

Probable developments
Operation 2.0

Lifecycle costing in operation



CONTENT

AGENDA

- 01 LIFE COSTING FOR TUNNELS
- 02 LCC - COST MODEL
- 03 LCC COSTING – EXAMPLE
- 04 LCC – BIM – DIGITAL TWIN

Stephan Engelhardt

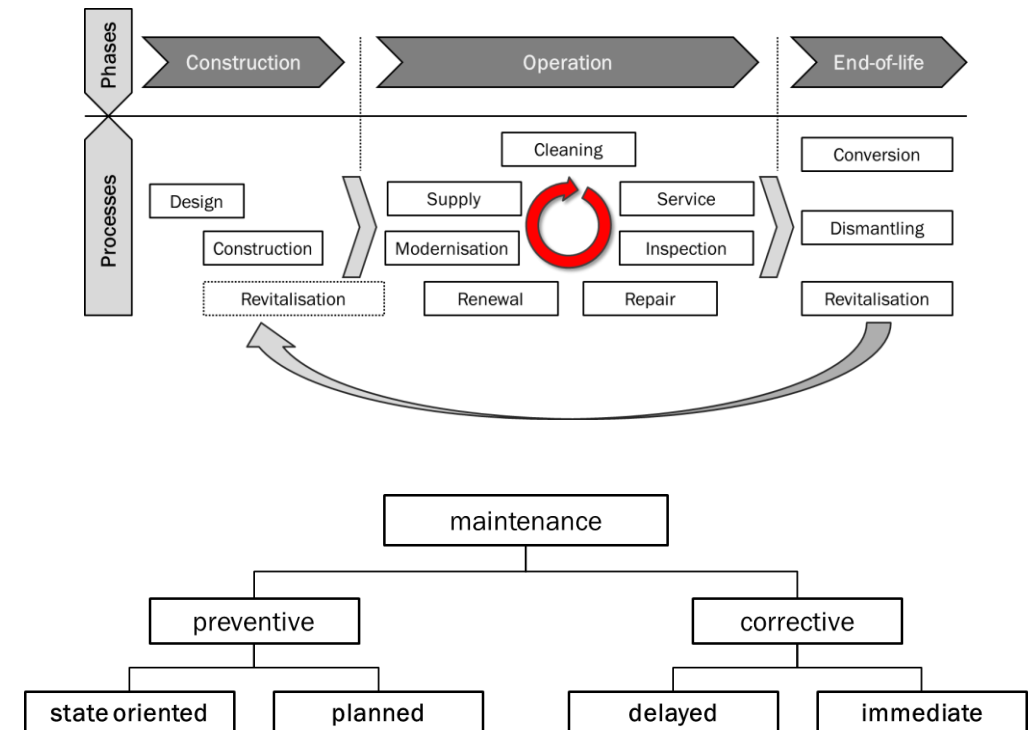


REASONS FOR LCC TUNNEL

Investment decisions or operation strategies are often technology-driven and not take into account life cycle aspects

Targets for a LCC Model:

- holistic cost overview
- identification of cost drivers
- knowledge about cost optimisations / substitutions
- decision support (investment, maintenance strategy, ...)
- element of risk management
- basis of sustainability



LIFE COSTING FOR TUNNELS

Recommendation of German Tunnelling Committee (DAUB)

- 2018 -> LCC Cost model for road tunnels
- 2023 -> LCC Cost model for road tunnels (updated)
& for urban and public transport tunnel

DAUB Recommendations Lifecycle Costs (2nd version, 2023)

Recommendations for the Determination of Lifecycle Costs for Tunnels

Design Construction Operation

Roads

Public transport

Railway

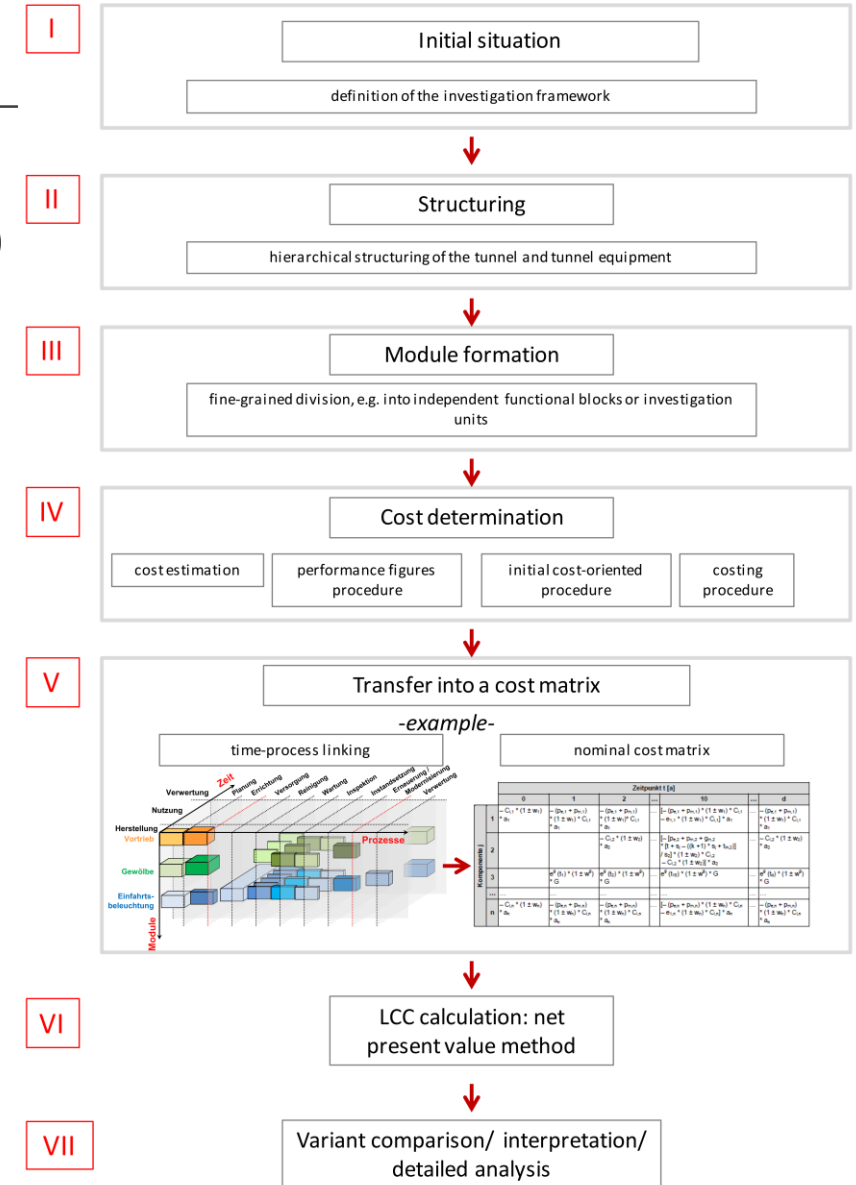
DAUB Deutscher Ausschuss für unterirdisches Bauen e. V.
German Tunnelling Committee (ITA-AITES)



LCC COST MODEL

Recommendation of German Tunnelling Committee (DAUB)

- 2018 -> LCC Cost model for road tunnels
- 2023 -> LCC Cost model for road tunnels (updated) & for urban and public transport tunnel



LCC COST MODEL

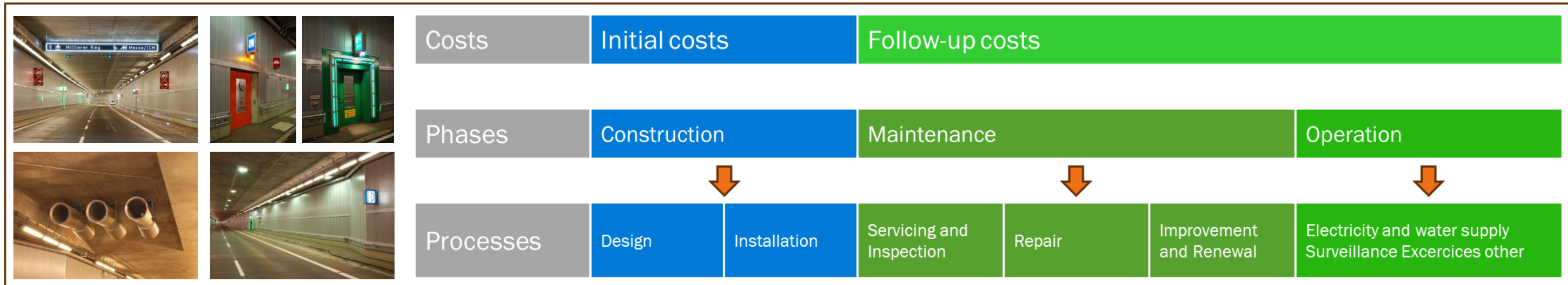
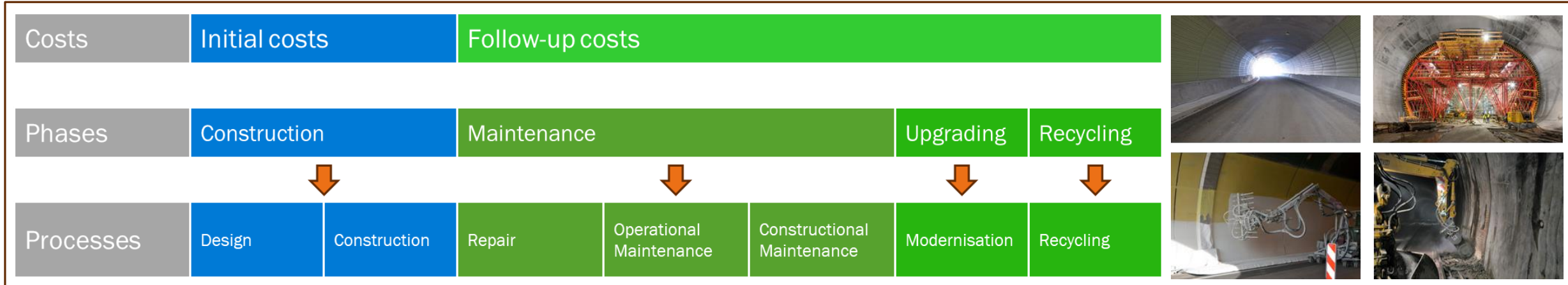
Requirements for LCC Cost Model

