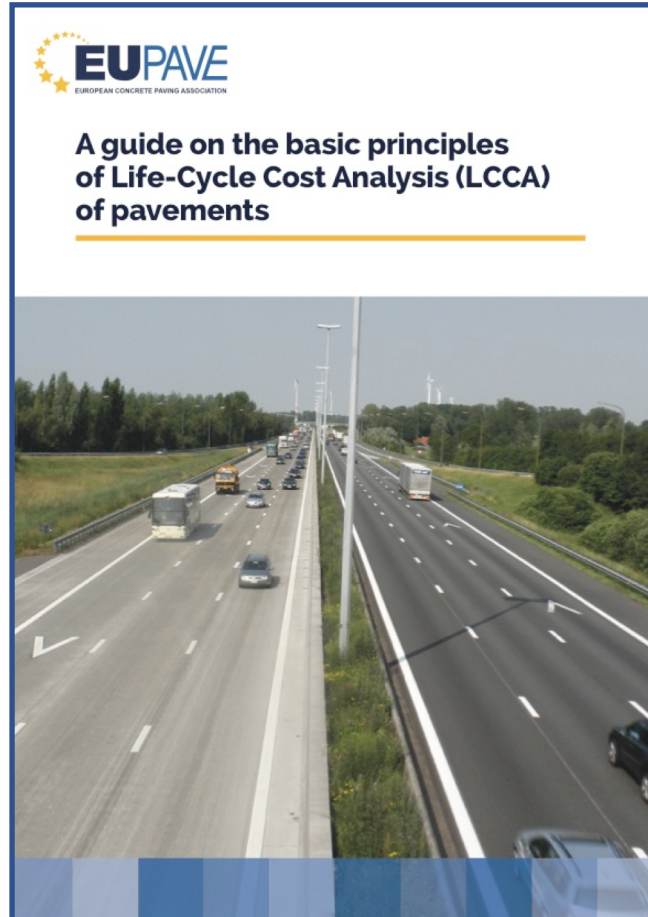


Life-Cycle Cost Analysis of Pavements



1. LCCA Guide – Content in general
2. LCCA for Rehabilitation Antwerp Ringroad

Purpose and scope EUPAVE Guide

- Technical guidance to apply standard procedure of a LCCA
 - Deterministic approach
- General description of more advanced procedures for a LCCA
 - Probabilistic approach (Risk analysis approach)

What is a LCCA - General

- Definition

LCCA is an economic analysis technique used to evaluate the long-term investment efficiency of competing design alternatives for the construction of an asset and for the long-term measures to maintain the performance objective of the asset

- LCCA can be conducted for any asset

What is a LCCA - Pavements

Life-Cycle Cost Analysis is a **process** for evaluating the **total economic worth** of a usable project segment by analyzing **initial costs** and **discounted future costs**, such as **maintenance, restoration, resurfacing, rehabilitation, reconstruction**, and **user** costs, over the life of the project segment.

Source: Transportation Equity Act for the 21st Century

Characteristics LCCA for pavements

- A LCCA
 - ✓ Converts future costs to **present value** using discounting
 - ✓ Compares **differential costs** only
 - ✓ Identifies **lowest long-term cost strategy** to meet project objectives

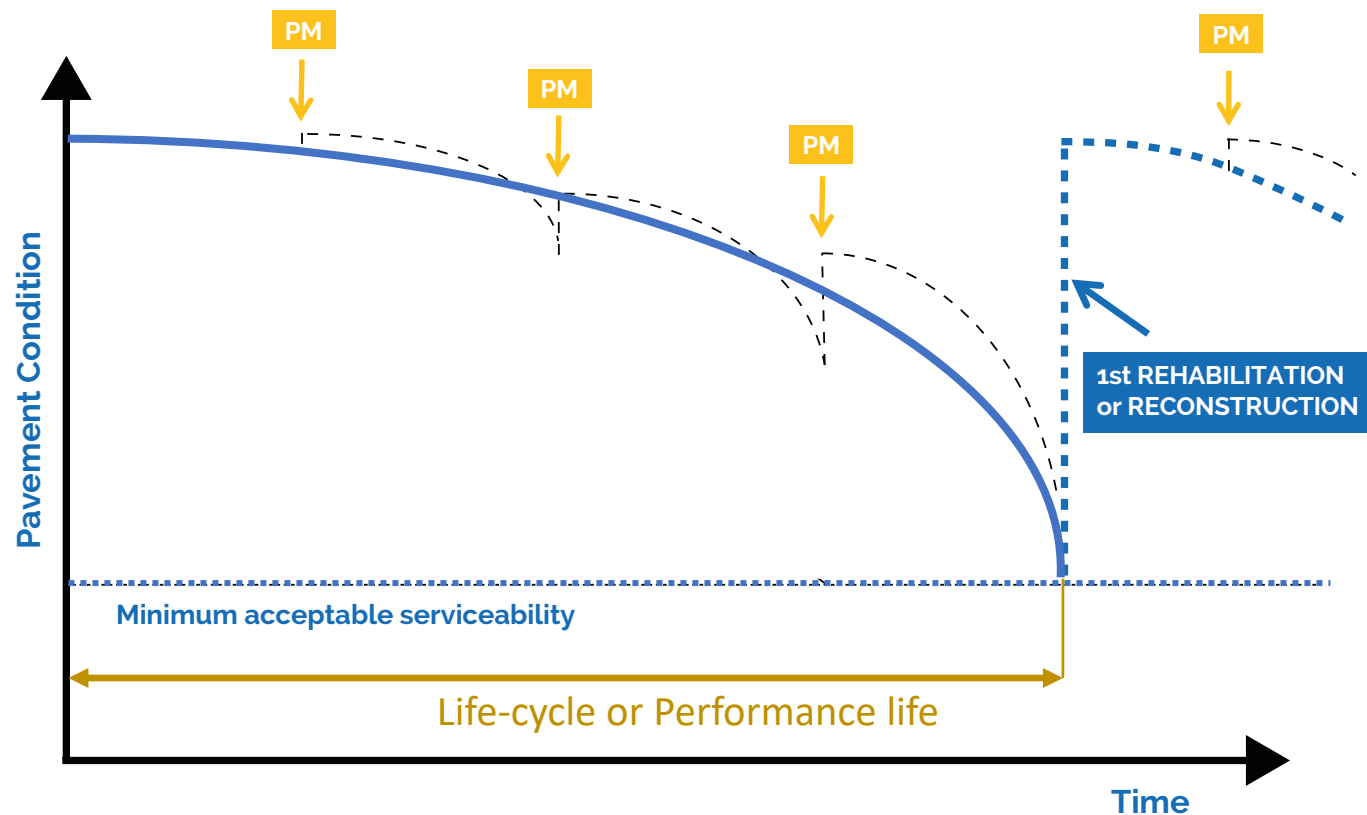
Characteristics LCCA for pavements

- A LCCA
 - ✓ Is applied to a **project** that will actually be **built**
 - ✓ Requires **equivalent benefits** over the performance period
 - ✓ Is conducted to analyse **competing** pavement **strategies**
- A pavement strategy = combination of initial design and future maintenance and rehabilitation activities

