Infrastructure Cost-Efficient & Sustainable Procurement & Management

Overview & Implementation

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FOLKBR

Who am I ?!

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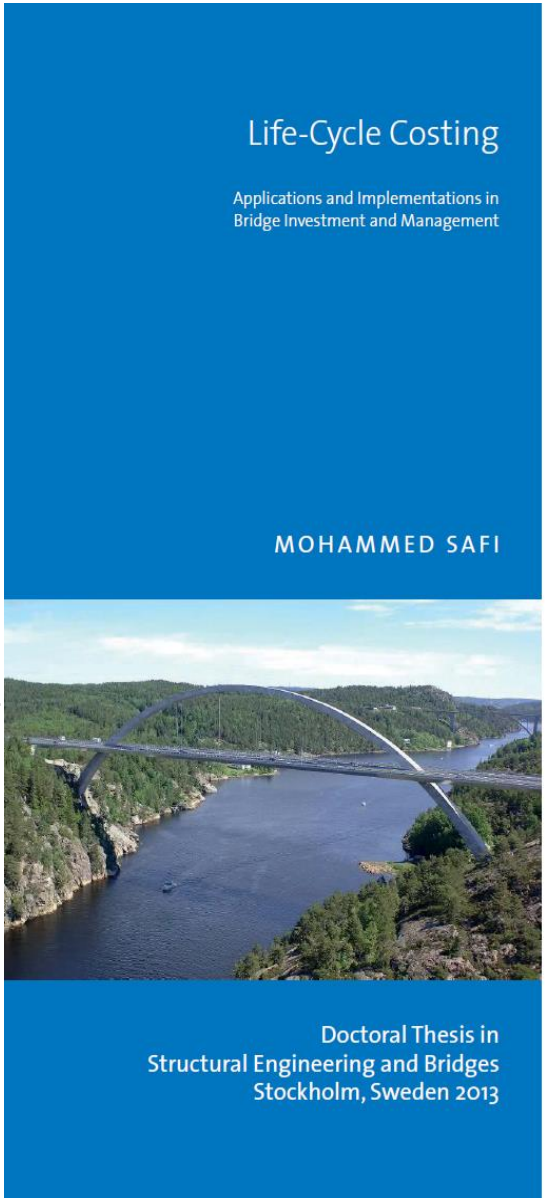


KTH Architecture and the Built Environment

EDUCATION & DEGREES

2013 **Ph.D.**, Structural Engineering and Bridges, KTH Royal Institute of Technology, Sweden.

Thesis: "*Life-Cycle Costing: Applications and Implementations in Bridge Investment and Management*"
Supervisors: Prof. *Håkan Sundquist* & Prof. *Raid Karoumi*
Opponent: Prof. *Jan-Eric Nilsson*/VTI
Evaluation Committee: Prof. *Anne Landin*-LTH, Prof. *Lennart Elfgren*-LTU & Prof. *Hans Lind*-KTH

CURRENT & PREVIOUS POSITIONS

2014 – Present	Infrastructure Life-Cycle Cost Analysis Specialist, FOLKBRO Konsult	FOLKBRO
2012 – 2013	Bridge LCC Analysis Specialist, Trafikverket – The Swedish Transport Administration	TRAFIKVERKET
2014 – Present	Researcher, KTH Royal Institute of Technology	KTH VETENSKAP OCH KONST — Structural Engineering & Bridges Division
2007 – Present	Board Member & Business Development Manager, AF-SAFI Company	AF-SAFI — General Trade, Contracting & Construction Material
2006 – 2007	Project Officer, UNRWA – United Nations Relief & Working Agency	UNRWA — Infrastructure Procurement & Development
2005 – 2006	Construction Engineer, AC-The Arab Contractors	Construction & Management

Agenda

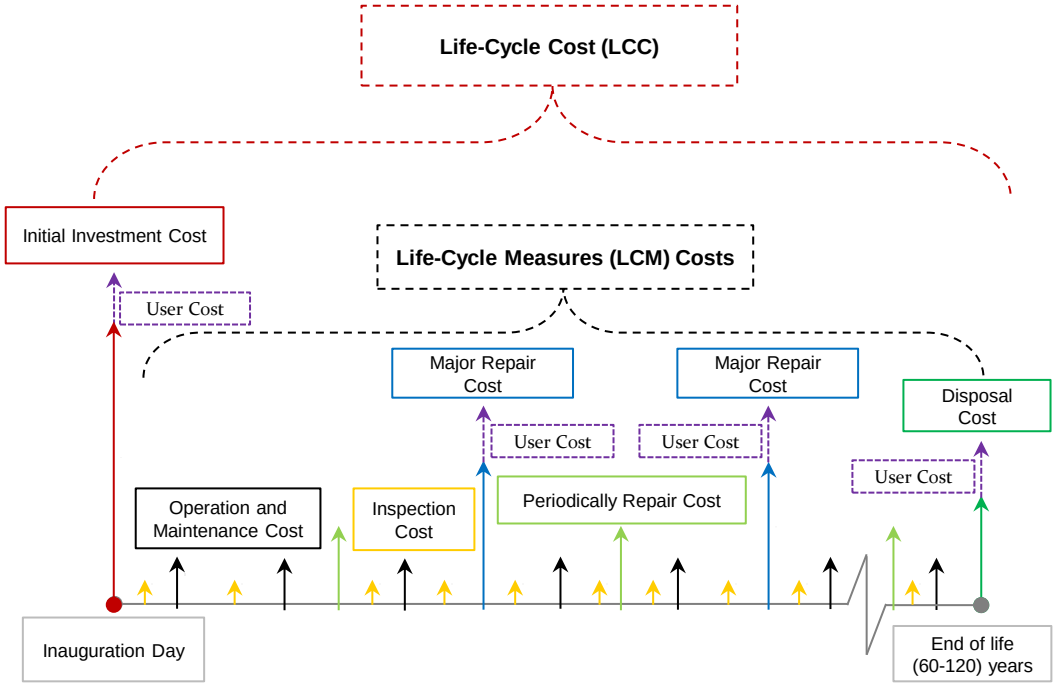
- Introduction
- Infrastructure life-cycle & the possible LCCA applications
- The Swedish bridge stock
- BaTMan and WebHybris
- LCCA for the procurement of new bridges
  - The optimal road/rail corridor
  - The optimal bridge design proposal
  - Holistic approach
- LCCA for management of existing bridges
  - Repair or replace a bridge?
- BaTMan-LCC tool & BaTMan-LCC course
- Questions & discussion

Background

- Selection from multiple alternatives
- Conventional financial costing
- Maximize efficiency, sustainability and ensure the optimum use of taxpayers' money
- Enhance infrastructure investment and management decisions by integrating LCCA into its procurement processes, thereby helping to optimize use of taxpayers' money and improve the sustainability of bridge infrastructure.

LCC & LCCA

Bridge **L**ife-**C**ycle **C**ost: LCC

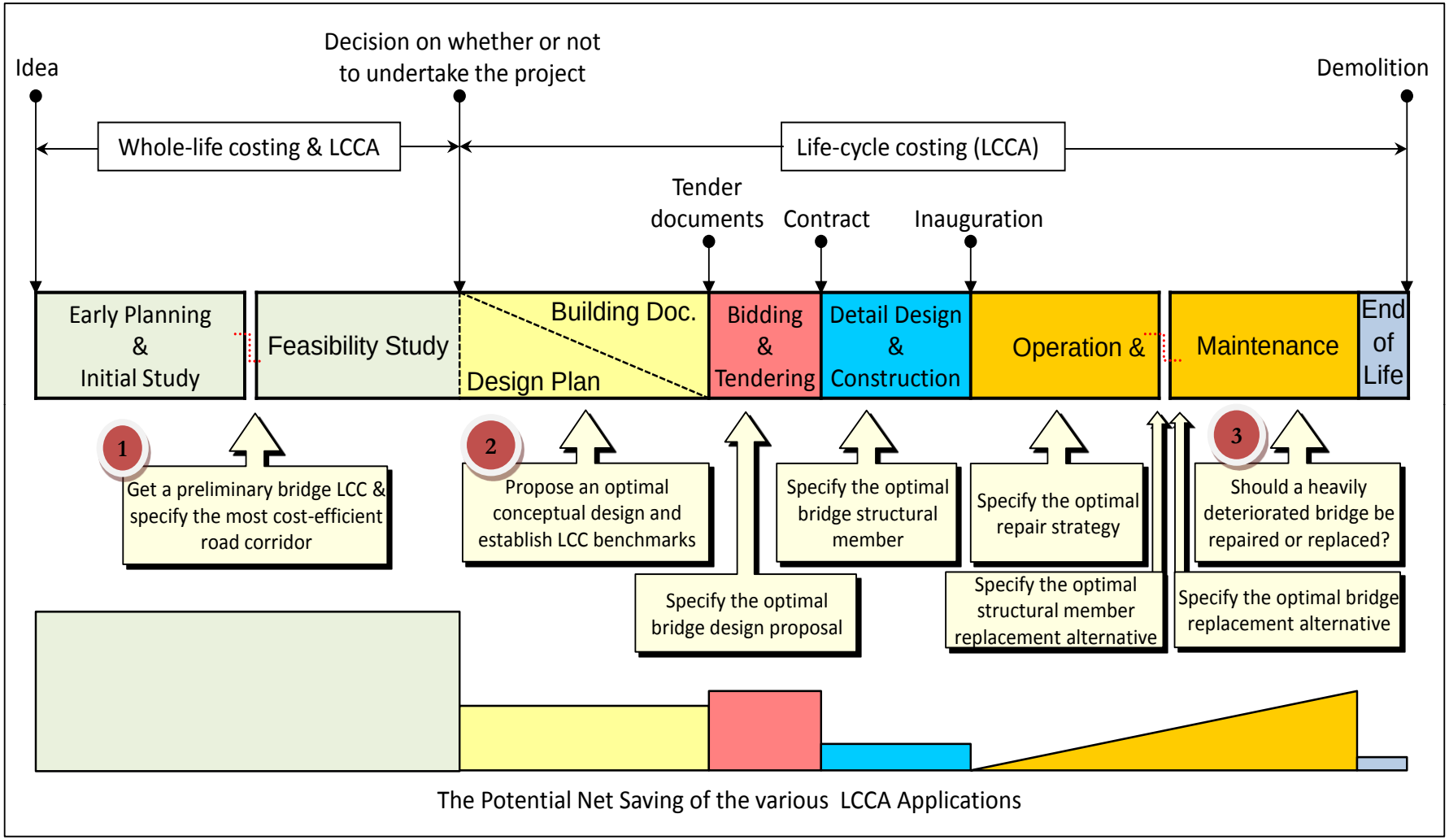


- The time value of money, discount rate
- Life-Cycle Costing/**L**ife-**C**ycle **C**ost **A**nalysis (LCCA)