- holistic consideration
- reusability and consistent structure
- transparency and reproducibility
- adaptability and flexibility
- generation of optimisation measures

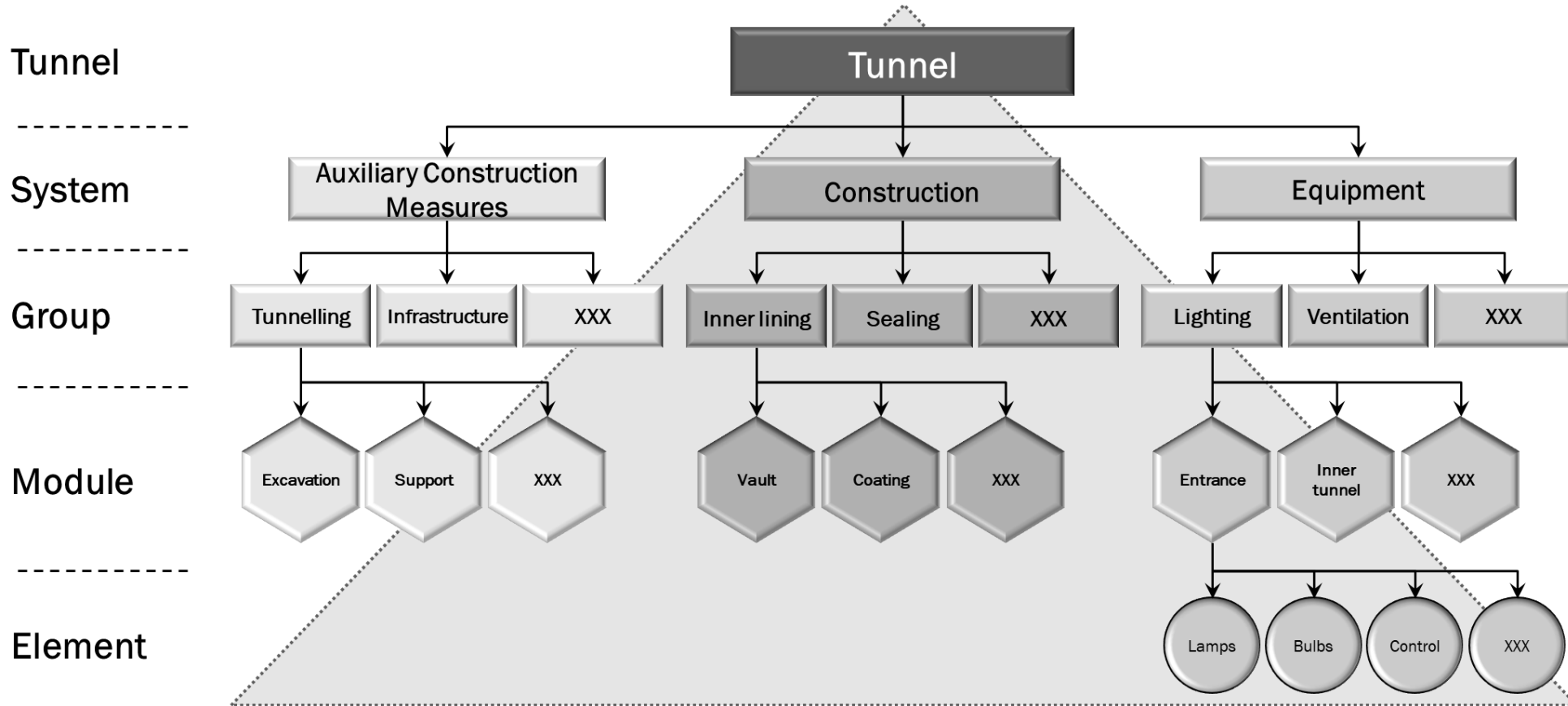
A reliable and complete database is required!



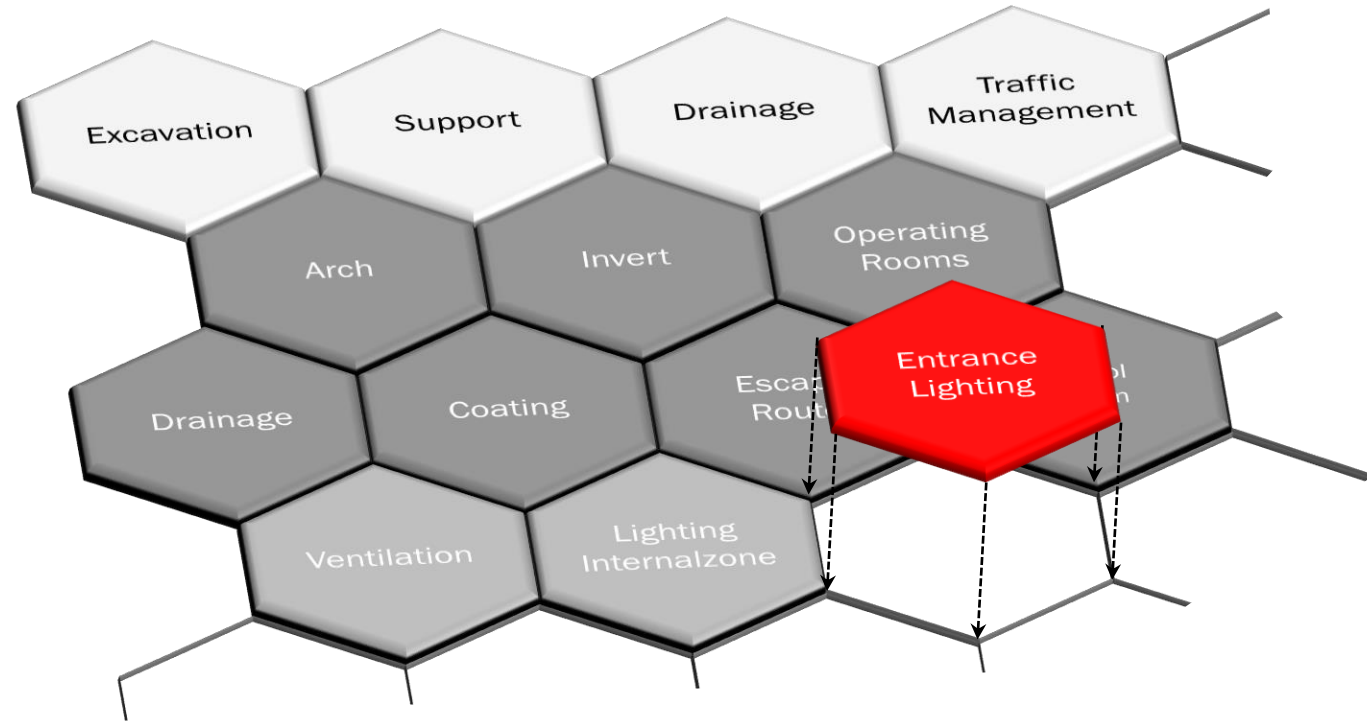
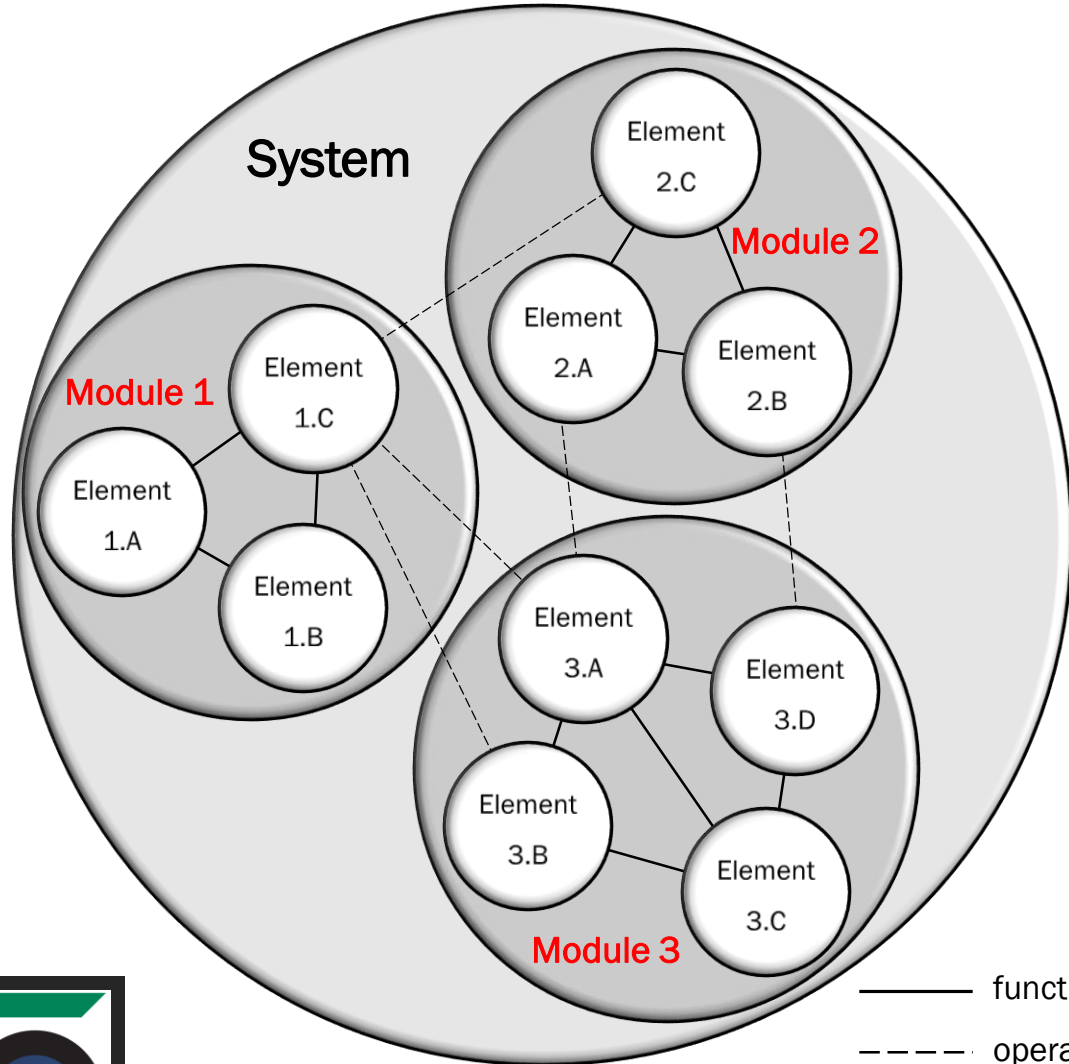
LCC Cost Model – LIFECYCLE PHASES