What LCCA is not

- Is not a Cost/Benefit analysis
- Is not a life cycle assessment (analysis of carbon footprint)
- Is not complicated, although varying levels of detailing are possible
- Is not a decision in and of itself
- Is not material specific
- Is not biased

Evolution pavement condition Schematic



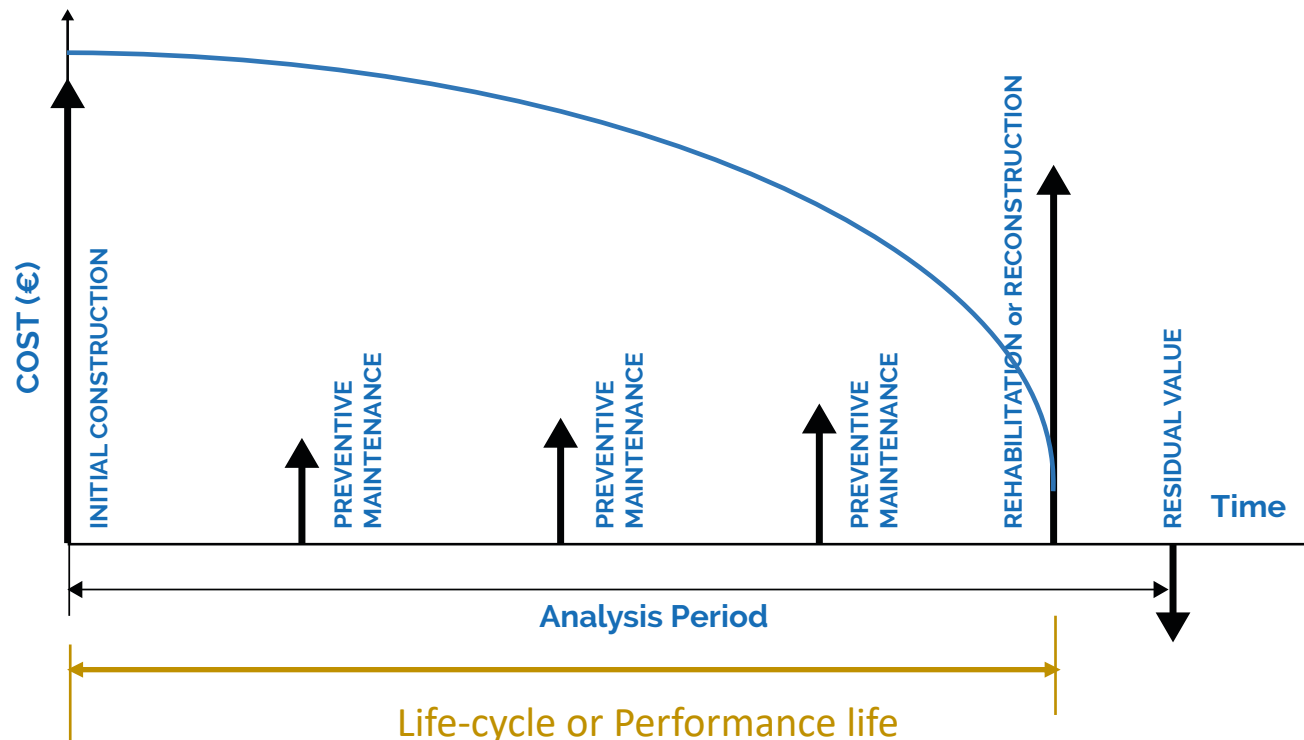
Types of costs in LCCA

- **AGENCY COSTS:**
always taken into account
 - Initial construction
 - Maintenance
 - Rehabilitation or reconstruction
- **USER COSTS:**
sometimes taken into account

