Lecture on **Pavement Management Systems**

in the course

Road Construction and Maintenance
Spring 2014

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UNITED BY OUR DIFFERENCE

WSP

Asset Management Systems

Pavement Management Systems is a component in Asset Management Systems

Management questions

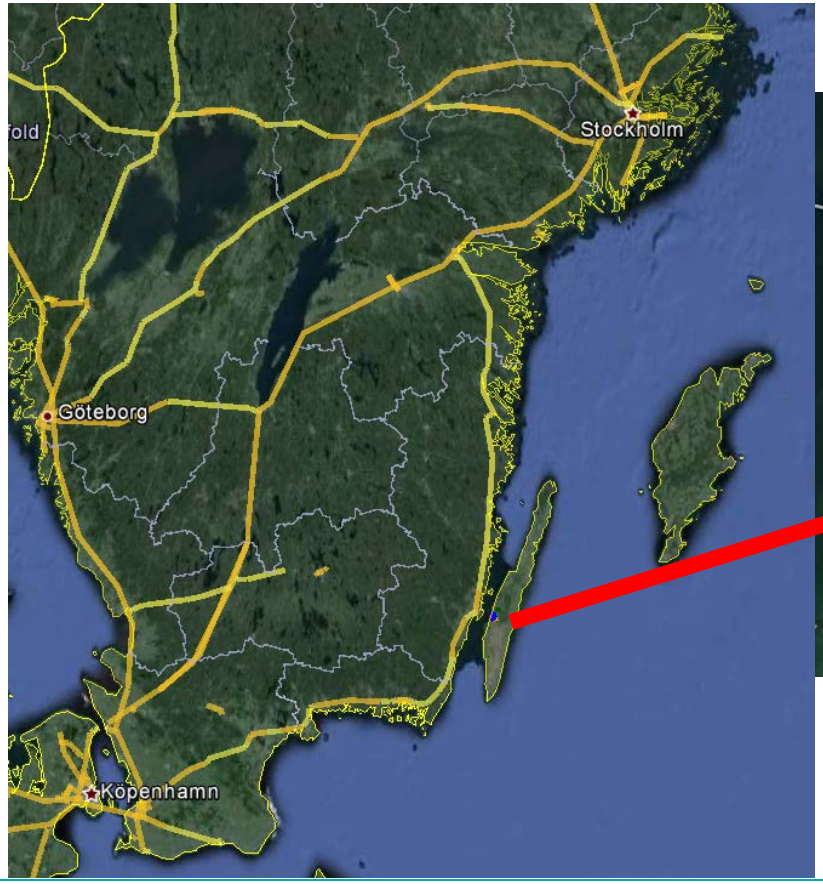
- What are the needs? – How much money do I need?
- How much money do I get to manage my assets?
- How should I spend the money in the best (optimal) way?
  - Roads, railroads, brigdes etc.
  - Structural treatments, safety etc.
- Where should I spend them?
- When in time should I spend them?
- What treatments should I select?
- Which strategy will I have?
- How will my network perform in the short term?
- How will my network perform in the long term?
- What are the benefits for me as a manager?
- What are the benefits for the society – for different stakeholders?
- How well can I explain this complex reality for the politicians that decide?

Pavement Management Systems is multidiciplinary

- Highway engineering
- Geotechnical engineering
- Structural engineering
- Mechanical engineering
- Business economics
- Socio economics
- IT
- Logistics
- Measurements
- etc

Example: Municipality of Mörbylånga

- Visual Inspection and Pavement Management Analysis of app. 20 km streets
- Färjestaden



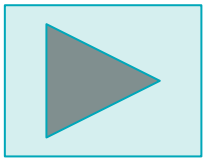
Equipment

Inspection

- Visual field inspection
- GPS positioning– all inspections have a coordinate
- speed app 10 km/h

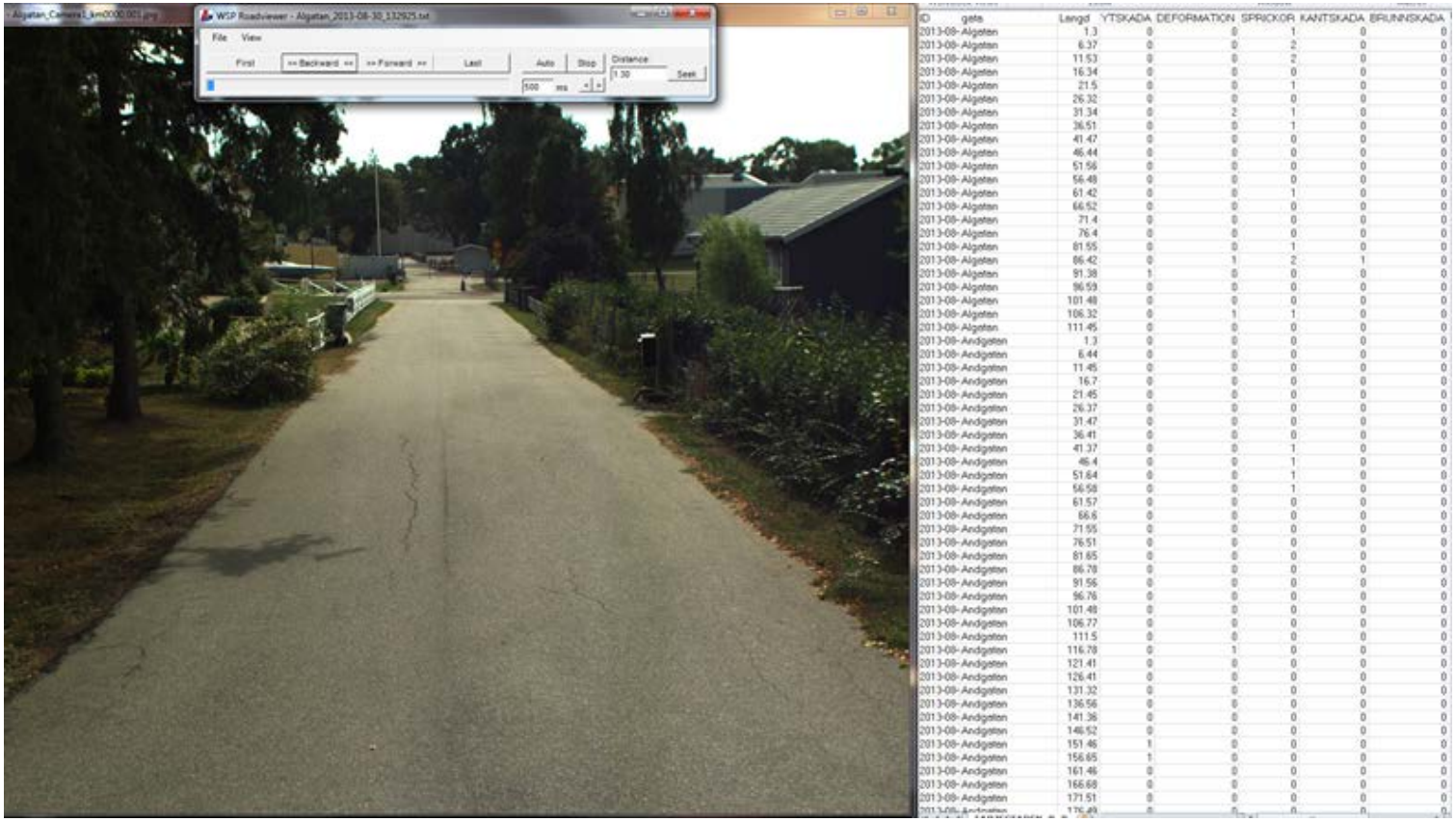
+

- Stereoimages
- 360 images
- Laser scanning



Inspection from images

- In the same way as field inspection
- Severity of deformations, surface defects and cracks
- Inspection every 5 m



Laser skanning - Orkidegatan

Laser skanning, färg. Andgatan

Inspection from images

Purpose: Quality Assurance

But…

- A general conclusion is that visual inspection from images are better than field inspection. The images give a good trackability and inspections can be repeated

General problems in visual inspections

- Longitudinal and transversal deformations can be hard to see
- Backlight
- Wet or dry surfaces

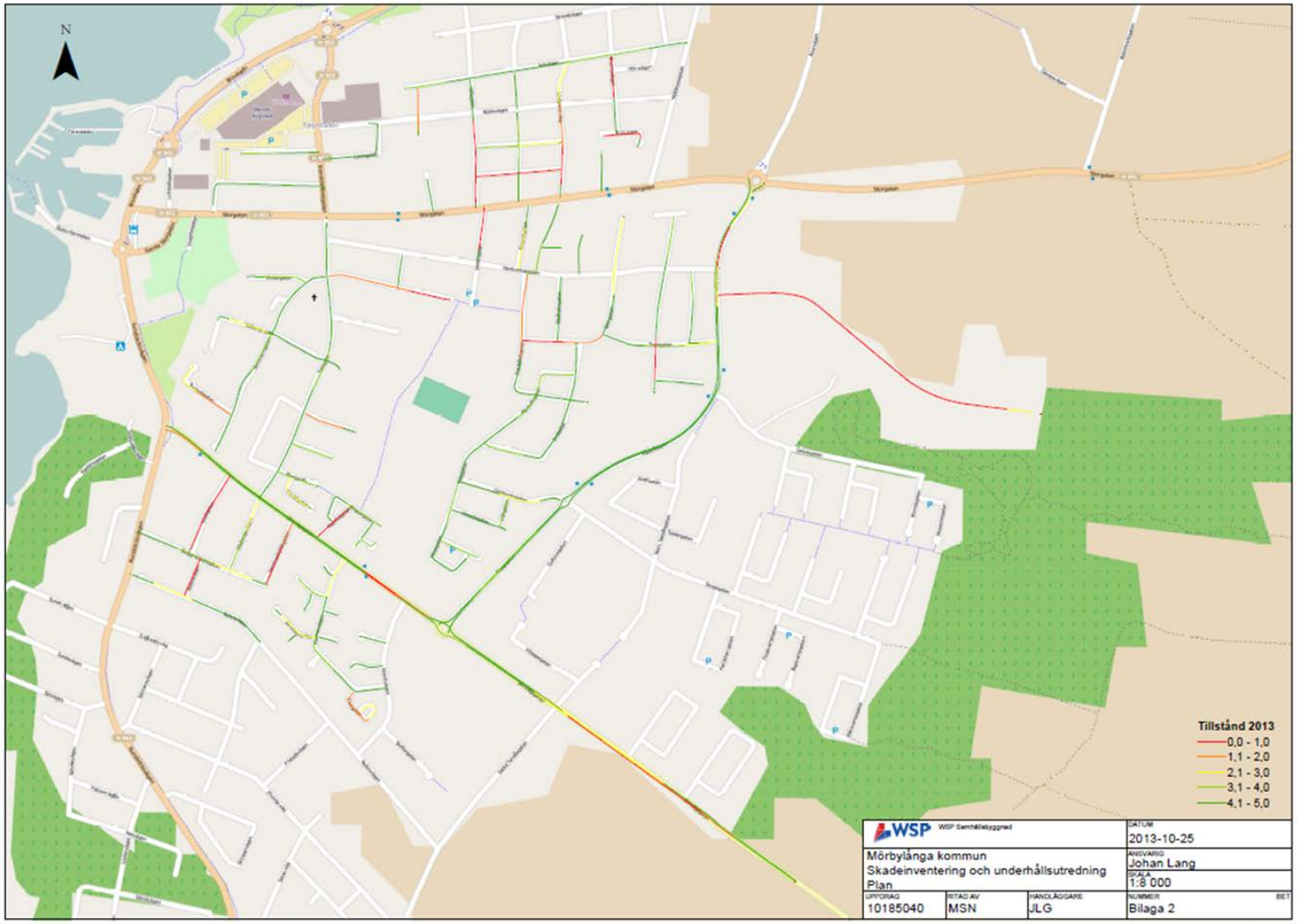
Pavement Management Analysis

- Severity and estension of 100 m sections
- Classification of type of damage per section in the scale 0-5 where 4-5 is ”Very good” and 0-1 is “Very poor”

Tillstånd	
0-1	Mycket dåligt
1-2	Dåligt
2-3	OK
3-4	Bra
4-5	Mycket bra

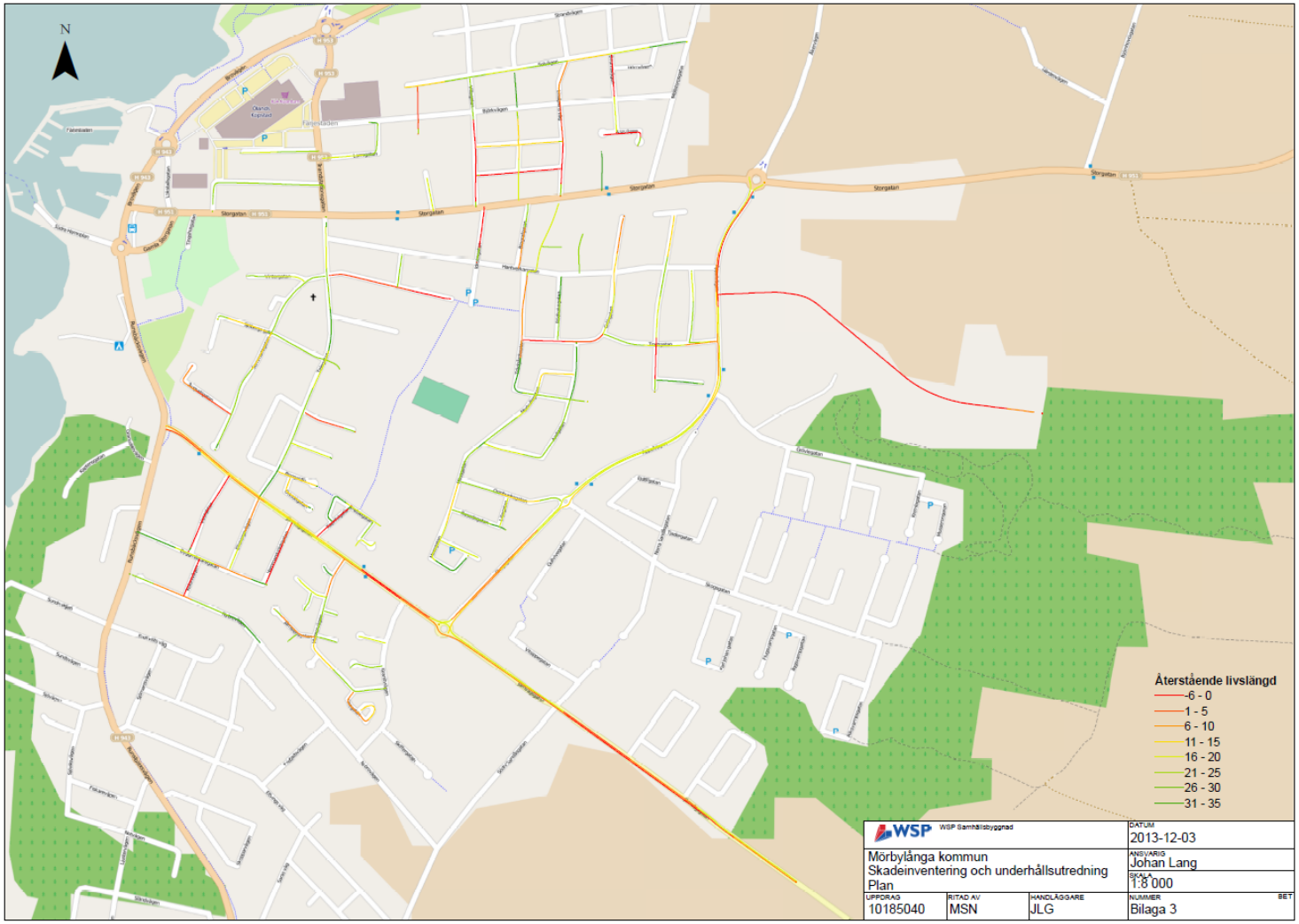
- Calculation of remaining life
- Treatment selection
- Treatment cost
- Calculation of maintenance backlog
- Scenario analysis 2014-23

Condition classes



All ”red” sections are ”Very poor”

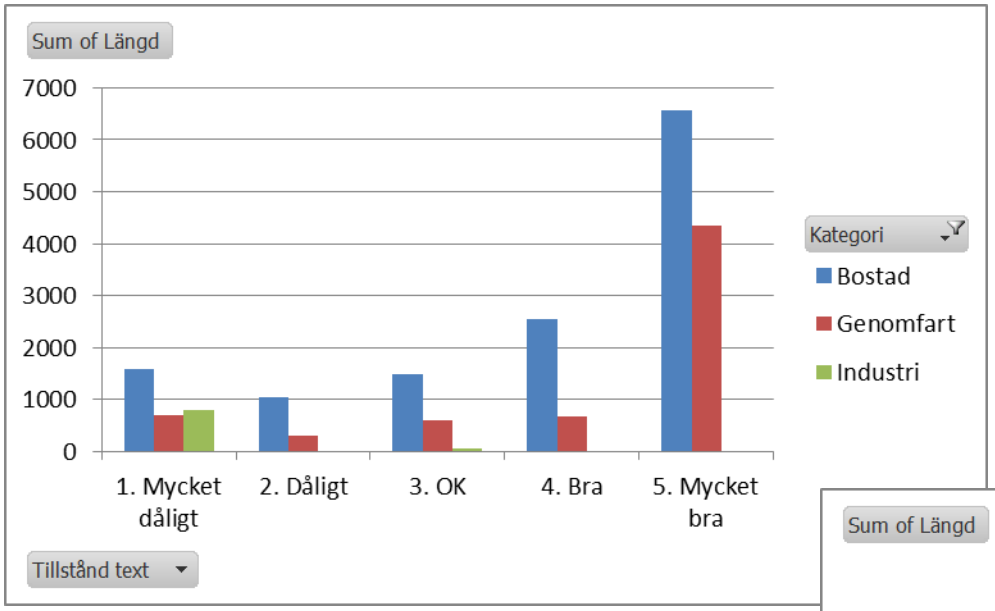
Remaining life



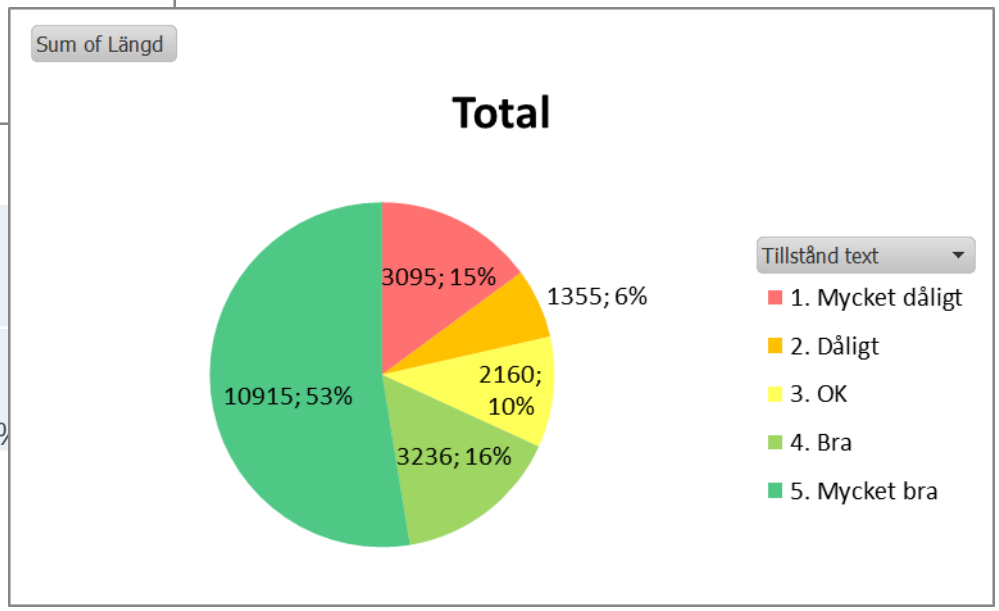
All ”red” sections have a remaining life <=0

Very poor section

Condition distribution



	Residence	Way through	Industry	Total
1. Very poor	12%	11%	92%	15%



Treatment selection and treatment cost

- Crack sealing
- Slurry seal
- Thin layer
- Hot Mix + levelling

Poor condion cracks(preventive treatment)

Poor condition surface (preventive treatment)

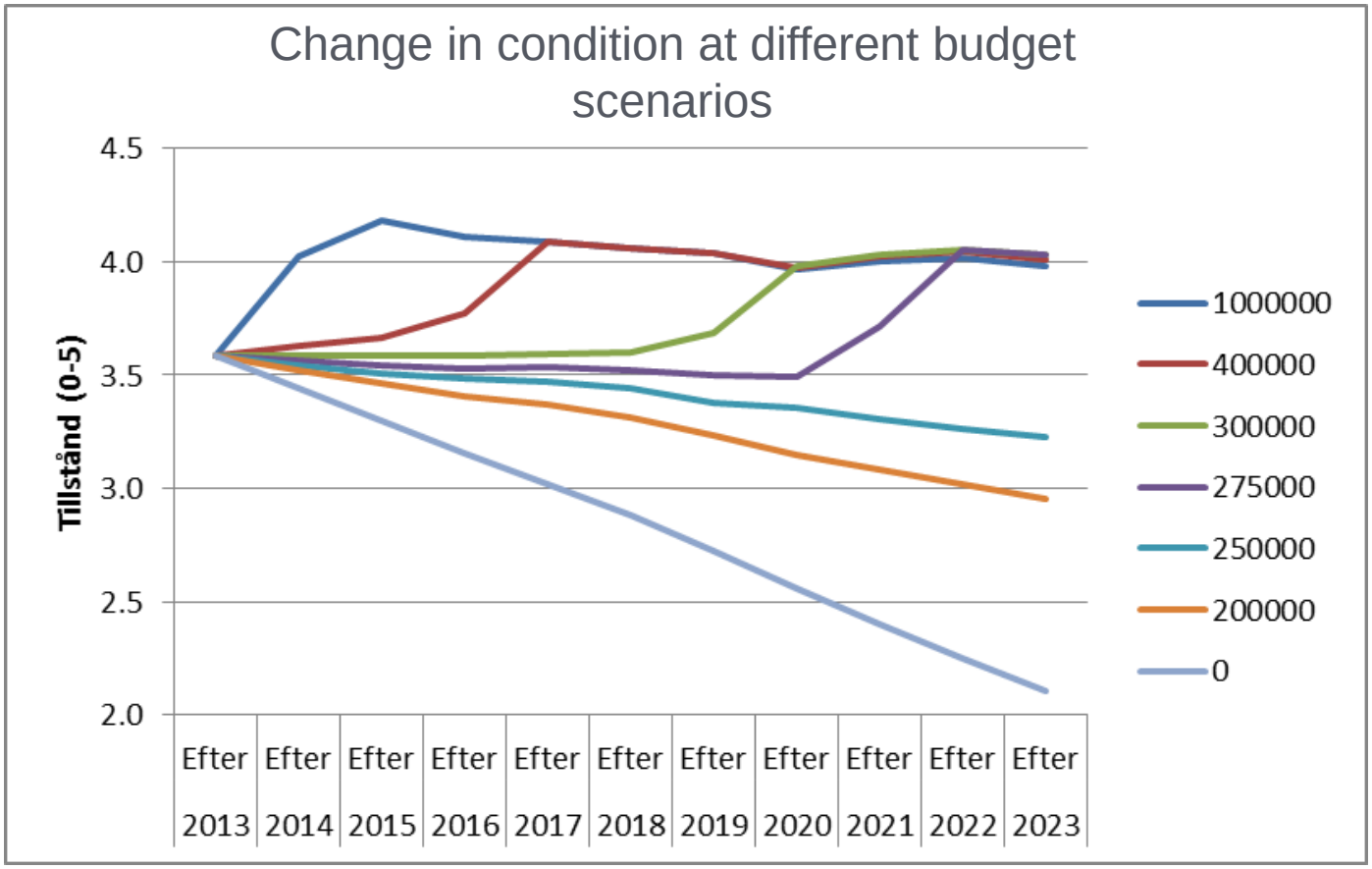
Very poor condition surface

Very poor condition (deformations, cracks)

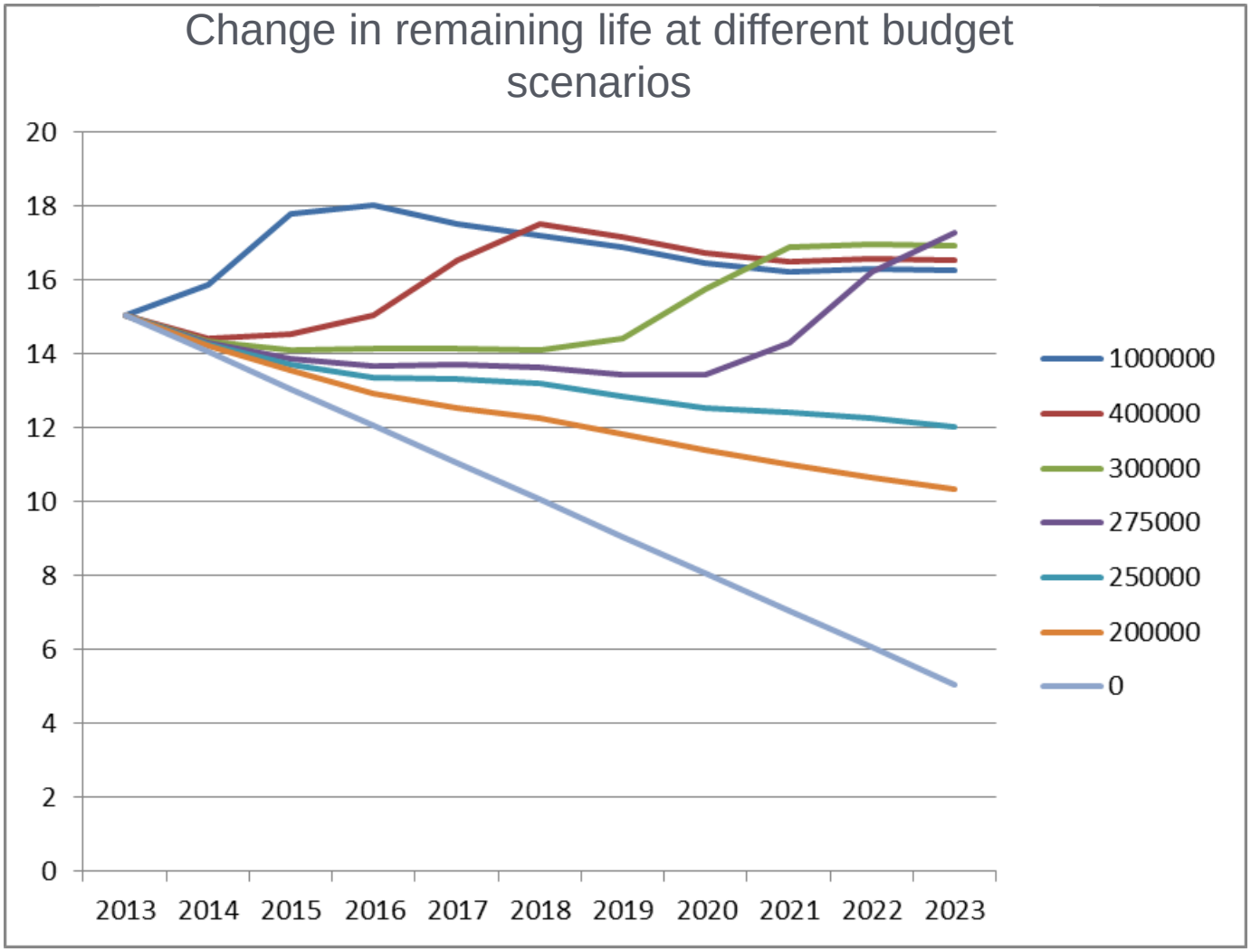
All treatments have a cost per sq m

Pavement Management Analysis

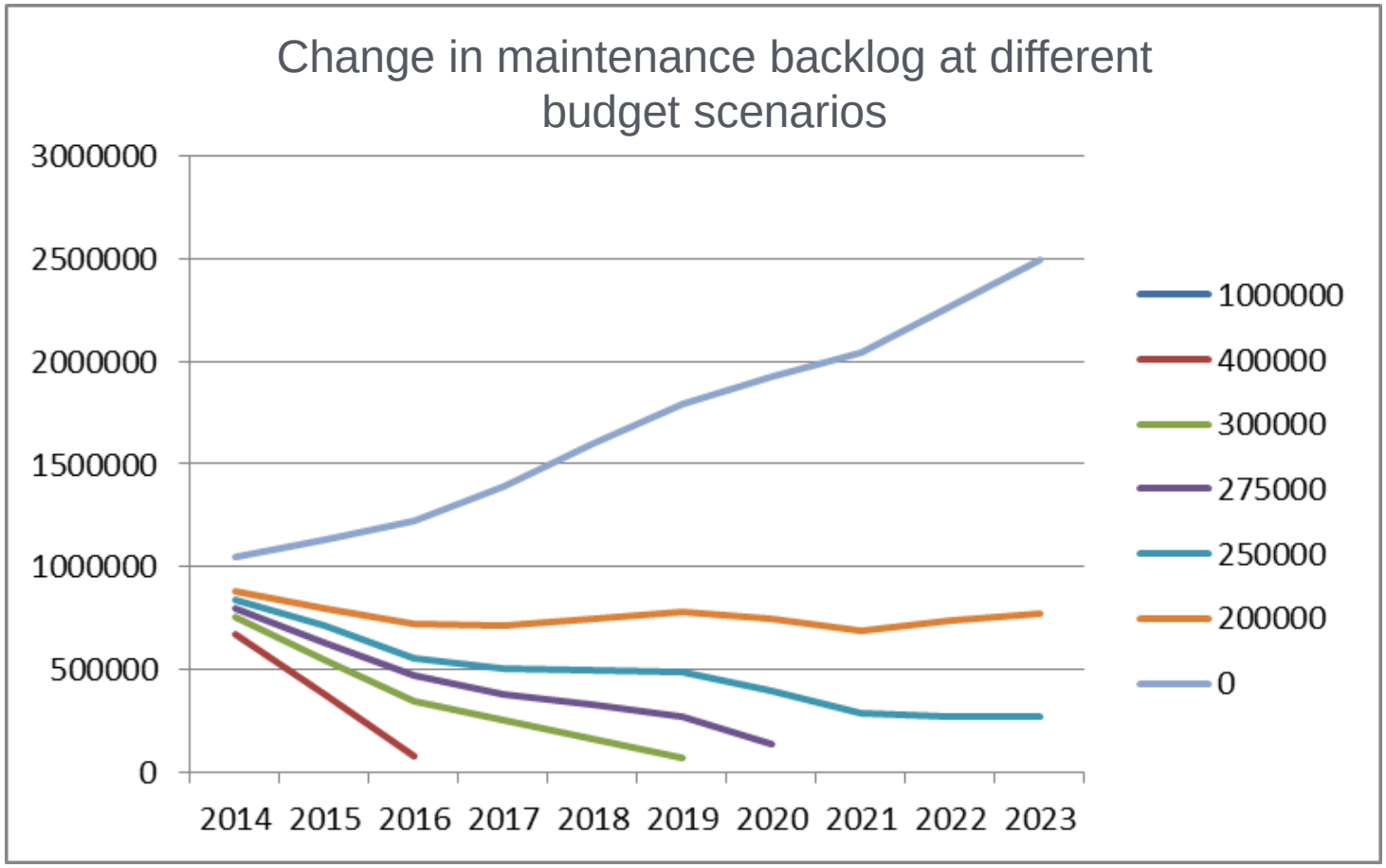
- Different strategies for a period of 10 years
- Different budget scenarios
- Establishing priorities – Way through streets have a higher priority than industry. Residence streets have the lowest priority.
- Stepwise analysis – when available budget are finished, next section are moved one year forward



