Closing Seminar
14-15 May, 2012
Malmö

NordFoU

ETSI
LCC Methodology

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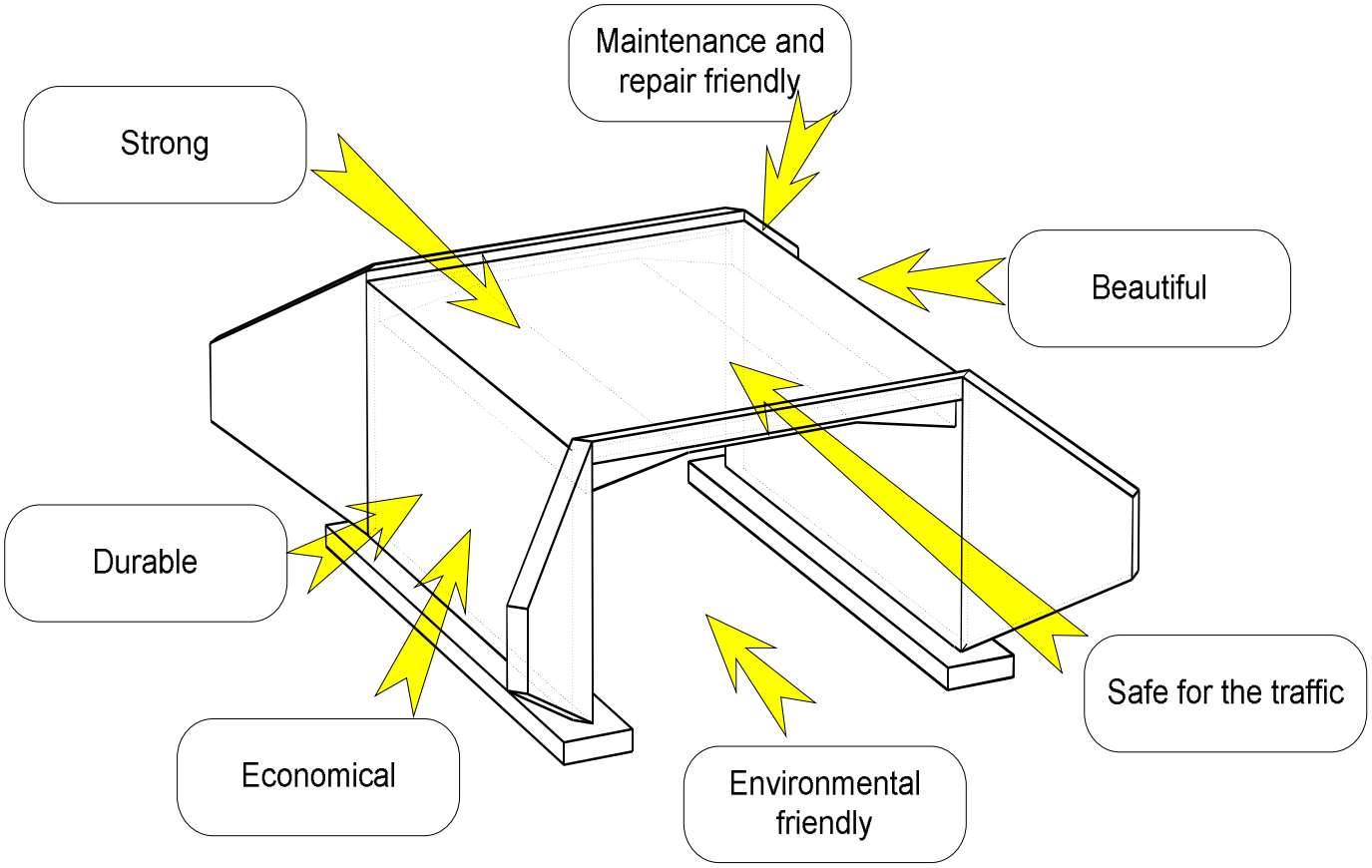
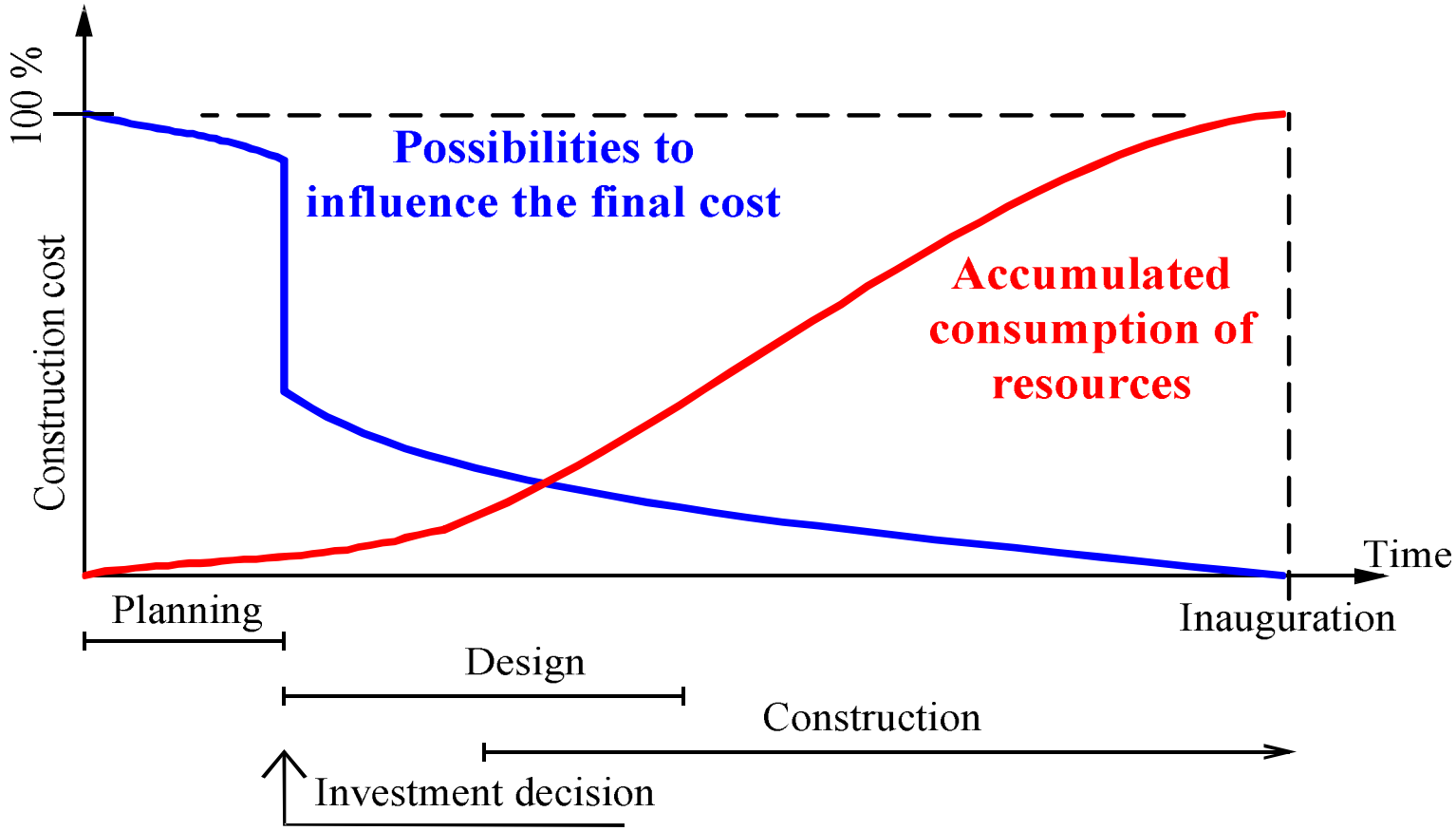
There are many requirements on a bridge