Typical cash flow diagram in LCCA Schematic

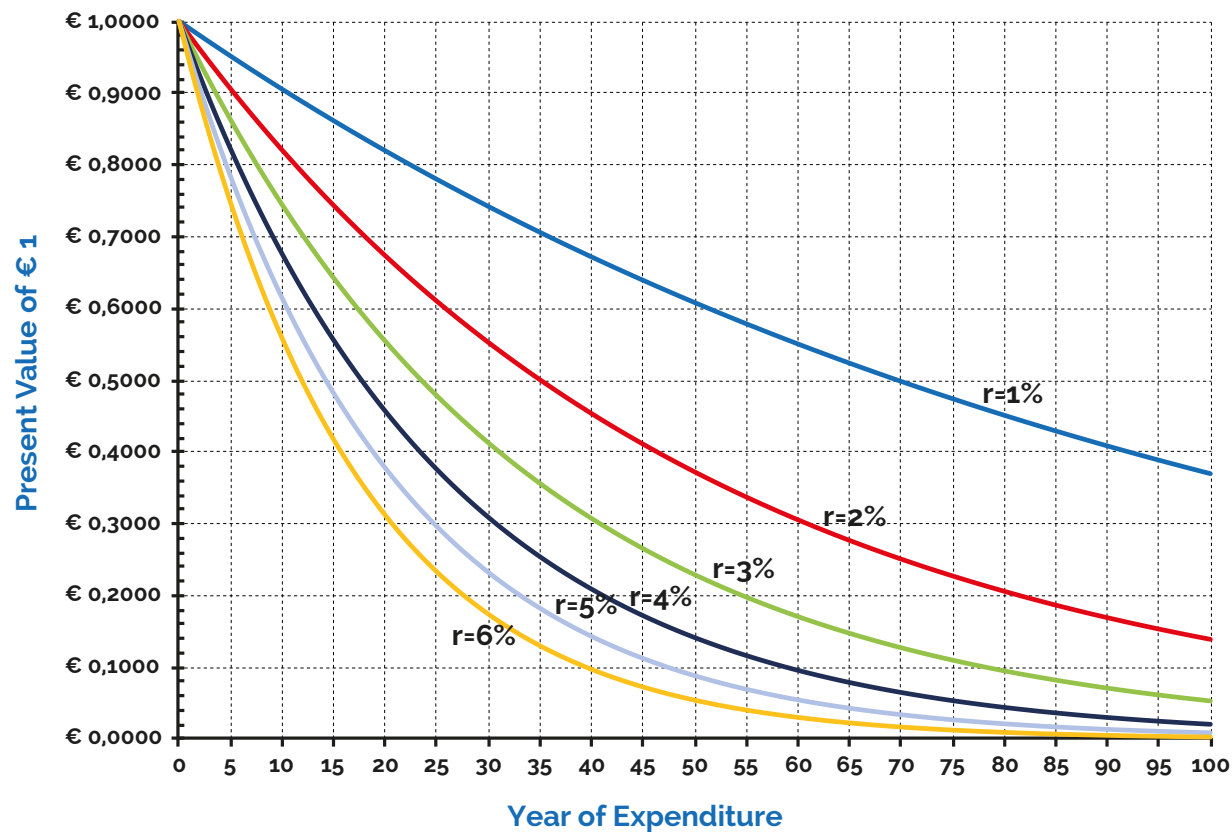
$$PV = FC \times \left[\frac{1}{(1+D)^y} \right]$$

$$NPV = IC + \sum_{k=1}^Q FC_k \left[\frac{1}{(1+r)^{y_k}} \right] - RV \left[\frac{1}{(1+r)^p} \right]$$



Variation of Present Value versus real discount rate r

Figure 3-8. Present Value of € 1,00 spent in various years at varying real discount rates



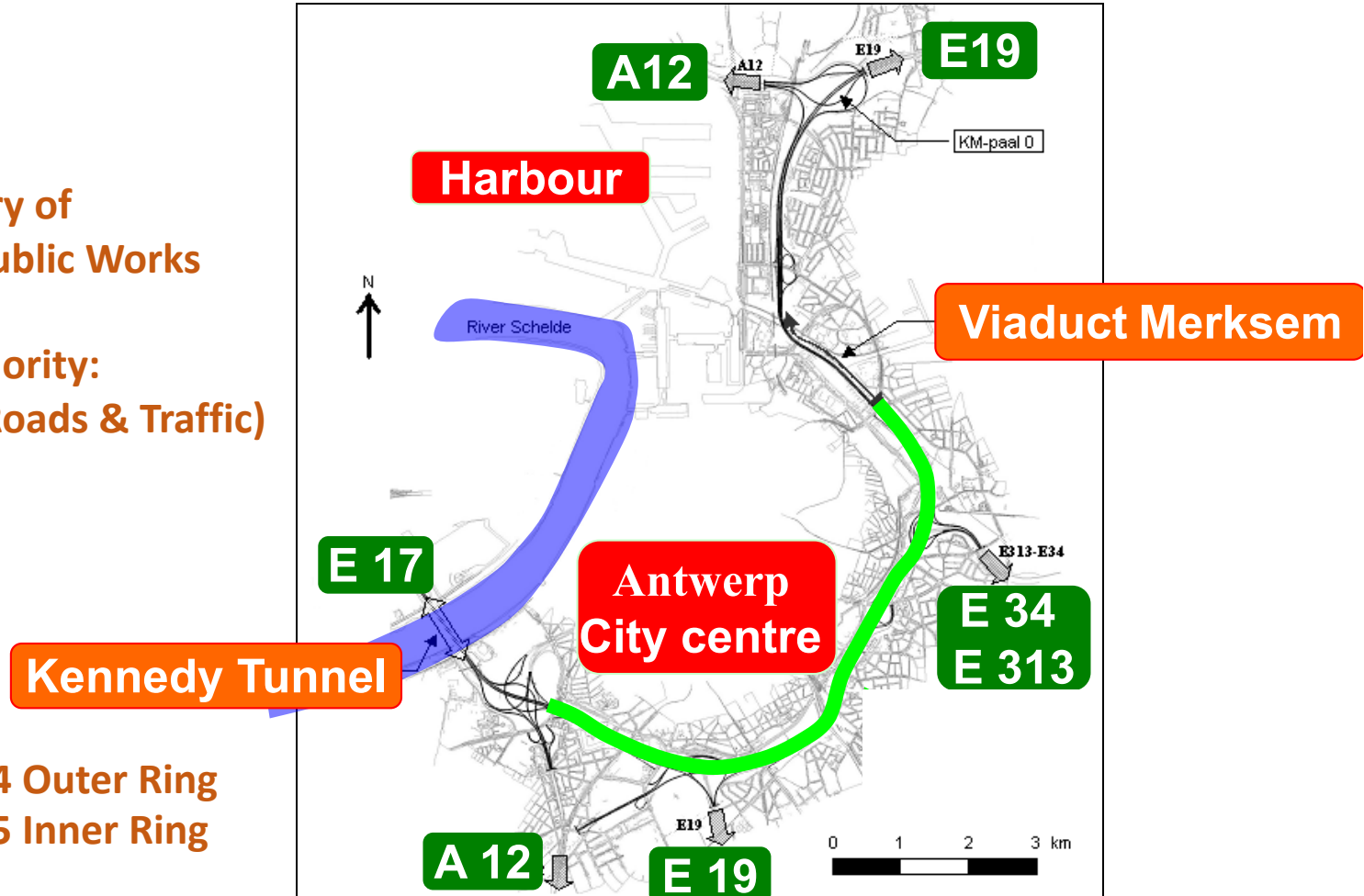
Antwerp Ringroad

Rehabilitation of pavement

Owner:
Flemish Ministry of
Mobility and Public Works

Operating Authority:
AWV (Agency Roads & Traffic)