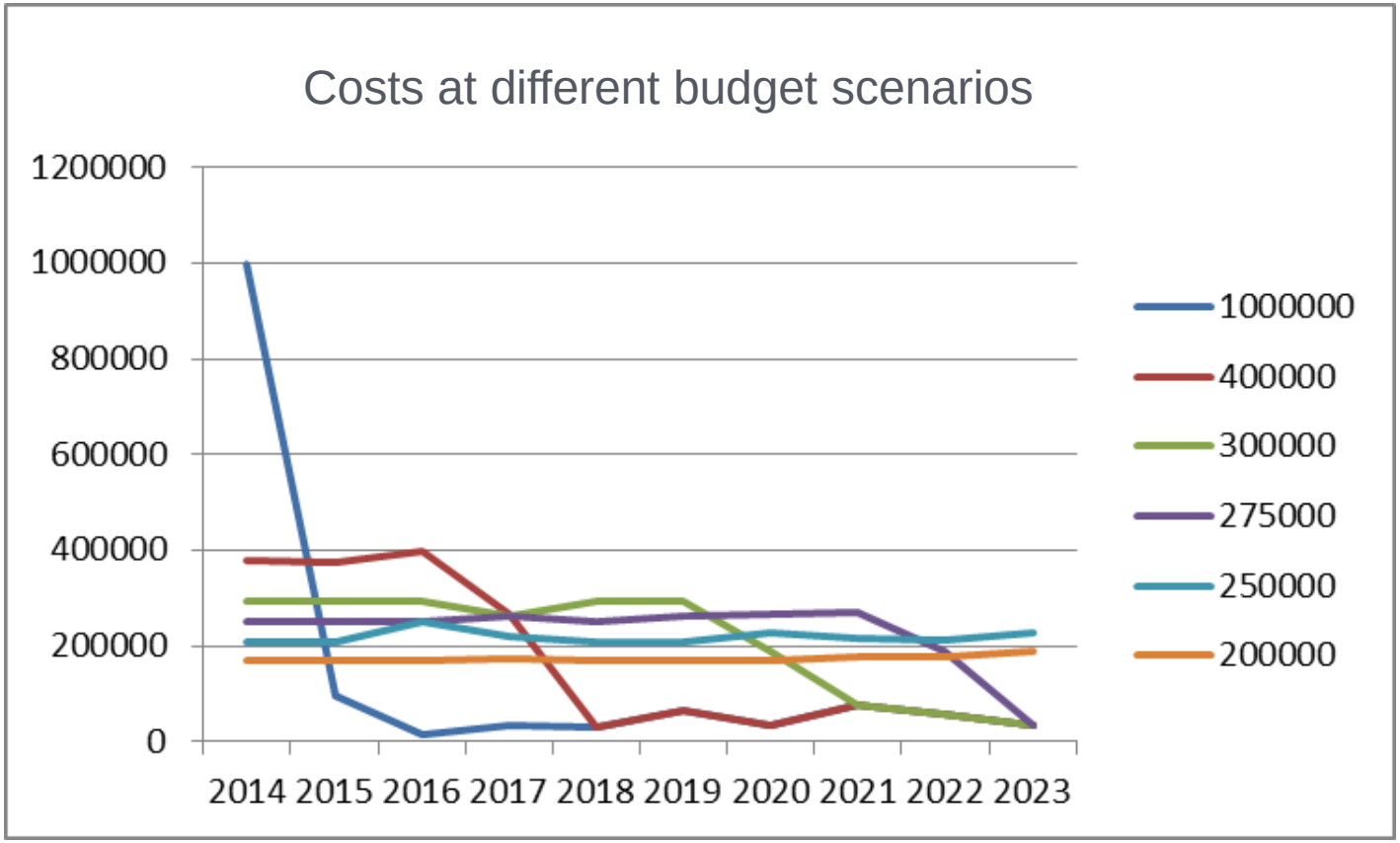
Conclusion:
The budget should be larger than 250000 SEK otherwise the condition will getter worse



Conclusion:
The budget should be larger than 250000 SEK otherwise the remaining life will decrease



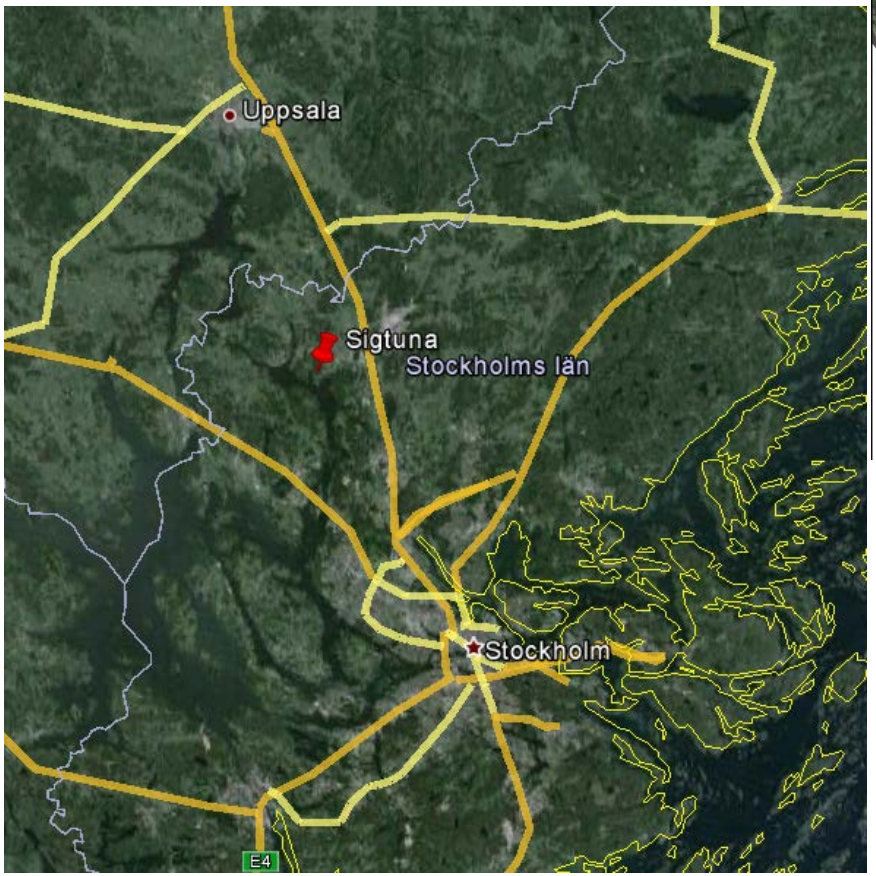
Conclusion:
A budget above 200000 SEK results in a reduction of the maintenance backlog.
A budget above 275000 SEK eliminates the maintenance backlog

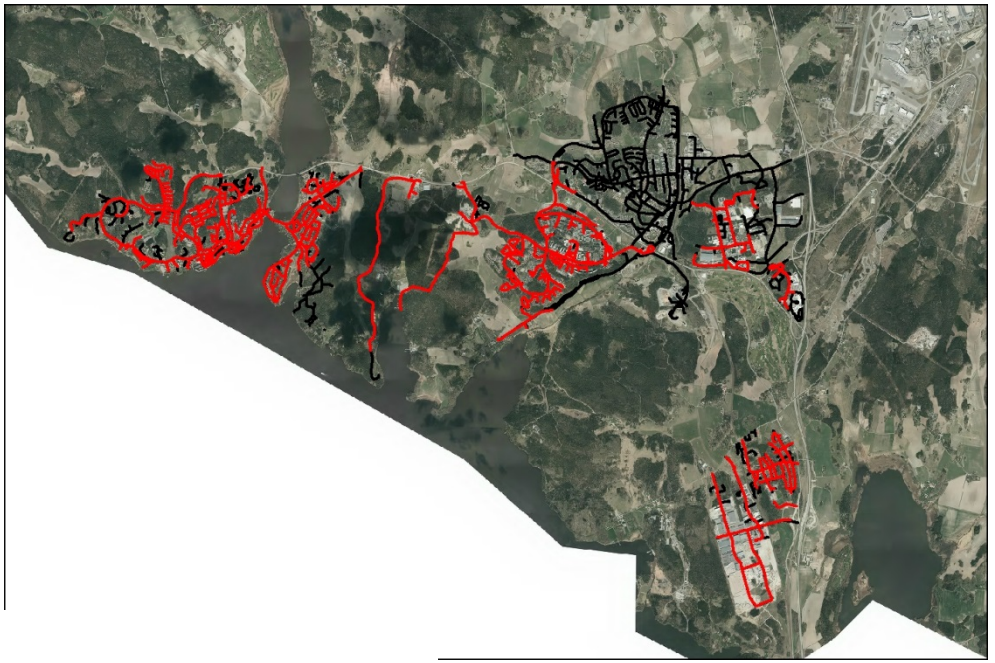

Costs at different budget scenarios
1200000
1000000
800000
600000
400000
200000
0
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
1000000
400000
300000
275000
250000
200000

Conclusions

- A significant maintenance is apparant. It is essential to find a strategy
- It is important to get an even (not jumping) budget
- The best strategy is to have a budget of app 250 000 SEK
- Do a new inspection after 5 years

Example: Municipality of Sigtuna





App 150 km

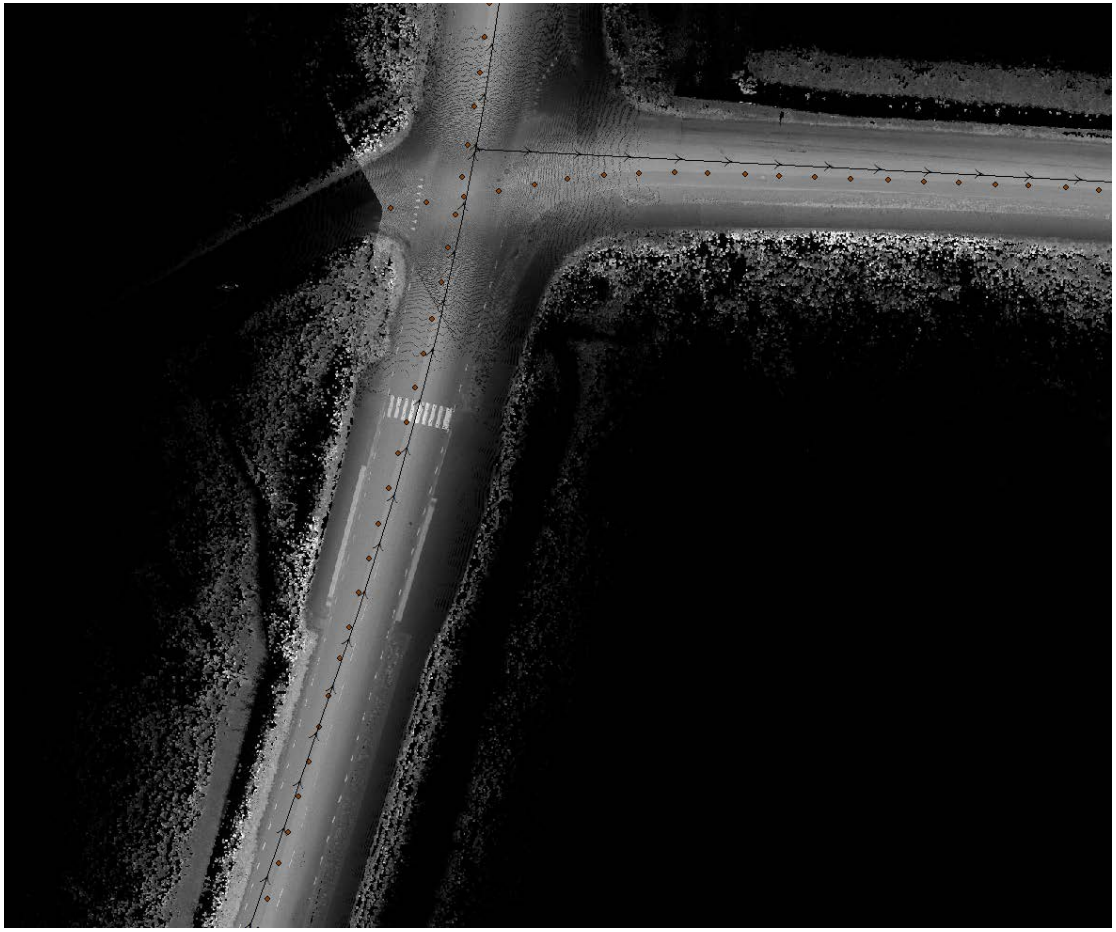
Road inventory

Laserdata

Images

Ortofoto

LV (NVDB)- reference



Road inventory

Laserdata

Images

Ortofoto

LV (NVDB)- reference

Road inventory

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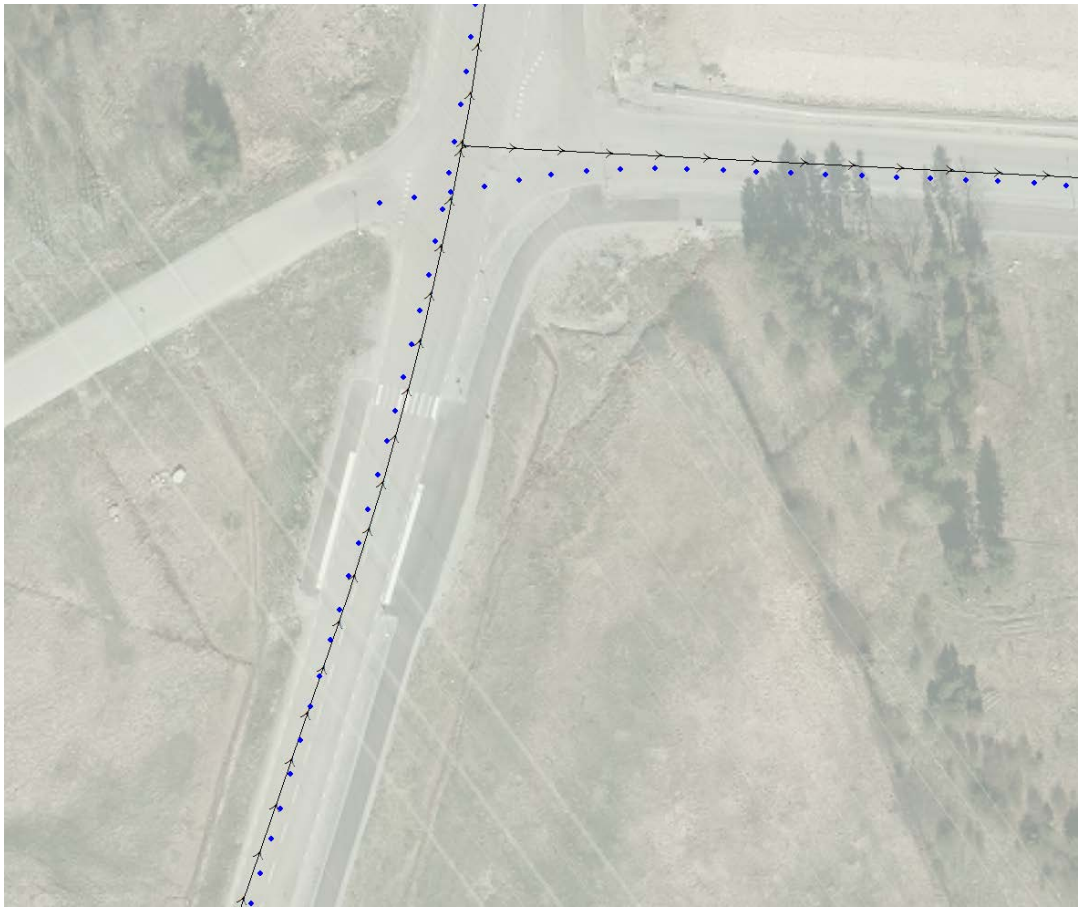
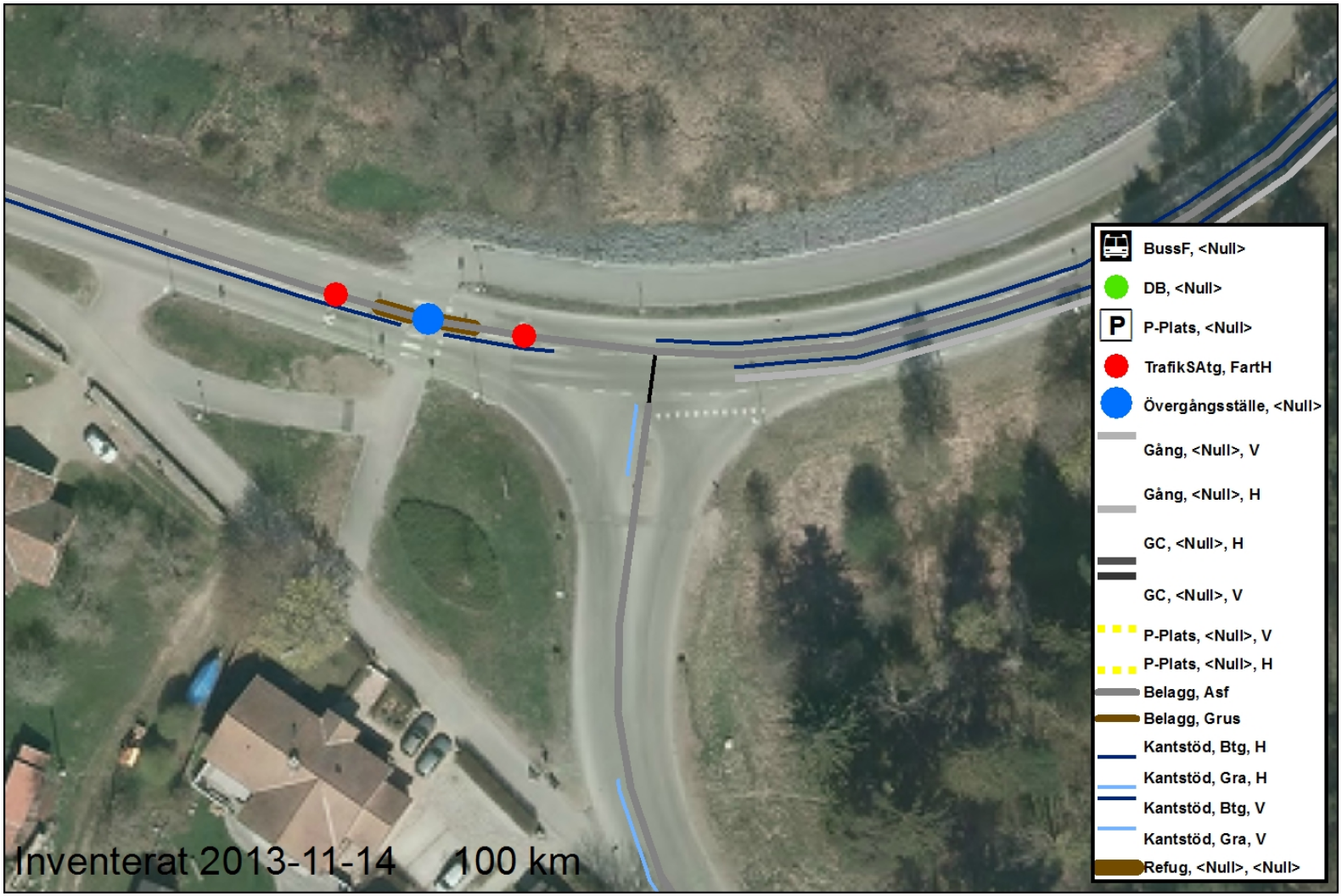


Inventering

Inventering



Inventering från bild

- Severity of deformations, surface defects and cracks
- Inspection every 5 m

ID	gata	Längd	YTSKADA	DEFORMATION	SPRICKOR	KANTSKADA	BRUNNSKADA
2013-08-	Algatan	1.3	0	0	1	0	0
2013-08-	Algatan	6.37	0	0	2	0	0
2013-08-	Algatan	11.53	0	0	2	0	0
2013-08-	Algatan	16.34	0	0	0	0	0
2013-08-	Algatan	21.5	0	0	1	0	0
2013-08-	Algatan	26.32	0	0	0	0	0
2013-08-	Algatan	31.34	0	2	1	0	0
2013-08-	Algatan	36.51	0	0	1	0	0
2013-08-	Algatan	41.47	0	0	0	0	0
2013-08-	Algatan	46.44	0	0	0	0	0
2013-08-	Algatan	51.56	0	0	0	0	0
2013-08-	Algatan	56.48	0	0	0	0	0
2013-08-	Algatan	61.42	0	0	1	0	0
2013-08-	Algatan	66.52	0	0	0	0	0
2013-08-	Algatan	71.4	0	0	0	0	0
2013-08-	Algatan	76.4	0	0	0	0	0
2013-08-	Algatan	81.55	0	0	1	0	0
2013-08-	Algatan	86.42	0	1	2	1	0
2013-08-	Algatan	91.38	1	0	0	0	0
2013-08-	Algatan	96.59	0	0	0	0	0
2013-08-	Algatan	101.48	0	0	0	0	0
2013-08-	Algatan	106.32	0	1	1	0	0
2013-08-	Algatan	111.45	0	0	0	0	0
2013-08-	Andgatan	1.3	0	0	0	0	0
2013-08-	Andgatan	6.44	0	0	0	0	0
2013-08-	Andgatan	11.45	0	0	0	0	0
2013-08-	Andgatan	16.7	0	0	0	0	0
2013-08-	Andgatan	21.45	0	0	0	0	0
2013-08-	Andgatan	26.37	0	0	0	0	0
2013-08-	Andgatan	31.47	0	0	0	0	0
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2013-08-	Andgatan	41.37	0	0	1	0	0
2013-08-	Andgatan	46.4	0	0	1	0	0
2013-08-	Andgatan	51.64	0	0	1	0	0
2013-08-	Andgatan	56.58	0	0	1	0	0
2013-08-	Andgatan	61.57	0	0	0	0	0
2013-08-	Andgatan	66.6	0	0	0	0	0
2013-08-	Andgatan	71.55	0	0	0	0	0
2013-08-	Andgatan	76.51	0	0	0	0	0
2013-08-	Andgatan	81.65	0	0	0	0	0
2013-08-	Andgatan	86.79	0	0	0	0	0
2013-08-	Andgatan	91.58	0	0	0	0	0
2013-08-	Andgatan	96.76	0	0	0	0	0
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2013-08-	Andgatan	121.41	0	0	0	0	0
2013-08-	Andgatan	126.41	0	0	0	0	0
2013-08-	Andgatan	131.32	0	0	0	0	0
2013-08-	Andgatan	136.56	0	0	0	0	0
2013-08-	Andgatan	141.36	0	0	0	0	0
2013-08-	Andgatan	146.52	0	0	0	0	0
2013-08-	Andgatan	151.46	1	0	0	0	0
2013-08-	Andgatan	156.65	1	0	0	0	0
2013-08-	Andgatan	161.46	0	0	0	0	0
2013-08-	Andgatan	166.68	0	0	0	0	0
2013-08-	Andgatan	171.51	0	0	0	0	0

Summary Sigtuna

- Road inventory (Pavements, refuges, bicycle roads, edge support, parkinglots etc)
- Visual road condition inspection of 32000 images
- All images have coordinates whick make it possible to connect to the link-note system in the system Tekis
- All data convered to the Tekis system
- Added later: inventory of road signs

Pavement Management Systems - PMS

Value for money

PMS - Pavement Management Systems

Planning pavement maintenance and rehabilitation activities

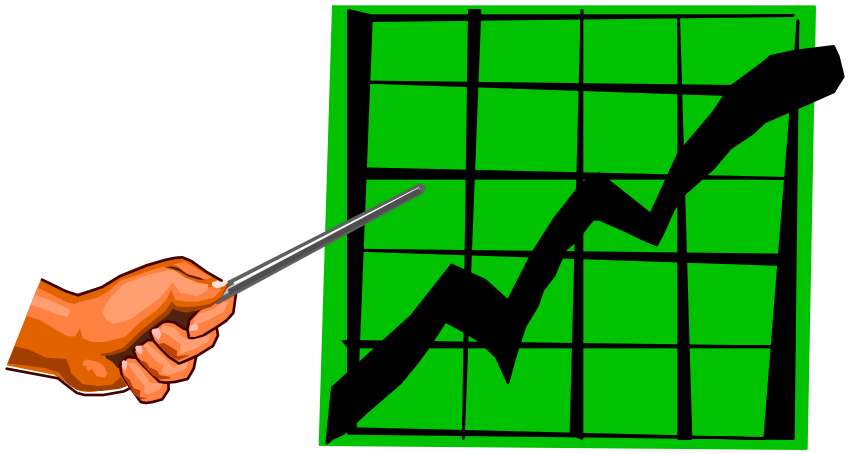
A tool for the pavement engineer to decide

- WHERE
- WHEN
- HOW

an action will be done

PMS Objectives

- Optimal Pavement Management based on socio-economic considerations



BENEFITS OF PMS

- A base to show the needs of funds now and in the future as well as the consequences of lack in funds
- Allocation of funds based on facts
- Use of funds to get the best result possible and be able to show it
- Feed-back of pavement performance
- An uniform and objective picture of pavement condition

PMS is international

- All countries have pavement management
  - For as long as they have had roads
- Most countries have pavement management systems
  - IT development have opened the door to handle large amounts of information
  - Sometimes it is a requirement from loaning institutes (Worl Bank)