Bridge Life Cycle Optimisation



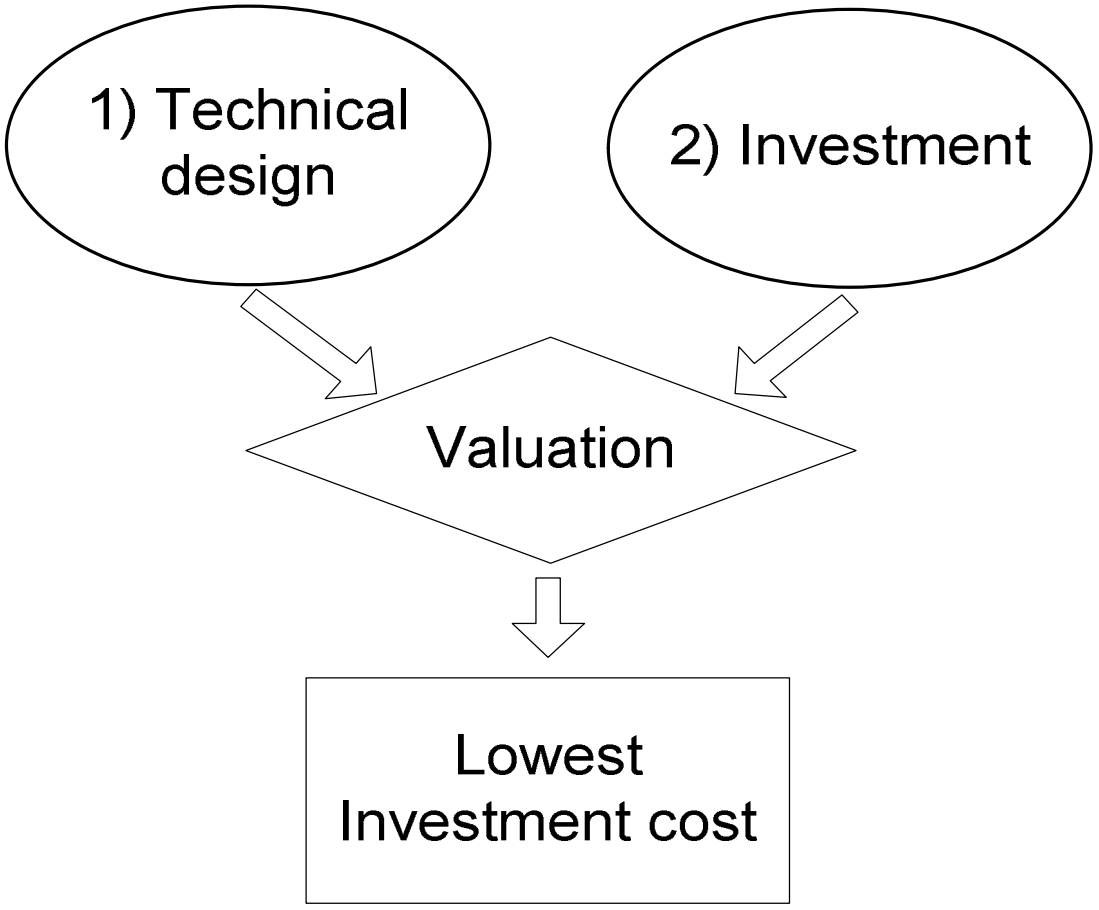
The classic task

Bridge Life Cycle Optimisation



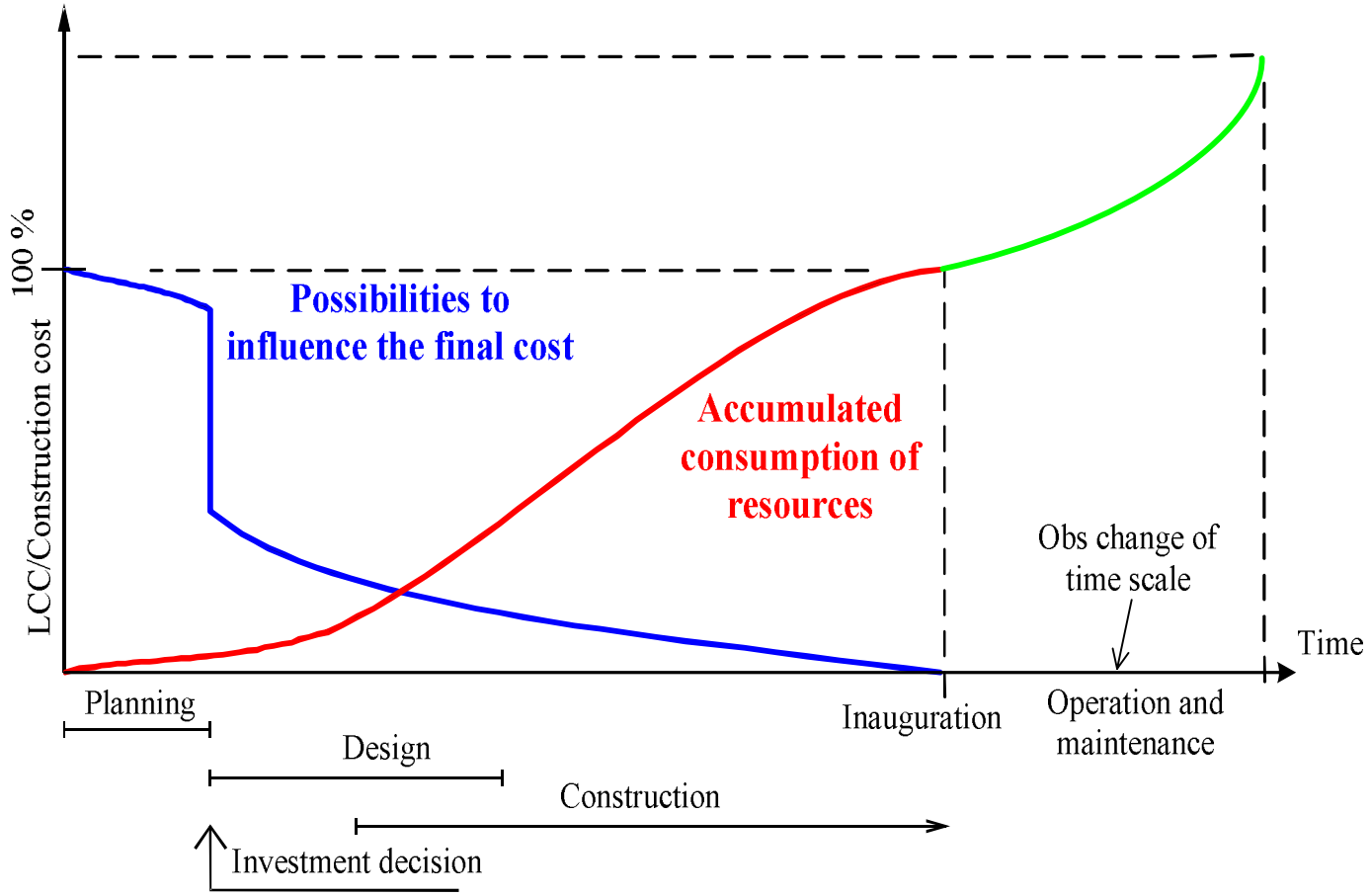
The classic bridge design task

