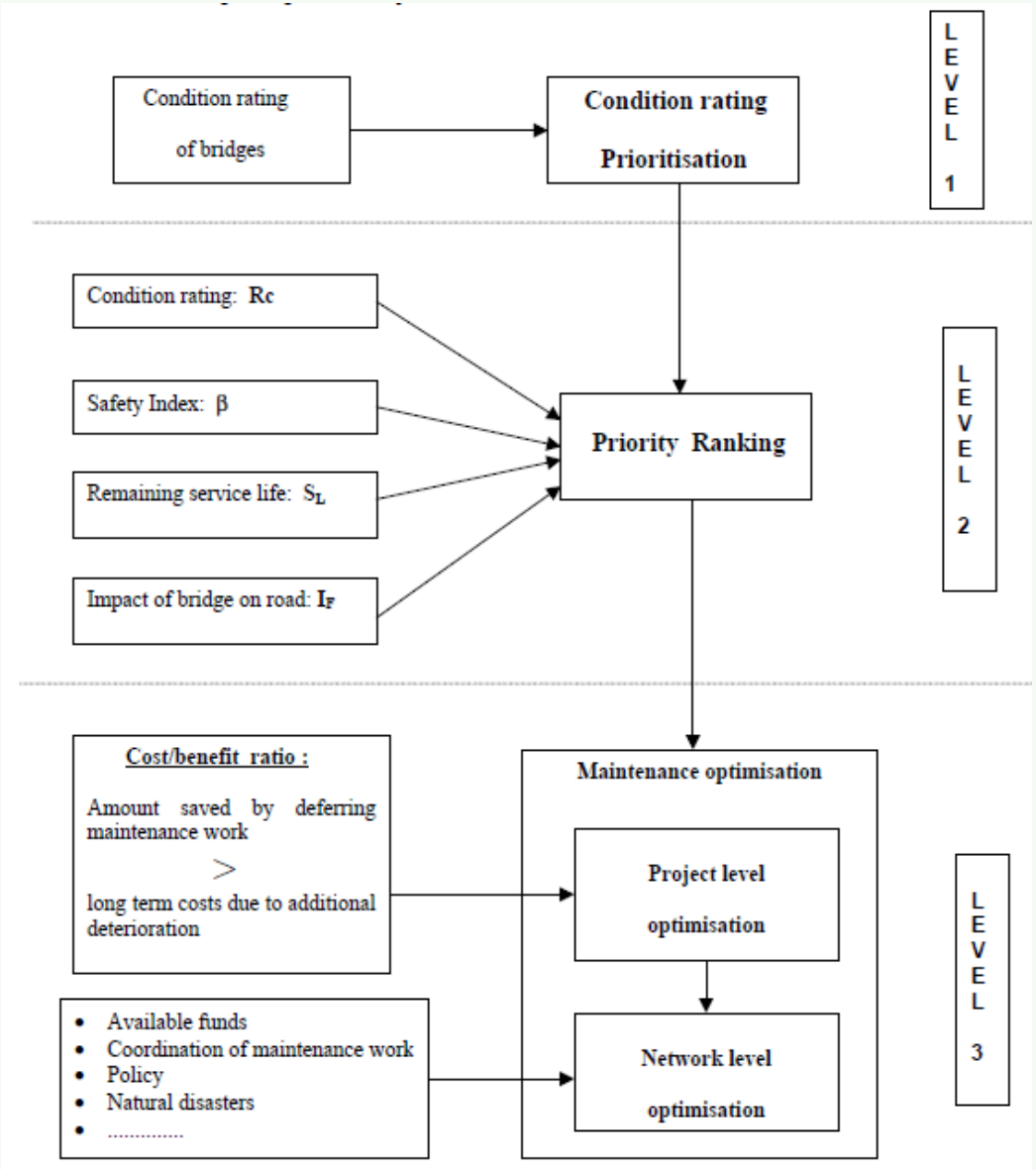
- condition appraisal (DIN 1076),
- assessment of load carrying capacity (Guideline for Recalculation)
- rate of deterioration (RI-EBW-PRÜF),
- structural assessment of deteriorated structures
- deciding maintenance strategies and methods (Federal Ministry and State Administrations)
- prioritizing maintenance work (Federal Ministry and State Administrations)

Results from BRIME-Project (II)