Important to Acknowledge

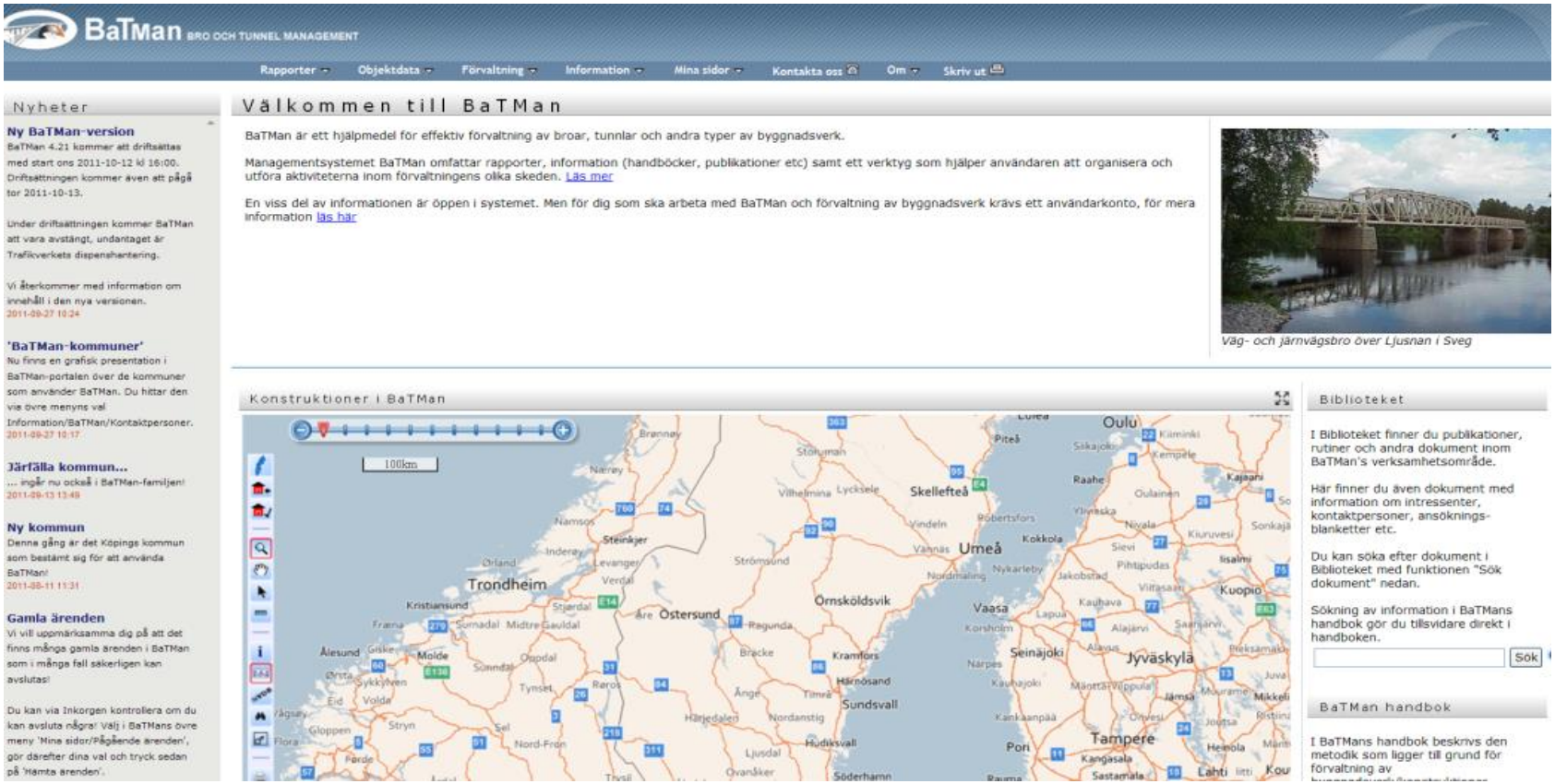
- The objective of LCCA is the minimization of the bridges' LCC not only the LCM costs.
- Not necessarily the most LCC-efficient alternative is the one associated with the least LCM cost or the longest life-span.
- It is the function of the design standards and the qualification requirements to minimize the LCM costs of the bridges.
- Proper implementation of LCC could at least save **488 Mkr/year** from Trafikverket's annual budget assigned for bridge investment and management.

LCCA Applications for Bridges



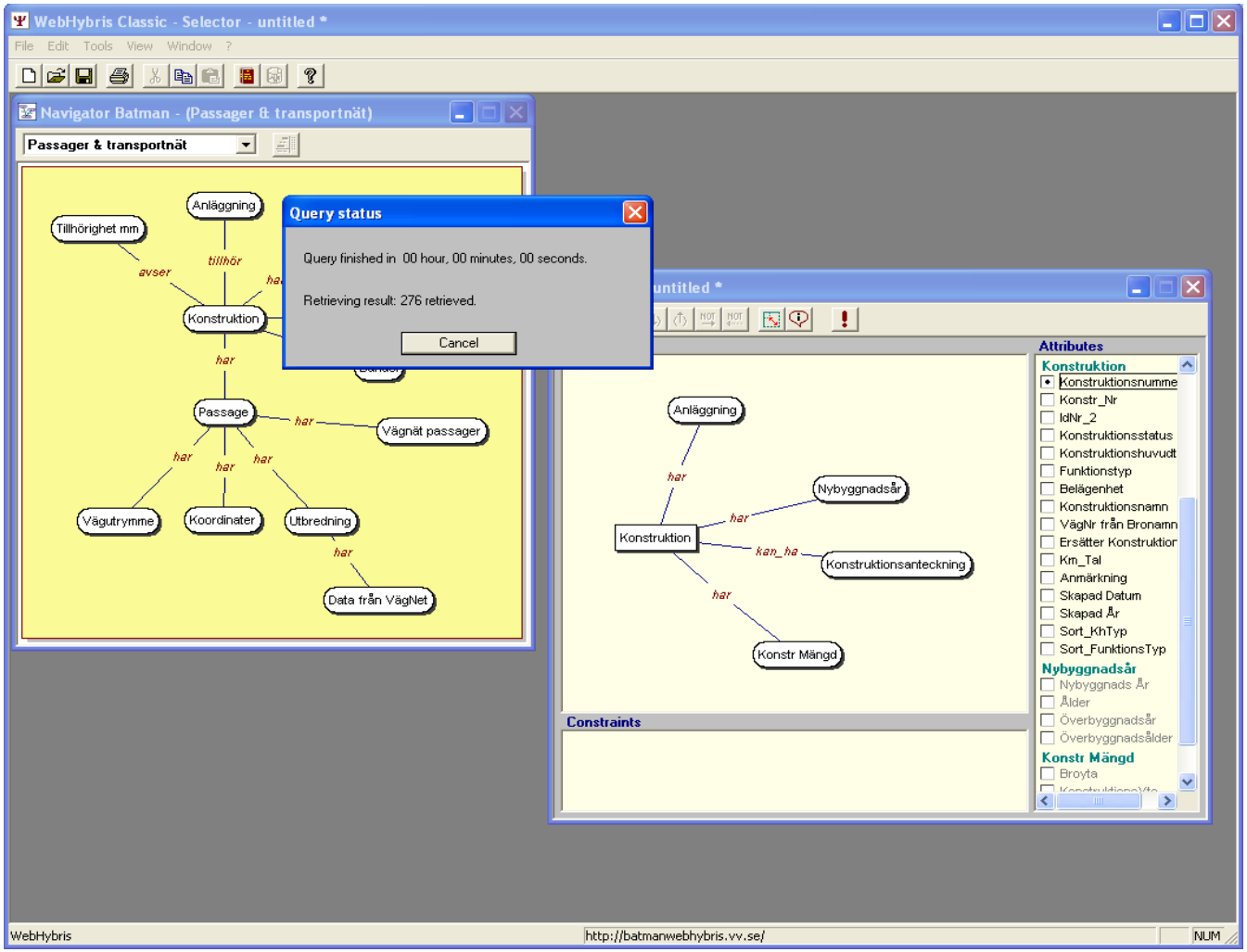
The Potential Net Saving of the various LCCA Applications

The Swedish Bridge and Tunnel Management System "BaTMan"



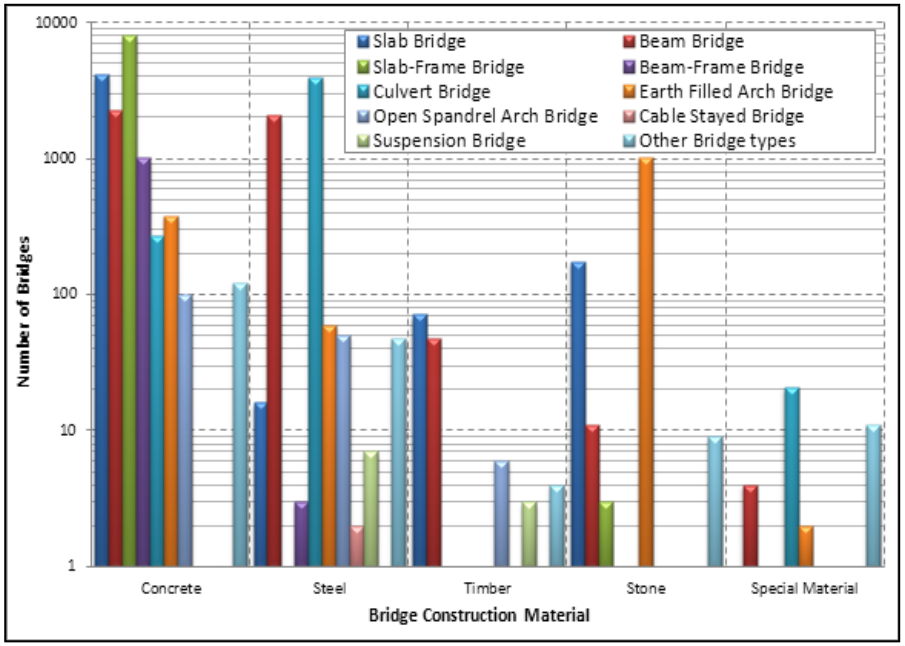
https://batman.vv.se/batman/

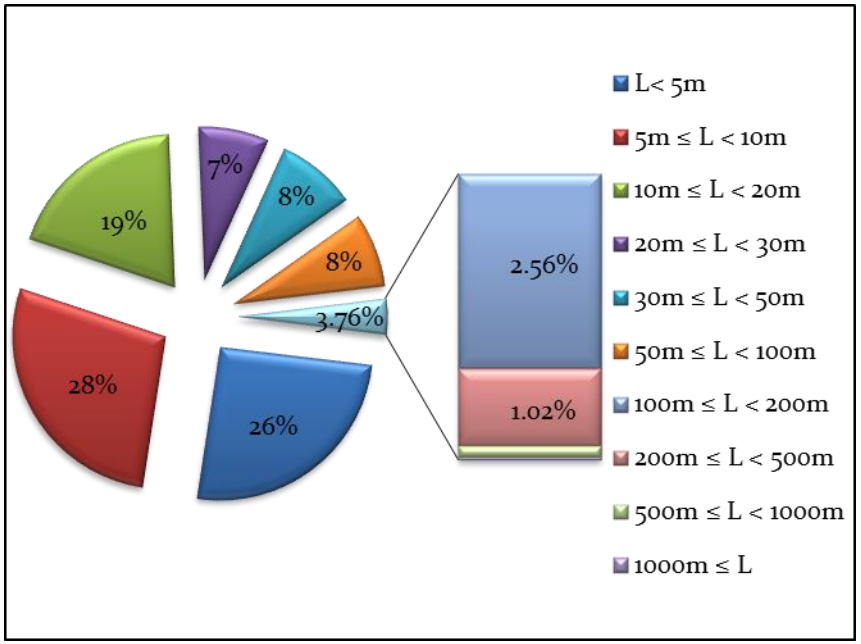
BaTMan’s Navigation Tool (WebHybris)



