Hochschule Karlsruhe
Technik und Wirtschaft
UNIVERSITY OF APPLIED SCIENCES

IGS Institut für
Grund- und Straßenbau

A Canada-Germany Summer Workshop
„Hands on sustainable urban mobility“

Infrastructure Management

Prof. Dr.-Ing. Markus Stoeckner
Institut für Grund- und Straßenbau

Content

- Importance of Cycle Traffic
- Network Planning
- Operation of Cycle Networks
- Structural Maintenance – Asset Value
- Structural Maintenance – Calculation Models
- Operation – Pavement S&A
- Operational Approach for M&R
- Strategic Approach – PMS-Apllications

Institut für Grund- und Straßenbau

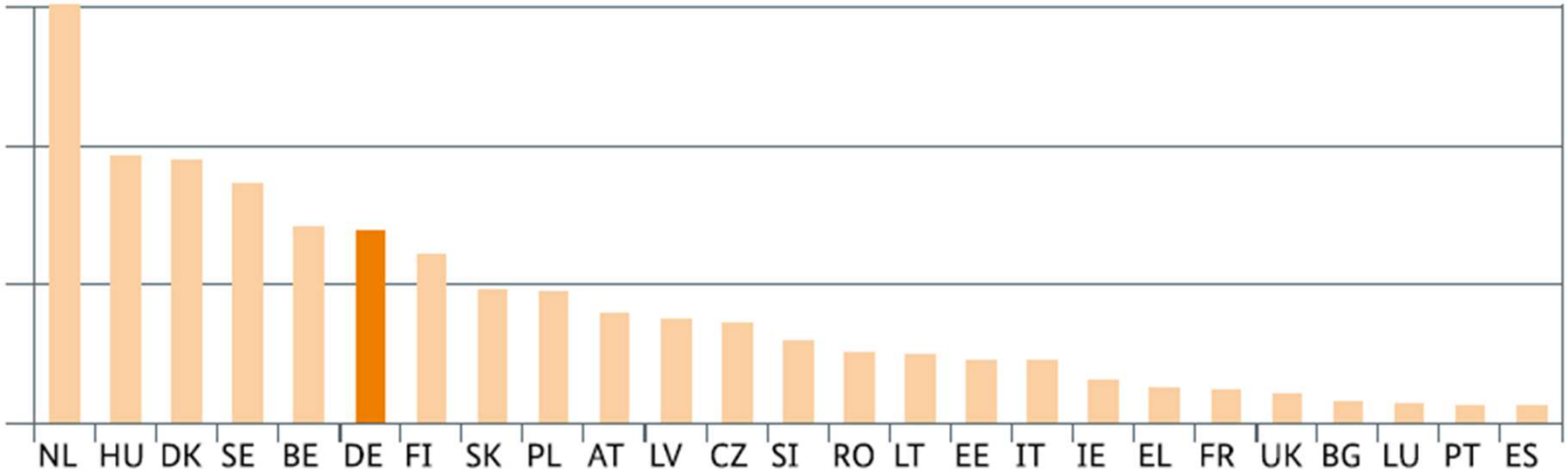
Research Fields:

- Strategic Network Development
- Pavement Condition survey and assessment
- Pavement Management Systems and Information Systems
- Finance requirements for traffic network systems
- Design Methods for Pavements
- Airfield Management

Funding: Projects from different Institutions

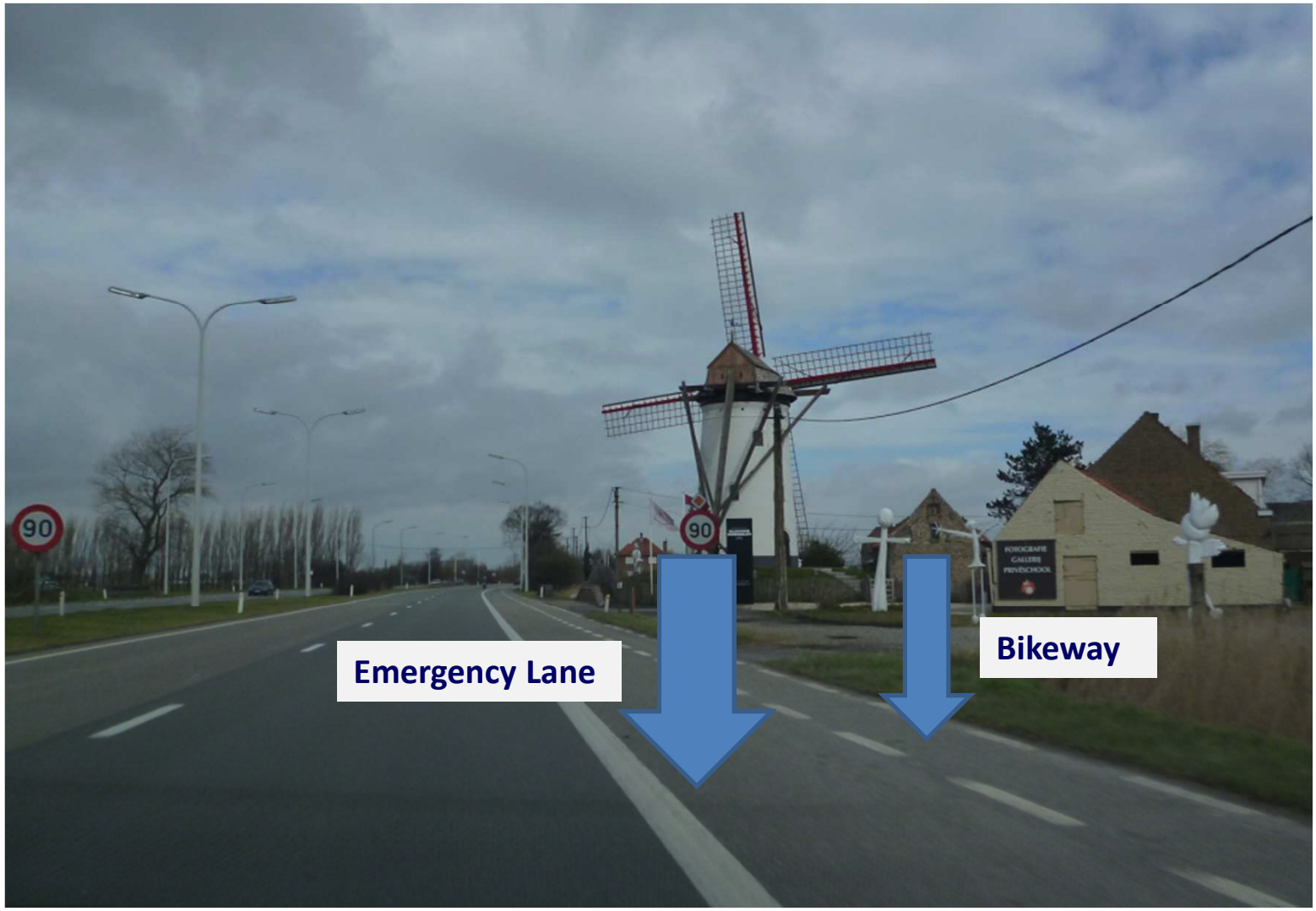
Cycle Traffic in Germany: European context

Cycle traffic proportion in Europe
(Netherlands = 100 %)



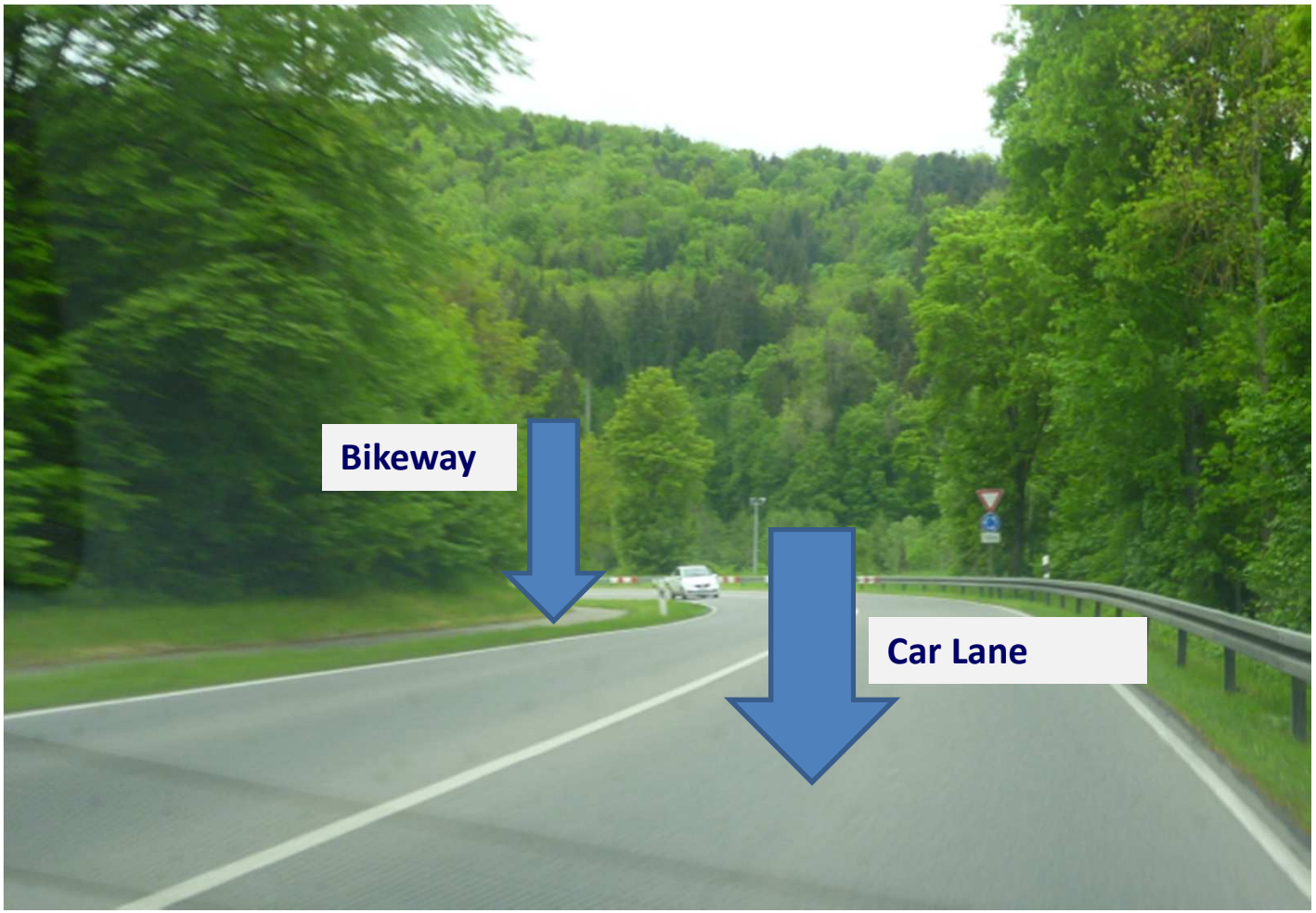
[European Commission, 2011; Nationaler Radwegeverkehrsplan, 2012]

Expressway Belgium:



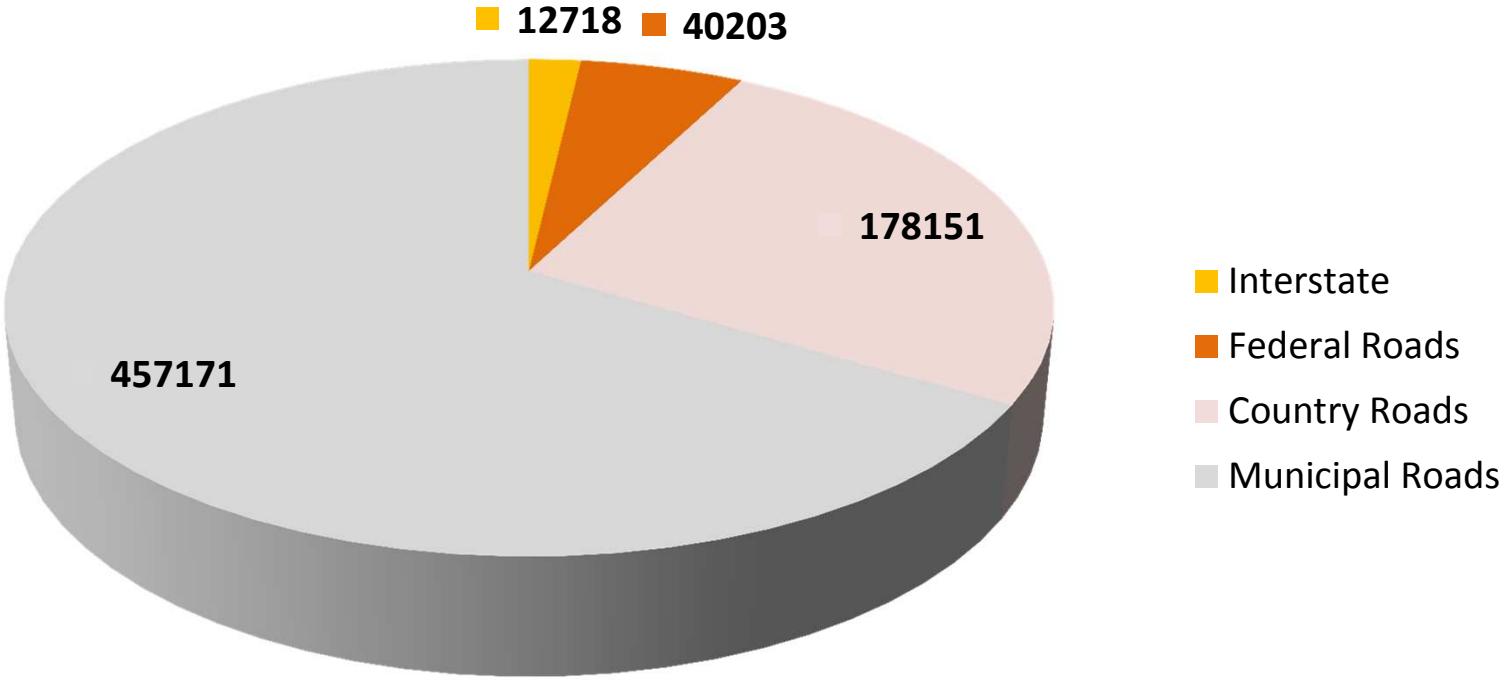
Cross Town Expressway Belgium:

Federal road B28 / Calw County / Black Forest



Overview: Network Length of Road Infrastructure in Germany

Area Interstates: 269,04 km²
Area Federal Roads: 344,54 km²

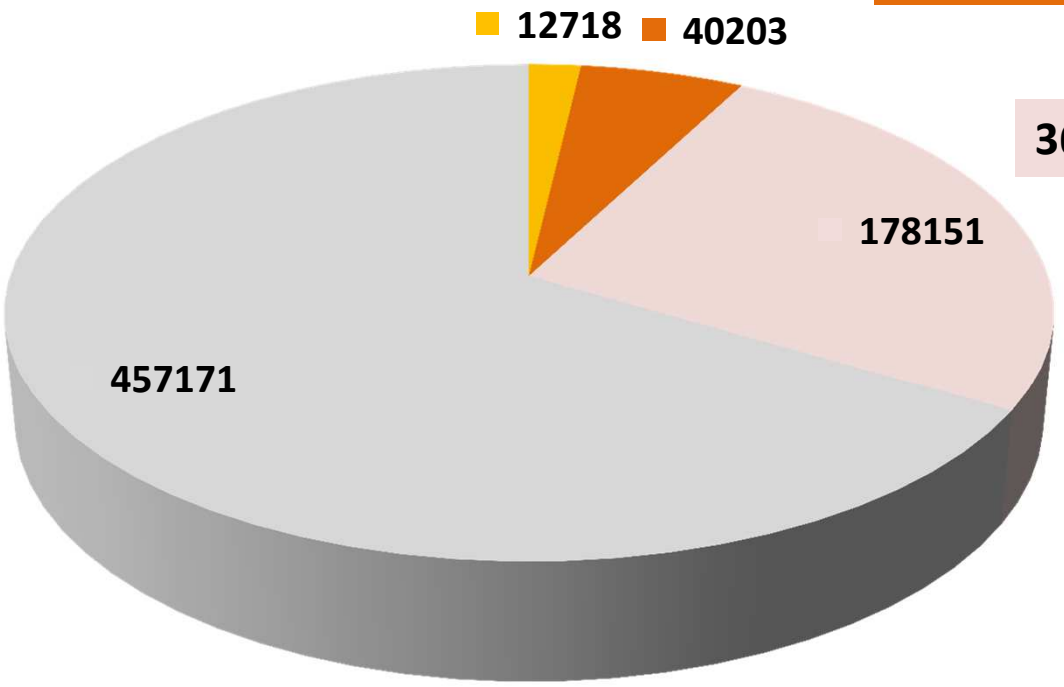


Network length in [km]
Overall network length: 688.243 km

[Der Elsner, 2012; own chart]

Comparison: Road Network Length vs. Bikeway Network Length in Germany

15.698 = 39 % with bikeways

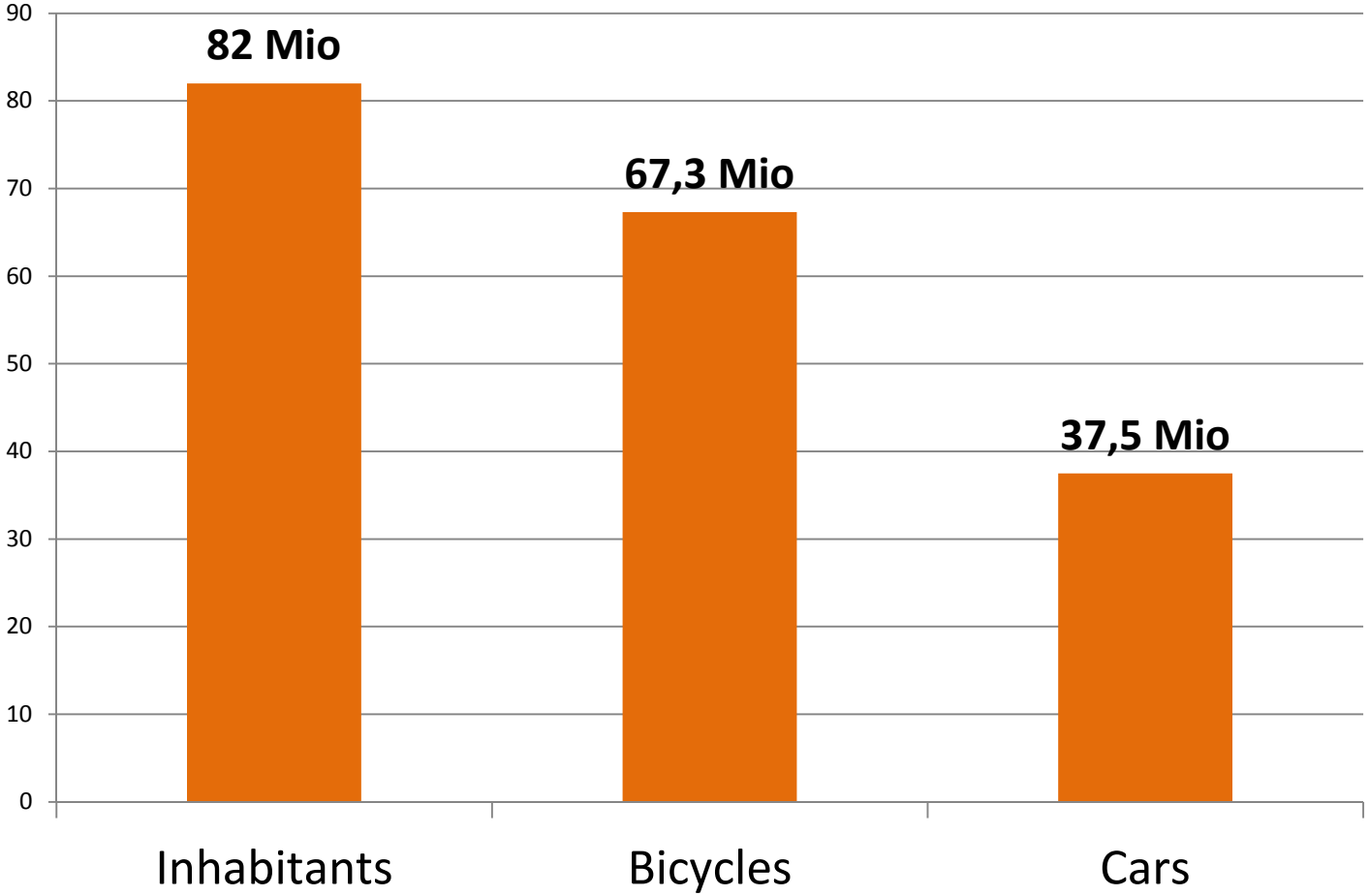


36.232 = 20 % with bikeways

Example State Capital Munich:
Road Network: 1.200 km
Bikeway Network: 1.200 km

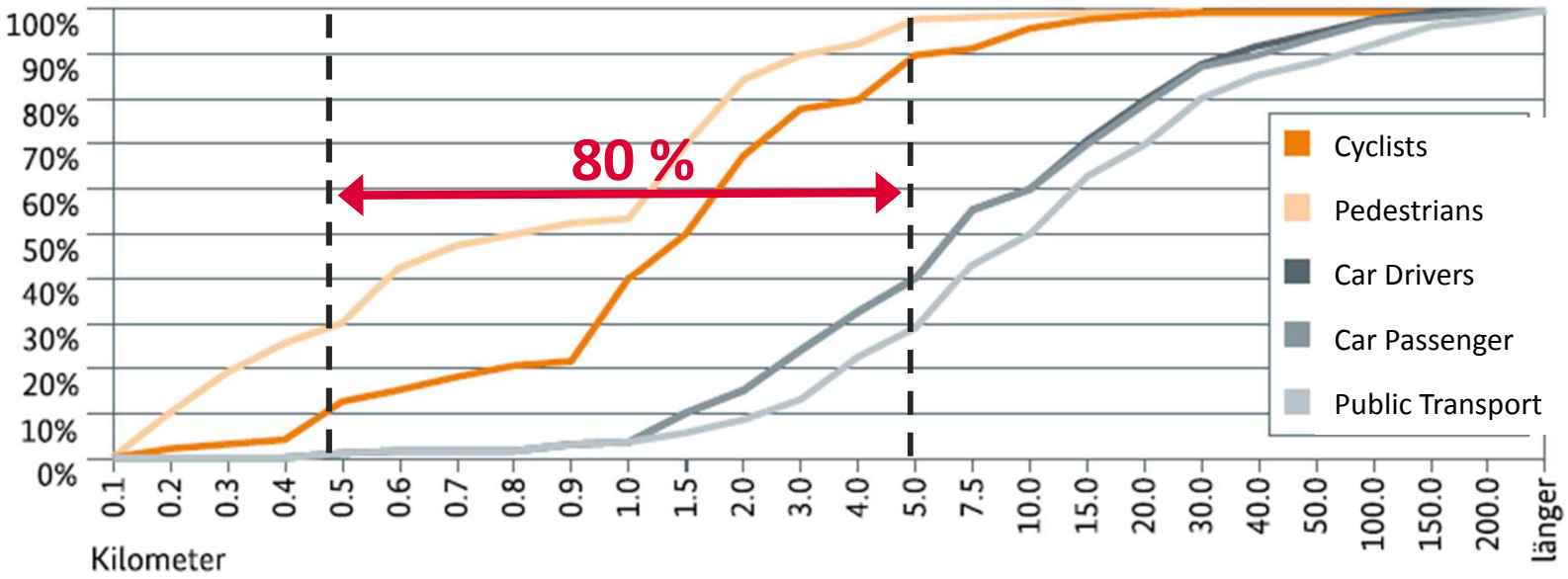
[Der Elsner, 2012; own data]