Old poor road

Sweden

Poor road stops the school bus

Russia

Federal highway in Russia

Russia

England

”Repaired” pothole

Poor roads

USA

Cameroon

India

Good roads

Morocco

Congo

Mali

Tanzania

Good roads

Canada

Chile

USA

Serbia

Good roads

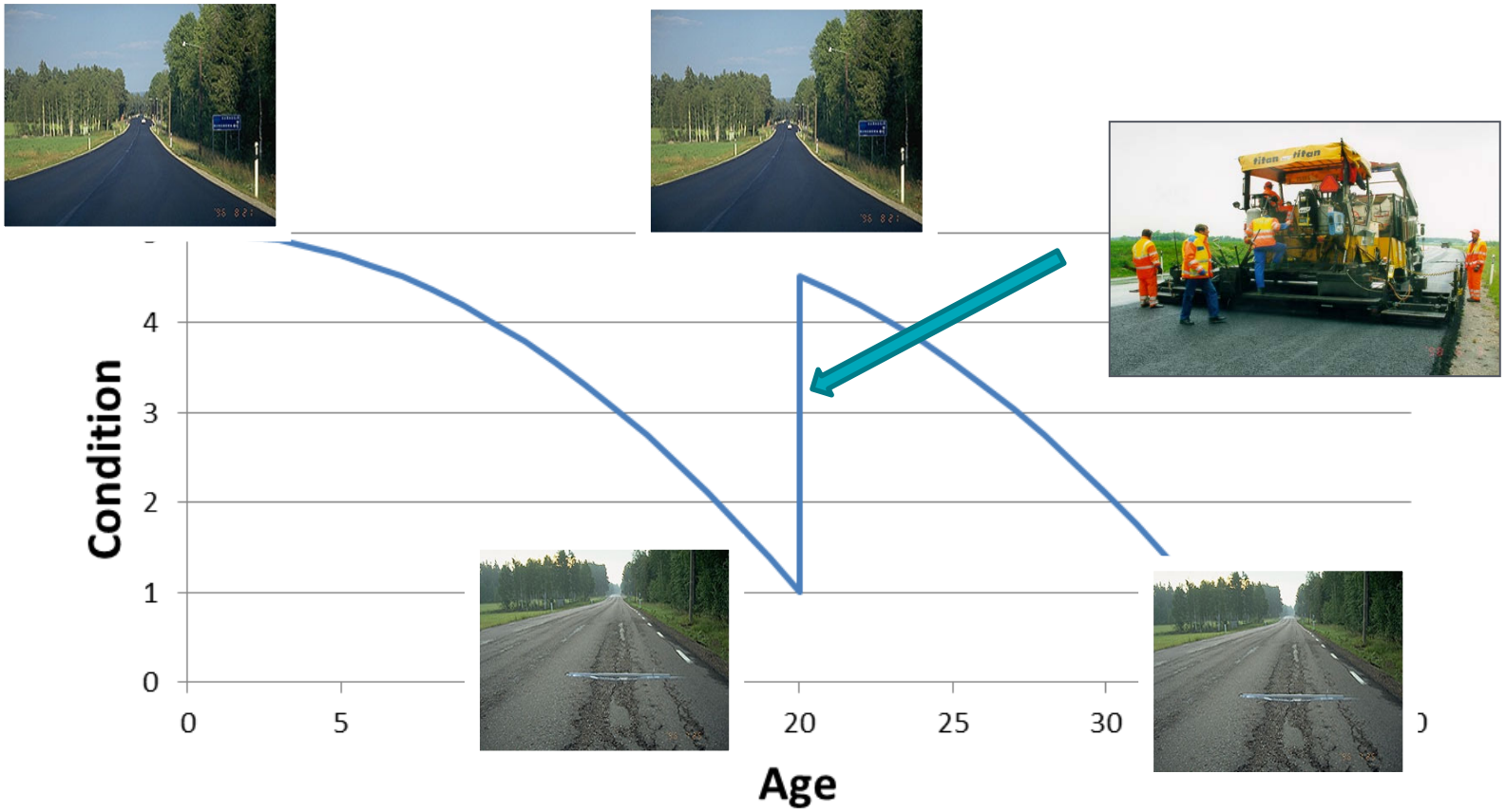
New Zealand

Spain

Sweden

Sweden

A pavements life cycle



Roads for the users

Pavements for the road users

Comfort

Road Safety

Internal

Noice

External

Fuel

Vehicle operating costs

Tire

Rep-air

Particles

PM10 PM2.5l

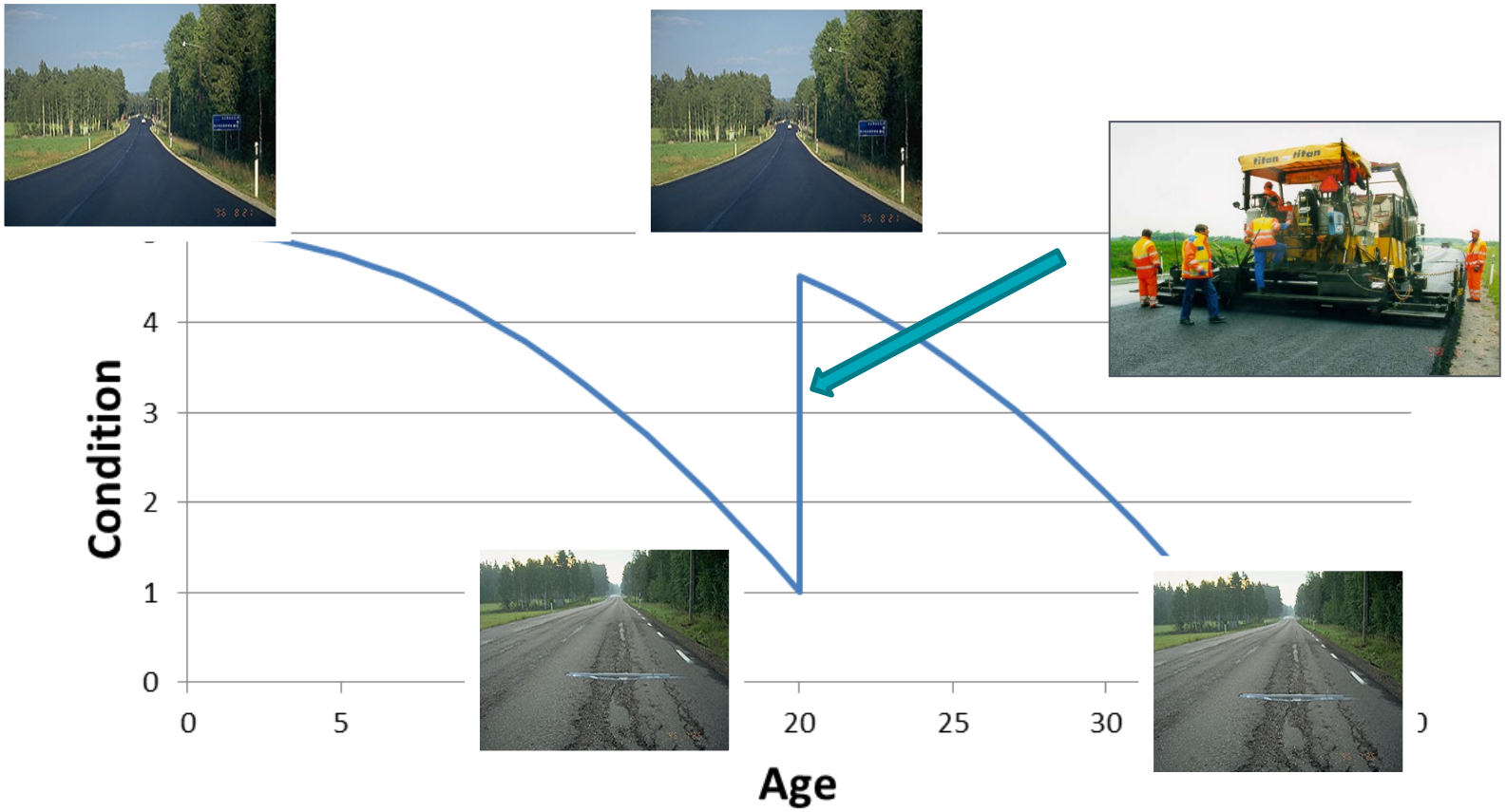
Emission

CO2

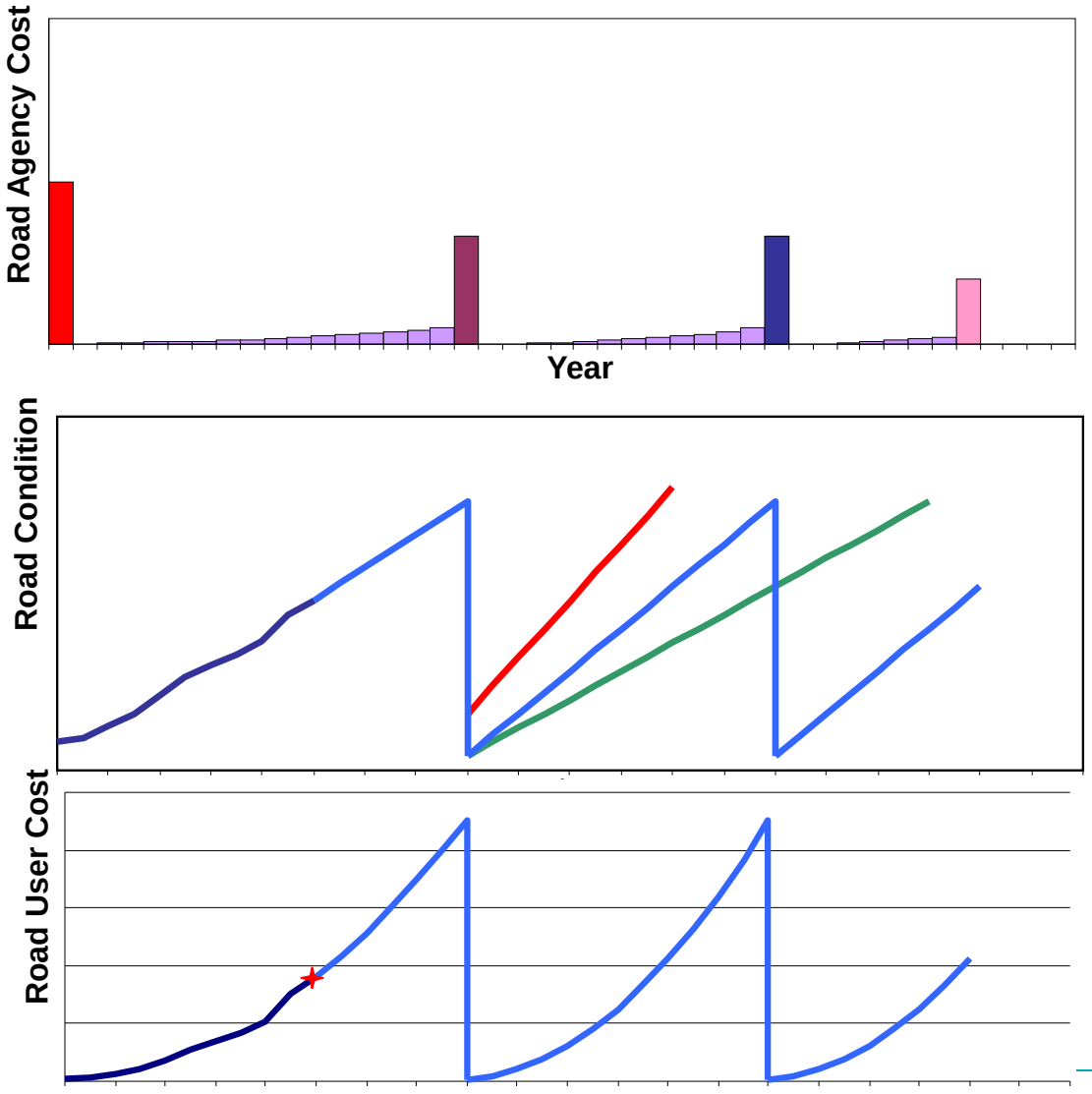
Travel time

Access

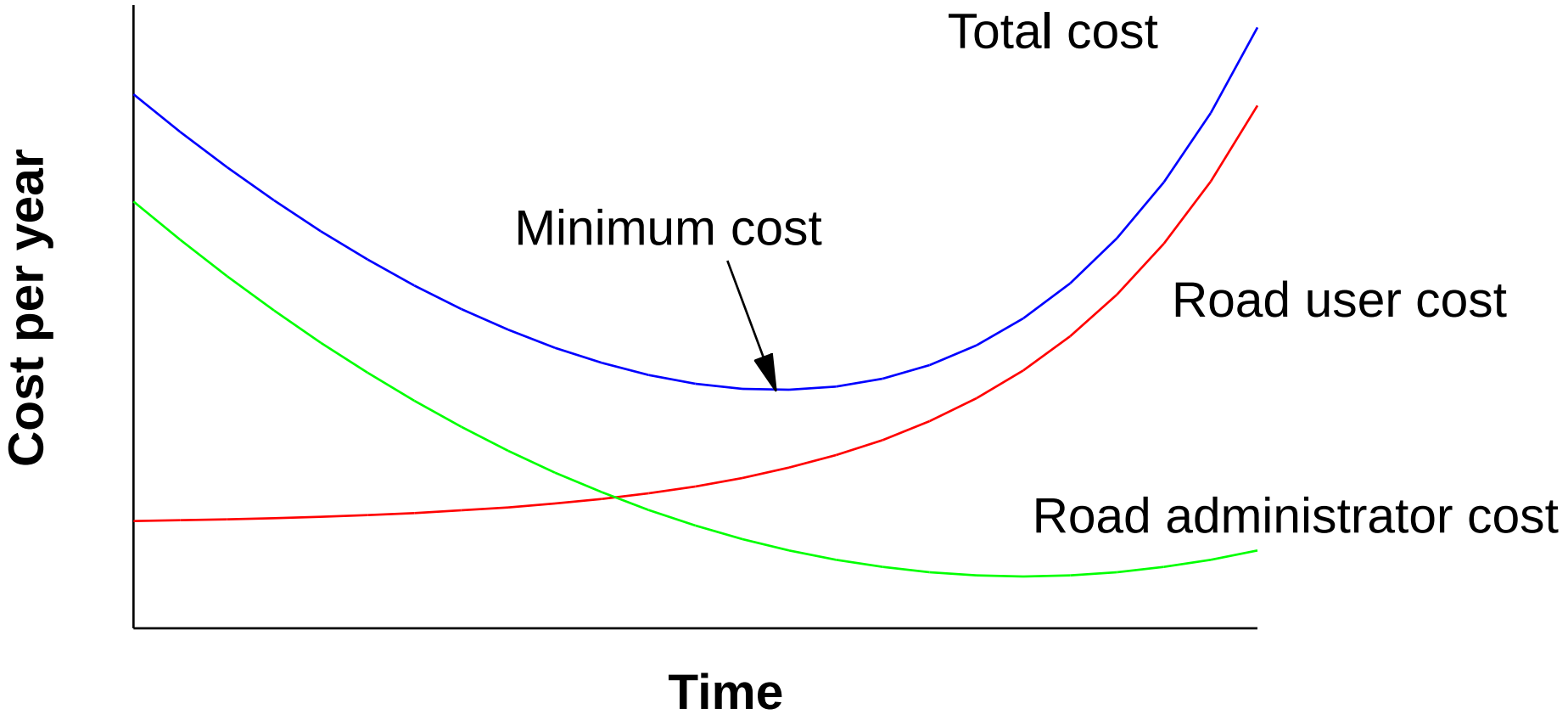
A pavements life cycle



Pavement Life Cycle Cost

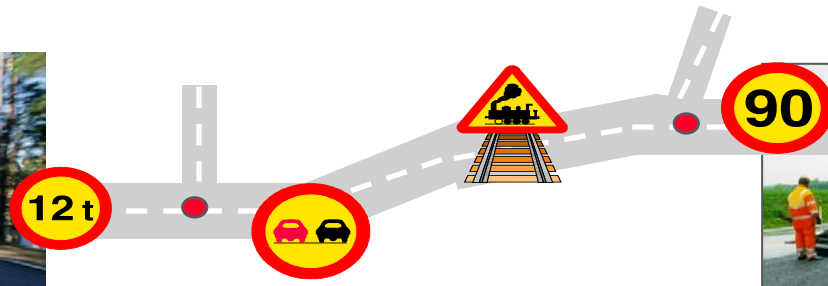


Optimizing


Total cost
Minimum cost
Road user cost
Road administrator cost
Cost per year
Time

