

Bridge LCCA

Overview & Implementation

Mohammed SAFI

PhD Student-KTH
Specialist Teknik-Trafikverket

Peter Simonsson

Specialist Teknik-Trafikverket



TRAFIKVERKET

Agenda

- Introduction
- Benefits of BaTMan & WebHypris for Bridge LCCA
- Bridge Life & the Possible LCCA Applications for Bridges
- Bridge Investment Case Studies & Large-Scale Feasibility
 - App. No. (1): The Optimal Road Corridor, Bridges
 - App. No. (2): The Optimal Bridge Design
 - App. No. (3): Repair or Replace Väg & Järnväg Broar ?
- BaTMan-LCC Program & BaTMan-LCC Course
- Questions & Discussion

Introduktion

Syfte:

- ☐ Skapa rätt förutsättningar för beslut vid projektering
- ☐ Rätt nivå på DoU för ägandet av broar sett över en livslängd
- ☐ Optimal totalinvestering för broar

Ta fram det mest kostnadseffektiva alternativet för samhället i specifika fall/objekt

Introduktion forts.

LCC-beräkningarna påverkas av:

- ☐ Kalkylränta
- ☐ Trafikantkostnader
- ☐ Underhållskostnader och intervall
- ☐ Val av brotyp
- ☐ Förväntad livslängd
- ☐ Politiska beslut
- ☐ Övriga samhällskostnader (tex utebliven inkomst för näringsliv)
- ☐ Mm



Idag och Framtiden

Var står vi idag?

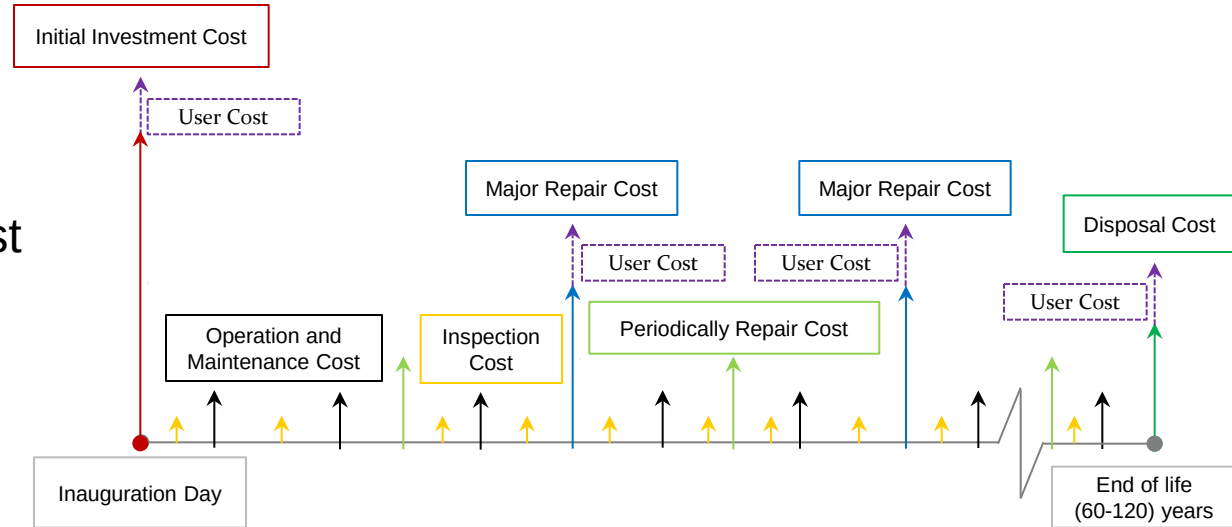
- Kravformuleringar i Förfrågningsunderlag (FU)
- Underlag för alternativstudier

Vad kvarstår i projektet?

- Standardiserade tekniska lösningar
- Anbudsutvärdering
- Kostnadsdatabaser

Introduction

- **Bridge Life-Cycle Cost (LCC)**



- The time value of money, discount rate
- Life-Cycle Costing/**Life-Cycle Cost Analysis (LCCA)**
- **Life-Cycle Assessment (LCA)**
- The concept of the lowest proposal & the concept of least LCC proposal



The Swedish Bridge and Tunnel Management System "BaTMan"

BaTMan BRO OCH TUNNEL MANAGEMENT

Rapporter - Objektdata - Förvaltning - Information - Mina sidor - Kontakta oss - Om - Skriv ut

Nyheter

Ny BaTMan-version

BaTMan 4.21 kommer att driftsättas med start ons 2011-10-12 kl 16:00. Driftsättningen kommer även att pågå för 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 13:24

'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 13:17

Järfälla kommun...

... ingår nu också i BaTMan-familjen!
2011-09-13 13:49

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 Inkorgen kontrollera om du kan avsluta några! Välj i BaTMans övre meny 'Mina sidor/Pågående ärenden', gör därefter dina val och tryck sedan på 'Nämsta 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](#)

Väg- och järnvägsbro över Ljusnan i Sveg

Konstruktioner i BaTMan

100km

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.

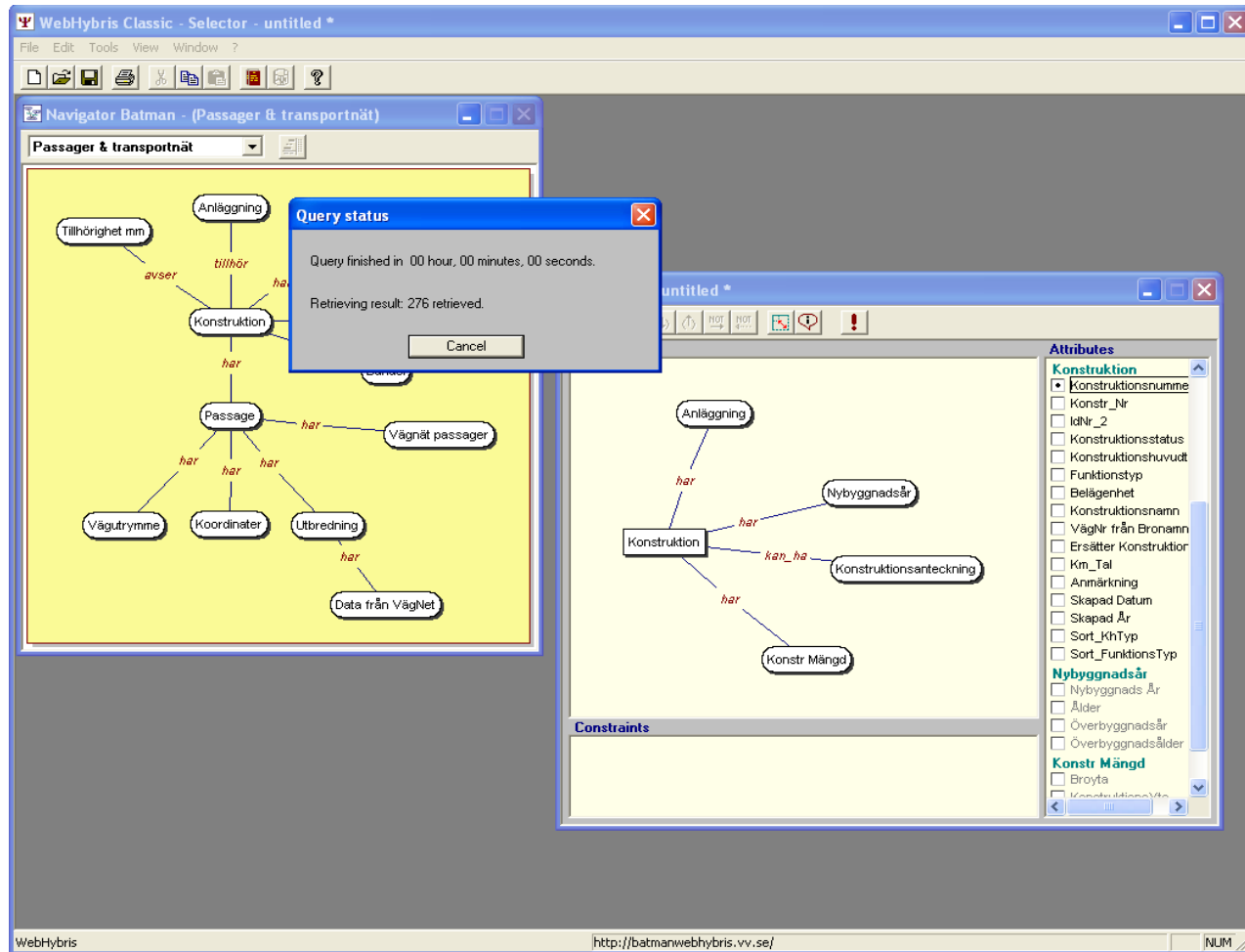
Sökning av information i BaTMans handbok gör du tillsvare direkt i handboken.