PHASE 1: 2004 Outer Ring
PHASE 2: 2005 Inner Ring



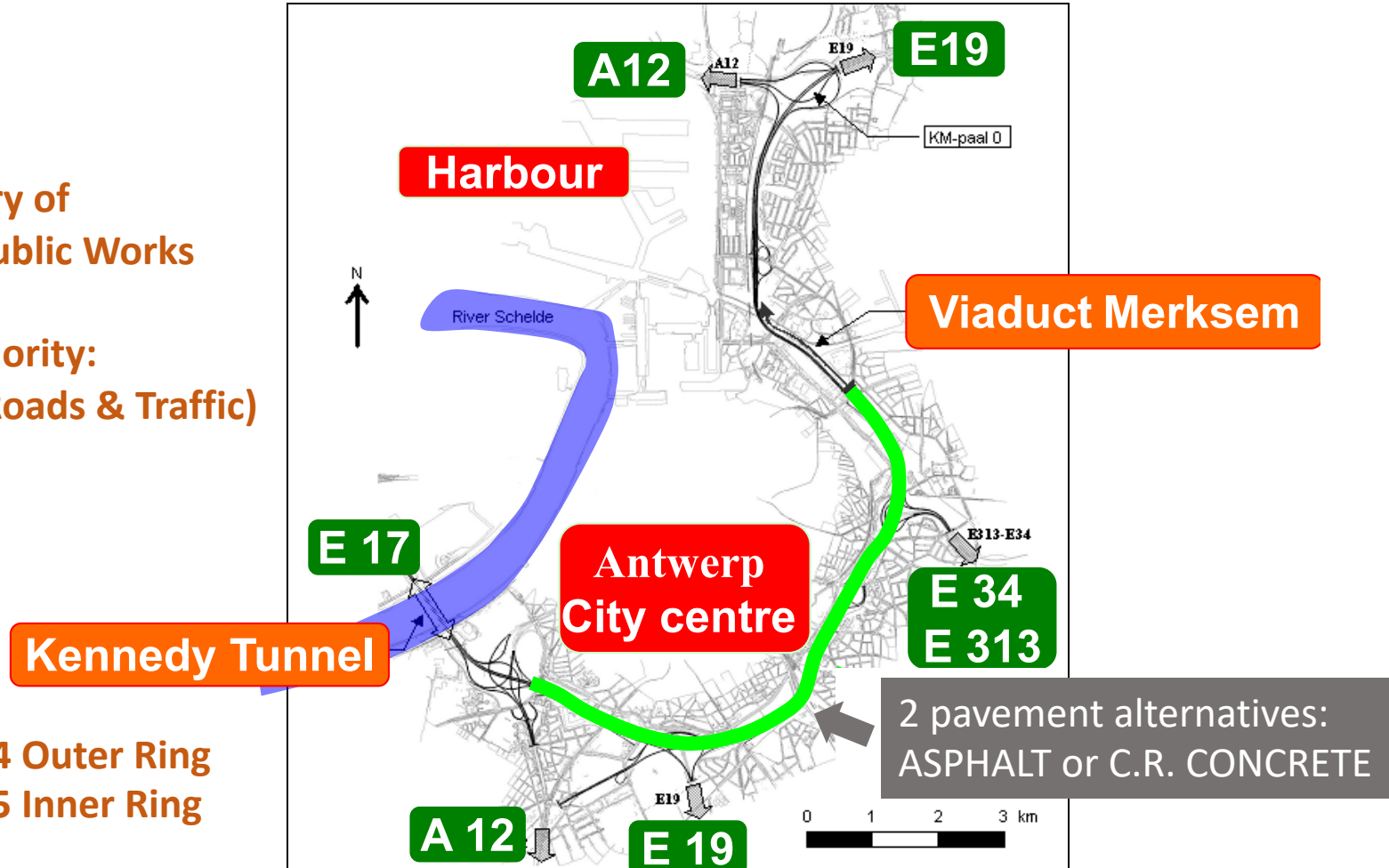
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Antwerp Ringroad

Project specifics

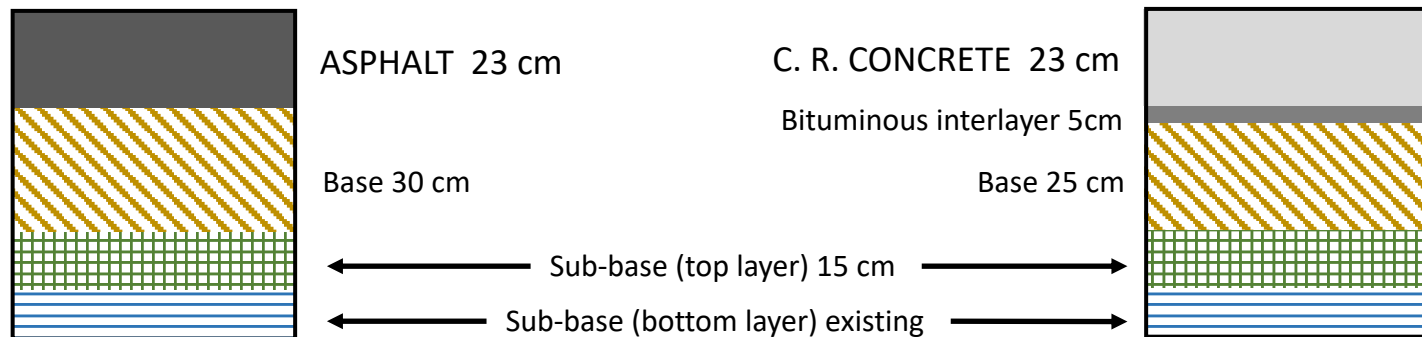
MOTORWAY of INTERNATIONAL IMPORTANCE	
Dual carriageway	14,2 km long
5 Interchanges	30 km long
Total surface of pavement	500.000 square metres
Traffic intensity	> 200.000 adt
Traffic composition	> 25% lorries
Number of lanes	4 to 7 + emergency lane

Antwerp Ringroad

Choice of pavement

Two alternative pavement structures considered

- Asphalt
- Continuously Reinforced Concrete (CRC)