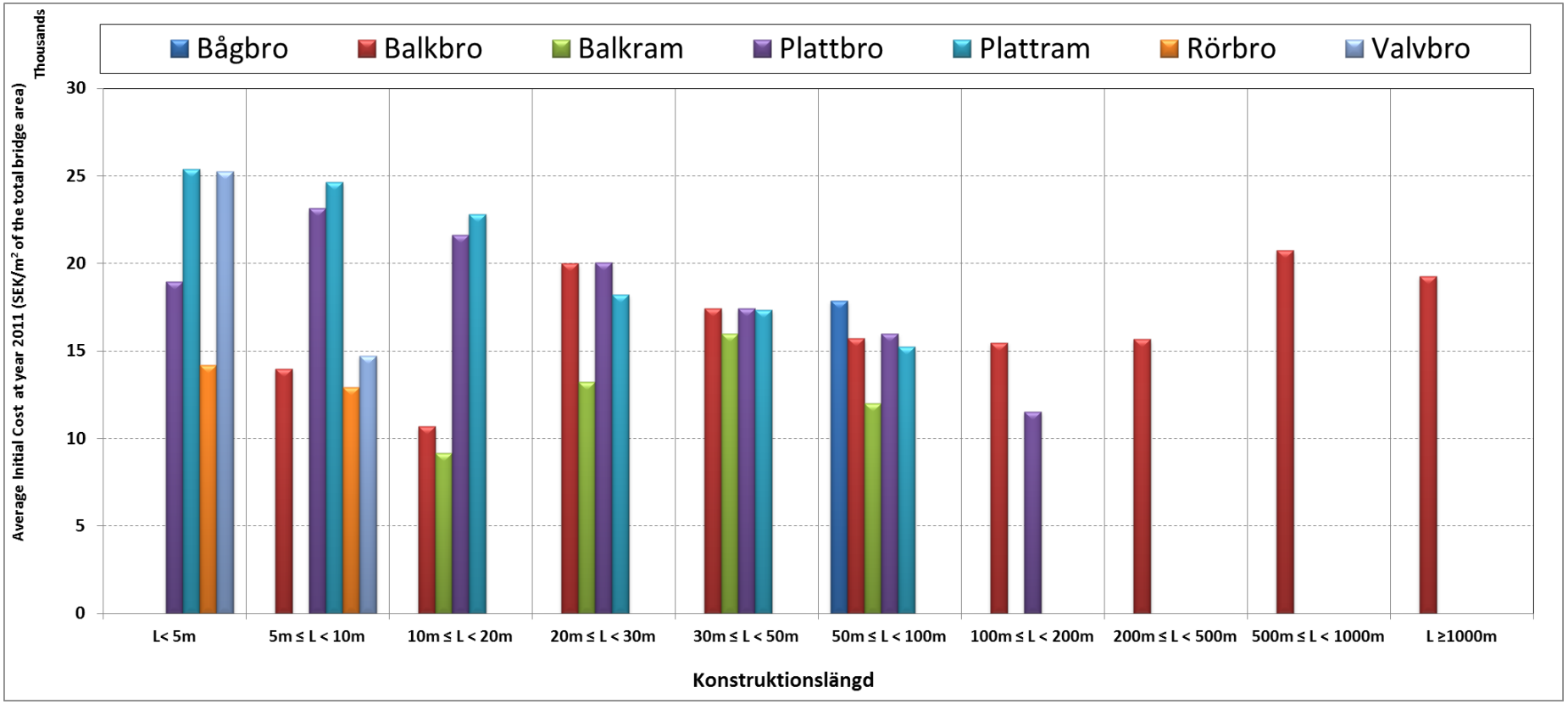
The Swedish Bridge Stock

	Bridge Function Type				Total No. Of Bridges	Bridge Total Area (m^2)	Bridge Total Length (m)
	Roadway	Railway	Pedestrian & Bicycle	Other			
BaTMan's Bridges	23,848	4,411	1,619	251	**30,129**	7,644,208	668,381
Trafikverket's Bridges in BaTMan	20,050	3,179	207	14	**23,450**	5,858,570	528,905



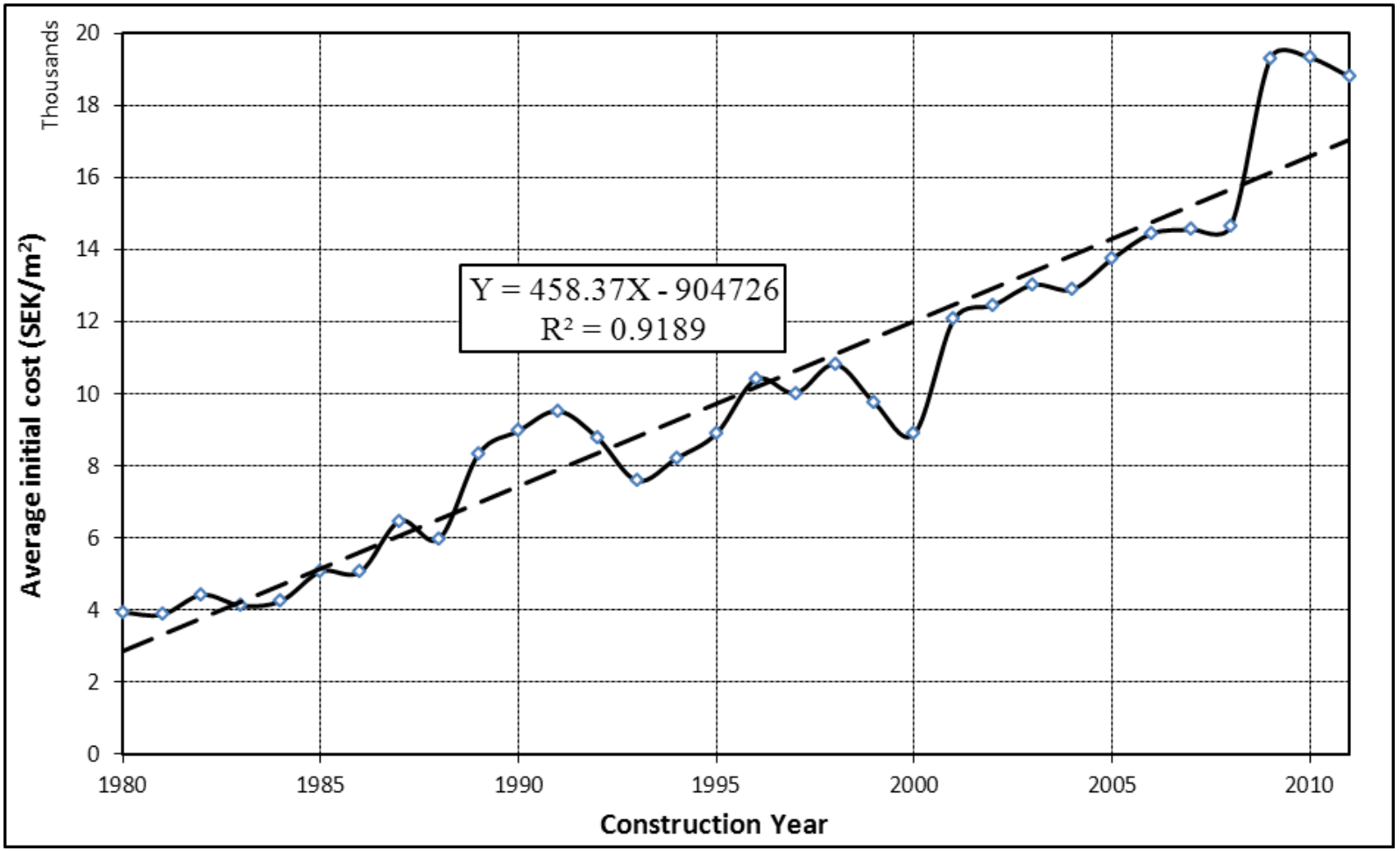


Swedish Bridges Real INV Cost



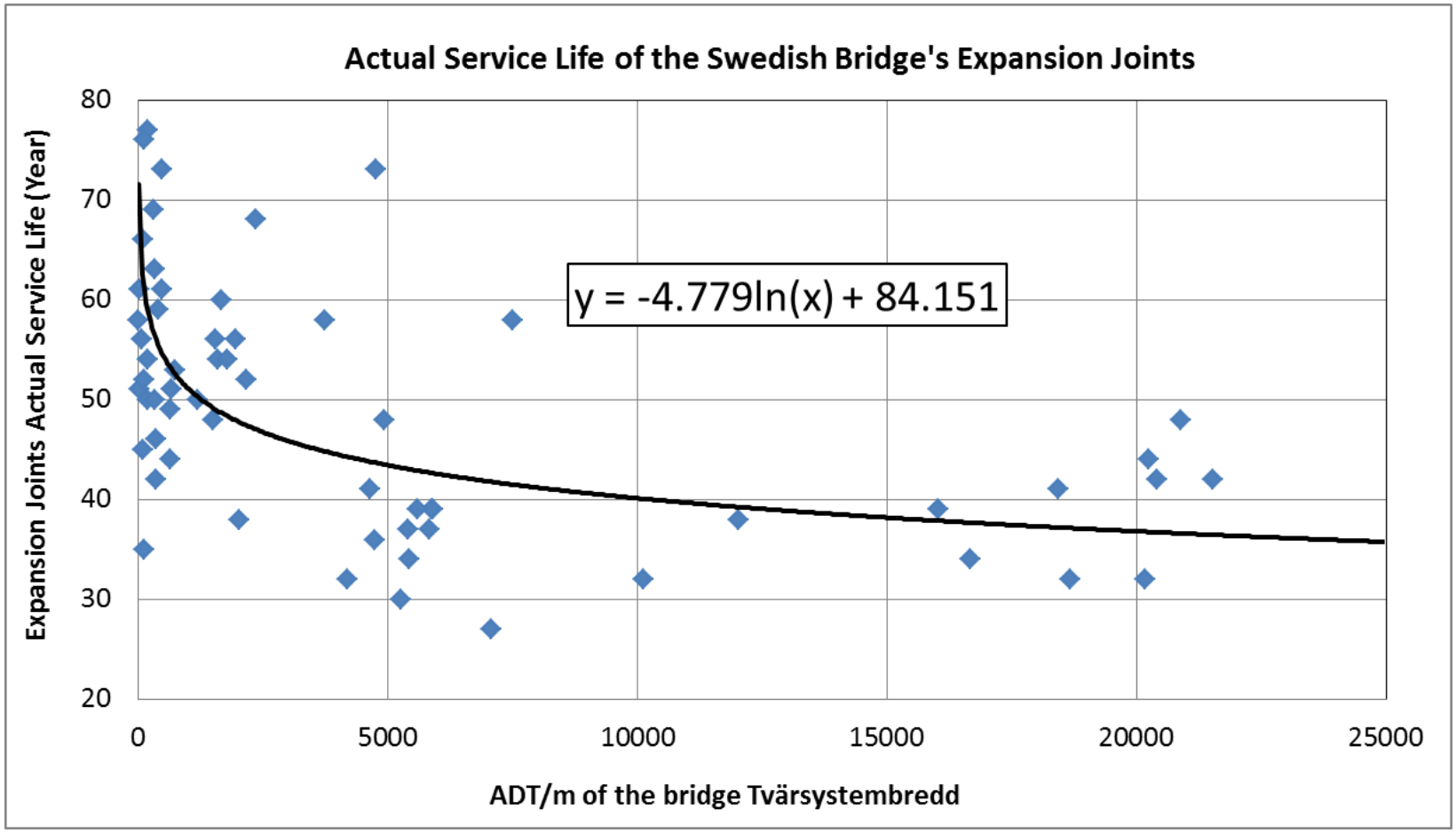
The average real initial costs of the Swedish bridges different types, based on cost data for 2,508 bridges constructed between 1980 and 2011.