Bridge Life Cycle Optimisation



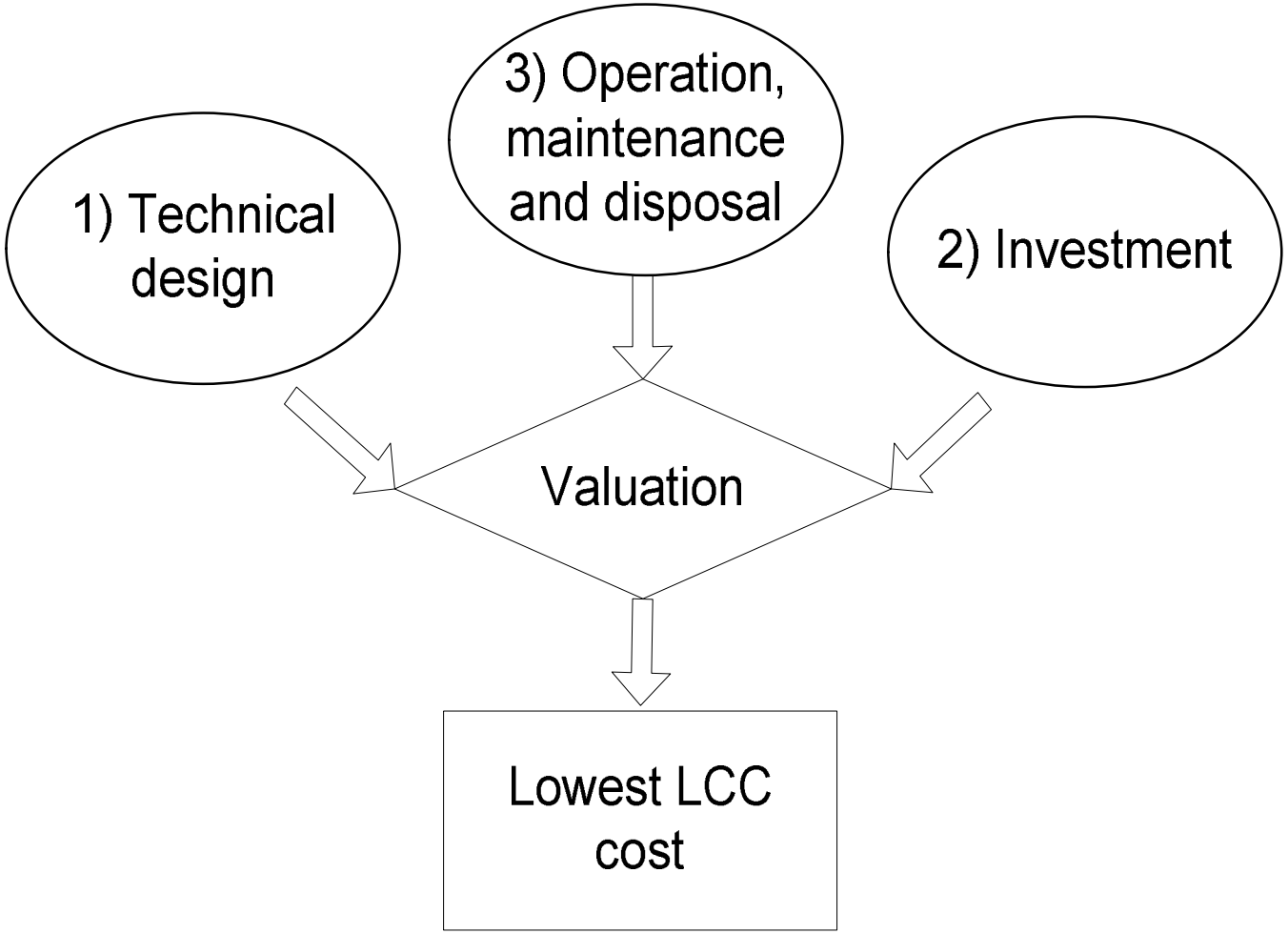
LCC optimization

Bridge Life Cycle Optimisation



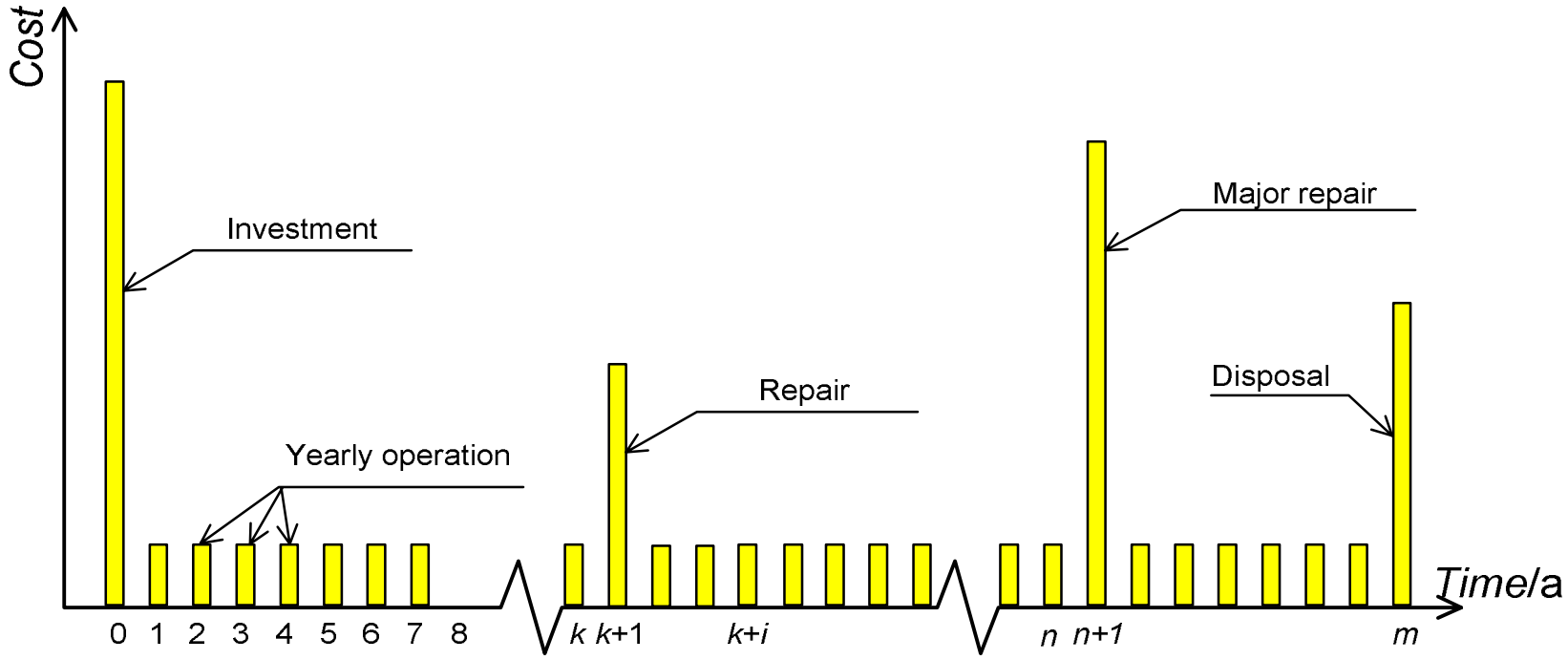
Include maintenance and operation costs

Bridge Life Cycle Optimisation