regular Bridge Inspection

Guideline for Recalculation

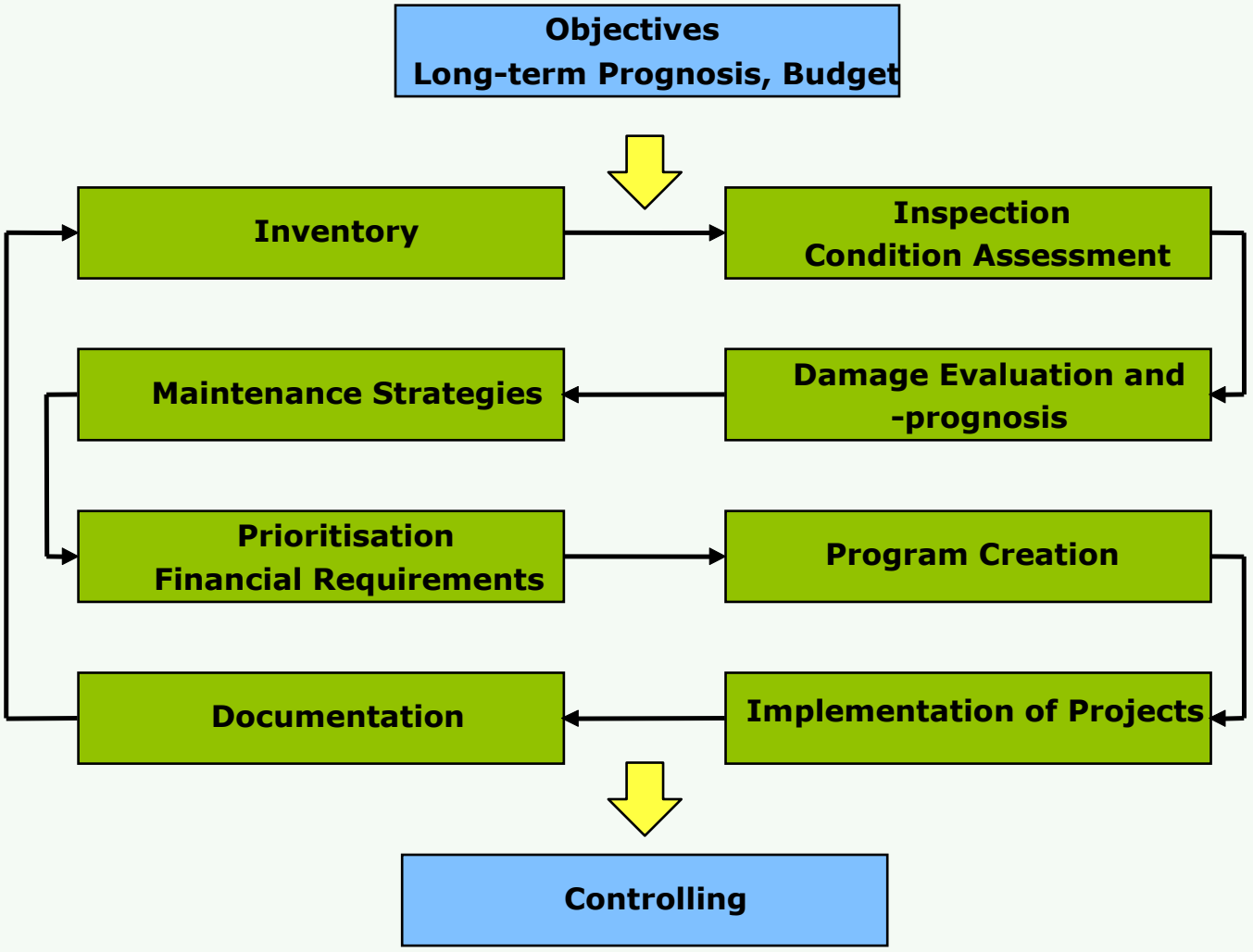
BMS-MB; BMS-EP



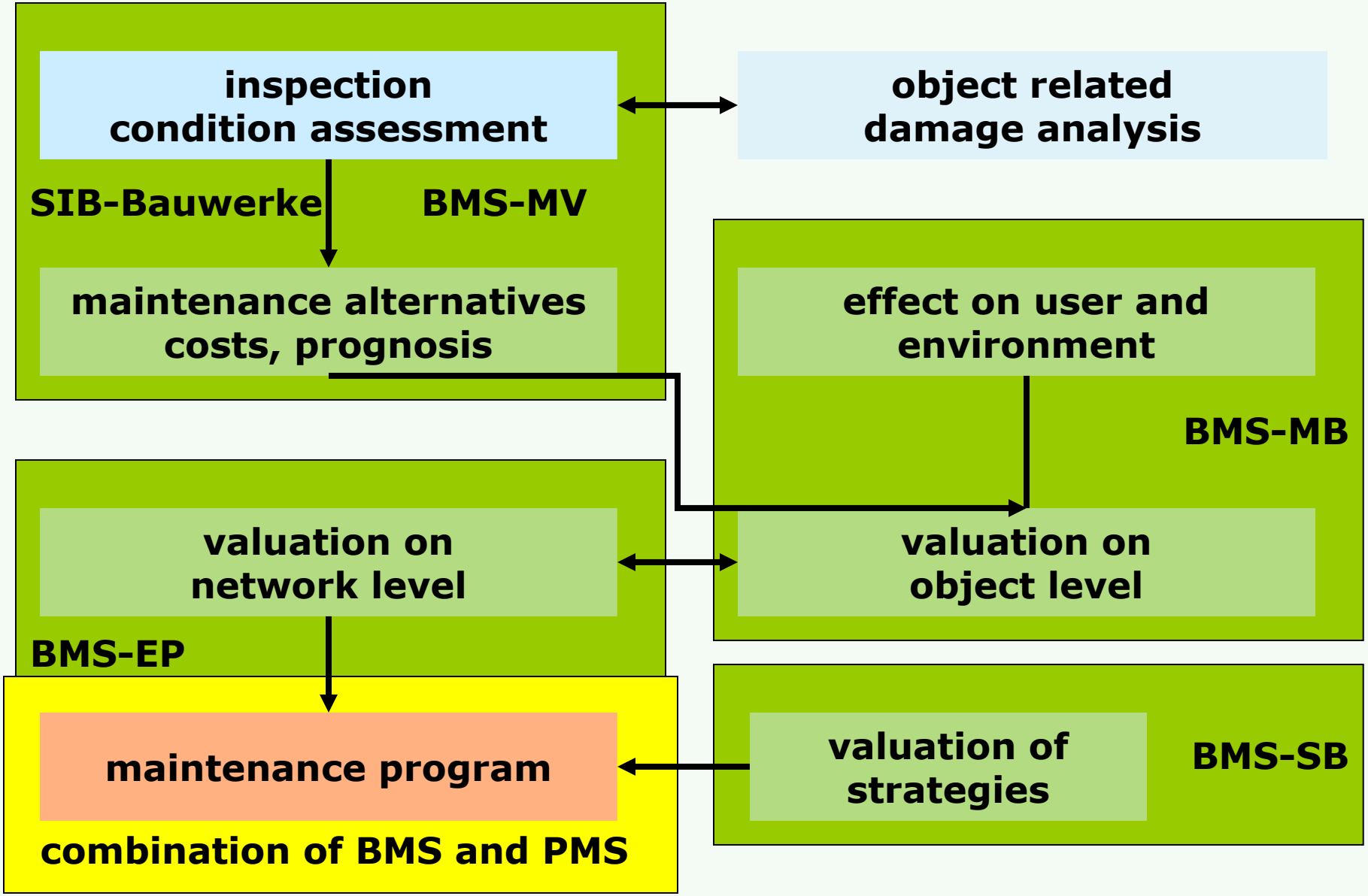
Basics of Maintenance planning

Principles of maintenance planning

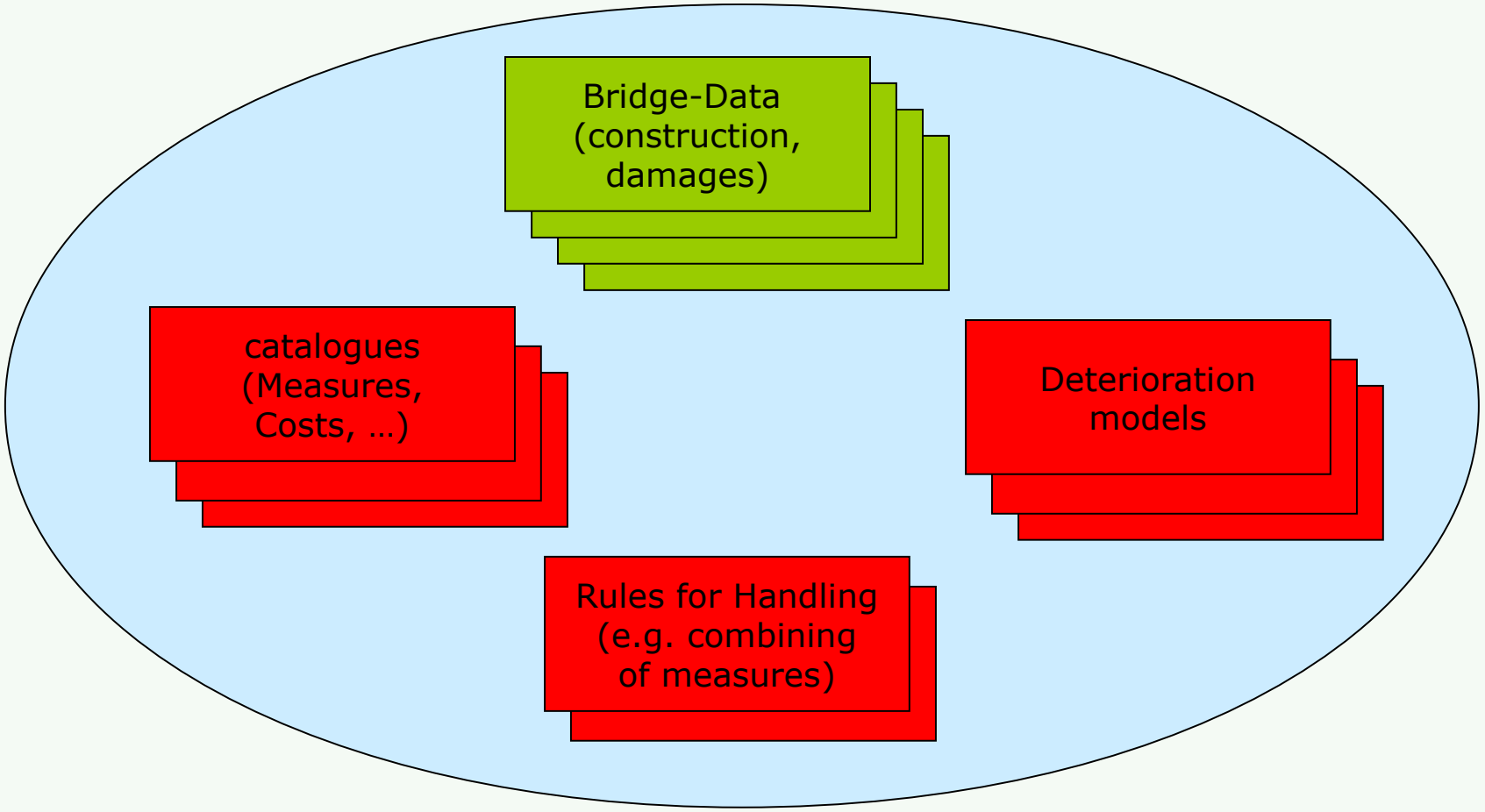
- Ensuring the safety and ease of traffic,
- Minimize traffic-interference,
- combination of actions (BMS, PMS, Asset Management)
- Results of Recalculation (structural weaknesses: securing off remaining service life)
- Prioritization:
  - Condition,
  - Importance of Highway/ of the structure in the network,
  - Reconstruction of Highways,
  - Requirements from PMS,
  - Political requirements,