Swedish Bridges Anticipated INV Cost



The inflation rate for the Swedish bridges initial costs

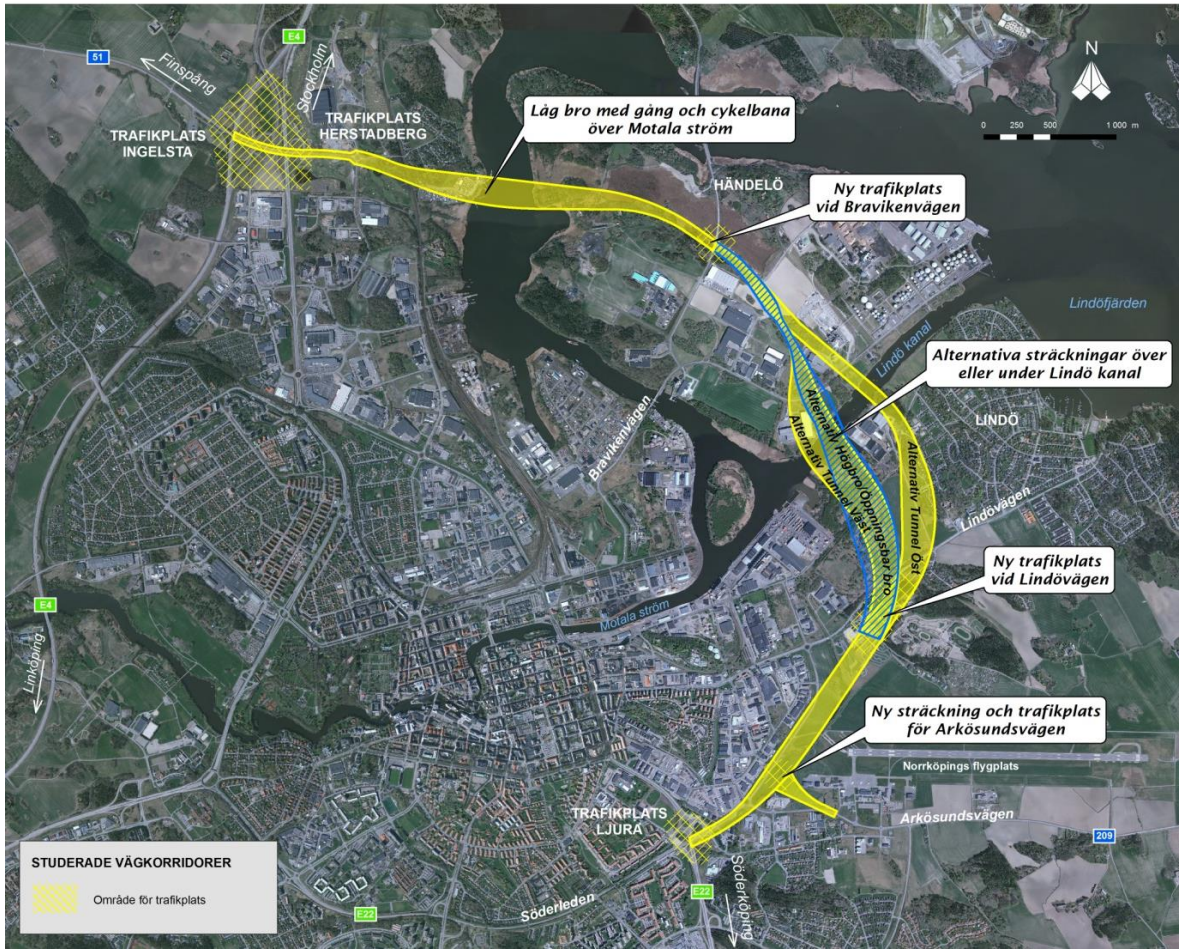
Structural-Members Life-Cycle Measures

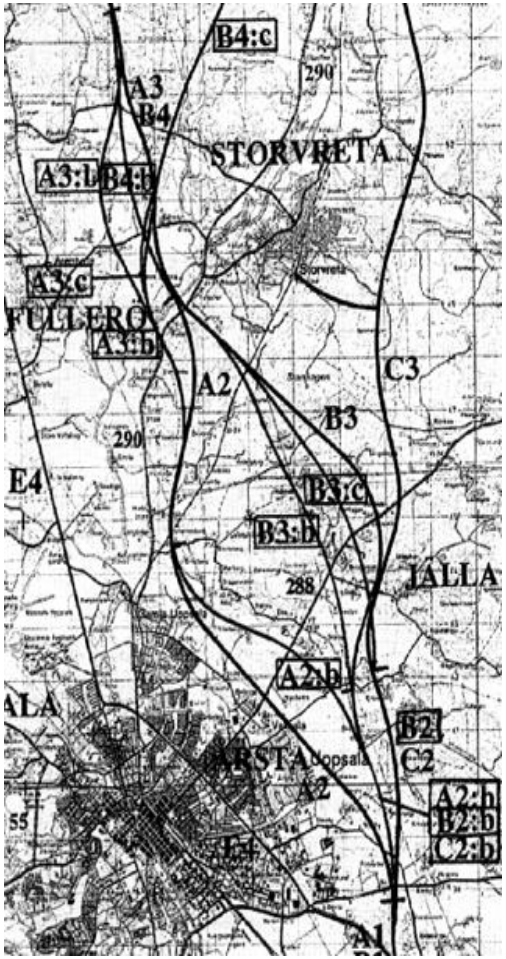


Based on 288 Replacement Actions performed between 1979 and 2010

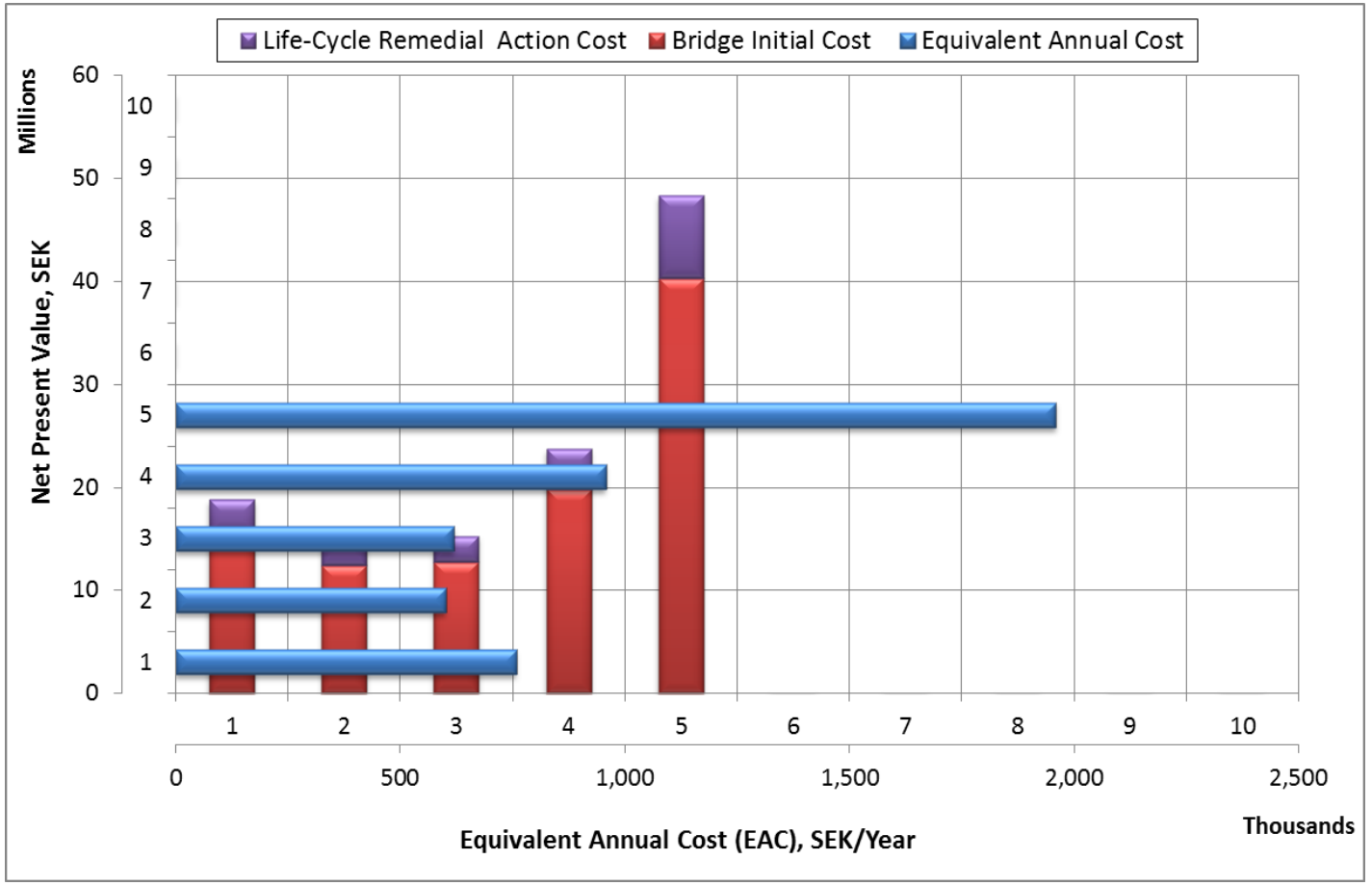
LCCA for Procurement of New Bridges

App. No. (1): Specify the most life-cycle cost-effective road corridor

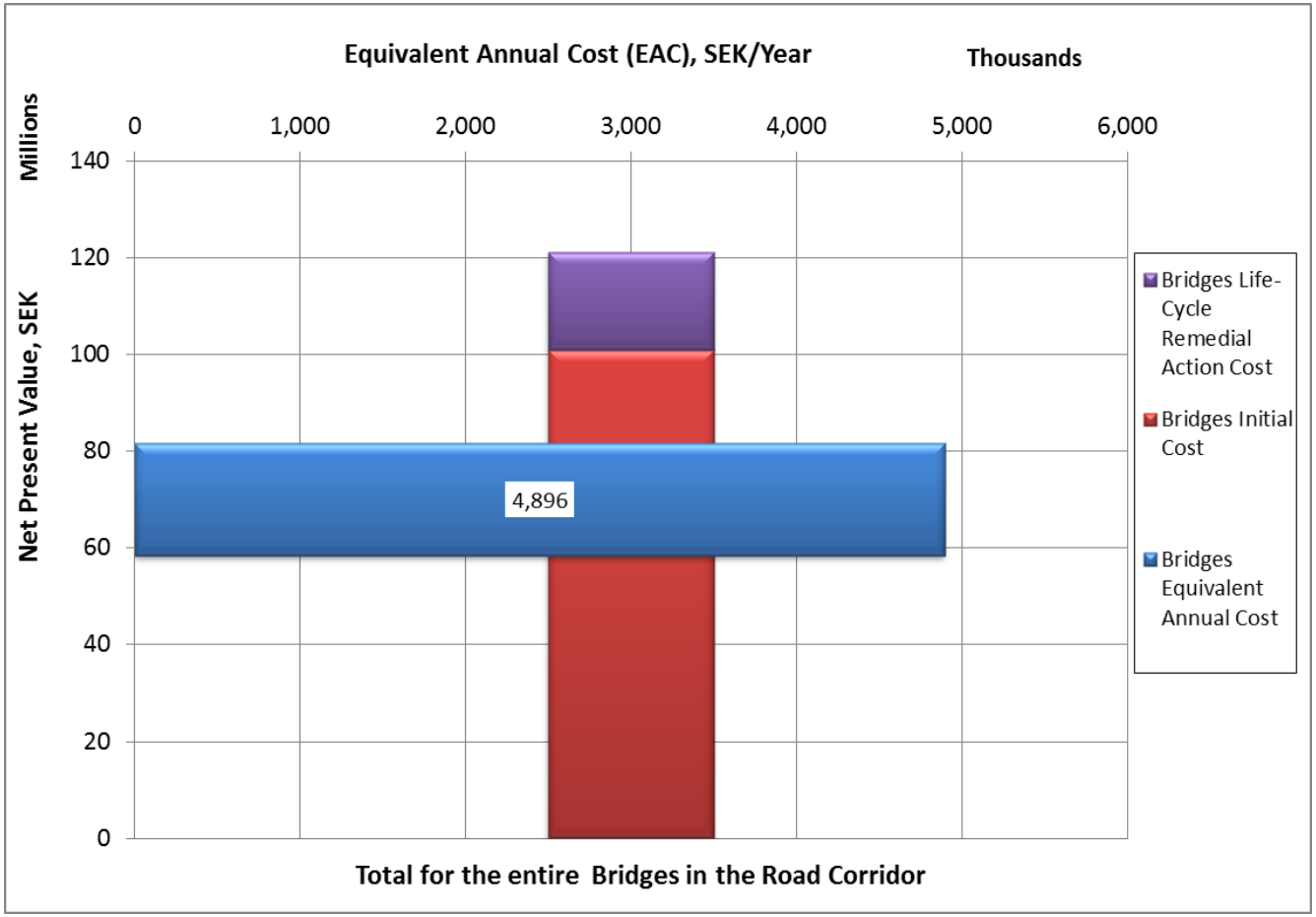




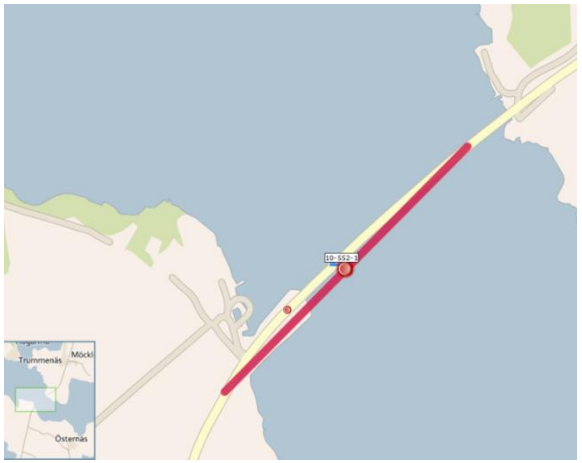
App. No. (2): Specify the most life-cycle cost-effective road corridor