Antwerp Ringroad

Choice of pavement

Choice based on two approaches

1. Life-Cycle Cost Analysis – LCCA

- Agency costs: included

 - ☐ Initial construction

 - ☐ Maintenance

 - ☐ Demolition

 - ☐ Reconstruction

- User costs: not included

- NPV calculations based on real discount rate of 4%

2. Multi Criteria Analysis – MCA

- Social costs

- Qualitative aspects

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Choice of pavement

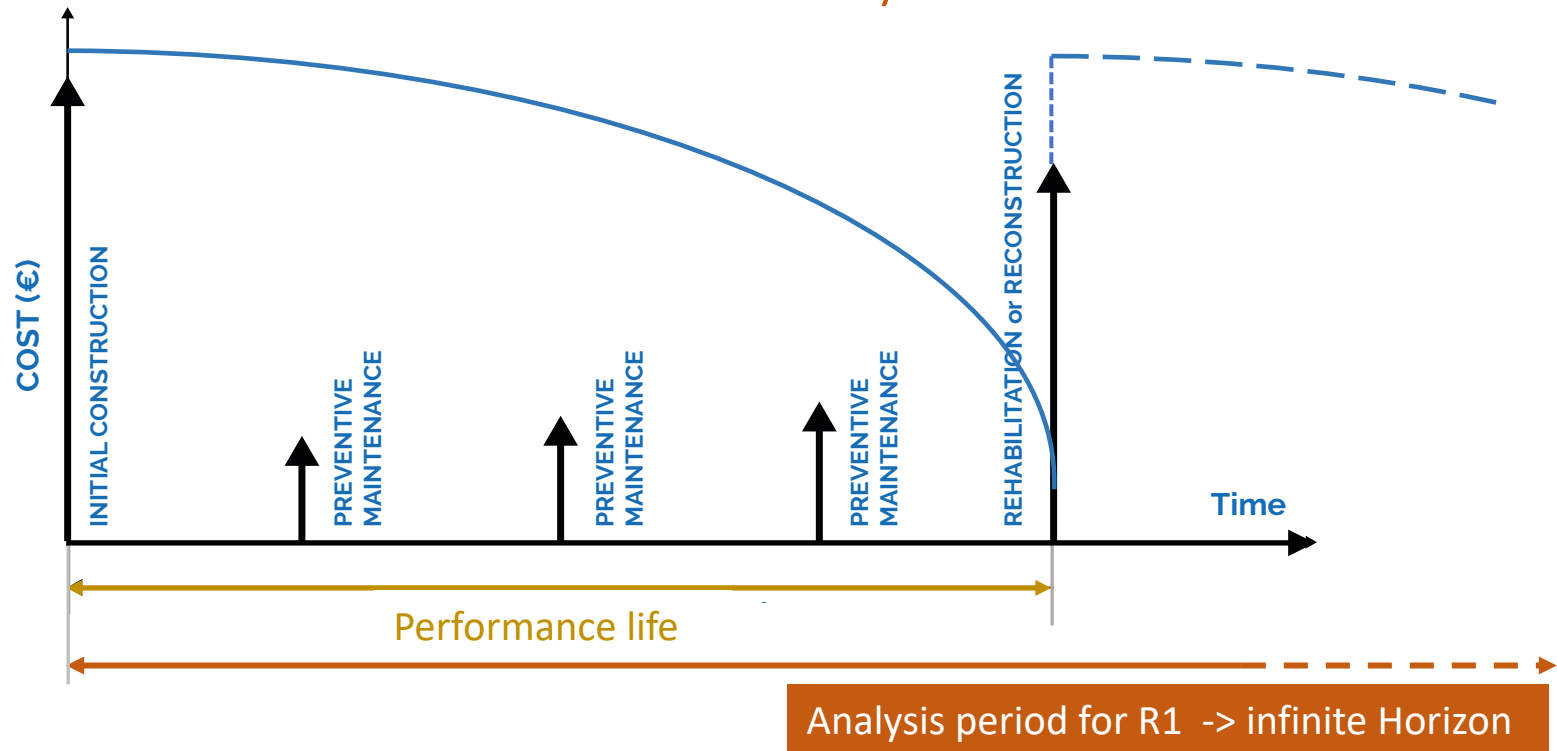
Choice based on two analyses

1. Life-Cycle Cost Analysis – LCCA
 - Agency costs: included
 - ☐ Initial construction
 - ☐ Maintenance
 - ☐ Demolition
 - ☐ Reconstruction
 - User costs: not included
 - NPV calculations based on real discount rate of 4%
2. Multi Criteria Analysis – MCA