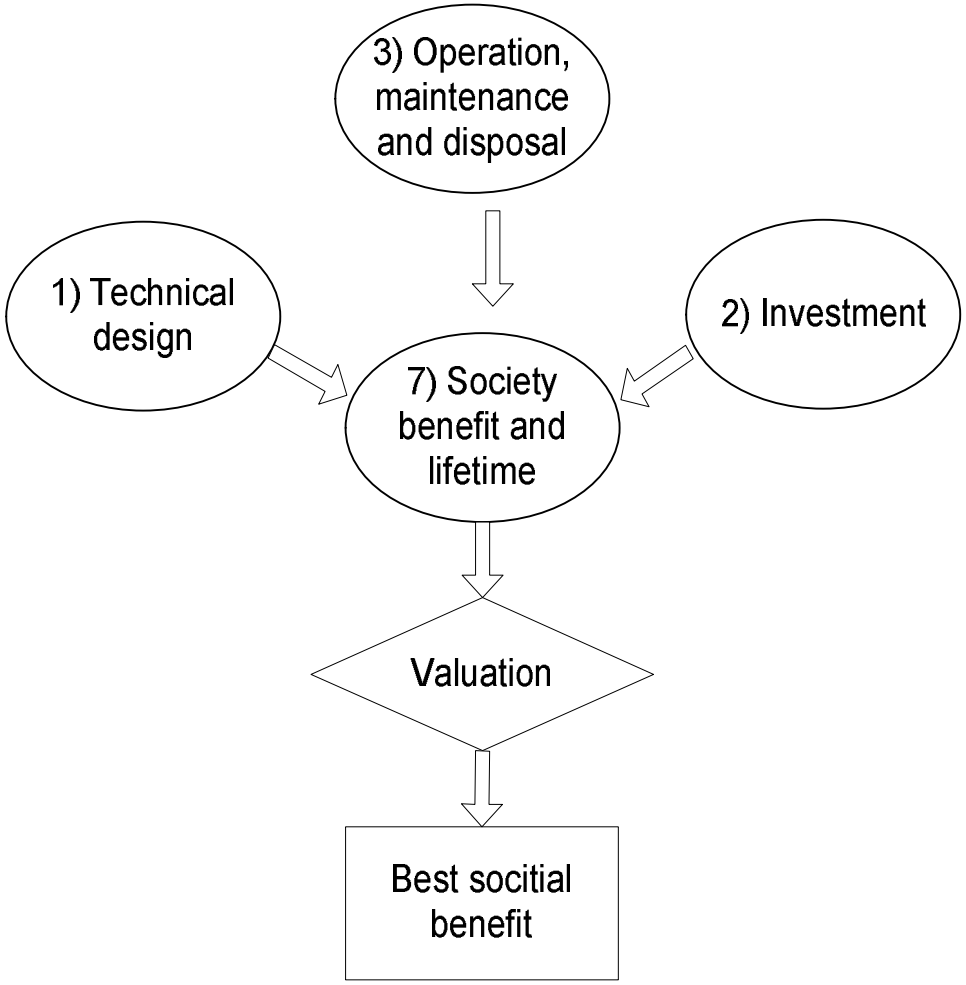
Agency or owner costs

Bridge Life Cycle Optimisation



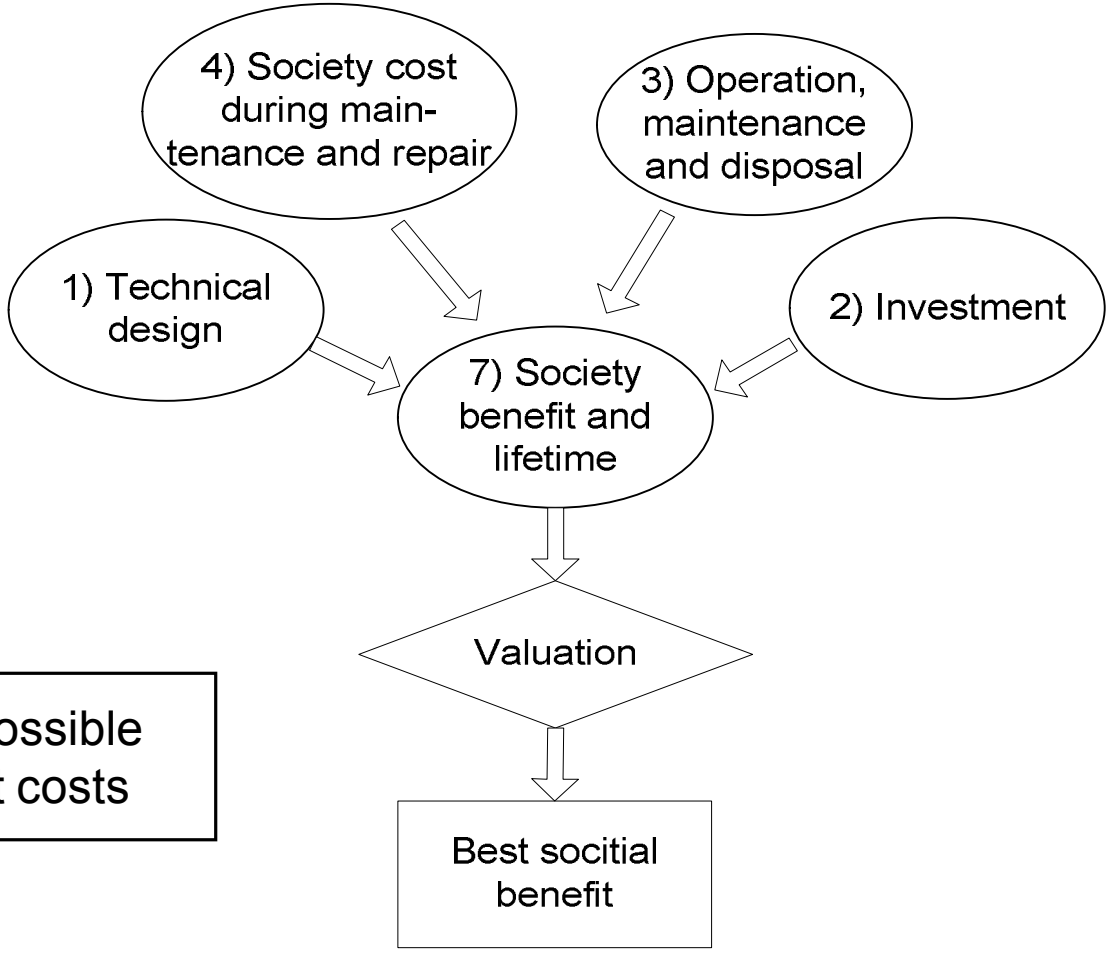
The bridge must also contribute economically to the society