PMS - Overview

PMS Components



Road condition

Road Inventory

Pavement information

Longitudinal unevenness

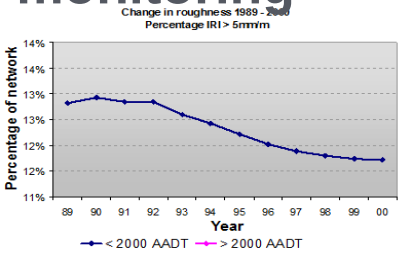
Transversal unevenness

Database

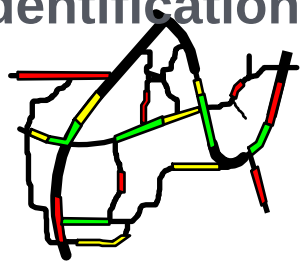
Evaluation models

Budget needs

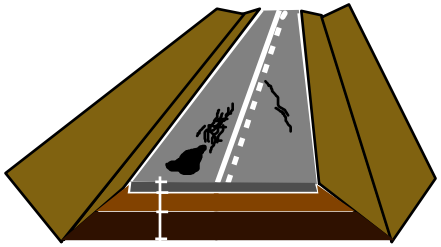
Condition monitoring



Project identification



Follow-up contracts



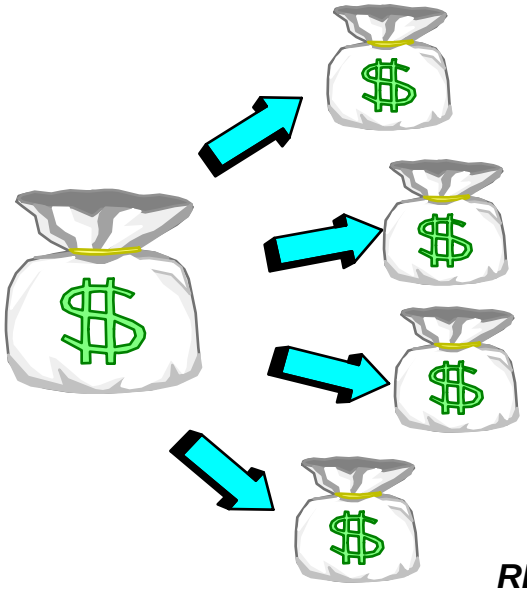
Network level - Overview

GOVERNMENT

ROAD ADMINISTRATION

REHABILITATION

MAINTENANCE

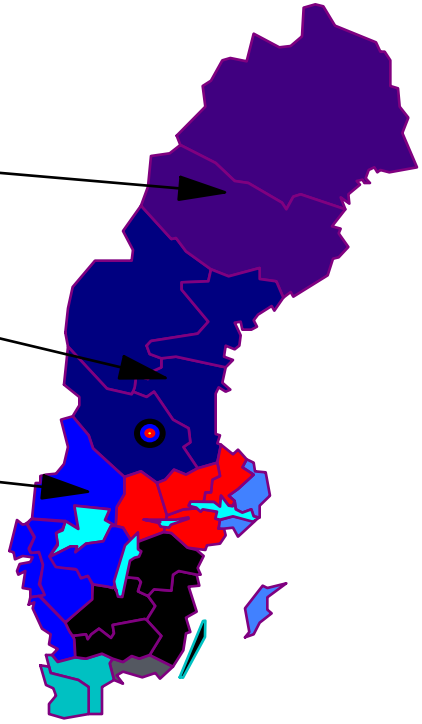


REGION 1

REGION 2

REGION 3

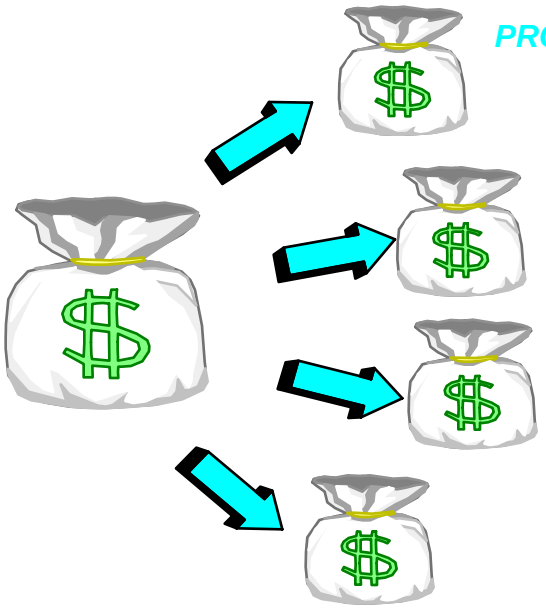
REGION XX



Network to project level

Network - identification of projects

ROAD ADMINISTRATION



PROJECT 1

PROJECT 2

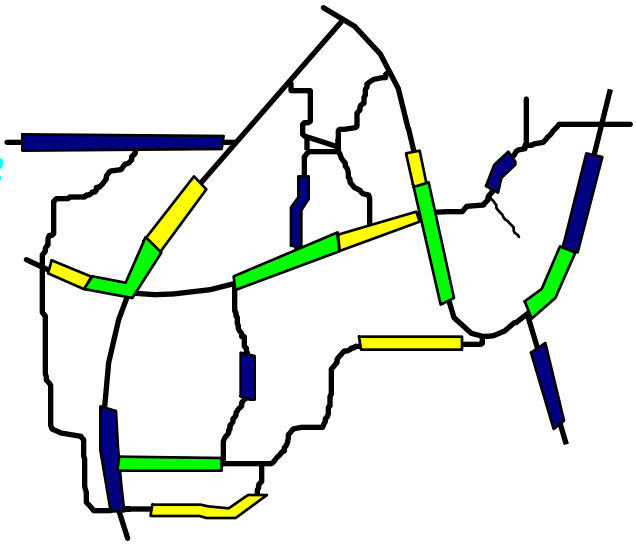
PROJECT 3

PROJECT NN

PRIORITY 1

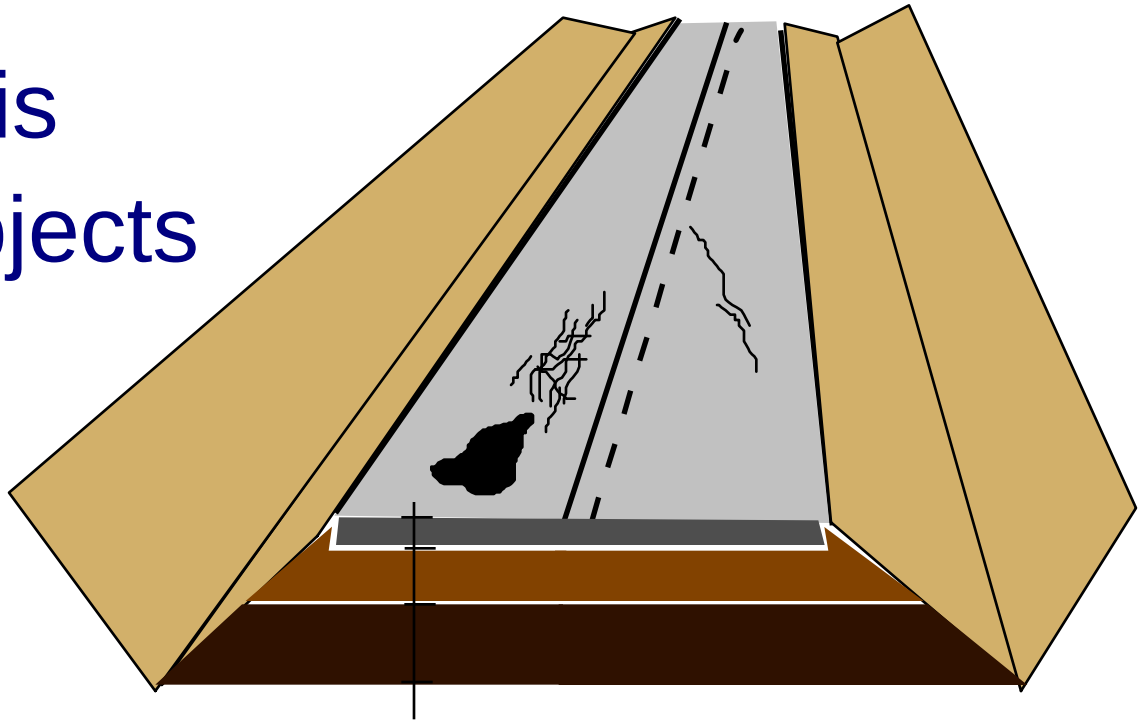
PRIORITY 2

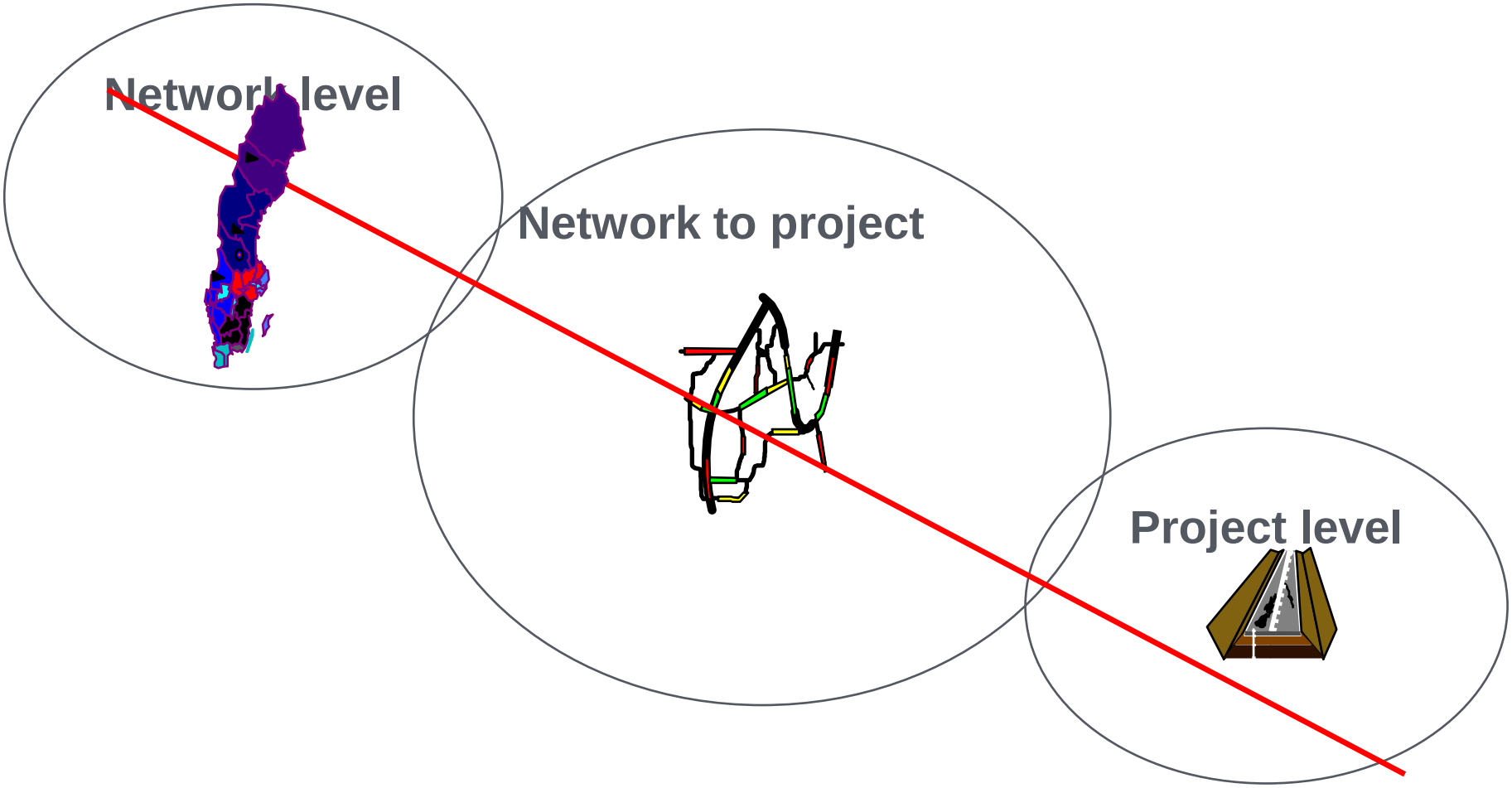
PRIORITY 3



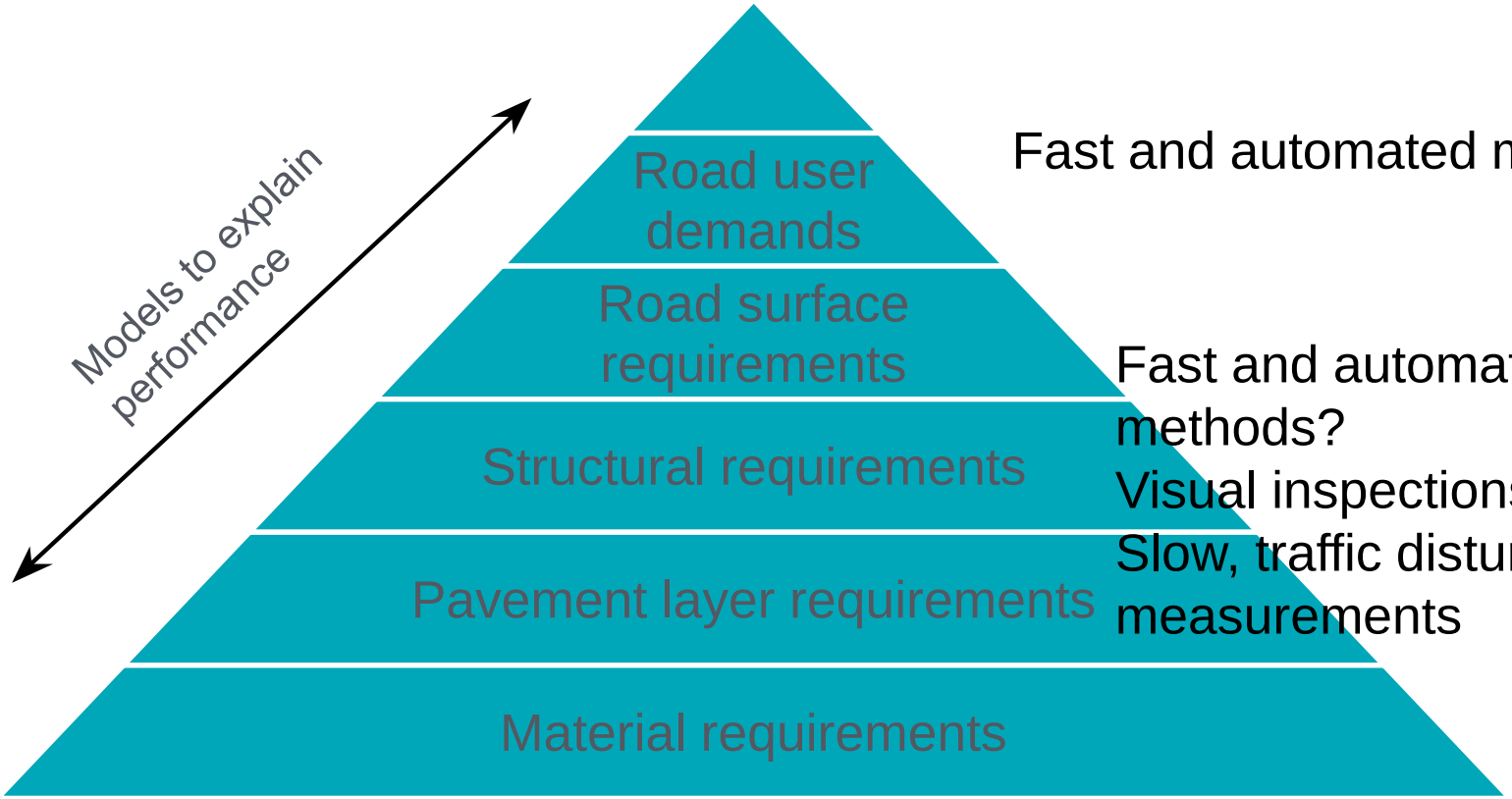
PMS - Project Level

Detailed analysis
of individual projects




Network level
Network to project
Project level

Need of information



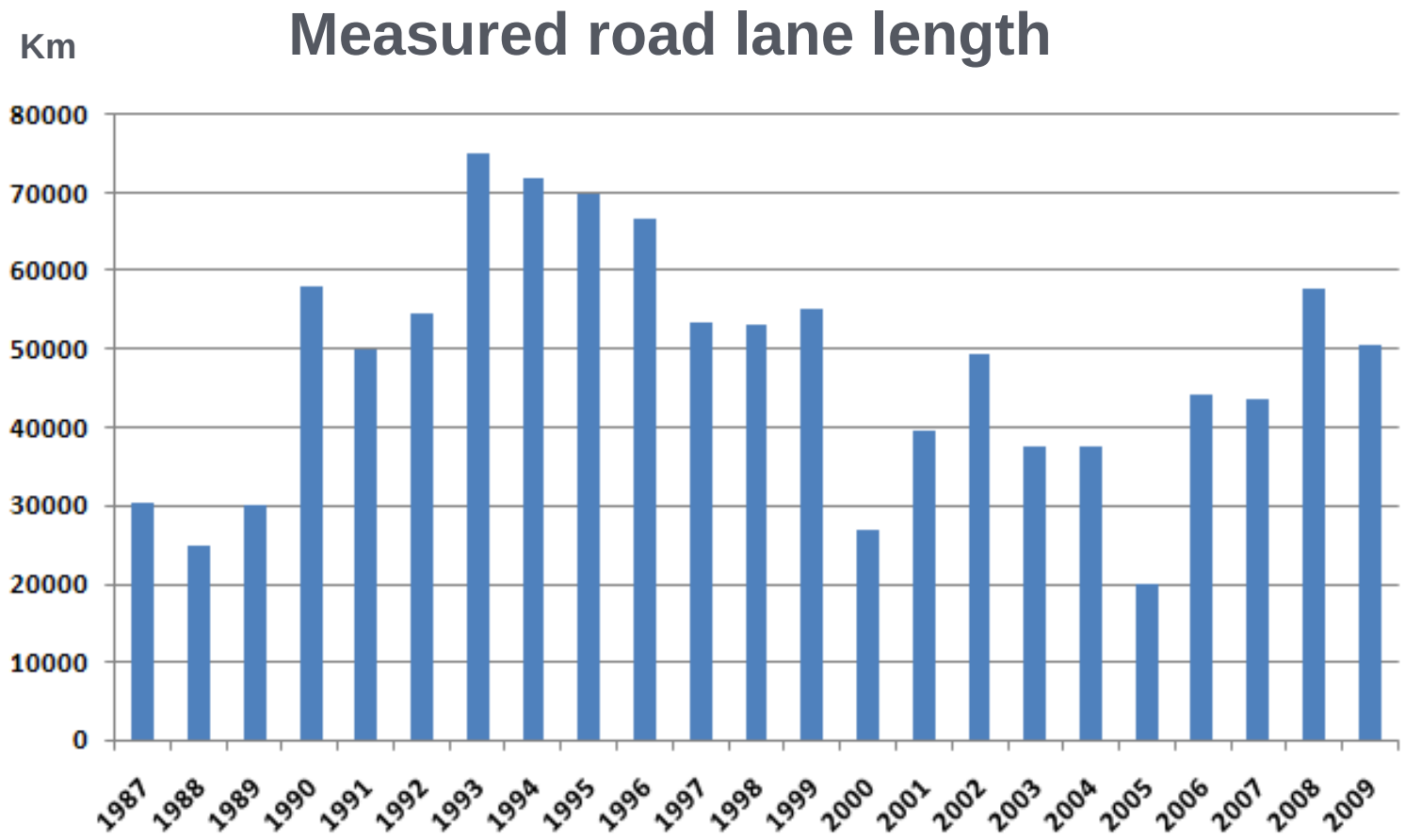
Automated measurements

Automated measurements

Condition data

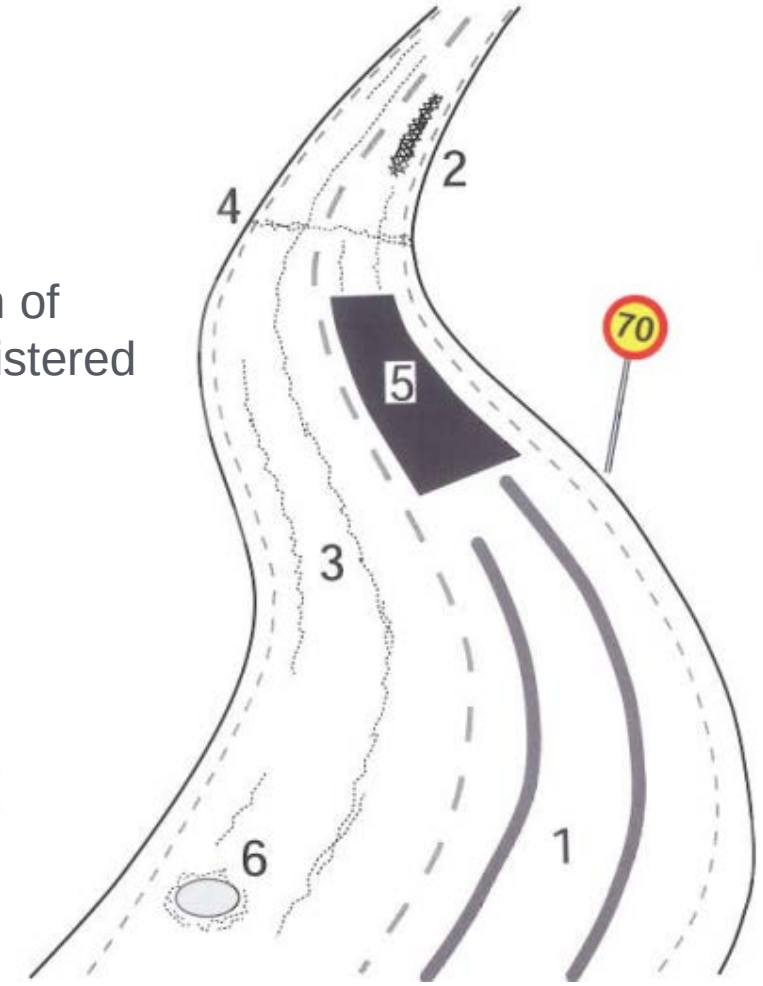
- Rut depth (1987)
- Unevenness IRI (1987)
- Cross fall, curvature, hilliness (1991)
- Cross profile
- Texture (2005)
- Edge deformation (2002)
- Longitudinal profile
- Cracks (not yet)
- Pictures

Automated measurements



Visual inspection

Severity and extension of different damages are registered



Unevenness – Roughness - Smoothness

Local uneveness or bumps

Rut depth

Wear of studded tires

Plastic deformation

Structural deformation

Poor surface drainage

Macrotexture

Cracking

Cracks

Frost dependent cracks

Edge cracking

Poor drainage

Water plants in the ditches

Stagnant water in the ditches

Eroded soil is filling the ditches

Pot holes

Bleeding asphalt

Ravelling

Svårighetsgrad 1

Svårighetsgrad 2

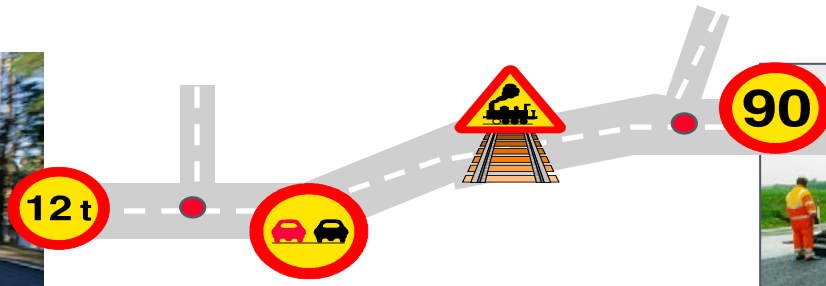
Svårighetsgrad 3

Surface dressing where stones get loose

Patching and local repair

PMS - Overview

PMS Components



Road condition

Longitudinal unevenness

Transversal unevenness

Road Inventory

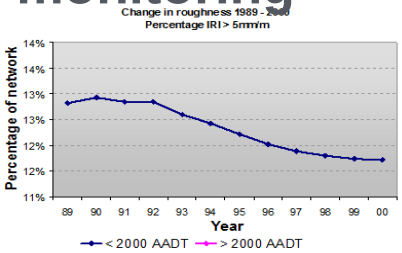
Pavement information

Database

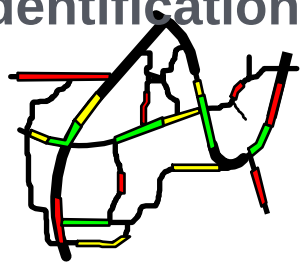
Evaluation models

Budget needs

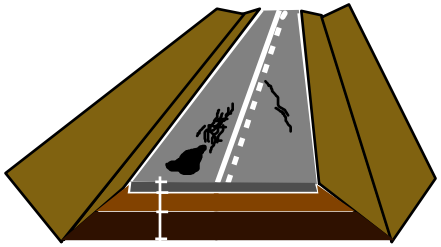
Condition monitoring



Project identification

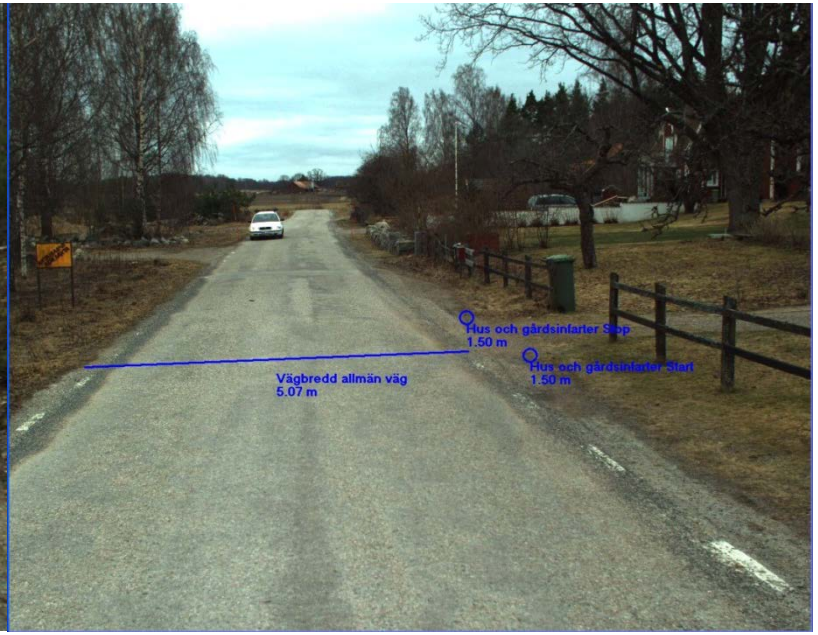


Follow-up contracts



Automated measurements

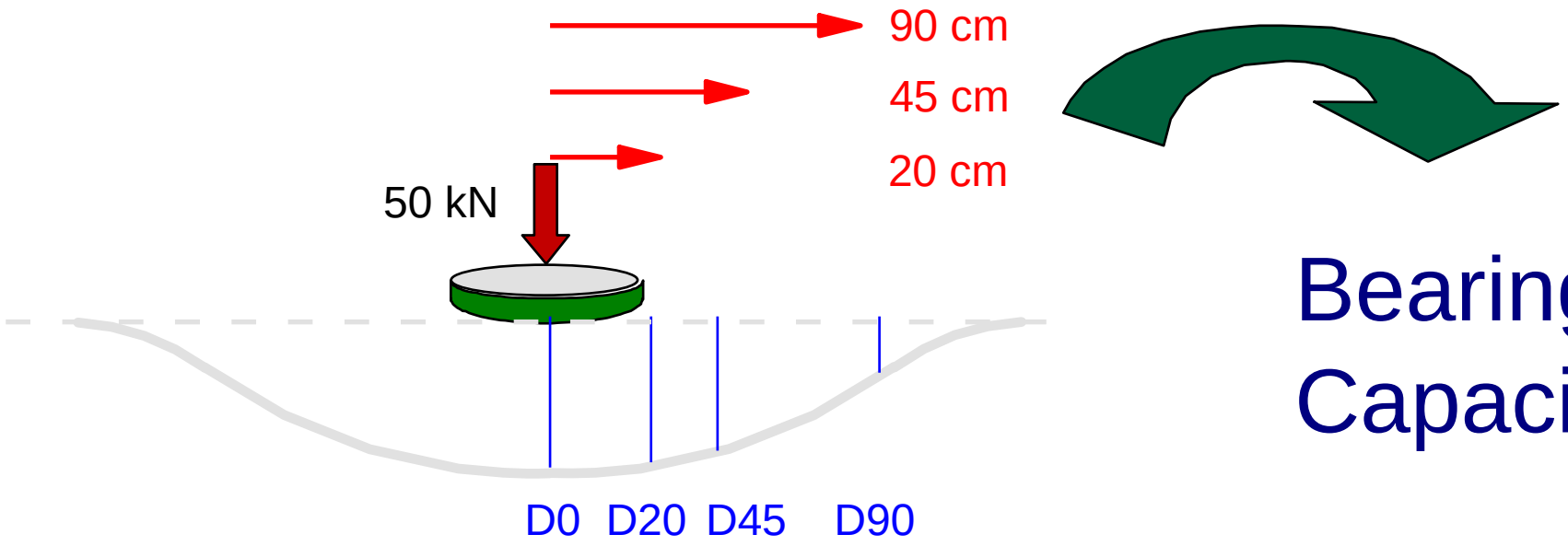
Visual inspection by using images



Inspection of damages

Measurement in stereo images

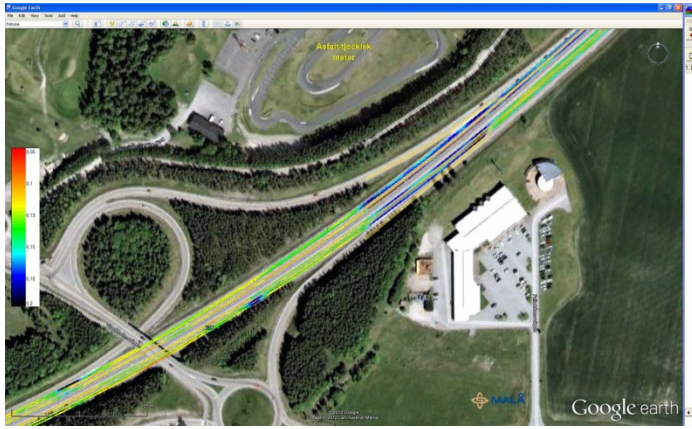
Falling Weight Deflectometer - FWD

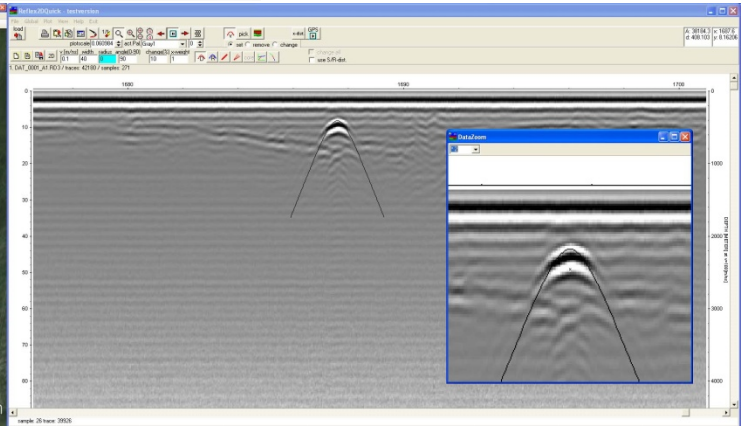


Bearing Capacity

Ground Penetrating Radar (GPR)

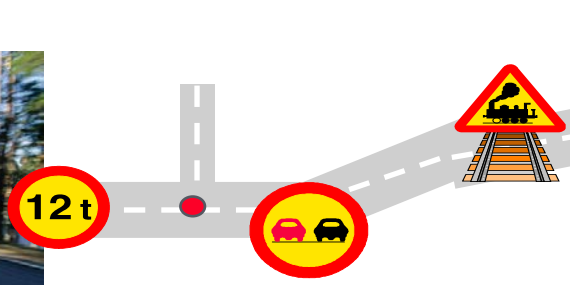
- Measuring thicknesses of pavement layers.
- Identifying solid objects in the road construction
- Different antennas for different depth





PMS - Overview

PMS Components



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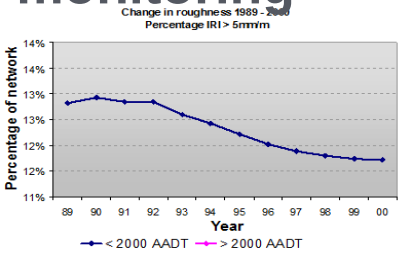
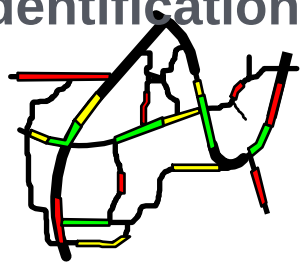
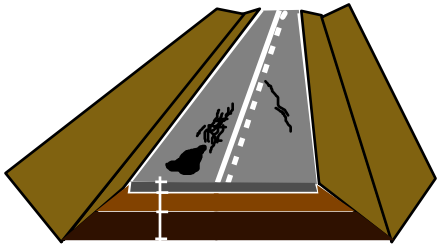
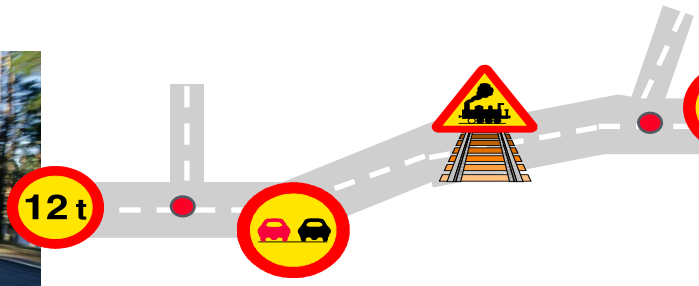


Project identification



Follow-up contracts





Road condition

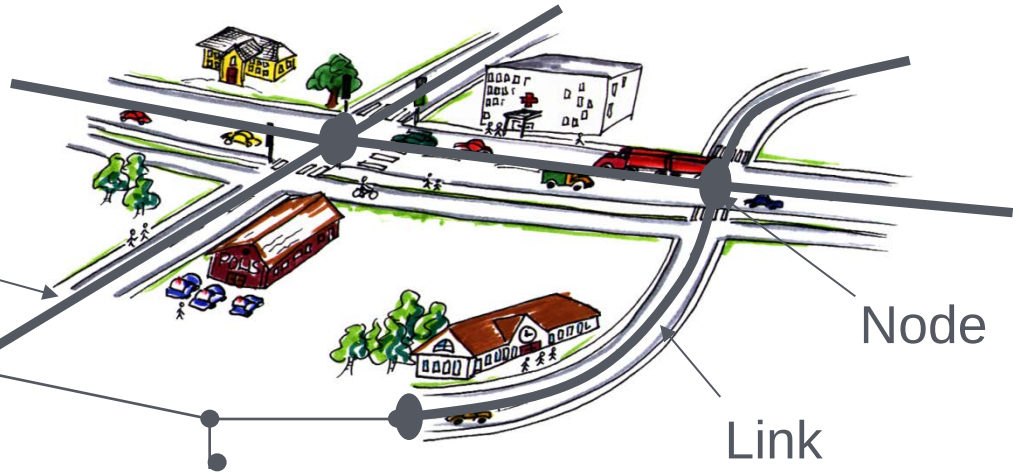
Road Inventory

Pavement information

Longitudinal unevenness

Transversal unevenness

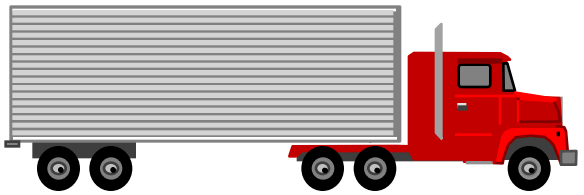
Coordinates x, y, z



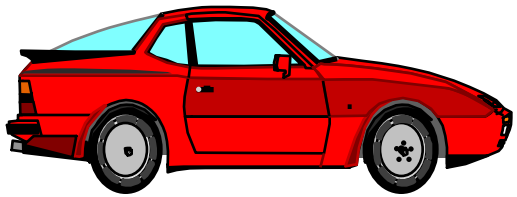
Node

Link

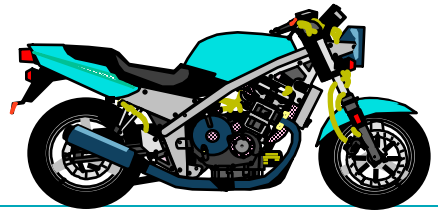
Traffic numbers are collected in the "Traffic Measurement System"



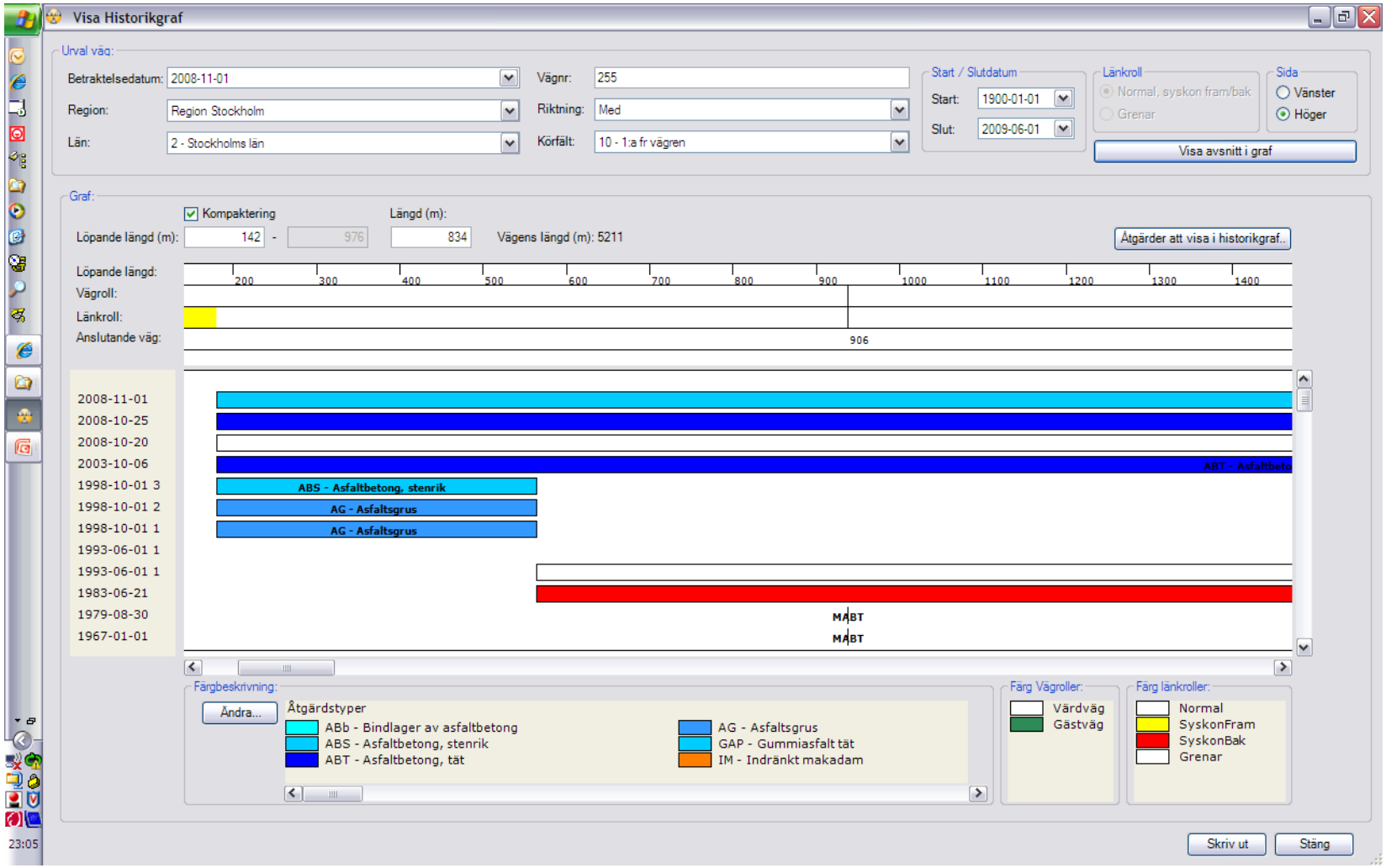
- Number of vehicles
- Number of axles
- Vehicle type