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Typical cash flow diagram

Estimation performance life
Asphalt -> 36 years
C.R.Concrete -> 50 years



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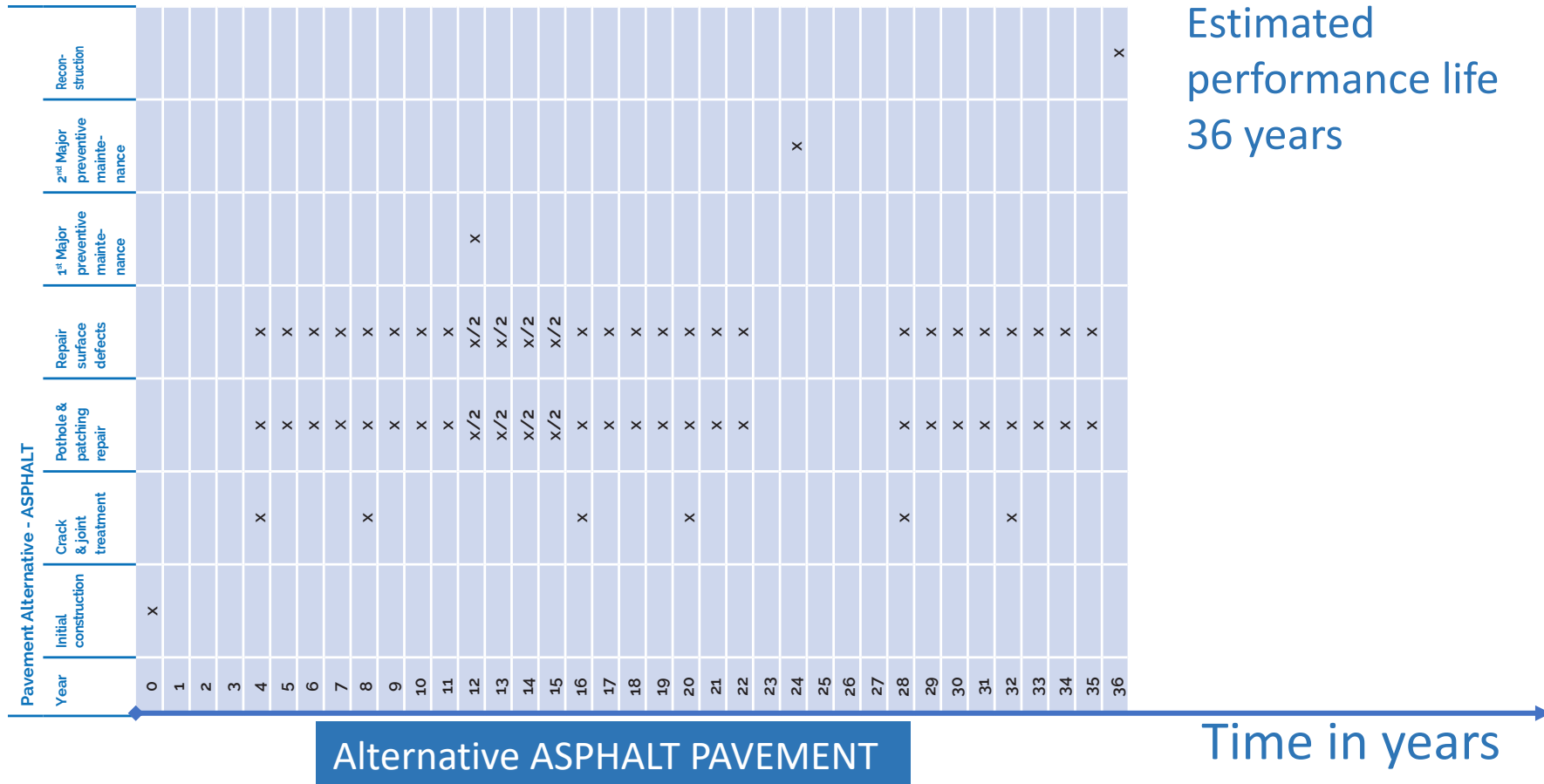
Maintenance strategy ASPHALT

ACTIVITY	FREQUENCY	START at
Crack & joint treatment	every 4 years	year 4
Pothole & patching repair	every year	year 4
Repair surface defects	every year	year 4
1 st Major preventive maintenance	once	year 12
2 nd Major preventive maintenance	once	year 24
Reconstruction	every 36 years	year 36

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Scheme of maintenance strategy vs. time

Maintenance activities



Antwerp Ringroad

Maintenance strategy C. R. CONCRETE

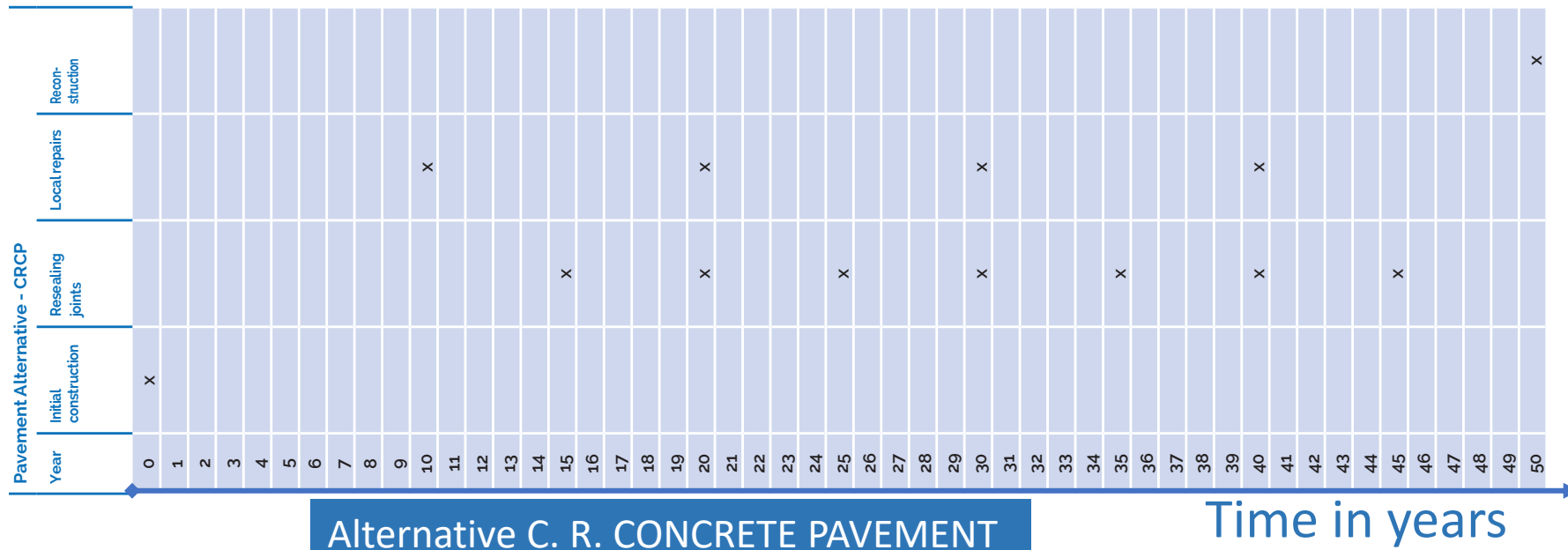
ACTIVITY	FREQUENCY	START at
Resealing joints	every 5 years	year 15
Local repairs	every 10 years	year 9
Reconstruction	every 50 years	year 50

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Scheme of maintenance strategy vs. time

