

**Infrastructure Cost-
Efficient &
Sustainable
Procurement &
Management**

*Overview &
Implementation*

Mohammed SAFI



Who am I ?!

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Infrastructure Life-Cycle Cost Analysis Specialist

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EDUCATION & DEGREES

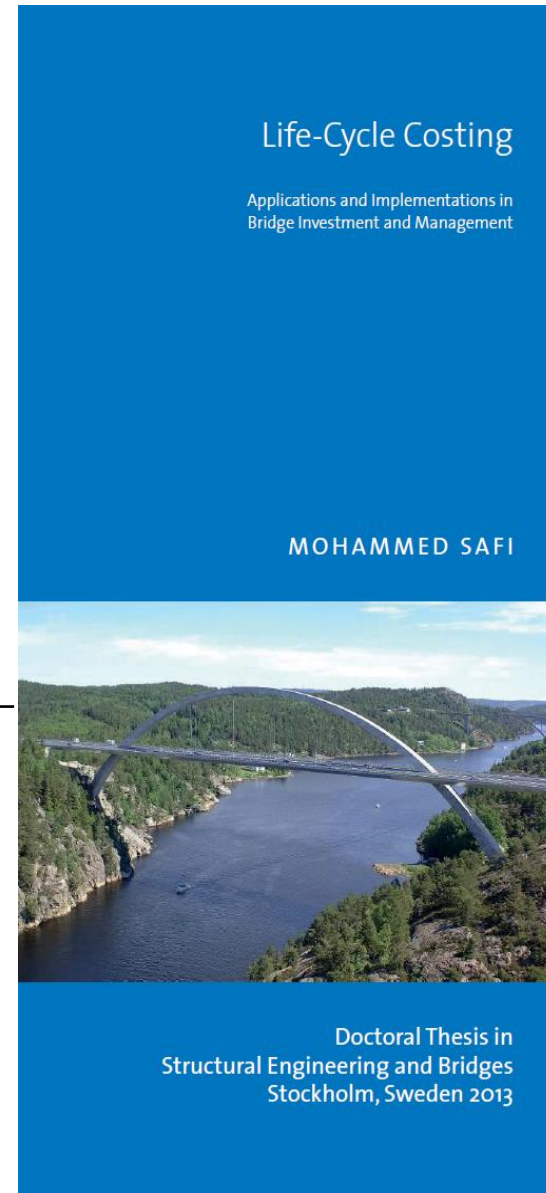
2013 **Ph.D.**, Structural Engineering and Bridges, KTH Royal Institute of Technology, Sweden.

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



KTH Architecture and
the Built Environment

CURRENT & PREVIOUS POSITIONS

2014 – Present Infrastructure Life-Cycle Cost Analysis Specialist,
FOLKBRO Konsult



2012 – 2013 Bridge LCC Analysis Specialist, Trafikverket – The
Swedish Transport Administration



2014 – Present Researcher, KTH Royal Institute of Technology



Structural Engineering
& Bridges Division

2007 – Present Board Member & Business Development Manager,
AF-SAFI Company



General Trade,
Contracting &
Construction Material

2006 – 2007 Project Officer, UNRWA – United Nations Relief &
Working Agency



Infrastructure
Procurement &
Development

2005 – 2006 Construction Engineer, AC-The Arab Contractors



Construction &
Management

Agenda

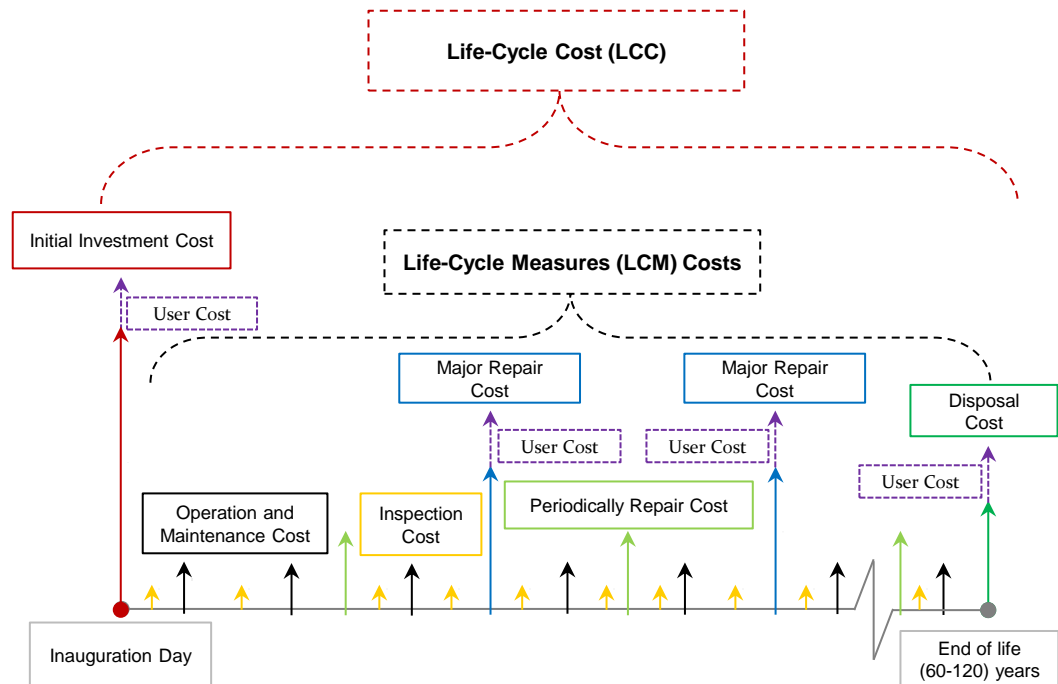
- Introduction
- Infrastructure life-cycle & the possible LCCA applications
- The Swedish bridge stock
- BaTMan and WebHybris
- LCCA for the procurement of new bridges
 - The optimal road/rail corridor
 - The optimal bridge design proposal
 - Holistic approach
- LCCA for management of existing bridges
 - 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 Life-Cycle Cost: LCC



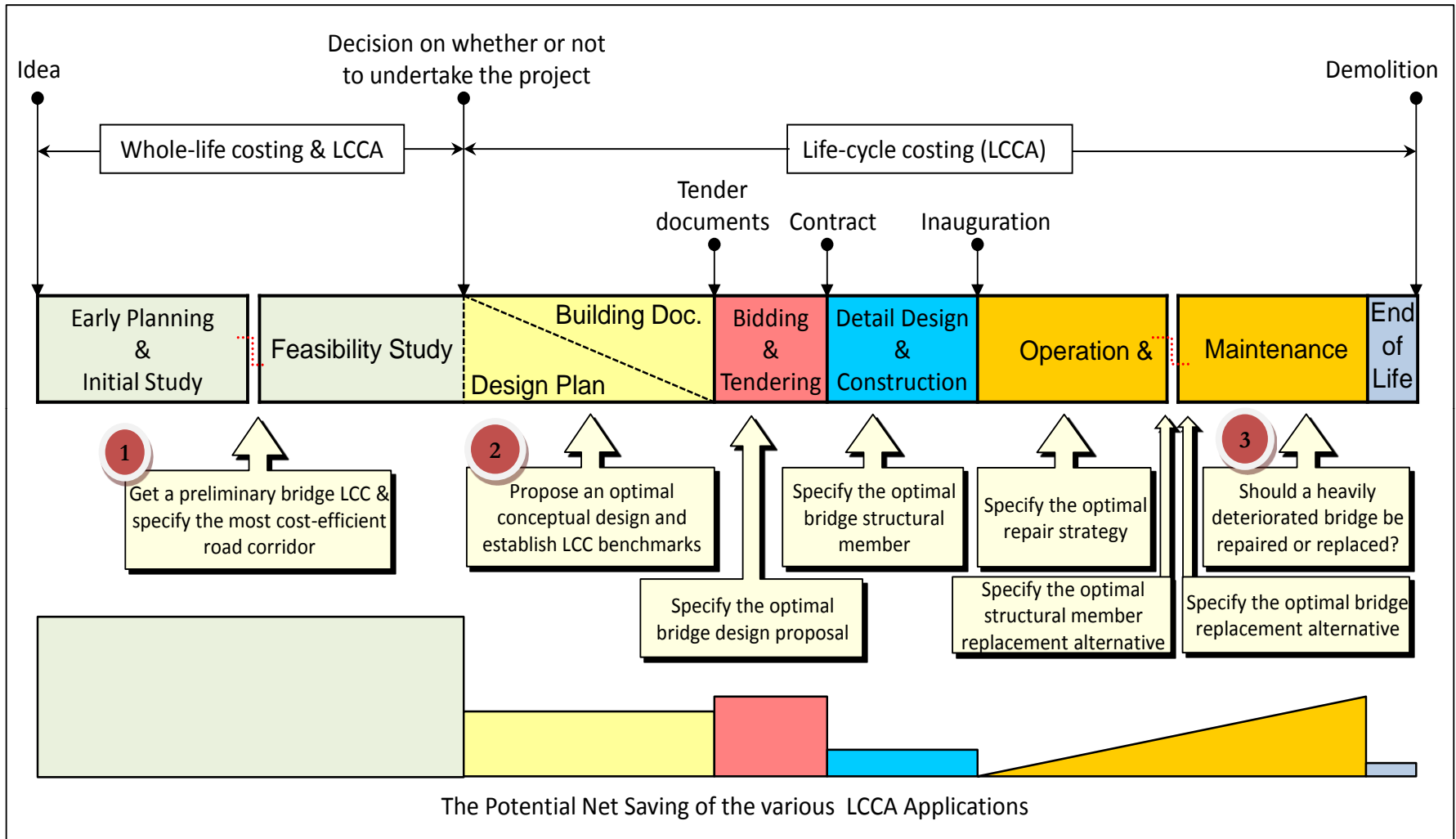
- The time value of money, discount rate
- Life-Cycle Costing/**Life-Cycle Cost Analysis (LCCA)**



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 Swedish Bridge and Tunnel Management System "BaTMan"

Nyheter

Ny BaTMan-version
BaTMan 4.21 kommer att drifställas med start ons 2011-10-12 kl 16:00. Driftsättningen kommer även att pågå tor 2011-10-13.
Under driftsättningen kommer BaTMan att vara avstängt, undantaget är Trafikverkets dispenshantering.
Vi återkommer med information om innehåll i den nya versionen.
2011-09-27 15:24

'BaTMan-kommuner'
Nu finns en grafisk presentation i BaTMan-portalen över de kommuner som använder BaTMan. Du hittar den via övre menyns val.
Information/BaTMan/Kontaktpersoner.
2011-09-27 15:17

Järfälla kommun...
... ingår nu också i BaTMan-familjen!
2011-09-13 13:48

Ny kommun
Denna gång är det Köpings kommun som bestämt sig för att använda BaTMan!
2011-08-11 11:31

Gamla ärenden
Vi vill uppmärksamma dig på att det finns många gamla ärenden i BaTMan som i många fall säkerligen kan avslutas!
Du kan via Inkgören kontrollera om du kan avsluta några! Välj i BaTMans övre meny 'Mina sidor/Pågående ärenden', gör därefter dina val och tryck sedan på 'Ämsta ärenden'.