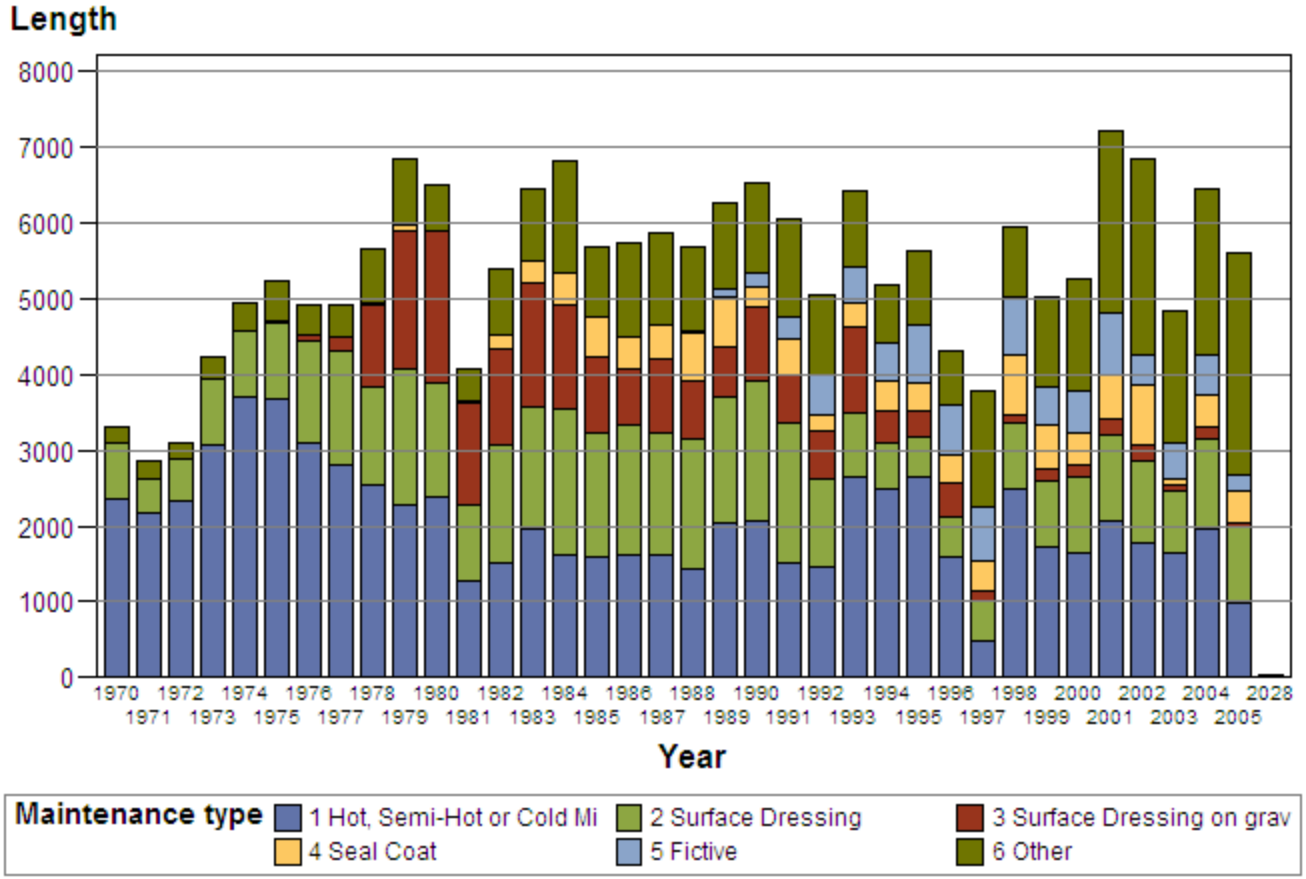
Based on traffic measurements Equivalent Standard Axle Loads is calculated



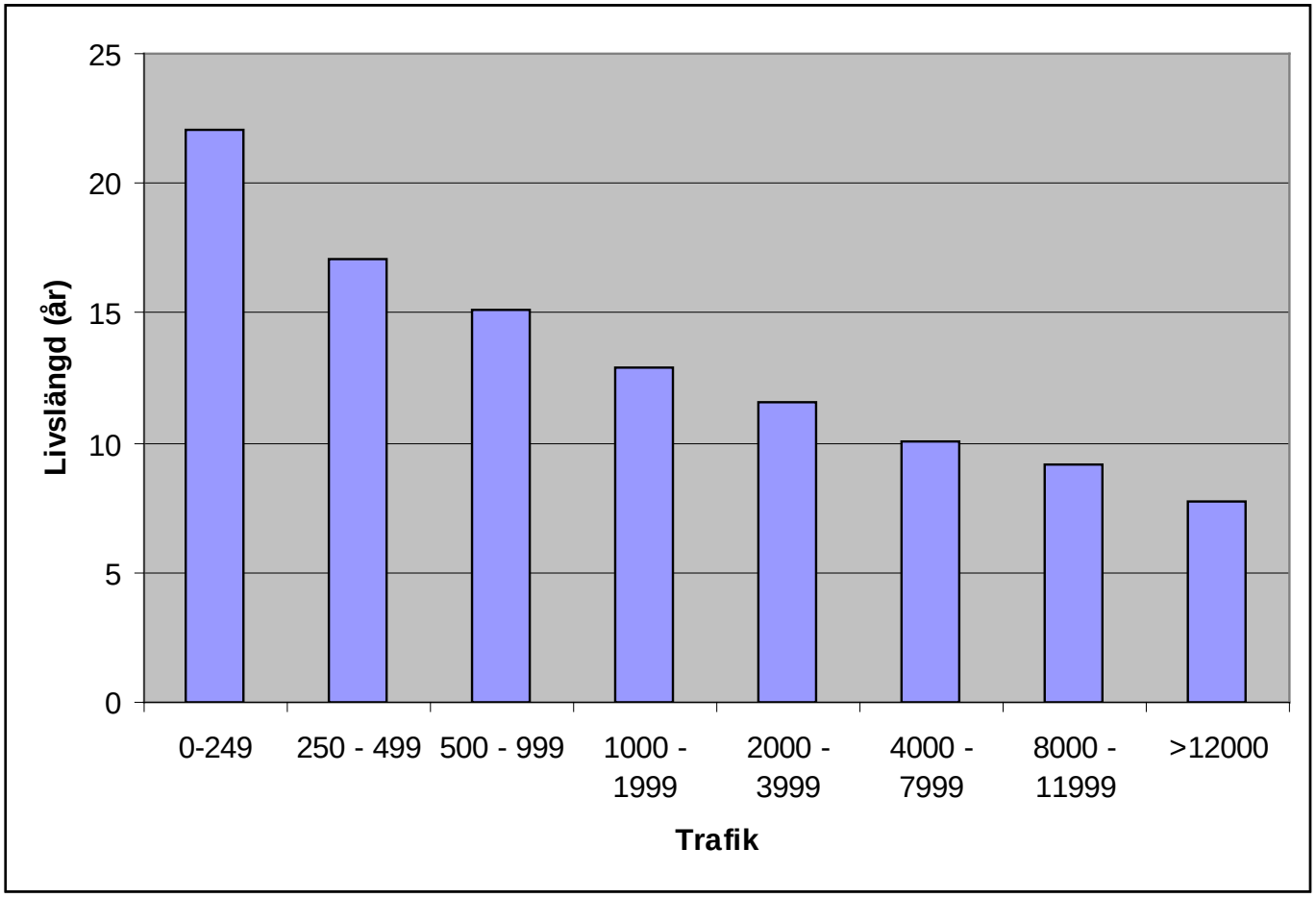
Example of output from the maintenance treatment database



The maintenance treatment database covers a long period



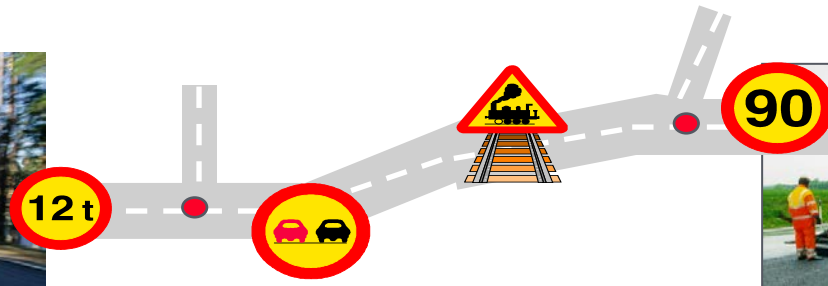
Expected durability



Survival analysis

PMS - Overview

PMS Components



Road condition

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Evaluation models

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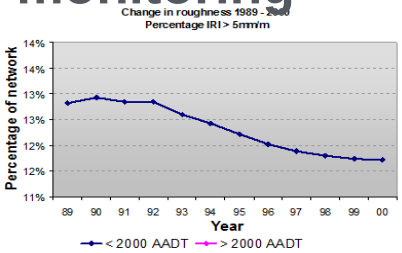
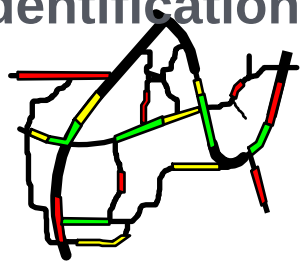
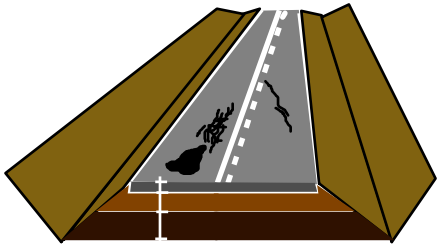
Condition monitoring

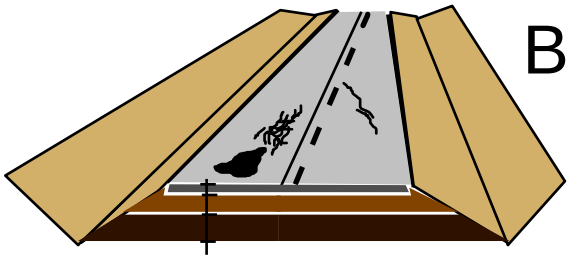


Project identification

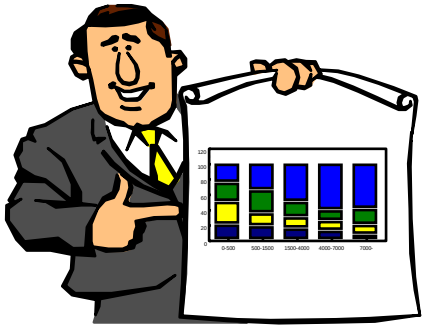


Follow-up contracts



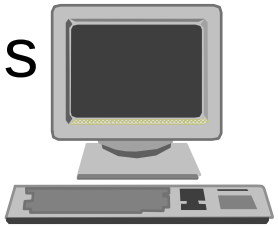


Benefits



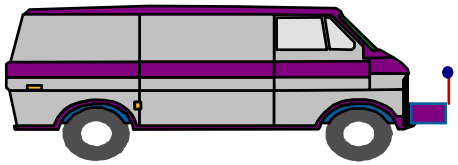
Users

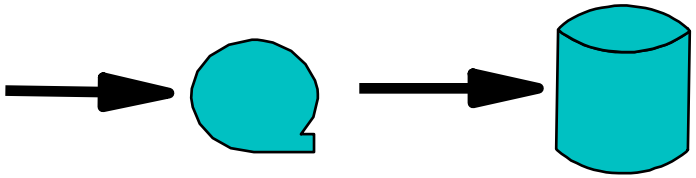
Systems



Evaluation

Data collection and storage





Road Data Bank

PMS is a

Decision

Support

System

Who are the users?

Primary users

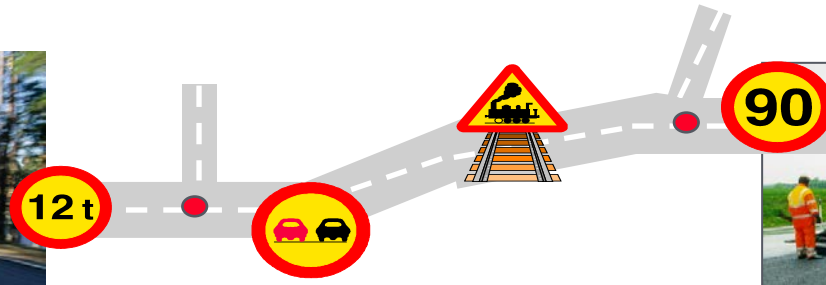
- Performs analysis and produce outputs from the system (measurements, data storage, analysis, further development)
- Skilled engineers

Secondary users

- Uses the results of the system
- Managers

PMS - Overview

PMS Components



Road condition

Longitudinal unevenness

Transversal unevenness

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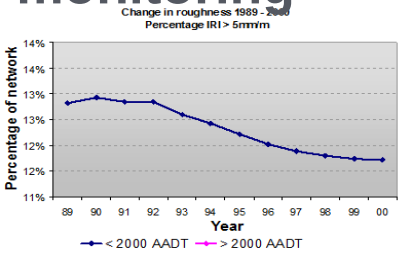

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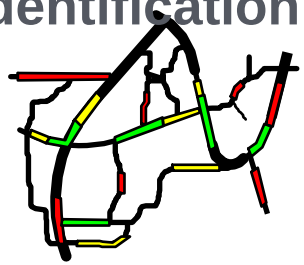

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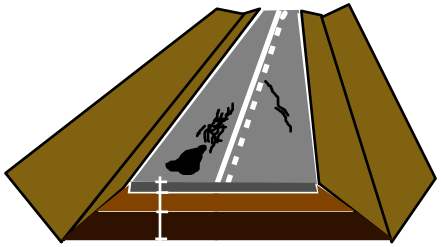
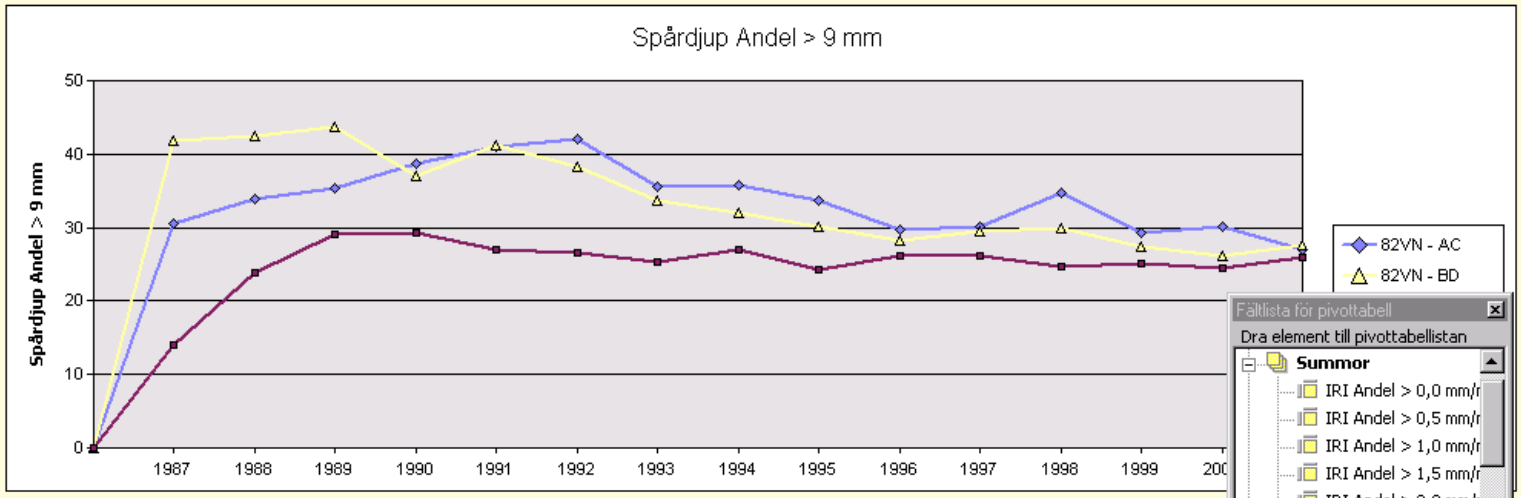


Vägverket

Uppföljning PMS Vägnät

Tillståndsförändring Spårdjup



IRI_Spar

Hastighet	Hastighetsklass	Trafikklass 1	Trafikklass 2	Trafikklass 3
All Hastighet	All Hastighetsklass	All Trafikklass 1	All Trafikklass 2	All Trafikklass 3

		Årtal	(tom)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Region	Lan	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj	Spårdj
⊟ 82VN	AC	######	31	34	35	39	41	42	36	36	34	30	30	35	29	30	27	
	BD	######	42	42	44	37	41	38	34	32	30	28	30	30	27	26	28	
⊞ 85VVAE		######	14	24	29	29	27	27	25	27	24	26	26	25	25	24	26	

Fel på sidan.

Fältlista för pivottabell

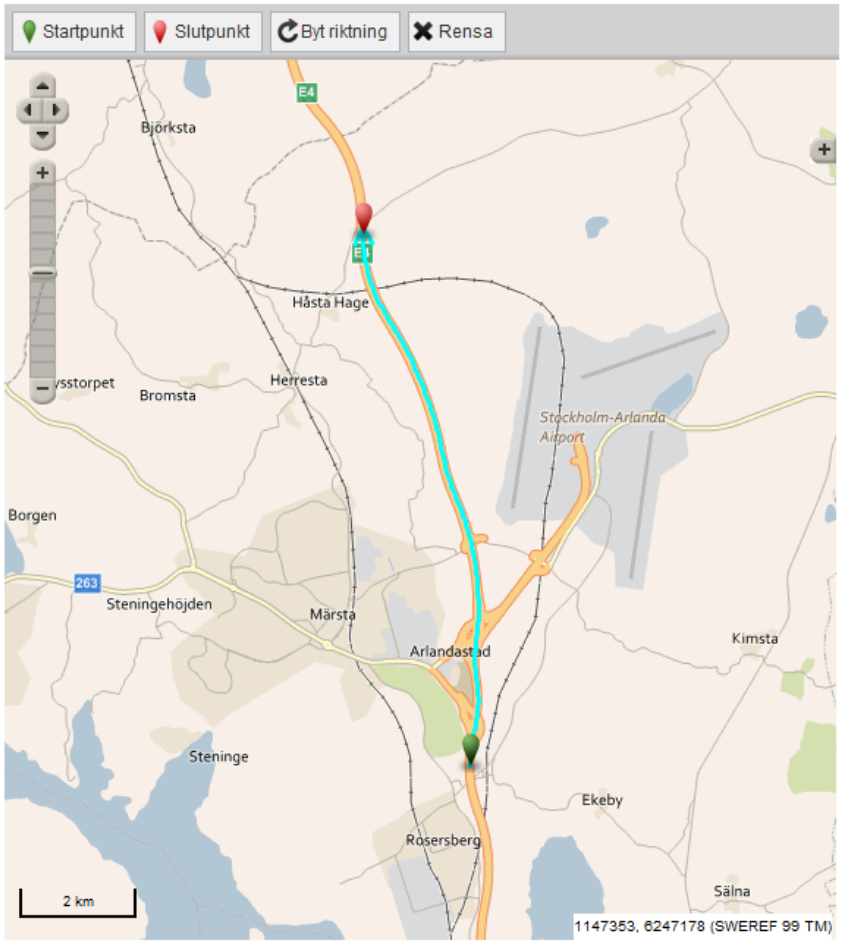
Dra element till pivottabellistan

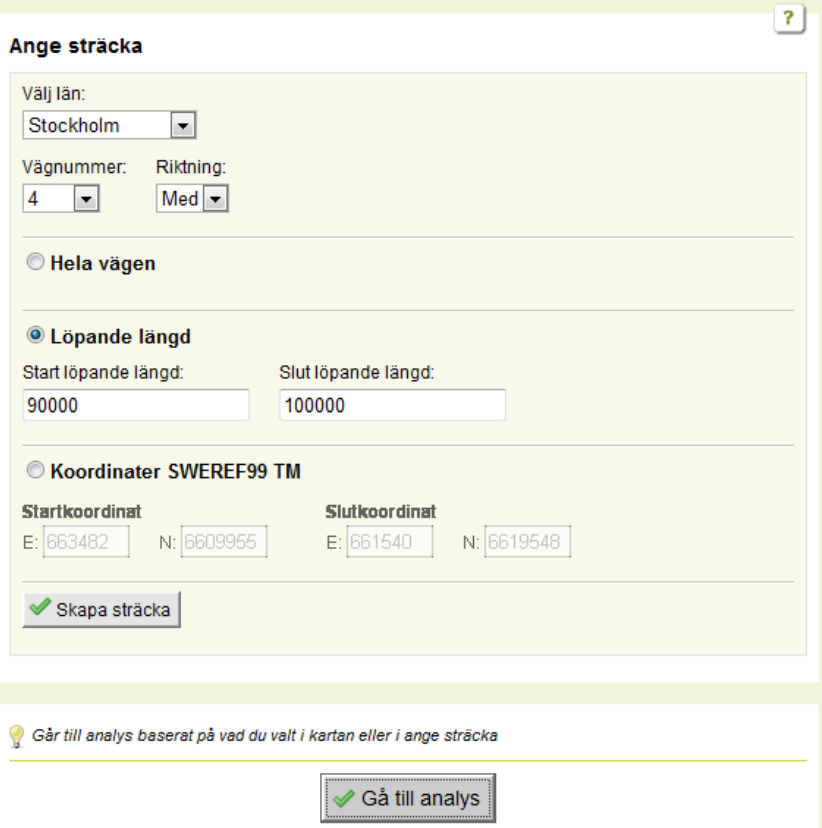
Summor

IRI Andel > 0,0 mm/r
IRI Andel > 0,5 mm/r
IRI Andel > 1,0 mm/r
IRI Andel > 1,5 mm/r
IRI Andel > 2,0 mm/r
IRI Andel > 2,5 mm/r
IRI Andel > 3,0 mm/r
IRI Andel > 3,5 mm/r
IRI Andel > 4,0 mm/r
IRI Andel > 4,5 mm/r
IRI Andel > 5,0 mm/r
IRI Andel > 5,5 mm/r
IRI Andel > 6,0 mm/r
IRI Andel > 6,5 mm/r

Lägg till | Radområde

Output example from the New Swedish PMS





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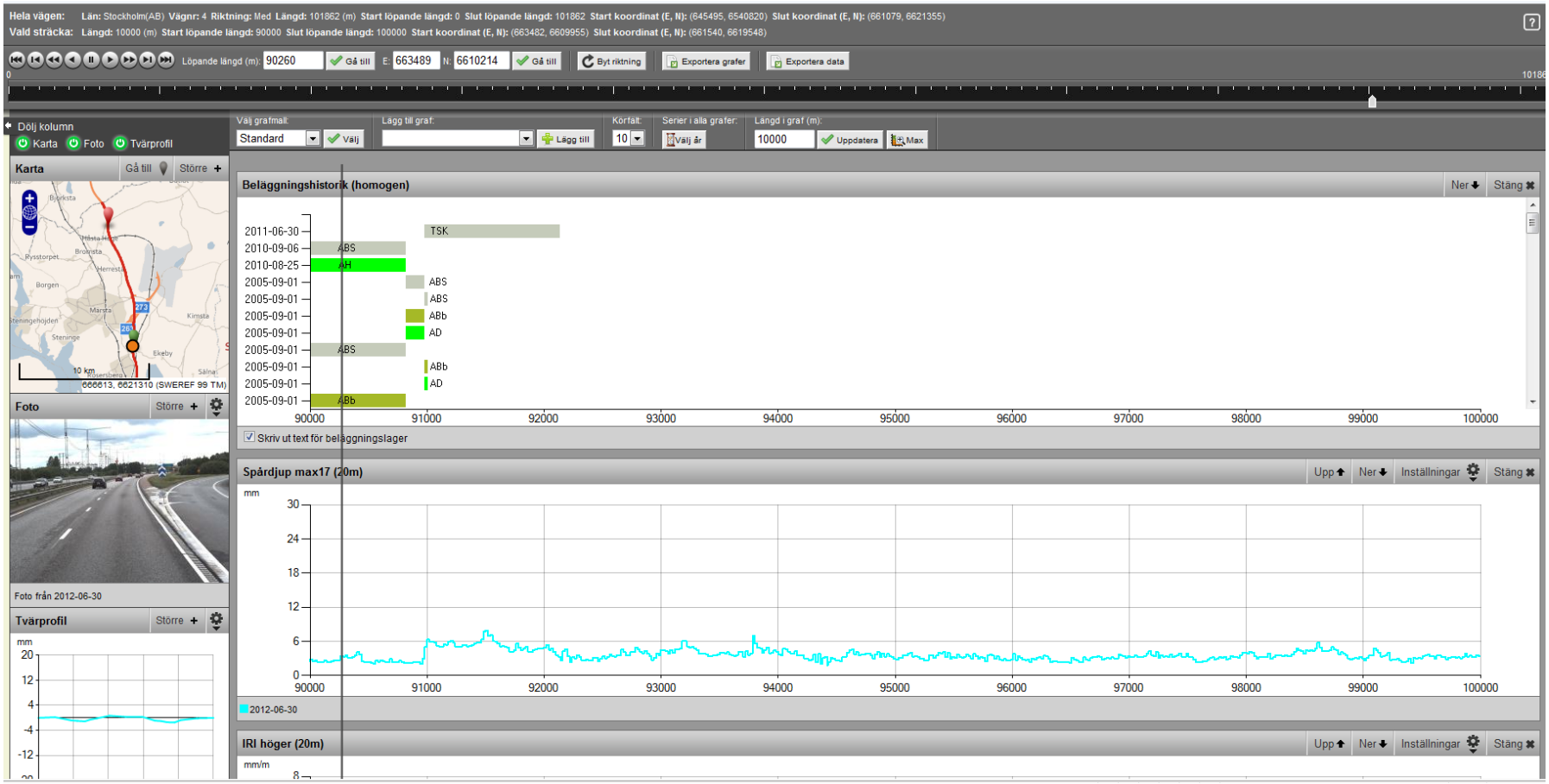
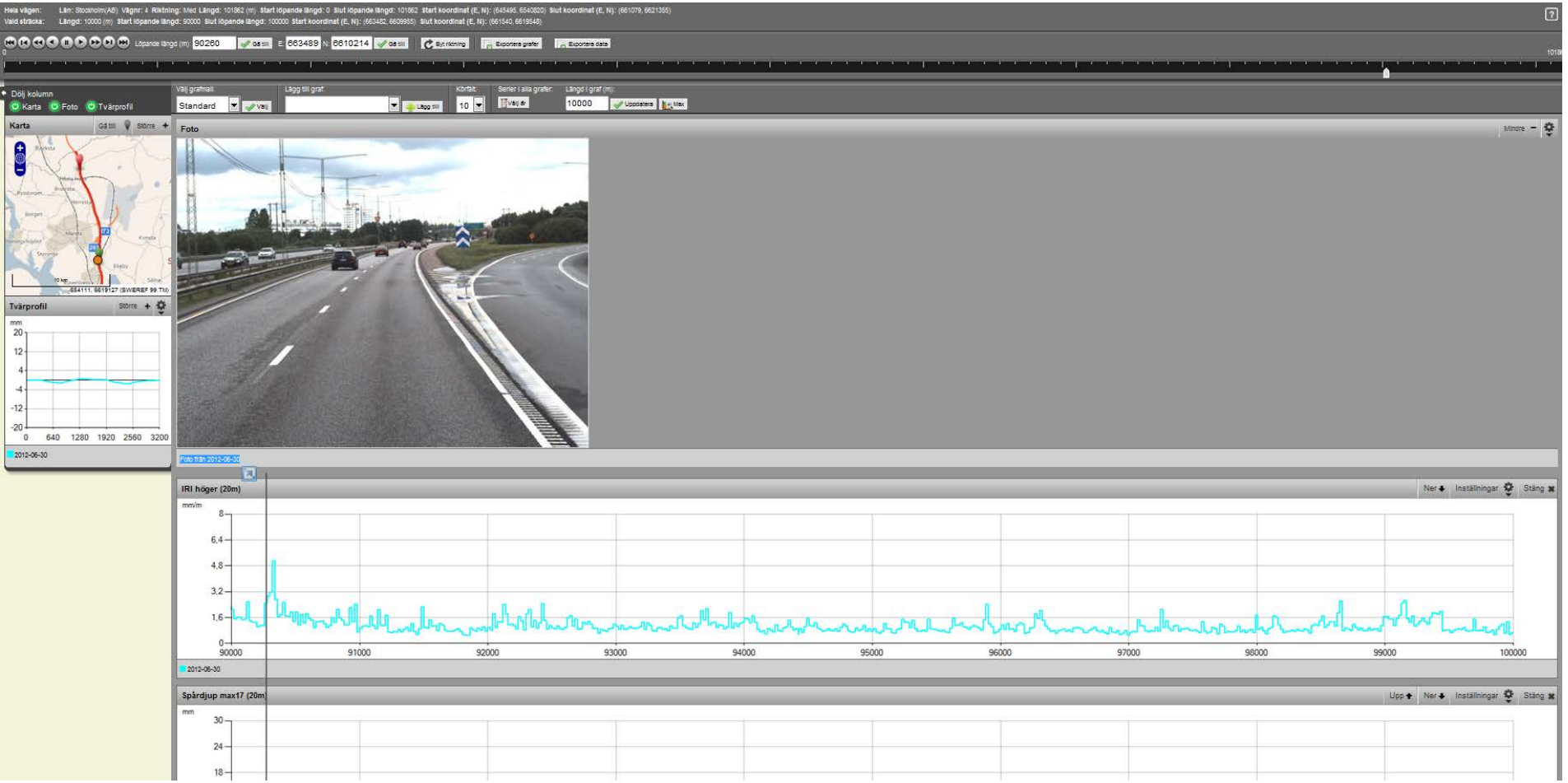