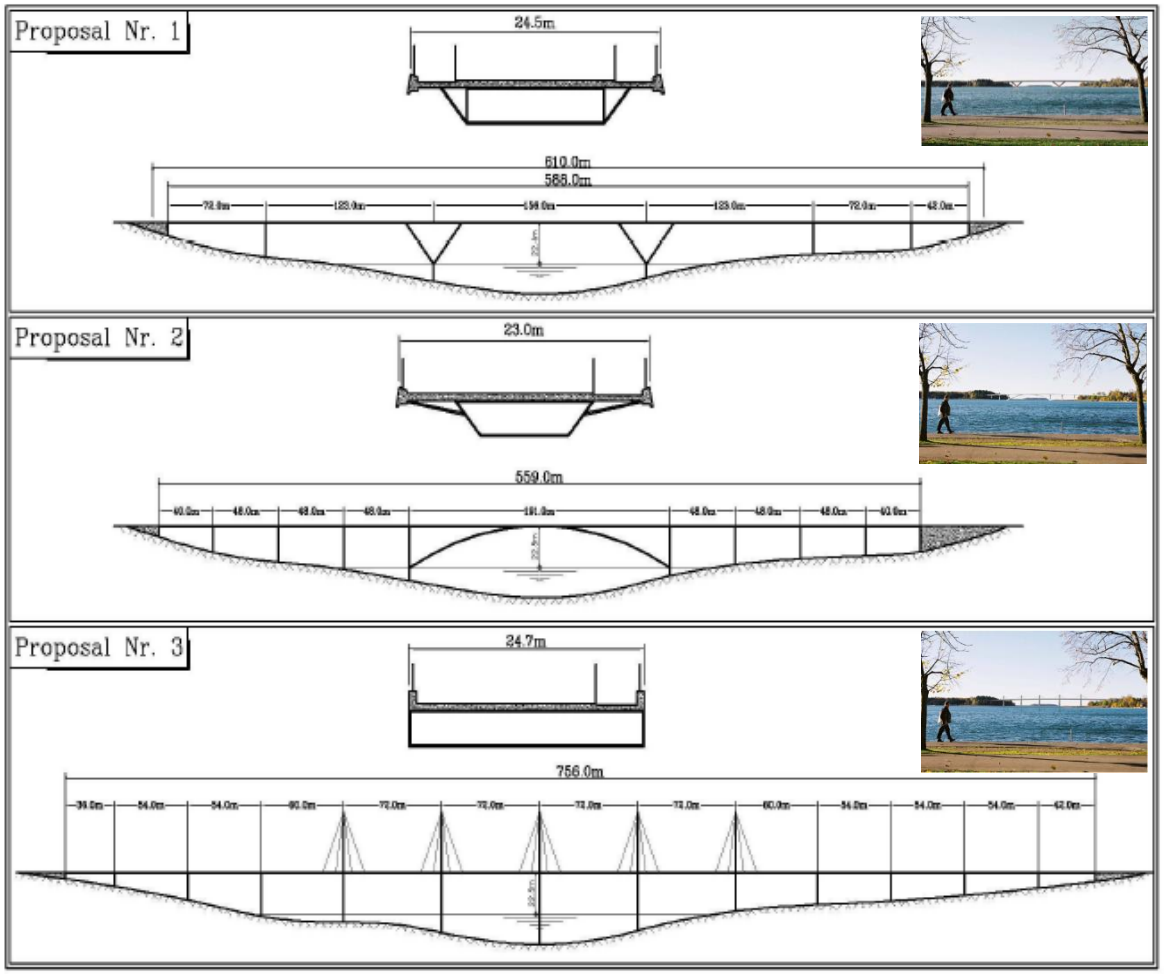


App. No. (2): Specify the most life-cycle cost-effective road corridor



App. No. (2): **Propose an optimal conceptual design during**





Procurement Principals within Public Agencies

"The Swedish Transport Administration is an authority and by law must endeavor to procure goods, services and contracts in competition"

To ensure credibility and transparency

Bridge Investment & Management from a LCCA Perspective

- The main difference lies in the procurement method/contract type
- Fixed target strategy in management but not usually fixed in investment, particularly under D-B
- The lowest bid and no consistent LCC guidelines
- Trafikverekt's goal is: 50% D-B by 2018
- A new award criterion under D-B: lowest LCC bid

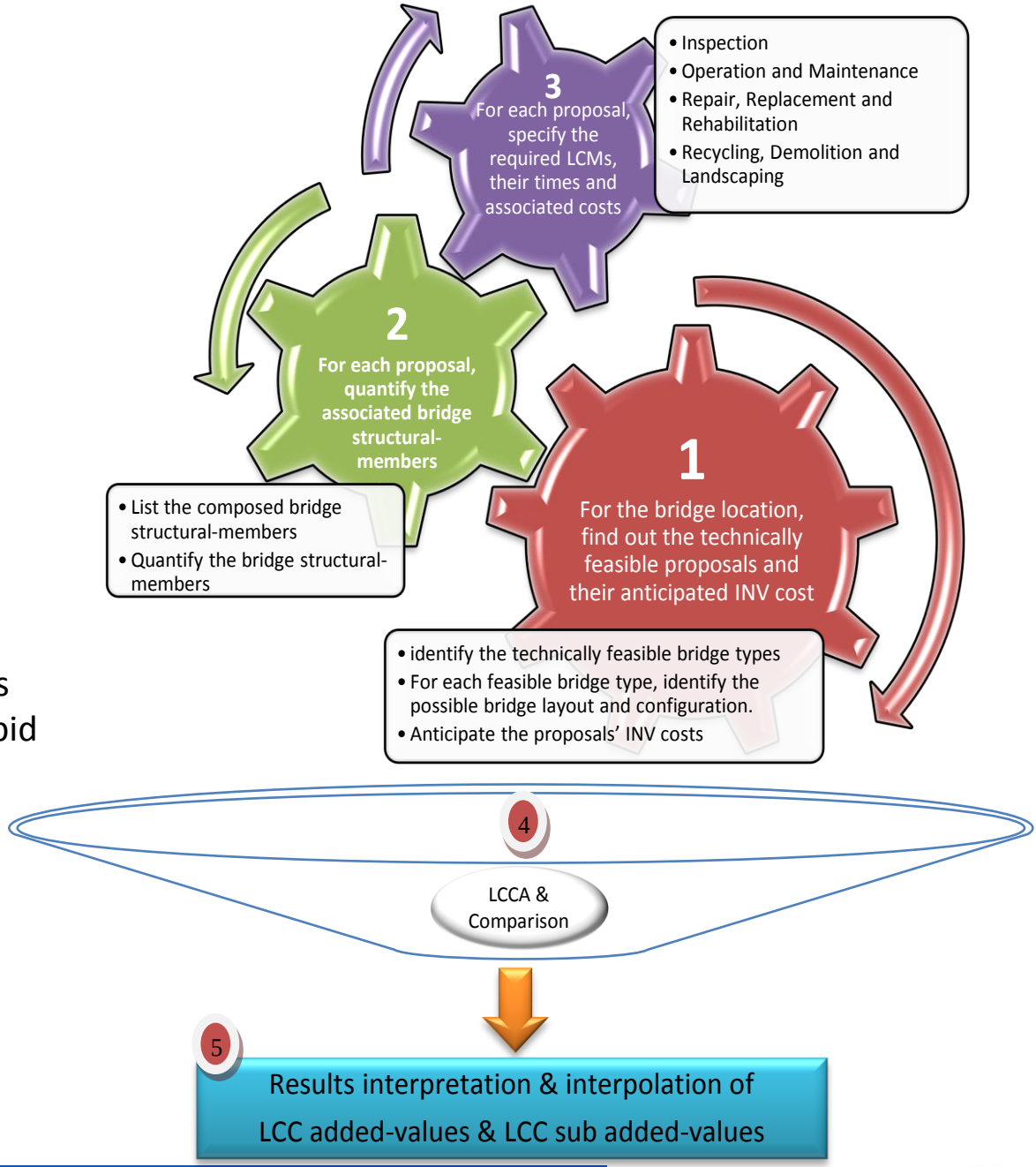
Unified LCC-Efficient Benchmarks

- There are several improper ways to employ the concept of the lowest LCC bid as the contract award criterion under D-B
- The optimal way is for procurers to establish consistent LCC-efficient benchmarks and guidelines then clearly present them as core specification in the tender documents.

Analysis Steps

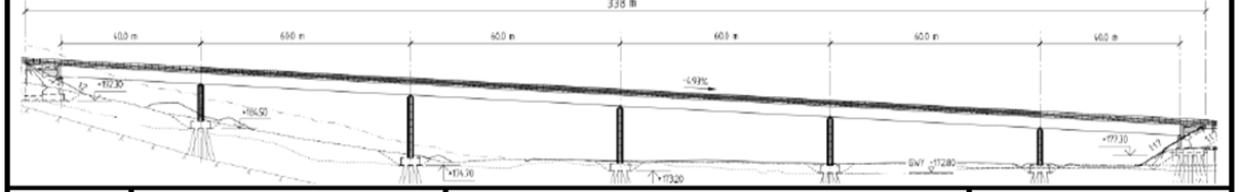
Comprehensive Approach:

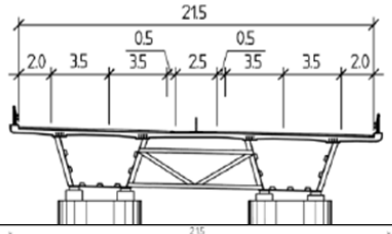
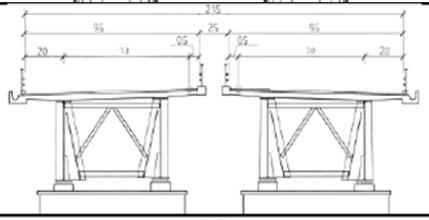
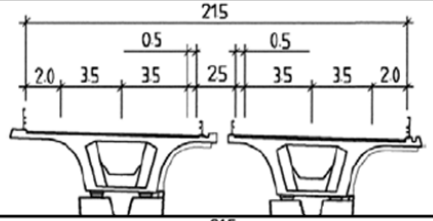
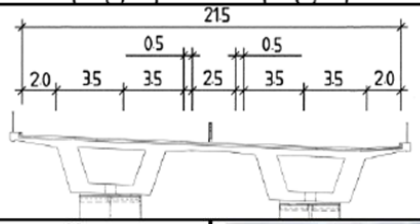
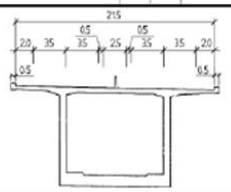
1. A preliminary LCCA
2. Monetary LCC-efficient benchmarks
3. Bid evaluation criteria: lowest LCC bid