Välkommen till BaTMan
BaTMan är ett hjälpmedel för effektiv förvaltning av broar, tunnlar och andra typer av byggnadsverk.
Managementsystemet BaTMan omfattar rapporter, information (handböcker, publikationer etc) samt ett verktyg som hjälper användaren att organisera och utföra aktiviteterna inom förvaltningens olika skeden. [Läs mer](#)
En viss del av informationen är öppen i systemet. Men för dig som ska arbeta med BaTMan och förvaltning av byggnadsverk krävs ett användarkonto, för mera information [läs här](#)

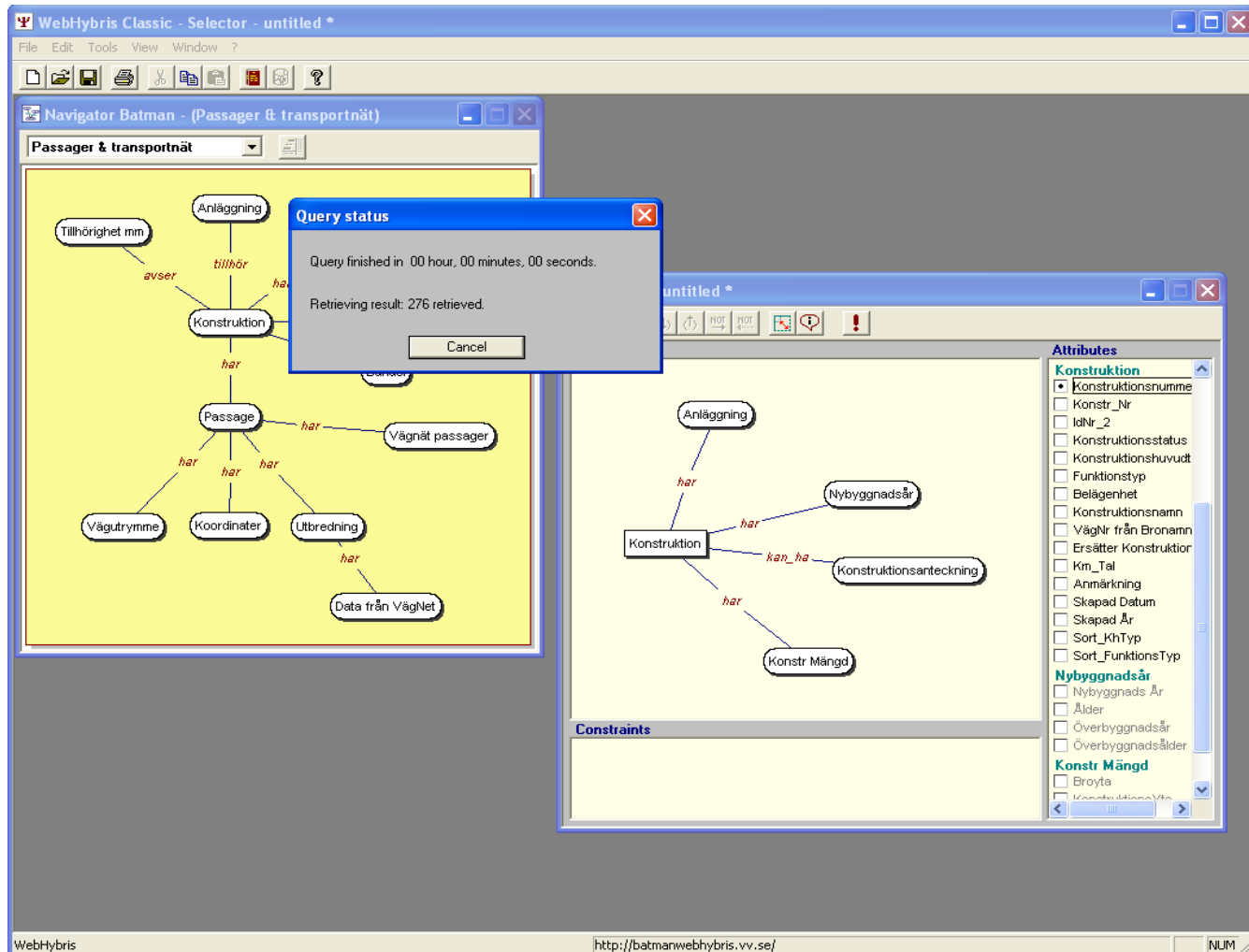
Konstruktioner i BaTMan

Biblioteket
I Biblioteket finner du publikationer, rutiner och andra dokument inom BaTMan's verksamhetsområde.
Här finner du även dokument med information om intressenter, kontaktpersoner, ansökningsblanketter etc.
Du kan söka efter dokument i Biblioteket med funktionen "Sök dokument" nedan.
Sökning av information i BaTMans handbok gör du tillsvärdare direkt i handboken.

BaTMan handbok
I BaTMans handbok beskrivs den metodik som ligger till grund för förvaltning av byggnadsverk.

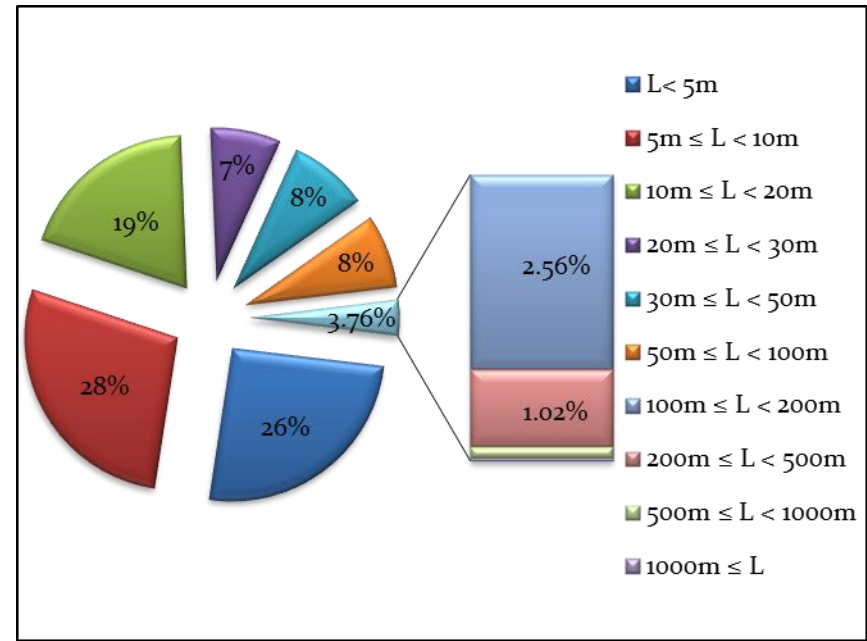
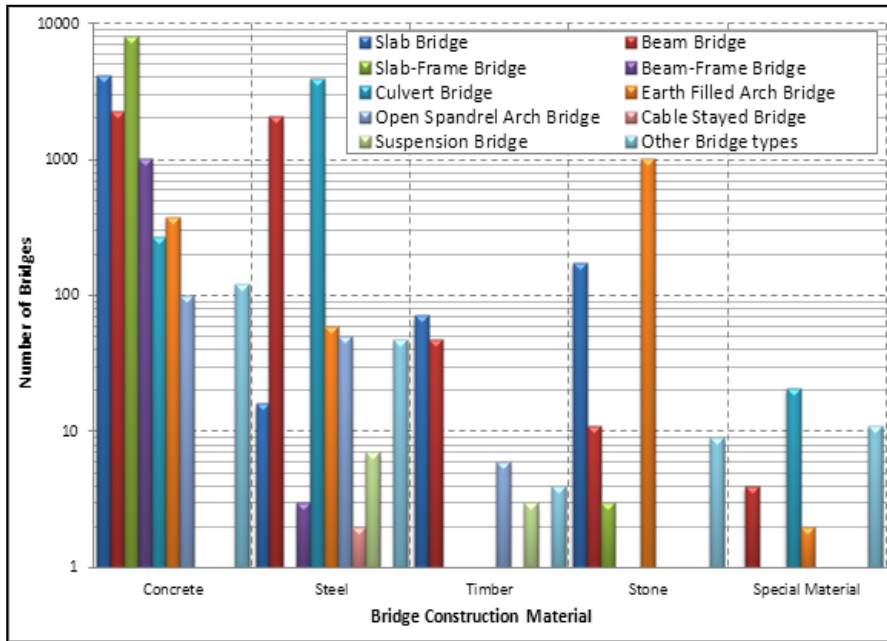
<https://batman.vv.se/batman/>

BaTMan's Navigation Tool (WebHybris)