Output example from the New Swedish PMS

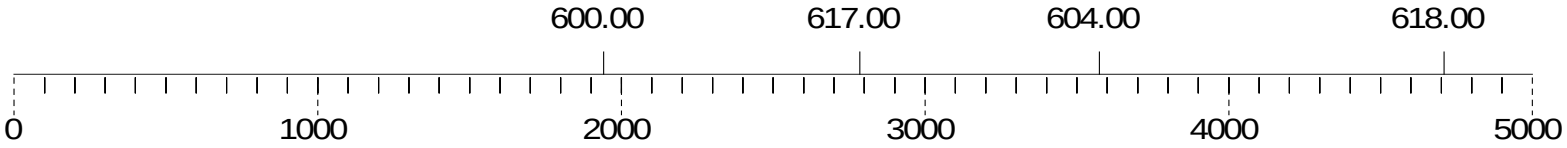


VÄGVERKET
PMS
20000531, 13.12

Road Surface Condition
Dalarnas län , Väg: 60.00

Sträcka: 0 - 5000, Körfält: 10, Riktning: Framåt, Sida för vägdata: 1

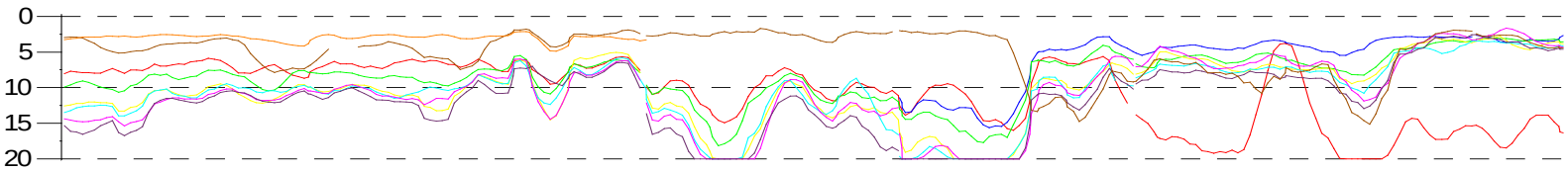
Vägversion: 19991205



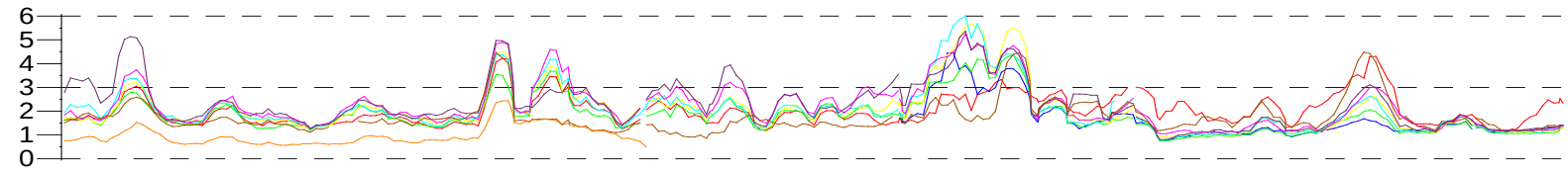
Vägbredd(m)	7.0			8.0				11.7
Trafik(ÅDT)	3190			6090			5780	
Tung traf(ÅDT)	.			550			530	
Bel.lager 1	0Y1B1681			35ABS1198			32HABS1293	
Bel.lager 2	16MABT1280			0ABT1698		1)	0MABT1292	
Bel.lager 3	24MABT1275			32HABT1287		2)	3)	28HABT1286

1)32MABT1285,2)24MABT1279,3)32MABT1285,

Spårdjup (mm)



Ojämnhet IRI(mm/m)



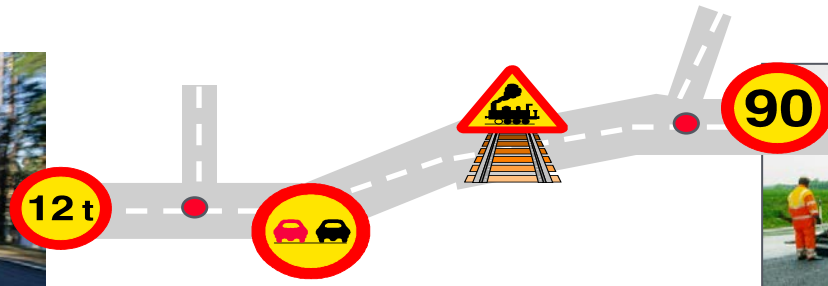
930601 930721 940530 950607 960609 970605
980627 990617 991023

Best1

https://pmsv3.trafikverket.se/

PMS - Overview

PMS Components



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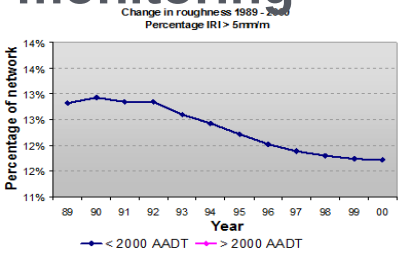
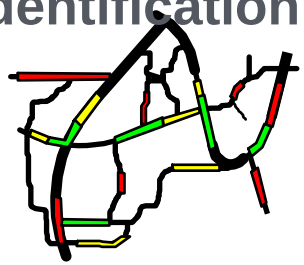
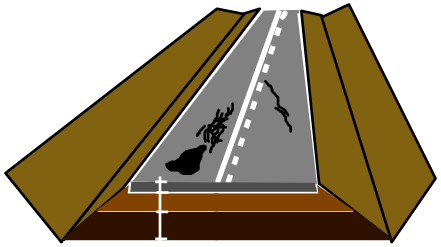


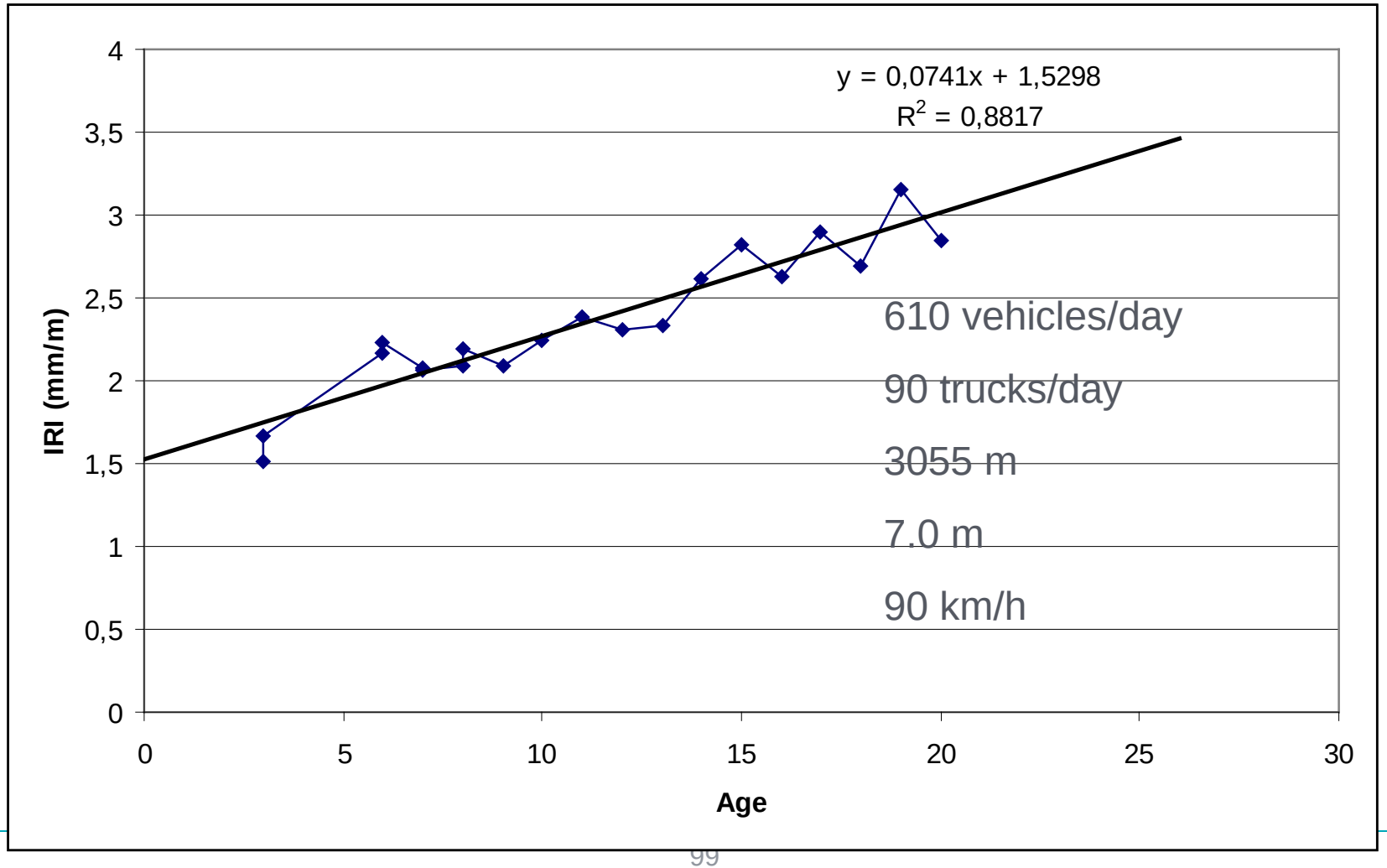
Project identification

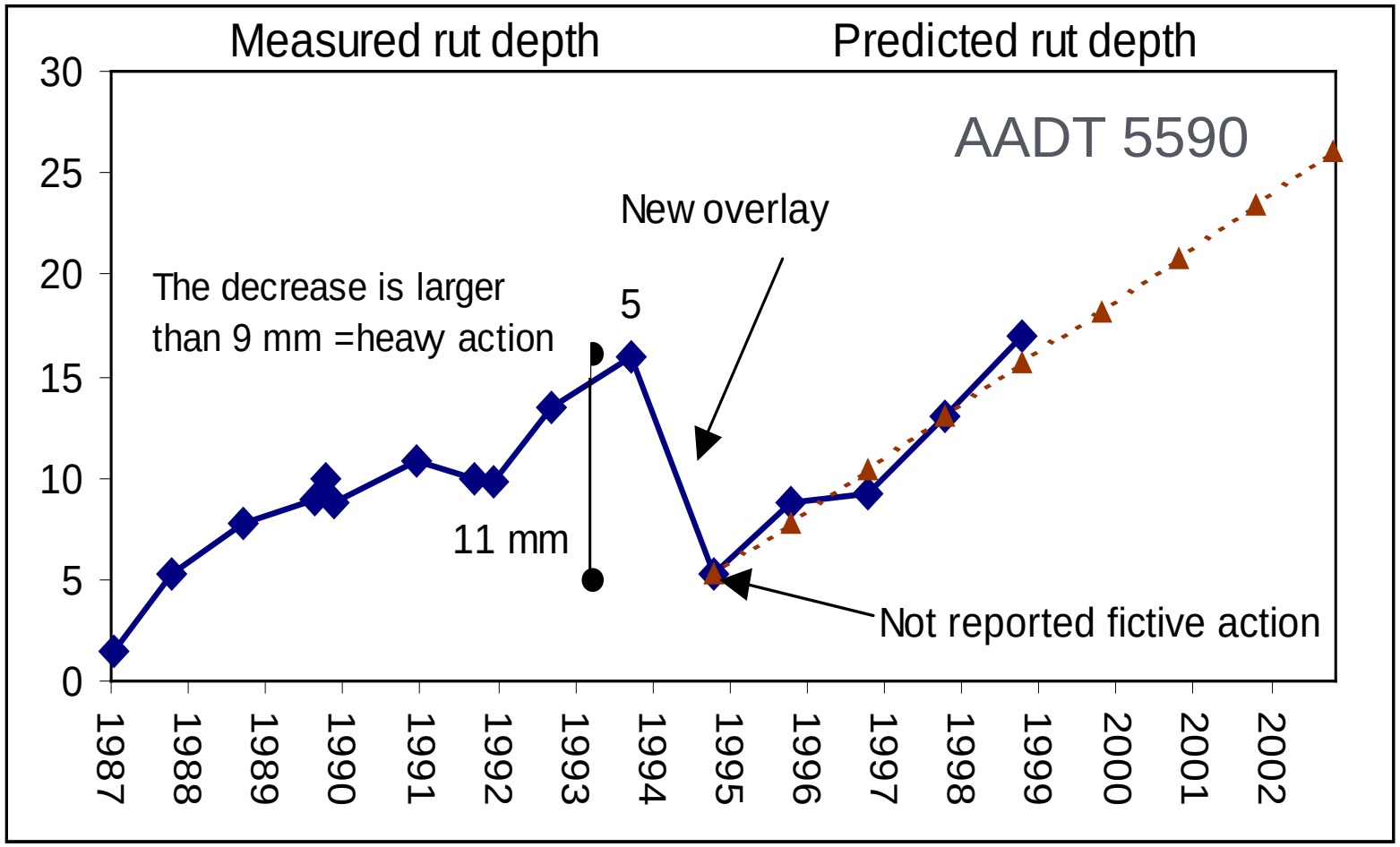


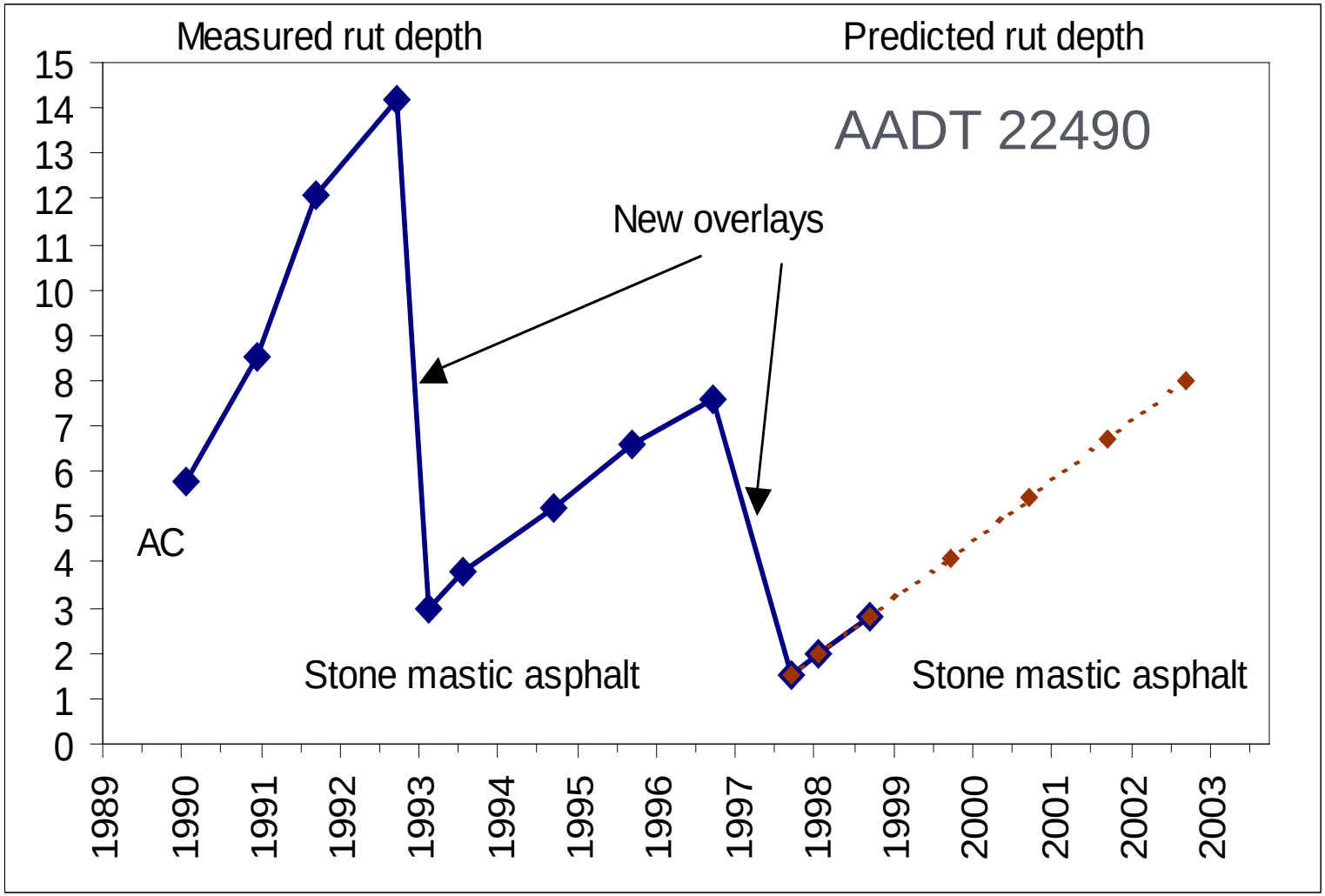
Follow-up contracts



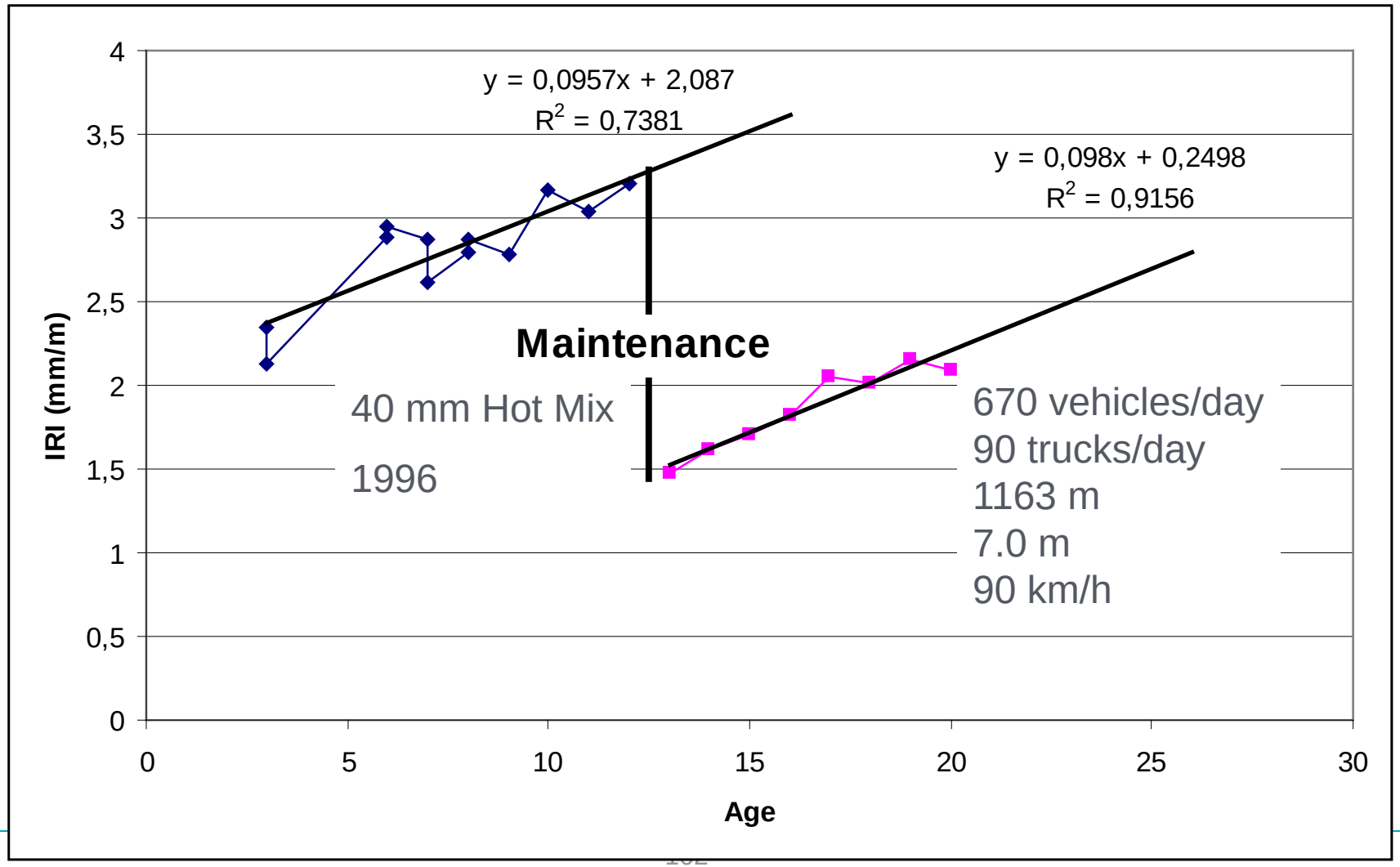
Change in condition



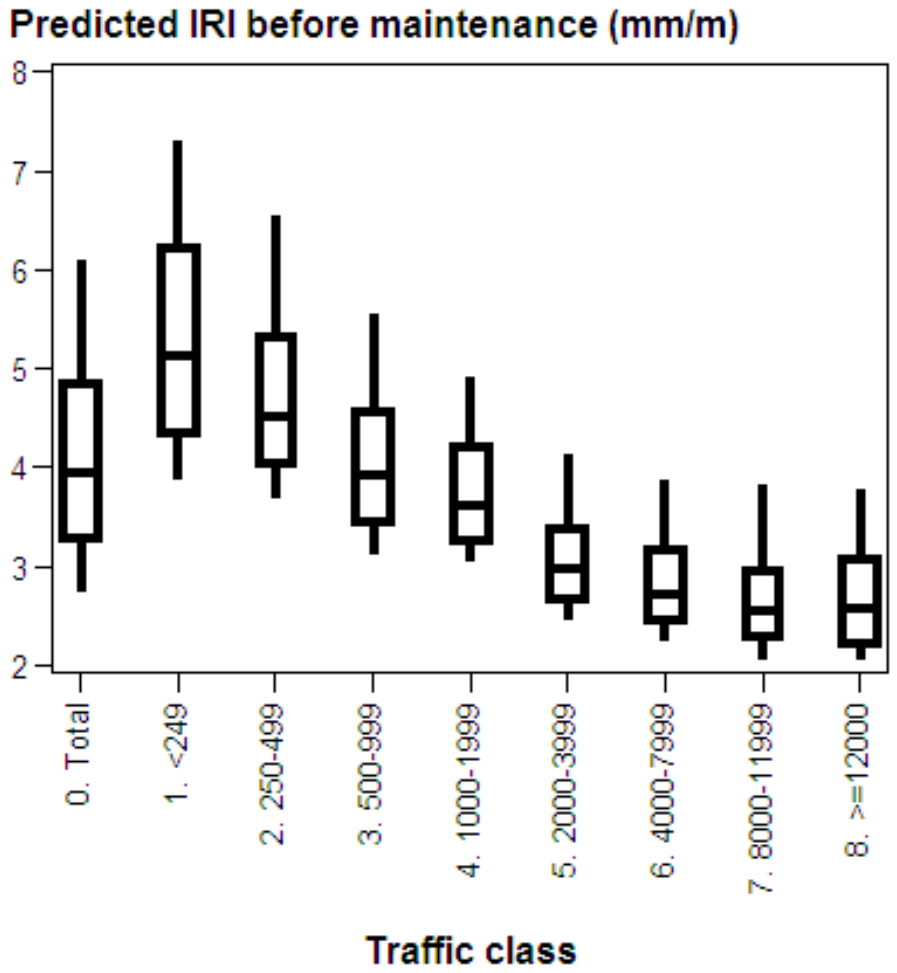

Measured rut depth
Predicted rut depth
AADT 5590
New overlay
The decrease is larger
than 9 mm =heavy action
5
11 mm
Not reported fictive action
30
25
20
15
10
5
0
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002


Measured rut depth
Predicted rut depth
AADT 22490
New overlays
AC
Stone mastic asphalt
Stone mastic asphalt
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

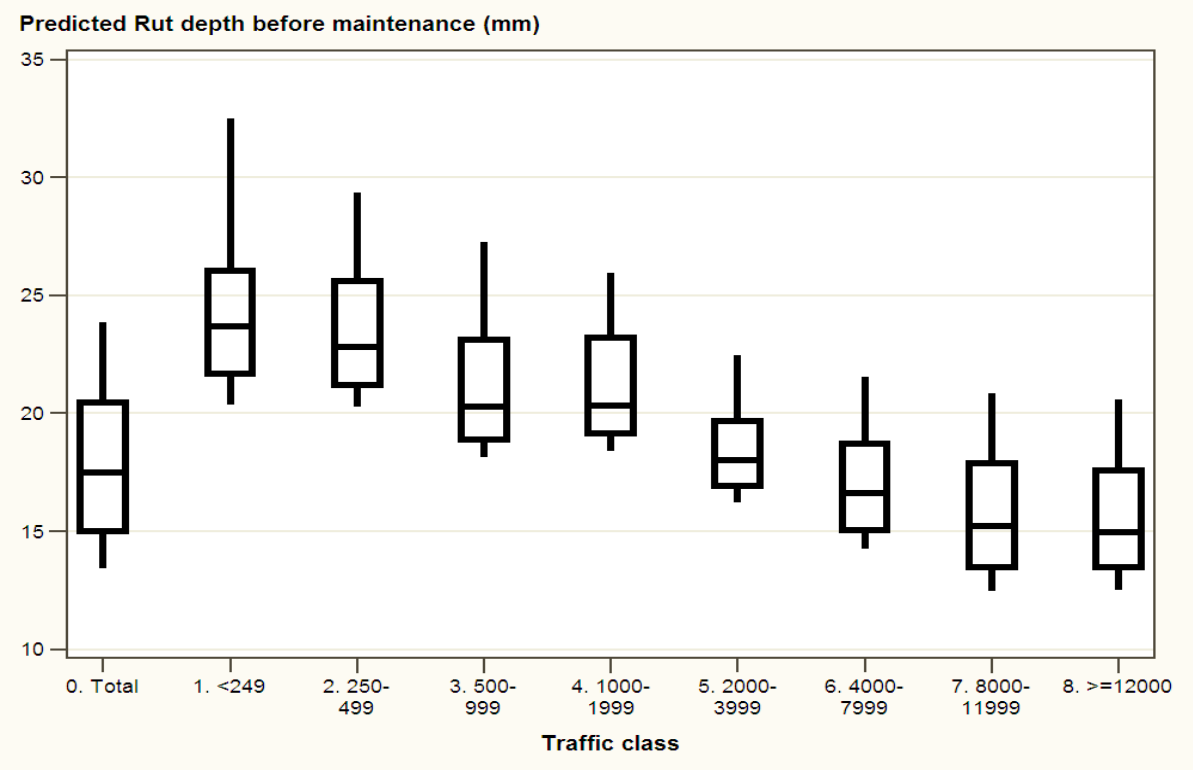
Maintenance effect



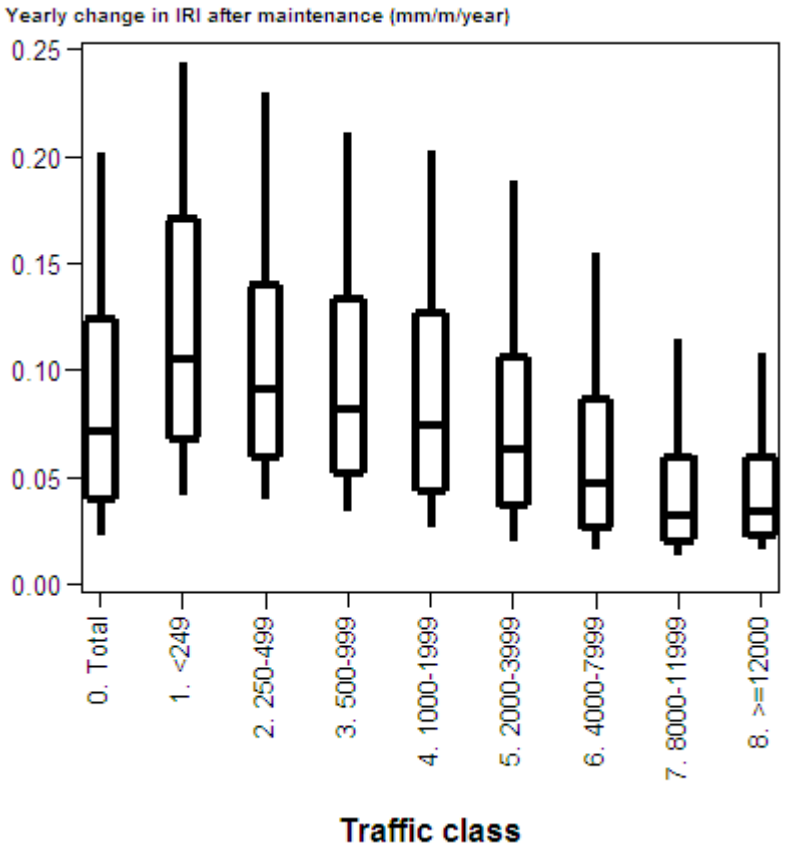
Predicted unevenness before maintenance

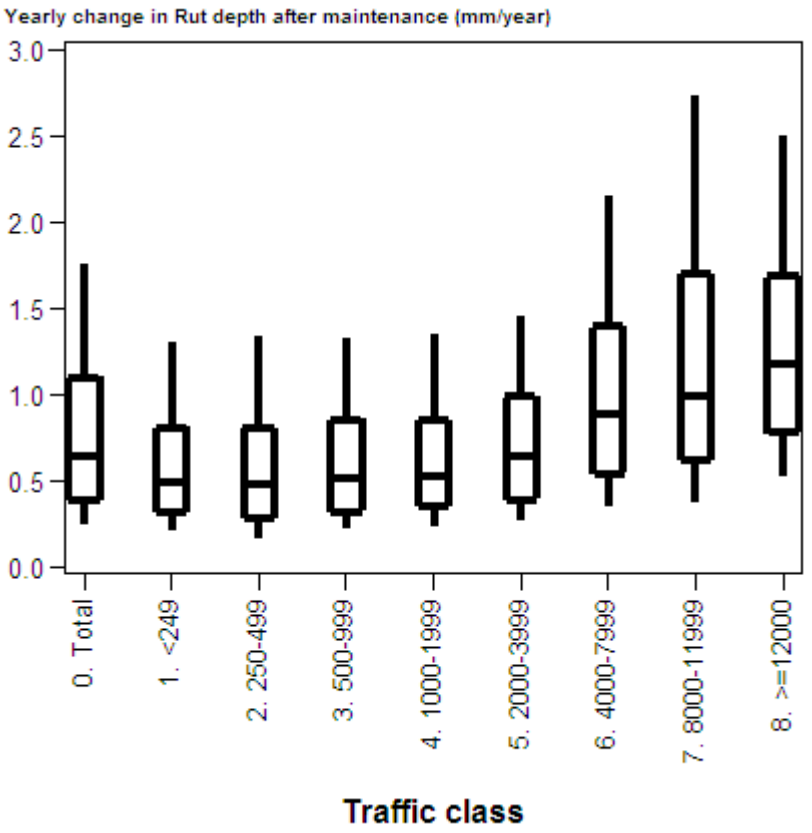


Predicted rut depth before maintenance



Yearly change in condition





How much can different types of maintenance improve the surface condition?