BaTMan handbok

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

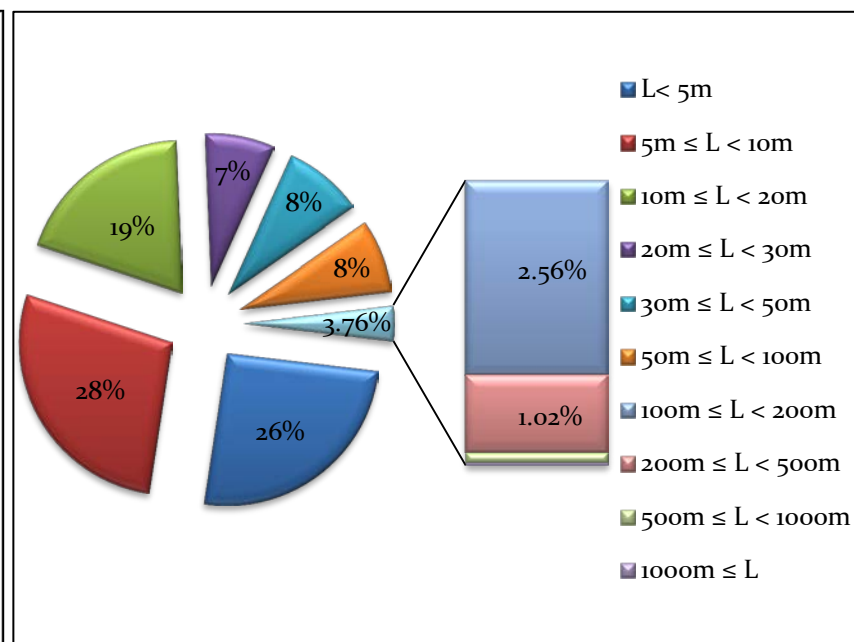
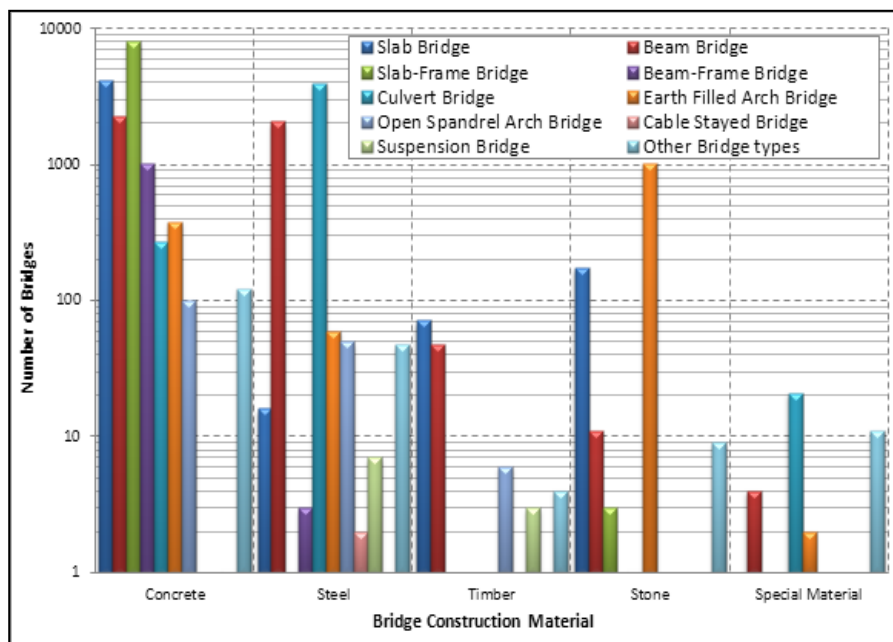
<https://batman.vv.se/batman/>

BaTMan's Navigation Tool (WebHybris)

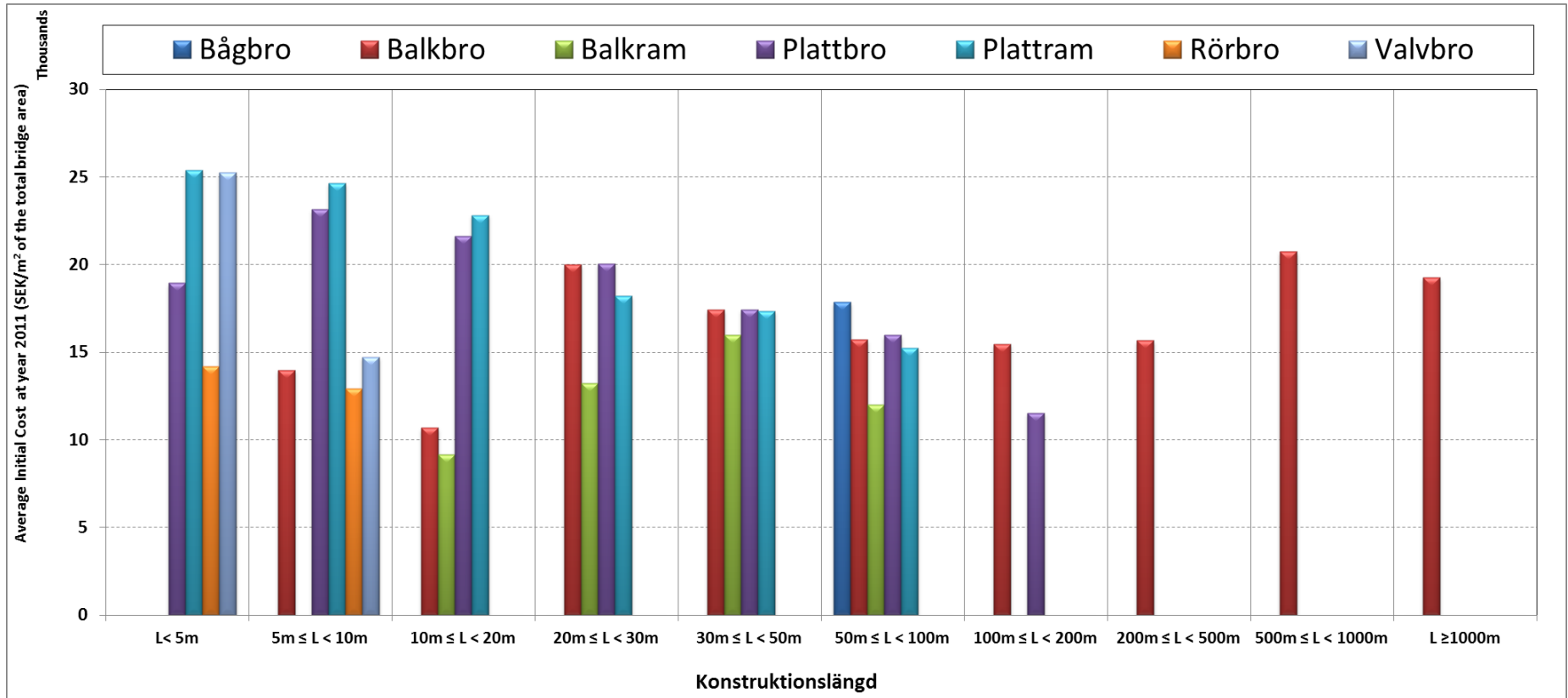


The Swedish Bridge Stock 2011

	Bridge Function Type				Total No. Of Bridges	Bridge Total Area (m²)	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