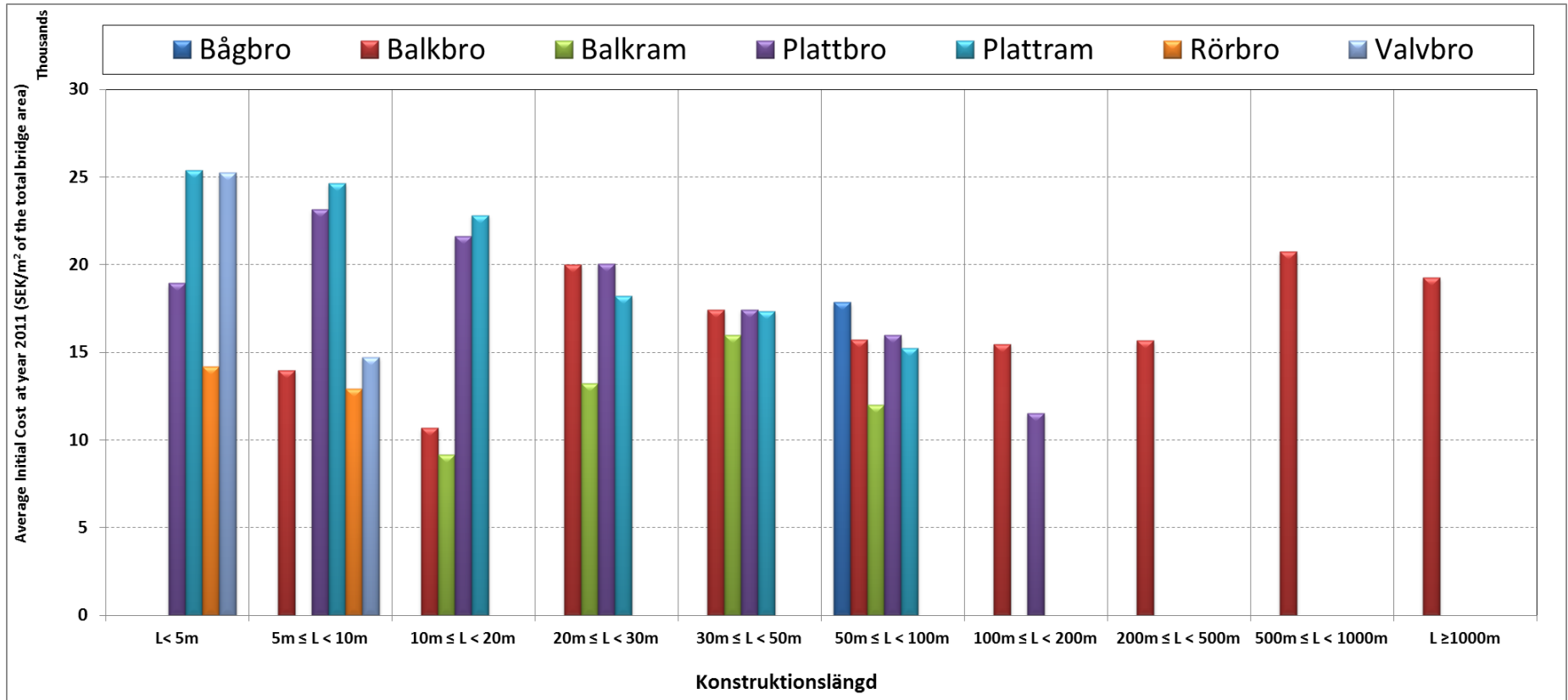


The Swedish Bridge Stock

	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

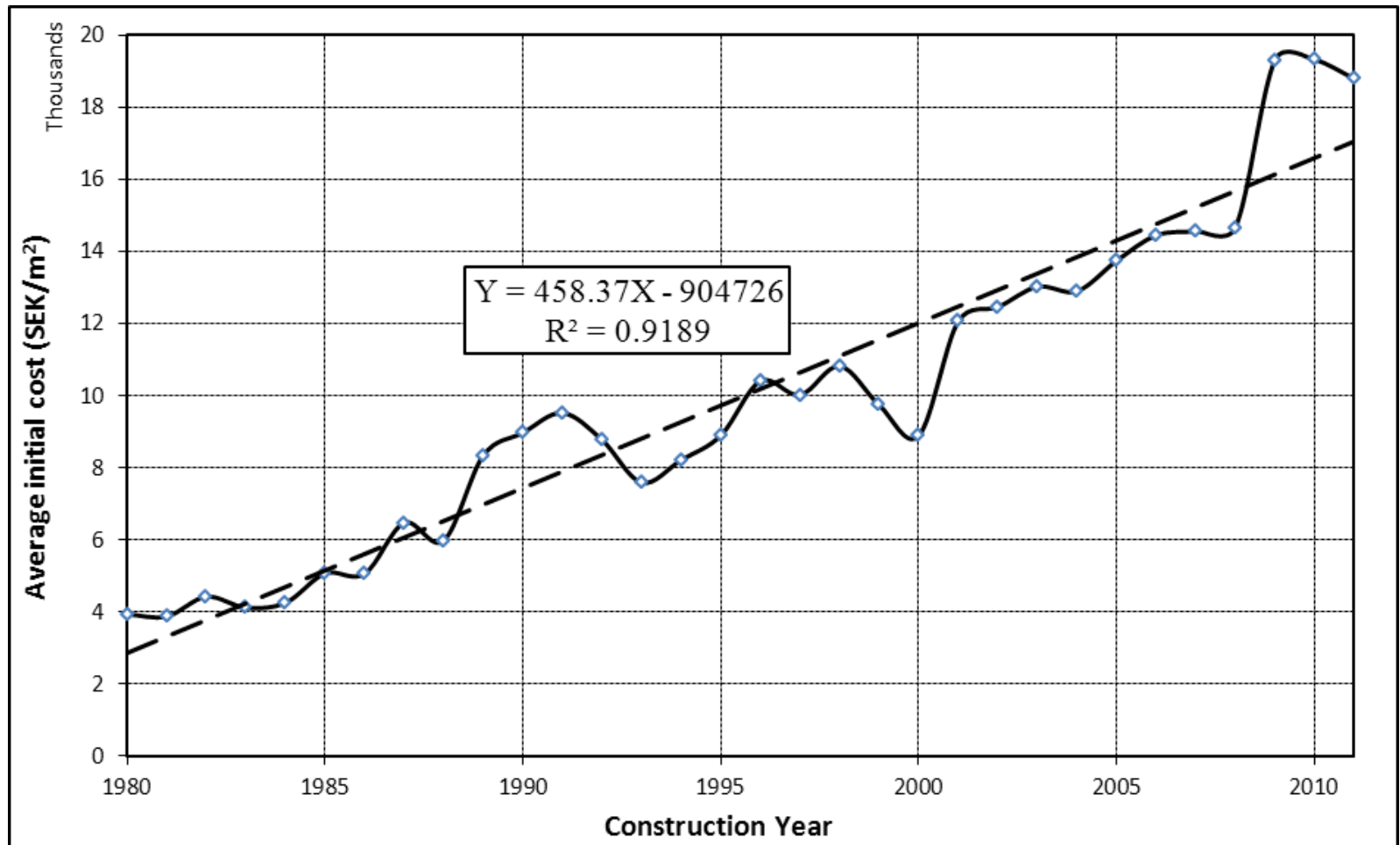


Swedish Bridges Real INV Cost



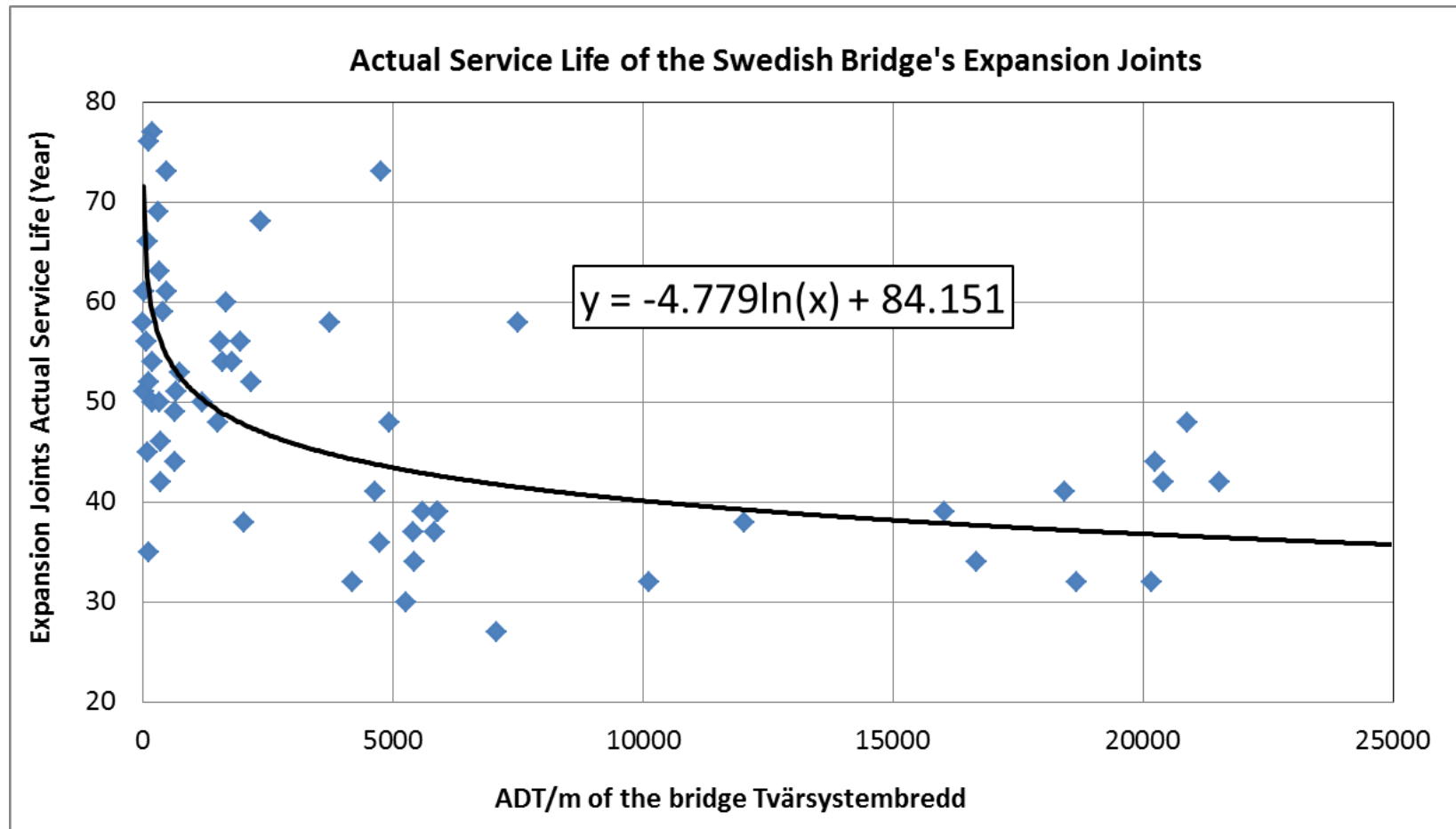
The average real initial costs of the Swedish bridges different types, based on cost data for 2,508 bridges constructed between 1980 and 2011.

Swedish Bridges Anticipated INV Cost



The inflation rate for the Swedish bridges initial costs

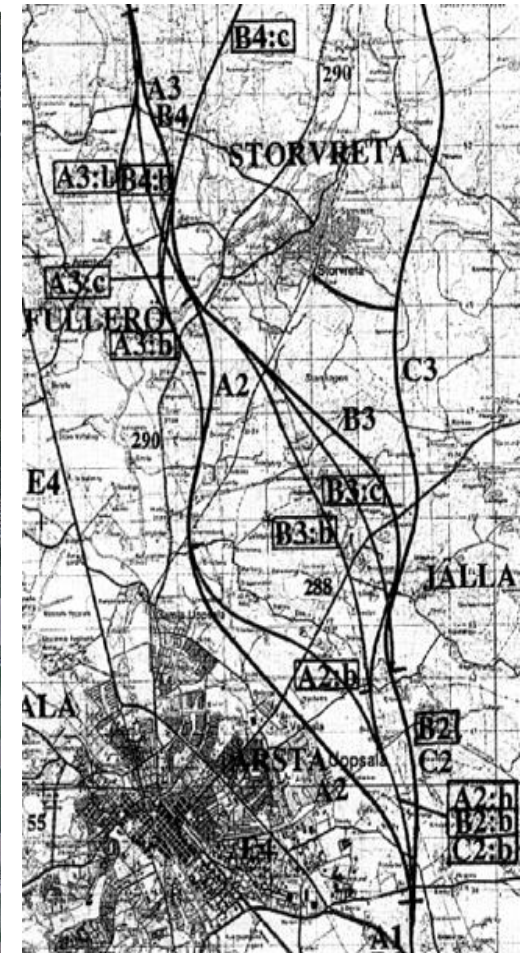
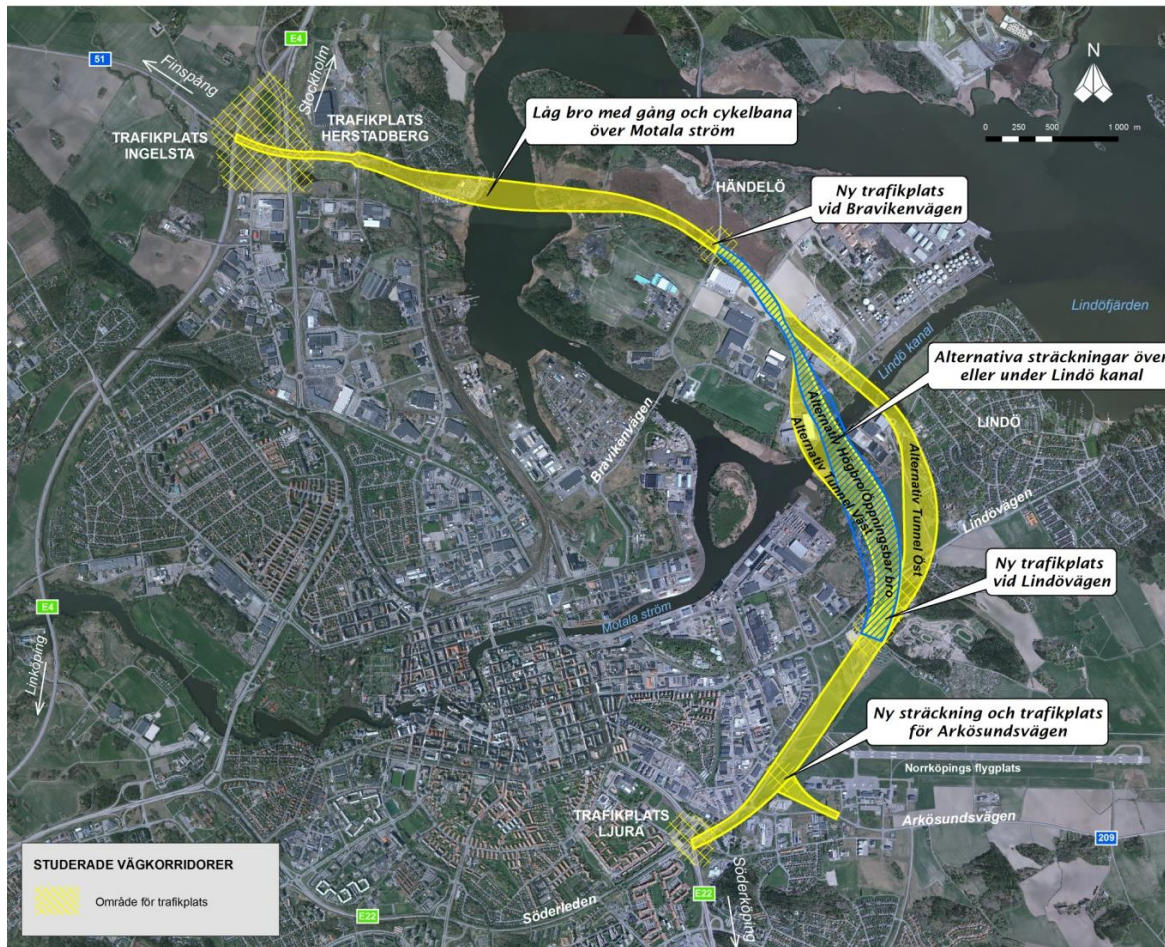
Structural-Members Life-Cycle Measures