Objectives
Long-term Prognosis, Budget
Inventory
Inspection
Condition Assessment
Maintenance Strategies
Damage Evaluation and
-prognosis
Prioritisation
Financial Requirements
Program Creation
Documentation
Implementation of Projects
Controlling

BMS – State Level



Generation of strategies

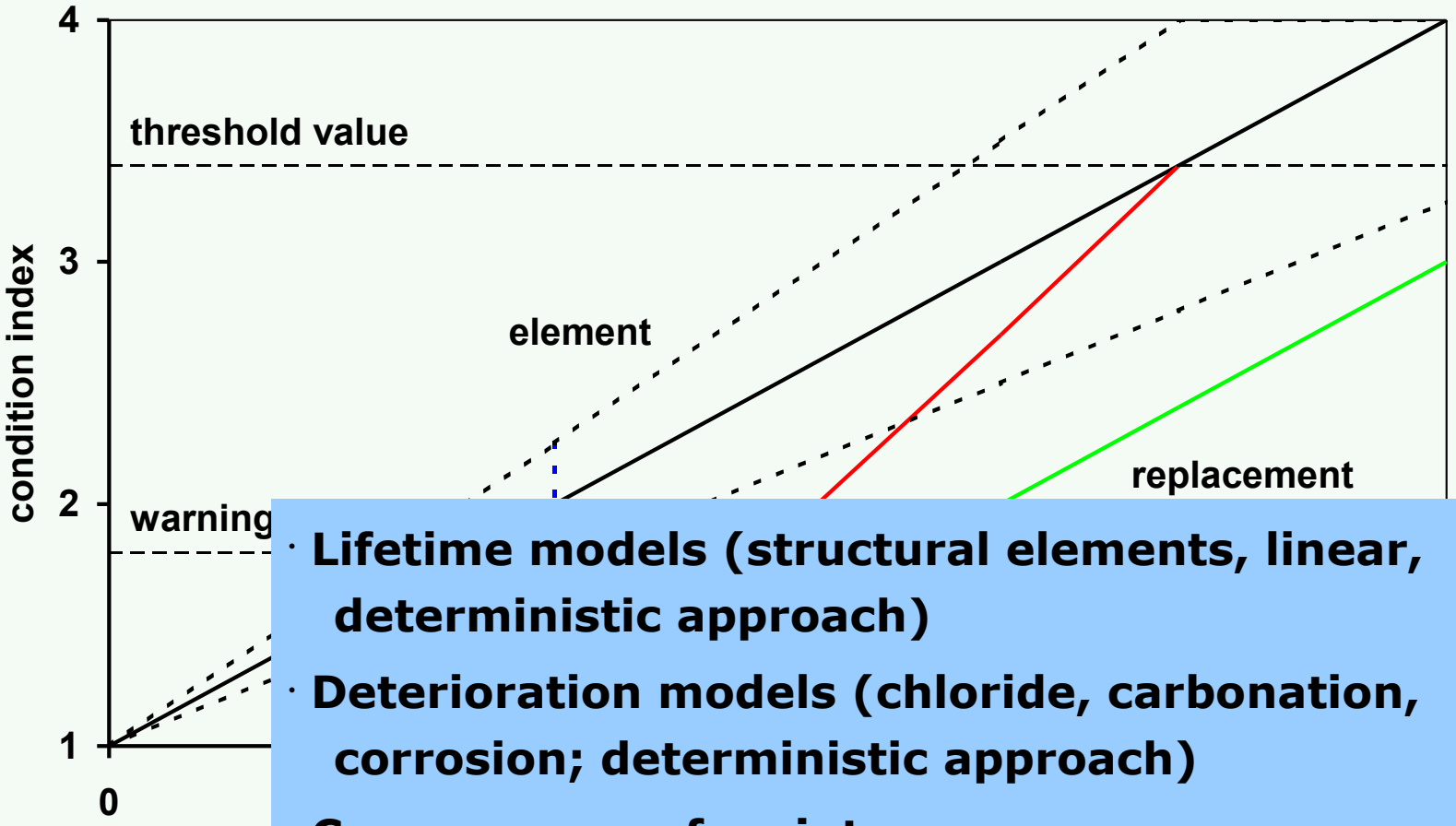


Catalogue of Measures

Bauwerksart, Hauptbauteil, Konstruktionsteil, Bauteilergänzung oder Hauptbaustoff, Schaden	Einheit des max Instandsetzungsumfangs	Verhaltensmodell (Fett: maßgebend (Standard))	S	V	D	Maßnahme 1	Einheit der Maßnahme	Rück setzung			Maßnahme 2	Einheit der Maßnahme	Rück-setzung		
BRÜCKEN, ÜBERBAU, ---, ---, --- (weitere BSP durch Angabe des Baustoffs, Schadens)			**S**	**V**	**D**			**S**	**V**	**D**					
durchgebogen (Bewertung abhängig vom Grad der Durchbiegung)		OSA													
BRÜCKEN, ÜBERBAU, ---, BETON außer Betondeckung, ---			**S**	**V**	**D**			**S**	**V**	**D**			**S**	**V**	**D**
Abplatzungen im oberflächennahen Bereich mit oder ohne freil. Bewehrung, **D = 1-2**	m² (Instands.fläche) Überbau unten	**FTB**, AKR, Ka, Cl	**0**	**0**		Reaktionsharz-mörtel an Unter-seiten (PC U)	m² Instands.fläche	0	0	0	Zementmörtel mit Kunststoff-zusatz (PCC II)	m² Instands.fläche	0	0	0
Abplatzungen wie vor, aber über Verkehrsraum, **V = 1-3, D = 1-2**	m² (Instands.fläche) Überbau unten	**FTB**, AKR, Ka, Cl	**0**			Reaktionsharz-mörtel an Unter-seiten (PC U)	m² Instands.fläche	0	0	0	Zementmörtel mit Kunststoff-zusatz (PCC II)	m² Instands.fläche	0	0	0
freiliegende Tragbewehrung mit korrodierter Bewehrung (keine nennenswerte Querschnittsminderung)	m² (Instands.fläche) Überbau unten	**Ko**, Cl	**1**	**0**	**2**	Reaktionsharz-mörtel an Unter-seiten (PC U)	m² Instands.fläche	0	0	1	Zementmörtel mit Kunststoff-zusatz (PCC II)	m² Instands.fläche	0	0	1