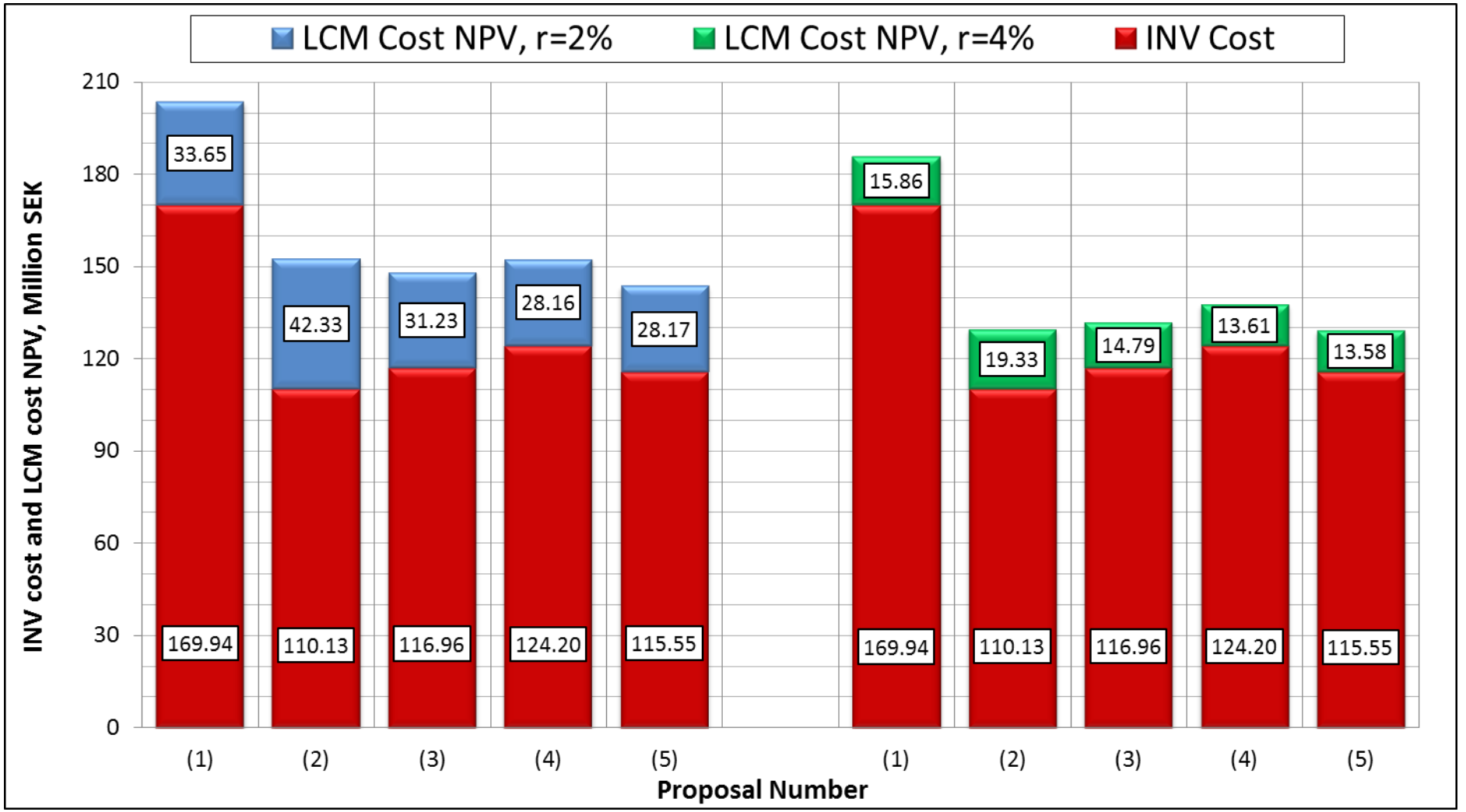
Case Study

The Karlsnäs Bridge
2013

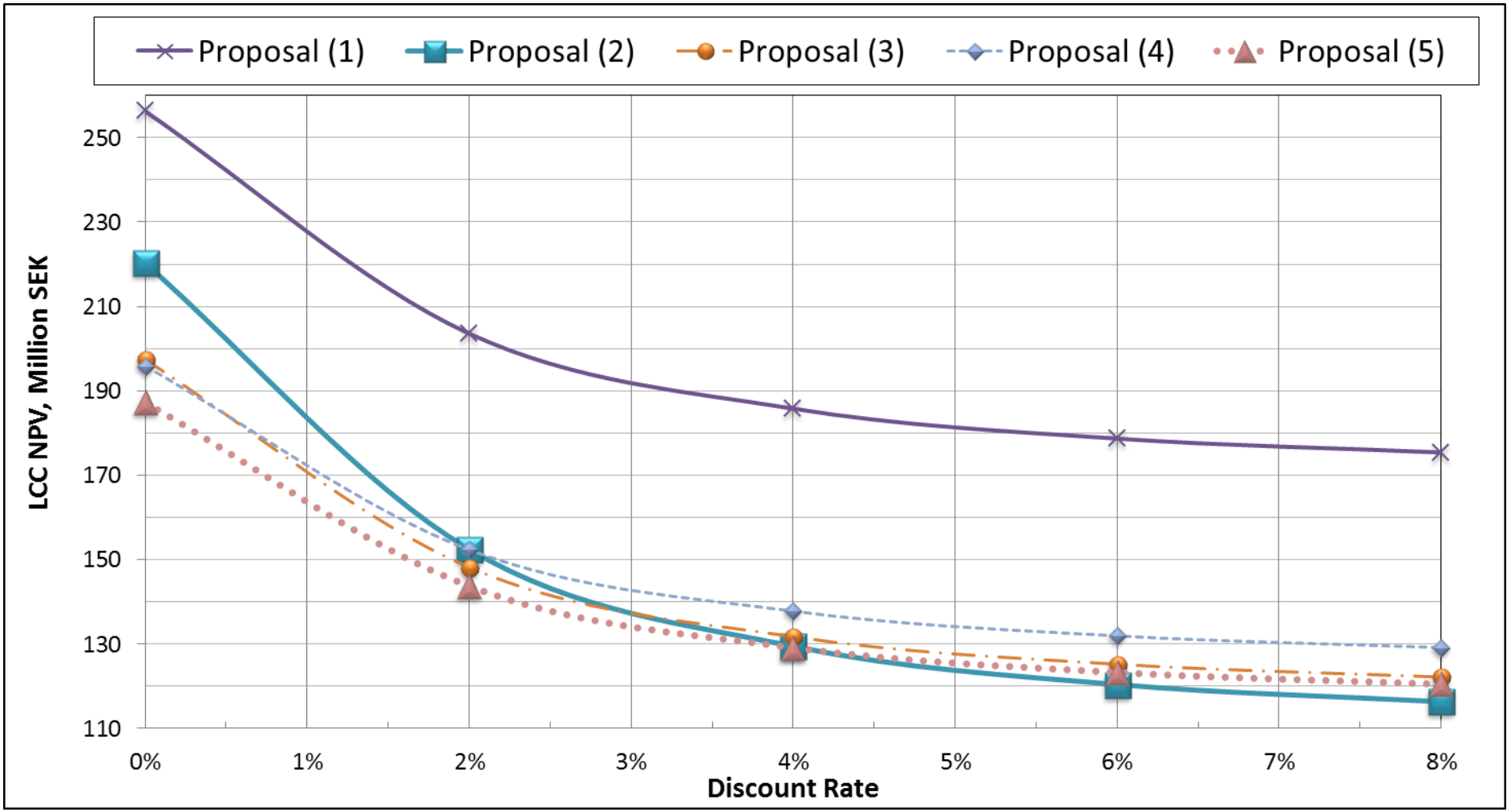


Proposal No.	Description	Cross-Section Details	Outlines & Remarks
1	One bridge, two steel boxes (Trafikverket's conceptual design)		5 Spans 4x60m + 2x40m Superstructure depth: 2.3m
2	Two bridges, two steel I beams per bridge		5 Spans 4x60m + 2x40m Superstructure depth: Haunch beam Max. 3.2m Min. 1.8m
3	Two bridges, one pre-stressed concrete box per bridge		7 Spans 5x50m + 2x35m Superstructure depth: Haunch beam Max. 2.8m Min. 1.6m
4	One bridge, two pre-stressed concrete boxes.		7 Spans 5x50m + 2x35m Superstructure depth: Haunch beam Max. 2.8m Min. 1.6m
5	One bridge, one integral-cantilever concrete box	 	4 Spans 2x100m + 2x60m Superstructure depth: Haunch beam Max. 6.5m Min. 2.3m

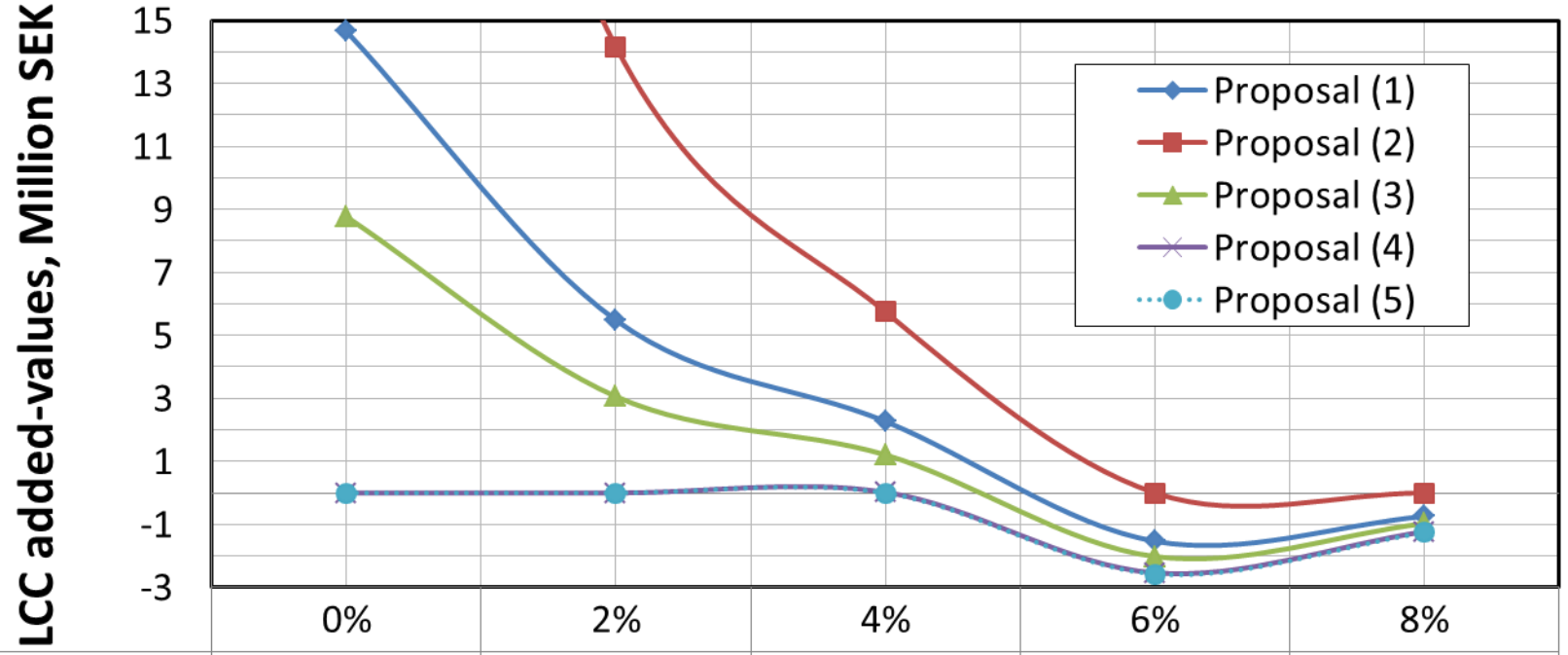
LCCA Results



Impact of varying the discount rate on the proposals' LCC



LCC added-values computed at indicated discount rates (SEK)



	0%	2%	4%	6%	8%
Proposal (1)	14.65	5.48	2.27	-1.54	-0.74
Proposal (2)	38.44	14.16	5.75	0.00	0.00
Proposal (3)	8.77	3.06	1.21	-2.02	-0.97
Proposal (4)	0.00	-0.01	0.02	-2.54	-1.23
Proposal (5)	0.00	0.00	0.00	-2.57	-1.26

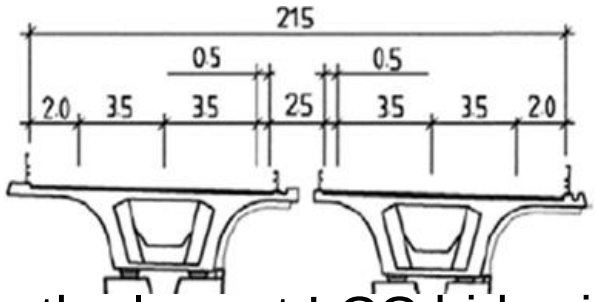
Structural-members' LCC added-values at a discount rate of 4%

To maintain contractors' freedom in D-B tendering processes and allow consideration of innovative/different designs.