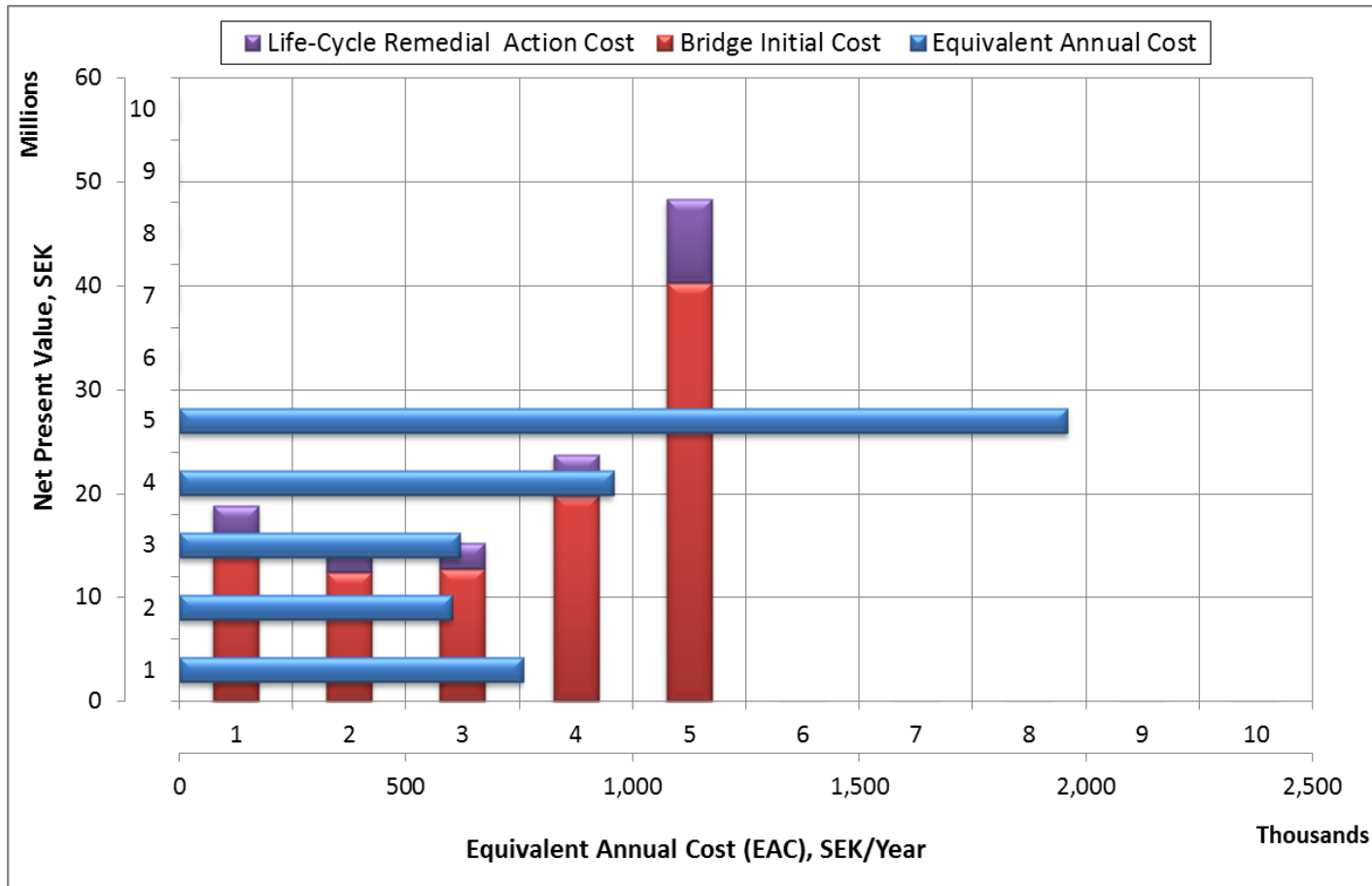
Based on 288 Replacement Actions performed between 1979 and 2010

LCCA for Procurement of New Bridges

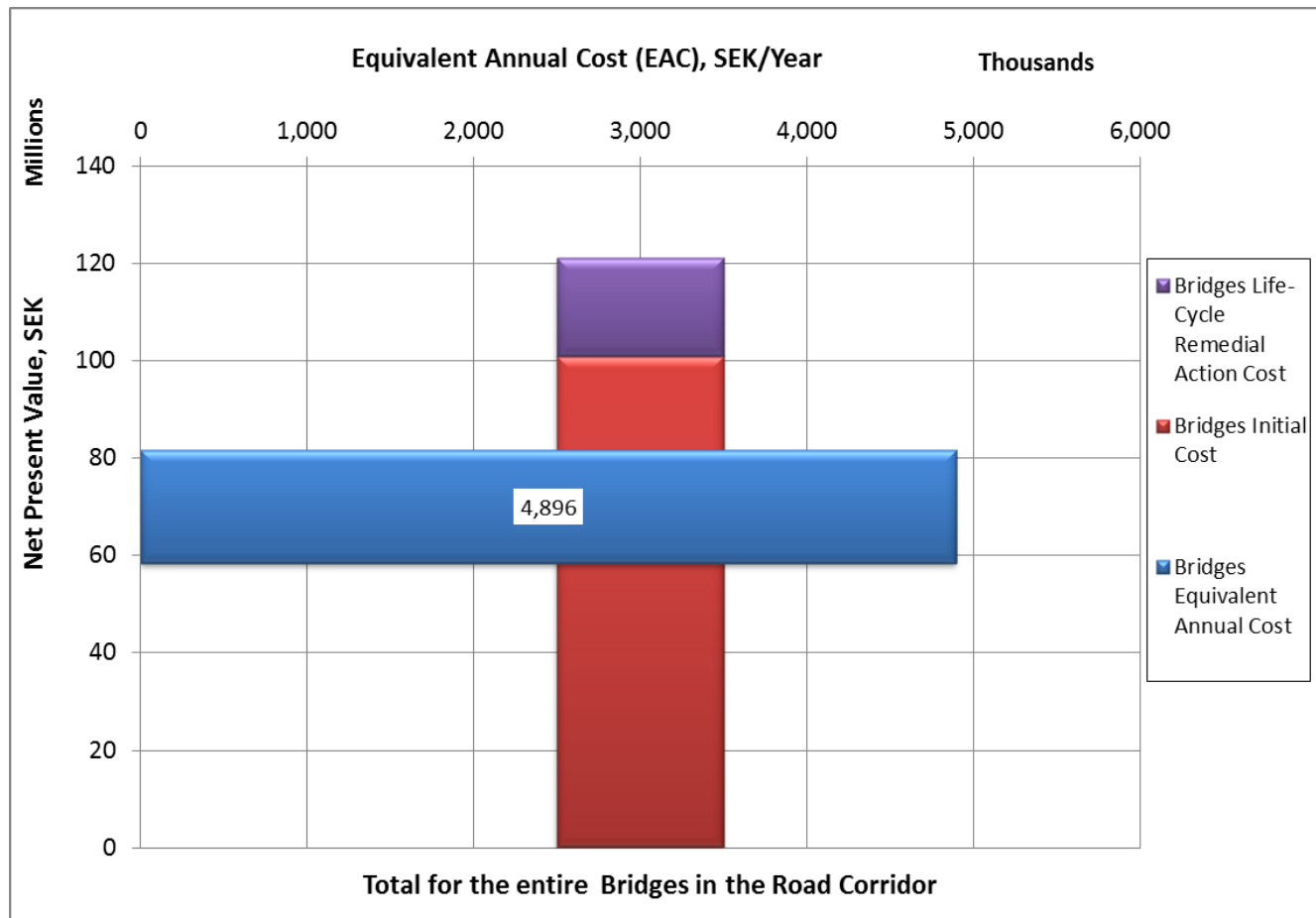
App. No. (1): Specify the most life-cycle cost-effective road corridor