Maintenance activities

Estimated
performance life
50 years



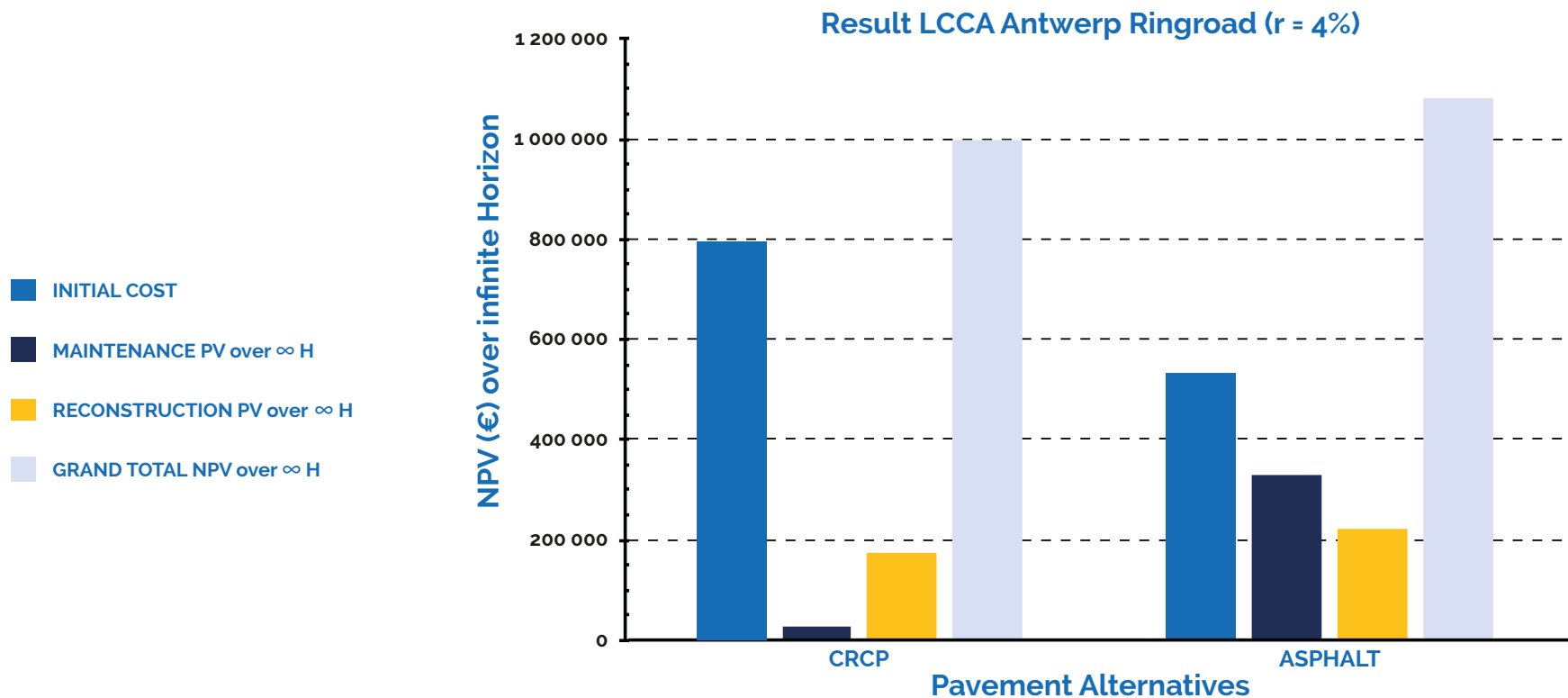
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Result LCCA

RESULT LCCA				
r %	TOTAL NPV €/km/Carriageway			
4,00	INITIAL COST	MAINTENANCE PV over ∞ H	RECONSTRUCTION PV over ∞ H	GRAND TOTAL NPV over ∞ H
CRCP	€ 794 970	€ 28 116	€ 174 112	€ 997 198
ASPHALT	€ 531 084	€ 328 047	€ 222 547	€ 1 081 678
Cost Ratio CRCP/ASPHALT	150%	9%	78%	92%

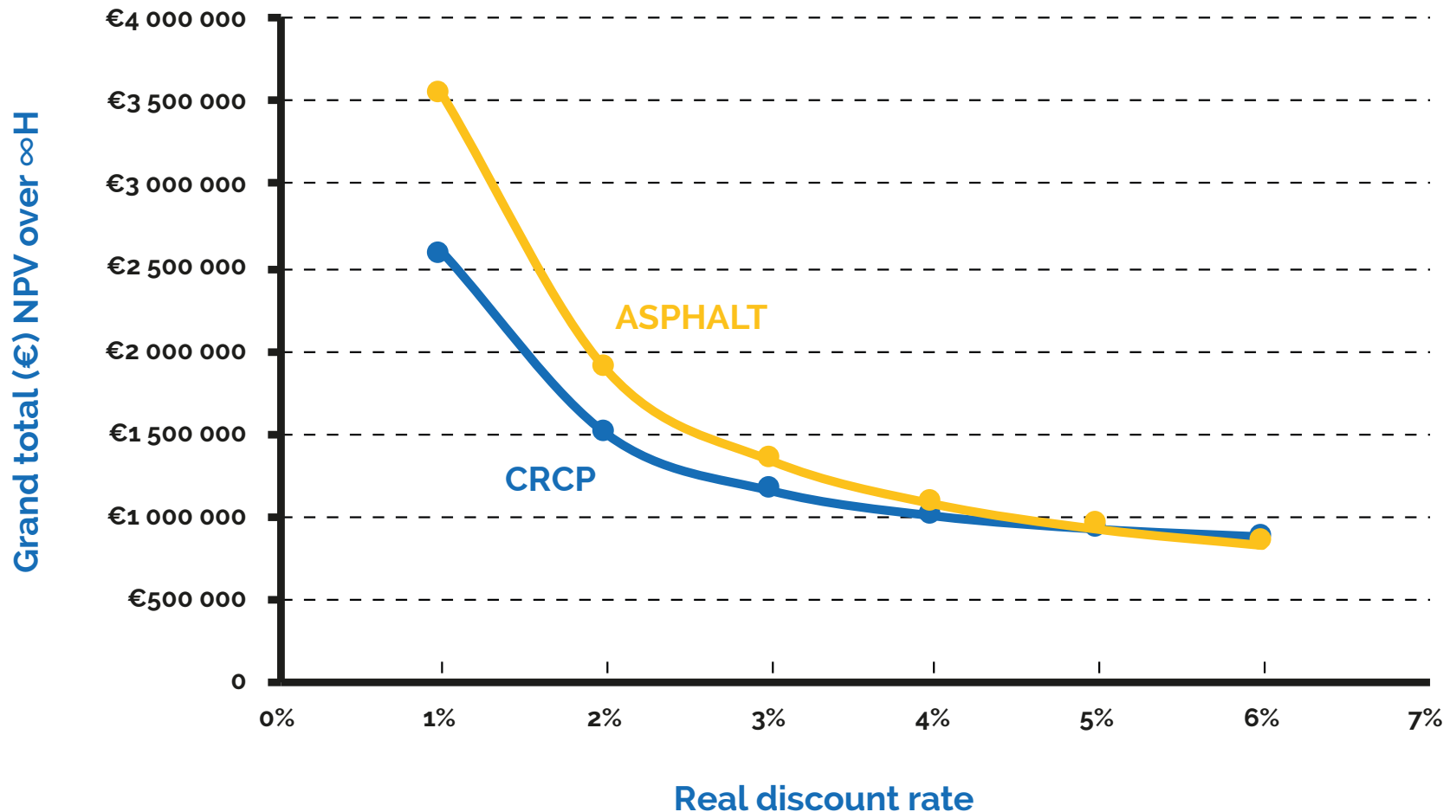
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Bar chart LCCA result