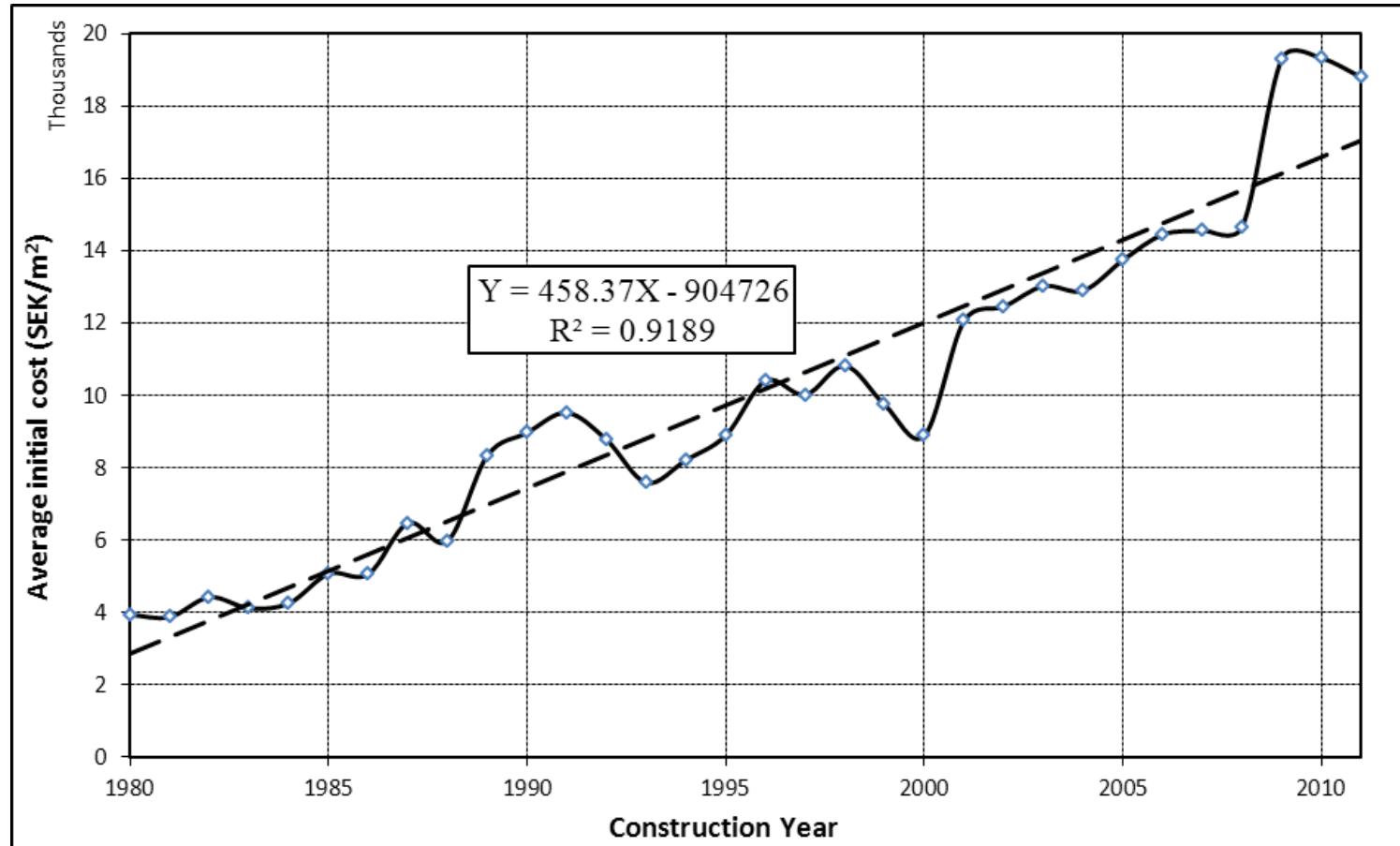


Swedish Bridges Real INV Cost



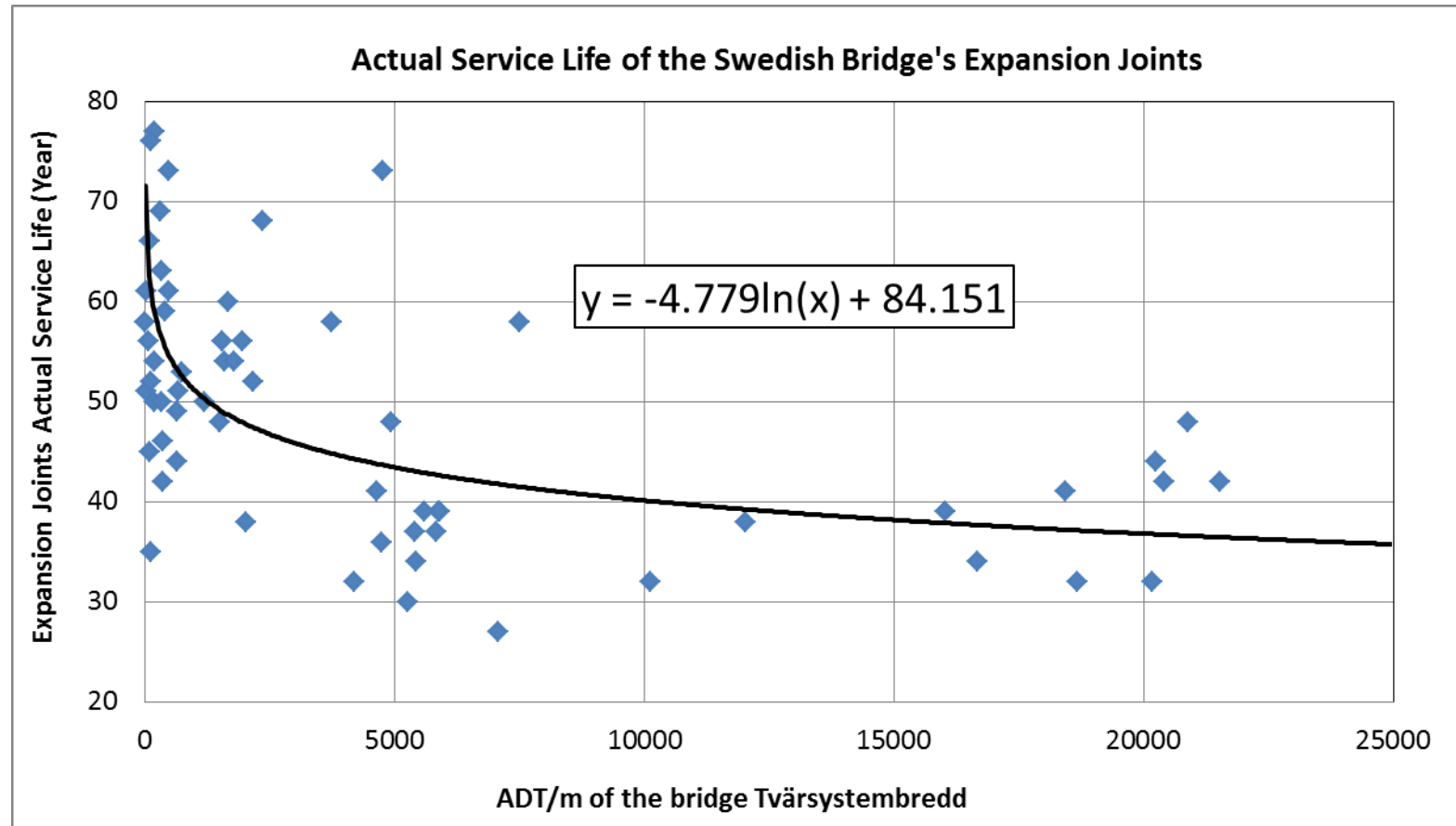
The average real initial costs of the Swedish bridges different types, based on cost data for 2,508 bridges constructed between 1980 and 2011.

Swedish Bridges Anticipated INV Cost



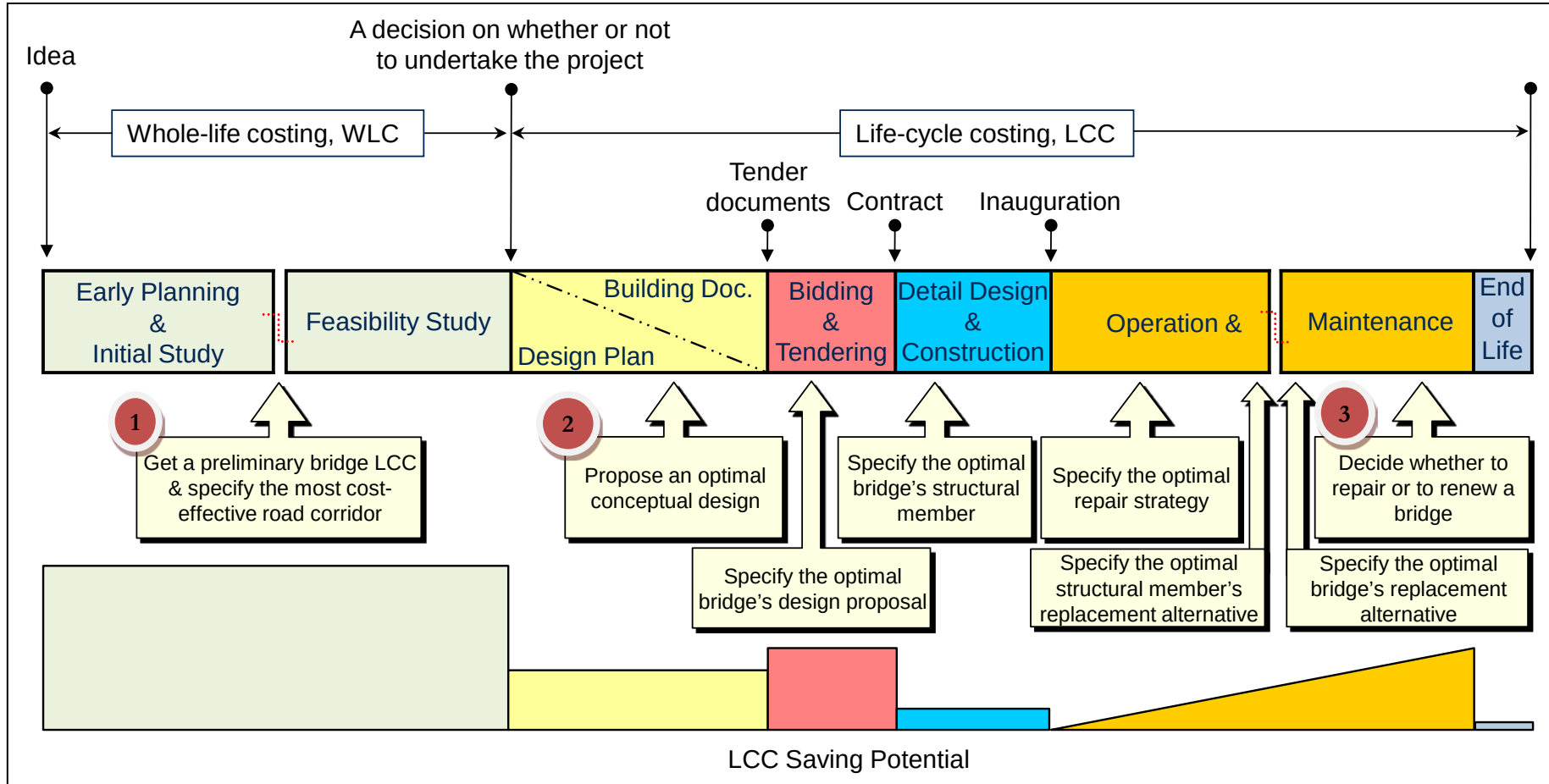
The inflation rate for the Swedish bridges initial costs

Structural-Members Life-Cycle Measures

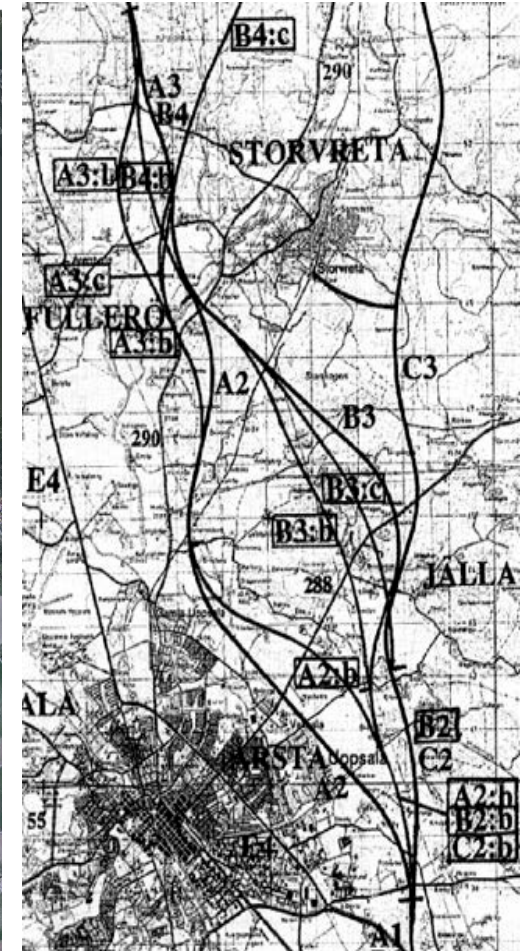
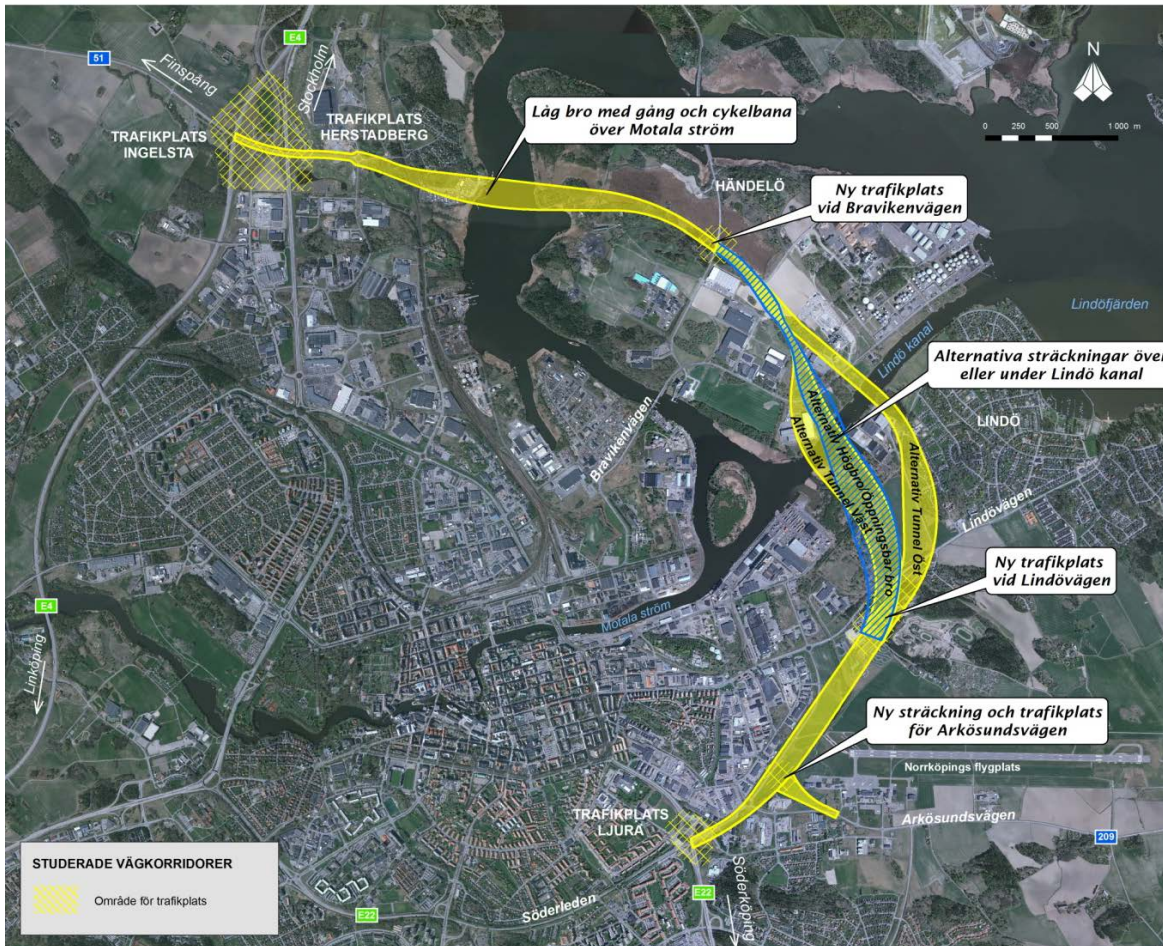