LCC COST MODEL – STRUCTURE



LCC Cost Model – STRUCTURE

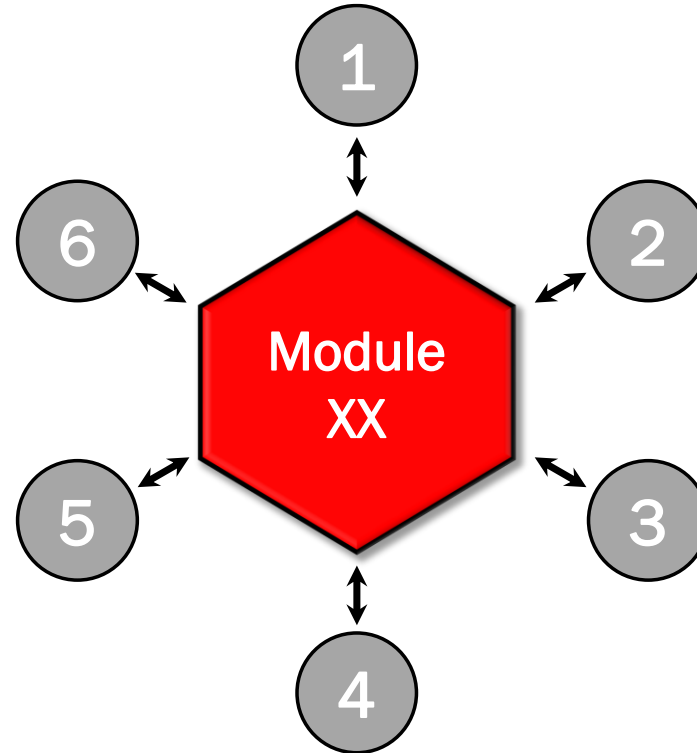


———— functional dependence
 - - - - - operational dependence

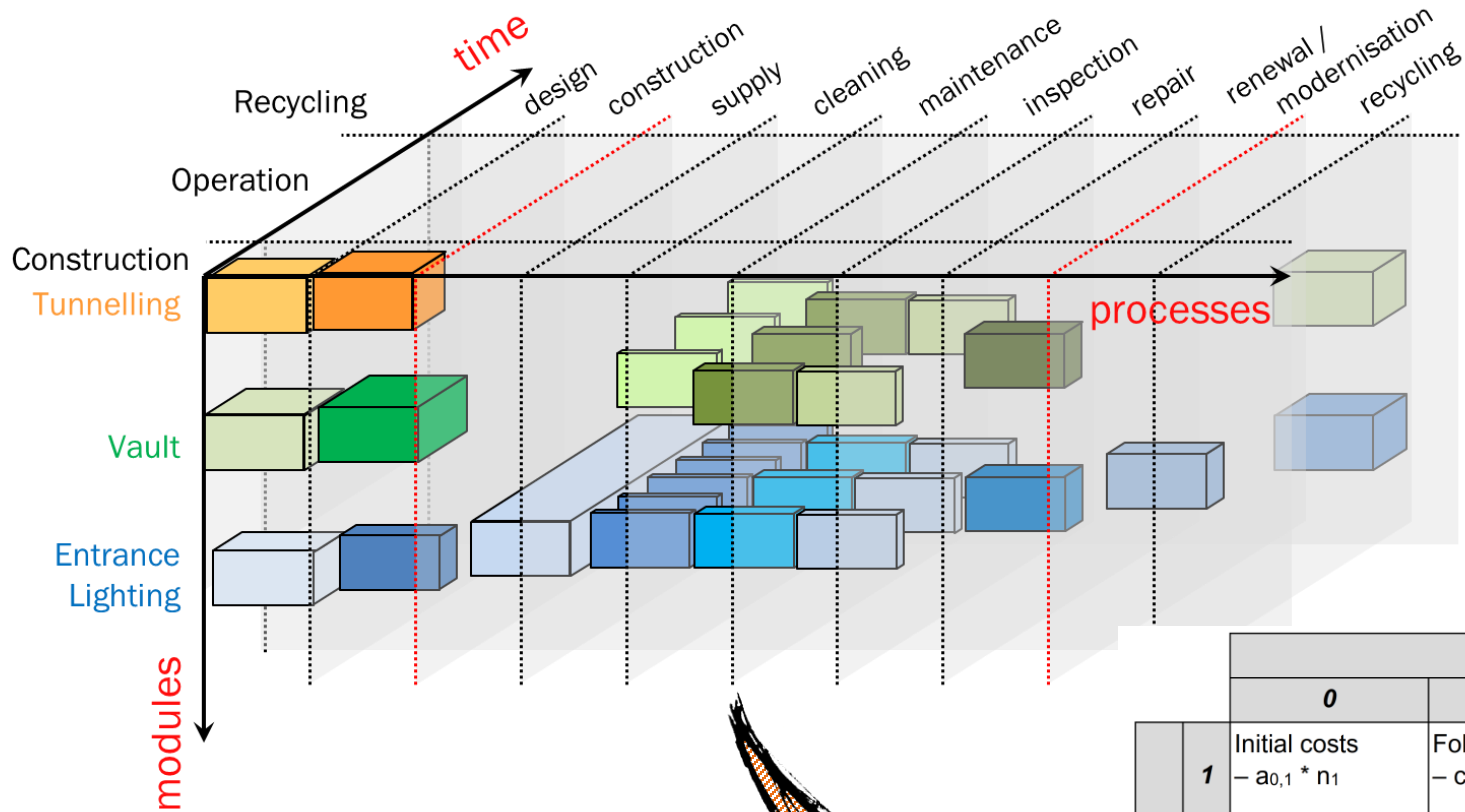


LCC COST MODEL – MODULES

- ① Elements
- ② Processes
- ③ Services
- ④ Costs
- ⑤ Time parameters
- ⑥ Interfaces