Tragbewehrung liegt im karbonatisierten Bereich und ist korrodiert (nicht Spannbewehrung)	m² (Instands.fläche) Überbau unten	**Ko**, Cl	**1**	**0**	**3**	Spritzbeton BII	m² Instands.fläche	0	0	0	Spritzbeton mit Kunststoff-zusatz (SPCC II)	m² Instands.fläche	0	0	0
freiliegende Tragbewehrung mit korrodierter Bewehrung (einsetzende Querschnittsminderung)	m² (Instands.fläche) Überbau unten	**Ko**, Cl	**2**	**0**	**3**	Reaktionsharz-mörtel an Unter-seiten (PC U)	m² Instands.fläche	1	0	1	Zementmörtel mit Kunststoffzusatz (PCC II)	m² Instands.fläche	1	0	1
stark korrodierte Tragbewehrung (fortgeschrittene Querschnittsminderung)	m² (Instands.fläche) Überbau unten	**Ko**, FTB, AKR	**3**	**0**	**3**	Zusatzbewehrung	OSA	0	0	0	Kohlefaser-lamellen zur Biegeverstärkung	OSA	0	0	0
stark korrodierte Tragbewehrung (teilweiser Ausfall von Tragbewehrung)	m² (Instands.fläche) Überbau unten	**Ko**, FTB, AKR	**4**	**0**	**4**	Zusatzbewehrung	OSA	1	0	1	Kohlefaser-lamellen zur	OSA	1	0	1
großflächige Durchfeuchtungen/Ausblühungen/Aussinterung, **D = 2-3**		**OSA**, Ka, Cl, Ko	**0**	**0**		Abdicht erneue									
BRÜCKEN, ÜBERBAU, ---, BETONDECKUNG, ---			**S**	**V**	**D**										
Betondeckung der Tragbewehrung > 30 mm - 45 mm schlechte Betonqualität	m² (Instands.fläche) Überbau unten	**Ka**, Cl	**0**	**0**	**2**	Hydropl OS-A									
Betondeckung der Tragbewehrung > 15 mm - 30 mm, gute Betonqualität	m² (Instands.fläche) Überbau unten	**Ka**, Cl	**0**	**0**	**2**	Hydropl OS-A									
Betondeckung der Tragbewehrung > 15 mm - 30 mm, schlechte Betonqualität	m² (Instands.fläche) Überbau unten	**Ka**, Cl	**0**	**0**	**3**	Hydropl OS-A									

- **maintenance alternatives**
- **object related strategies**
- **traffic safety measures**
- **owner costs**