Based on 288 Replacement Actions performed between 1979 and 2010

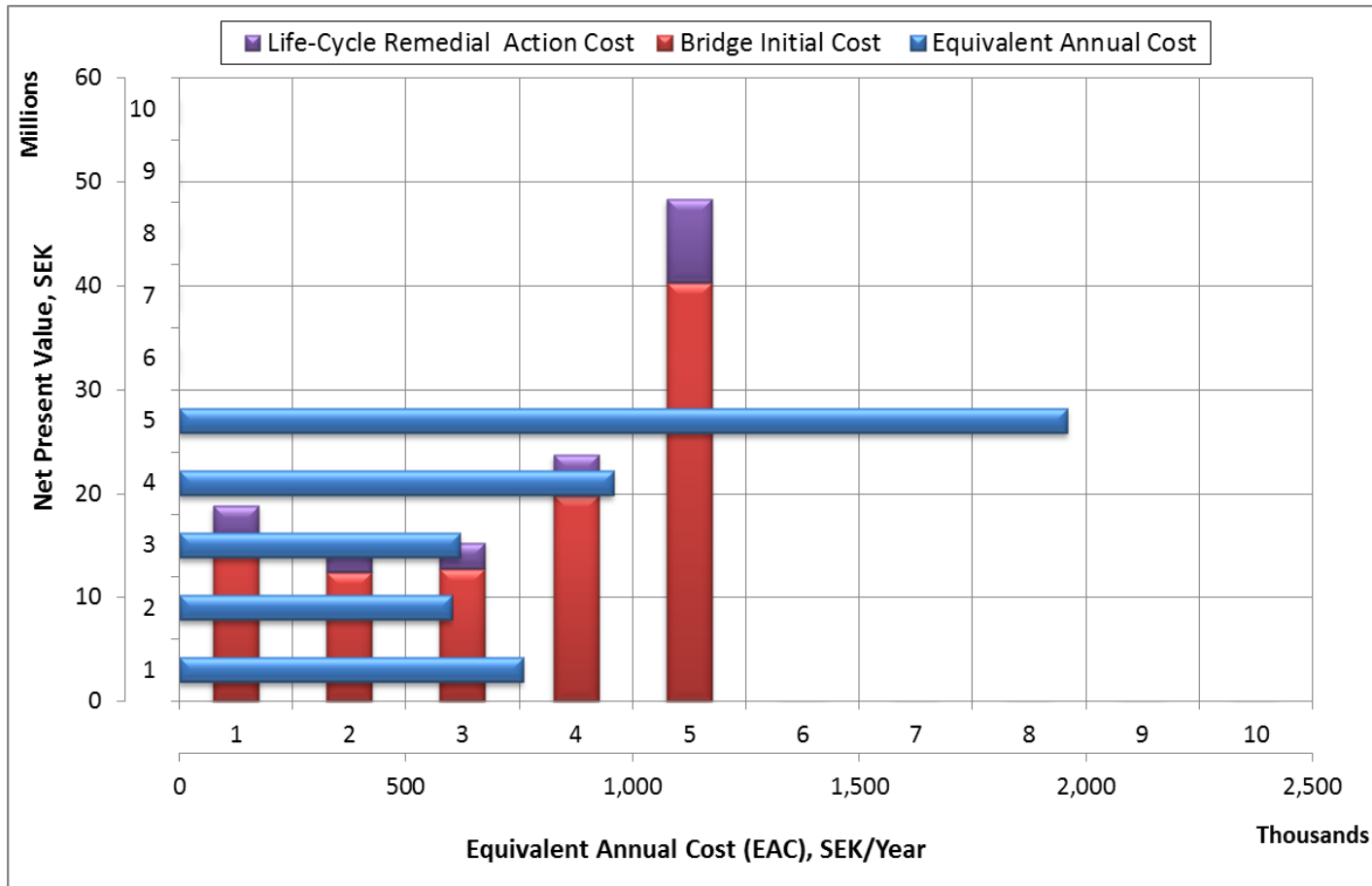
Bridge Life and the possible LCCA App.



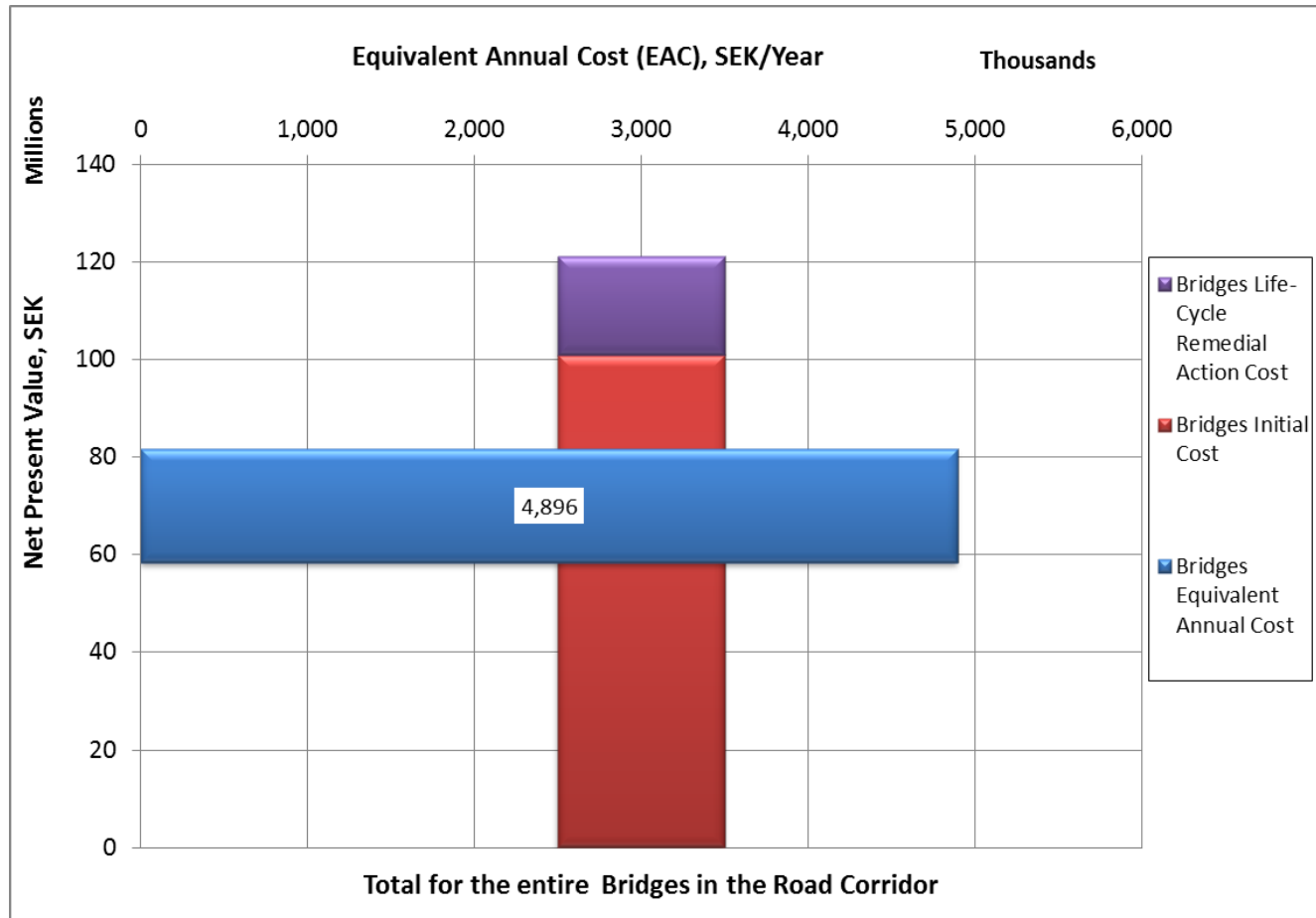
App. No. (1): Specify the most life-cycle cost-effective road corridor