Bicycles: Availability in Germany

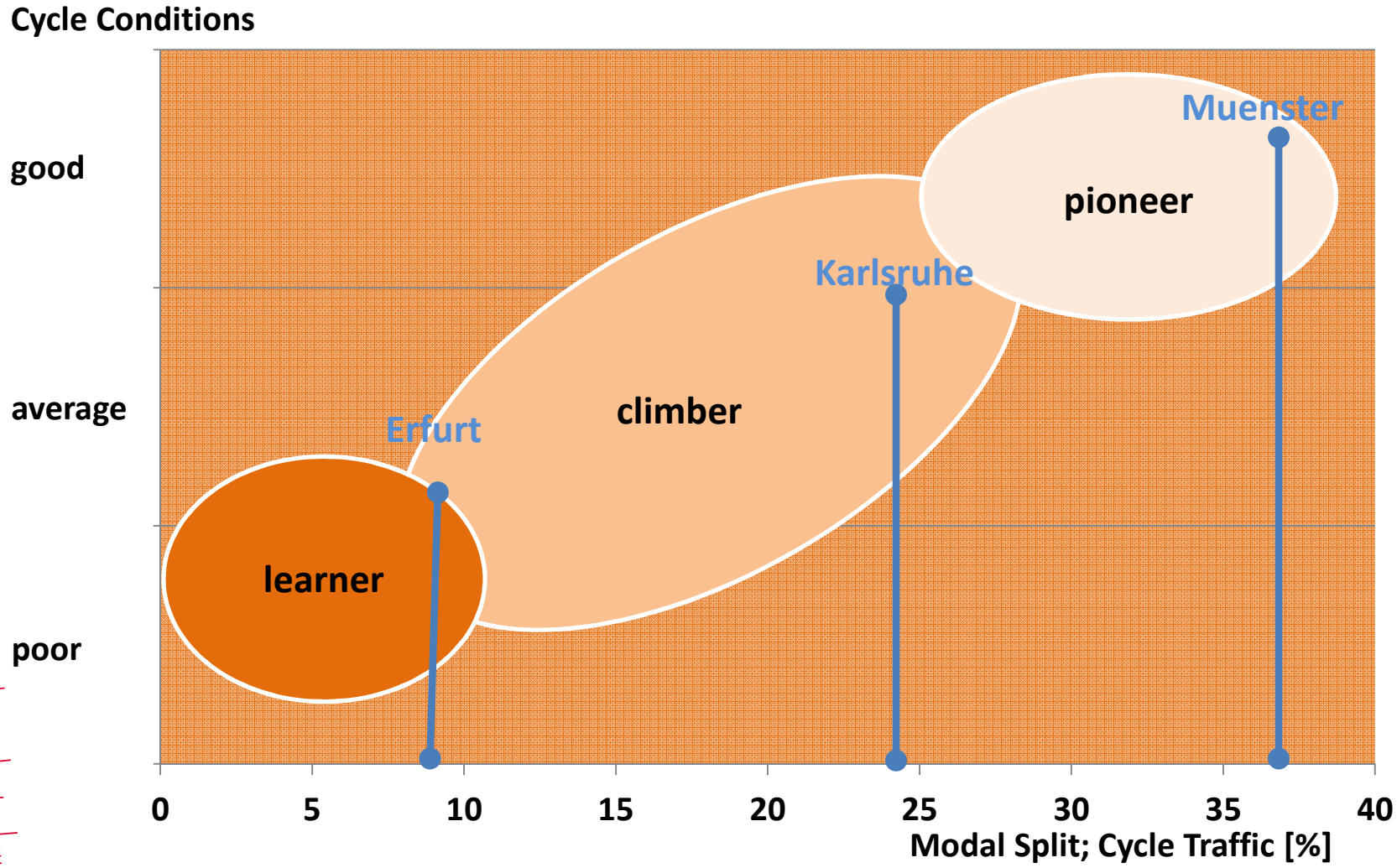


[Nationaler Radwegeverkehrsplan, BMVBS, 2020]

Distance covered with means of transport (accumulated)



BMVBS (Hrsg.): Mobilität in Deutschland 2008, Ergebnisbericht, Bonn/Berlin 2010



[Project Presot, 2010; Karlsruhe Community; Muenster Community; Erfurt Community]

Importance of Transport Infrastructure

- Road network
- Railway network
- Airports
- Ports and Waterways

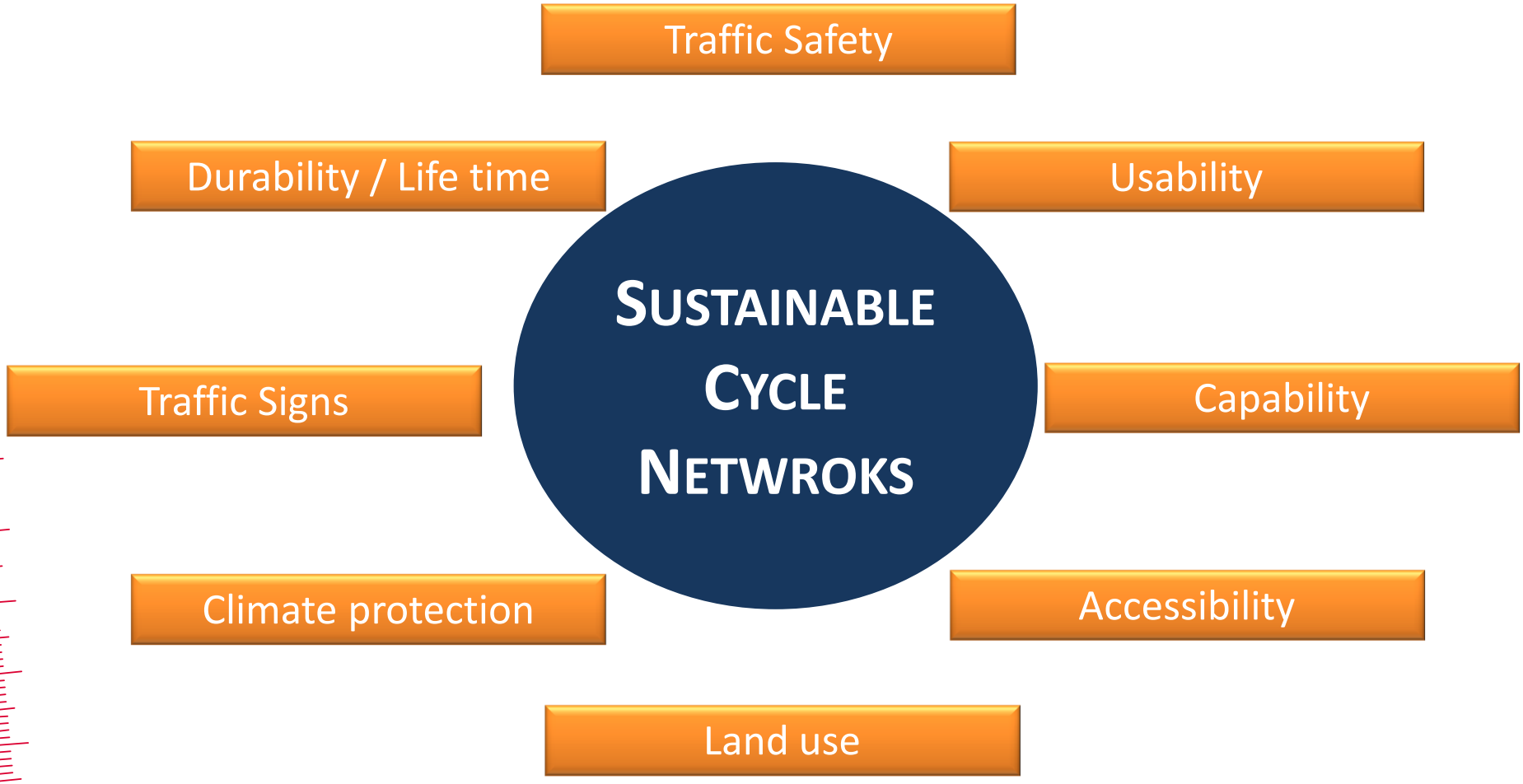
→

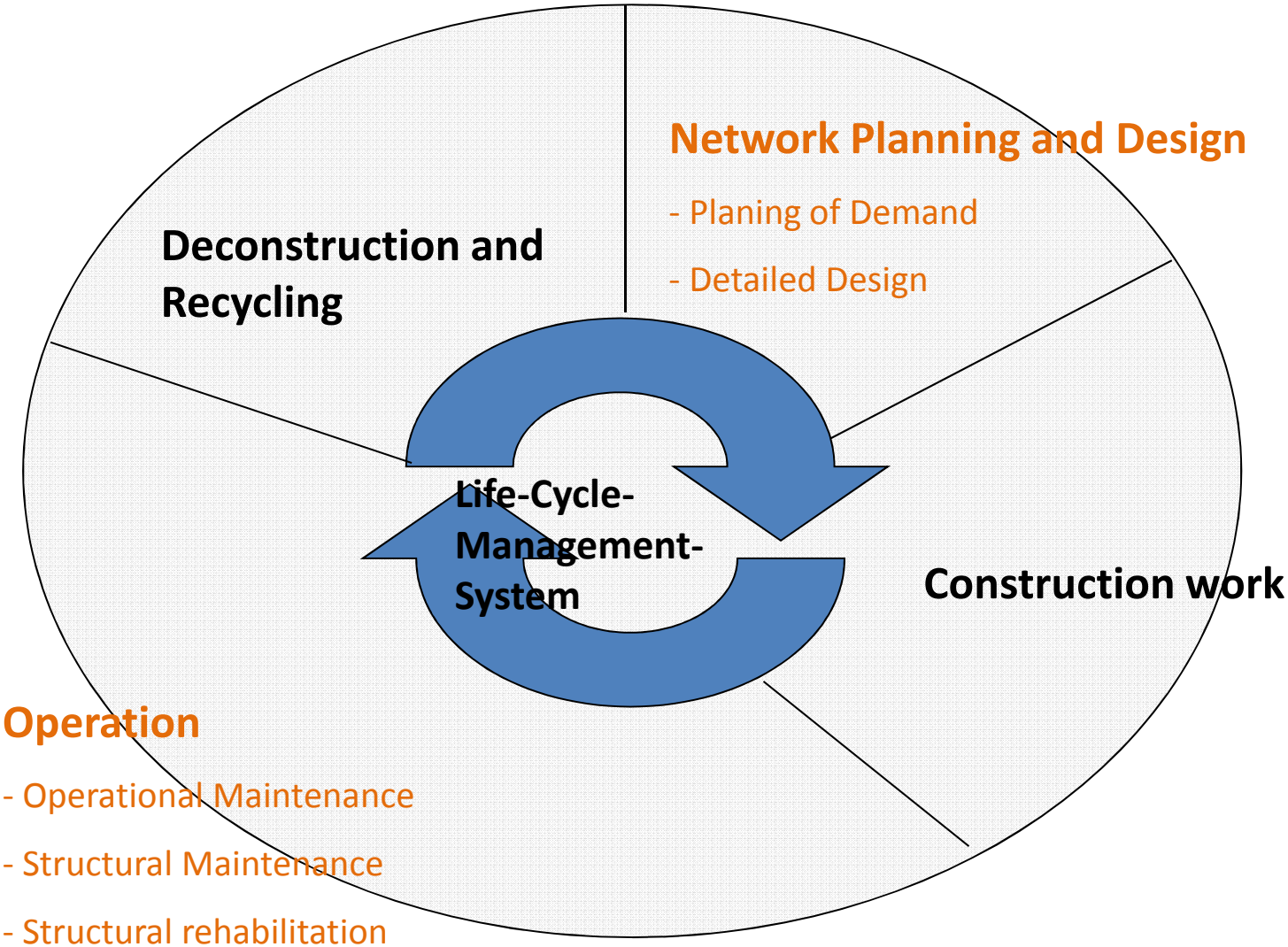
- Economic growth
- Social Balance
- Supply for necessary goods and services
- Distribution of Products

e.g. →

- Access to Education
- Access to Health Care
- Access to Aliment

Sustainable Transport Infrastructure – Requirements




Network Planning and Design
- Planing of Demand
- Detailed Design
Deconstruction and Recycling
Life-Cycle-Management-System
Construction work
Operation
- Operational Maintenance
- Structural Maintenance
- Structural rehabilitation

Network Planning and Design

- Planning of Demand
- Detailed Design

→ Strategic Network Development

↓

Forschungsgesellschaft für Straßen- und Verkehrswesen

Arbeitsgruppe Verkehrsplanung

FGSV

Richtlinien
für integrierte Netzgestaltung

R 1

RIN

Strategic network development: Quality standard

Tabelle 9: Verknüpfungsmatrix zur Ableitung von Verkehrswegekategorien für den Radverkehr

Kategoriengruppe / Verbindungsfunktionsstufe		außerhalb bebauter Gebiete	innerhalb bebauter Gebiete
		AR	IR
überregional	II	AR II	IR II
regional	III	AR III	IR III
nahräumig	IV	AR IV	IR IV
kleinräumig	V	–	IR V

Tabelle 10: Bezeichnung der Verkehrswegekategorien für den Radverkehr

Kategoriengruppe		Kategorie	Bezeichnung
AR	außerhalb County ebiete	AR II	überregionale Radverkehrsverbindung
		AR III	regionale Radverkehrsverbindung
		AR IV	nahräumige Radverkehrsverbindung
IR	innerhalb City Gebiete	IR II	innergemeindliche Radschnellverbindung
		IR III	innergemeindliche Radhauptverbindung
		IR IV	innergemeindliche Radverkehrsverbindung
		IR V	innergemeindliche Radverkehrsanbindung

II: Downtown (Hospital, University, Opera ….)

III: Town district (Mall, High School ….)

IV: Part of town district (Food store, primary school…)

V: Residential area

[FGSV: RIN 2008]

Strategic network development: Quality standard

Tabelle 15: Kategorien von Verkehrswegen für den Radverkehr und angestrebte Fahrgeschwindigkeiten für den Alltagsradverkehr

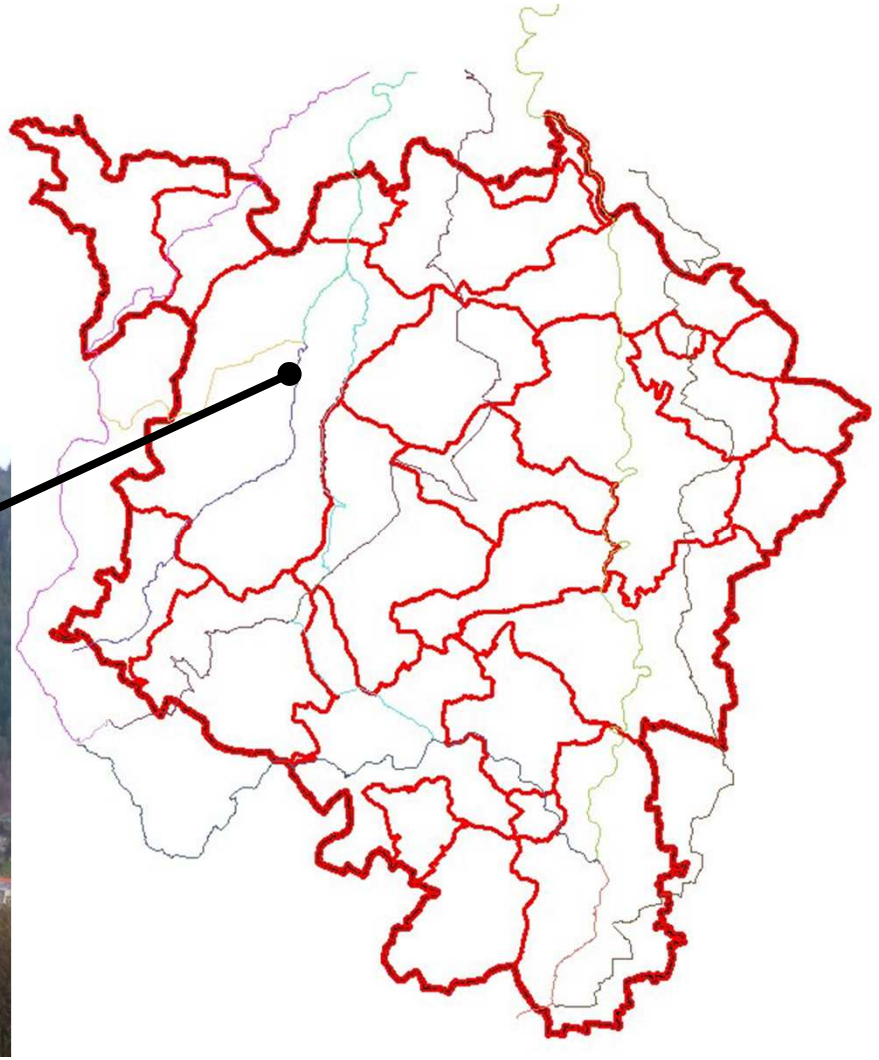
Category Type		Category		Distance bereich [km]	Speed keiten [km/h[1)]]
AR	außerhalb bebauter Gebiete County	AR II	überregionale Radverkehrsverbindung	10 – 70	20 – 30
		AR III	regionale Radverkehrsverbindung	5 – 35	20 – 30
		AR IV	nahräumige Radverkehrsverbindung	bis 15	20 – 30
IR	innerhalb bebauter Gebiete City	IR II	innergemeindliche Radschnellverbindung	–	15 – 25
		IR III	innergemeindliche Radhauptverbindung	–	15 – 20
		IR IV	innergemeindliche Radverkehrsverbindung	–	15 – 20
		IR V	innergemeindliche Radverkehrsanbindung	–	–

1) einschließlich Zeitverluste an Knotenpunkten

[FGSV: RIN 2008]

Calw Community / Black Forest:

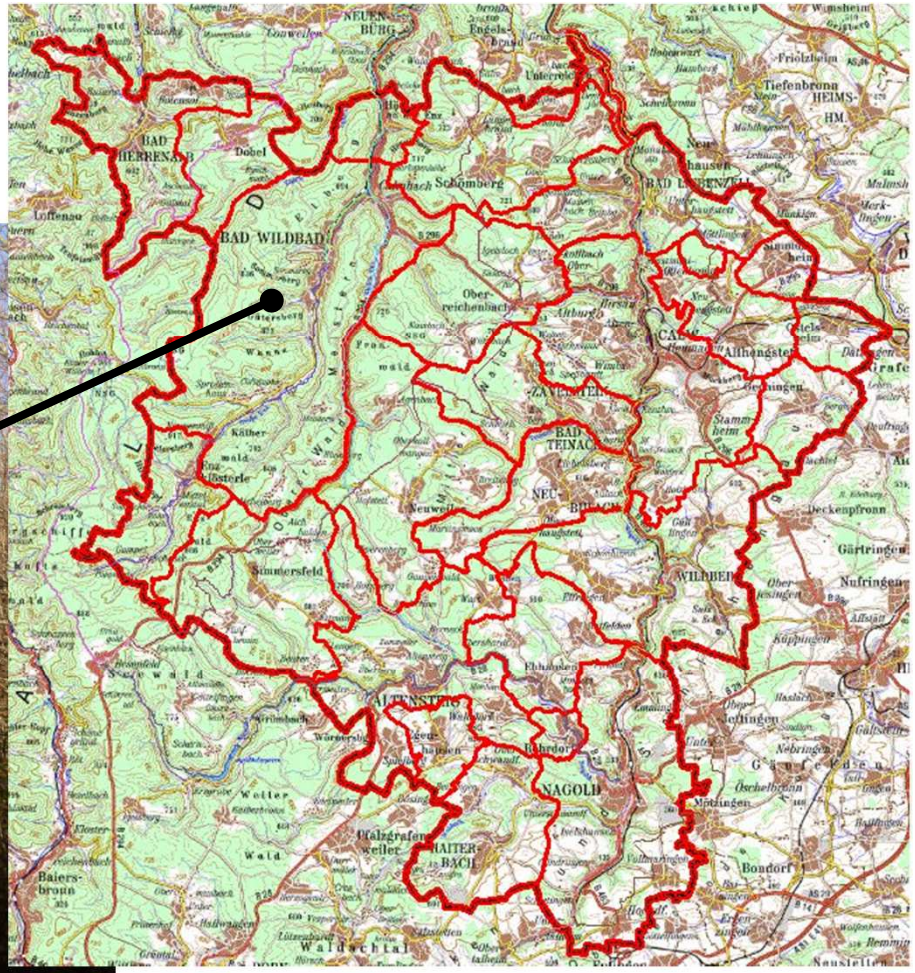
Cycle path for tourists:



[map: www.landkreis-calw.de]

Calw Community / Black Forest:

Cycle path for tourists:



[map: www.landkreis-calw.de]

Calw Community / Black Forest:

Strategic Network Development plan 2012:

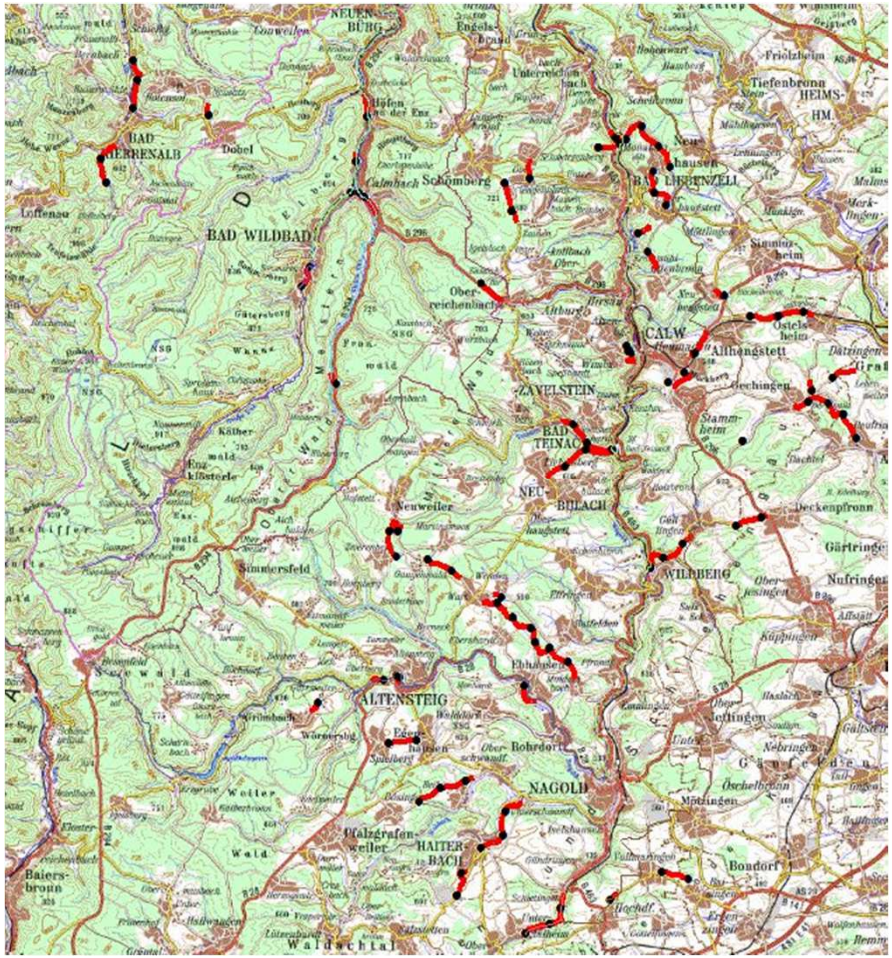
Targets:

Connection between communities

Raise modal split for cycles

Use of cycles for daily traffic

Reduce greenhouse gases



[map: www.landkreis-calw.de]]

Metropolitan Region Rhine-Neckar:

Strategic Network Development Plan 2013:

Mannheim City

Heidelberg City

Rhine-Neckar County

Target:

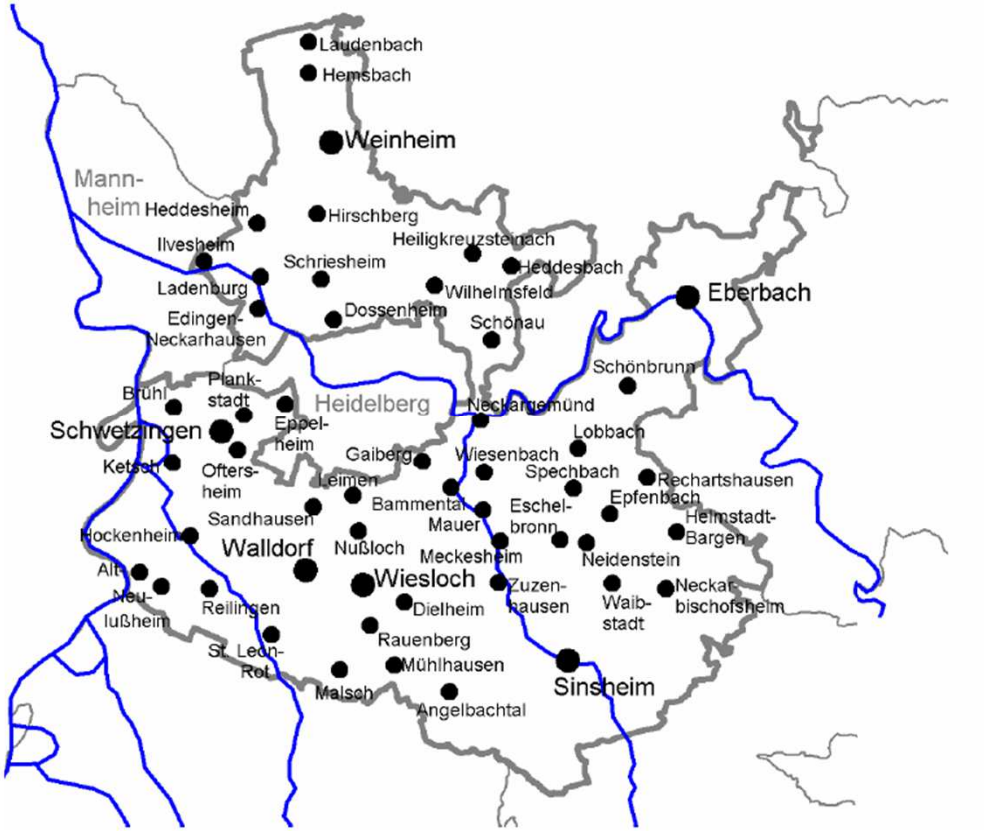
Reduce greenhouse gases

Demand Analysis

Network Concept

Sign Posting Concept

Public Relation Concepts



[map: www.landkreis-rhein-neckar.de]

Metropolitan Region Rhine-Neckar:

Strategic Network Development Plan 2013:

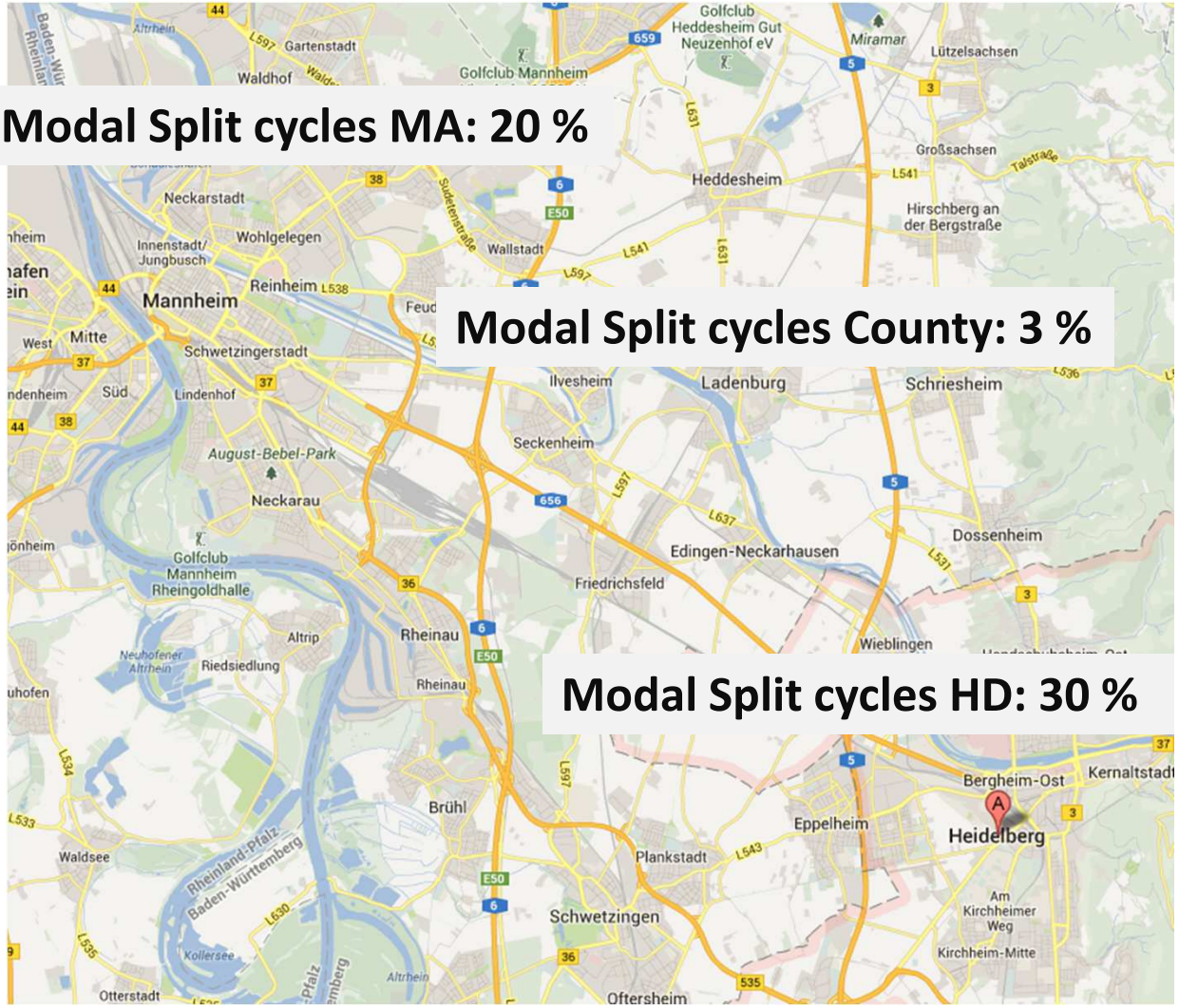
Connecting tree different networks with different service levels

Task for HsKA:

R&D-Part

Mediation between partners

Controlling of Consultants and Planers



[map: google maps, 2013]

Operational Maintenance

Legal duty to maintain traffic safety:

Cleaning / Winter Maintenance / Plants Maintenance / Small Surface Damages / Traffic signs Control ……

Structural Maintenance

Duty to conserve asset value:

Pavement Condition Assessment / Planning of M&R-Work /PMS-Applications

Winter Maintenance

Data Base for route planning

Required Network Database

- Road Name/ Number
- Network Nodes / Road Section / length
- Number and crossection of lanes

Database for Winter Maintenance

- Risk Sections
- Limitations for winter maintenance equipment
- Traffic significance
- Cycle part classification

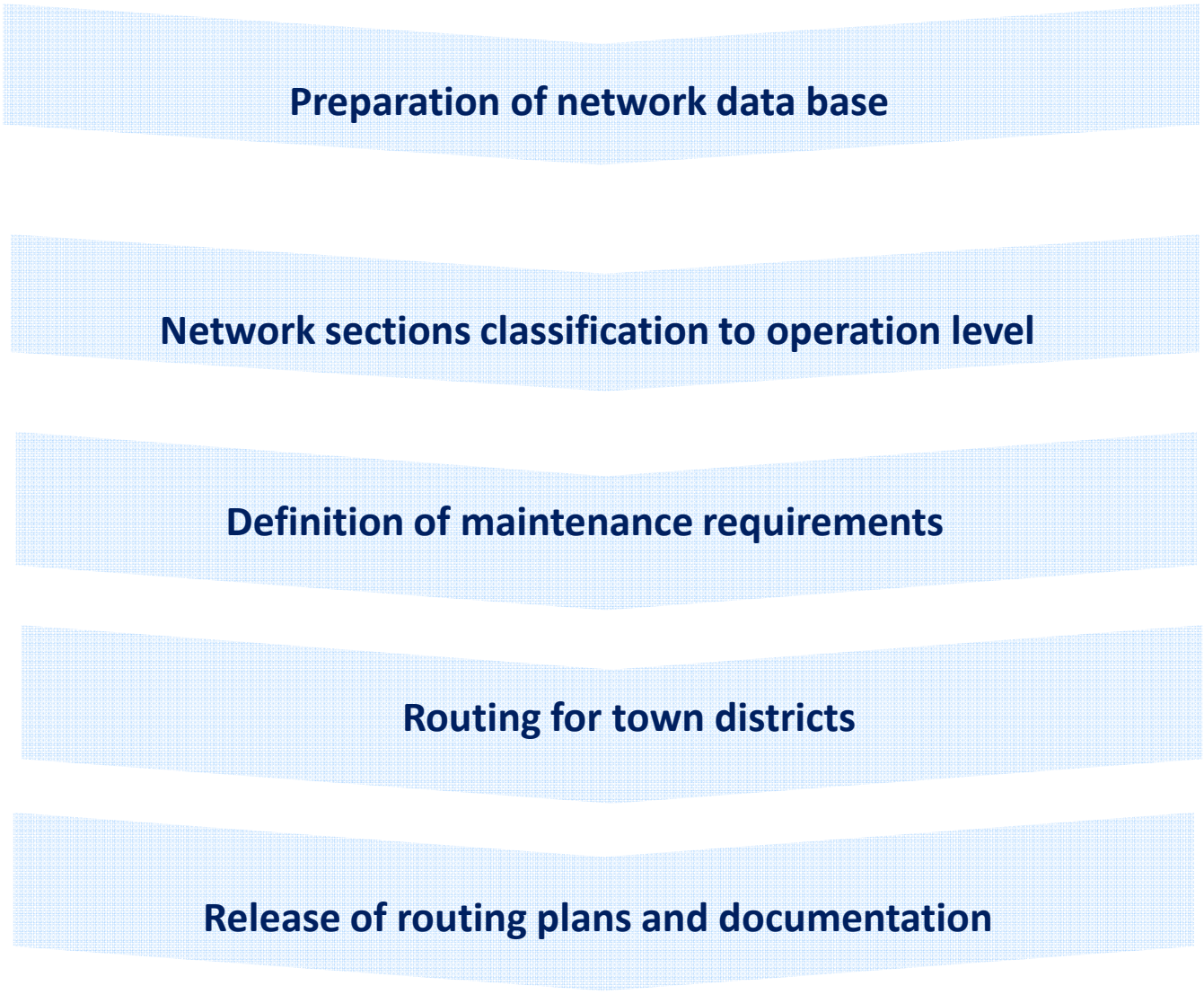
Winter Maintenance

Data Base for route planning

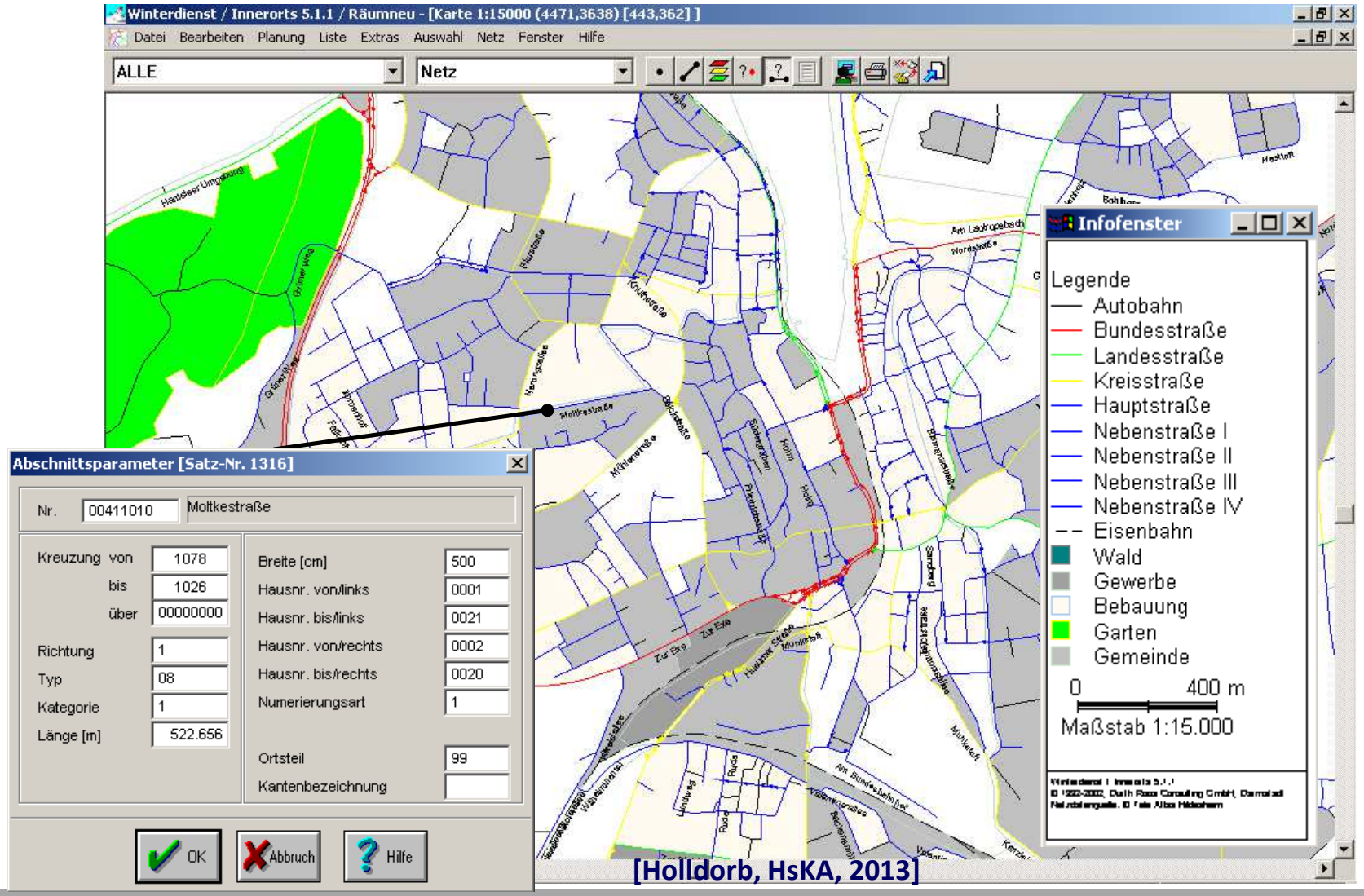
Requirements for Winter maintenance

- Time of circulation
- Reaction time after ice or snowfall
- Equipment capacity
- Allowed labor time
- Location of winter maintenance equipment
- Allowed de-icing materials

Winter Maintenance: Planing of winter maintenance operation

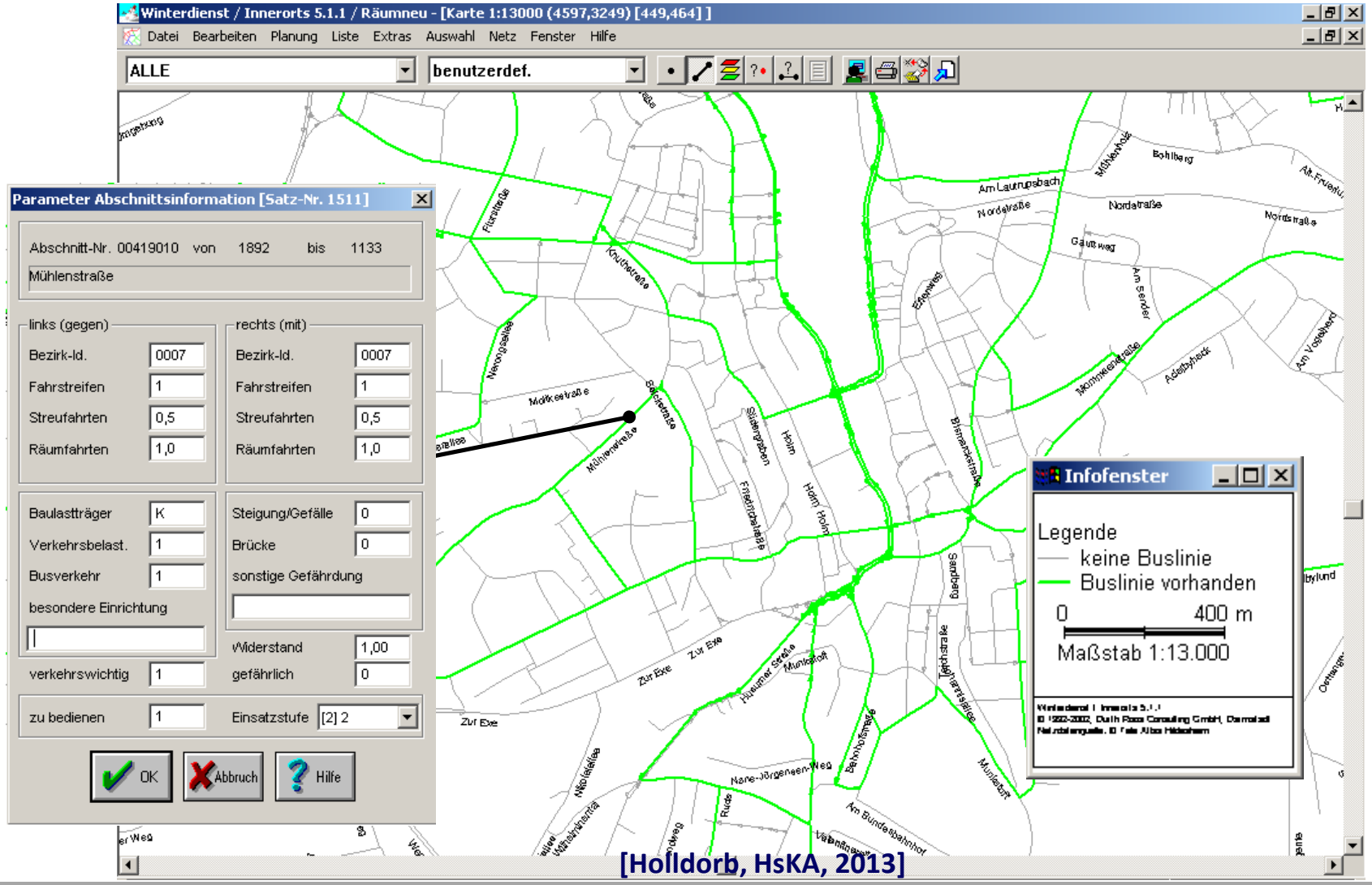


Winter Maintenance: Network data



[Holldorb, HsKA, 2013]

Winter Maintenance: Consideration of special requirements



[Holldorb, HsKA, 2013]

Winter Maintenance: Definition of service level

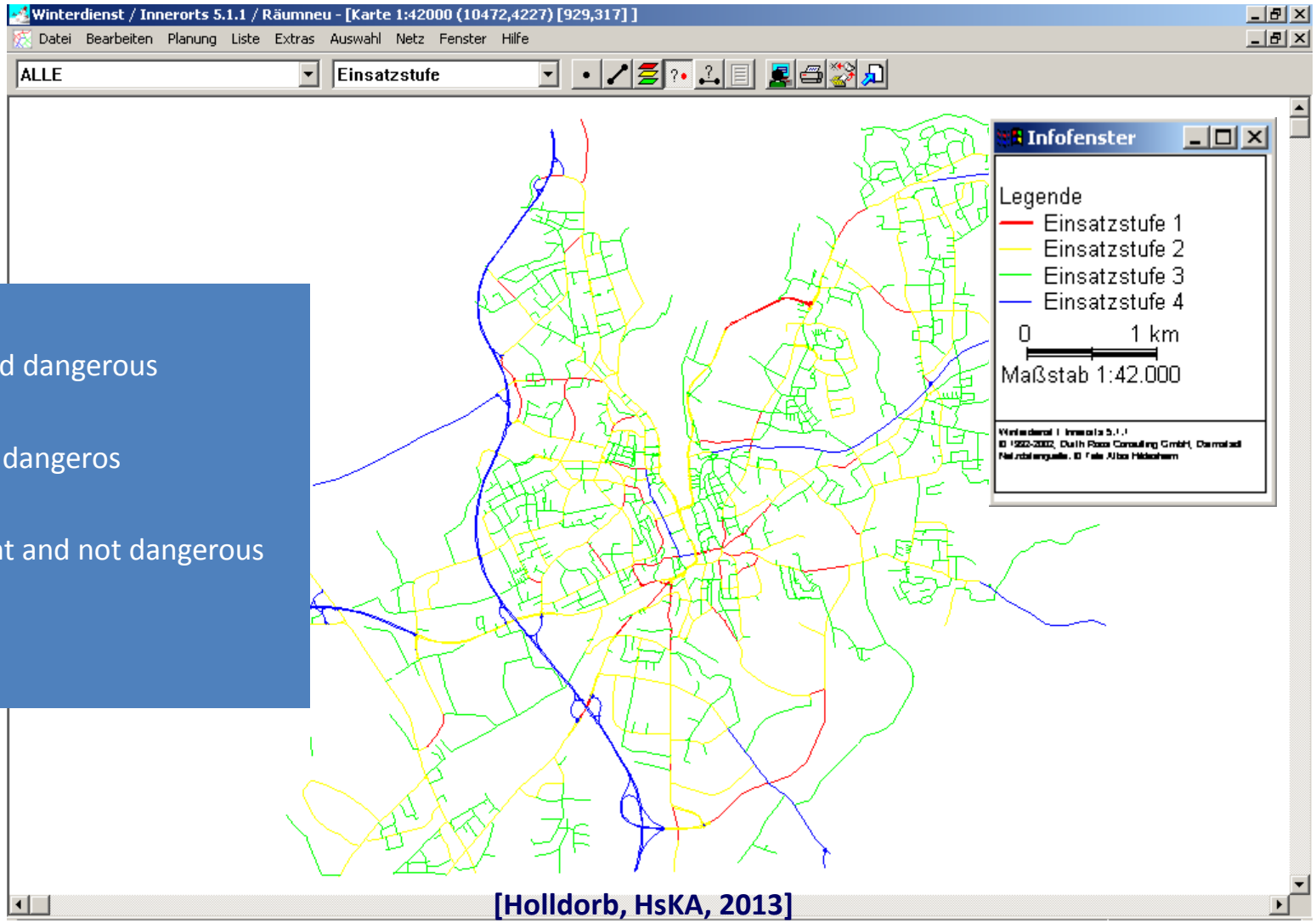
For example:

Important and dangerous
=> Level 1

Important or dangeros
=> Level 2

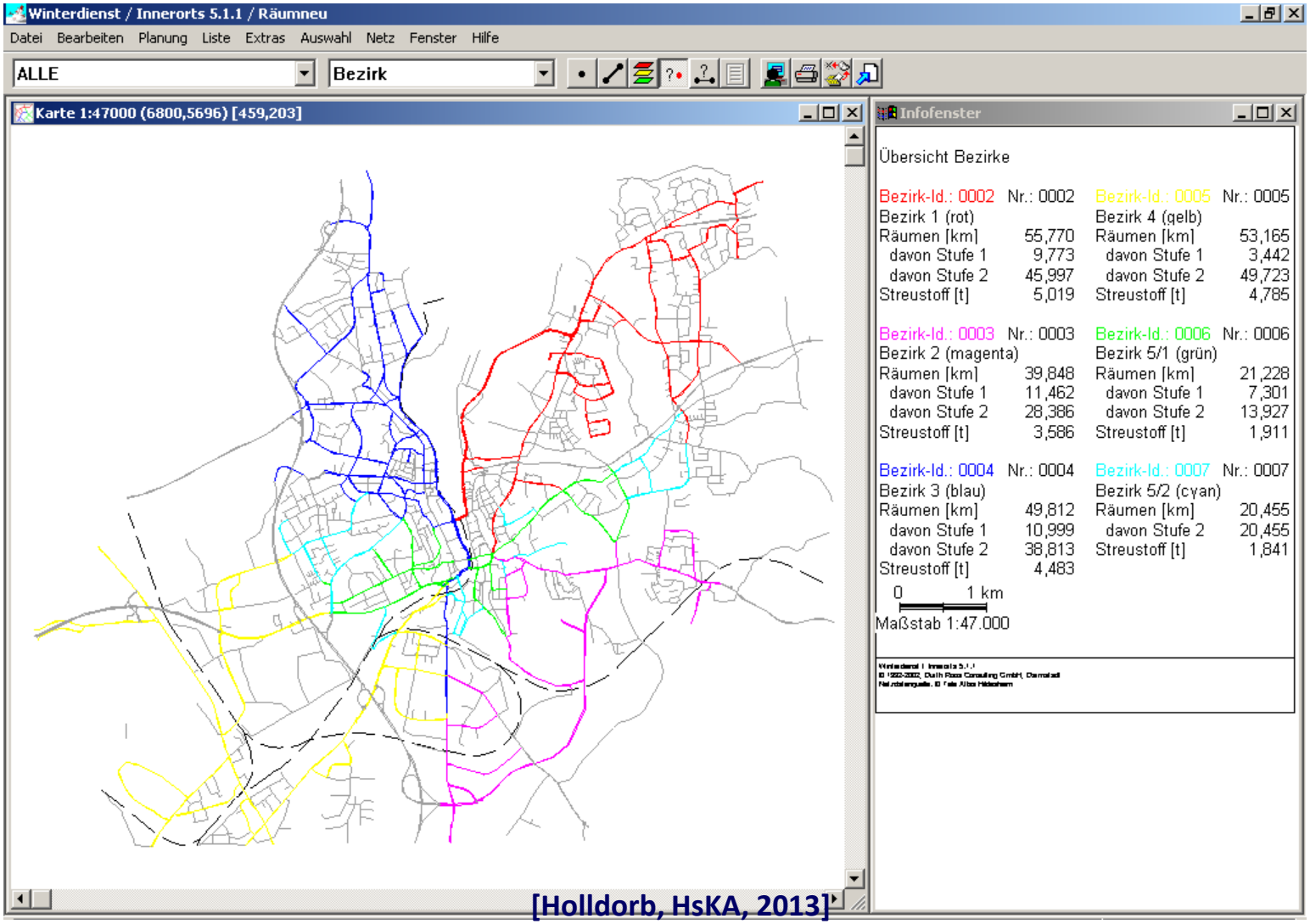
Not important and not dangerous
=> Level 3

No service
=> Level 4



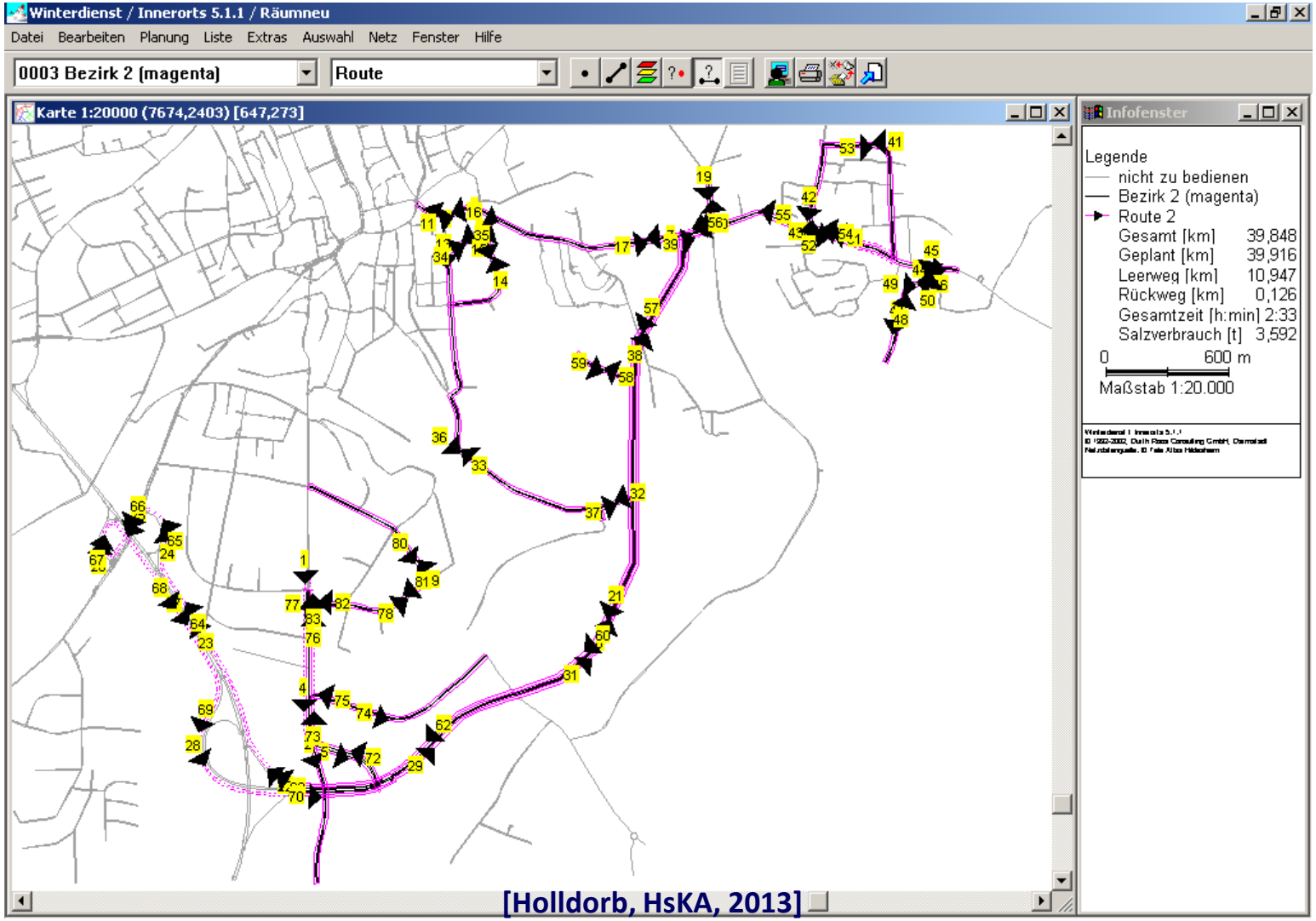
[Holldorb, HsKA, 2013]

Winter Maintenance: Routing Level 1 and 2



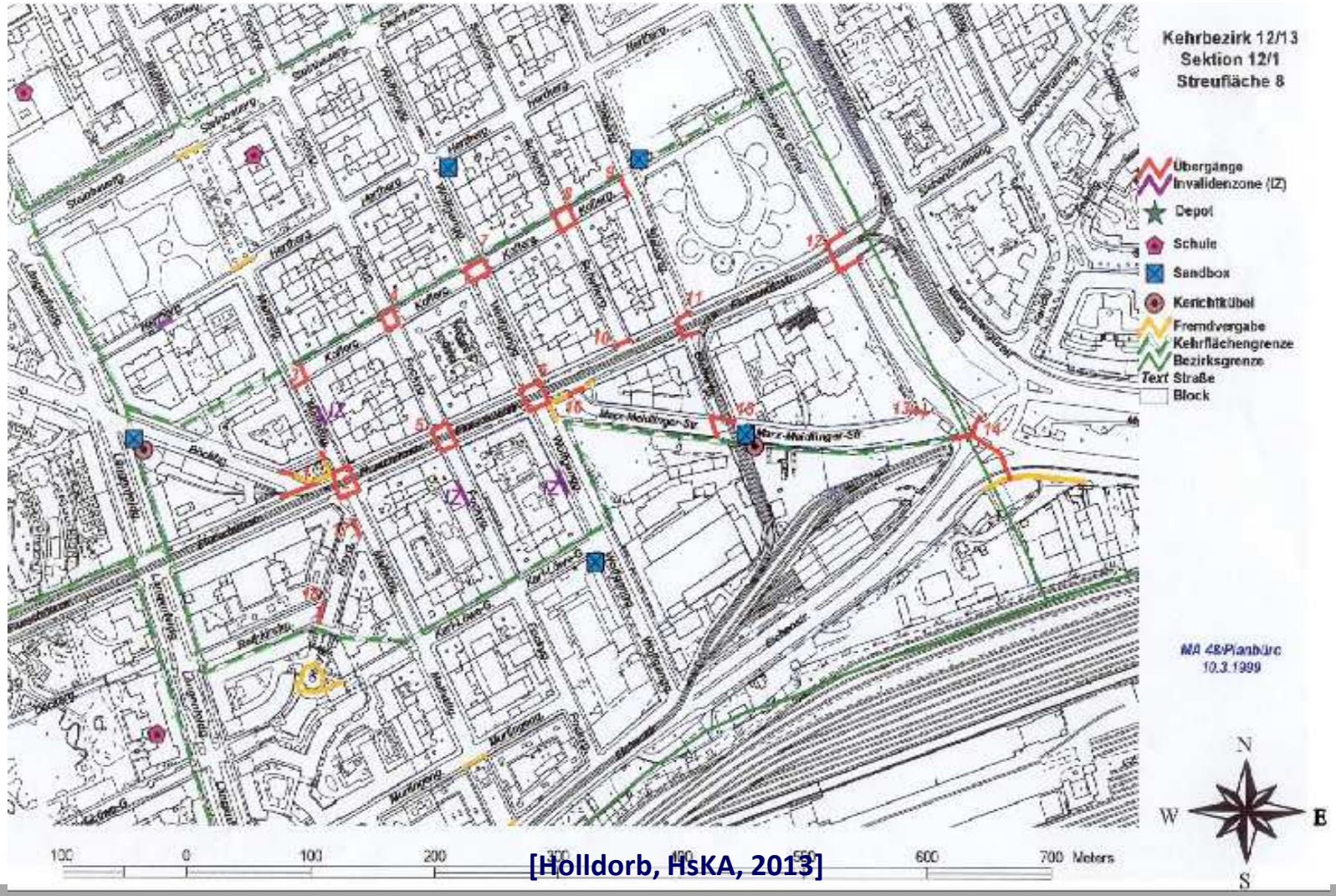
[Holldorb, HsKA, 2013]

Winter Maintenance: Routing plan



[Holldorb, HsKA, 2013]

Winter Maintenance: Operation plan for hot spots (Example Vienna)



[Holldorb, HsKA, 2013]

Conservation of Asset Value

German Interstate and Federal Roads (2010):

New Construction Network Value:	**230 Mrd. EUR**
Actual Network Value:	**170 Mrd. EUR**

[BASt, 2011]

Annual Investment Needs for M&R	**5,6 Mrd. EUR**

Without accumulated Investment Needs!

[Kruse, 2008]

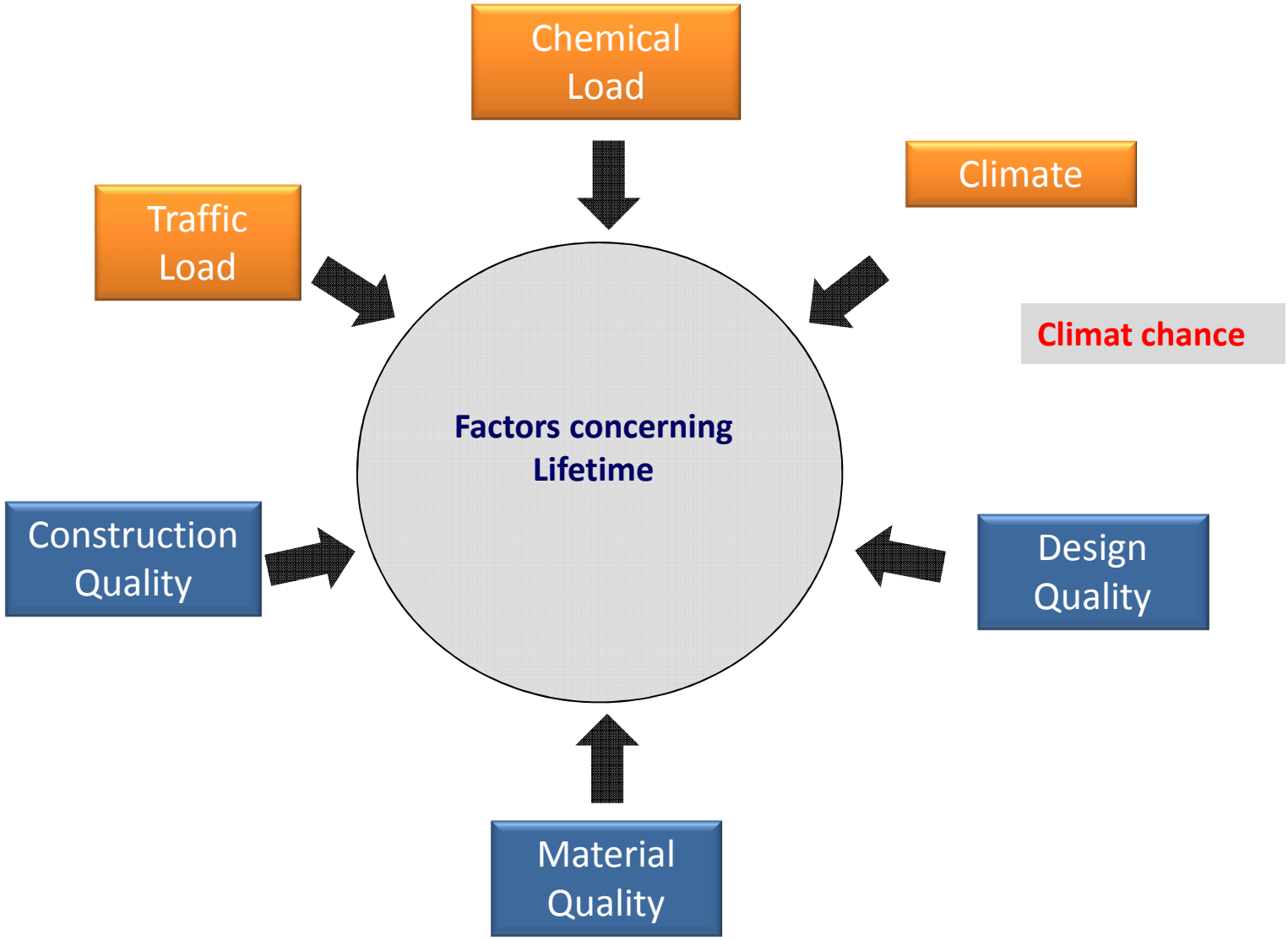
State Capital Munich (2012):

New Construction Network Value:	**3,4 Mrd. EUR**
Annual Investment Need for M&R:	**20 Mio. EUR**

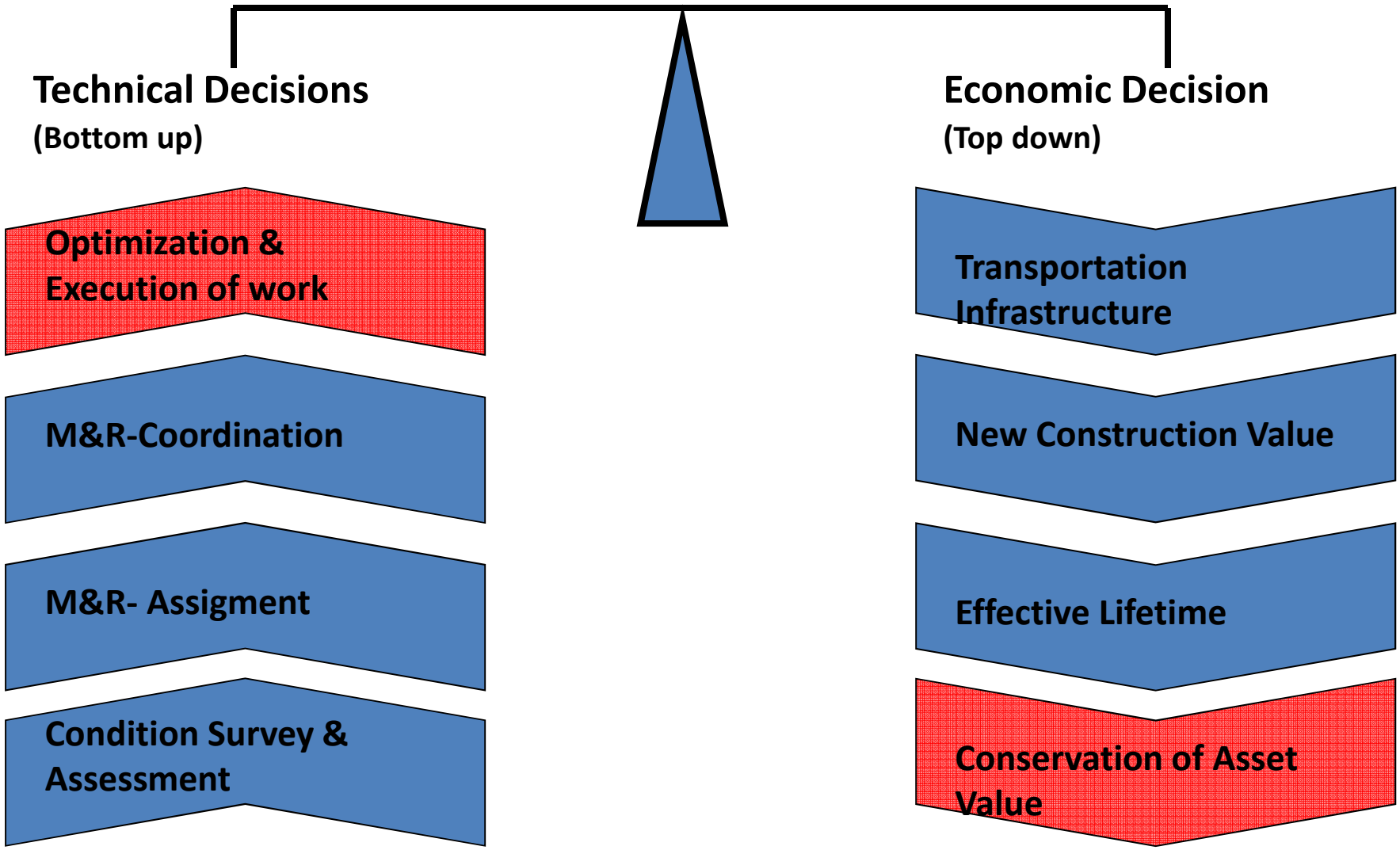
[own research project]

Conservation of Asset Value: Average Lifetime of pavements

Pavements:	
Concrete slabs:	30 years
Asphalt wearing course:	12 – 15 years
Asphalt binder course:	20 years
Unbound layers:	40 – 60 years
Bridges:	
Concrete structures	70 – 100 years
Corrosion prevention	20 – 30 years


Chemical Load
Climate
Traffic Load
Climat chance
Factors concerning Lifetime
Construction Quality
Design Quality
Material Quality

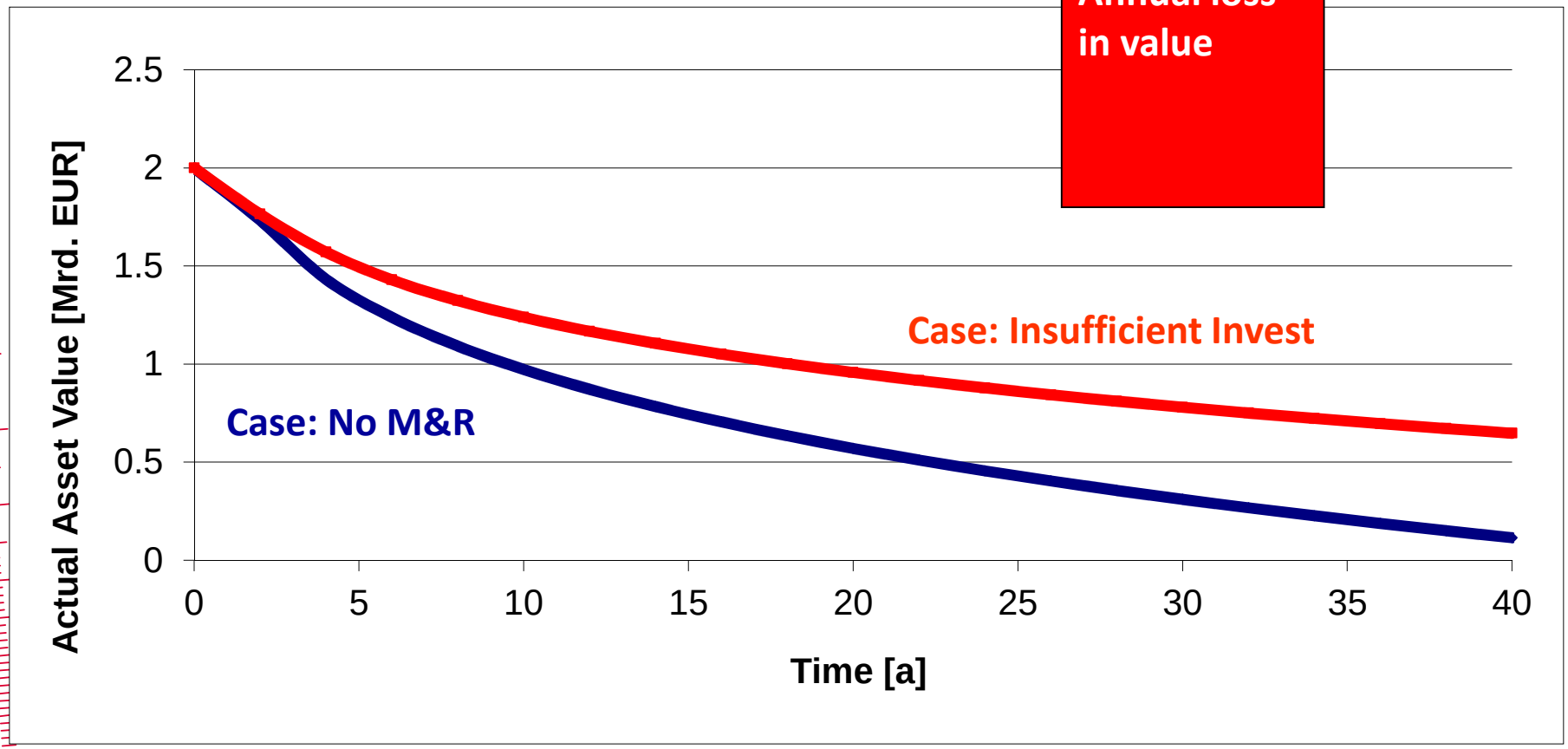
Conservation of Asset Value [SN 640 986 / Switzerland]