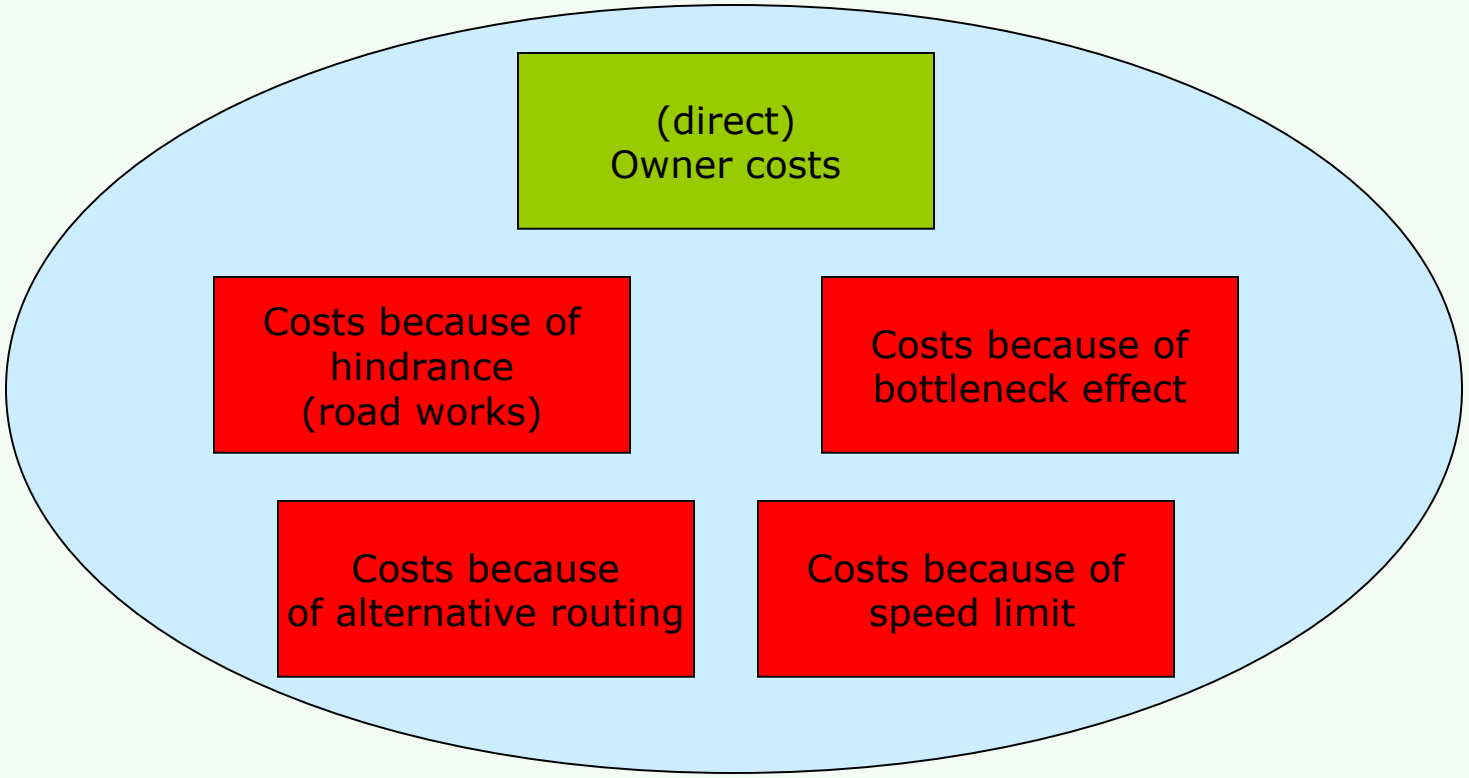
Future behaviour



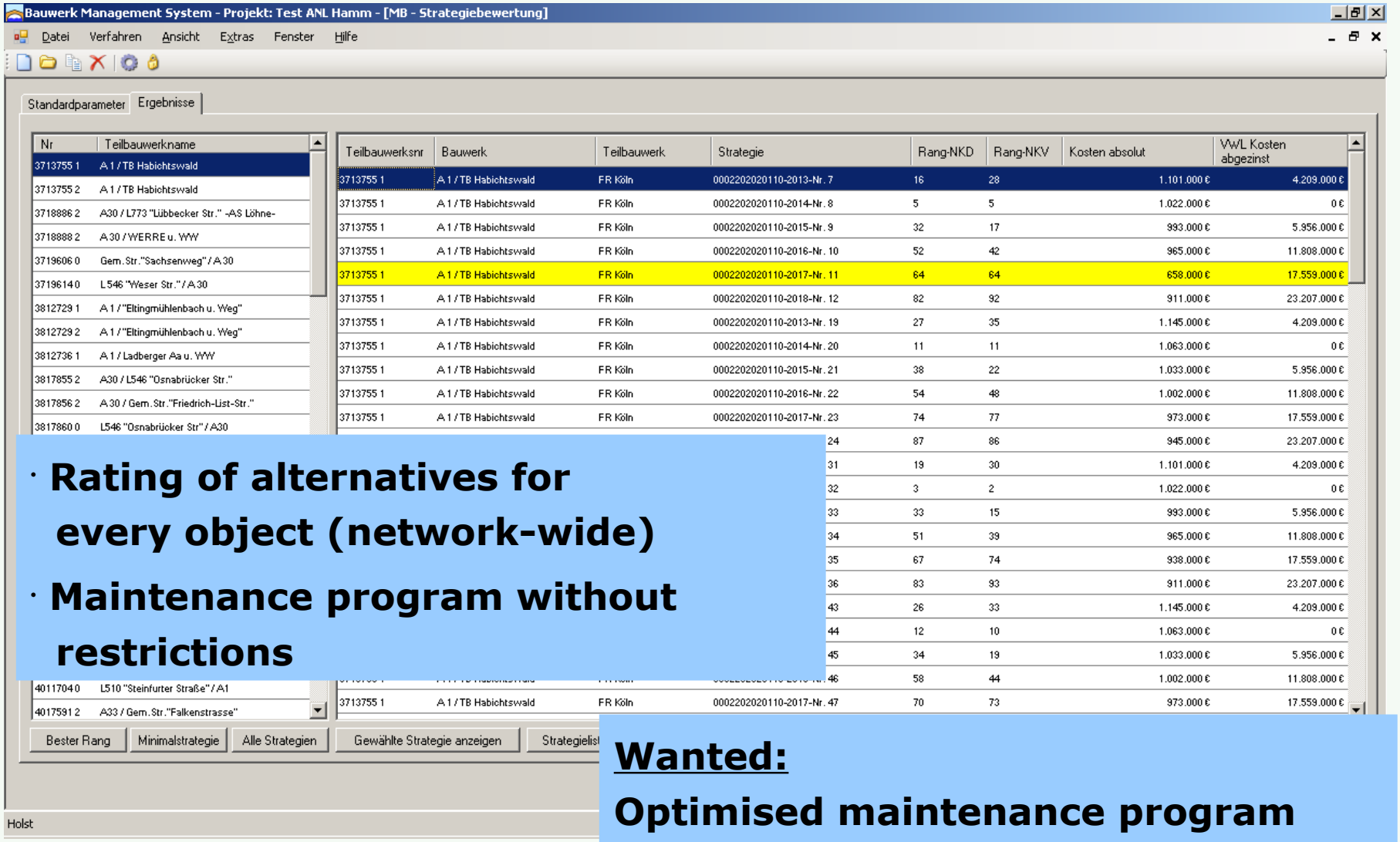
- **Lifetime models (structural elements, linear, deterministic approach)**
- **Deterioration models (chloride, carbonation, corrosion; deterministic approach)**
- **Consequence of maintenance**
- **Intervention interval (warning-/threshold v.)**