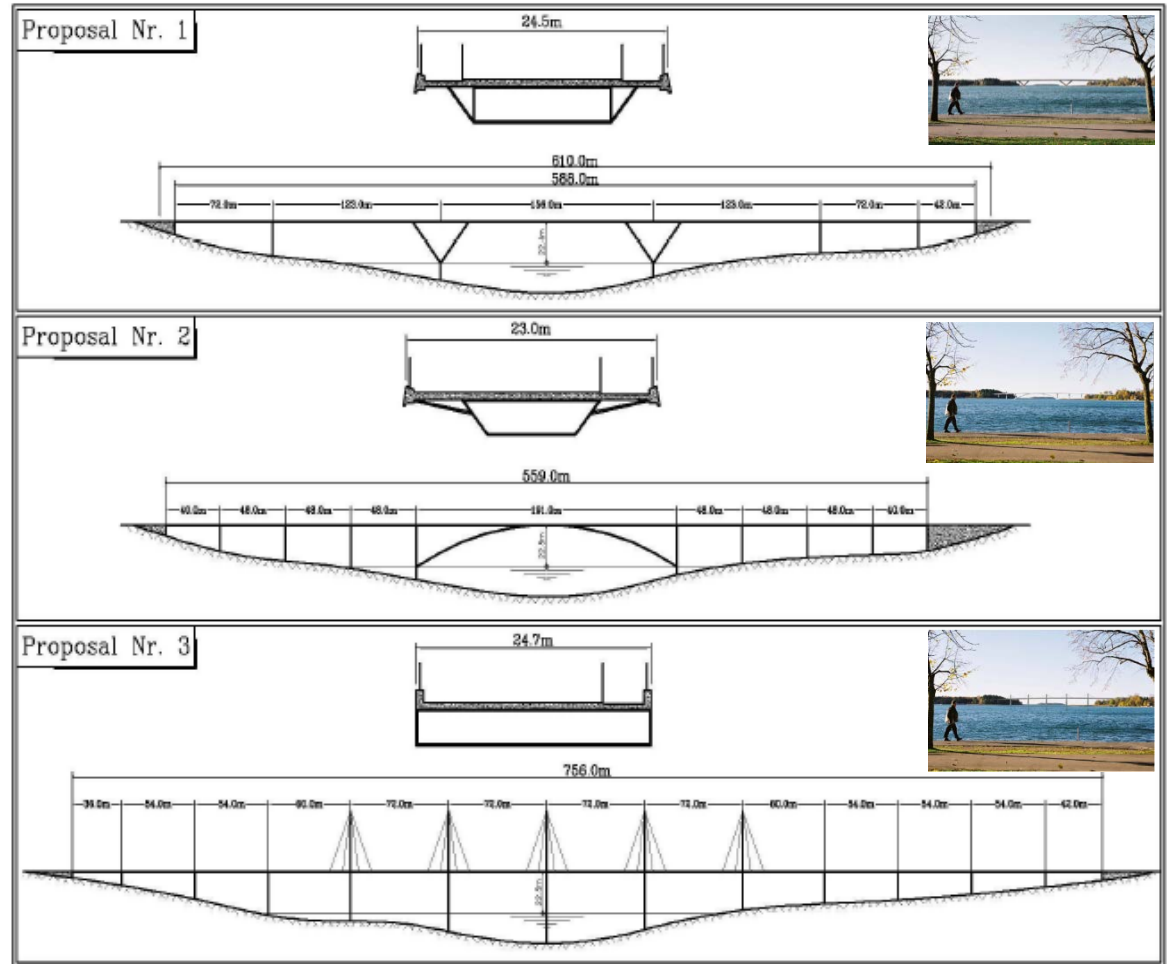
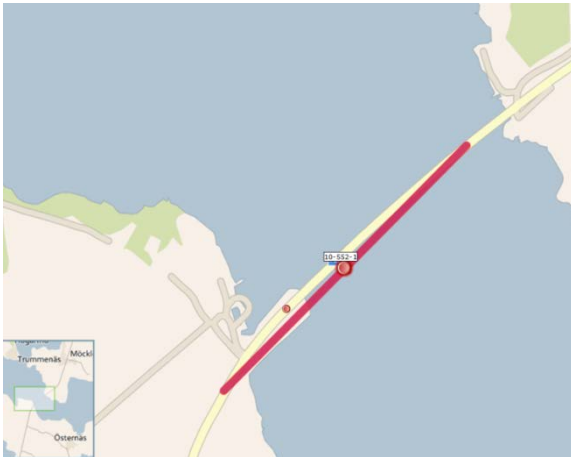
App. No. (2): Specify the most life-cycle cost-effective road corridor



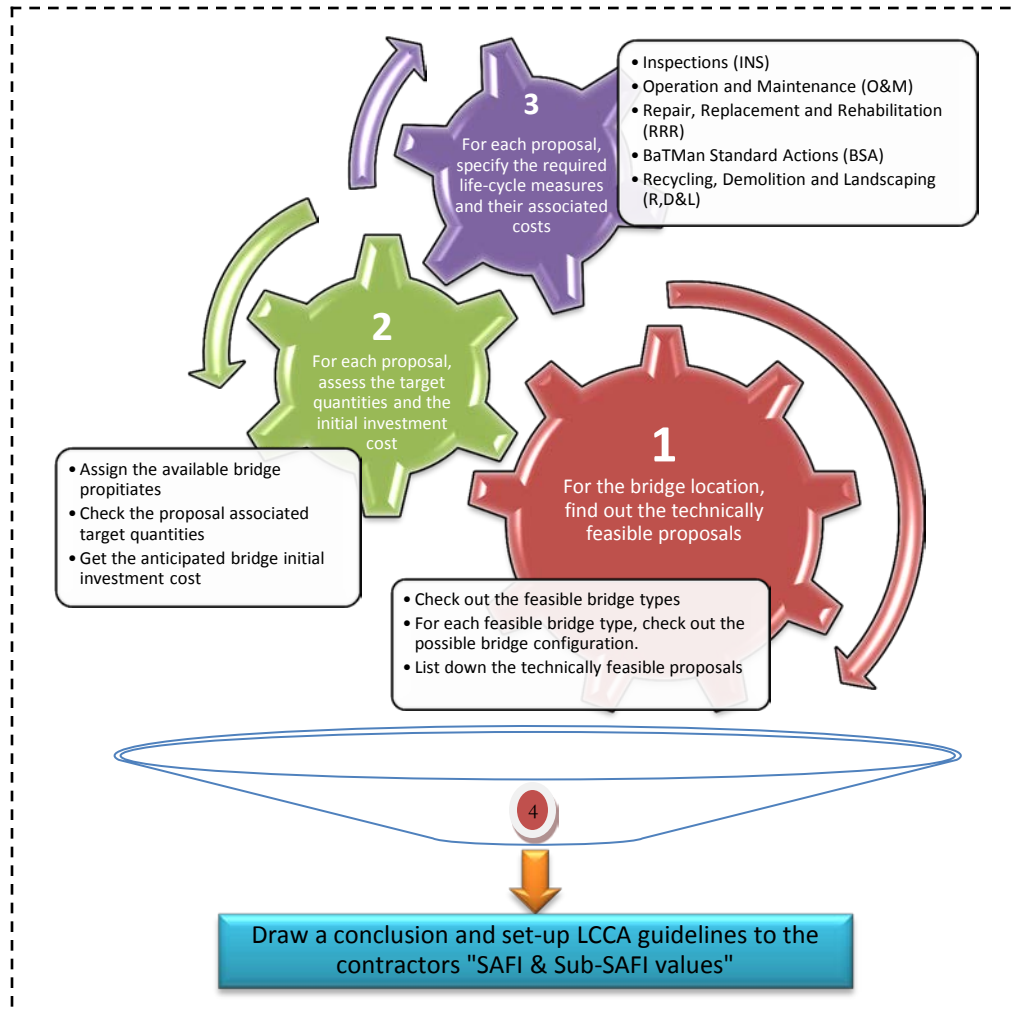
App. No. (2): Specify the most life-cycle cost-effective road corridor



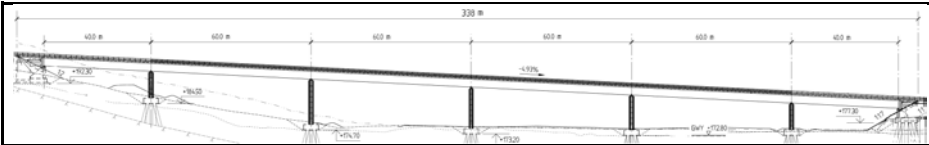
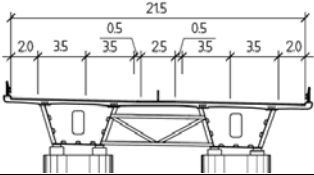
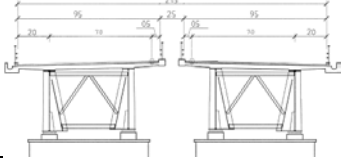
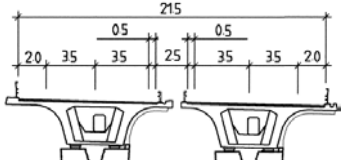
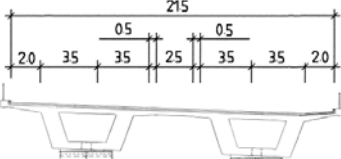
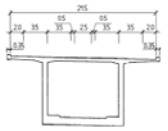
App. No. (2): Propose an optimal conceptual design during