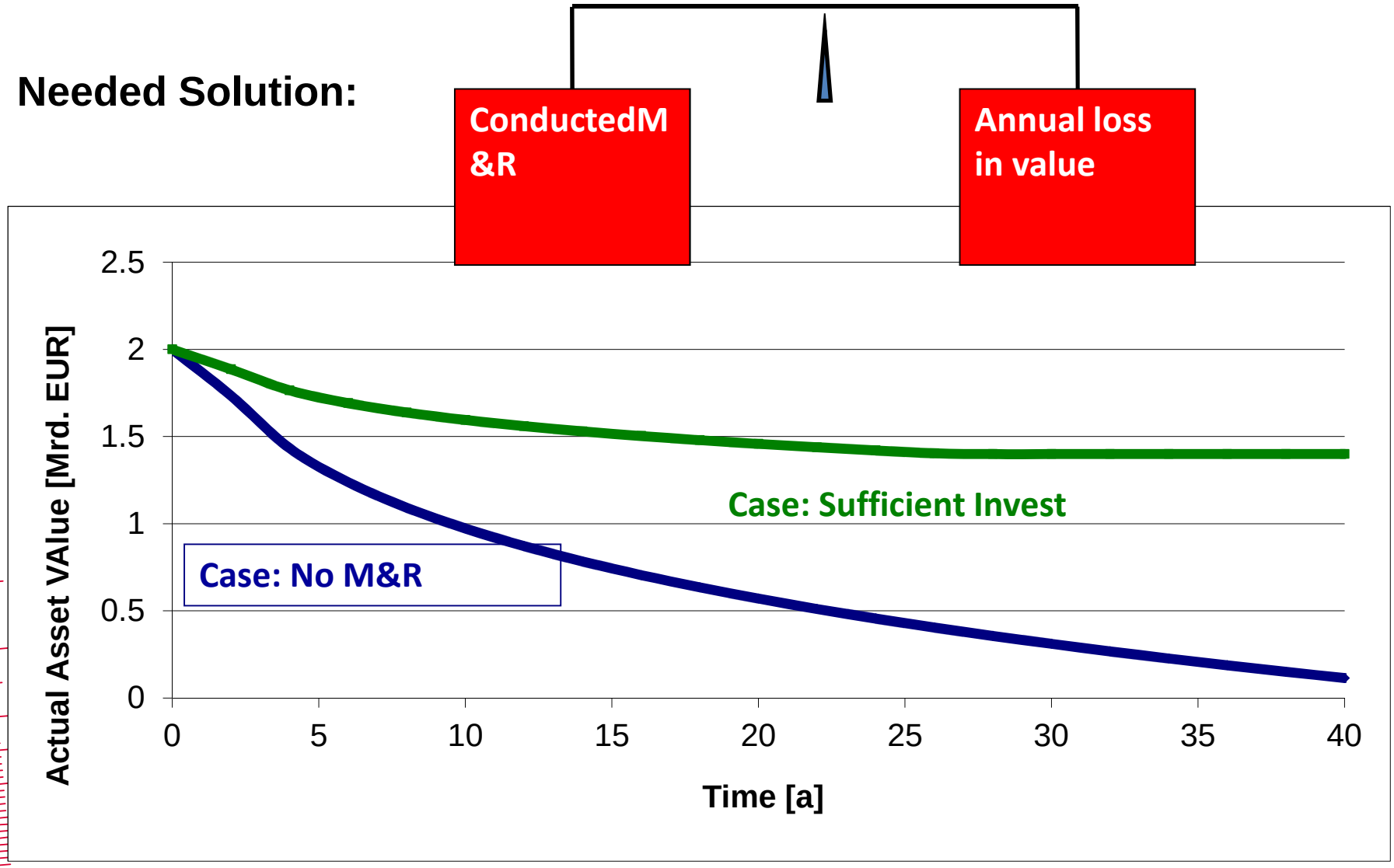
Actual Problem:

Conducted M&R

Annual loss in value



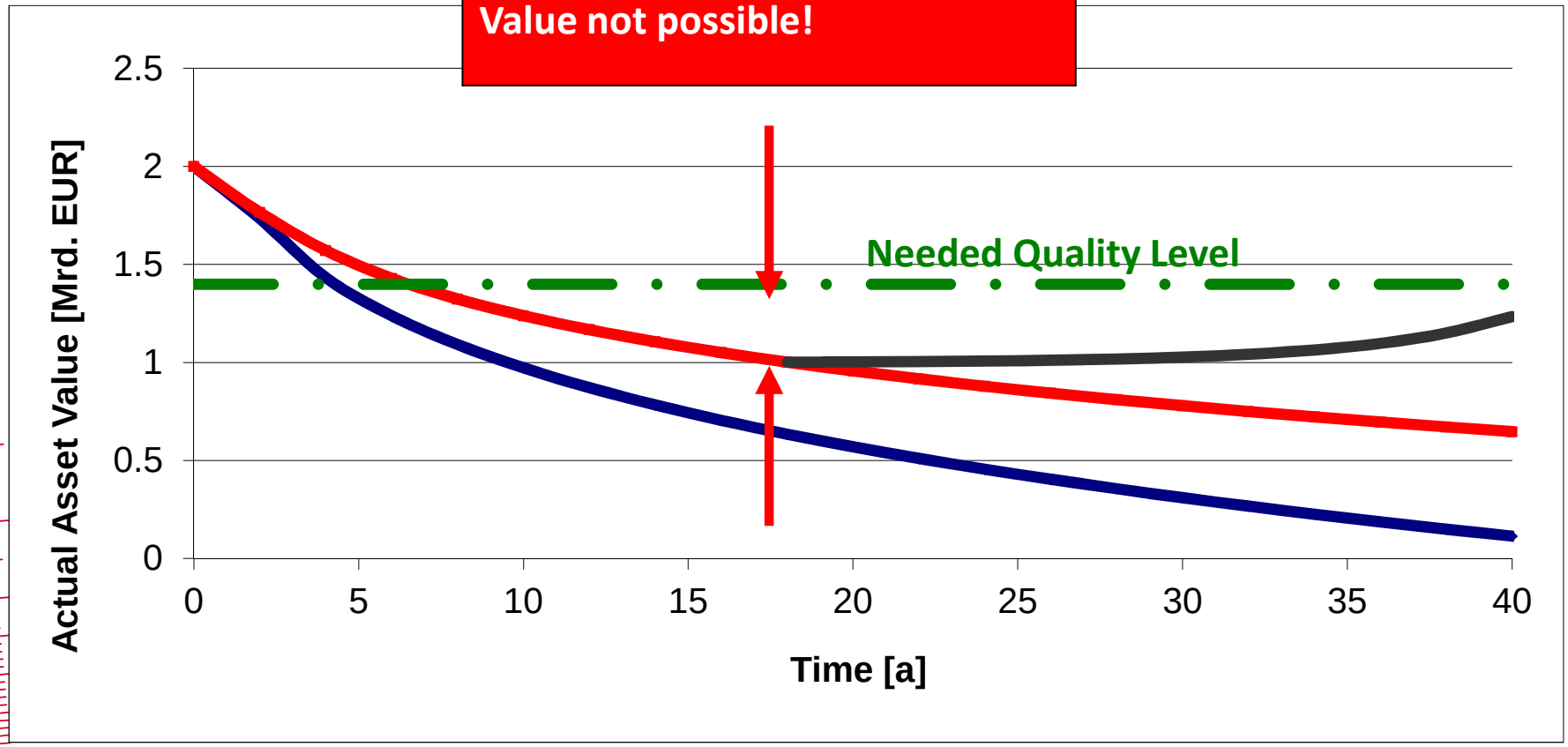
Needed Solution:



Consequence:

Point of no return!

Mid-Term Conservation of Asset Value not possible!



Key Questions for Life Cycle Management

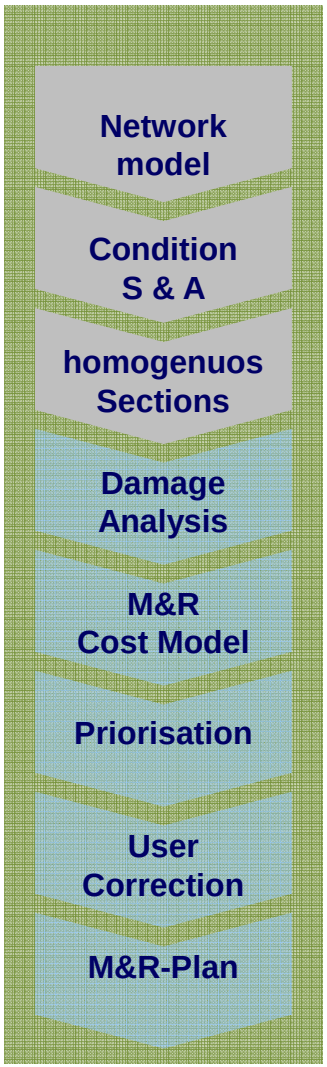
Operational Approach:

- Actual Network Condition?
- Actual Need for M&R and Costs?
- Reasonable Priority List?

Strategic Approach:

- Future Network Condition Development?
- Future Asset Value Development?
- Mid-Term optimal M&R-Strategy (Economic view)?
- Mid-Term optimal M&R-Programs (Technical View)?

Strategic Approach



Operational Approach

Pavement Condition Assessment: Condition Parameters

Flexible Pavements

Cracking (RIS)

Ravelling (SUB)

Patching(FLI)

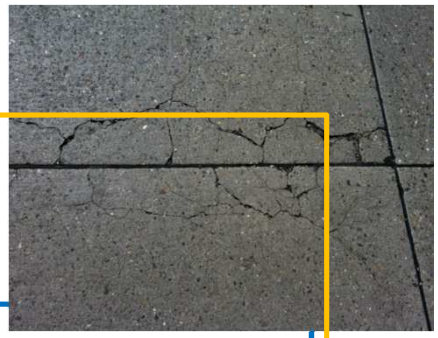
Disruption (AUS)

Depression/Setting (SEN)

Swelling (HEB)

Step Joint/Displacement (VER)

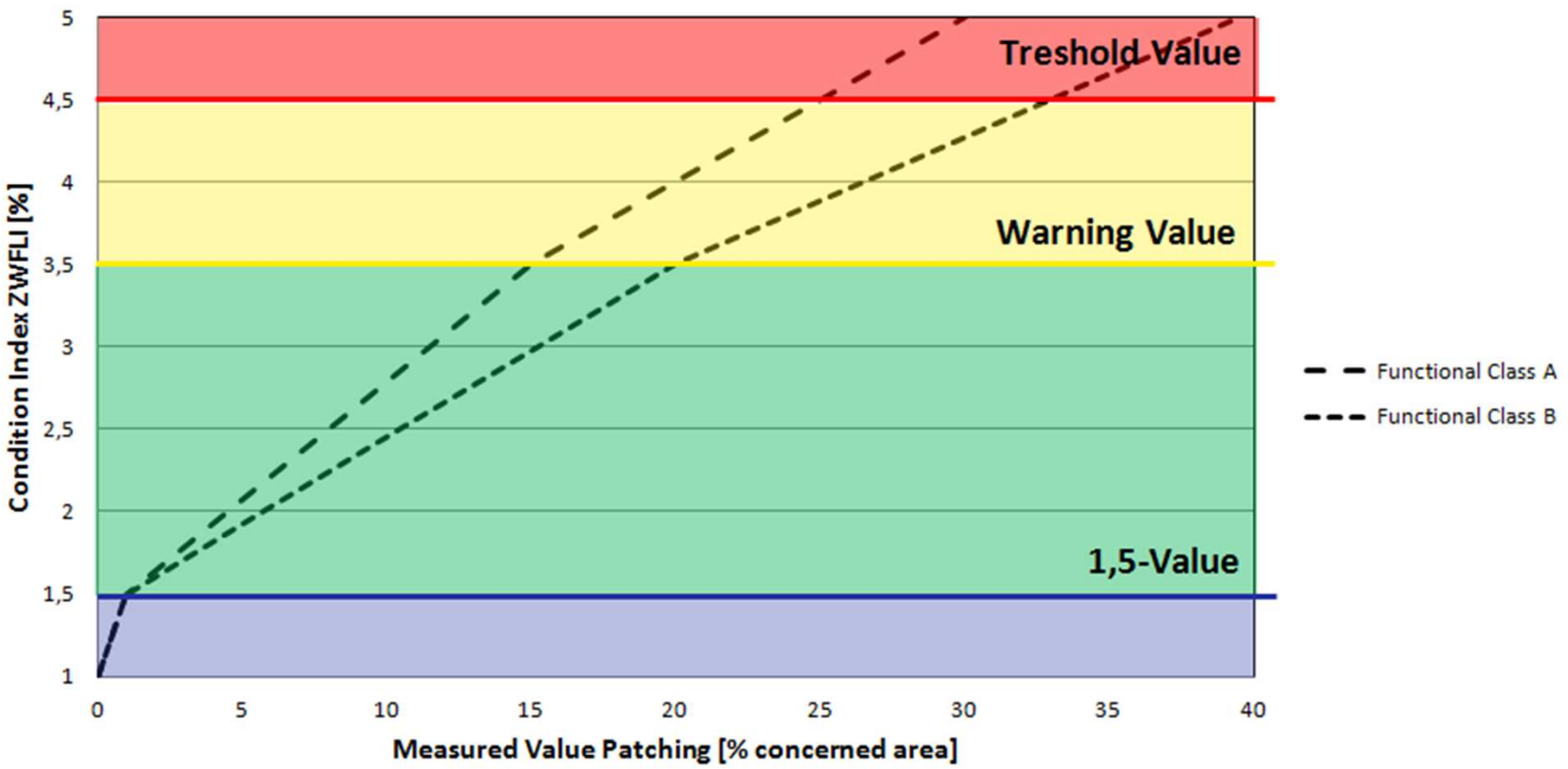
Rigid Pavements



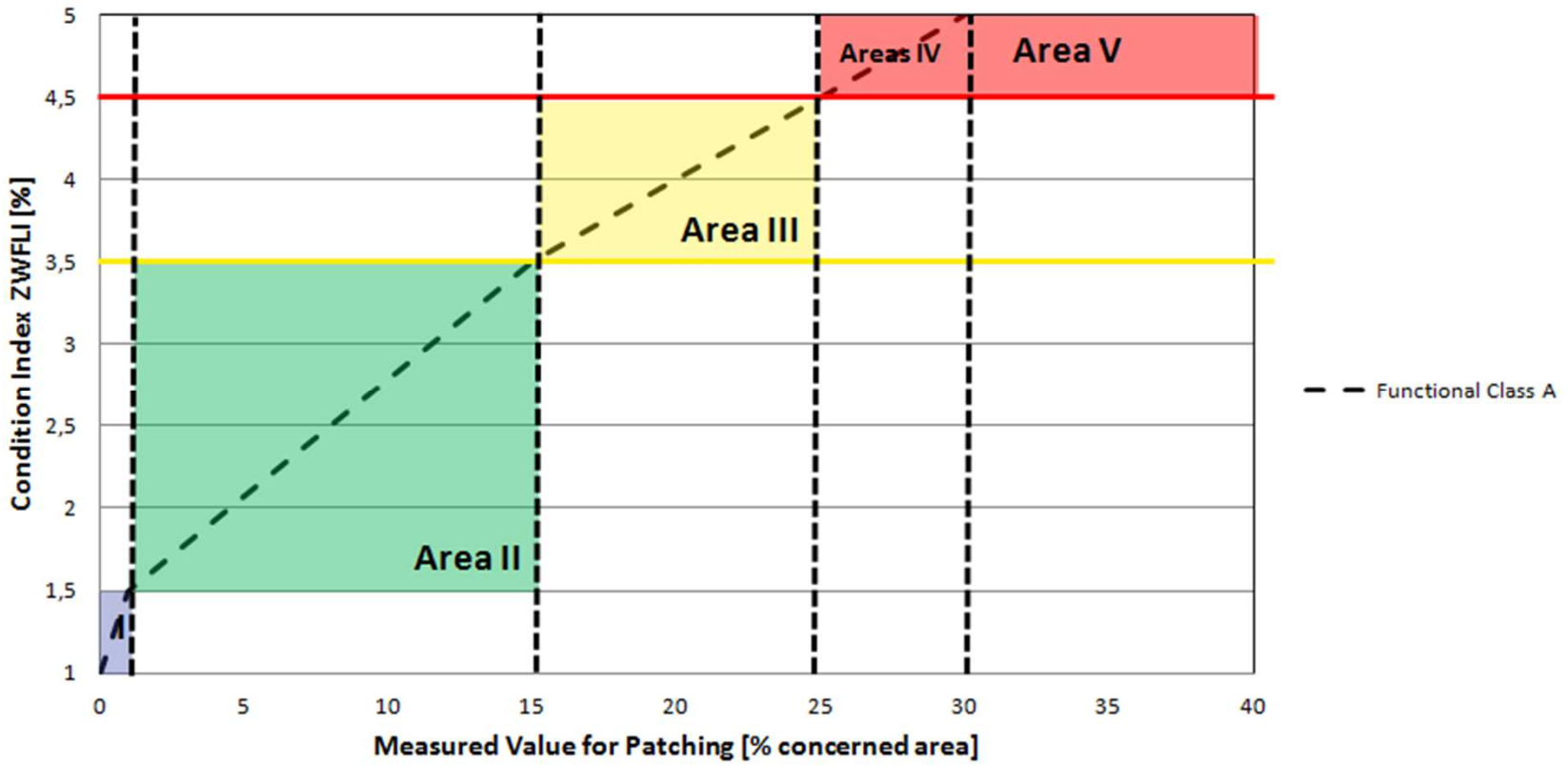
Unbound Pavements

Cobbled Pavements

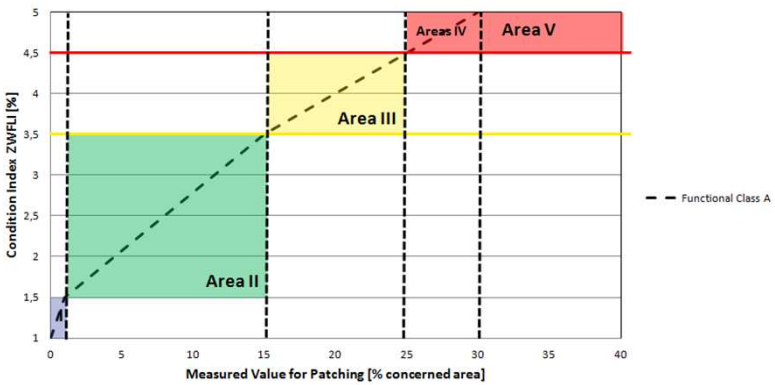
Pavement Condition Assessment: General German Model



Pavement Condition Assessment: Calculation Model



Pavement Condition Assessment: Calculation Model



E EMI 2012:
(German recommendations for urban roads)

Flickstellen

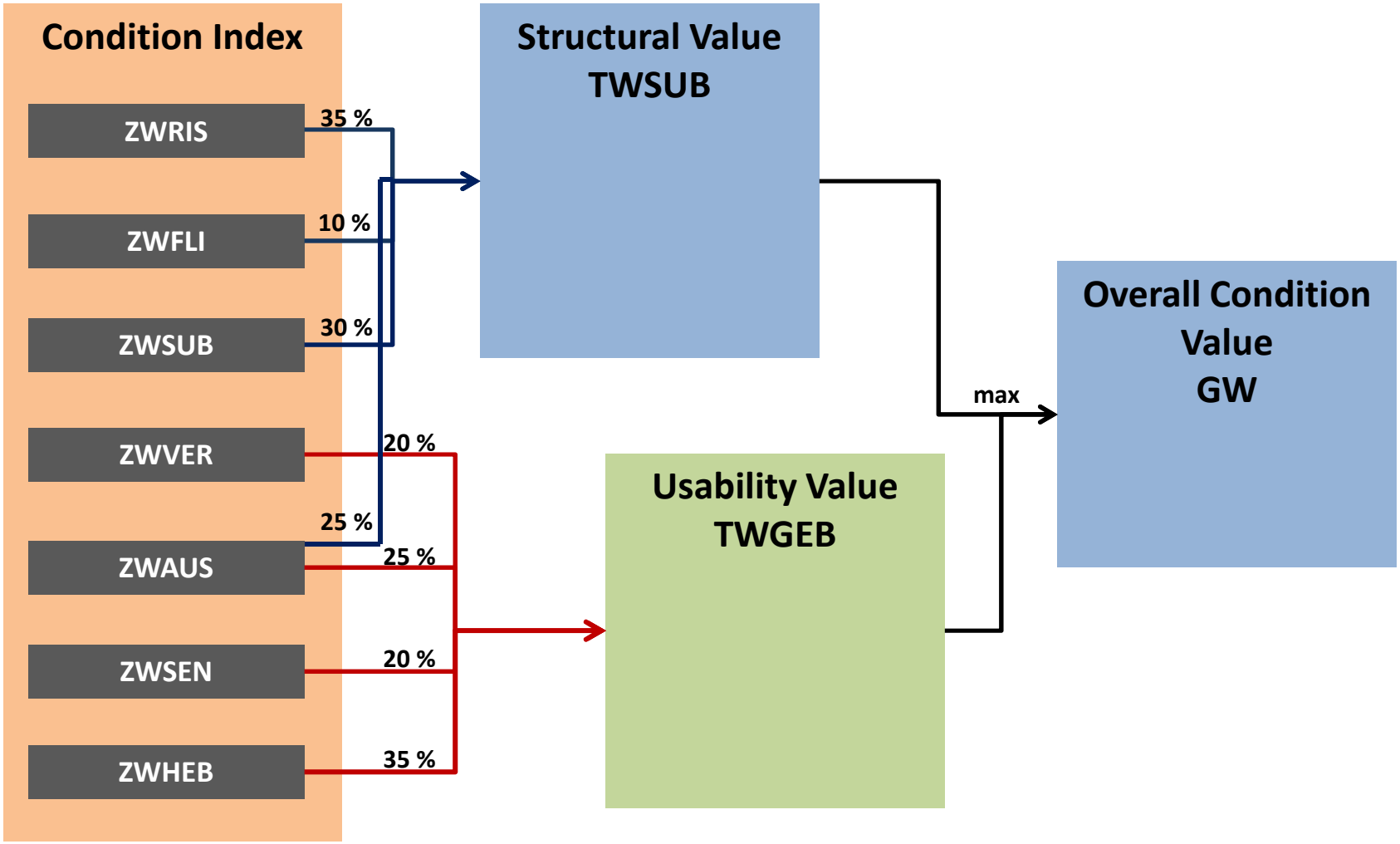
1,5-Wert (ZGI):	1,0 %
Warning Value (ZGII:	15,0 %
Treshold Value (ZGIII):	25,0 %
(ZG IV, 5,0-Wert):	*30,0 %*

Condition Assessment for single condition parameters:

Area I (ZG≤ZGI):	$1{,}0 + 0{,}5 \cdot \frac{(ZG)}{(ZGI)}$
Area II (ZGI<ZG≤ZGII):	$1{,}5 + 2{,}0 \cdot \frac{(ZG - ZGI)}{(ZGII - ZGI)}$
Area III: (ZGII<ZG≤ZGIII):	$3{,}5 + \frac{(ZG - ZGII)}{(ZGIII - ZGII)}$
Area IV: (ZGIII<ZG≤ZGIV):	$4{,}5 + 0{,}5 \cdot \frac{(ZG - ZGIII)}{(ZG\,IV - ZGIII)}$
Area V: (ZG>ZGIV):	5,00