LCC Cost Model – Cost Calculation

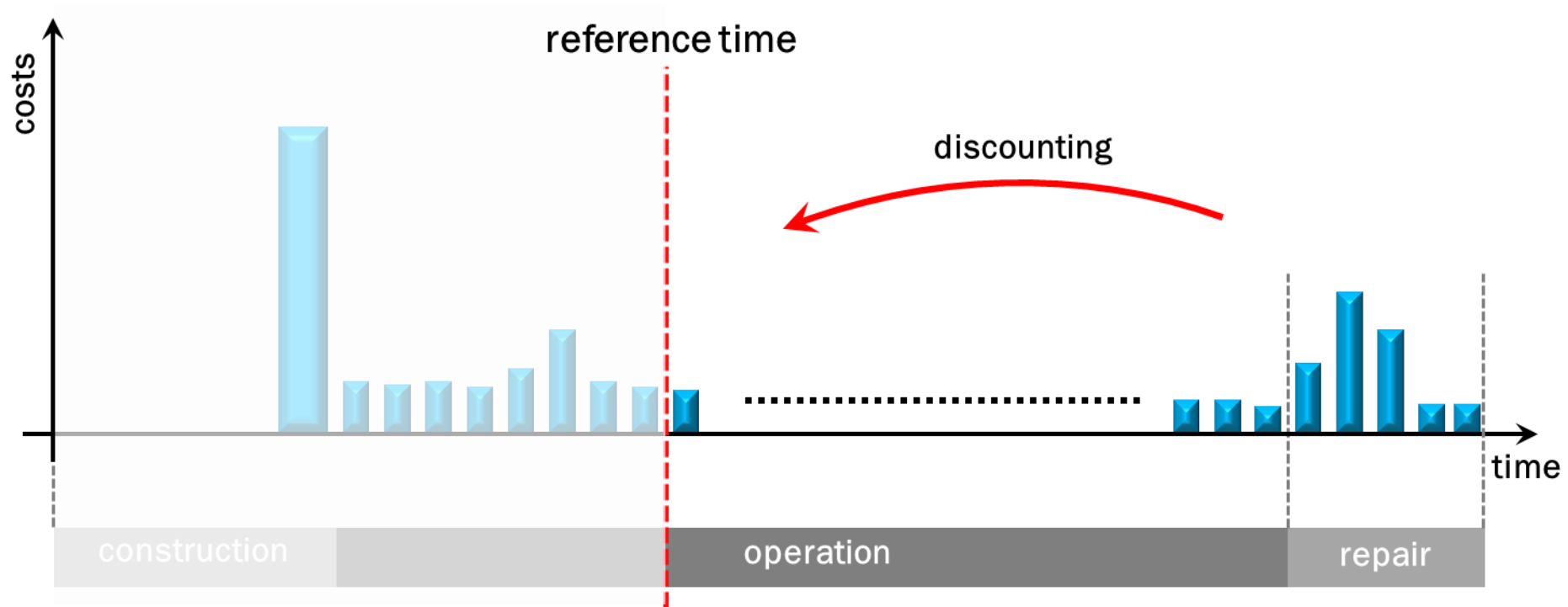


		Time point t [years]						
		0	1	2	...	10	...	z
Module j	1	Initial costs – $a_{0,1} * n_1$	Follow-up costs – $c_{1,1} * n_1$	Follow-up costs – $c_{2,1} * n_1$	...	Follow-up costs incl. replacement – $c_{10,1} * n_1 - a_{10,1} * n_1$	...	Follow-up costs – $c_{z,1} * n_1$
	2			Initial costs – $a_{2,2} * n_2$	...	Follow-up costs – $c_{10,2} * n_2$	...	Follow-up costs – $c_{z,2} * n_2$

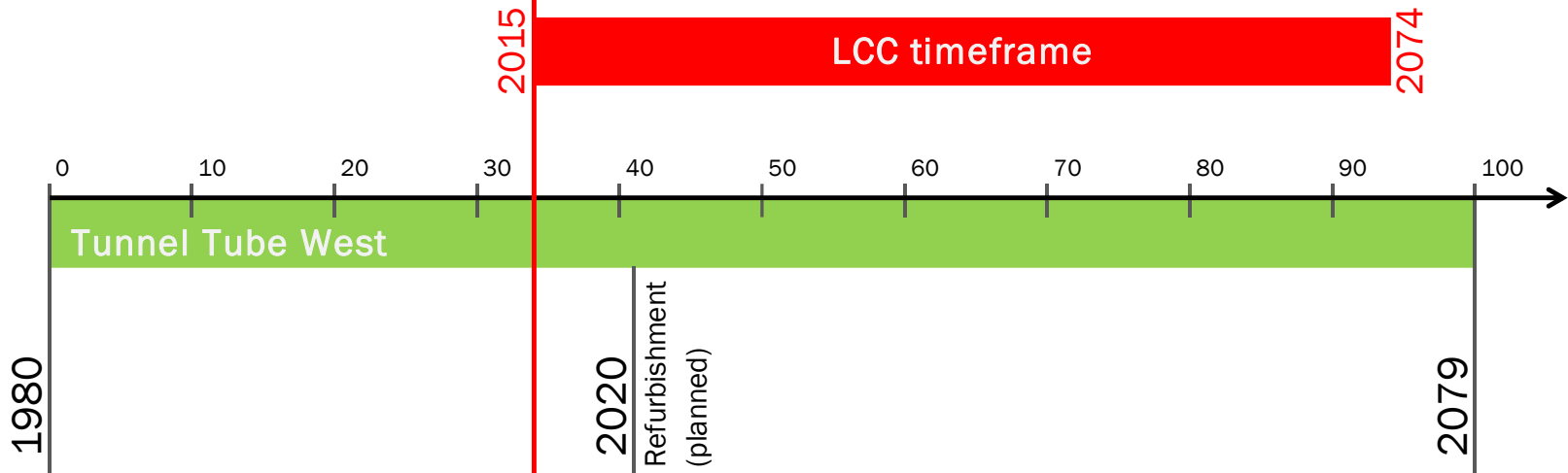
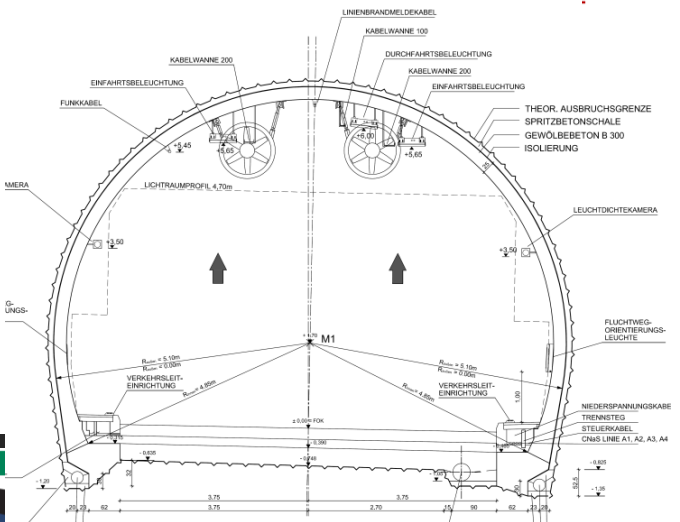
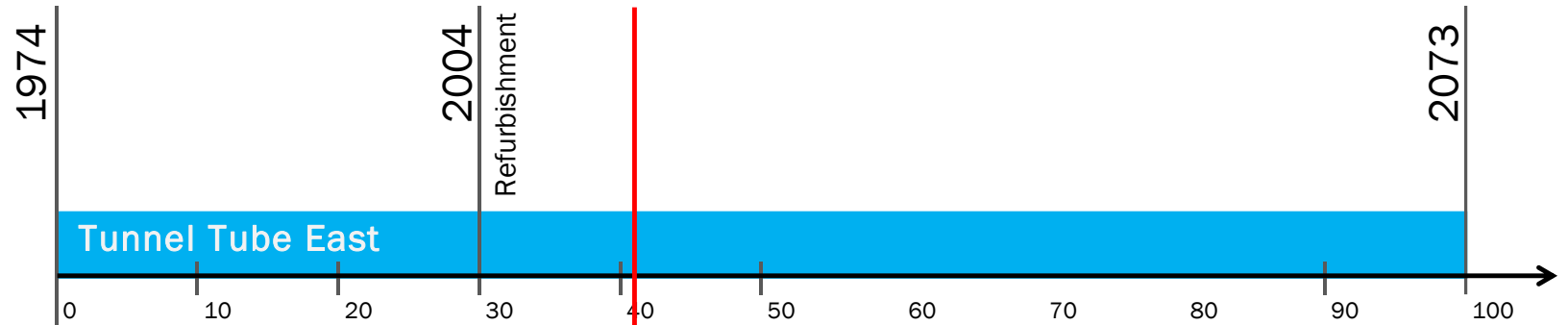
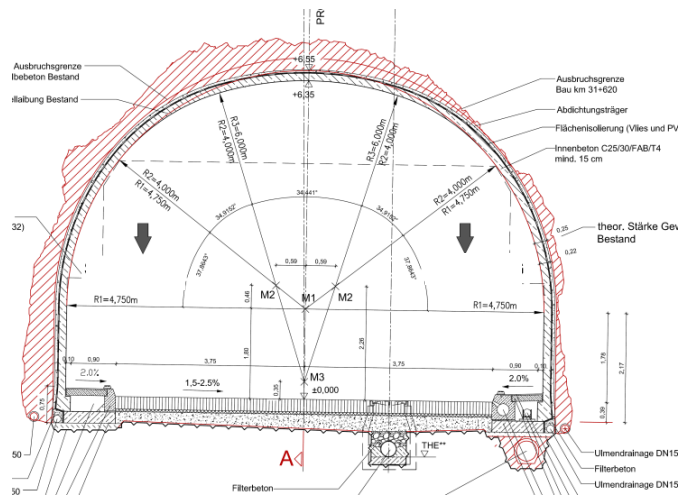
	x	Initial costs – $a_{0,x} * n_x$	Follow-up costs – $c_{1,x} * n_x$	Follow-up costs – $c_{2,x} * n_x$	...	Follow-up costs incl. replacement – $c_{10,x} * n_x - a_{10,x} * n_x$	...	Follow-up costs – $c_{z,x} * n_x$