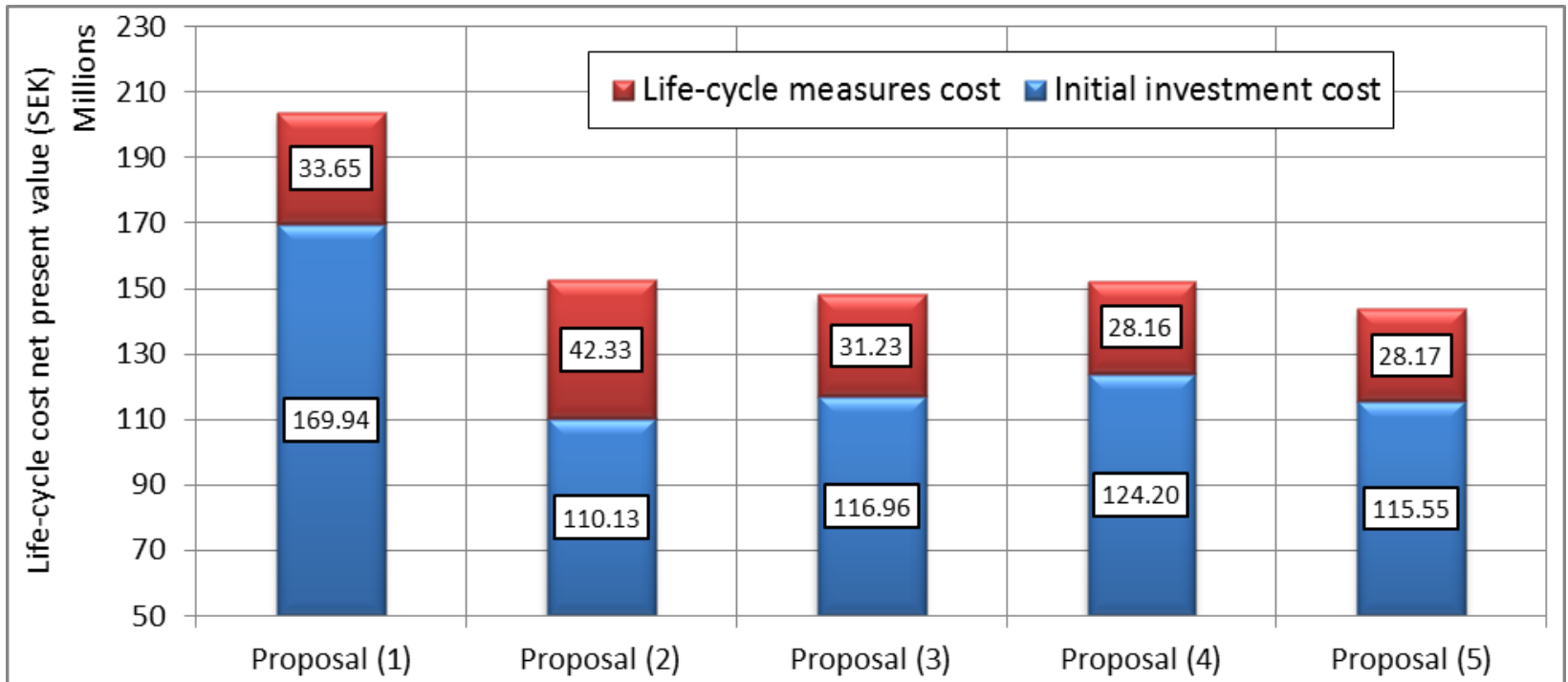
App. No. (2): Analysis Steps



Case-Study (1): The Karlsnäs Bridge

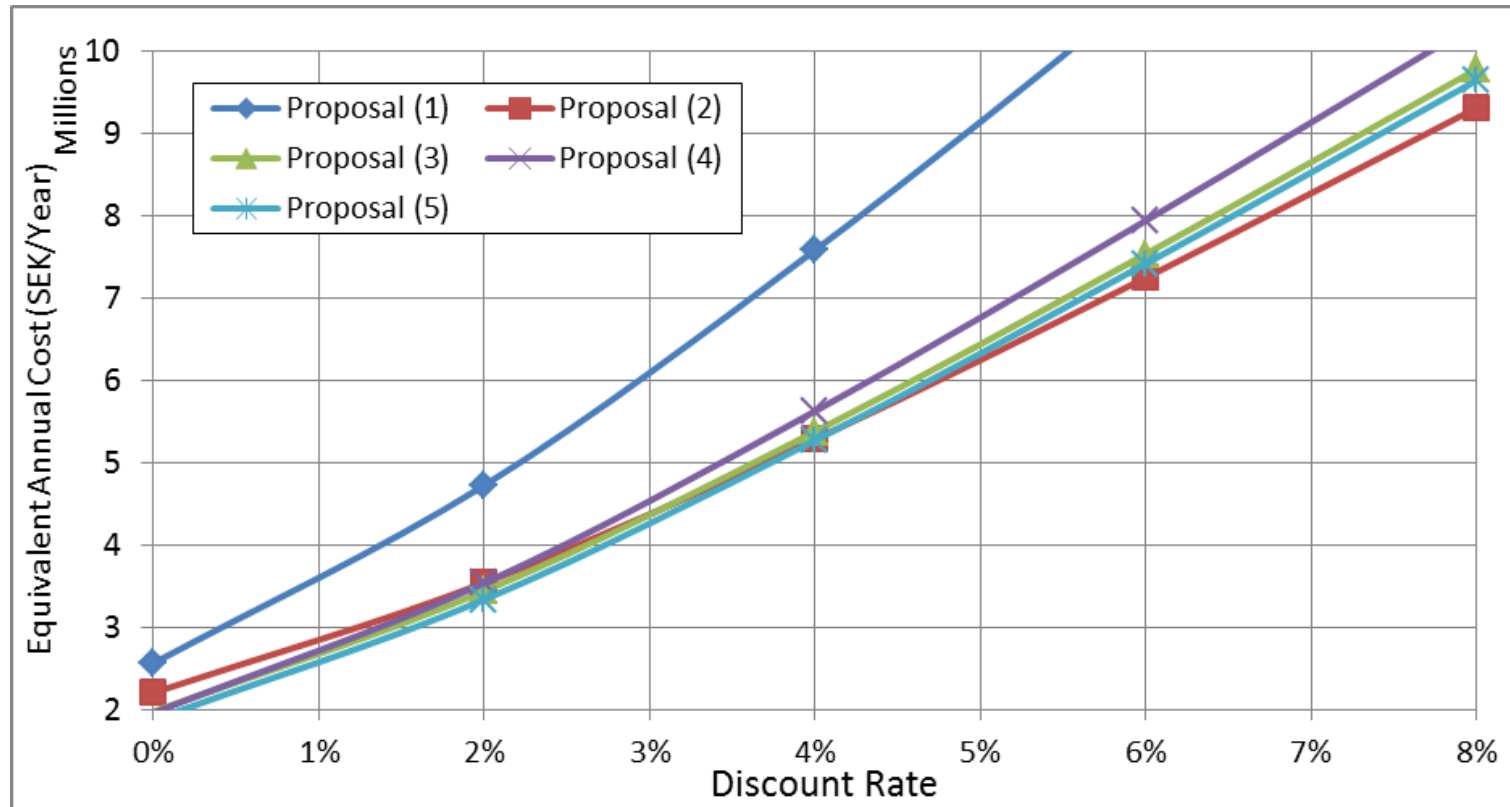
			
Proposal No.	Description	Cross-Section Details	Remarks
1	One bridge, two steel boxes		5 Spans 4X60m + 2X40m Superstructure depth: 2.3m
2	Two Bridges, two steel I beams per bridge		5 Spans 4X60m + 2X40m Superstructure depth: Haunch beam Max. 3.2m Min. 1.8m
3	Two bridges, one pre-stressed concrete box 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



- At discount rate equal to 4 %, the most cost-effective proposal is proposal (5) and the least cost-effective proposal is proposal (1).
- The Net Saving in case of implementing proposal (5) in comparison of implementing proposal (1) is equal to **56.7 Million SEK**.

Sensitivity Analysis



Regardless of the discount rate, proposal (1) is the least cost-effective proposal which is associated with the highest equivalent annual cost.

LCCA Guidelines in the Tender Documents

SAFI-Proposal Level

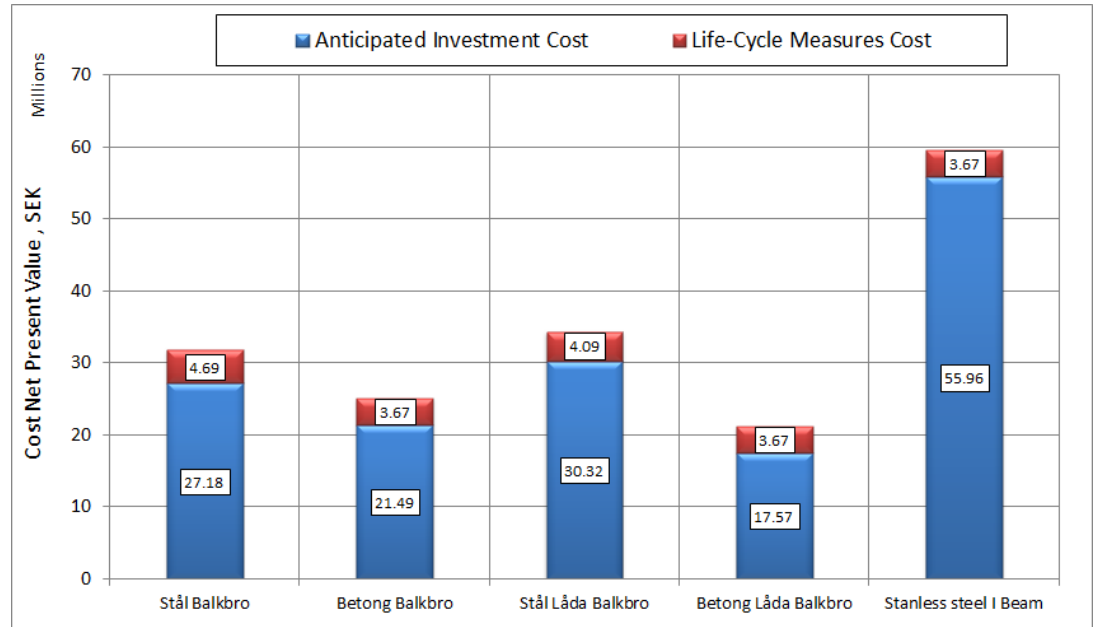
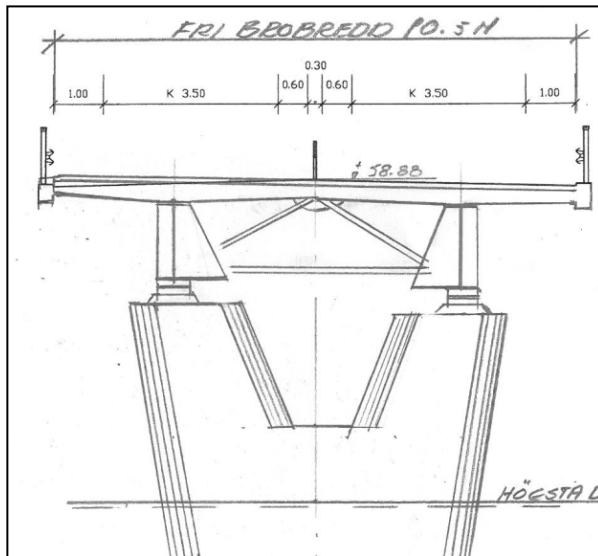
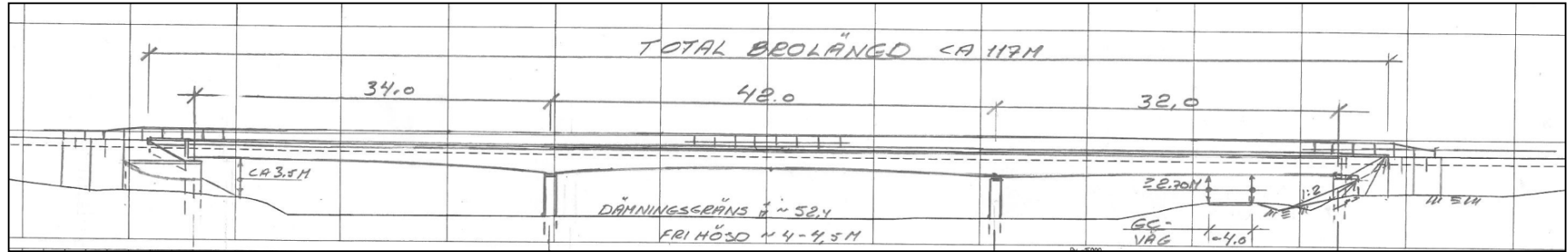
LCCA Guidelines in the Tender Documents					
Proposal No.	1	2	3	4	5
Anticipated INV Cost (M SEK)	169.94	110.13	116.96	124.20	115.55
LCM Cost NPV (M SEK)	15.86	19.33	14.79	13.61	13.58
Total LCC NPV (M SEK)	185.79	129.46	131.75	137.80	129.13
Cost-effectiveness Rank	Worst	Second best	Third best	Fourth best	Best
SAFI (K SEK), Bridge-Owner	2,272	5,750	1,210	22	0
During the Bid Evaluation Process					
INV Cost (M SEK)	163.6	124.8	121.6	145.6	--
Total LCC NPV (M SEK)	165.87	130.55	122.81	145.62	--
Cost-effectiveness Rank	Worst	Second best	Best	Third Best	--