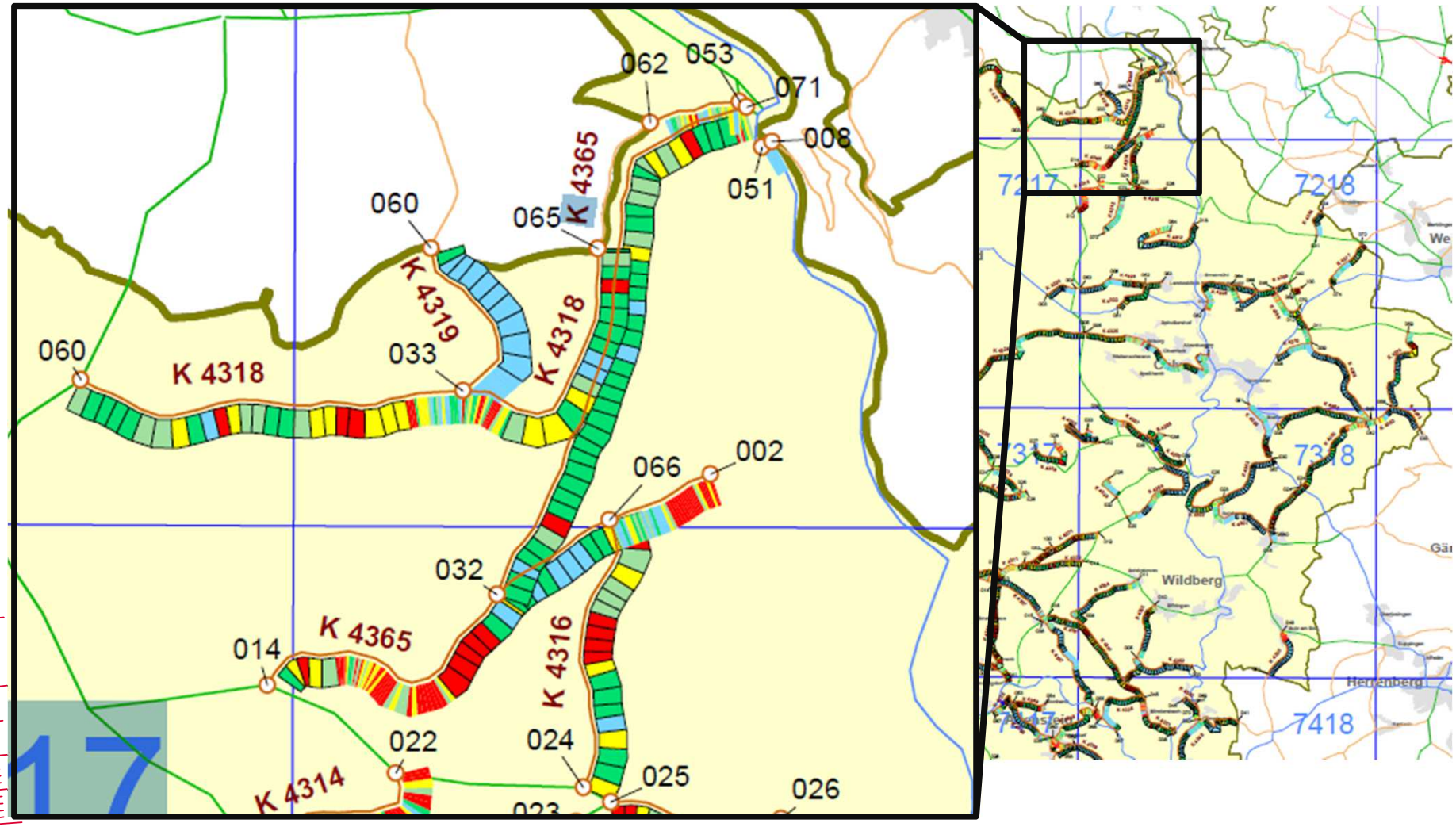
Pavement Condition Assessment: Calculation Model for TWSUB, TWGEB, GW

(Proposal for an actual research project)



Pavement Condition Assessment: Project documentation

(Condition assessment maps; Result from an actual research project)



Pavement Condition Assessment: Project documentation

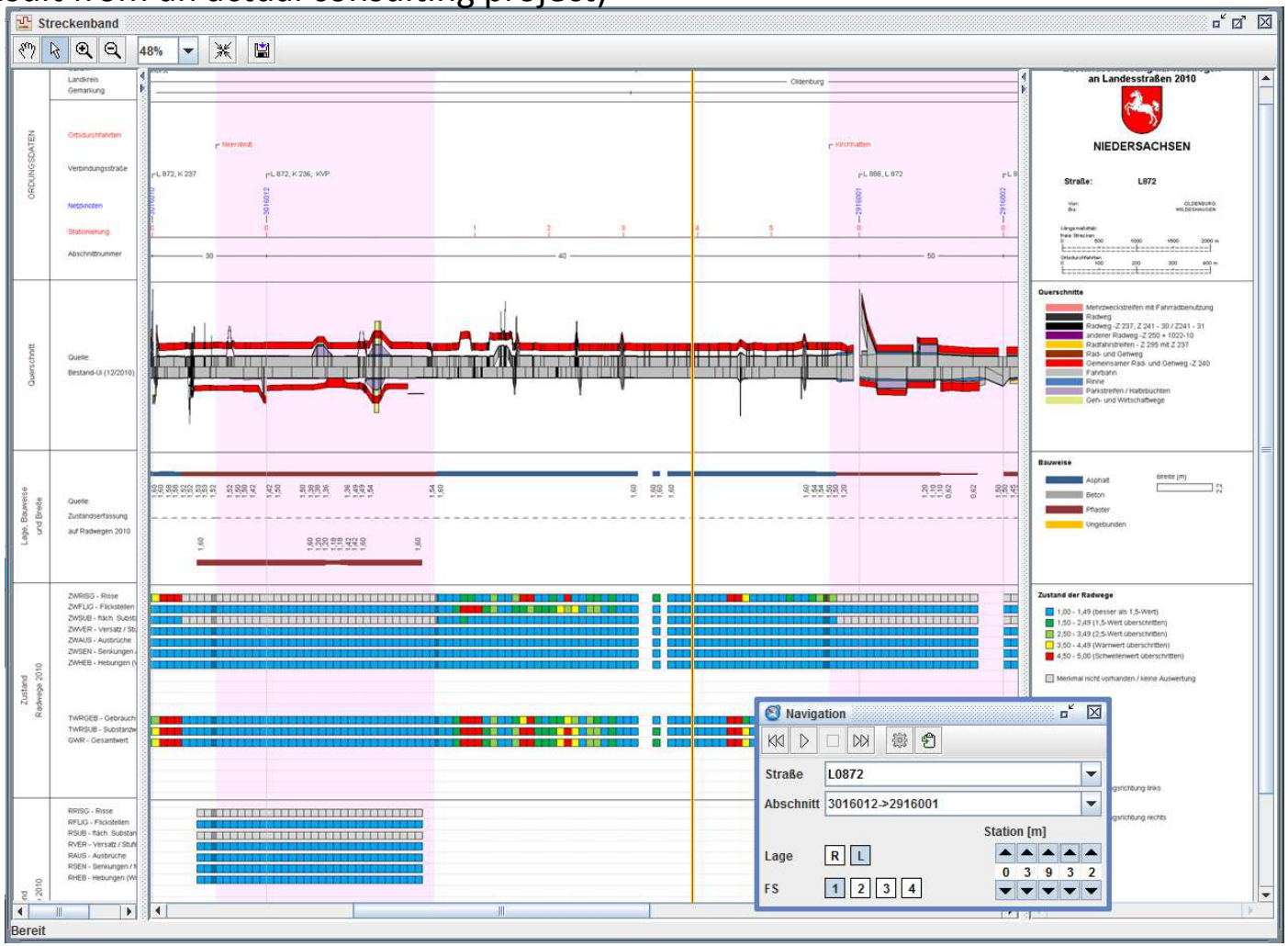
(Section data sheet; Result from an actual consulting project)

Network data

Cross Section

Pavement Type

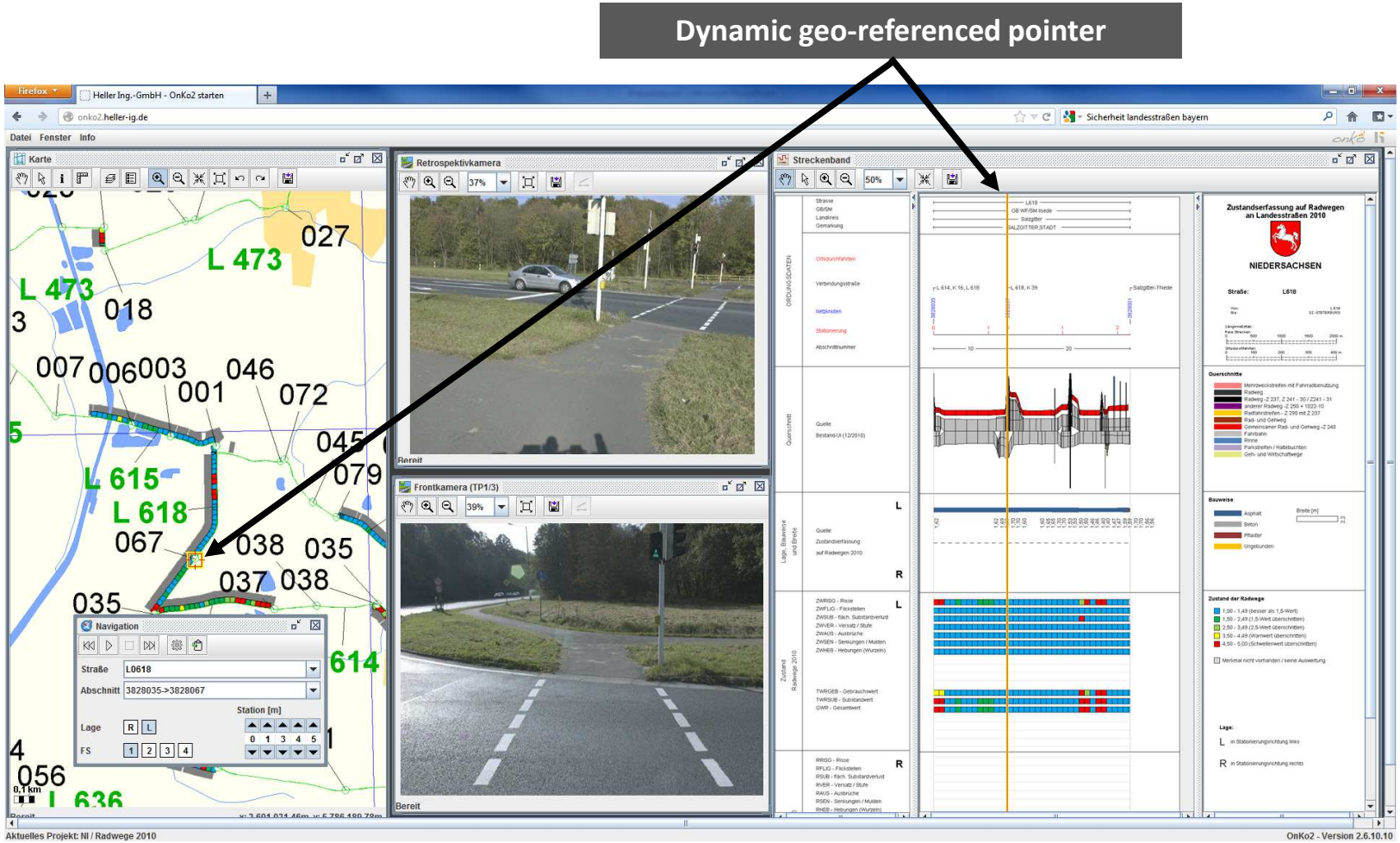
Condition Data



[Heller Ingenieurgesellschaft mbH, 2013; www.heller-ig.de]

Pavement Condition Assessment: Project documentation

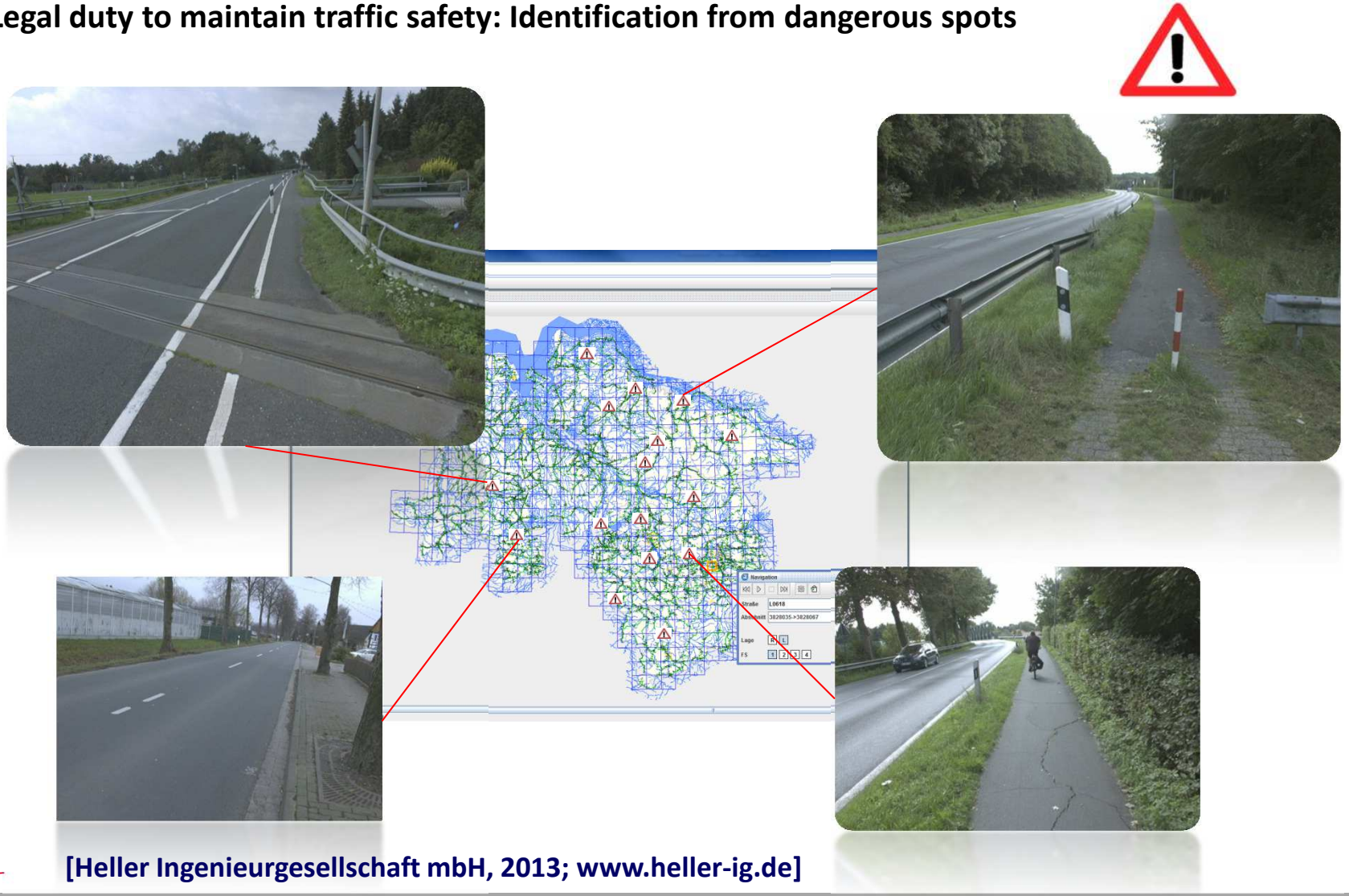
(Online Data Information System OnKo2; used by German federal government)



[Heller Ingenieurgesellschaft mbH, 2013; www.heller-ig.de]

Pavement Condition Assessment: Side effect

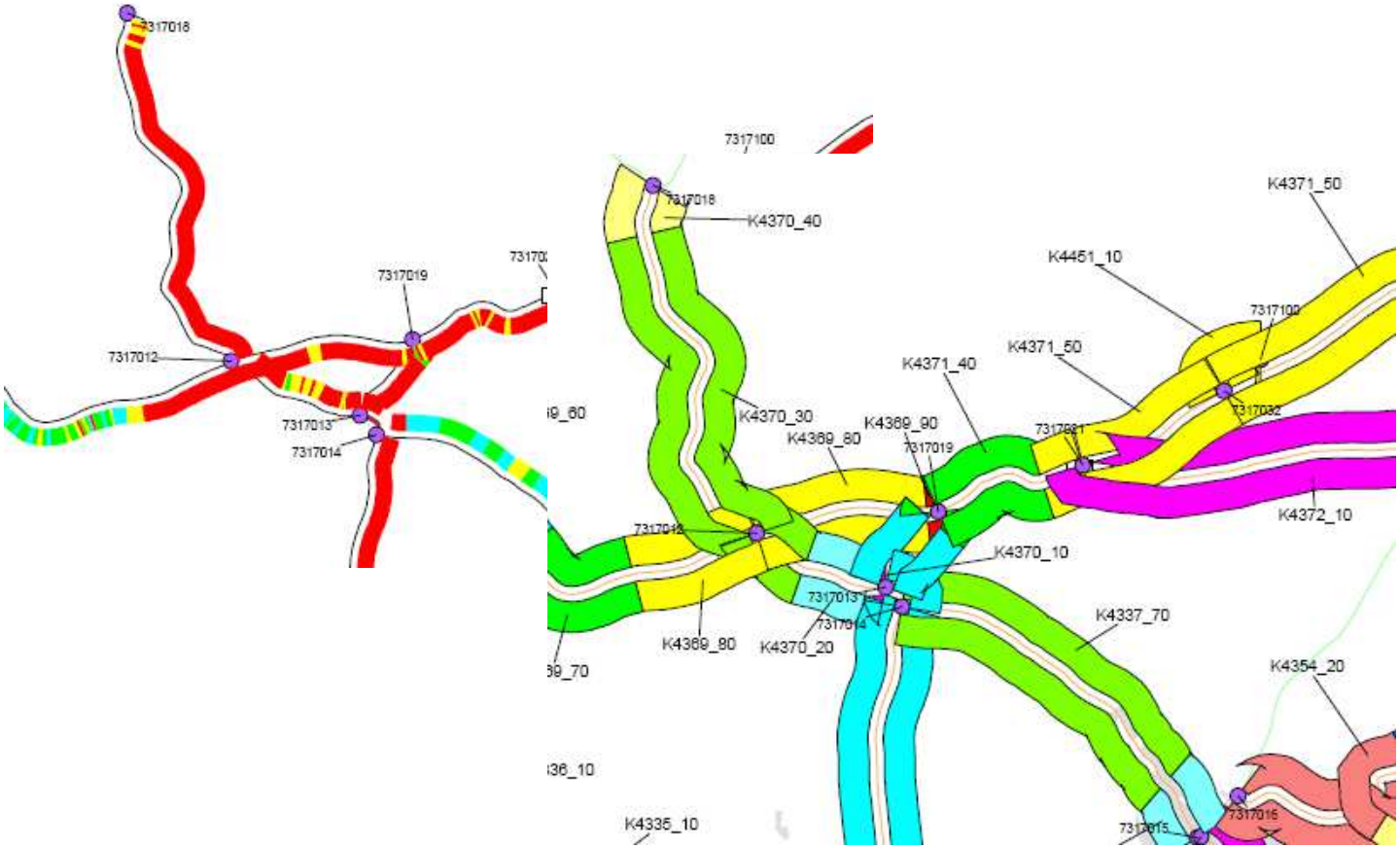
Legal duty to maintain traffic safety: Identification from dangerous spots



[Heller Ingenieurgesellschaft mbH, 2013; www.heller-ig.de]

Ermitteln erhaltungsbedürftiger Abschnitte

- **Homogenous Sections**
- Maßnahmenu nd Kosten
- Dringlichkeits-reihung
- Nachbear-beitung
- Bauprogramm



Erhaltungs-abschnitte

Maßnahmenu nd Kosten

Priorisation

Nachbear-beitung

Bauprogramm

Determination of the priority class and M&R-Sections

Structural Value (SUB_x)

Usability Value(GEB_x)	(1,0 – 3,5)	(3,5 – 4,5)	(4,5 – 5,0)
(1,0 – 3,5)	9	7	4
(3,5 - 4,5)	8	6	2
(4,5 – 5,0)	5	3	1

Priorisation of M&R-Sections

(Result from an actual research project)

Ranking within an priority class

$$AK_{Dringl} = F_x \cdot \mu(SUB_x) + F_y \cdot \mu(GEB_x)$$

F_x, F_y: Decision making parameters; traffic load, priority class ……

μ: Weighting factors, actually 0,39 for GEB; 0,61

Ermitteln der Maßnahmen und benötigten Haushaltsmittel

Erhaltungs-abschnitte

Maßnahmenu nd Kosten

Priorisation

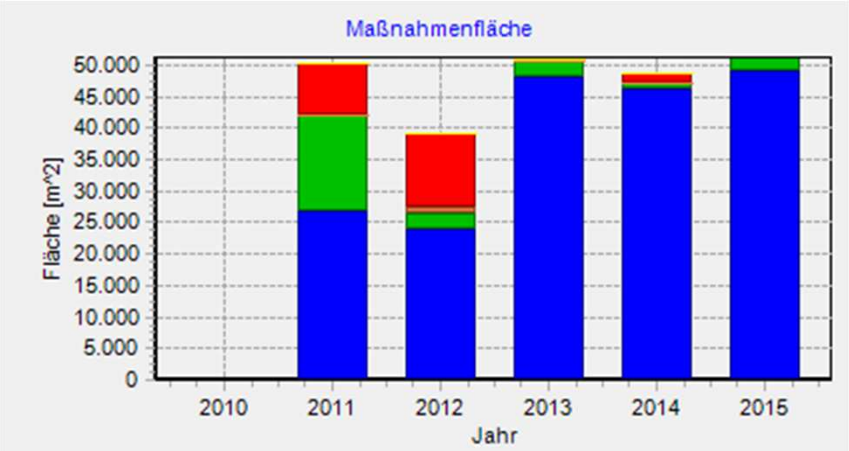
User Correction

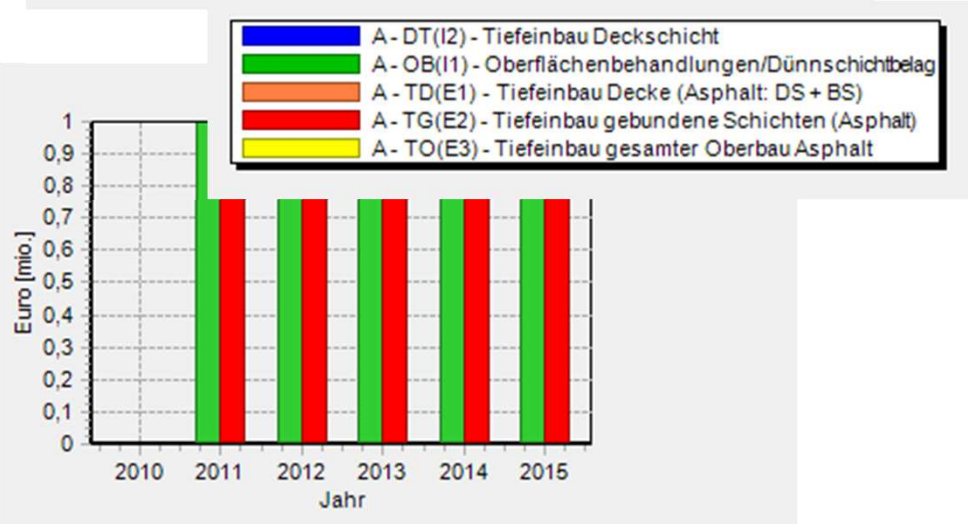
M&R Plan

Damage Classification

Assigement of M&R-Type

Cost Calculation





Aufstellen transparenter und belegbarer Prioritätenlisten

Erhaltungs-abschnitte

Maßnahmenu nd Kosten

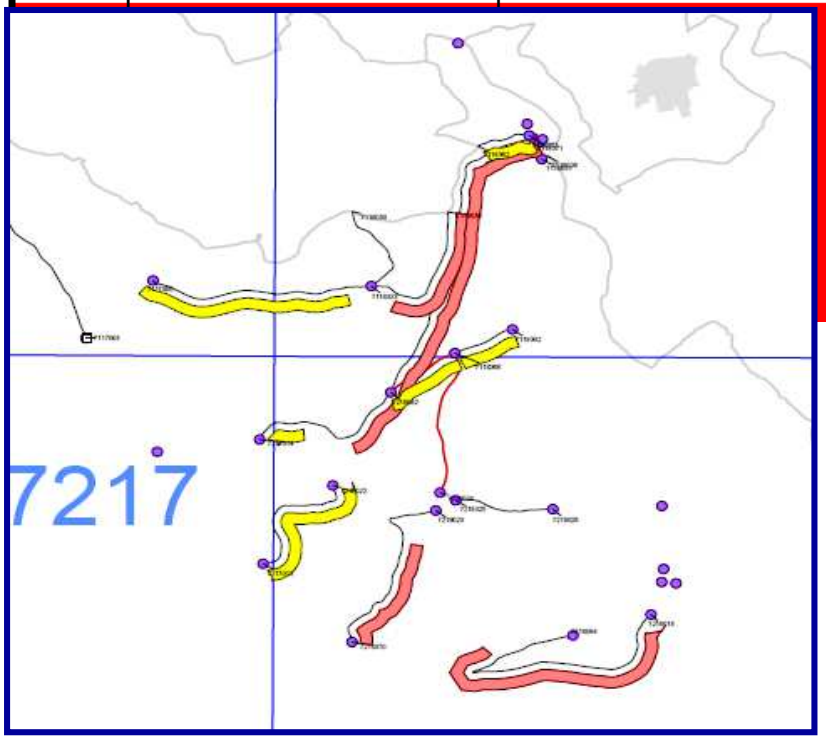
Priorisation

User Correction

M&R Plan

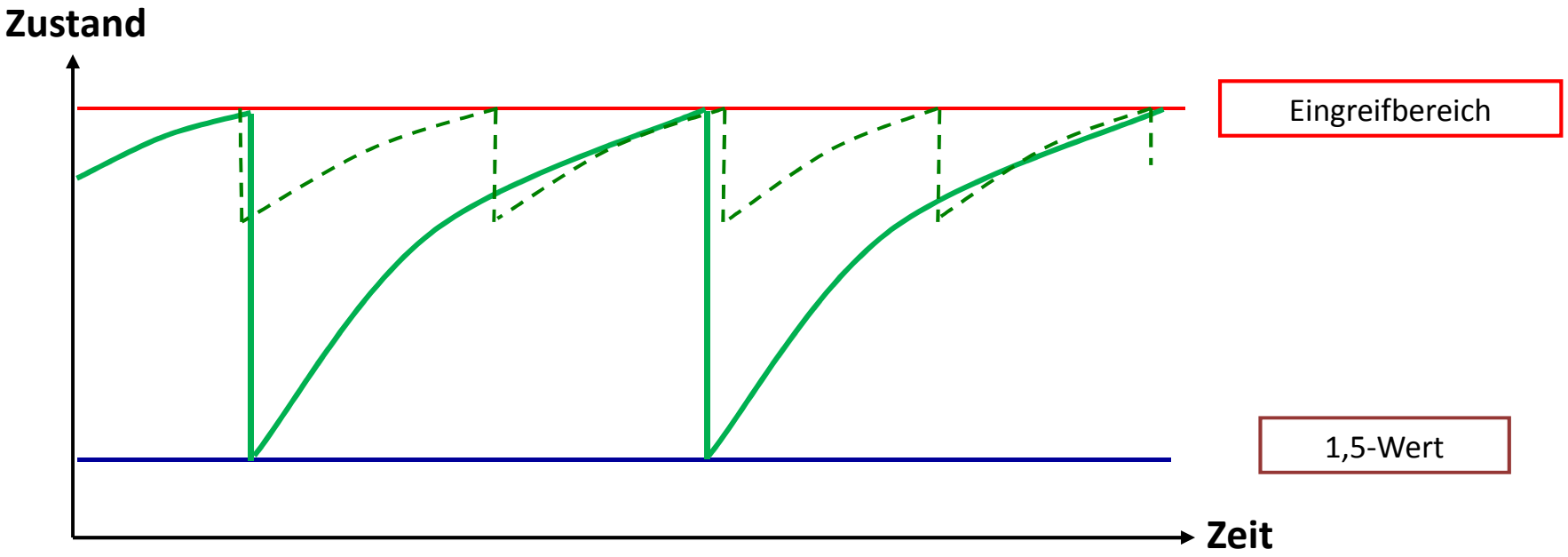
Erhaltungsprogramm 2010 bis 2014

Straße	Örtlichkeit		Abschnitts-länge	Breite	Fläche
	von	bis			
			2.660	5,0	13.300
			2.020	4,6	9.292
			880	4,7	4.136
			6.078	6,0	36.468
			500	5,9	2.950
			1.155	5,3	6.122
			1.428	5,0	7.140
			800	6,0	4.800
			500	7,0	3.500



Strategic Optimization

What will be the best strategic M&R Plan?