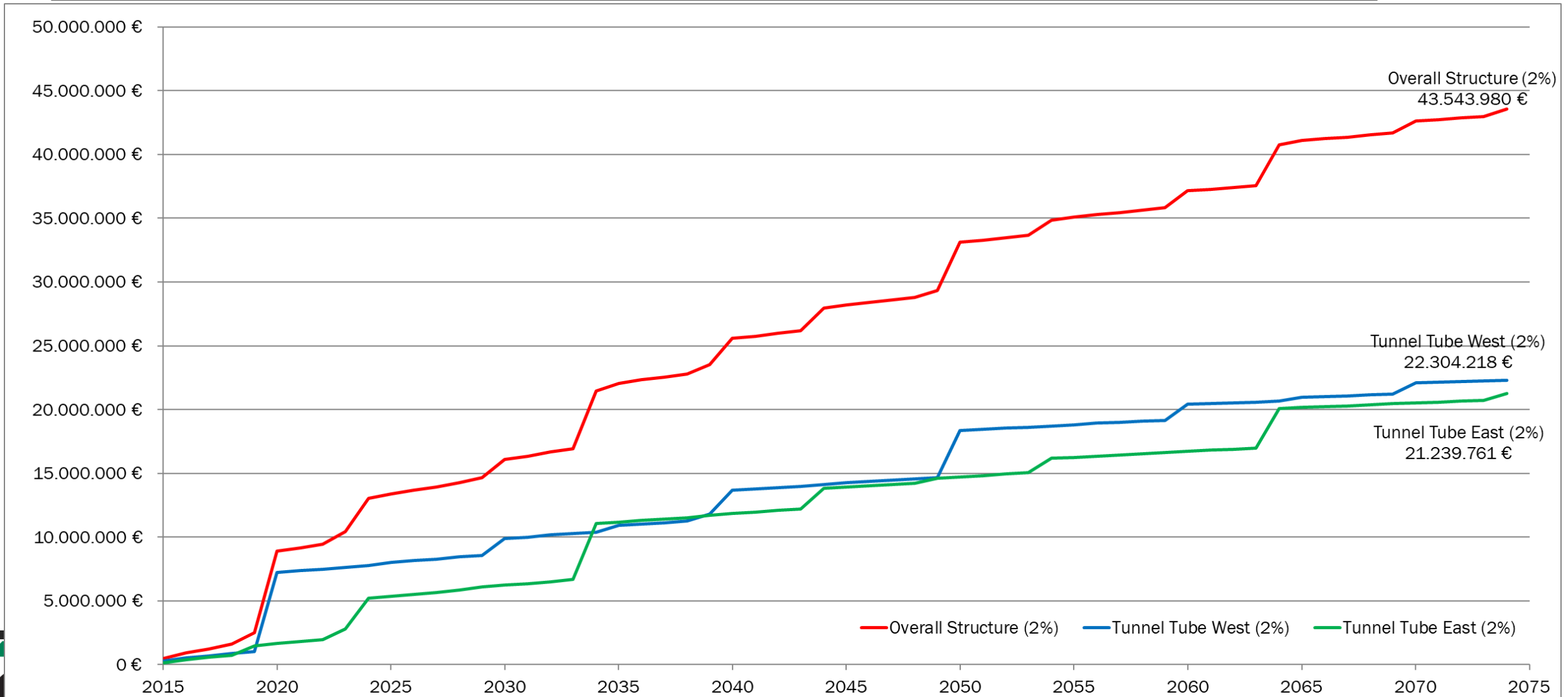
LCC COST MODEL – NET PRESENT VALUE



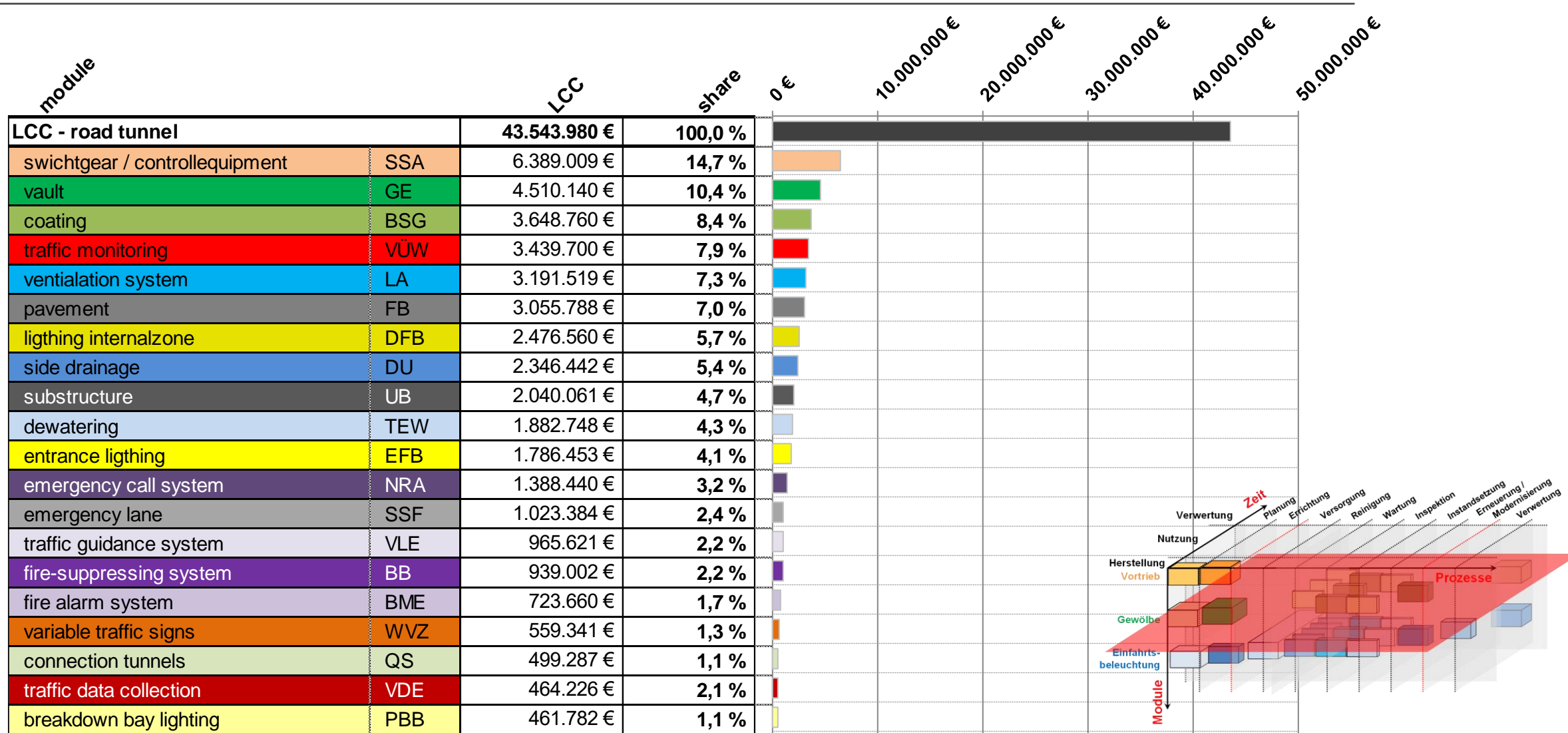
LCC COST MODEL – EXAMPLE



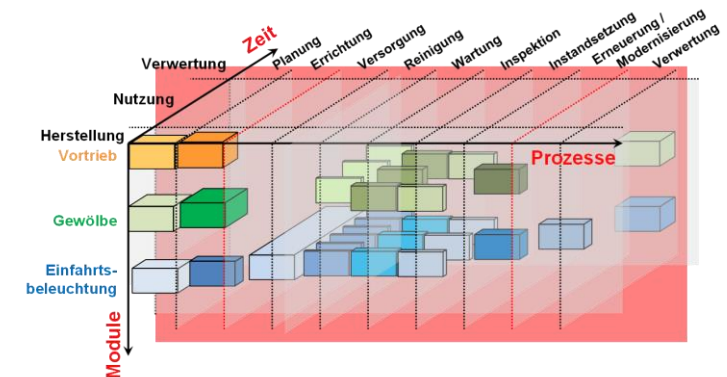
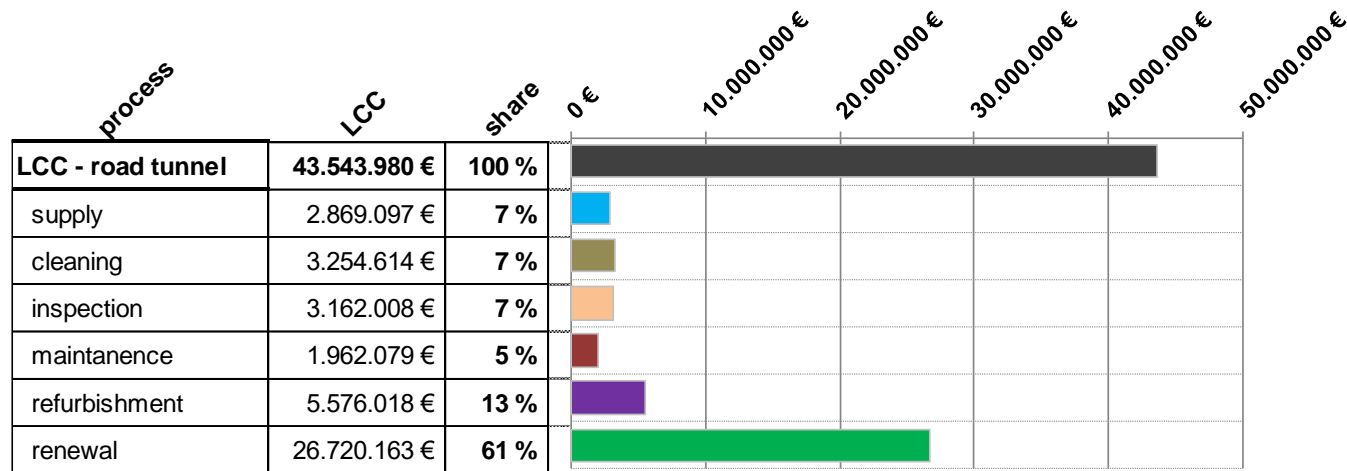
LCC COST MODEL – RESULTS | ANALYSIS