LCCA Guidelines in the Tender Documents

SAFI-Structural Member Level

Target Part	Unit	Free BQ	Sub-SAFI		Proposal (1)		Proposal (6)		
			Unit LCM cost (K SEK/Unit)	Fixed Cost (K SEK)	Variation	Sub-SAFI Sub-total (K SEK)	Target quantities	Variation	Sub-SAFI Sub-total (K SEK)
Bearings number	set	6	7.01	54.42	22	154	14	8	56
Drainage system points	set	5	32.67	0	2	65	7	2	65
Edge beam length	m	676	1.62	108.30	0	0	676	0	0
Expansion joint length	m	89	5.78	156.37	-45	-258	45	-45	-258
Painted area	m ²	0	0.35	85.29	6,315	2,310	6,315	6,315	2,310
Parapets length	m	676	0.99	0	0	0	676	0	0
Paved area	m ²	7,267	0.53	462	0	0	7,267	0	0
Slops and cons area	m ²	2,141	0.38	0	0	0	2,141	0	0
Superstructure area	m ²	7,176	0.14	0	0	0	7,176	0	0
Total bridge area	m ²	7,537	0.62	0	0	0	7,537	0	0
SAFI (K SEK), Contractor					2,272		2,174		

Case-Study (2): The Kolbäcksån Bridge



Comparing proposal No. 1 with 4, Trafikverket can save 10.6 Million SEK.

Large-Scale Feasibility

- Based on both case studies: The average net saving is equal to 8384 SEK/m².
- It can roughly be said that Trafikverket is expected in the coming ten years to annually build an average bridge total area of 55000 m² that are equivalent to of 200 bridges.
- Consider that 50 % of the Trafikverket's new bridges might be subjected to a wrong decision.
- This means that Trafikverket can annually save **230 million SEK**. This annual loss is 220 million SEK as initial investment cost and 10 million SEK as LCM cost.

App. No. (3): Repair or Replace Vägbro?

Paper I: Struc. & Infrastructure Eng. J.
[6-367-1] Bro över Lillån
Construction Year: 1934

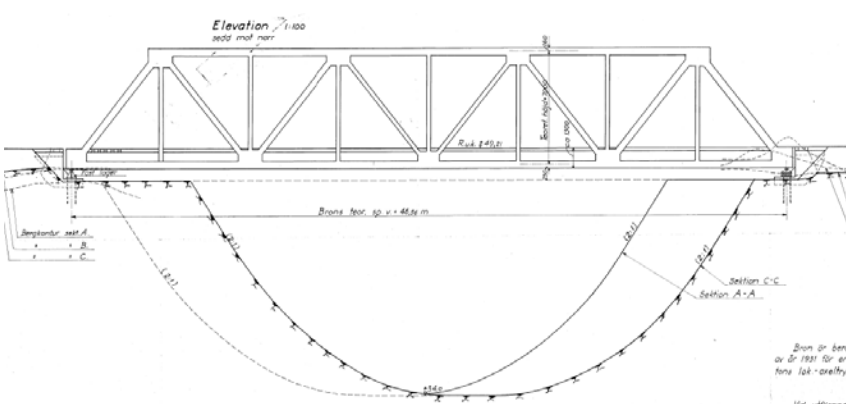


Paper II: TRR Journal
[18-352-1] Bro över Täbyån, Höjen
Construction Year: 1929



(Residual service life is not more than three years, if no action is taken CC2)

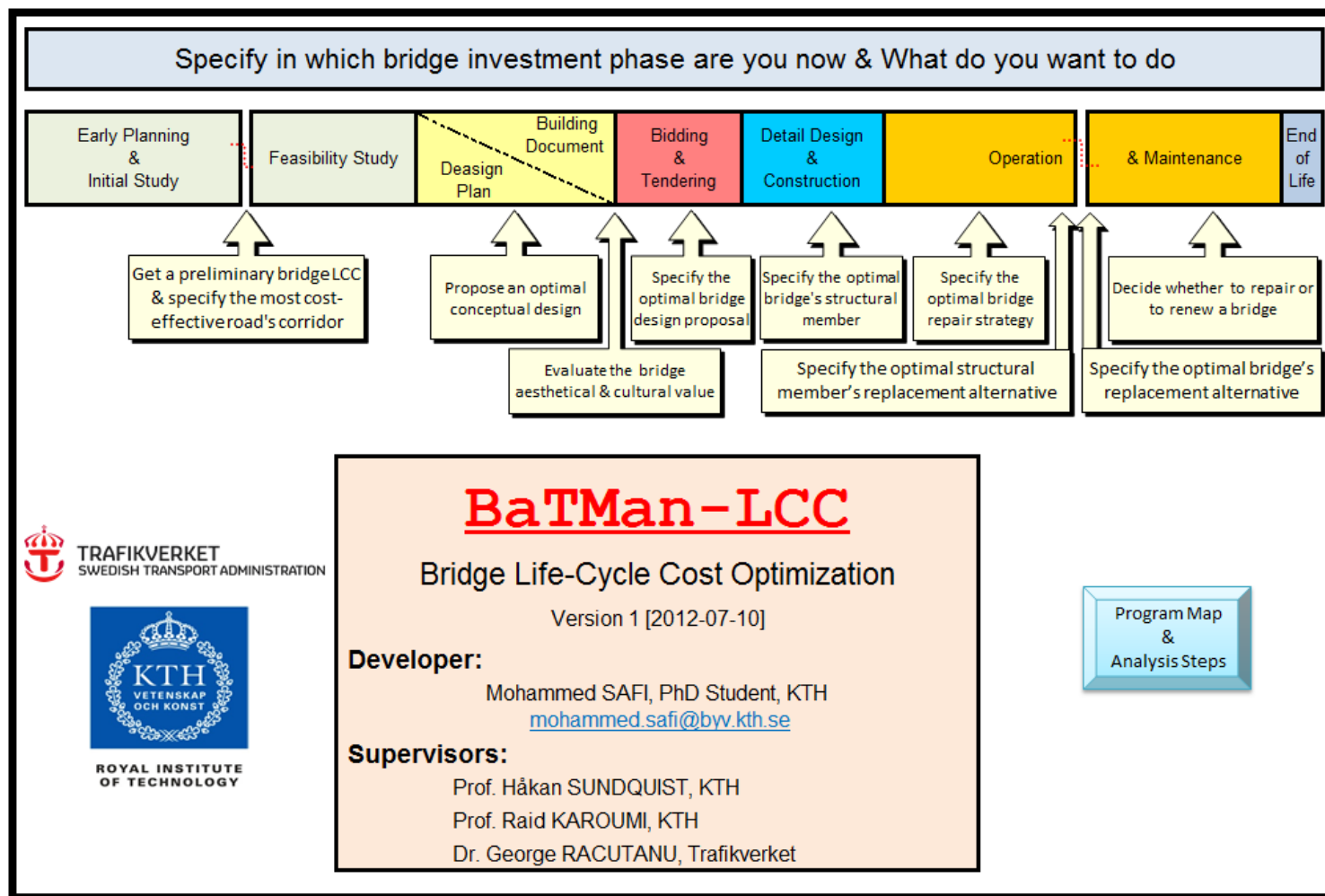
App. No. (3): Repair or Replace Järnvägsbro?