Bridge Life Cycle Optimisation



Include society costs during maintenance and repair

Bridge Life Cycle Optimisation

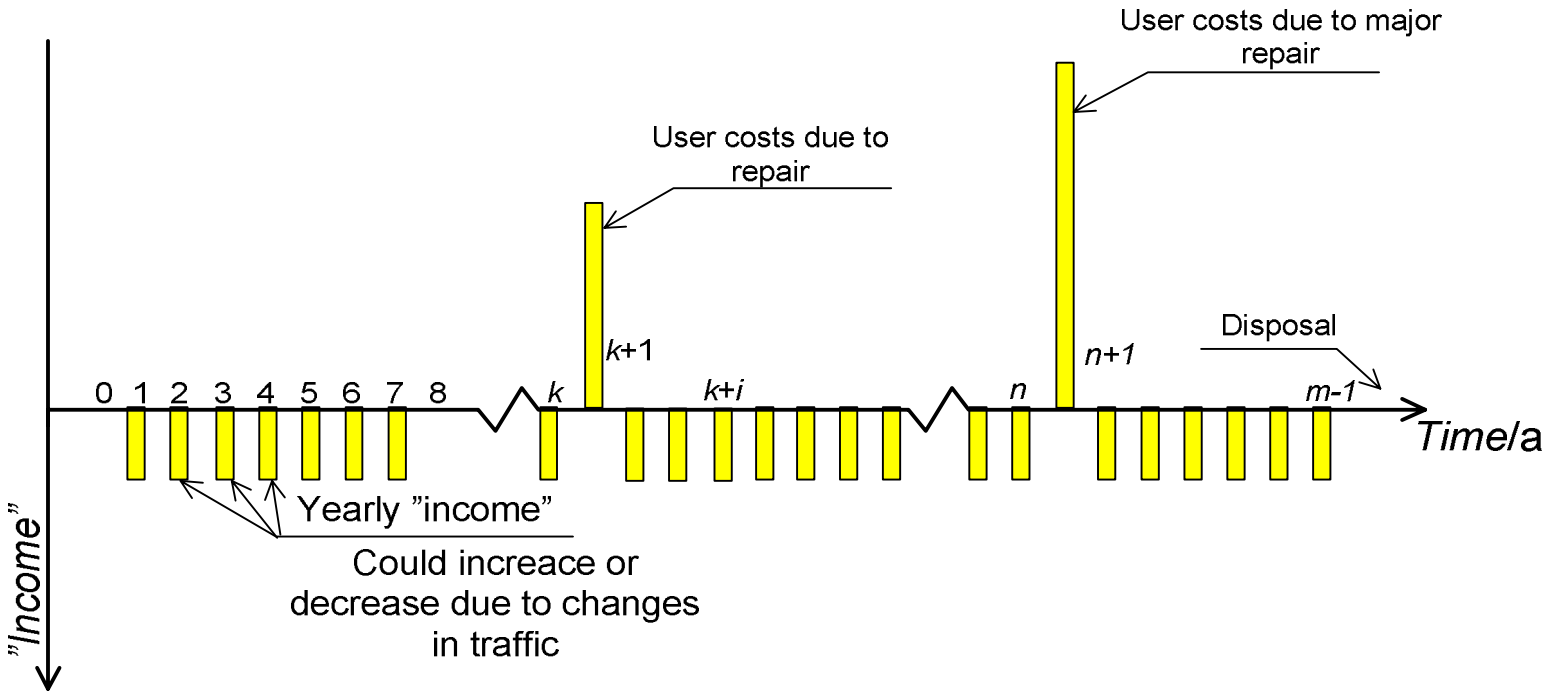


Include possible accident costs

Traffic disturbances are costly for users!

User benefit and cost

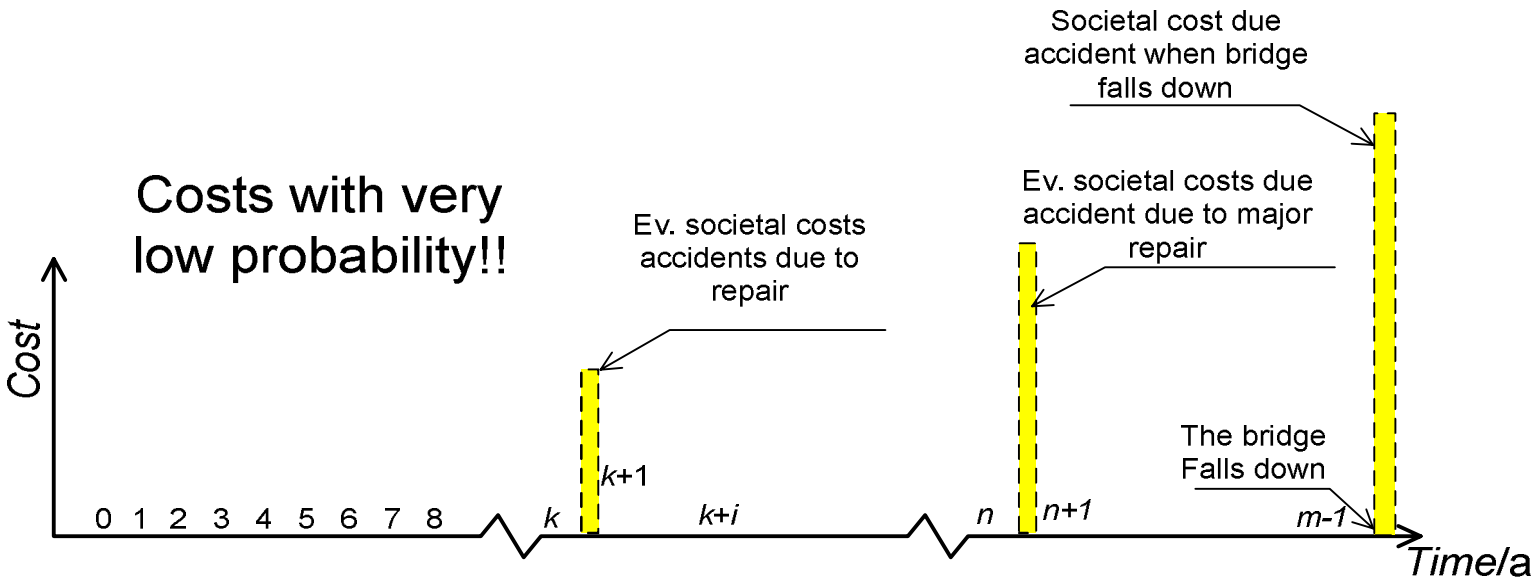
Bridge Life Cycle Optimisation



Costs for the society due to accidents and total failure

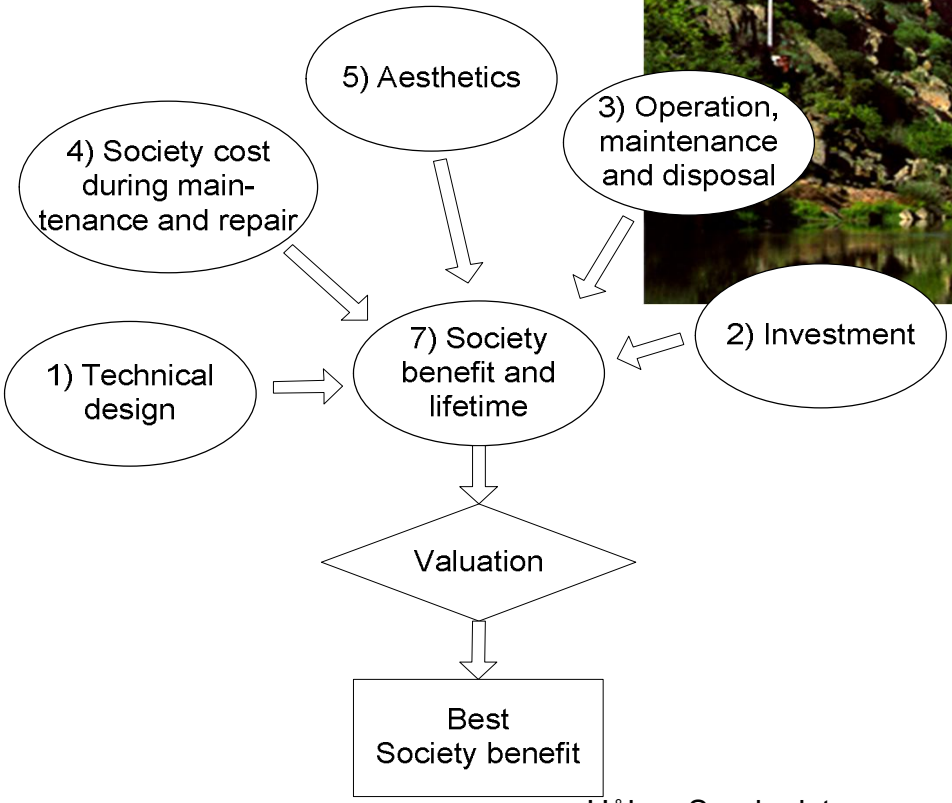
Bridge Life Cycle Optimisation

- Accidents are usually covered by the society and not by agencies like TrV or FinnRA