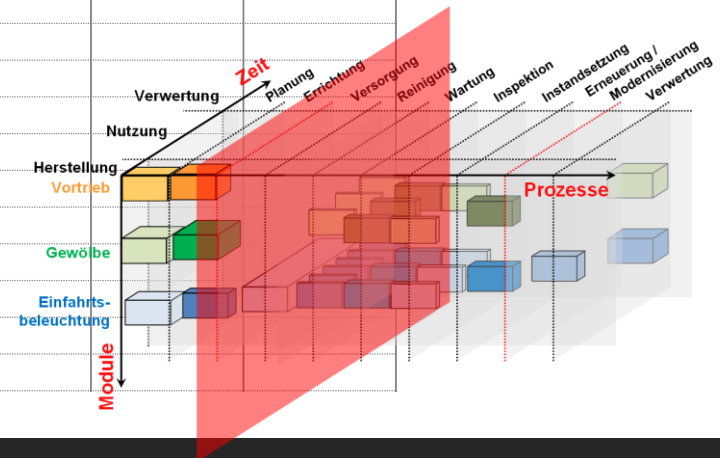
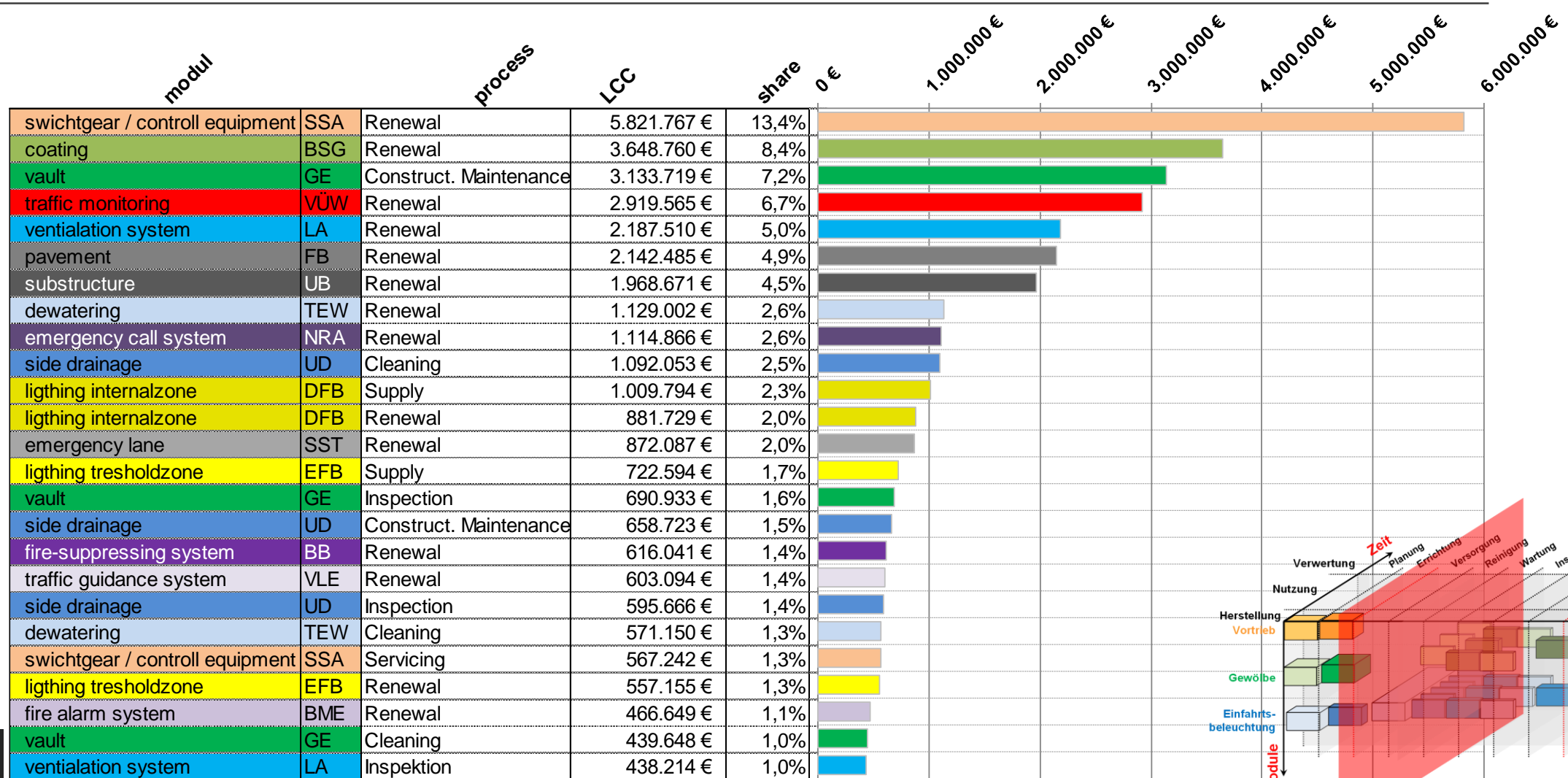
LCC COST MODEL – RESULTS | ANALYSIS



LCC COST MODEL – RESULTS | ANALYSIS



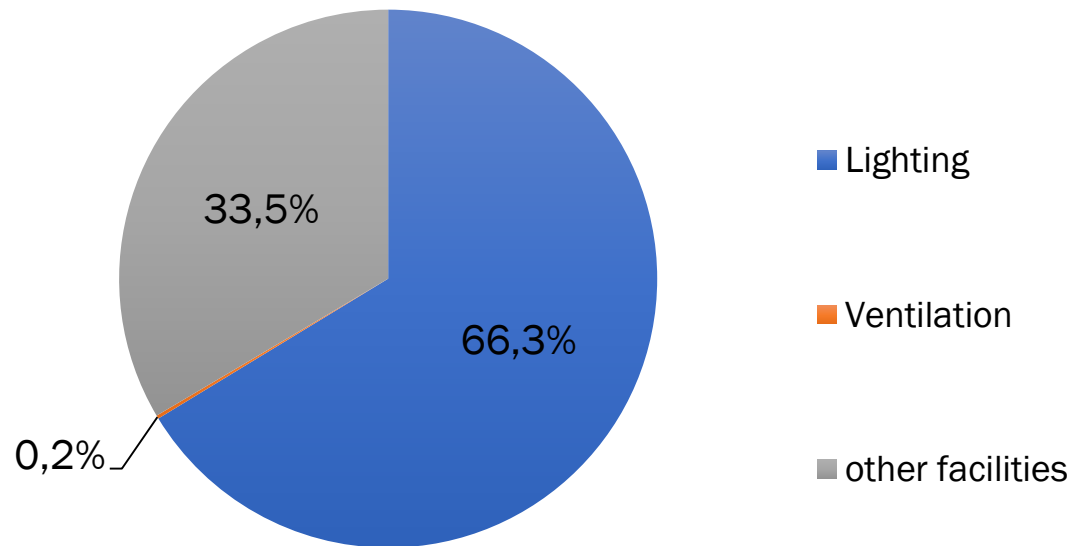
LCC COST MODEL – RESULTS | ANALYSIS



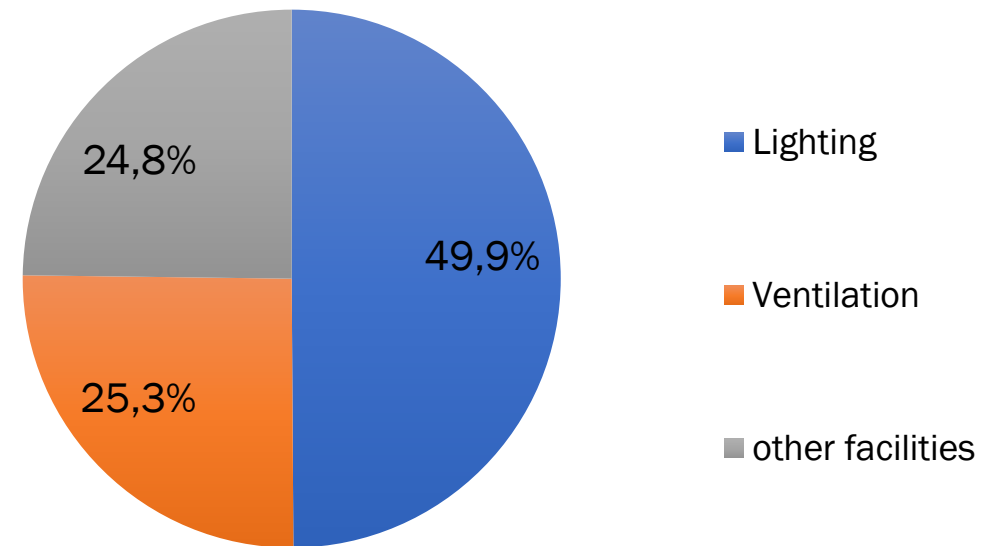
LCC COST MODEL – RESULTS | ANALYSIS

Energy consumption and energy costs in consideration of costs for monthly power peaks