Bridge structural-member	Unit	LCC sub added-value	
		Unit LCM cost (K SEK/Unit)	Fixed Cost (K SEK)
Bearings number	set	7.0	54.4
Expansion joint length	m	5.8	156.4
Edge beam length	m	1.6	108.3
Painted area	m^2	0.4	85.3
Parapets' length	m	1.0	0.0
Paved area	m^2	0.5	462.0
Drainage system points	set	32.7	0.0
Slopes and cones area	m^2	0.4	0.0
Superstructure area	m^2	0.2	0.0
Total bridge area	m^2	0.6	0.0

Procurement of the Karlsnäs Bridge

- The LCC added-values and BSM's LCC added-values had been stated in the tender documents.
- 5 Contractors had participated, all of them are Proposal 3



- The contract was awarded to the lowest LCC bid, with an INV cost of 115 million SEK.
- **Trafikverket has saved 57 million SEK**

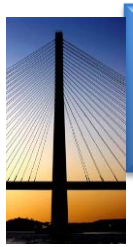
Paper V: Holistic Approach

Bridge LCC

Agency cost
INV & LCM

User Cost

Society Cost



Aesthetical &
Cultural Effects

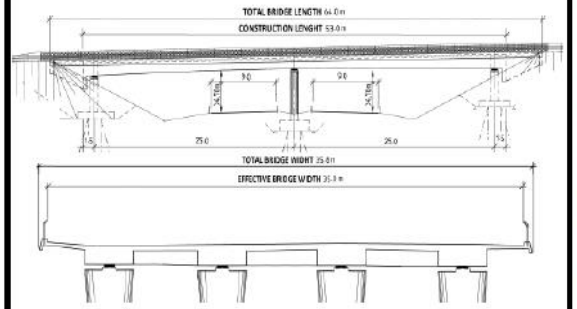
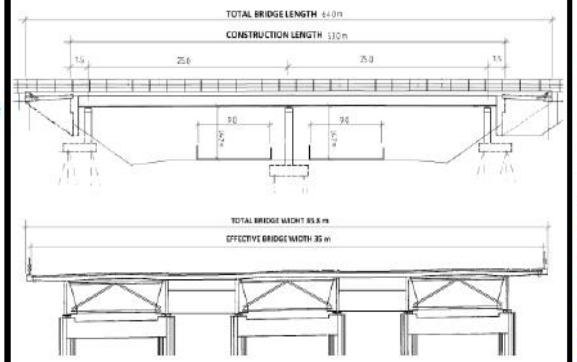
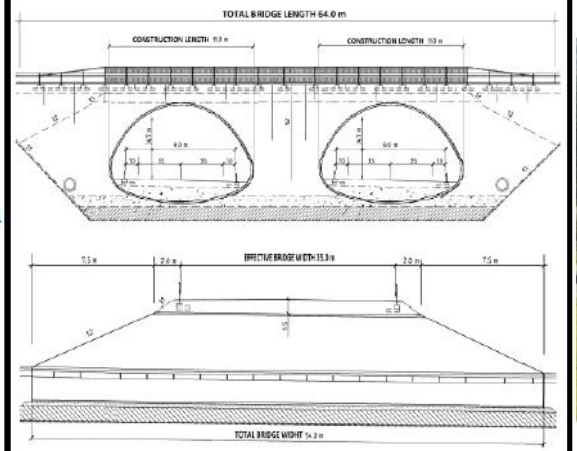
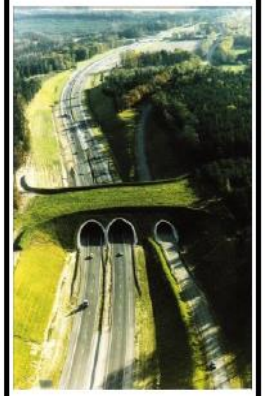
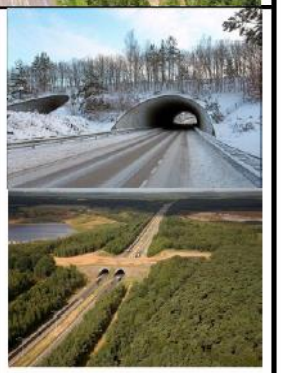
Environmental
Impact (LCA)

Holistic Approach

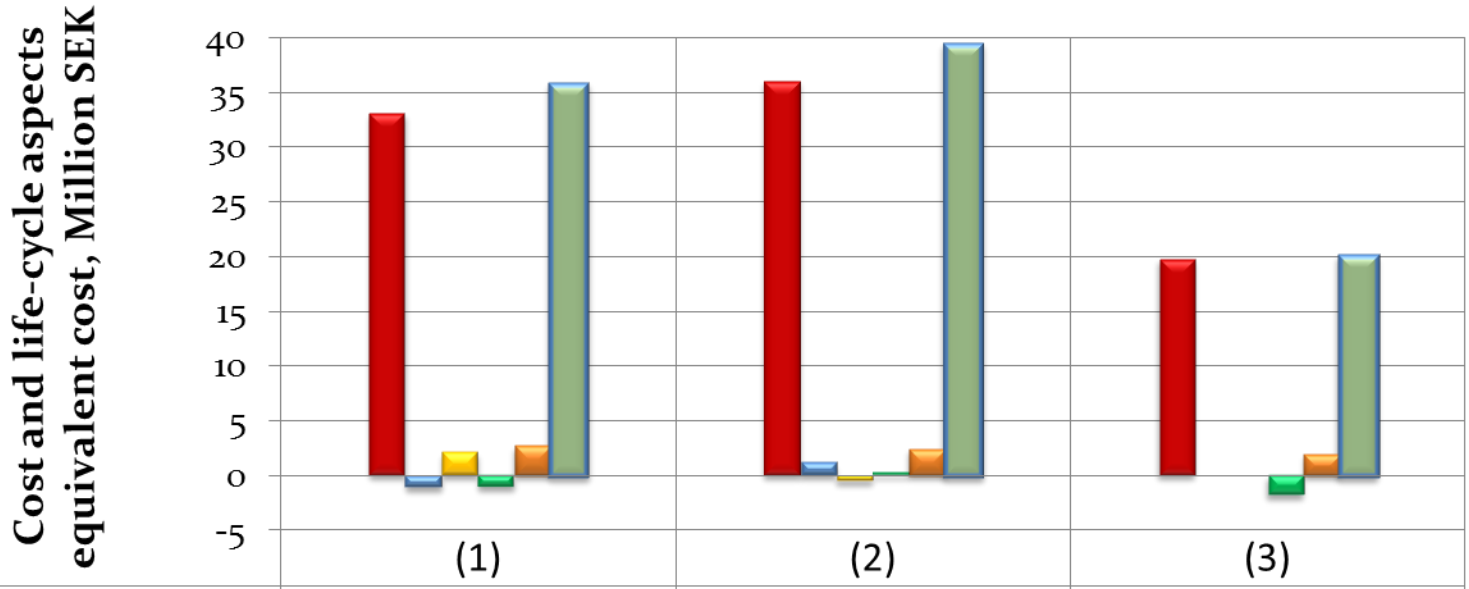
- The **lowest Net Equivalent LCC bid** should be the criterion used to identify the most sustainable bridge proposal and select the D-B contractor offering it.
- The approach combines LCC Added-Value analysis with other novel techniques that make proposals' aesthetic merit and environmental impact commensurable,
- Thereby enabling agencies to establish **Monetary Benchmarks** concerning those aspects in an early planning phase and embed them in the tender documents as core specifications.

Case Study

A wildlife crossing bridge over the European route E6 in Gothenburg, 2015.

No.	Description	Elevation and Cross-Section	Similar Existing Bridges
1	Concrete beam bridge with integrated breast wall (Trafikverket's conceptual design)		 
2	Steel I-beam bridge composite with concrete slab with integrated breast wall		 
3	Two steel pipe-arch culverts		  

Life-cycle aspects' contributions and net equivalent LCC costs of Proposals



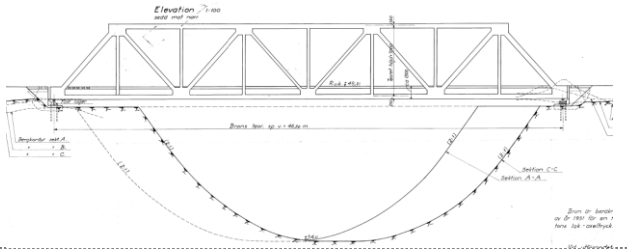
	(1)	(2)	(3)
Anticipated INV & TCP cost	33.07	36.08	19.79
LCC added-value	-1.13	1.11	0.00
User cost added-value	2.10	-0.54	0.00
CEEM	-1.06	0.26	-1.83
CEEI	2.74	2.45	2.01
The net equivalent LCC	35.72	39.35	19.97

LCCA for Management of Existing Bridges

Bridge Management

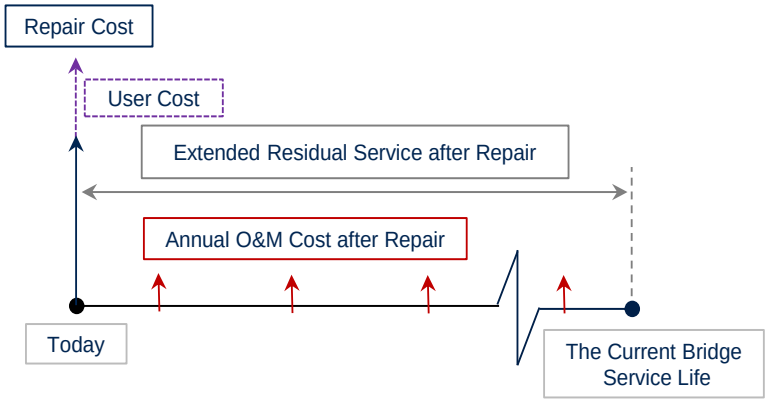
Repair or replace a heavily deteriorated bridge?

Road Bridges		Railway Bridges
Paper I: Str. & Infra. Eng. J. [6-367-1] Bro över Lillån Construction Year: 1934	**Paper III:** TRR Journal [18-352-1] Bro över Täbyån, Höjen Construction Year: 1929	**The Extended Summary** [3500-2593-1]Bro över Huvudnäskanalen Construction Year: 1937
An action is required within a 3 years period, CC2		An immediate action is required, CC3

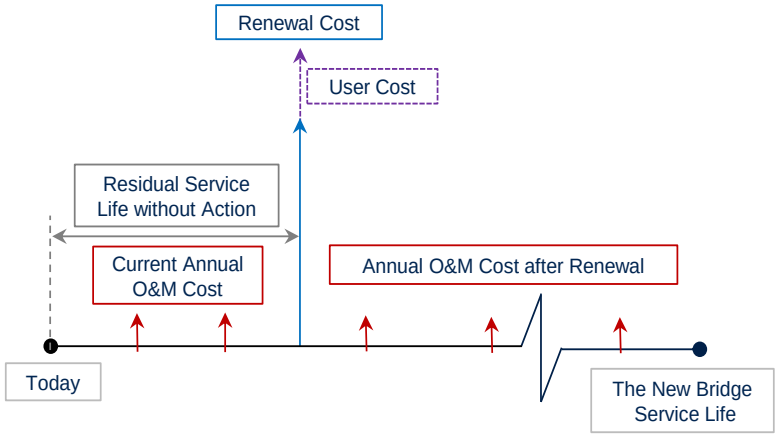


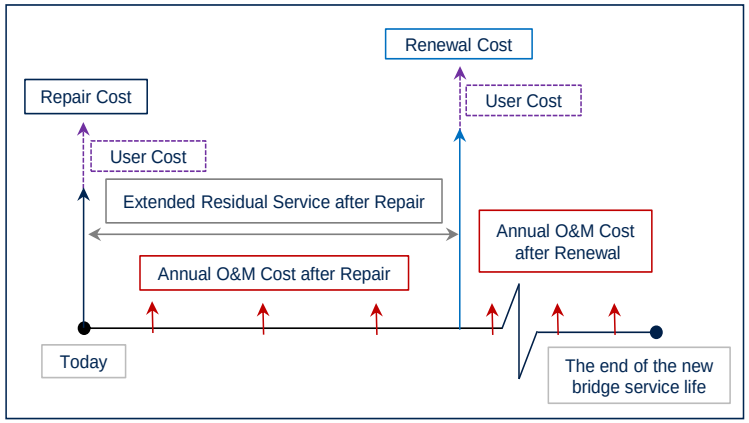
Strategies Formulation

Strategy A: Immediately repair the bridge



Strategy B: Utilize the bridge for its residual service life without action and then renew it





Sensitivity analysis:

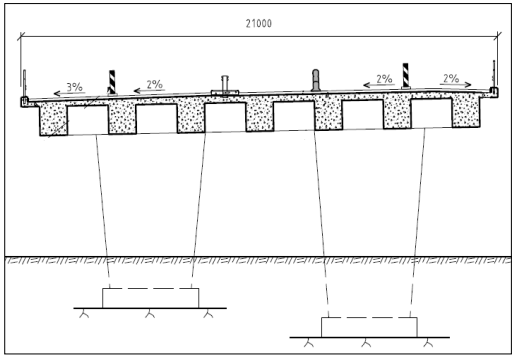
1. Discount rate
2. The INV cost of a new bridge
3. Residual service life extension after repair
4. Residual service life without action
5. Actual service life of a new bridge
6. Long- and short-term planning of the repair
7. User cost inclusion

Bridge Management

Repair or replace a bridge structural-member?