BMS on Object level

Macroeconomic Evaluation on Object level



Analysis on Object Level



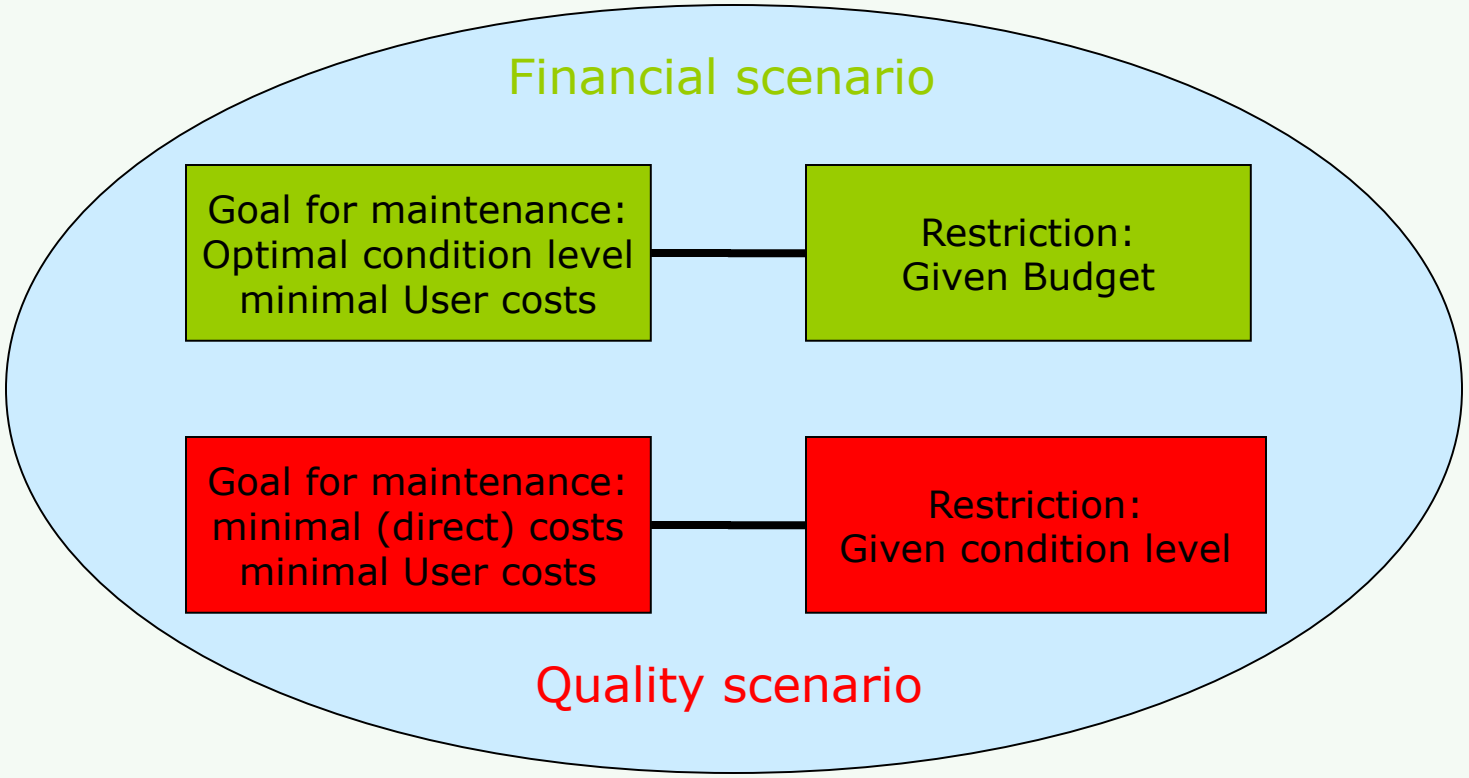
- **Rating of alternatives for every object (network-wide)**
- **Maintenance program without restrictions**