Annual energy consumption [%]



Annual energy costs [%]



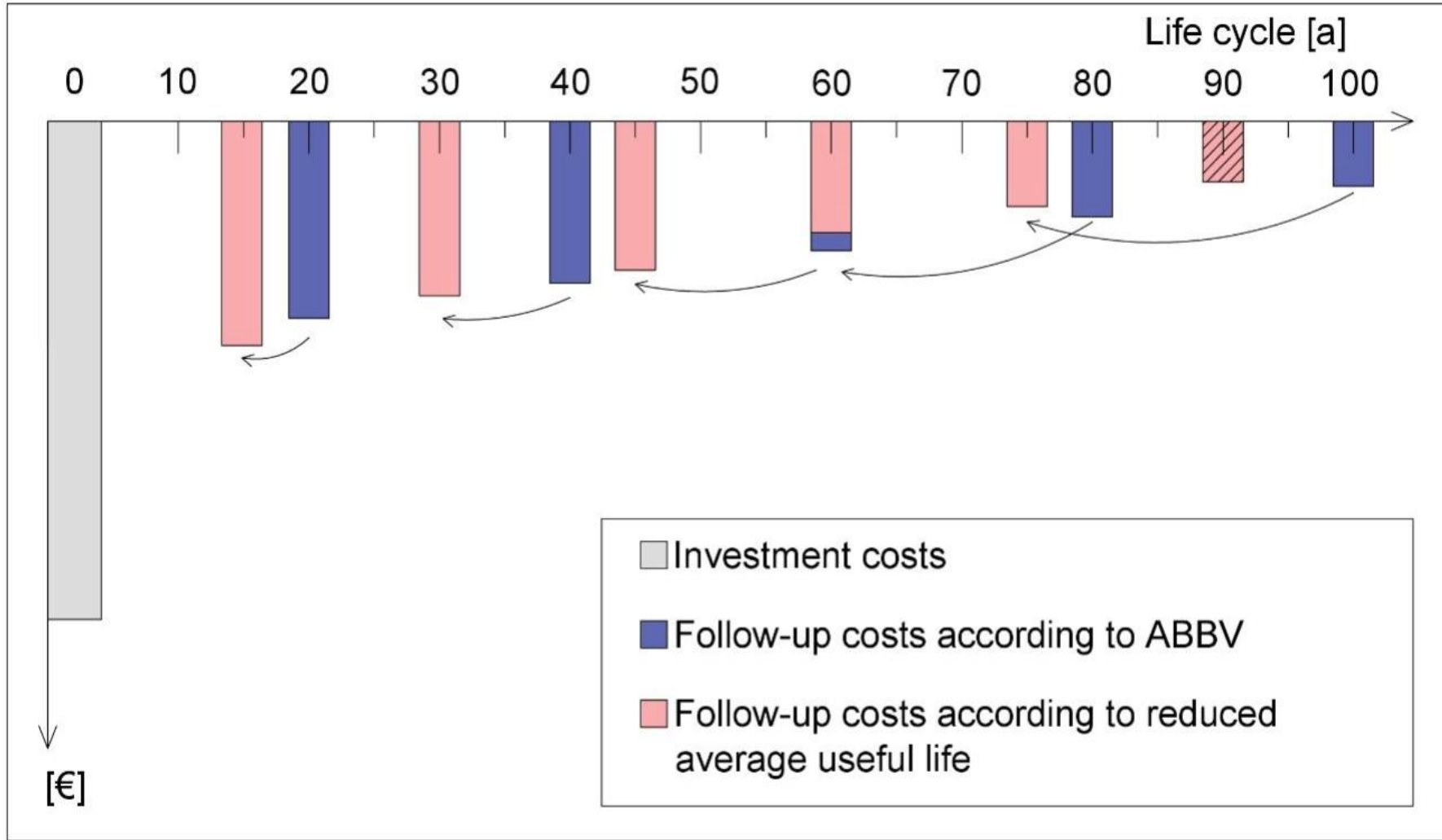
LCC Cost Model – EXAMPLE



Module Entrance Lighting - Tube east

Parameter	Elements	Amount
High pressure sodium vapor lamps (GSB)	High pressure sodium vapor lamps 150 W	50 piece
Double-row light arrangement tunnel ridge	High pressure sodium vapor lamps 250 W	0 piece
Step switching	High pressure sodium vapor lamps 400 W	66 piece
Luminance L20 (200 cd/m ²)	Cable	5.310 m
Directional traffic	Cable trough	220 m
		1 piece
		1 piece

Entrance Lighting - s
Operating hours in the ir stage
operating hours
Equivalent operating hours under full load
Luminares
Energy consumption of lu
Power loss ballast (VVG)
Number of luminares
System power under full l
Energy cost Luminares
Energy cost sensors
outdoor luminance L20
Luminance viewing distar



Interfaces	Amount
	22.500,00 €
	10.000,00 €
	54.132,80 €
	22.577,10 €
	23.000,00 €
	132.209,90 €

* Consideration of an annual increase in performance until renewal



PROBLEMS | OBSTACLES

Lack of reliable information on historical costs and performance, which is needed for accurate estimation of costs.

Lack of information is the uncertainty inherent in any forecast of future costs and performance. How a building and its functional subsystems behave - over the course of a 25-to 30-year service life.

[Controlling Cost of Ownership from Design Throughout the Service Life of Public Buildings. Washington, DC: The National Academies Press. <https://doi.org/10.17226/1750>.]

The traffic data and service data often are separated from each other in tunnel operations management.

An improvement in the collaboration between different stakeholders is needed!

Probleme bei der Informationsbeschaffung zur Ermittlung der Lebenszykluskosten (insbesondere der Nutzungskosten)

Allgemeine Daten und Kostenkennwerte zu Folgekosten

Schlechte Verfügbarkeit belastbarer Kennwerte/Angaben

Projektspezifische Ist-Daten und Planungsdaten als Grundlagen

Teilweise schlechte Verfügbarkeit und ggf. schwierige Datenerhebung

The majority of experts see problems in the **availability** of **reliable general cost indicators** and information that is needed to determine usage costs...

[Research report F3218 – Zukunft Bau – 2020, Authors: Guido Spars, Olivera Obadovic]



OPPORTUNITIES FOR LCC-MODEL – BIM – DIGITAL TWIN

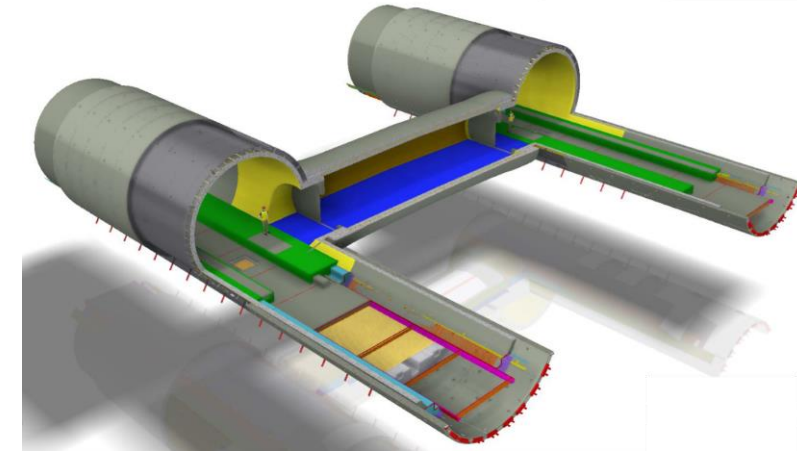
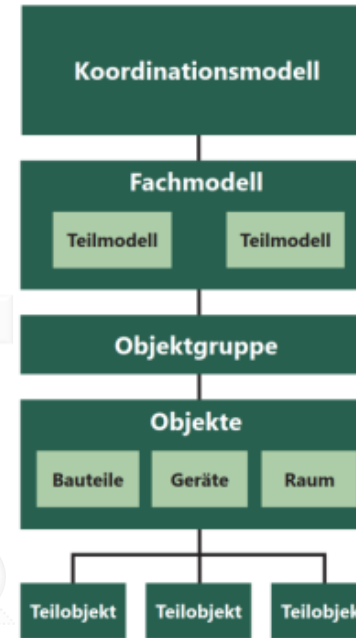
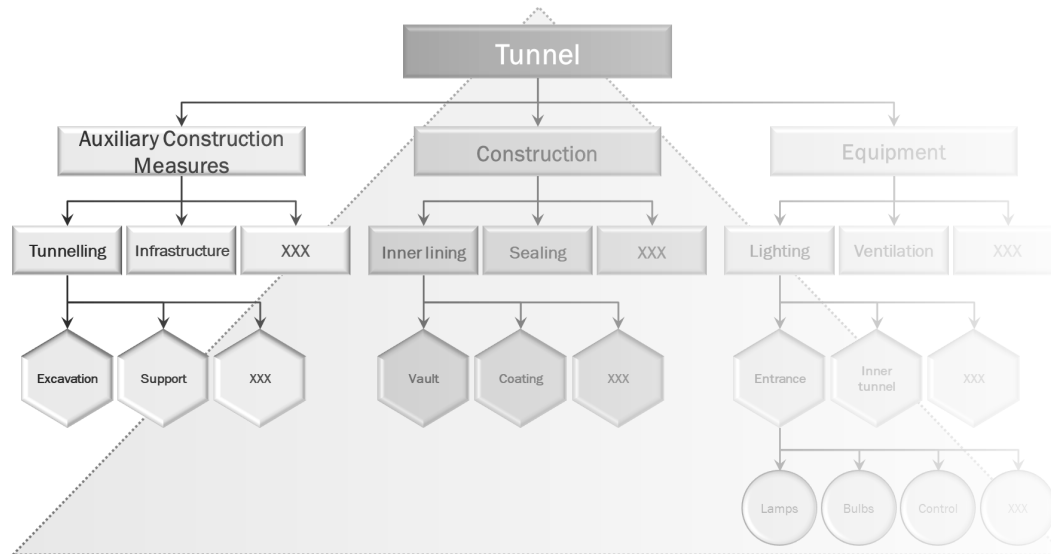
Tunnel