An action is required within a 3 years, CC2

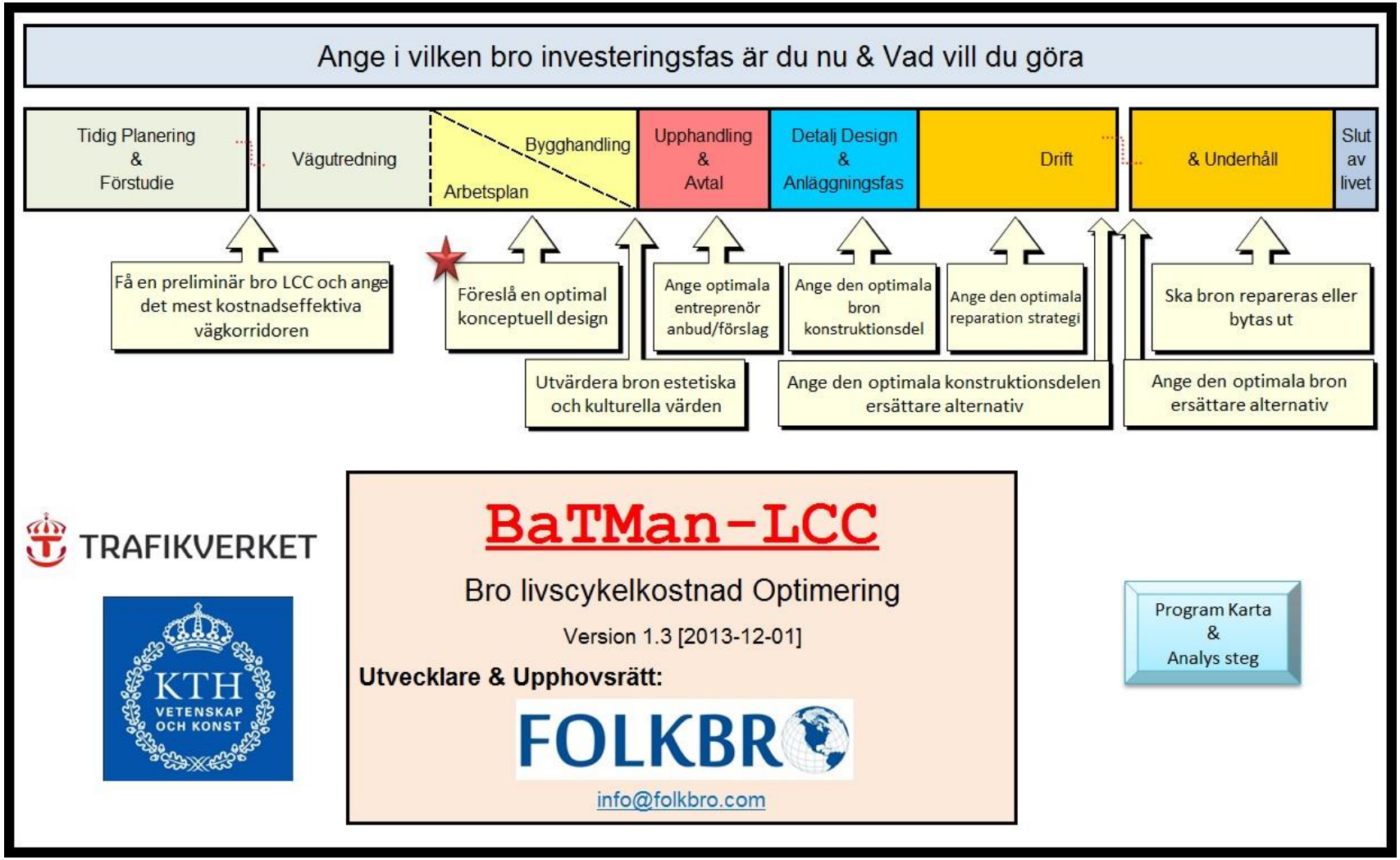
Vårbyvägen Bridge [1-813-1]
The surfacing of the bridge deck is CC 2, 3 years
The bridge deck, CC 0



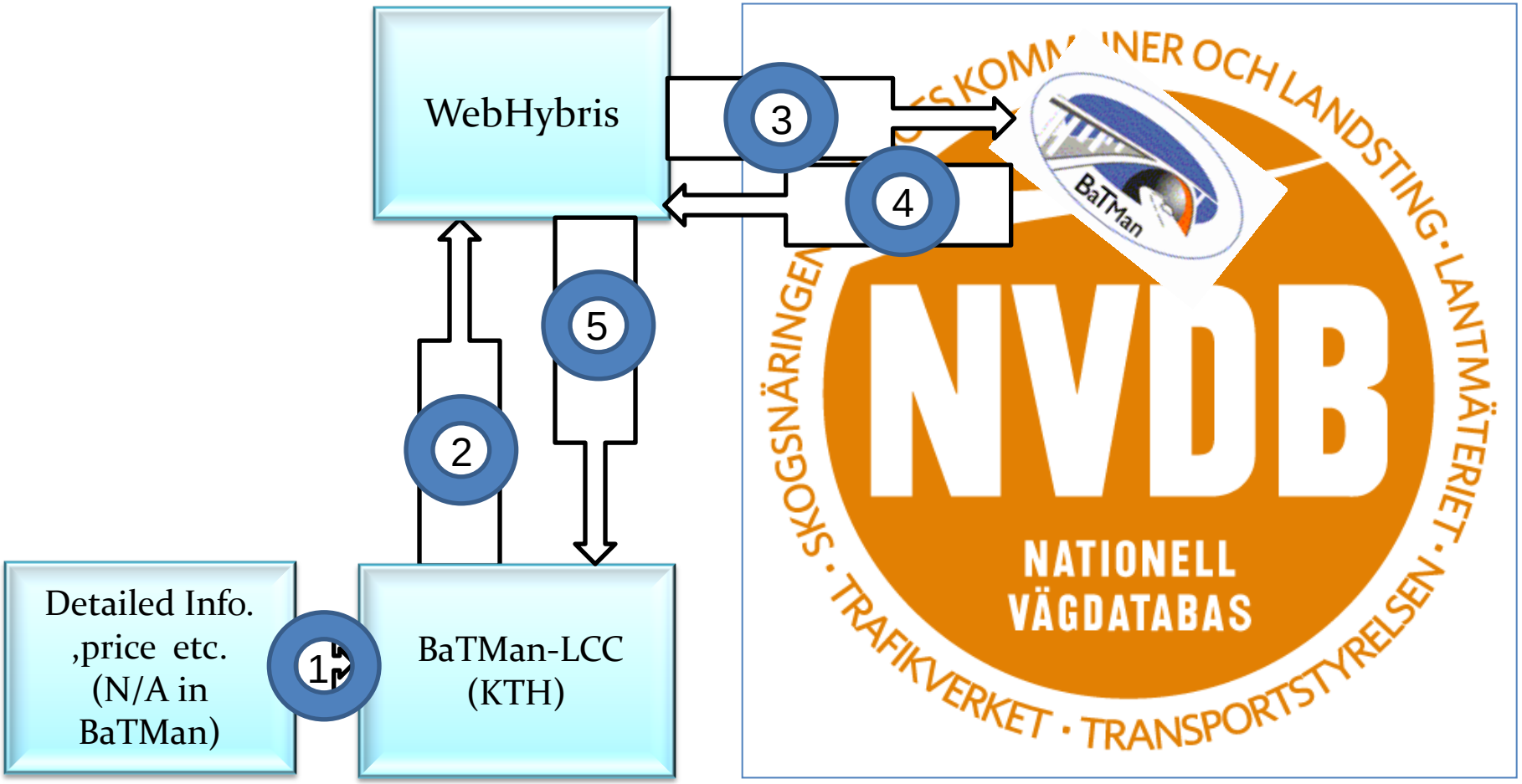
Parameters affecting the analysis, Sensitivity analysis:

1. Discount rate
2. The INV cost of the various strategies
3. User cost inclusion
4. Residual service life without action
5. Dominating structural member residual service life
6. Impact of the various strategies on the residual service life extension

Practical Implementation

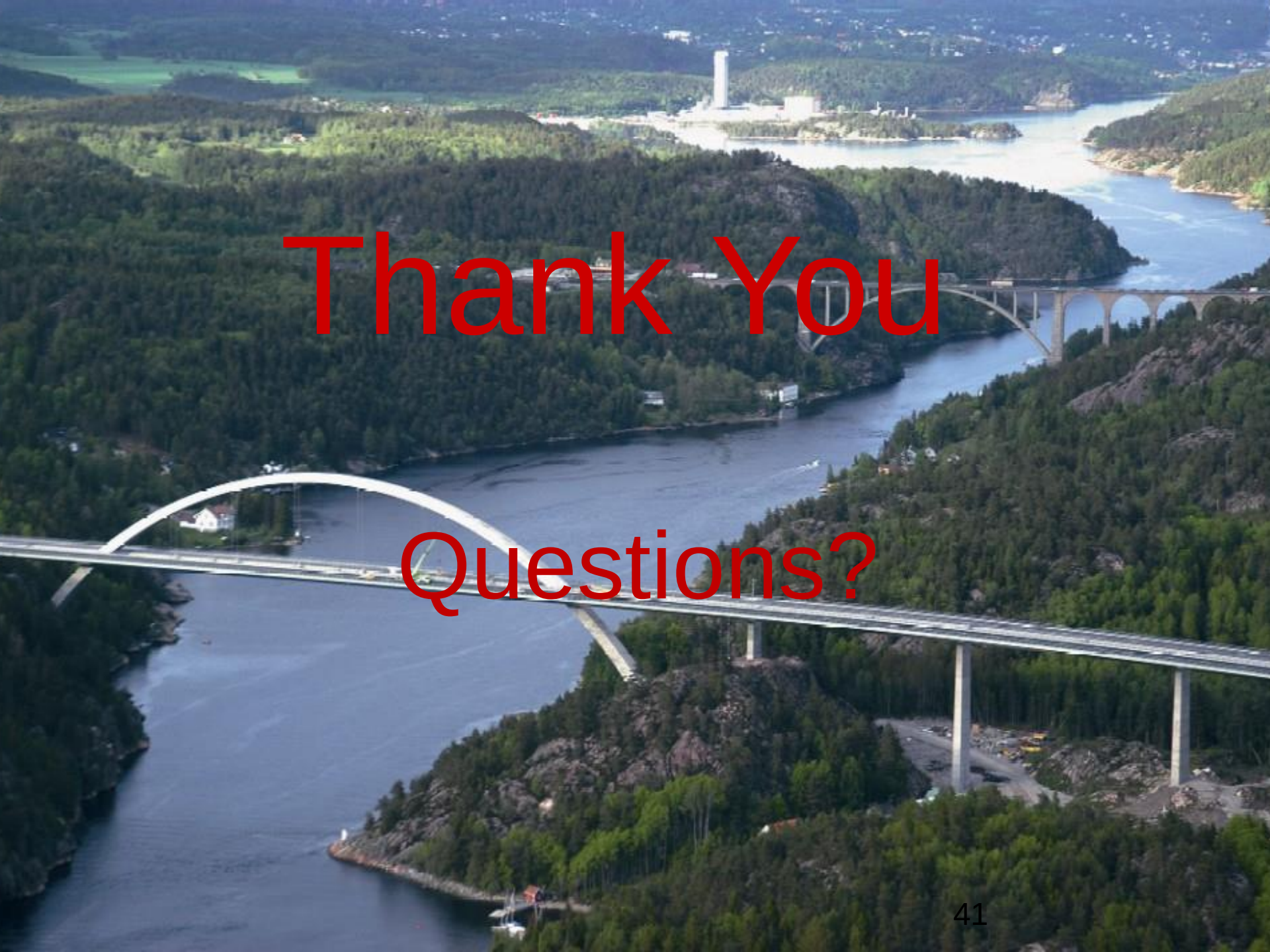


BaTMan-LCC relation with BaTMan



BaTMan-LCC Course

FOLKBR


Thank You
Questions?