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Sensitivity analysis NPV vs. rate r



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Choice of pavement

Choice based on two approaches

1. Life-Cycle Cost Analysis – LCCA

- Agency costs: included

- ☐ Initial construction

- ☐ Maintenance

- ☐ Demolition

- ☐ Reconstruction

- User costs: not included

- NPV calculations based on real discount rate of 4%

2. Multi Criteria Analysis – MCA

- Social costs

- Qualitative aspects

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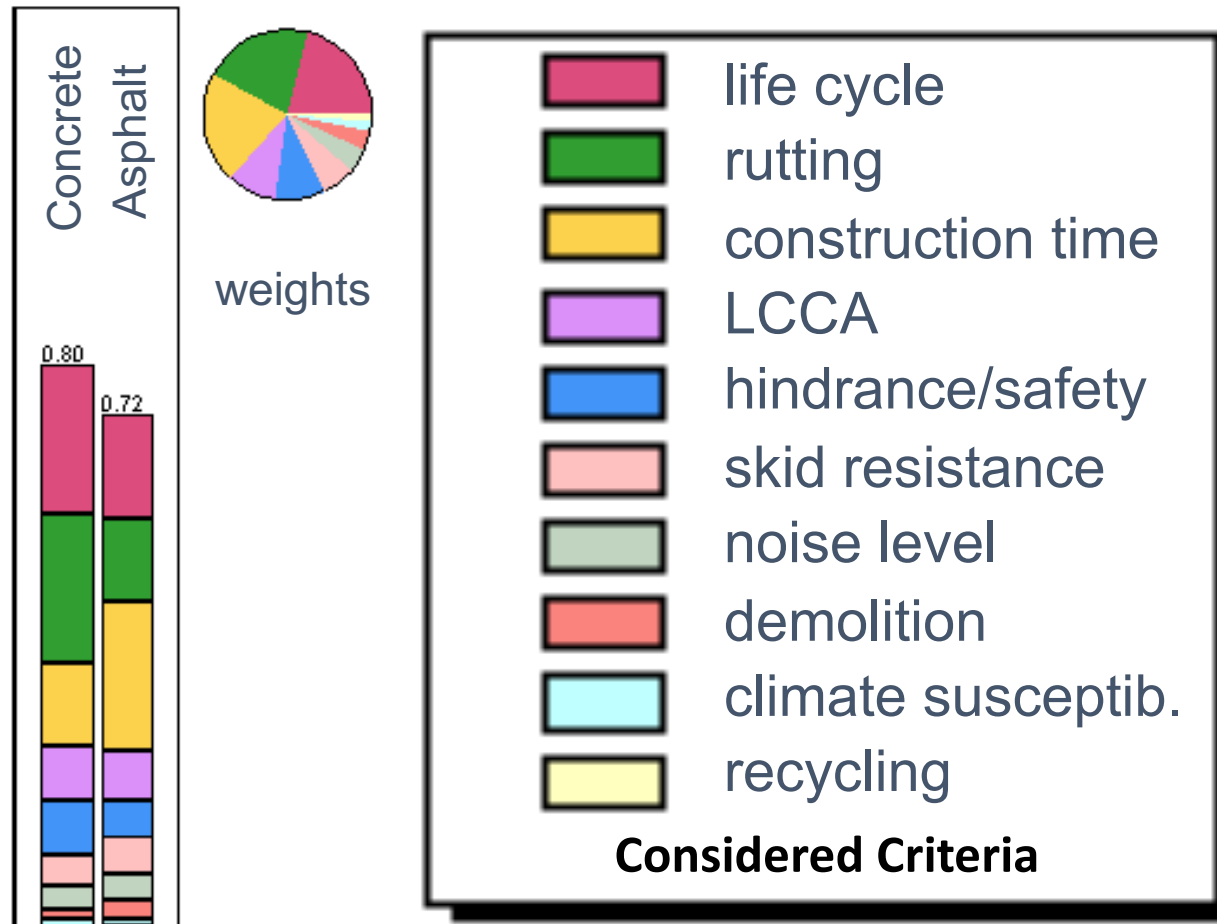
Multi Criteria Analysis – Considered CRITERIA

MCA CRITERIA

- ☐ Life cycle
- ☐ Rutting
- ☐ Construction time
- ☐ LCCA
- ☐ Hindrance/safety
- ☐ Skid resistance
- ☐ Noise level
- ☐ Demolition
- ☐ Climate susceptibility
- ☐ Recycling

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Multi Criteria Analysis – RESULT



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Conclusion

- LCCA -> sensible support tool to take a decision regarding pavement type
- LCCA -> both alternatives nearly the same NPV
- MCA -> useful supplement for non-economical aspects
- MCA -> slightly better result for concrete pavement

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Conclusion

- Final choice for concrete pavement based on
 - ❑ Results LCCA & MCA
 - ❑ Long term advantages
 - ✓ No rutting
 - ✓ Longer performance life
 - ✓ Lower work zone user costs

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Pictures during construction

Milling of existing pavement



Transport of demolished pavement



Large scale recycling of materials



Execution of concrete pavement



Finished concrete pavement



Aerial views of rehabilitation works



October 17, 2018

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Life-Cycle Cost Analysis of Pavements

Thank you for
your
kind attention

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