System

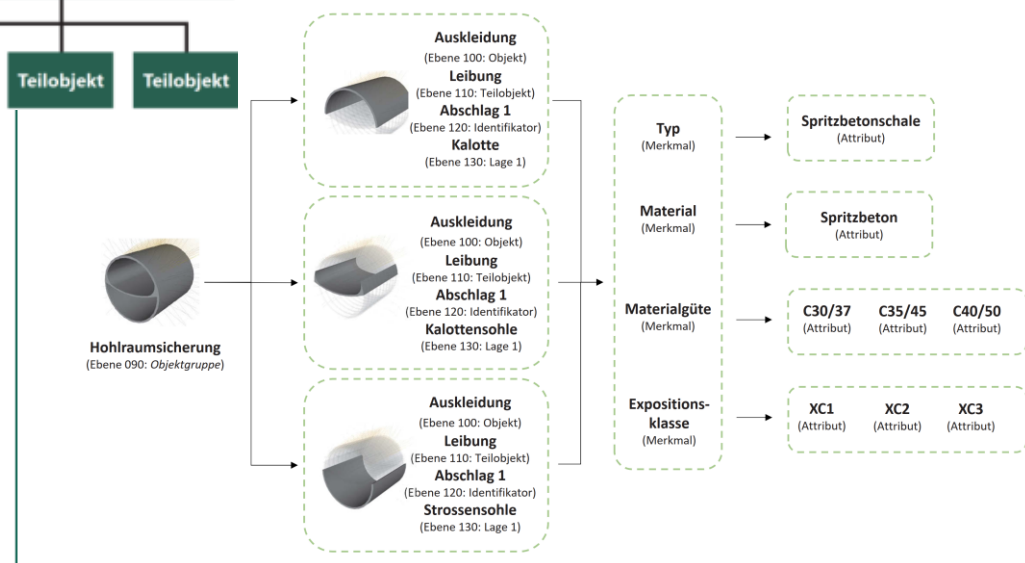
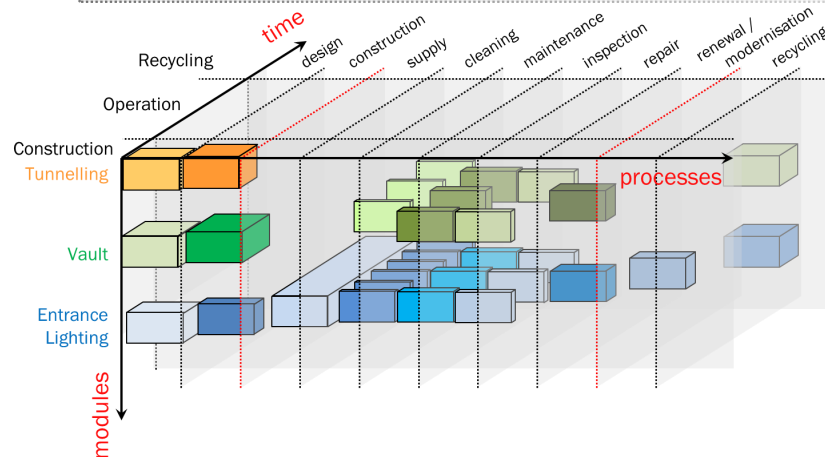
Group

Module

Element



Objektkatalog Merkmalkatalog



OPPORTUNITIES FOR LCC >> DIGITAL TWINS

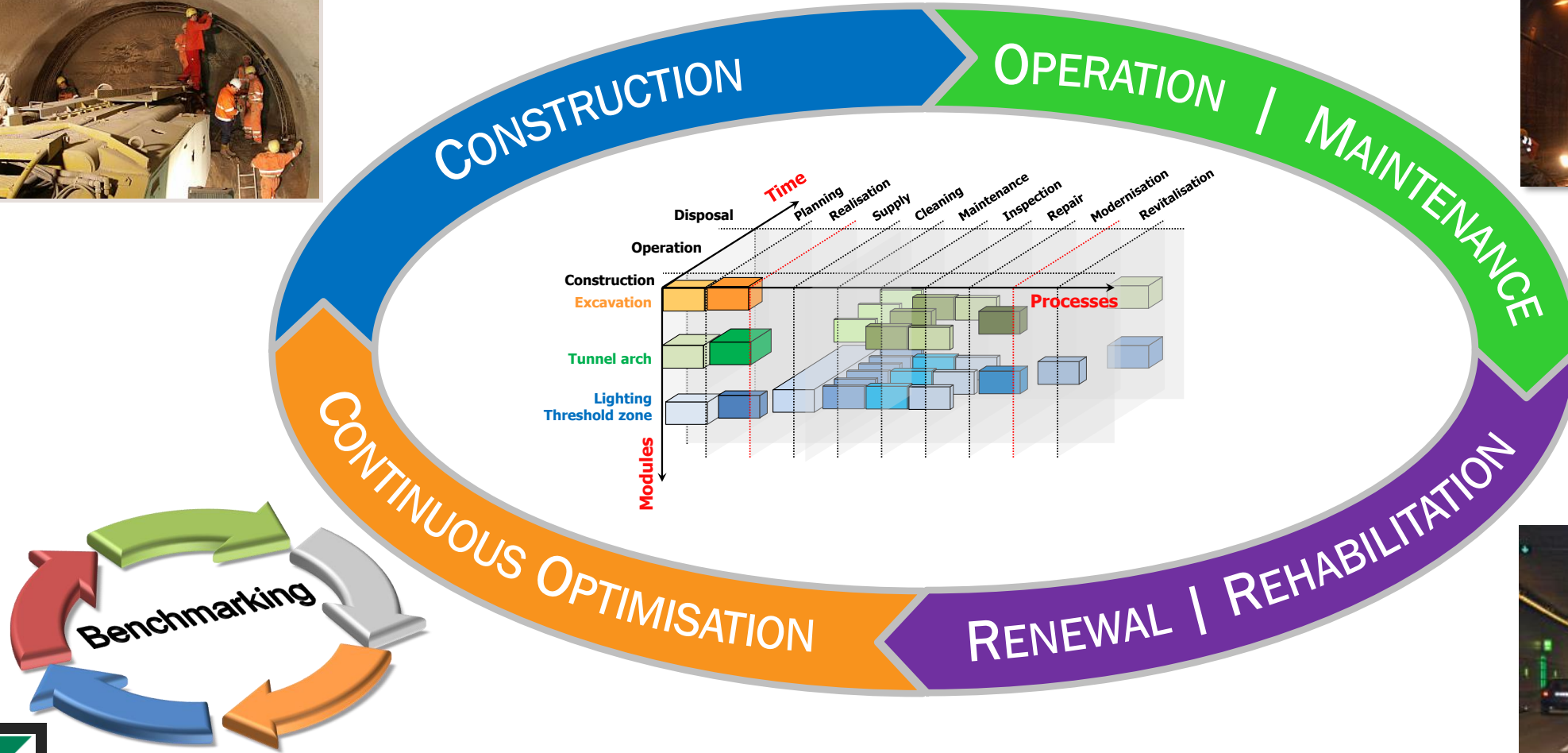
Smart monitoring

Predictive operations

Predictive maintenance



OPPORTUNITIES FOR LCC >> DIGITAL TWINS



A photograph of a tunnel under construction. The tunnel is illuminated by several bright lights, creating a high-contrast scene. In the center, a yellow excavator is positioned on a dirt path. To the left, there is a piece of equipment with a bright light. In the background, a person is visible near a structure. The tunnel walls are rough and uneven, and the ceiling is supported by a network of cables and pipes. The overall atmosphere is industrial and busy.

LIFECYCLE COSTING IN OPERATION

THANKS FOR LISTENING