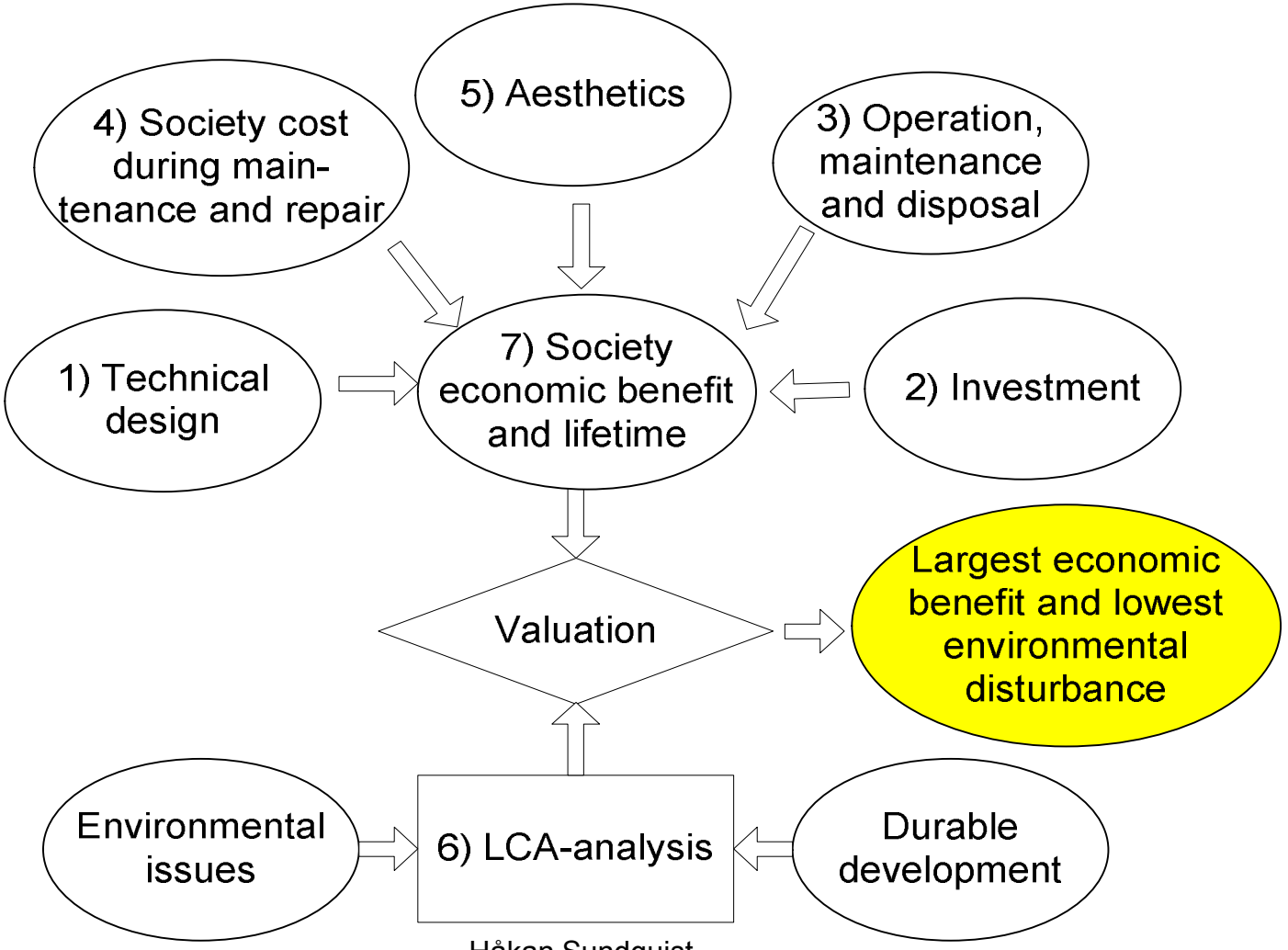
“Soft values” must also be included

Bridge Life Cycle Optimisation



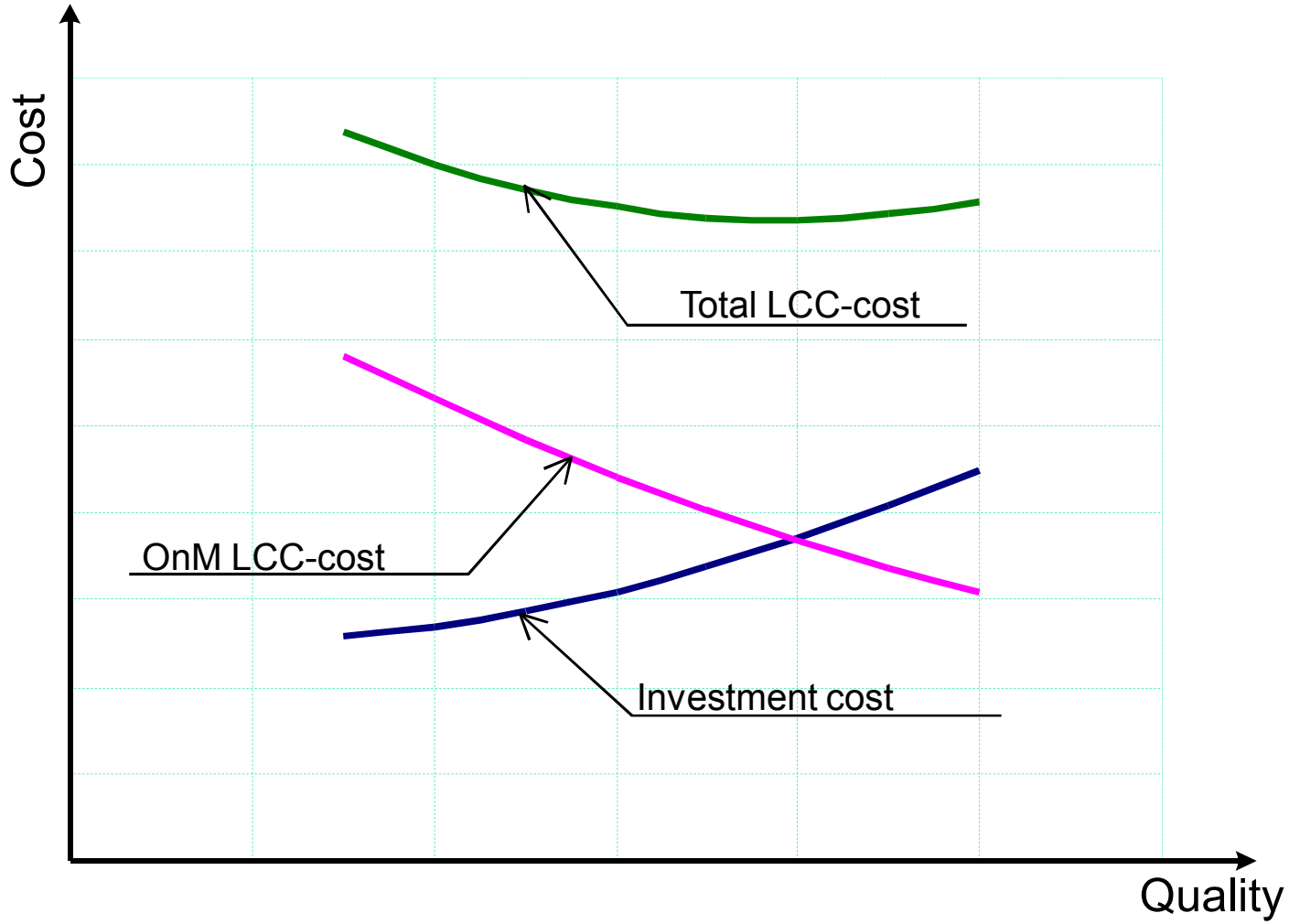
Environmental issues must also be included!