Strategic Approach / Basic Requirements for Modelling

- Pavement Condition Assessment
- Section Identification
- Prediction Models
- M&R Work , section assignment options
- M&R Work , effects for different options
- Network optimization management targets
- M&R Work, find strategic decision

Data Base

- Network identification data
- Pavement condition survey and assessment
- Structural pavement Data
- Homogenous Section Identification

Model Assumptions

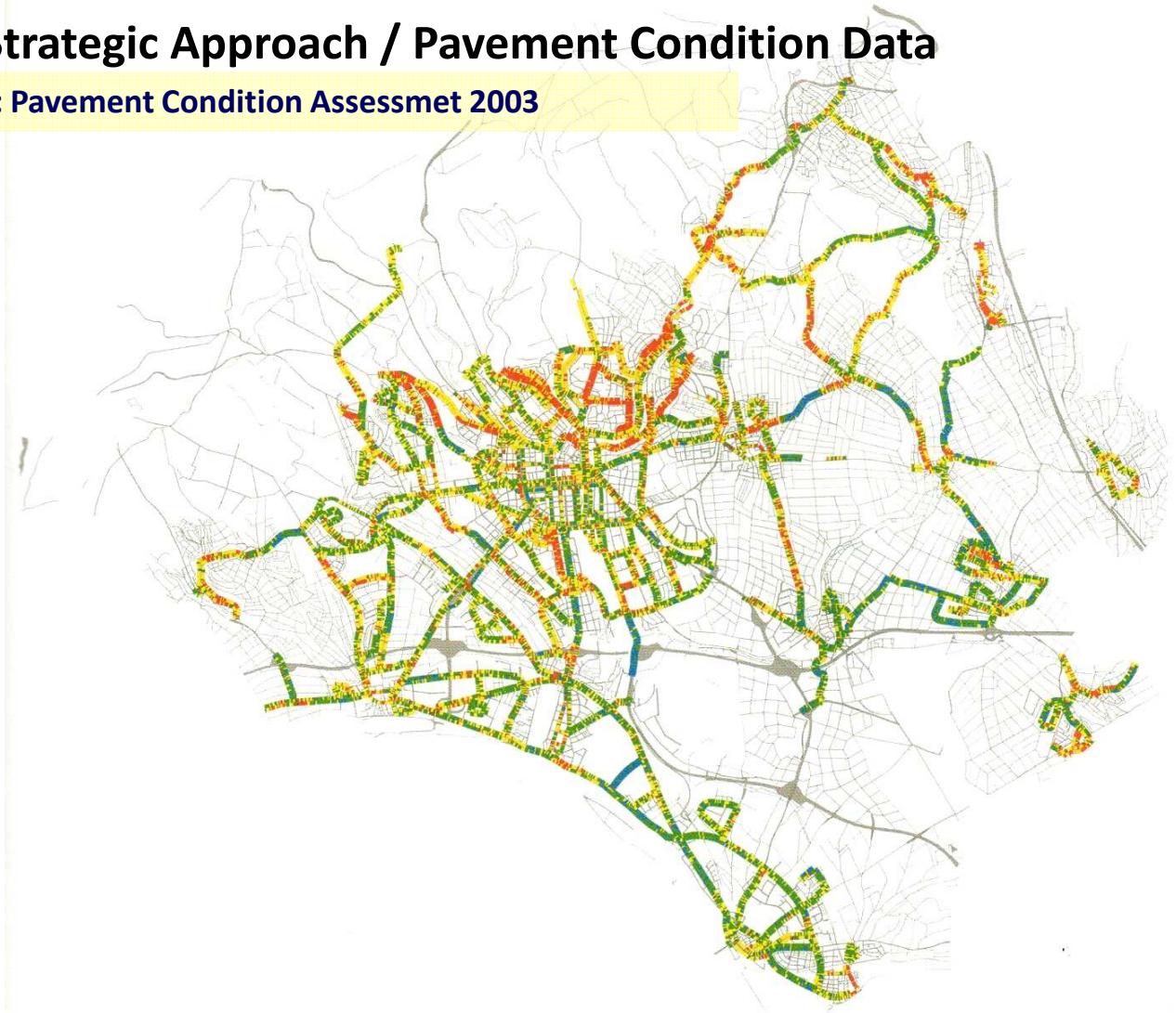
- Pavement Prediction Models
- Allocation of M&R Work Options
- Prediction of long term behavior for different M&R Work Options
- Economic Model
- Definition of different Optimizition Targets

Target

- Comparision of different management strategies and decision making

Actual Strategic Approach / Pavement Condition Data

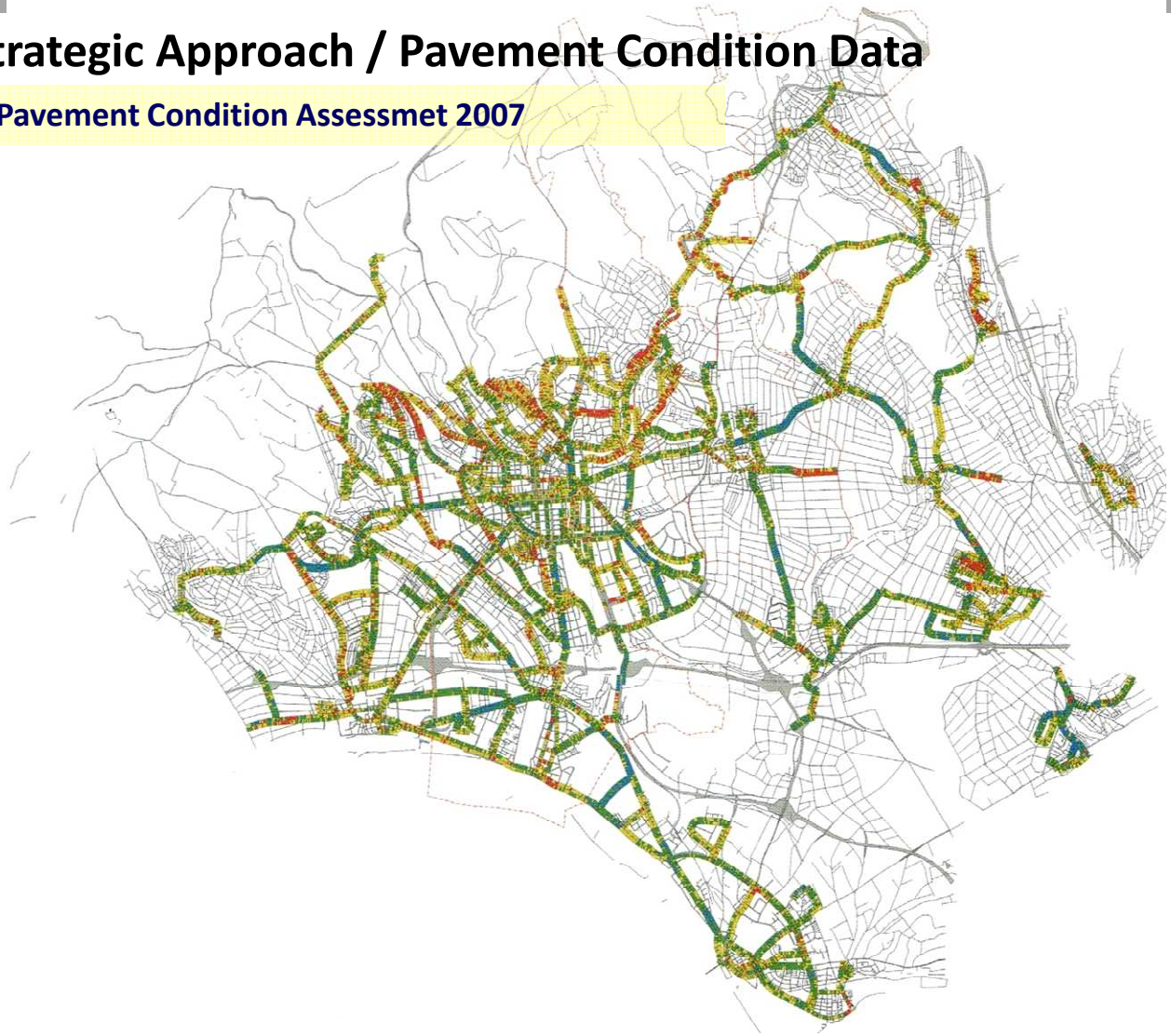
Example: Pavement Condition Assessmet 2003



[State Capital Wiesbaden]

Actual Strategic Approach / Pavement Condition Data

Example: Pavement Condition Assessmet 2007



[State Capital Wiesbaden]

Actual Strategic Approach / Model Assumptions

Model-Setup:

Task:
Development of a Mathematical Modell for Infrastructure Management

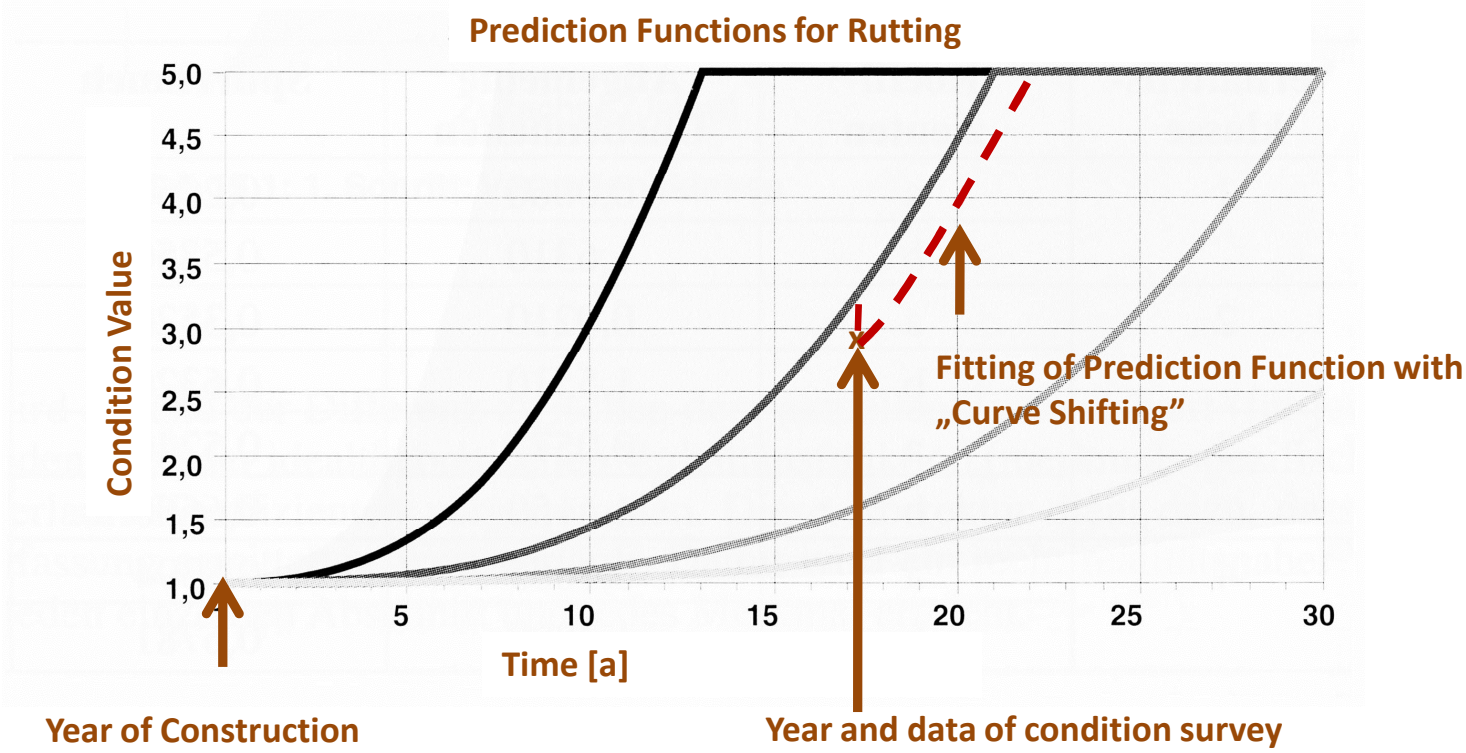
M&R Work Type assignment:
Modelling of structure-specific cause of damage and allocate of related M&R-Types,
Assessement of their effectivness and future behavior

Lifetime Predicition Modelling:
Structure Condition Prediction Models

Cost/Benefit-Assessement:
Defintion of Cost Factors, Definition of Benefit, ecnomic or quality aims

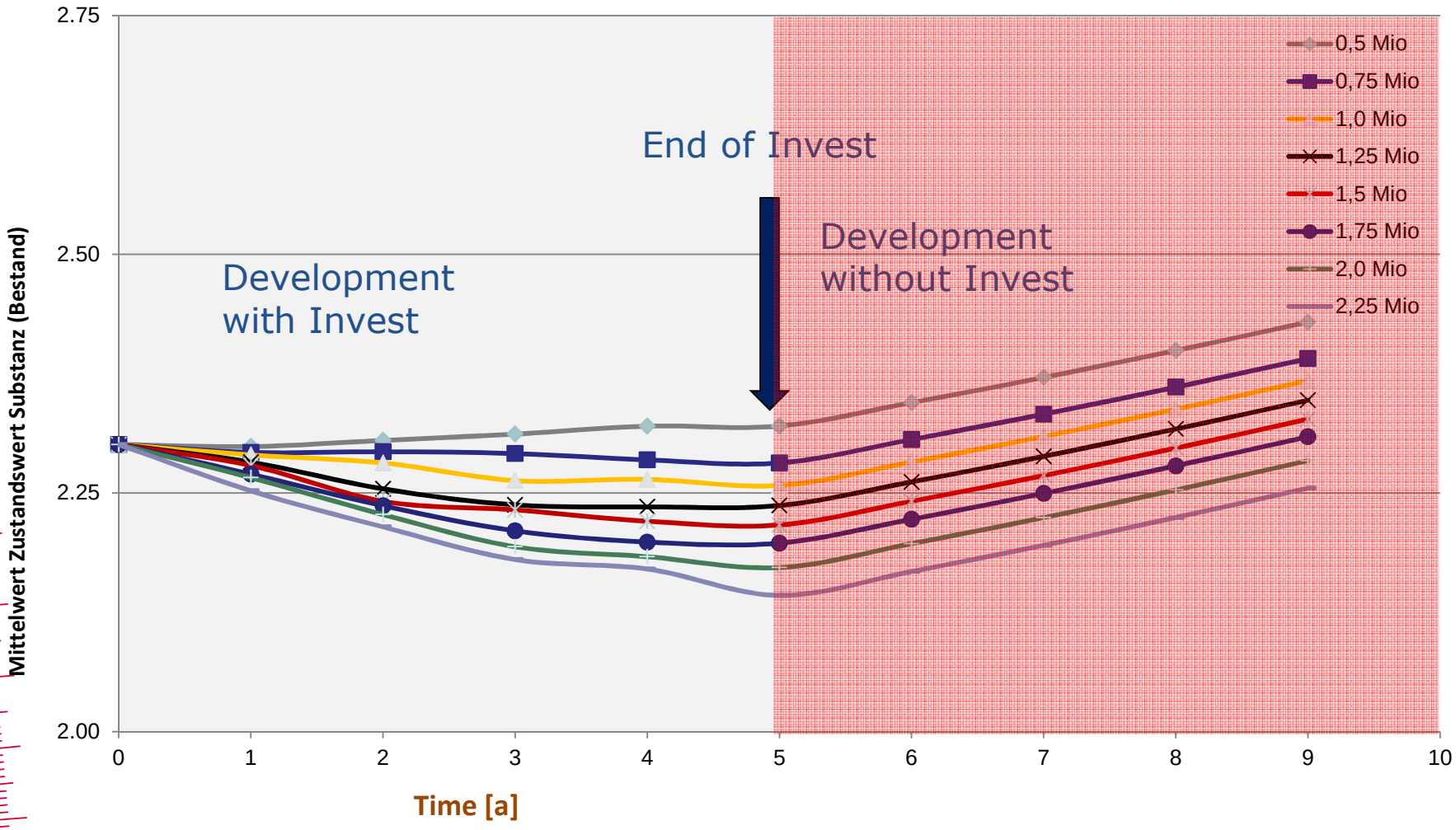
Strategic Approach / Future Demands

Actual Prediction Model:



[RPE Stra 2001; Volume 1001, Forschung Straßenbau und Straßenverkehrstechnik, 2008]

Expected Result: Impact of different level sof invest

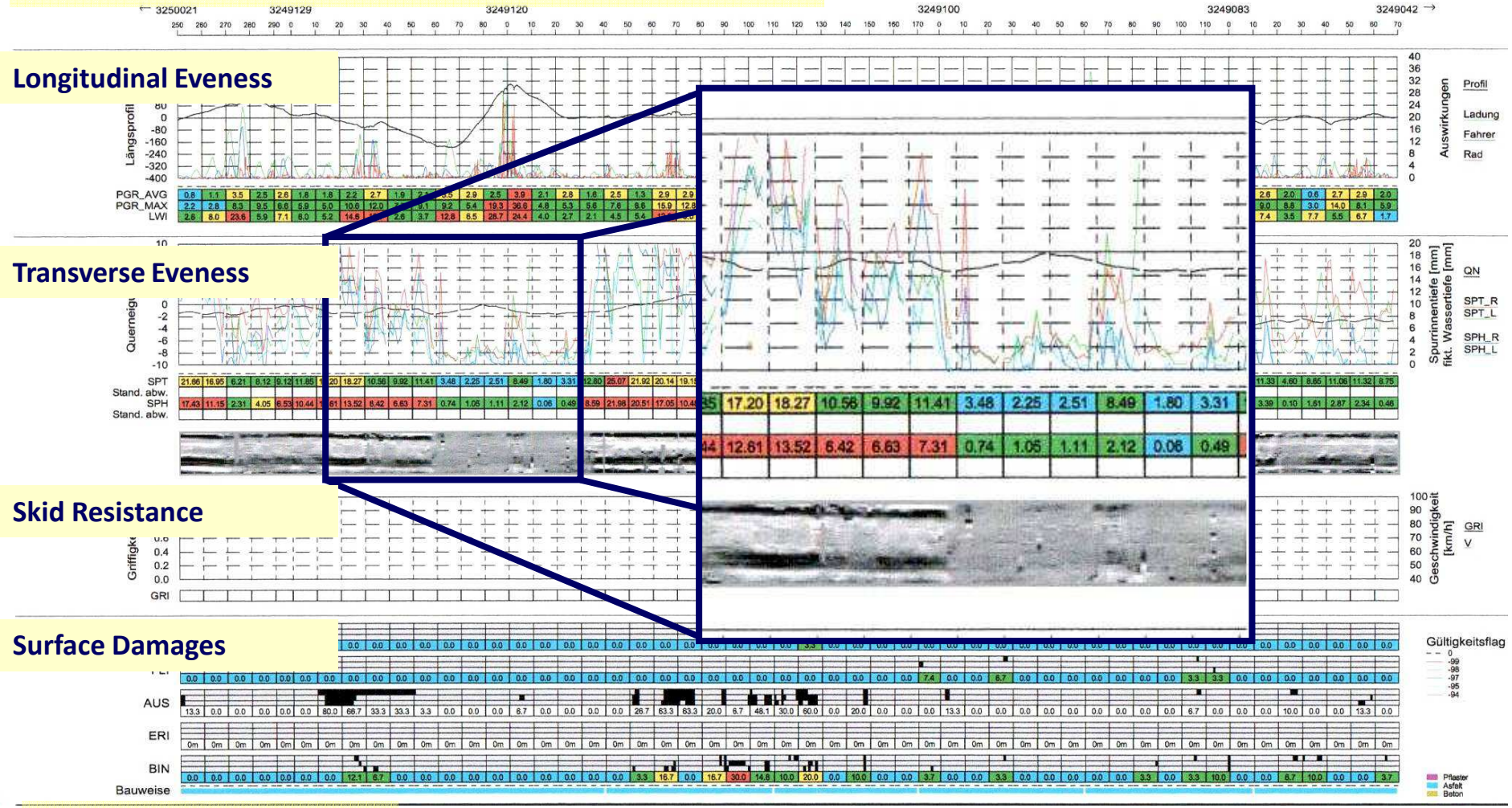


Strategic Approach / Basic Requirements for Modelling

- Pavement Condition Assessment
  - Which Characteristics / Datas should be considered?
- Section Identification
- Prediction Modells
  - Which Characteristics can be predicted?
- M&R Work , section assignment options
  - Which M&R Work Type can be used?
- M&R Work , effects for different options
  - What are the long term effects of defined M&R Work Types?
- Network optimization management targets
- M&R Work, find strategic decision