Bridge General Information	Bridge Layout
Konstruktionsnamn: Bro över Huvudnäskanalen km 29+709 Konstruktionsnummer: 3500-2593-1 Konstruktionstyp: Stål Balkbro fackverk fritt upplagd Nybyggnadsår: 1937, 67 År gammal Konstruktionslängd= 47 m Konstruktionsbredd= 5.7 m Konstruktionsyta= 268 m² Water depth at mid span: 12m Superstructure depth restrictions <1.8 m	 

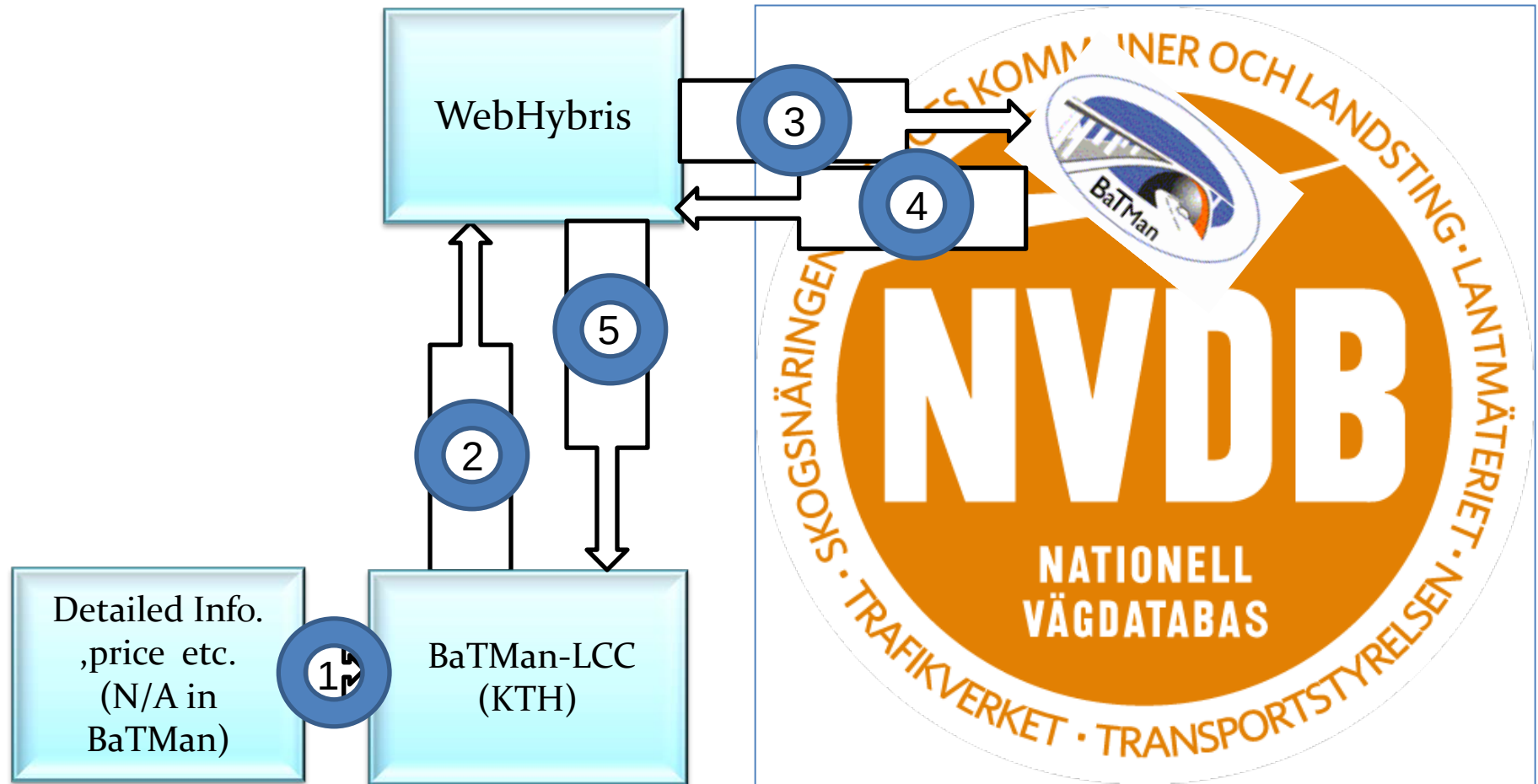
Large-Scale Feasibility

- The bridges should not be repaired and should be replaced after utilizing their residual service life.
- The analysis shows that, the opportunity loss is equal to 241 SEK/year/m²
- Trafikverket is responsible for:
 - 23,948 bridges with a total bridge area of 5,516,590 m²
 - 6,268 bridges older than 70 years, total bridge area of 619,944 m².
- Consider that 50% of the Trafikverket's old bridges might be subjected to wrong decision, This means:
 - Trafikverket can save **74.7 million SEK** each year
- This loss will stand for 20 year, this also means:
 - Trafikverket can save **1.49 billion SEK** during the coming 20 years

BaTMan-LCC Program



BaTMan-LCC relation with BaTMan



BaTMan-LCC Course



TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION

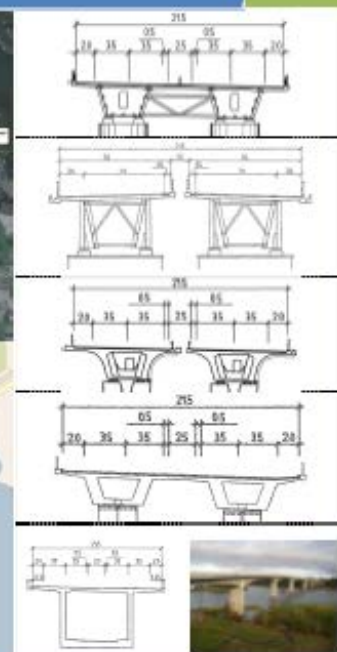
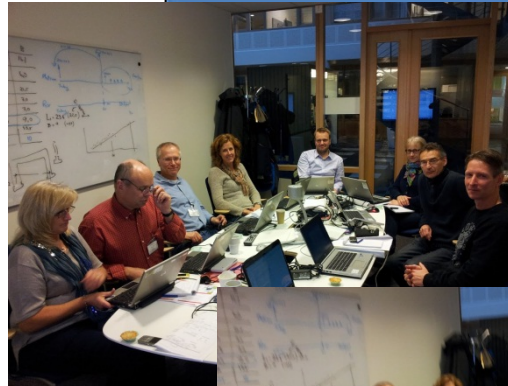


ROYAL INSTITUTE
OF TECHNOLOGY

2012

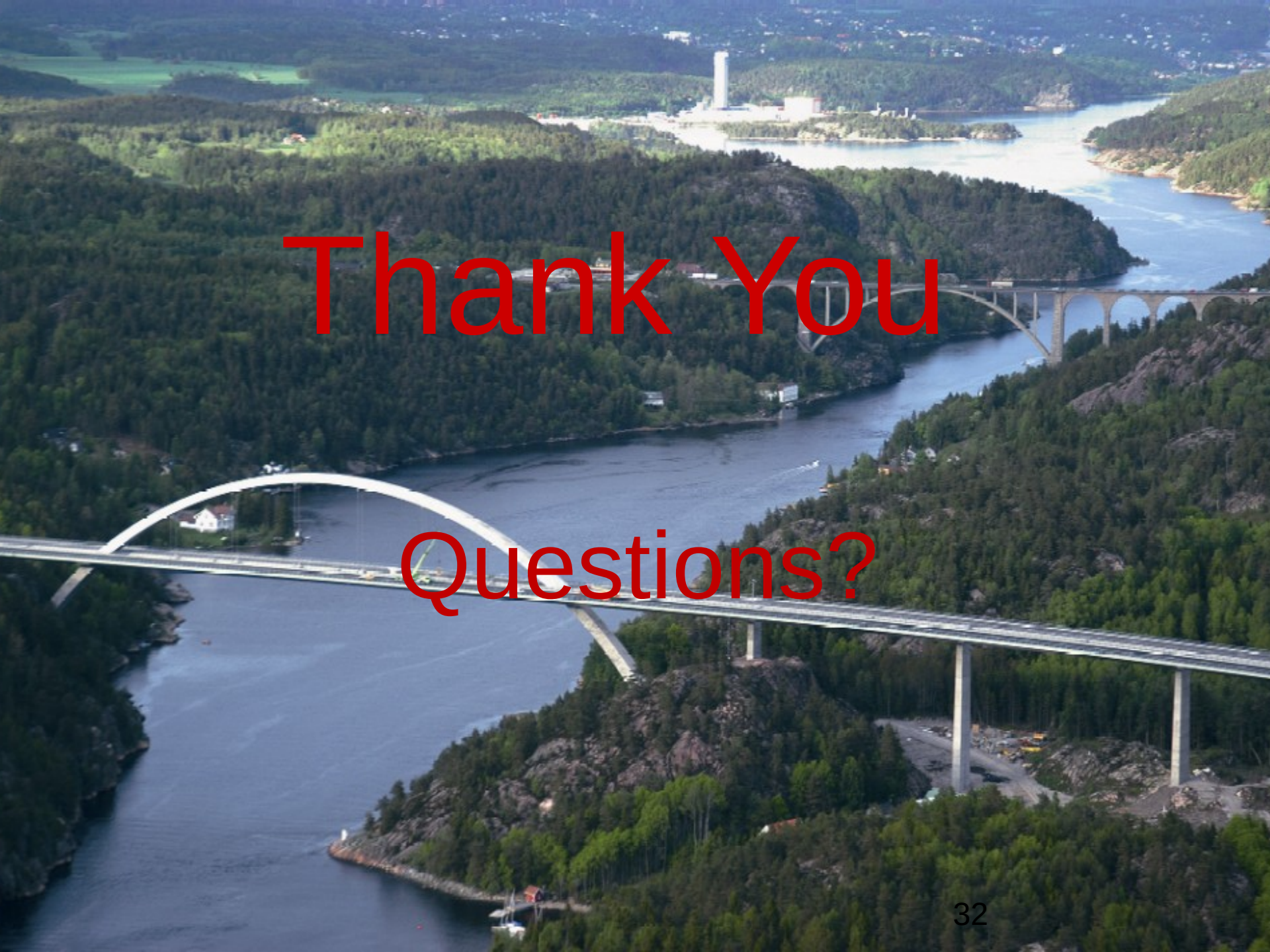
BaTMan-LCC User Manual

- **Course Coordinators:**
 - Peter Simonsson
 - Mohammed Safi
 - George Racutanu
- **7 Super-Users**
- **Course Outlines**
 - **Frist Session:**
 - November 12, 2012
 - November 13, 2012
 - November 14, 2012
 - **Second Session:**
 - December 4, 2012
 - December 5, 2012
 - December 6, 2012
 - **Summing Up day 2013**



Approach and Tool for the most life-cycle cost-effective bridge bid selection based on the concept of life-cycle 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 forests and rolling hills. In the background, a small town or industrial area is visible on a distant shore. The text "Thank You" is overlaid in large red letters across the upper portion of the image.

Thank You

Questions?