Bridge Life Cycle Optimisation



Optimising

Bridge Life Cycle Optimisation

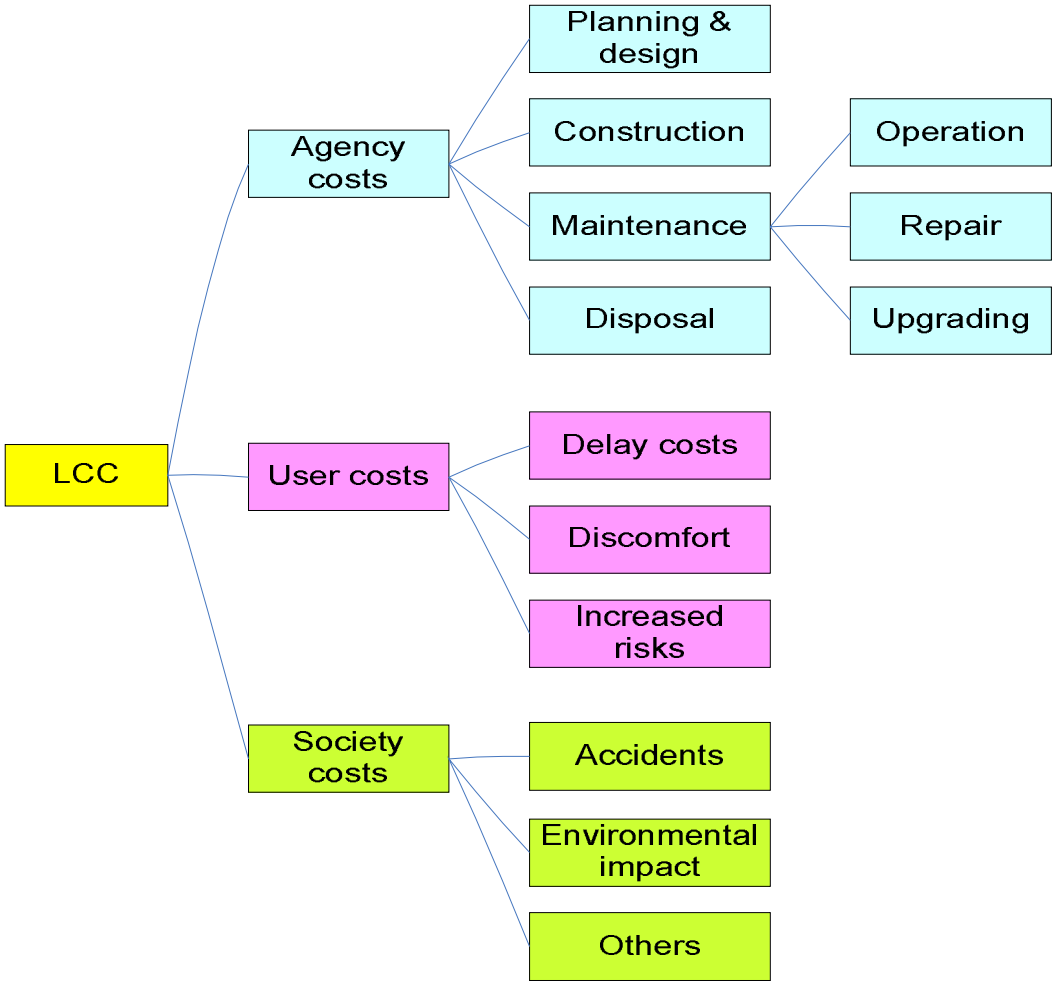


LCC

- Life Cycle Costing LCC is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors
  - initial capital costs
  - future operational and maintenance costs
    - owner costs
    - user costs
    - society costs
  - future disposal cost
- Used methodology is usually the present value of the total cost of this asset over its lifetime

LCC scheme

Bridge Life Cycle Optimisation



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Bridge Life Cycle Optimisation

LCC

Tools and formulas

The costs are recalculated to one point in time usually the day of opening the bridge or other structure

$$LCC_{\text{owner}} = \sum_{t=0}^{T} \frac{C_{\text{t}}}{(1+r)^{t}}$$

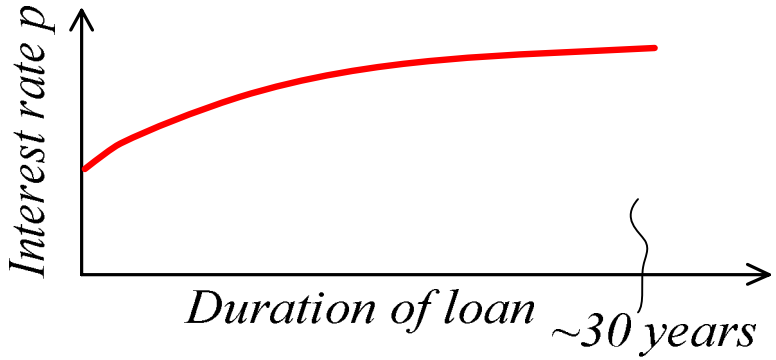
- C_t the sum of all costs incurred at time t,
- p the real interest rate or a rate taking into account changes in the benefit of the structure and
- t is the time period studied, typically for a structure for the infrastructure the expected life span.