CM=Cold Mix

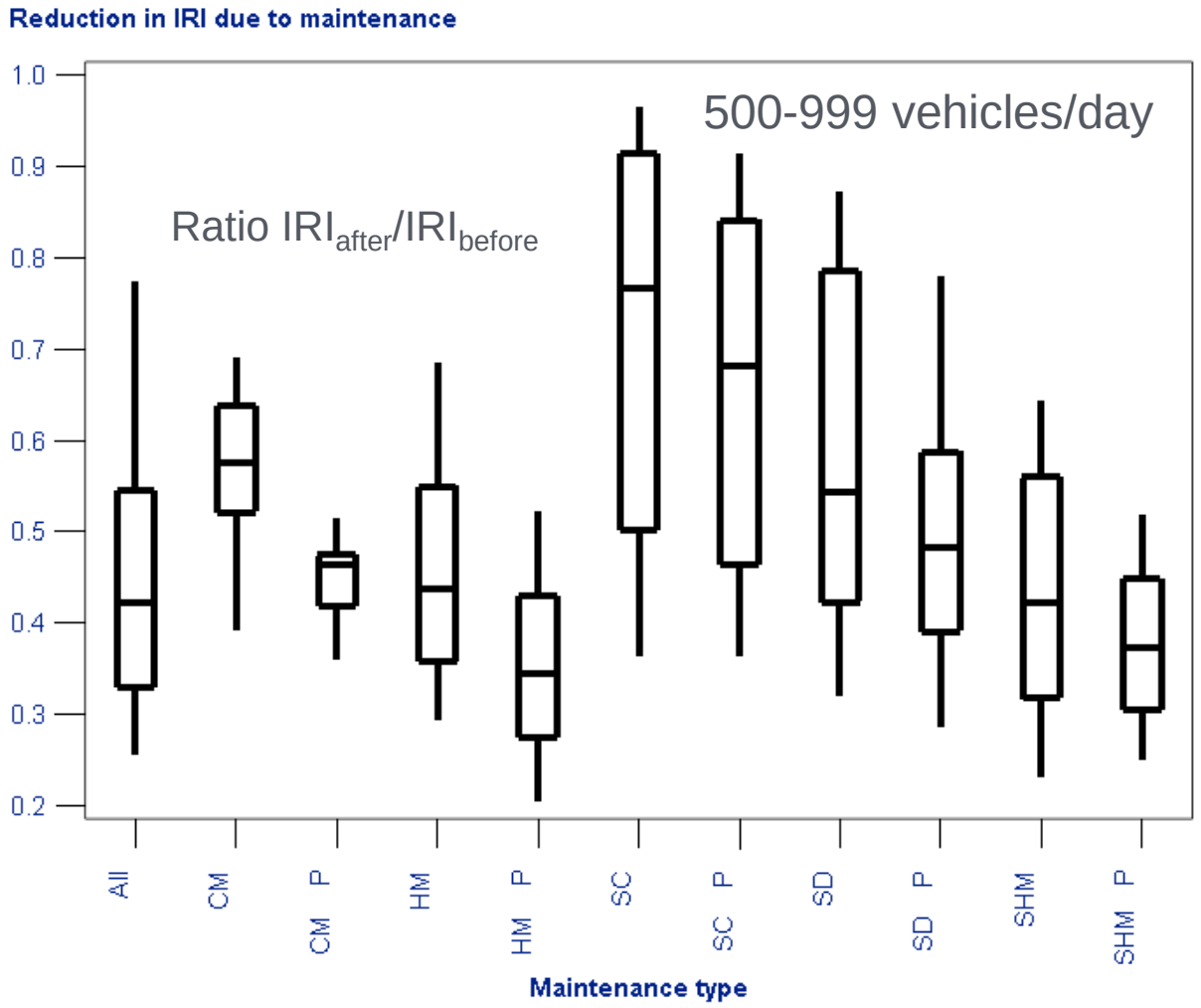
HM=Hot Mix

SC=Seal Coat

SD=Surface Dressing

SHM=Semi-Hot Mix

P=Preparatory work



Pavements for the road users

Comfort

Road Safety

Internal

Noice

External

Fuel

Vehicle operating costs

Tire

Rep-air

Particles

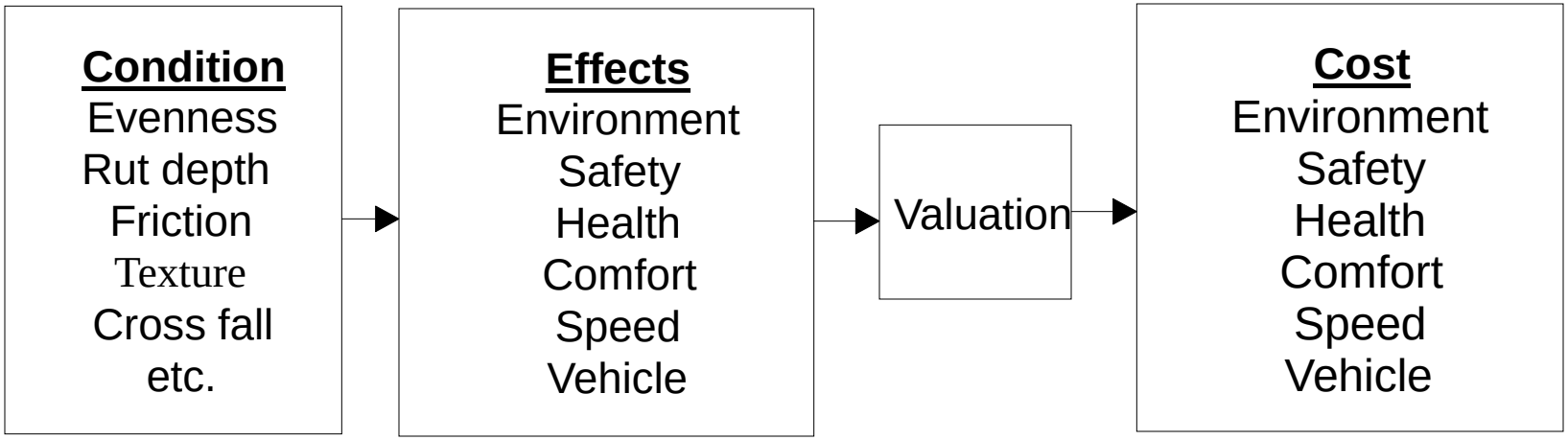
PM10 PM2.5l

Emission

CO2

Travel time

Access


Condition
Evenness
Rut depth
Friction
Texture
Cross fall
etc.
Effects
Environment
Safety
Health
Comfort
Speed
Vehicle
Valuation
Cost
Environment
Safety
Health
Comfort
Speed
Vehicle

Influence

Big

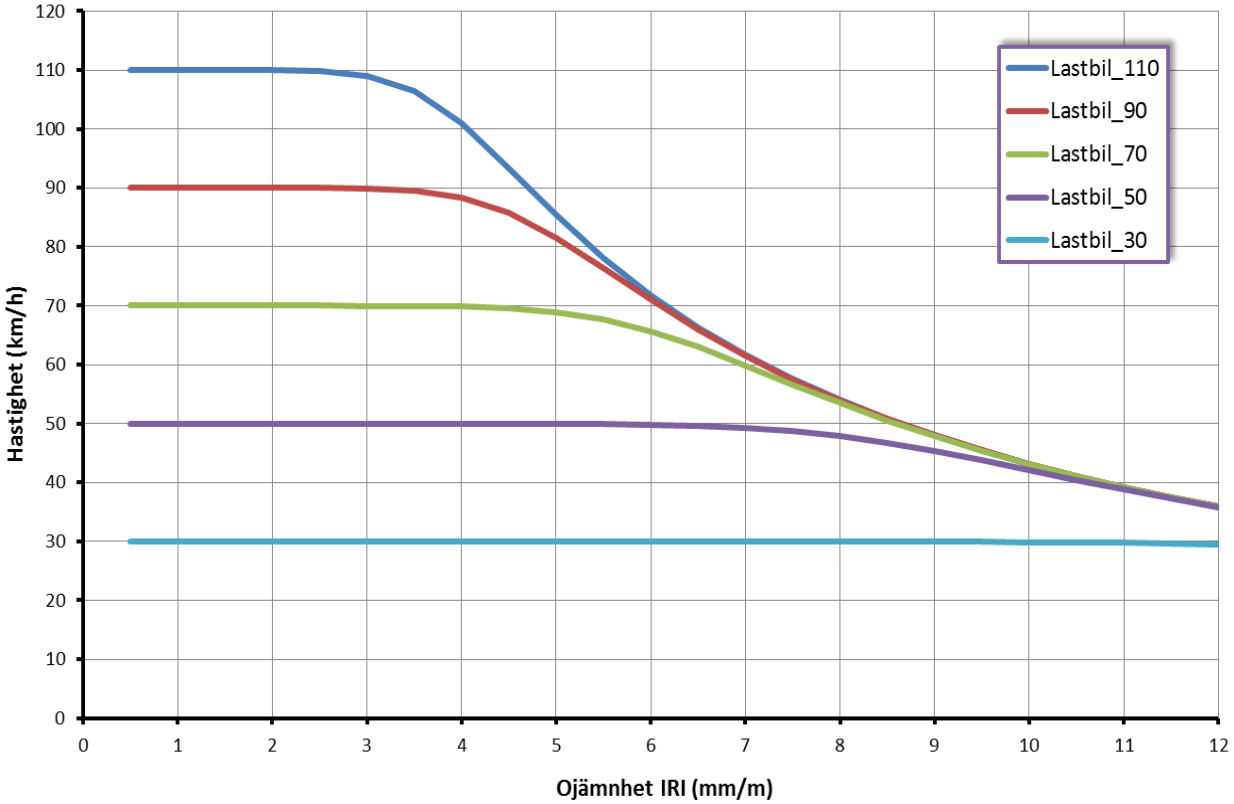
Fair

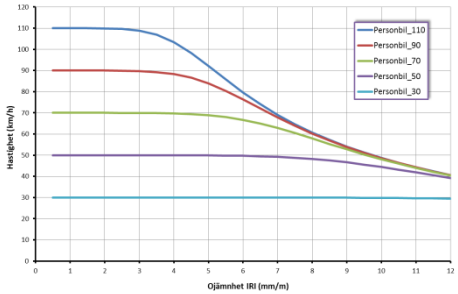
Low

None

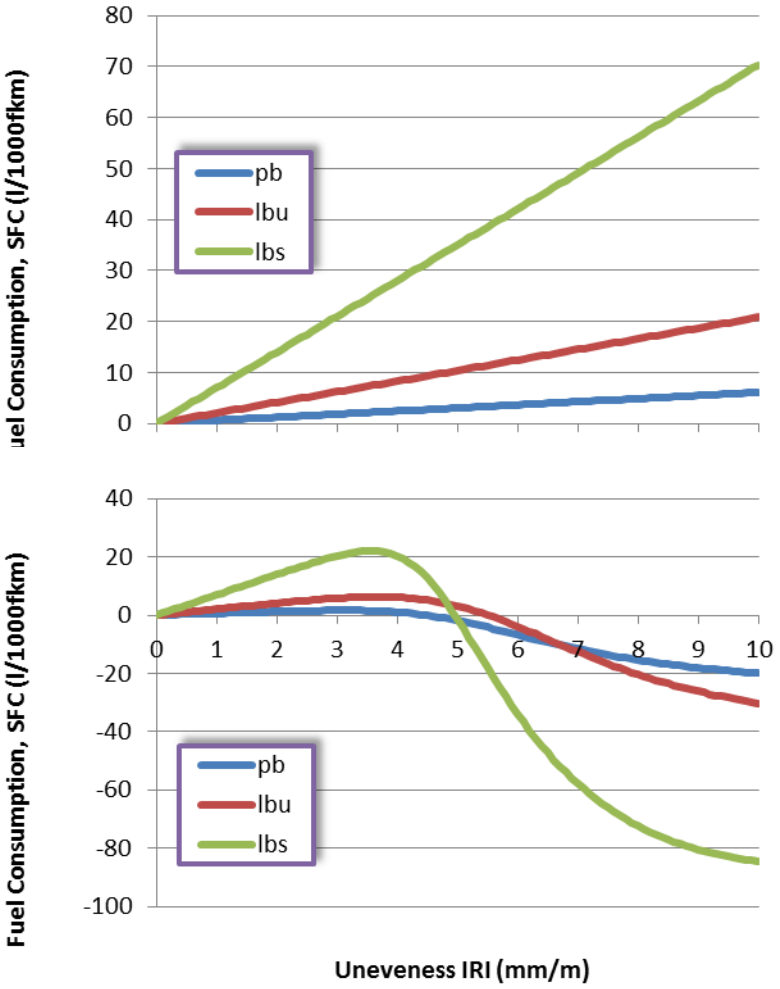
	Speed	Safety	Comfort	Vehicle damage	Tyre wear	Fuel consumption	Choice of road	Transport damage	Noice	Pollution	Longevity	Winter maintenance
Rut Depth	2	1	2	1	1	1	1	1	1	2	3	2
Rut shape	2	?	2	1	1	1	1	1	1	0	0	2
Roughness	3	2	3	3	2	3	3	3	2	1	3	2
Megatexture	2	2	3	3	2	3	2	3	3	1	2	2
Macrotexture	0	0	2	1	3	3	0	0	3	1	0	2
Microtexture	0	0	0	0	3	1	0	0	1	0	0	0
Friction	3	3	2	0	0	0	2	0	0	0	0	0
Retroreflection	2	2	2	0	0	0	1	0	0	0	0	0
Crossfall	1	1	1	1	1	1	0	0	0	1	2	0
Water permeability	2	2	2	0	0	1	1	0	1	3	1	2
Bearing Capicity	0	0	0	0	0	1	3	0	0	0	3	0
Stiffness	0	0	0	0	0	2	0	0	1	0	0	0

IRI vs Speed - Trucks

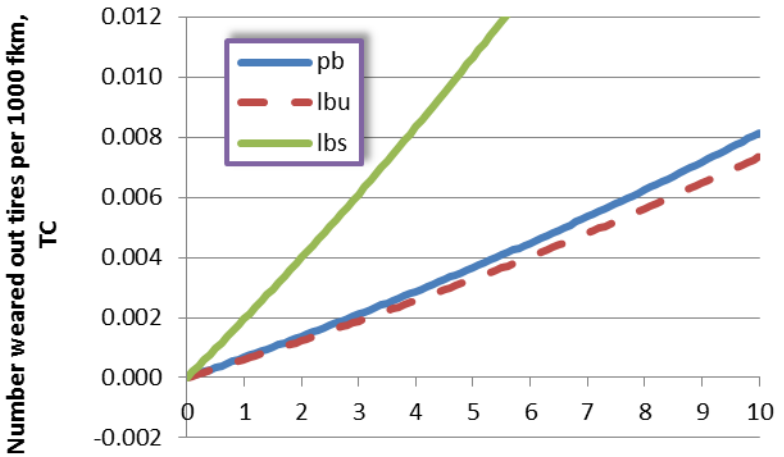


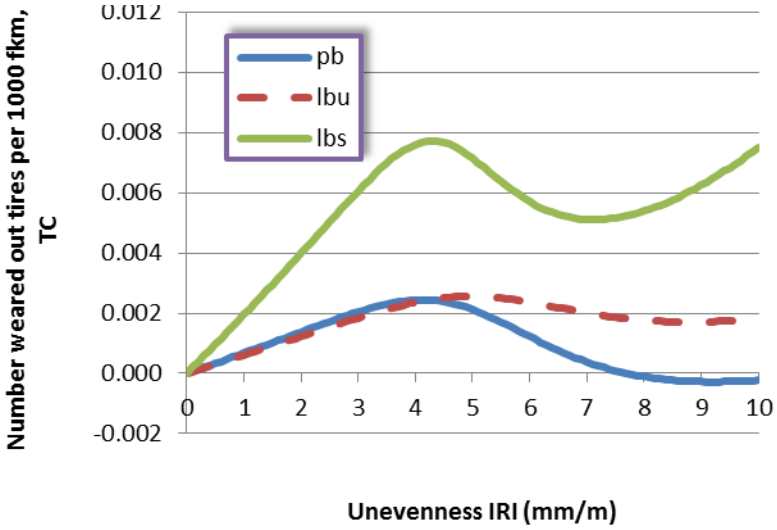


Fuel consumption

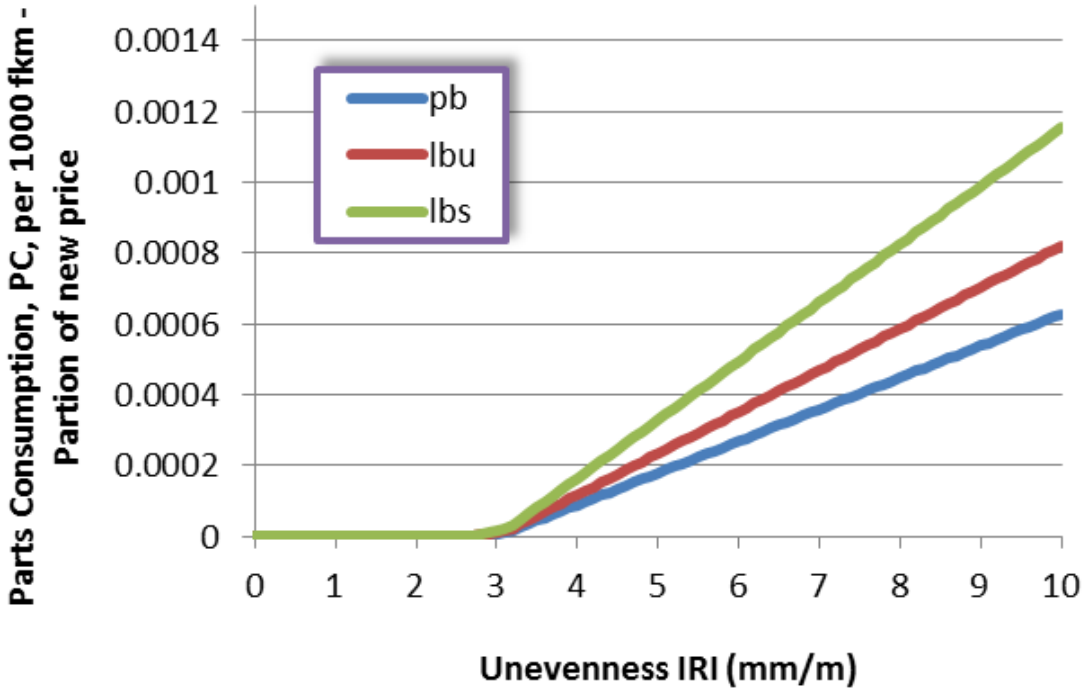


Tyre wear

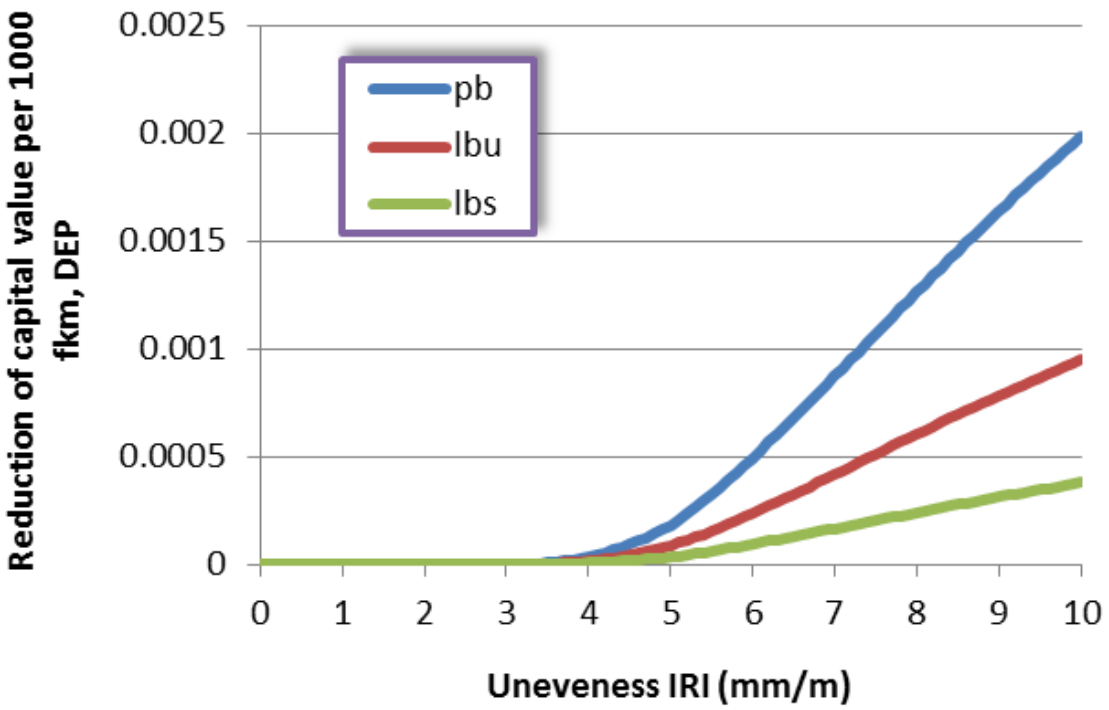

Number weared out tires per 1000 fkm, TC
0.012
0.010
0.008
0.006
0.004
0.002
0.000
-0.002
0 1 2 3 4 5 6 7 8 9 10
pb
lbu
lbs
Unevenness IRI (mm/m)


Number weared out tires per 1000 fkm, TC
0.012
0.010
0.008
0.006
0.004
0.002
0.000
-0.002
0 1 2 3 4 5 6 7 8 9 10
pb
lbu
lbs
Unevenness IRI (mm/m)