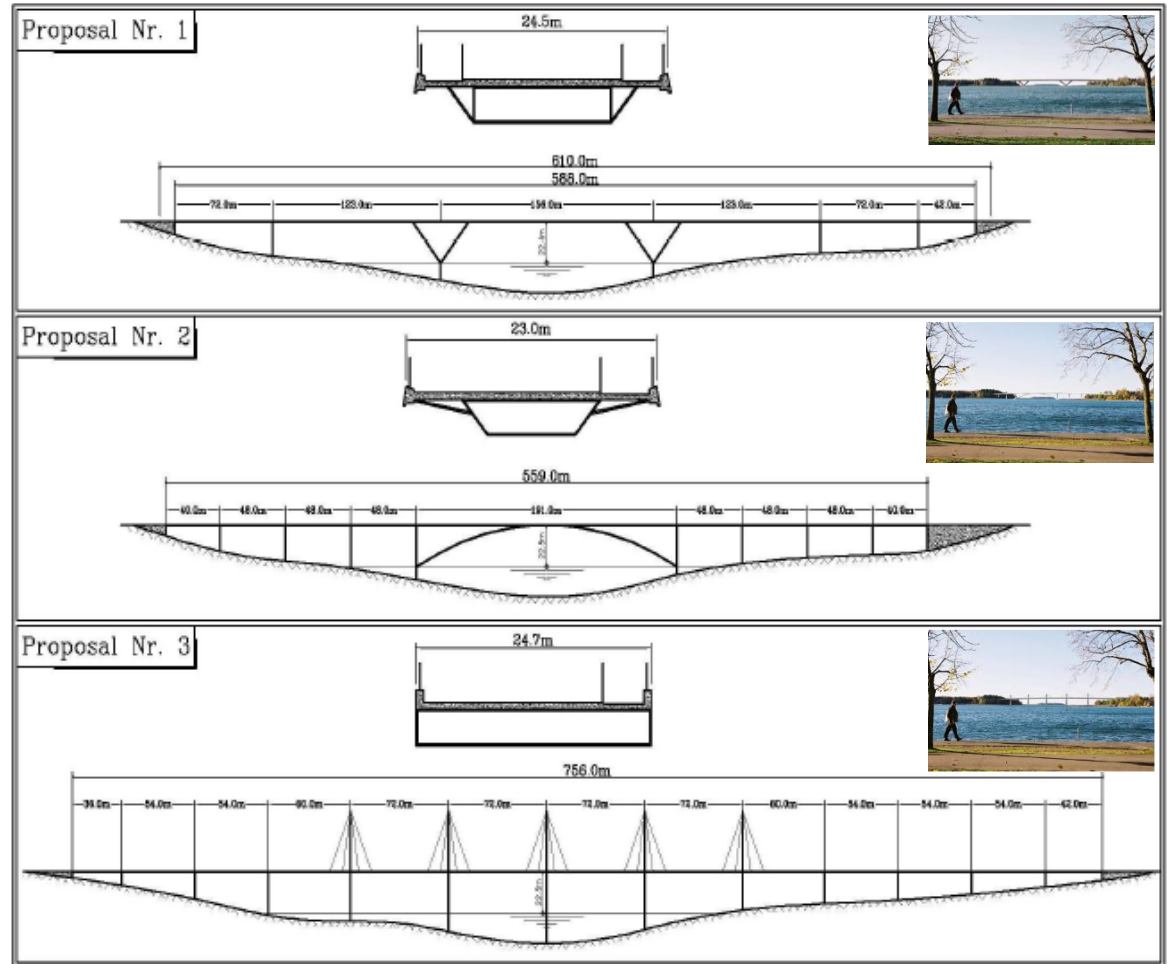
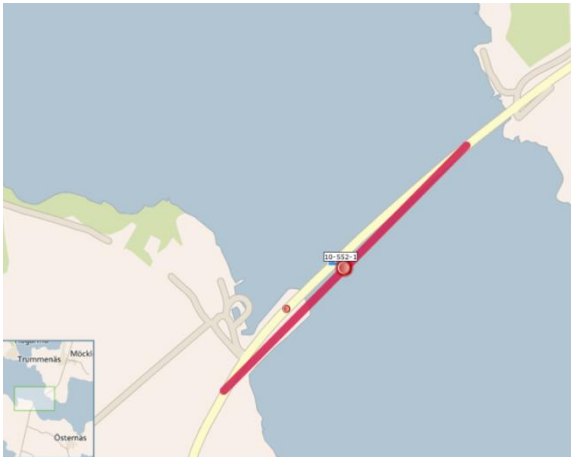
App. No. (2): Specify the most life-cycle cost-effective road corridor



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

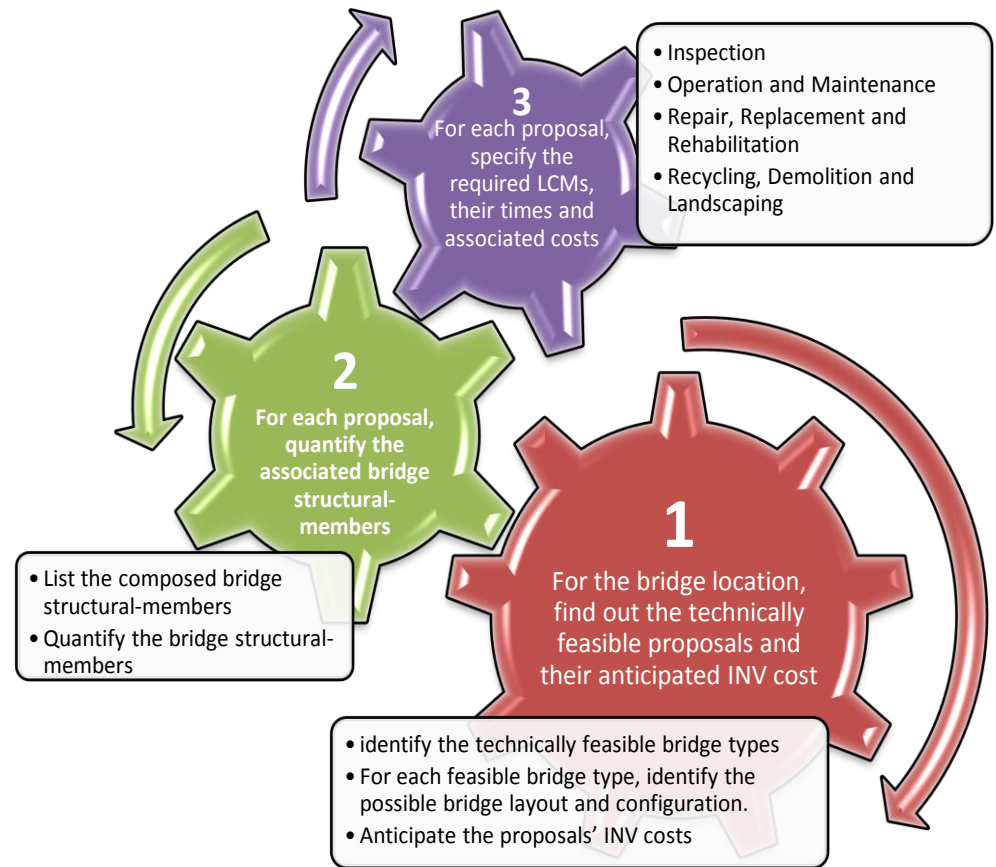
Bridge Investment & Management from a LCCA Perspective

- 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
- Trafikverket's goal is: 50% D-B by 2018
- A new award criterion under D-B: lowest LCC bid

Unified LCC-Efficient Benchmarks

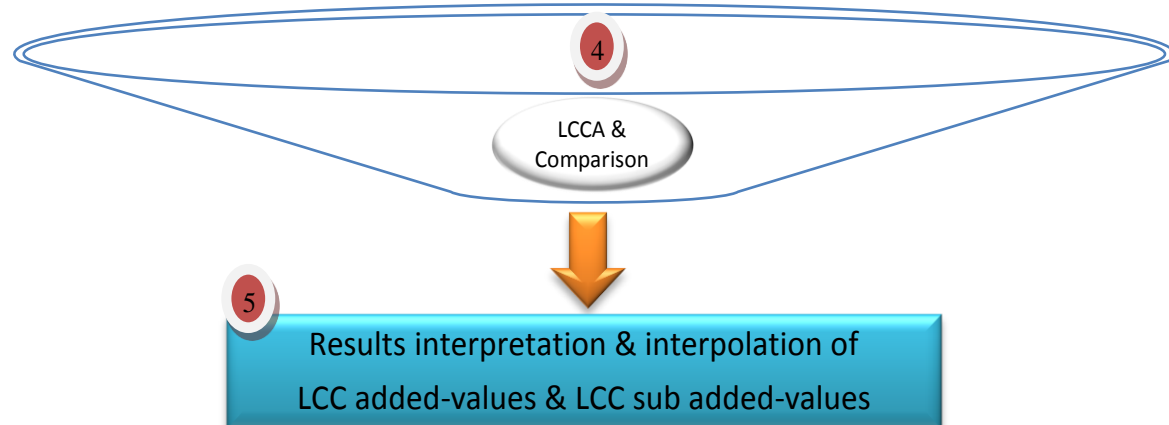
- There are several improper ways to employ the concept of the lowest LCC bid as the contract award criterion under D-B
- The optimal way is for procurers to establish consistent LCC-efficient benchmarks and guidelines then clearly present them as core specification in the tender documents.

Analysis Steps




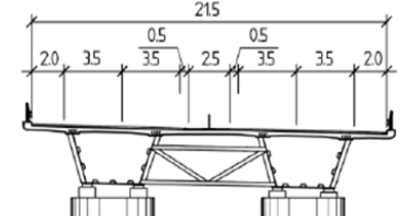
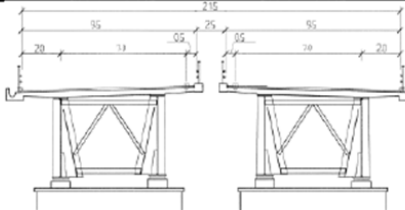
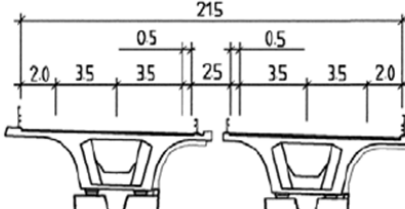
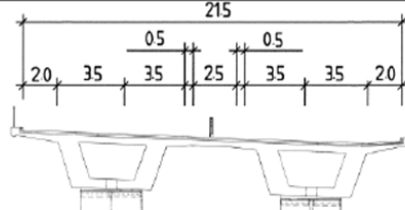
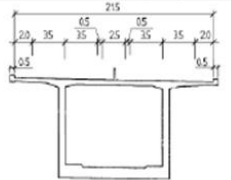

Comprehensive Approach:

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

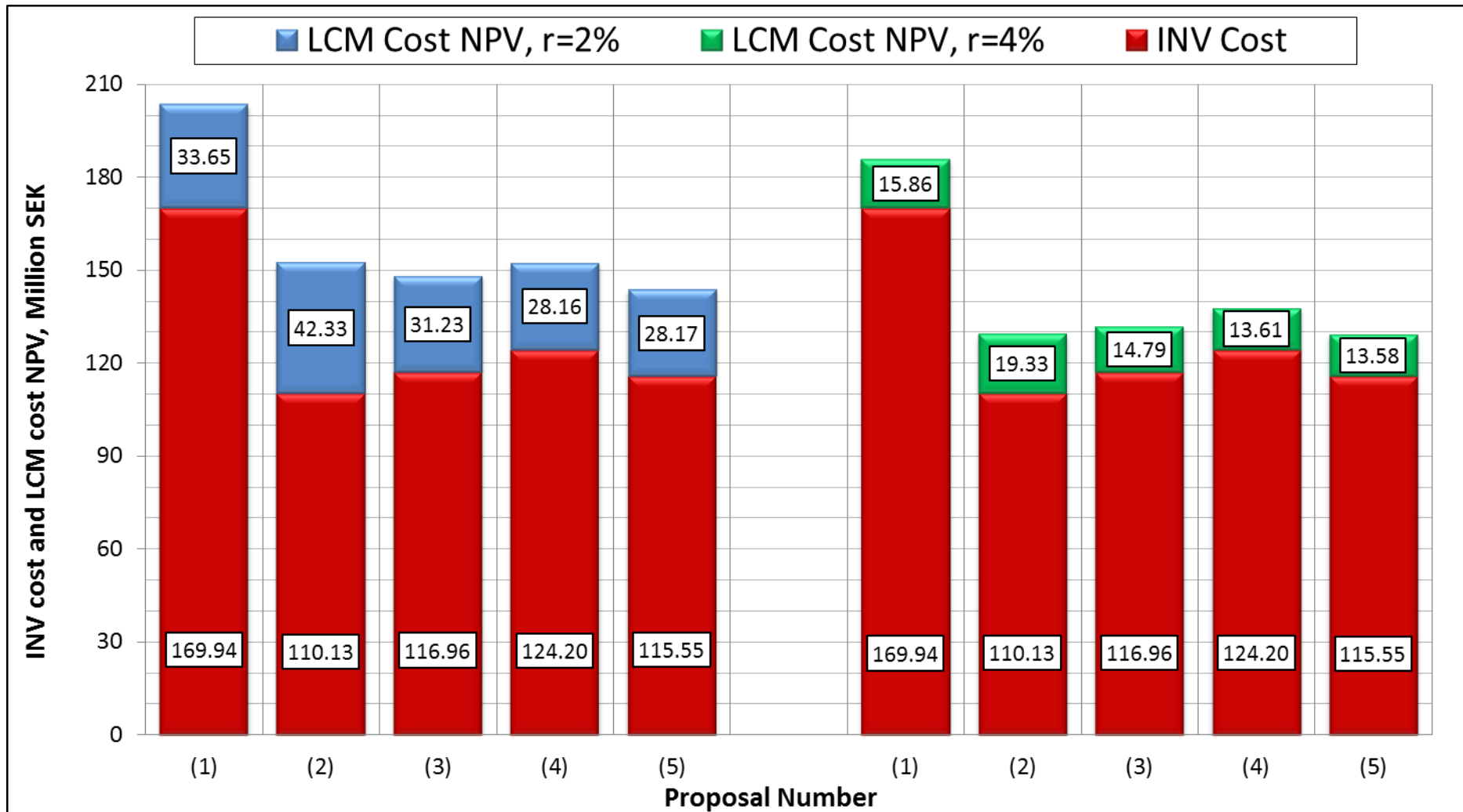


Case Study

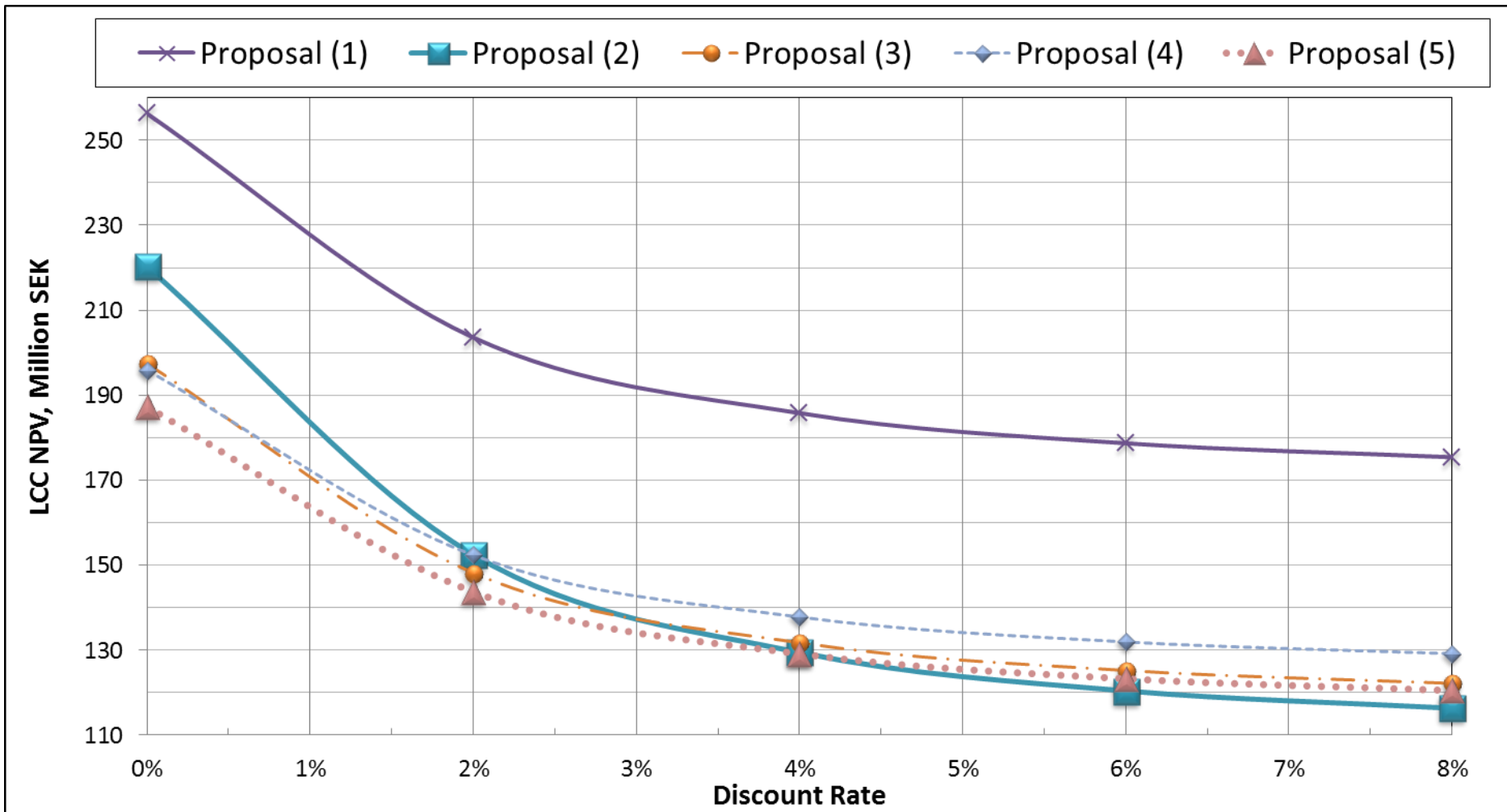
The Karlsnäs Bridge 2013

			
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

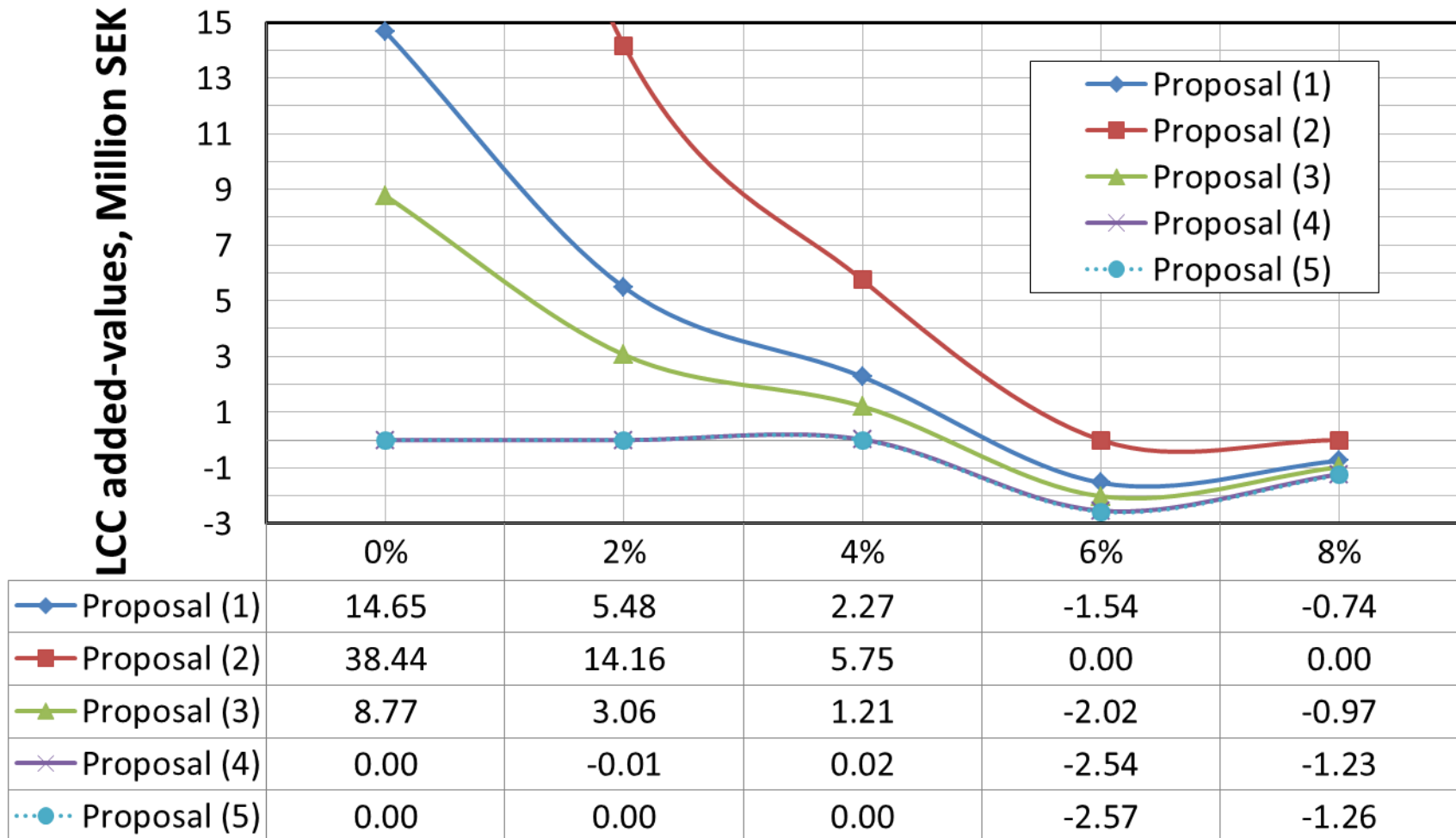
LCCA Results



Impact of varying the discount rate on the proposals' LCC



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



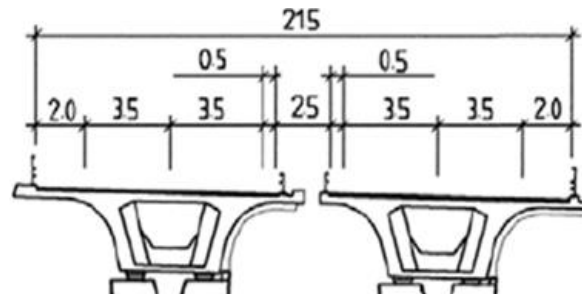
Structural-members' LCC added-values at a discount rate of 4%