Interest rate

$$p = \frac{p_L - p_i}{1 + p_i}$$

p_L interest rate for loans with long duration

p_i inflation

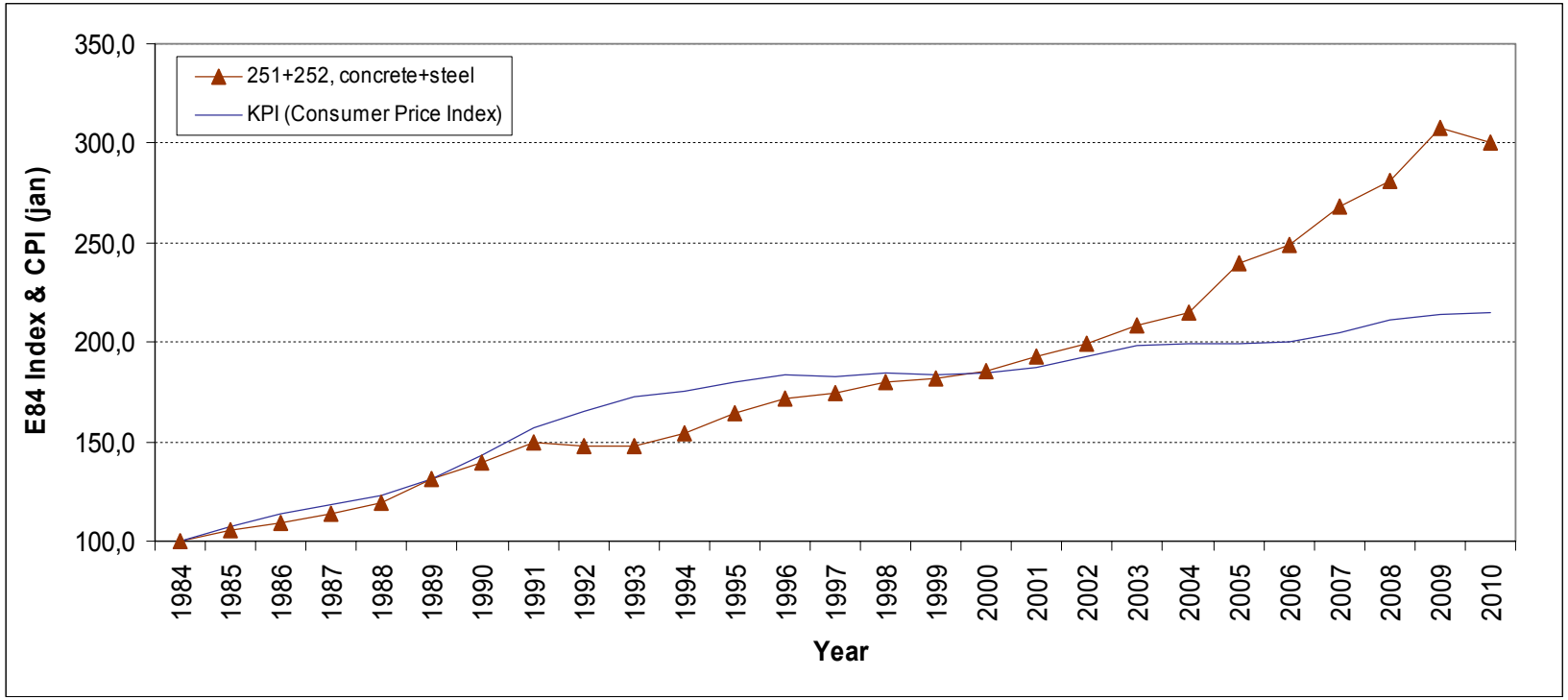


$$p = \frac{p_L - p_i - p_c}{1 + p_i}$$

p_c increase of usefulness of the bridge i.e. increase of traffic

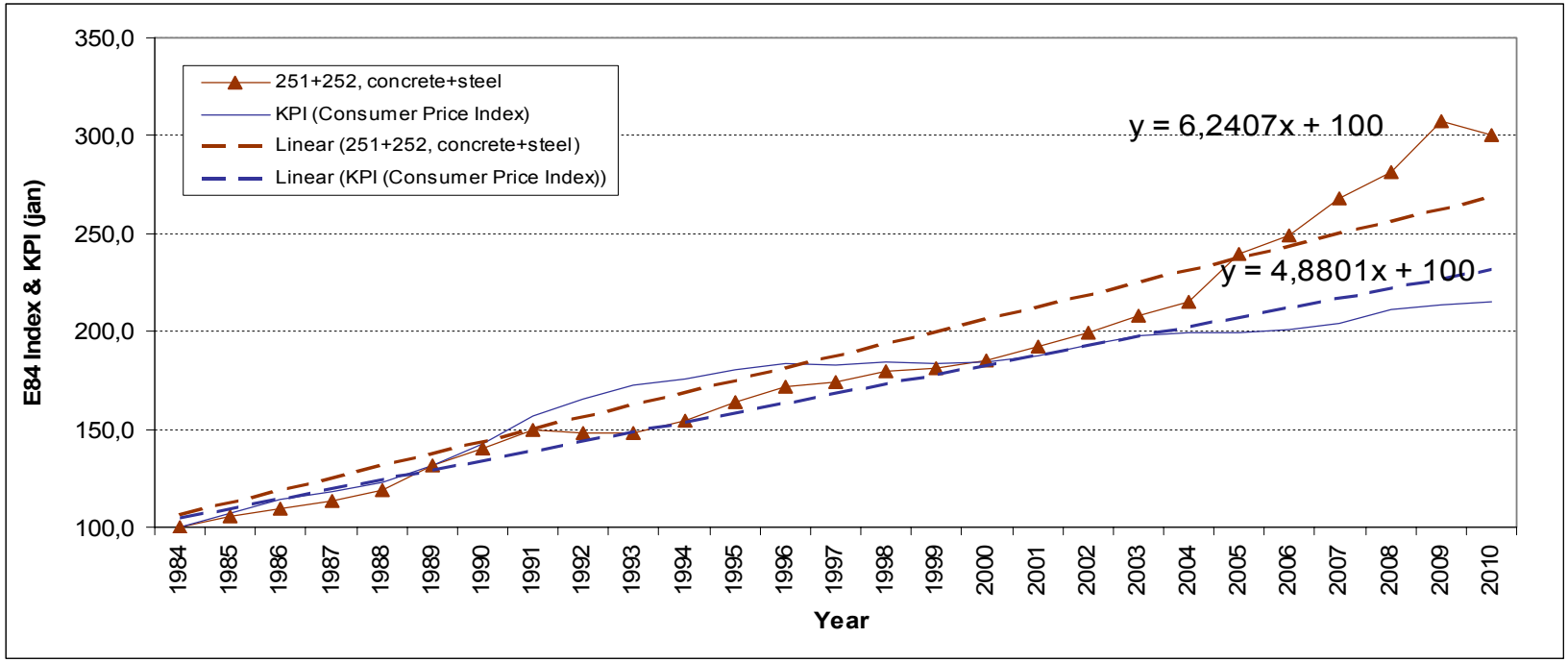
The crocodile

Bridge Life Cycle Optimisation



Trend lines

Bridge Life Cycle Optimisation



In average 6,24 %– 4,88 % = 1,36 %, but say 1 %

The most complicated factor in a LCC analysis

- Degradation rate and thus:
  - Time between inspections
  - Time between regular maintenance
  - Time between remedial actions
    - Repair
    - Strengthening
    - Upgrading
    - …

Methods for judging time between MR&R actions

Bridge Life Cycle Optimisation

1. Mechanistic or chemical models
2. Evaluation results from large field observations,
3. The up to day most applied method is to use experience from specialists, usually people deeply involved with inspection of bridges

Development of a computer program for LCC

Bridge Life Cycle Optimisation

- Based on the general formulas for calculating LCC
- Cost for inspections are from a database for cost
- Cost from repair actions is from a database on costs for all types of repair
- Time between repairs are chosen by the program user, but default values are from experience
- Both stand alone programs and Web-based programs have been developed and are now being refined and updated!
- A lecture will be given to-morrow

Methods for evaluation of degradation

- Evaluation using mechanistic methods
  - diffusion models for chlorides
  - carbonation rates
  - number of frost cycles
  - ...
- Regression and statistical methods based on inspections and classification of damages

Why we prefer statistical methods before mechanistic models for evaluation of degradation rates

Bridge Life Cycle Optimisation

- The mechanistic models like Fick´s law, carbonation rates, number of frost cycles must be based on a very good knowledge of materials, climate, construction and more
- There is an important coupling between the different degradation mechanisms not yet known
- The “domino”-effect. Degradation of one component leads to degradation of other components

Program description and use

Will be discussed in my lecture at session 3