Parts consumption vs. evenness



Capital value vs. evenness



Comfort

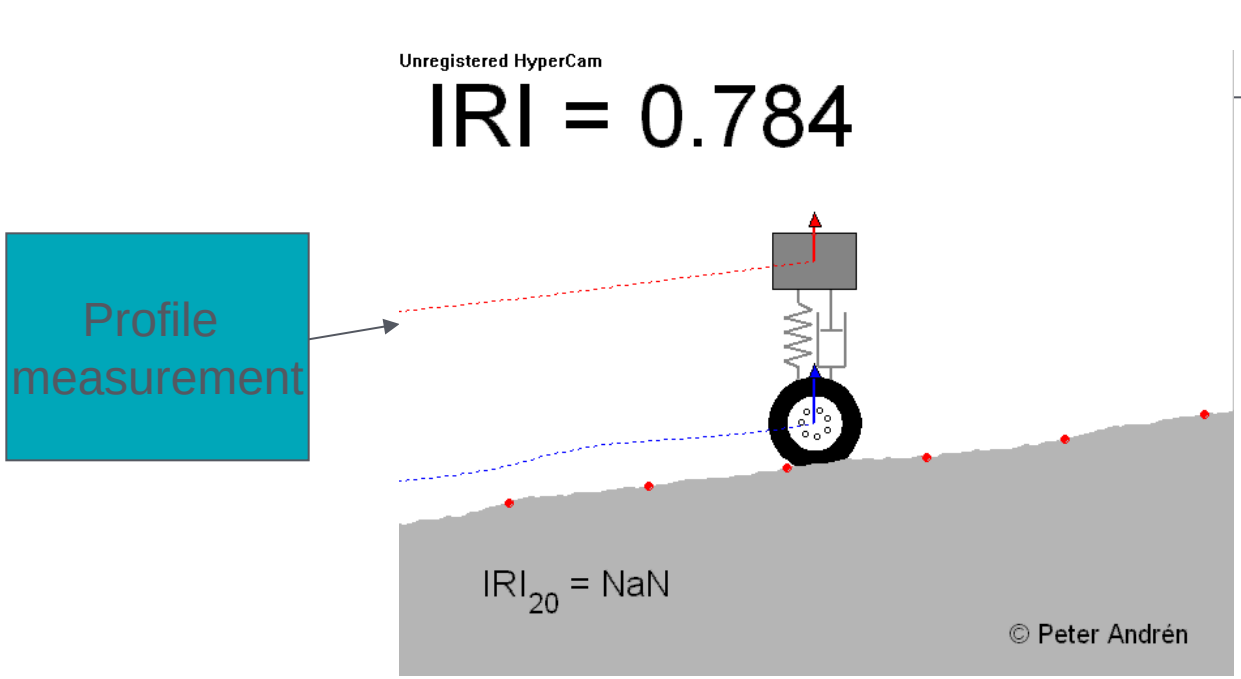
Profile measurement → QC-model → IRI

Vibration measurement

Panel rating

- ISO 2631
- Speed 70 km/h
- Passenger car

Comfort



Profile measurement

IRI

Panel rating

1 Very poor
2 Poor
3 Fair
4 Good
5 Very good

Comfort

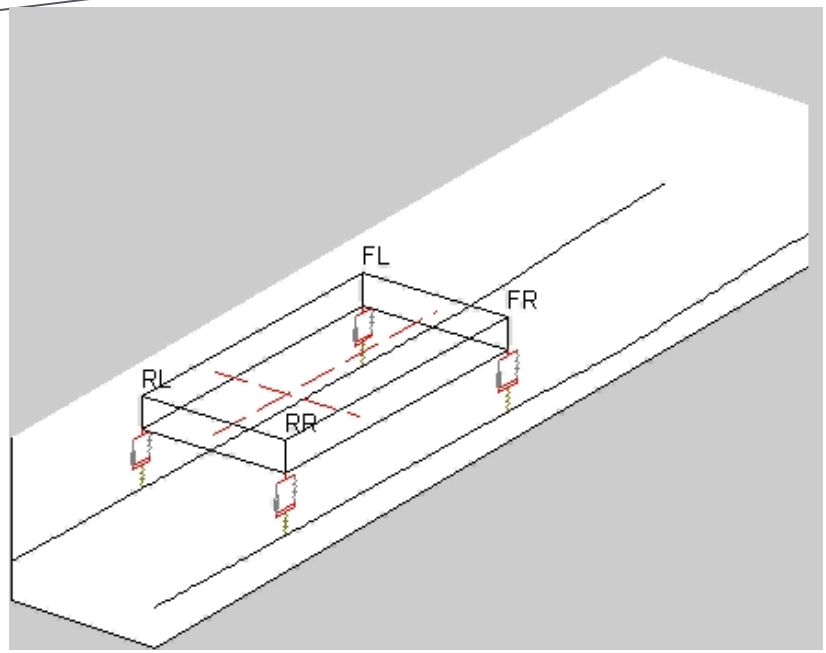
Profile measurement

QC-model

IRI

Panel rating

Vibration measurement

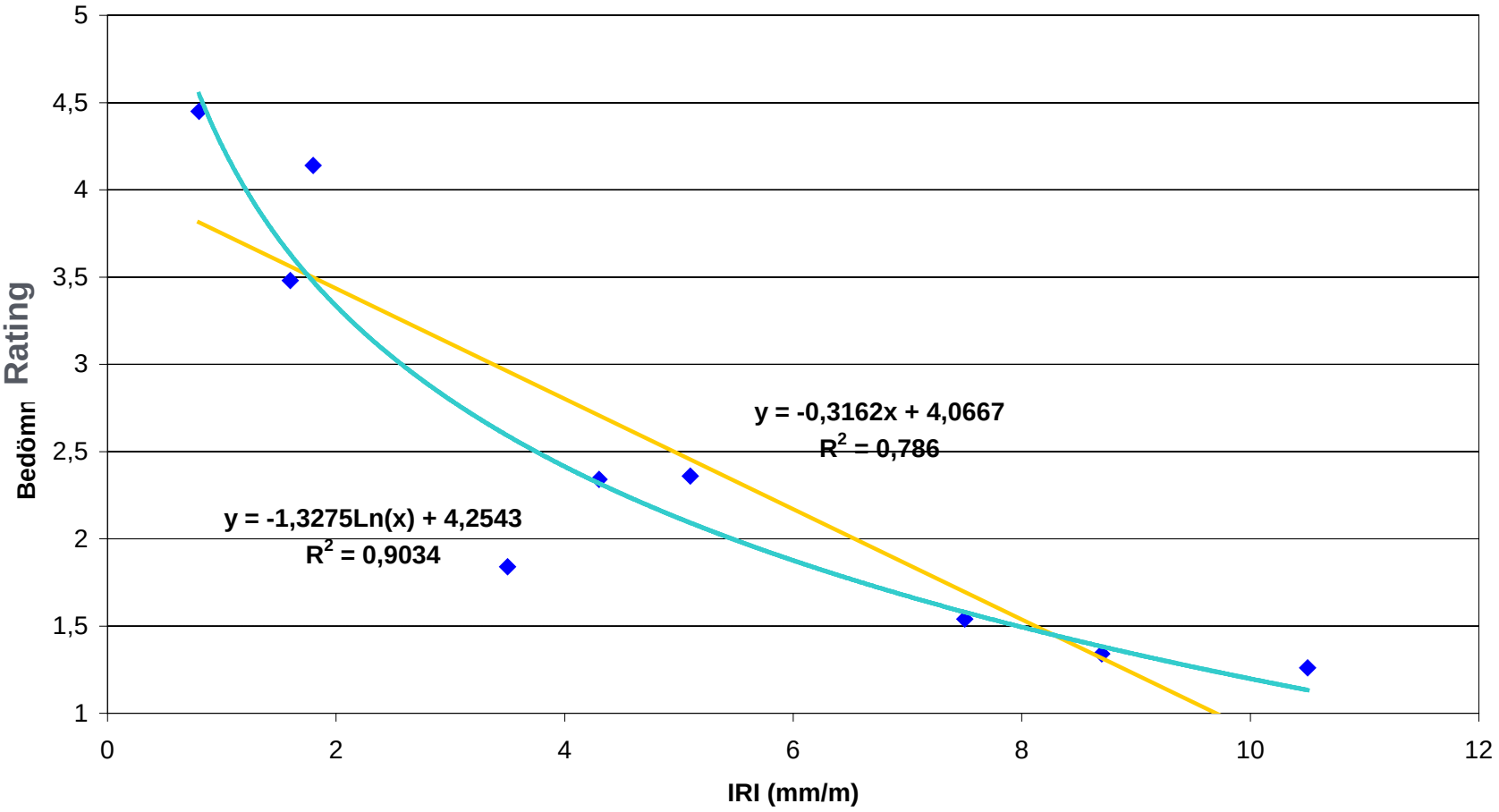


Profile measurement

Vibration

Comfort

IRI vs. Panel rating



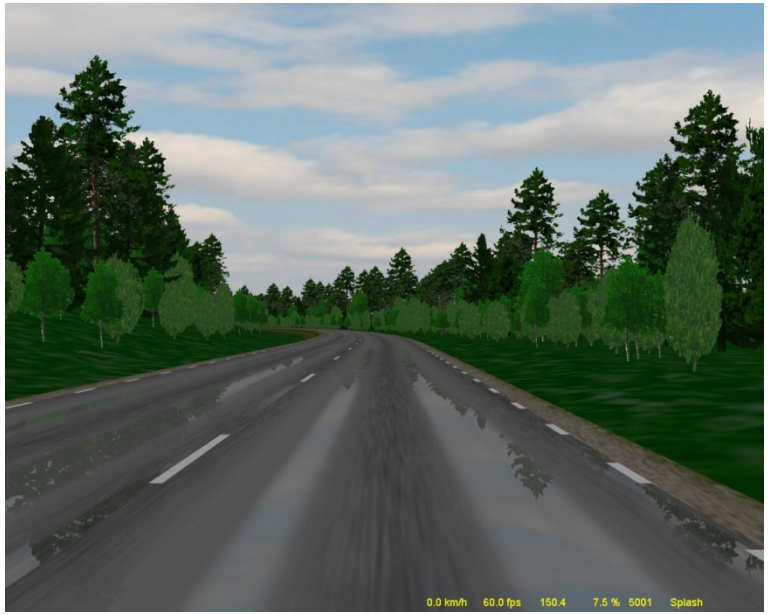
Road user requirements on road condition

Five reports (in swedish, summary in english)

1. Literature review
    - Many countries are making road user opinion studies but few have find a good connection between rod user opinion and condition measurements
2. Focusgroup discussions
    - Surface drainage is important
    - Important condition variables: rut depth, potholes, patches, roughness and cracks
    - Critical condition: If a driver must react to avoid a damage eg a pothole
    - Truckdrivers don’t like narrow road with weak edges
    - Good understanding of shortage of money
3. Questionnarie
4. Driving simulator
5. Summary

Driving simulator study

Road with water filled ruts



- Variation in image, vibration and noise
- Questions about experienced safety and comfort
- Clear indicator of poor safety at waterfilled ruts
    - Speed reduction

Maintenance standard IRI

Trafik (fordon/dygn)	Skyltad hastighet (km/h)							
	120	110	100	90	80	70	60	50
0-250		4,3	4,7	5,2	5,9	6,7	6,7	6,7
250-500		4,0	4,4	4,9	5,5	6,3	6,3	6,3
500-1000		3,7	4,1	4,5	5,1	5,8	5,8	5,8
1000-2000		3,0	3,3	3,7	4,2	4,8	5,2	5,2
2000-4000	2,4	2,6	2,9	3,2	3,6	4,1	4,9	4,9
4000-8000	2,4	2,6	2,9	3,2	3,6	4,1	4,9	4,9
>8000	2,4	2,6	2,9	3,2	3,6	4,1	4,9	4,9

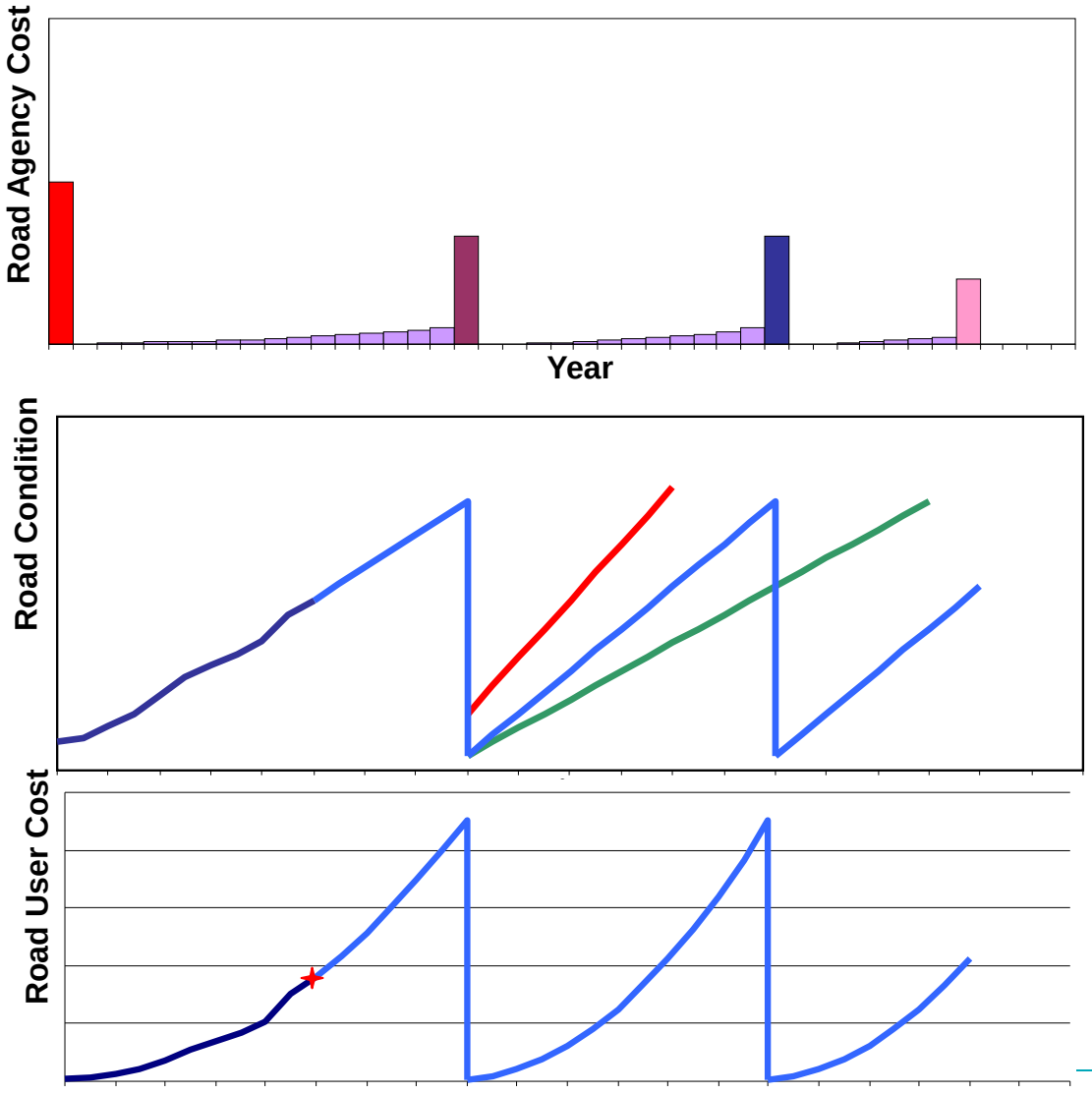
Maintenance standard rut depth

Trafik (fordon/dygn)	Skyltad hastighet (km/h)							
	120	110	100	90	80	70	60	50
0-250		18,0	18,0	24,0	24,0	30,0	30,0	30,0
250-500		18,0	18,0	22,0	22,0	27,0	27,0	27,0
500-1000		18,0	18,0	20,0	20,0	24,0	24,0	24,0
1000-2000		15,0	16,0	17,0	18,0	20,0	21,0	21,0
2000-4000	13,0	13,0	14,0	14,0	16,0	16,0	18,0	18,0
4000-8000	13,0	13,0	14,0	14,0	16,0	16,0	18,0	18,0
>8000	13,0	13,0	14,0	14,0	16,0	16,0	18,0	18,0

Old road after maintenance

Old road in need of maintenance

Pavement Life Cycle Cost



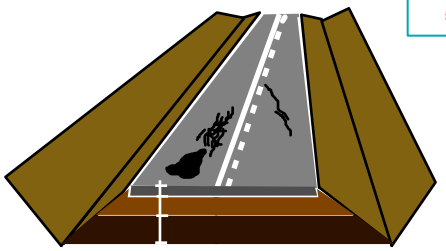
Benefits and costs – socio-economic analysis

- Benefits (B): Reduction in future reduction of road user costs
  - Not real cost but a valuation of costs
- Costs (C): all future road administrator costs to manage pavements
  - Including a tax factor that takes alternative use of money in account

- Net Present Value (NPV): B-C
- Net Present Value Ration (NPR): (B-C)/C
  - If NPR is larger than 0 it is profitable to do something

When to calculate benefits and costs?

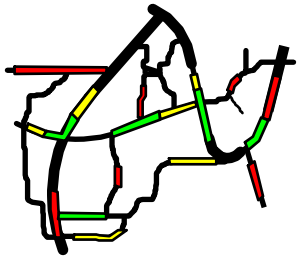
- Finding best treatment strategy for a project
  - Socio-economic or business economics



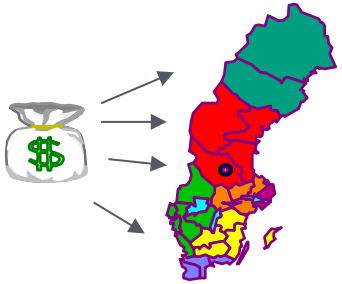
- Finding best candidate projects

  Or

- Finding best maintenance standard to be used in identification of candidate projects



- Finding budget needs
- Finding best network strategy



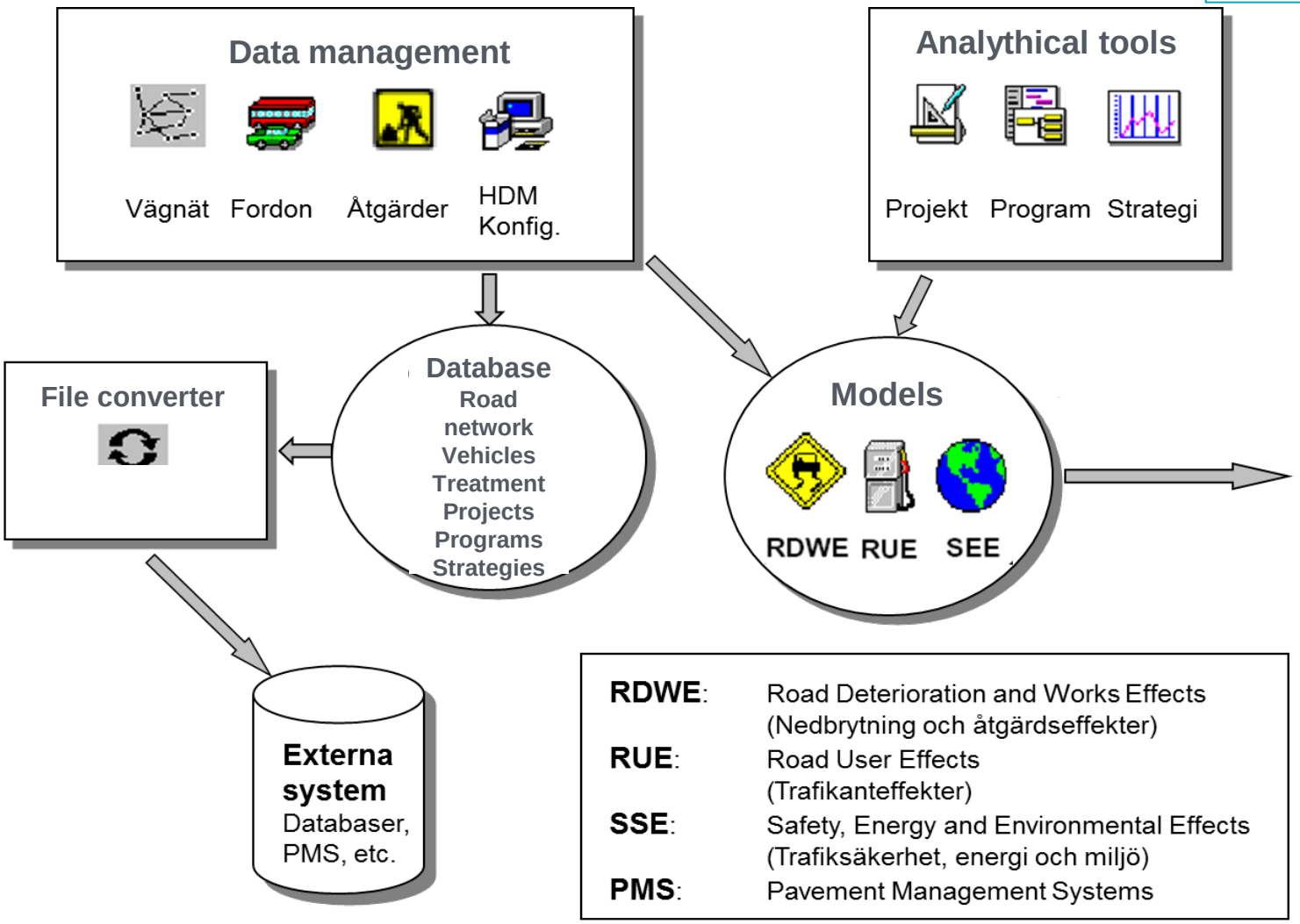
HDM-4 Highway Development and Management

HDM-III Highway Design and Maintenance Standards Model
HDM-4 Highway Development and Management

First developed by the World Bank

Today managed by PIARC (The World Road Association)

HDM-4 Highway Development and Management



Resultat

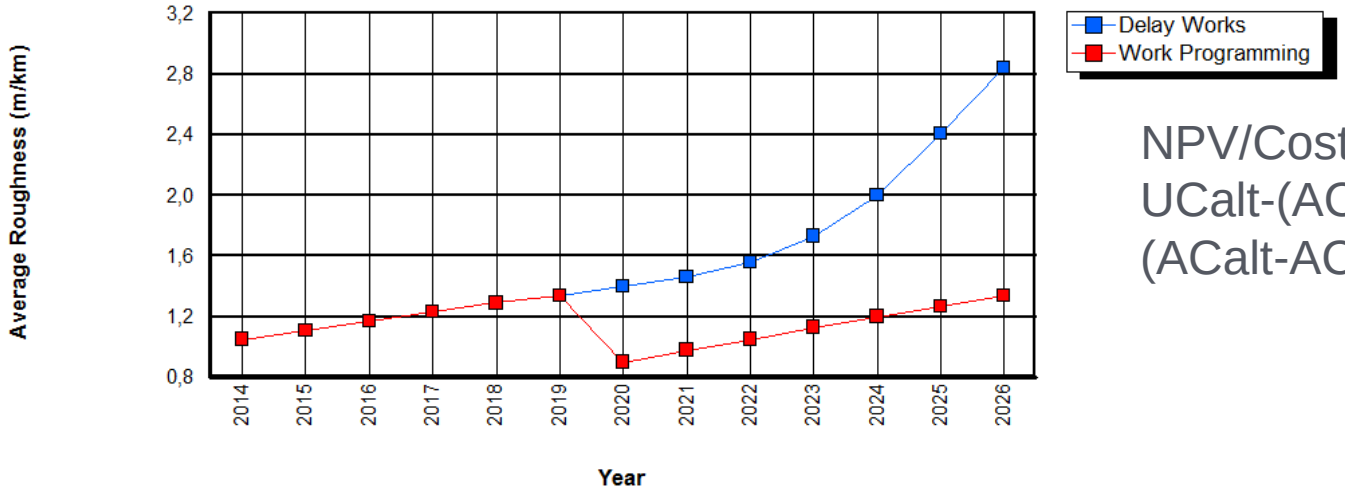
HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Average Roughness by Section (Graph)

Study Name: **MY3 Hdm_2012_300_10**
Run Date: **10-04-2013**

Section: 8210024
Sensitivity: No Sensitivity Analysis Conducted

ID: 8210024
Rise + Fall: 0,77m/km
Road Class: Övriga nationella vägar
Width: 7,00m
Length: 2,10km
Curvature: 2,60deg/km



NPV/Cost= (UCbase-UCalt-(ACalt-ACbase)/(ACalt-ACbase)

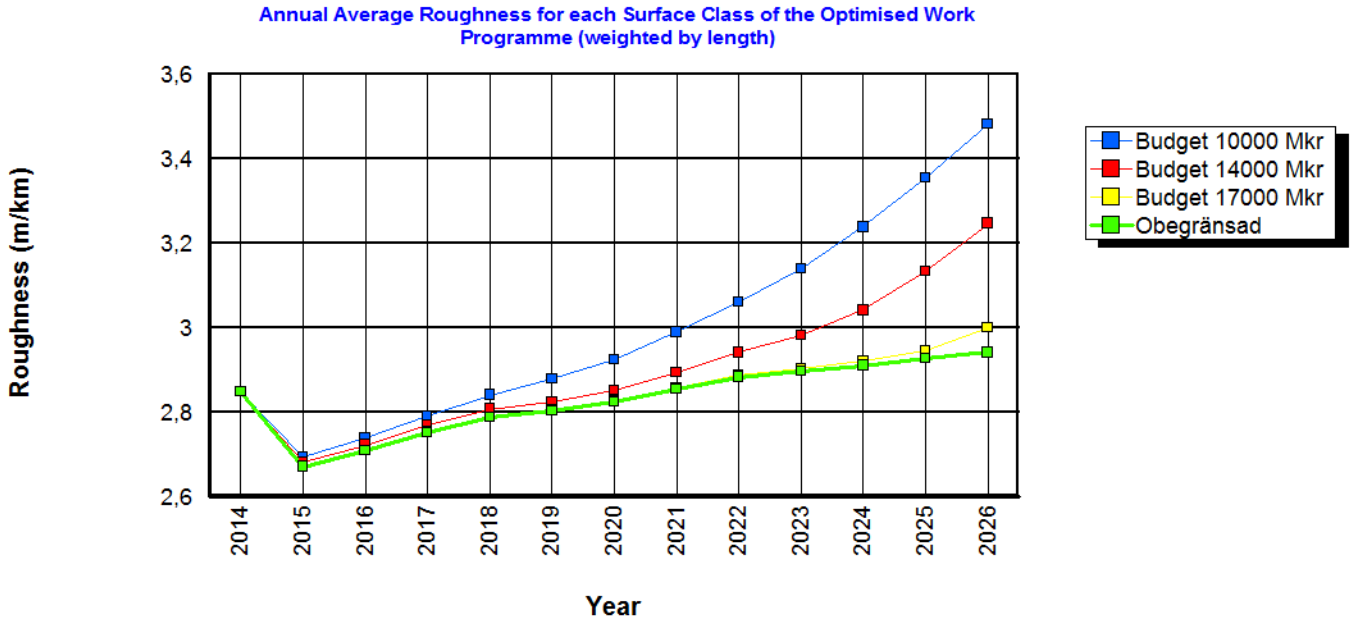
Resultat

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Roughness: Average for Road Network by Budget Scenario (Graph)

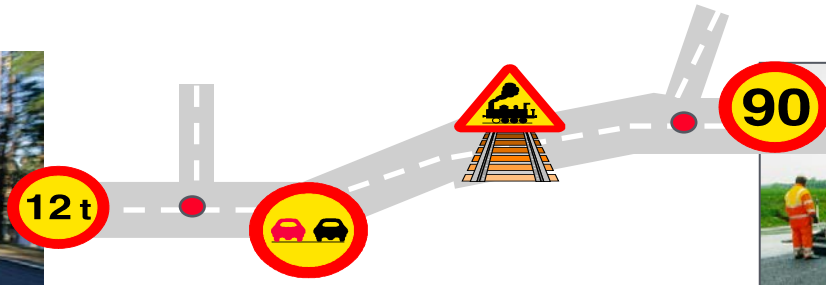
Study Name: MY3 Hdm_2012_300_10
Run Date: 10-04-2013

Surface Class: **Bituminous**



PMS - Overview

PMS Components



Road condition

Longitudinal unevenness

Transversal unevenness

Road Inventory

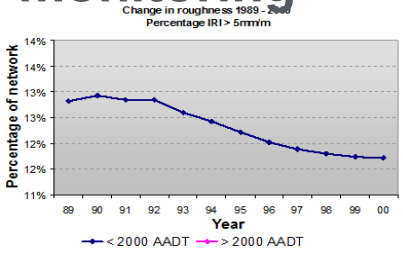
Pavement information

Database

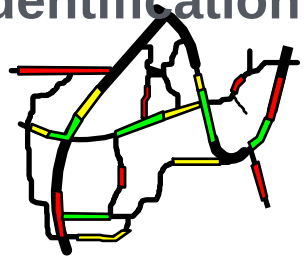
Evaluation models

Budget needs

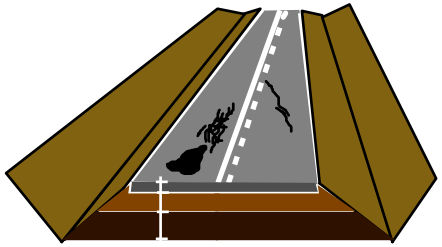
Condition monitoring

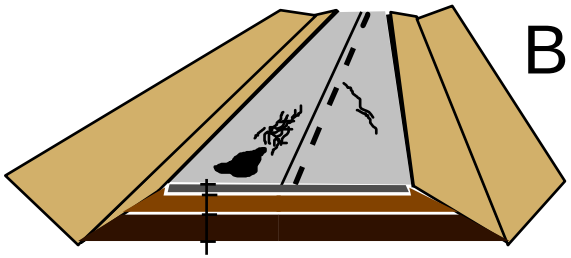


Project identification

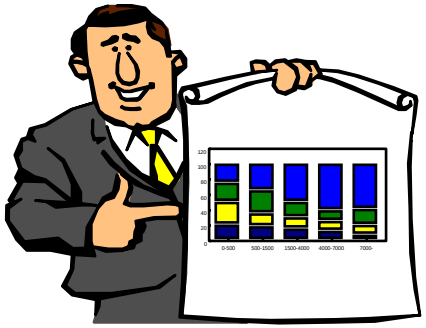


Follow-up contracts



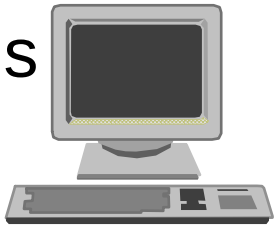


Benefits



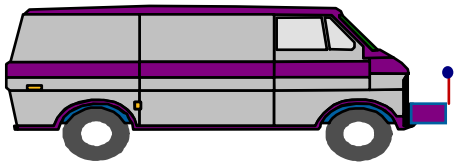
Users

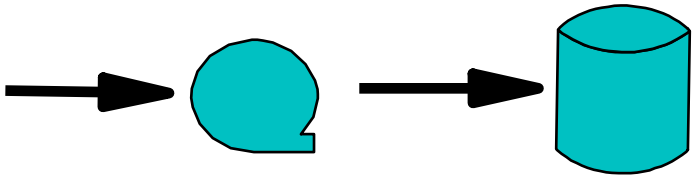
Systems



Evaluation

Data collection and storage





Road Data Bank