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

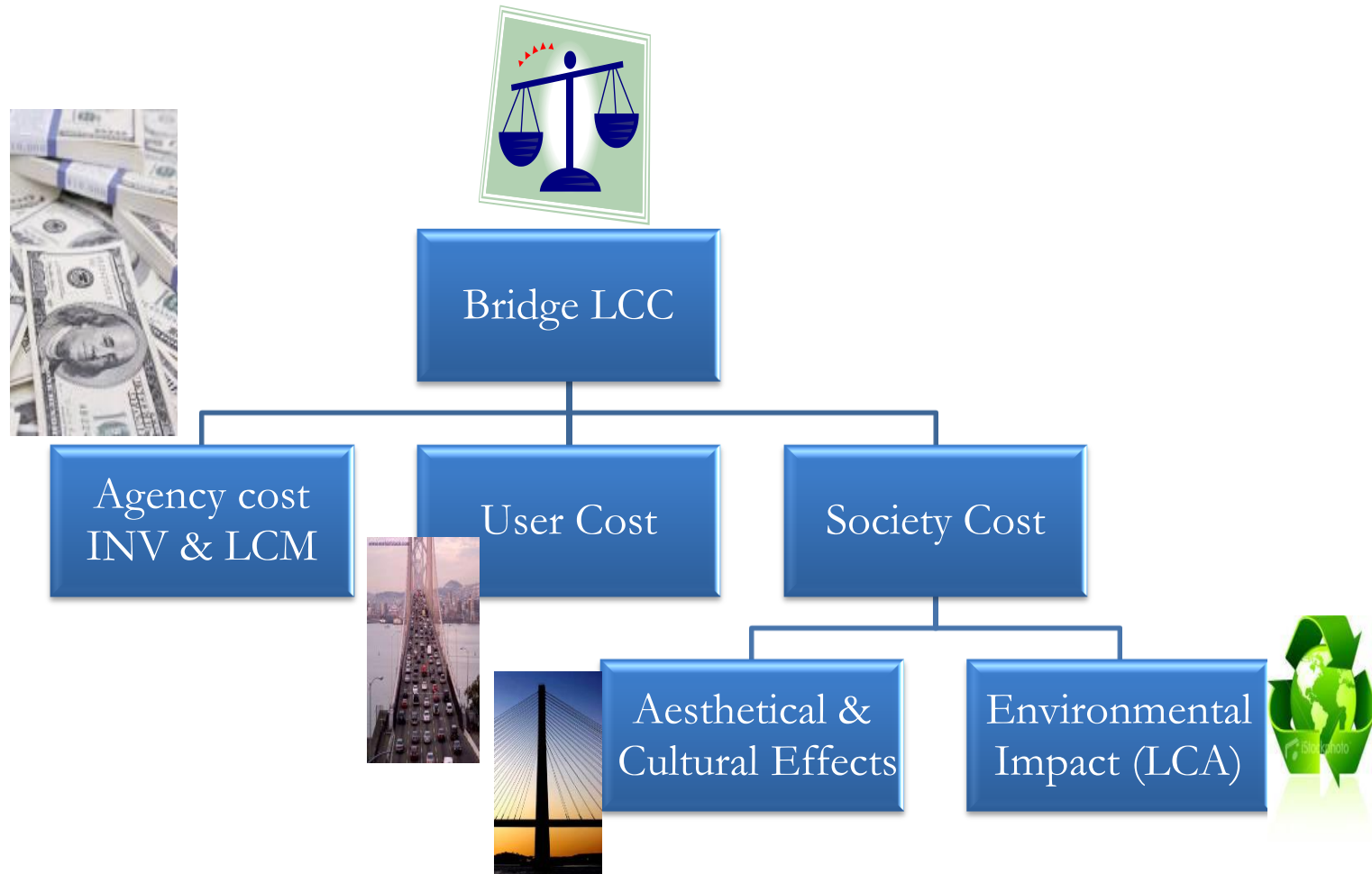
Procurement of the Karlsnäs Bridge

- 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

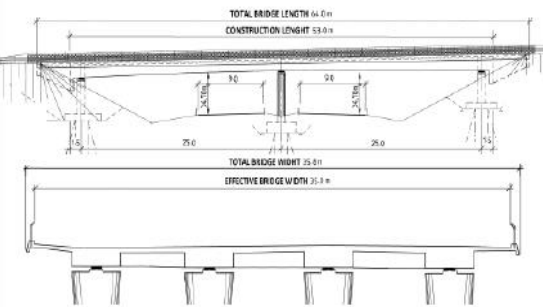

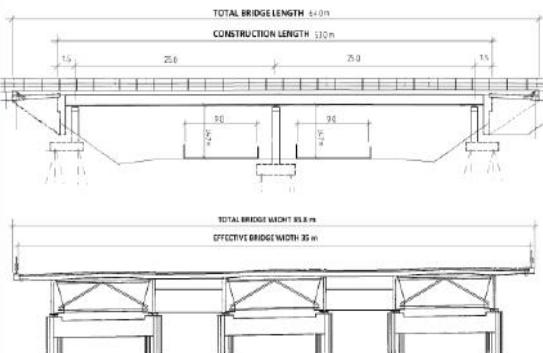

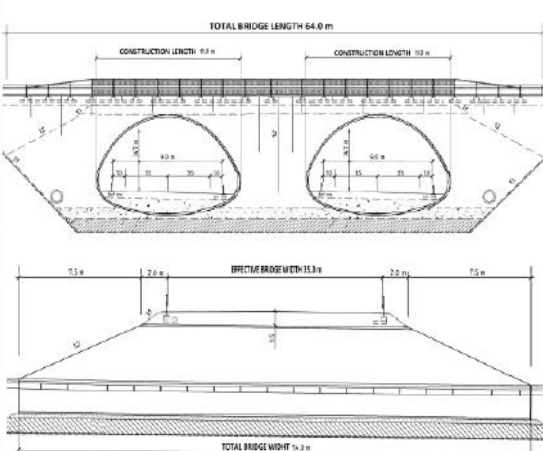
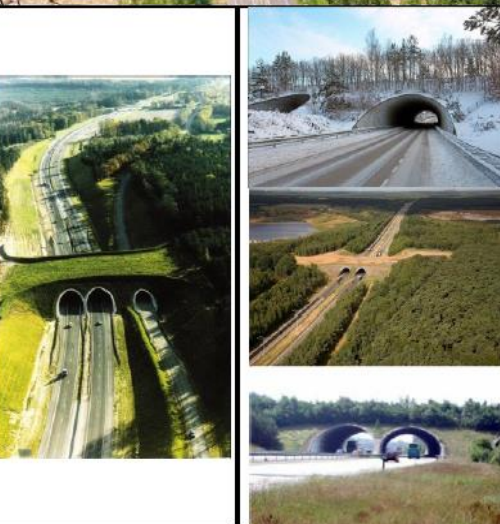


Holistic Approach

- 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.

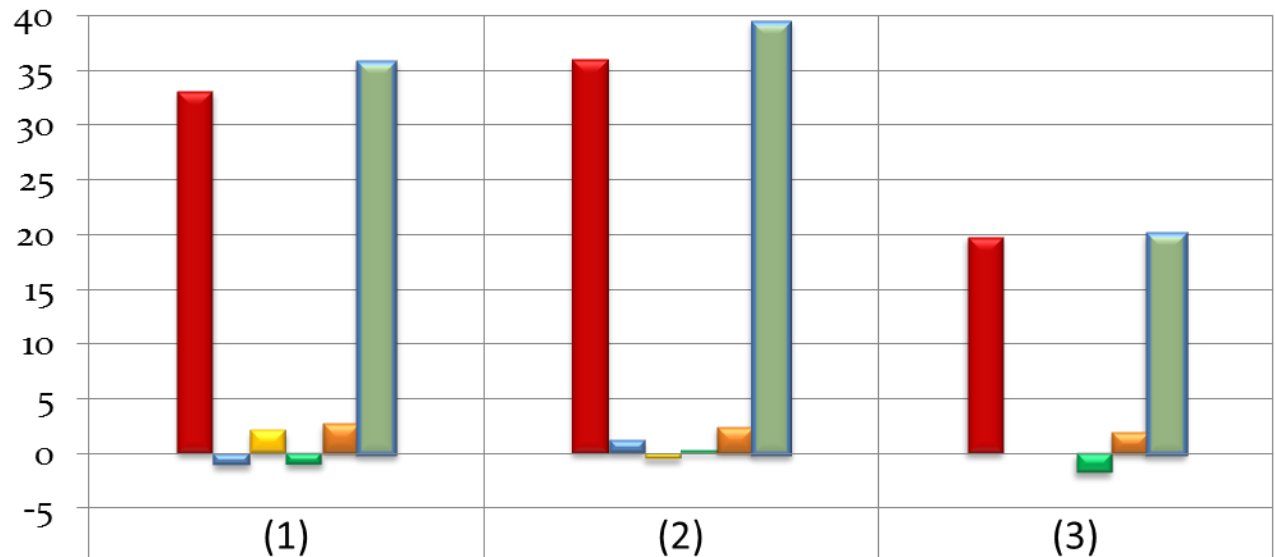
Case Study

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

Cost and life-cycle aspects
equivalent cost, Million SEK



■ 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

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

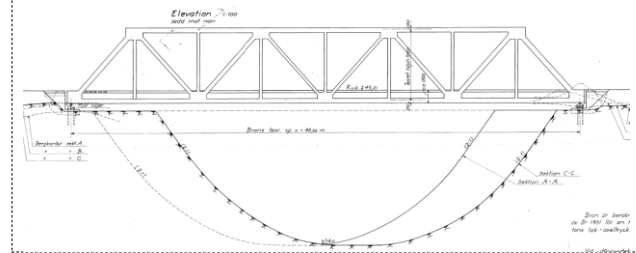
An action is required within a 3 years period, CC2



Railway Bridges

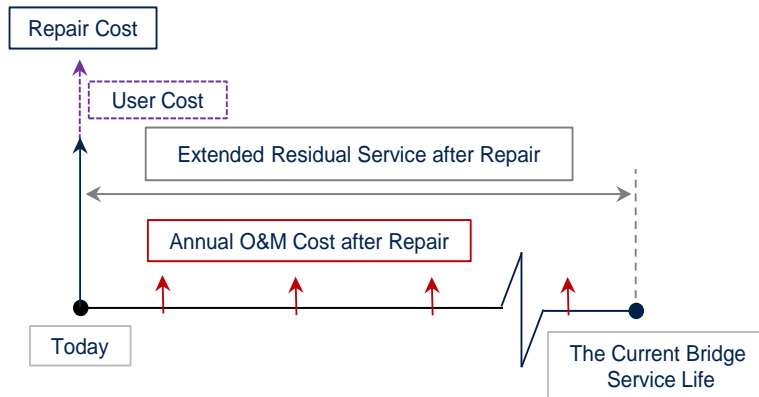
The Extended Summary
[3500-2593-1] Bro över Huvudnäskanalen
Construction Year: 1937