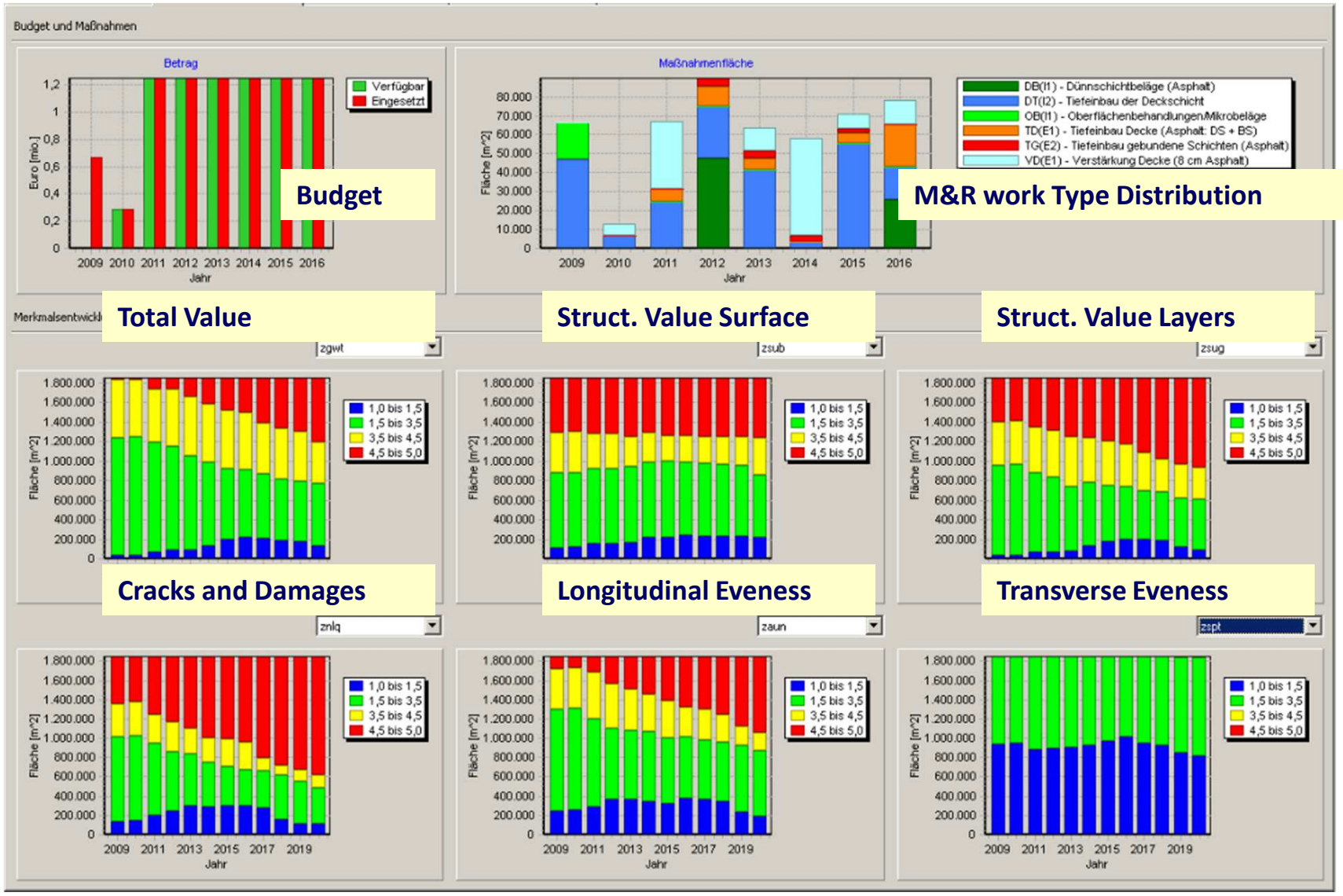
Actual Strategic Approach / Pavement Condition Data

Data Processing: Rough Data Profiles

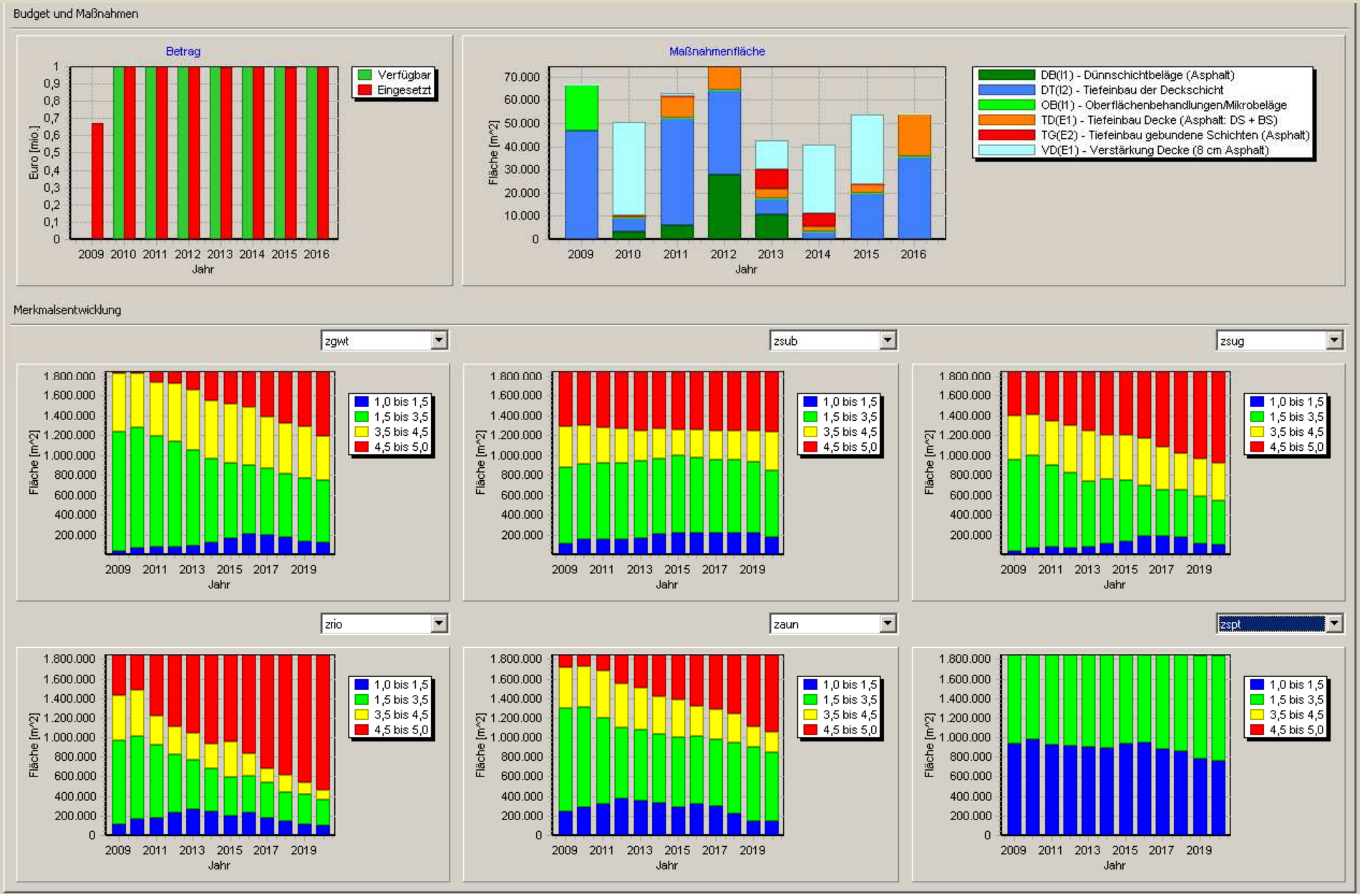


[HELLER IG, Darmstadt]

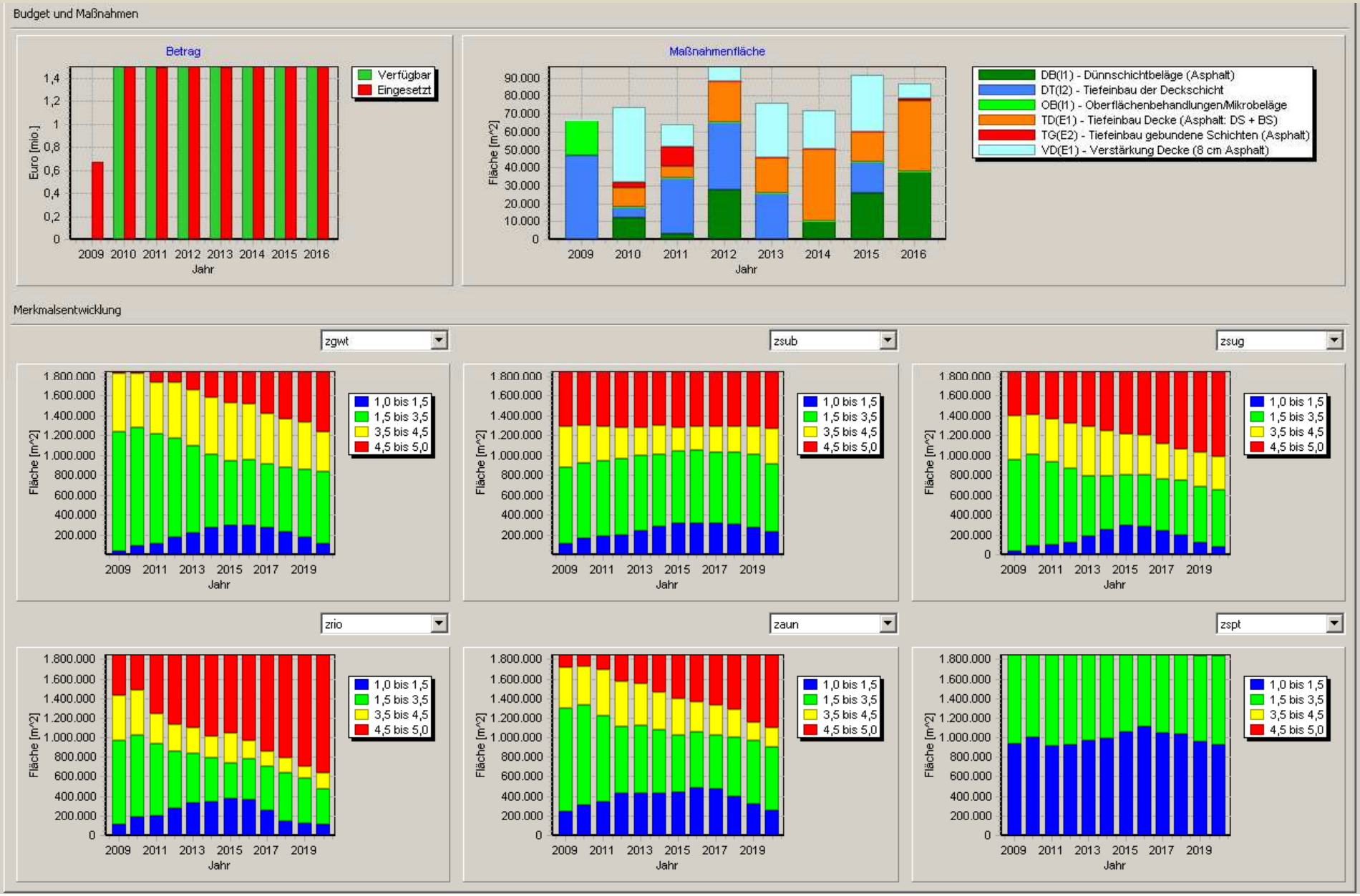
Actual Strategic Approach / Results



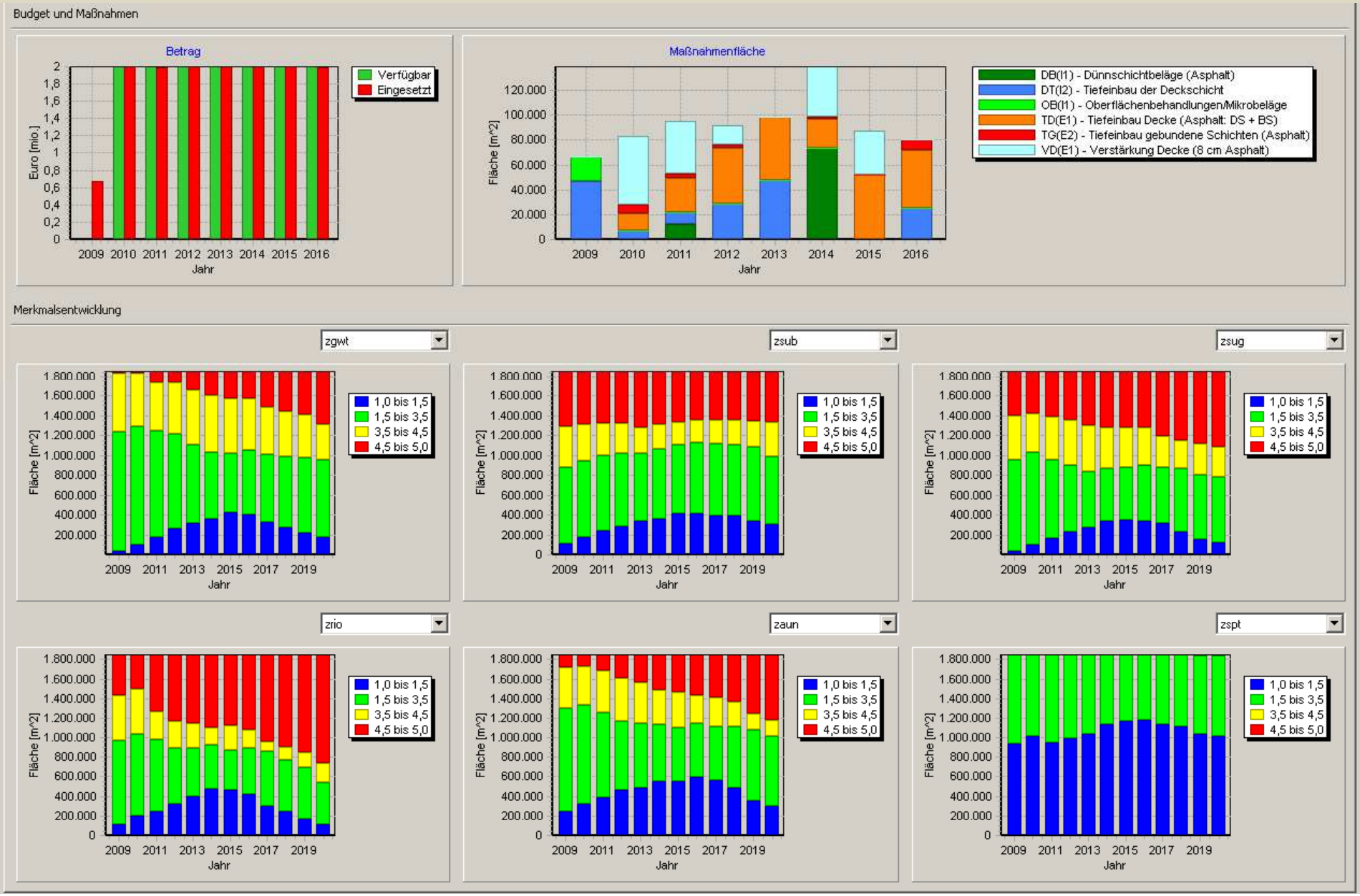
Optimale mittelfristige Erhaltungsstrategie / Budgetszenario 1.0



Optimale mittelfristige Erhaltungsstrategie / Budgetszenario 1.5



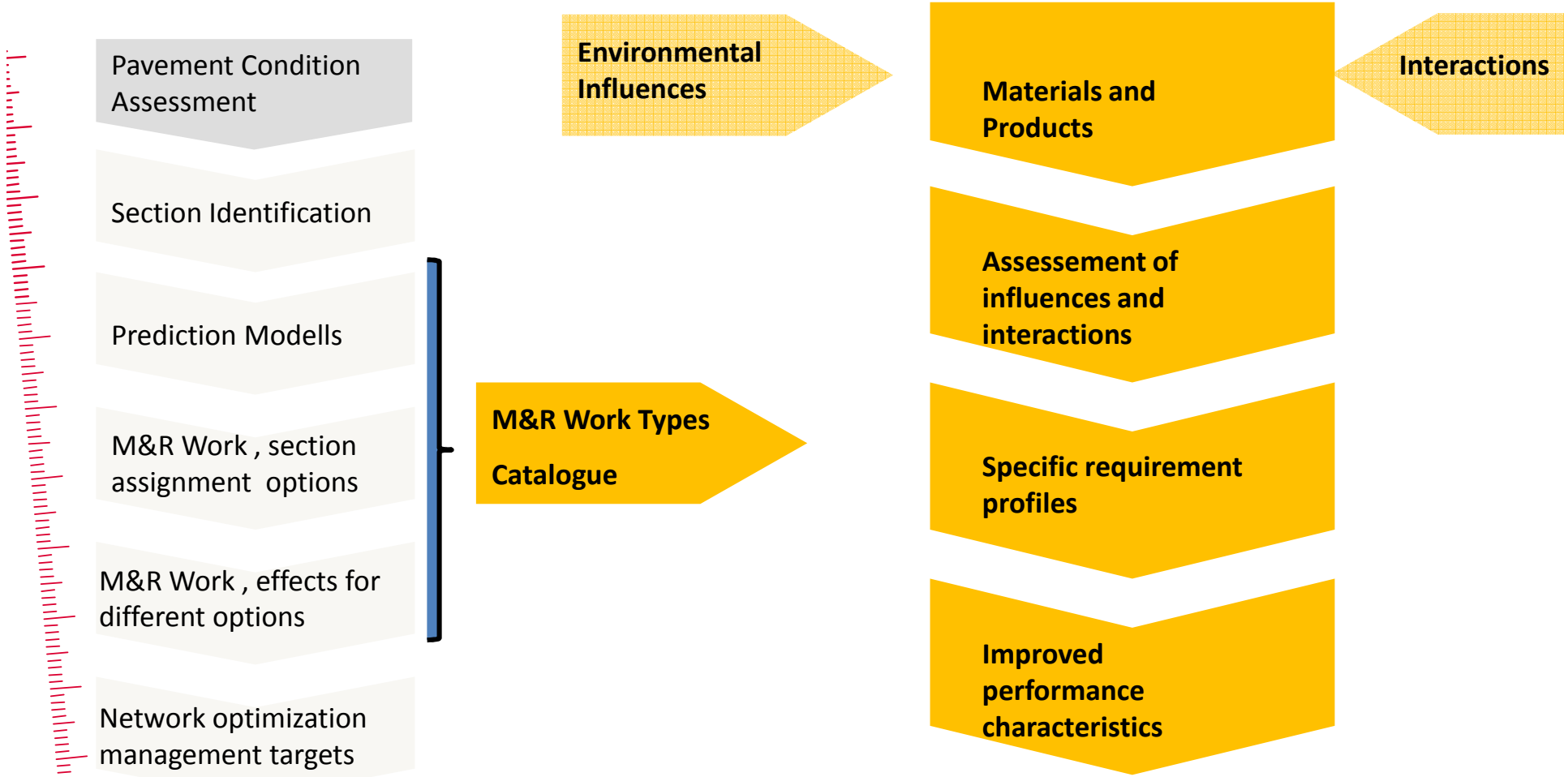
Optimale mittelfristige Erhaltungsstrategie / Budgetszenario 2.0



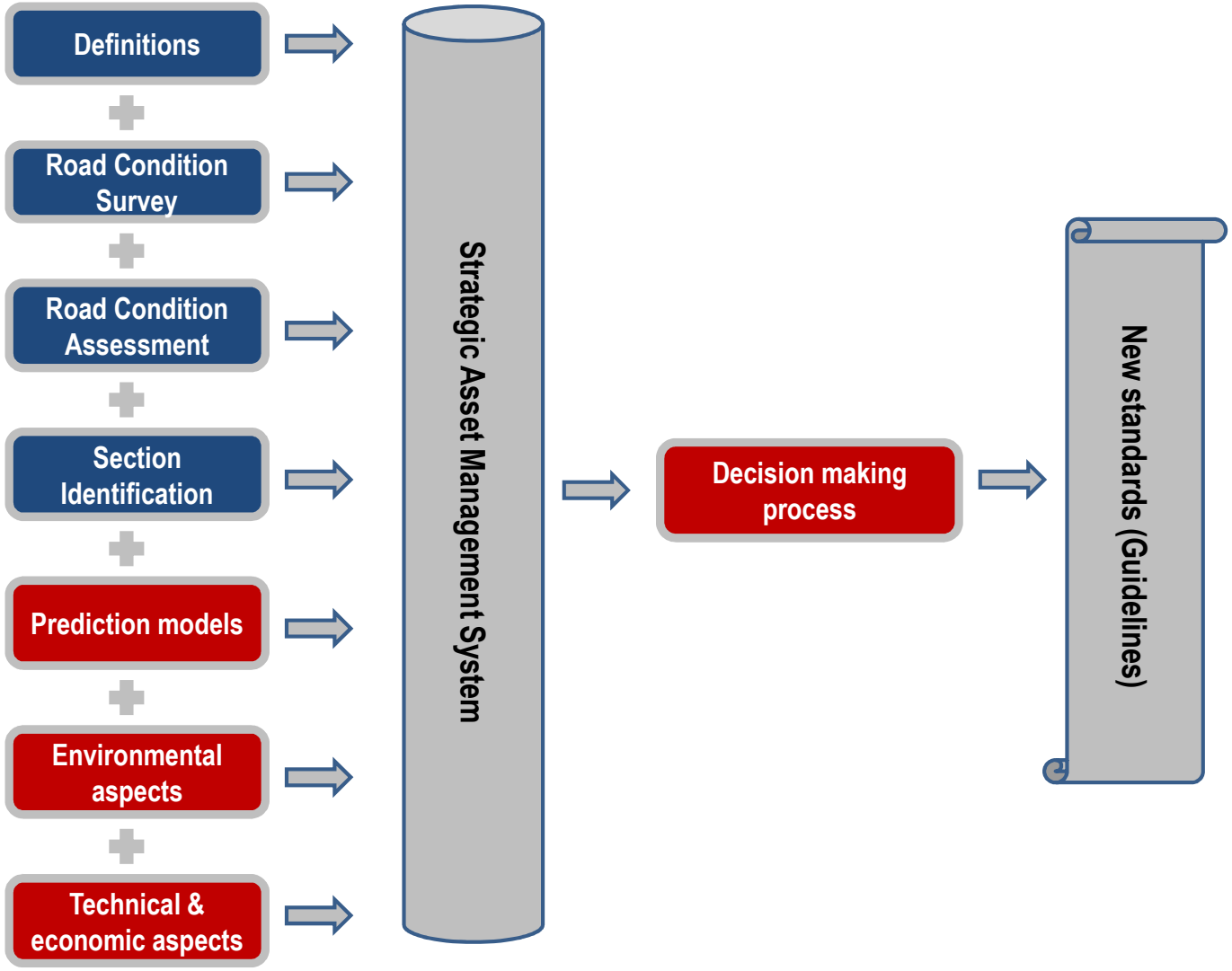
Strategic Approach / Future Demands

Pavement Condition Assessment	**Only Surface Characteristics are considered**
Section Identification	
Prediction Modells	**Only Surface Characteristics are predicted**
M&R Work , section assignment options	**M&R Work Type behaviors are only roughly estimated**
M&R Work , effects for different options	**Long term effects are only roughly estimated**
Network optimization management targets	**Targets considers only authorities point of view**

Strategic Approach / Future Demands



New Research Project “AssEssoR”



Thank your for your attention!

Contact:

Prof. Dr.-Ing. Markus Stöckner

Karlsruhe University of Applied Sciences

Moltkestraße 30

76133 Karlsruhe

Germany

Tel: **++49 721 925 1038**

Fax: **++49 721 925 1005**

E-Mail: **markus.stoeckner@hs-karlsruhe.de**