<u>Wanted:</u>

Optimised maintenance program (budget, other constraints)

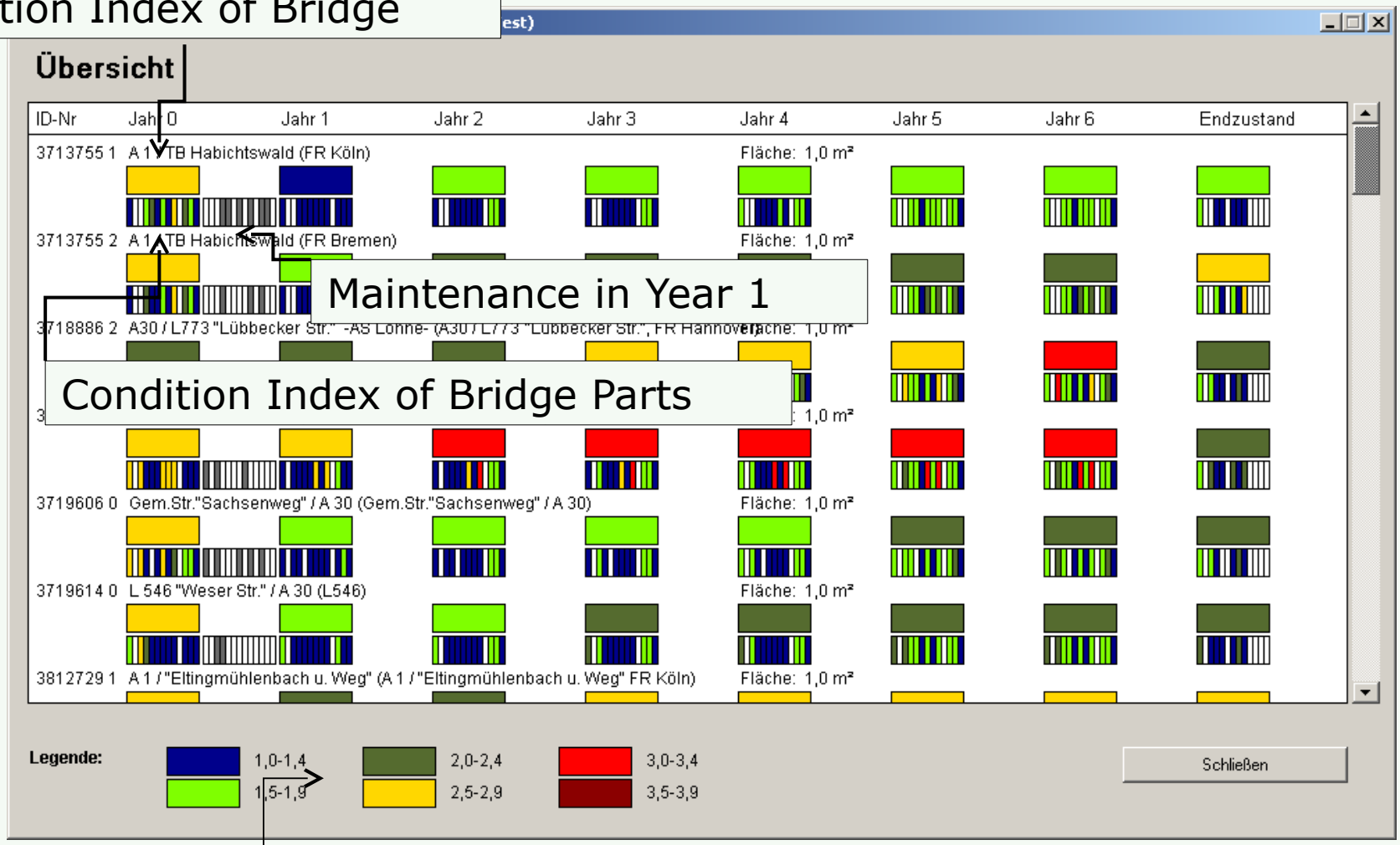
Analysis on Network Level

Macroeconomic Evaluation on Network level



Presentation of Results

Condition Index of Bridge



Maintenance in Year 1

Condition Index of Bridge Parts

Condition Index Class

Closure and Outlook

- Need for systematic maintenance is rising steadily,
- the information of the regular bridge inspection and additional investigations are the most important basis,
  - Data quality,
  - Data availability,
- A management system for optimization of financial resources with consideration of intervention in the traffic and technical possibilities is necessary,
  - Direct costs,
  - User costs,
- Selective use of sensors / sensor networks for better/earlier information about bridge condition,
- Extension to probabilistic approaches for the future (bridge inspection an management),

Thank you very much for your attention!