An immediate action is required, CC3

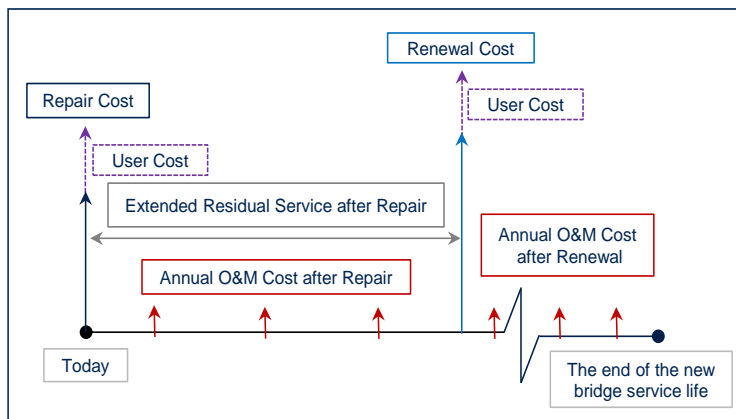
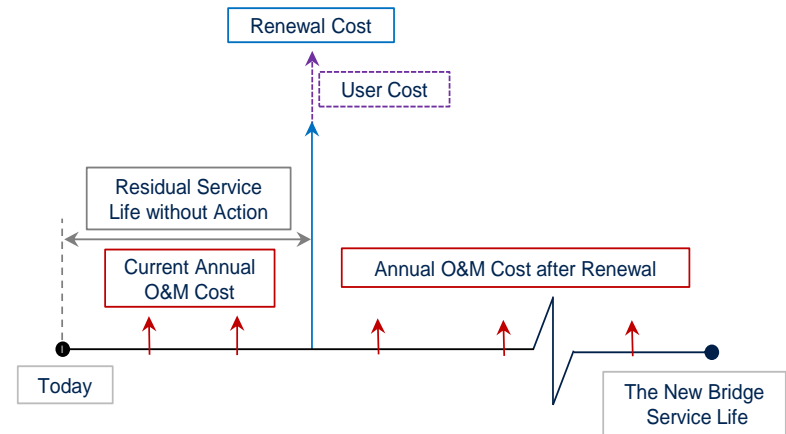


Strategies Formulation

Strategy A: Immediately repair the bridge



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



Sensitivity analysis:

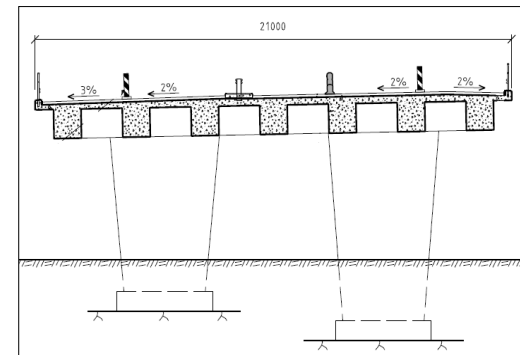
1. Discount rate
2. The INV cost of a new bridge
3. Residual service life extension after repair
4. Residual service life without action
5. Actual service life of a new bridge
6. Long- and short-term planning of the repair
7. User cost inclusion

Bridge Management

Repair or replace a bridge structural-member?

An action is required within a 3 years, CC₂

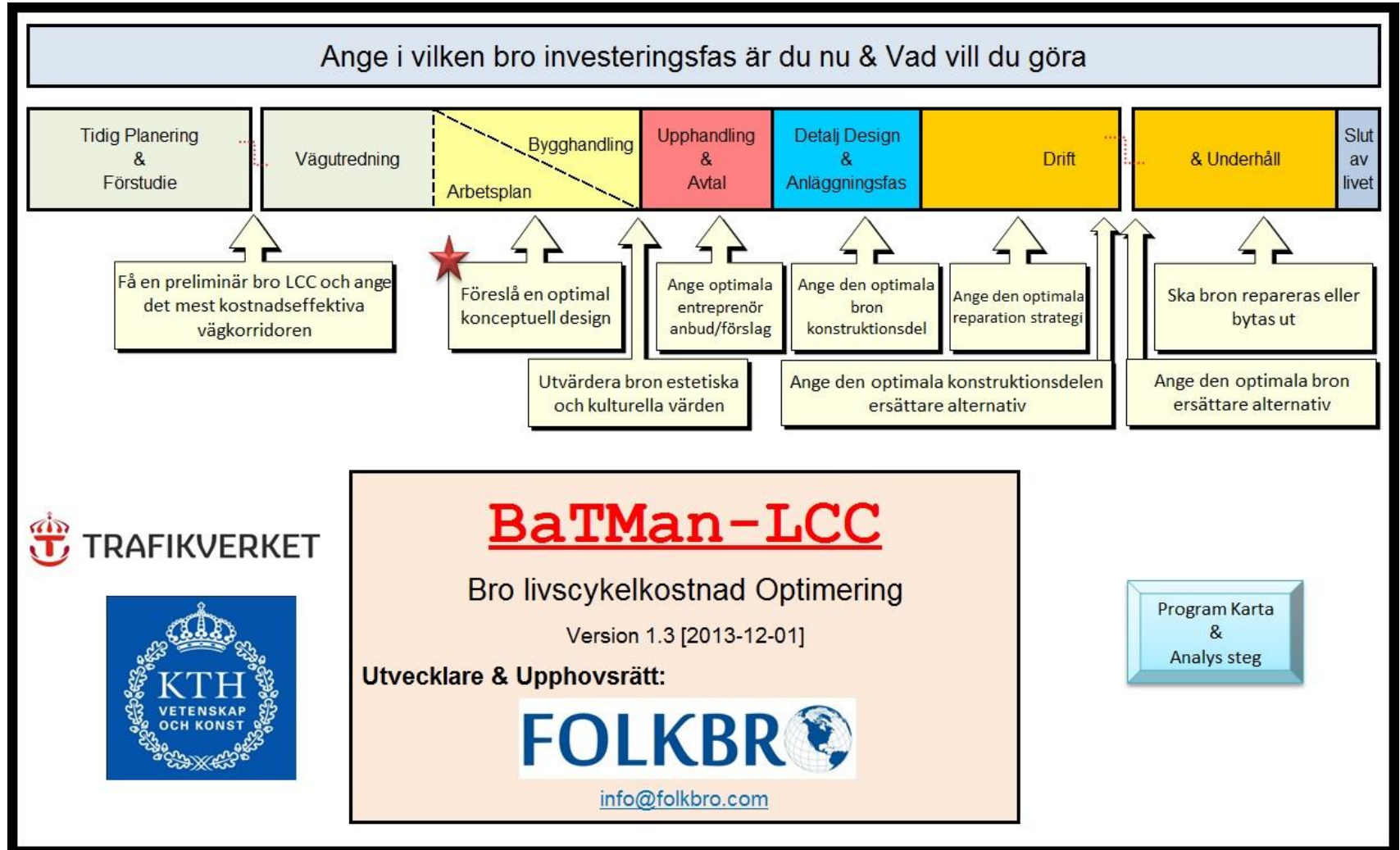
Vårbyvägen Bridge [1-813-1]
The surfacing of the bridge deck is CC 2, 3 years
The bridge deck, CC 0



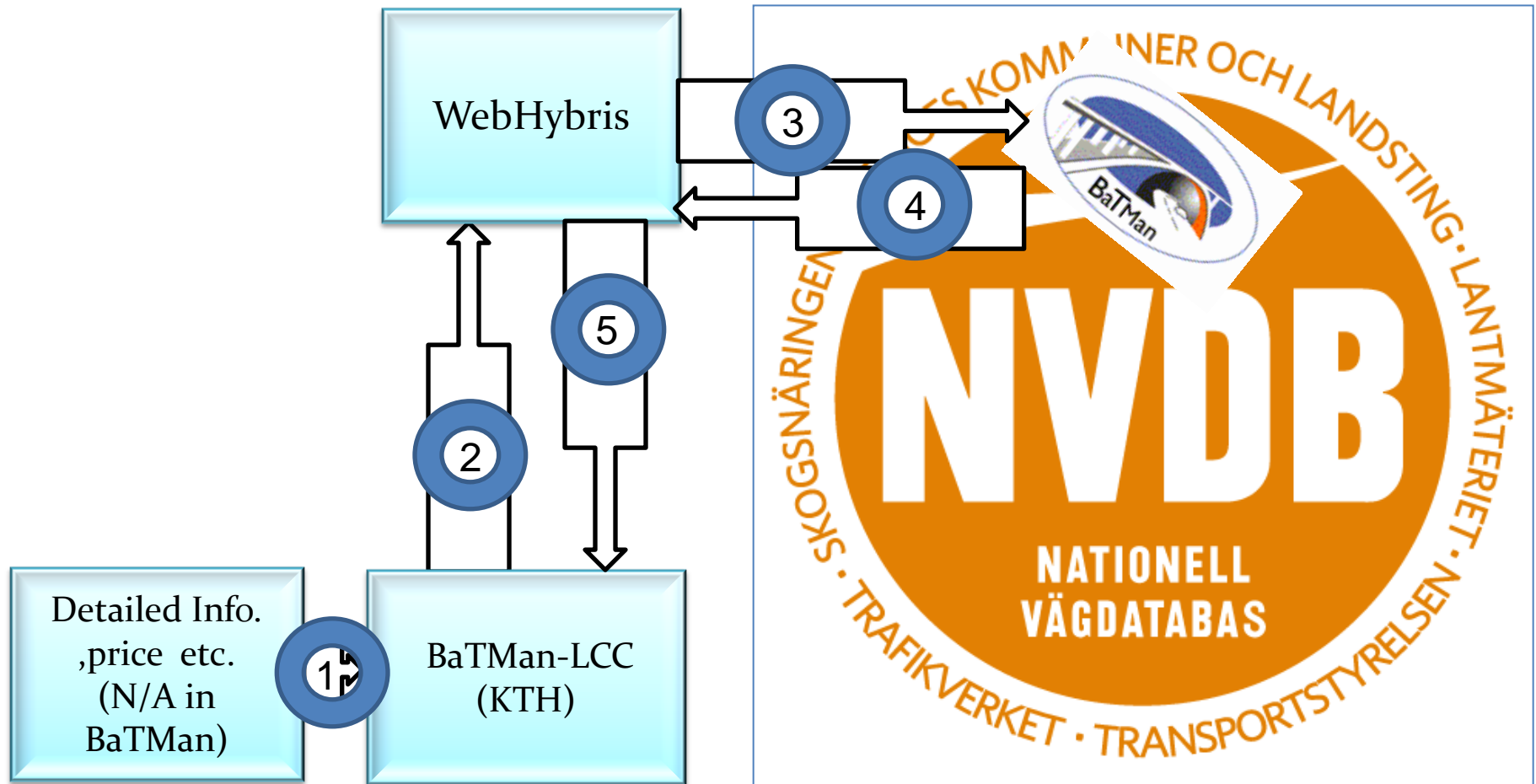
Parameters affecting the analysis, Sensitivity analysis:

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

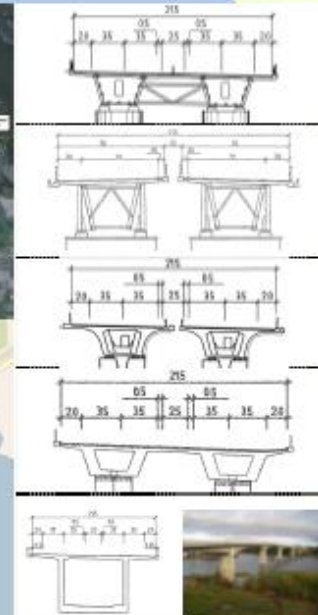


TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION



2012

BaTMan-LCC User Manual



...le cost-effective bridge bid
...le cost analysis (LCCA)

Mohammed Safi
KTH & Trafikverket
10/8/2012

An aerial photograph of a large, multi-span bridge crossing a wide river. The bridge features a prominent white arch on the left side and several concrete piers supporting the main span. The surrounding landscape is lush with green forest and rocky terrain. In the background, a power plant with a tall chimney is visible on a small island. The text "Thank You" is overlaid in large red letters.

Thank You

Questions?