Lean Construction Institute

Provider Number H561

Lean Design Forum P2SL/AIA/LCI 2016 Day One

P2SLDF20161

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

One day instruction and discussion devoted to Lean design in a variety of areas including cost estimates, conceptual estimating, project management, and problem solving. In-depth discussion and sharing of experiences will spotlight phases of the Lean journey. Increasing accuracy of conceptual estimates will be explained. Architects from different areas of practice will explain, and lead analysis of, how experience with Lean project management has changed the way they design. As a follow-up to the 2015 P2SL/AIA/LCI Design Forum presentations on problem framing, case studies of "wicked problems" will be shared and discussed.

Learning Objectives

1. At the end of this presentation, participants will be able to analyze the inaccuracy of conceptual estimates and learn steps they can take to make early assessments of a project's economic feasibility more accurate.
2. At the end of this presentations, participants will understand a process for aligning what customers want with their ability to pay, and a process for steering to cost targets in design and construction, in order to achieve the highest level of accuracy in cost estimates.
3. At the end of this presentation, participants will understand how to use framing to define "wicked problems" and recognize how to solve them.
4. At the end of this presentation, participants will be able to utilize Lean practices to improve the design process in varied areas of practice.

Haahtela

Yrjänä Haahtela

Professor,
Head of Haahtela Group

Ari Pennanen

Adjunct Professor,
Head of Research

Janne Ojala

Lead software
developer

Haahtela Group

RESEARCH & DEVELOPMENT

SOFTWARE

PROJECT MANAGEMENT


They are going to build a 30 million building here…


I wonder what the costs will actually be…

The client knows the activities and the performance.

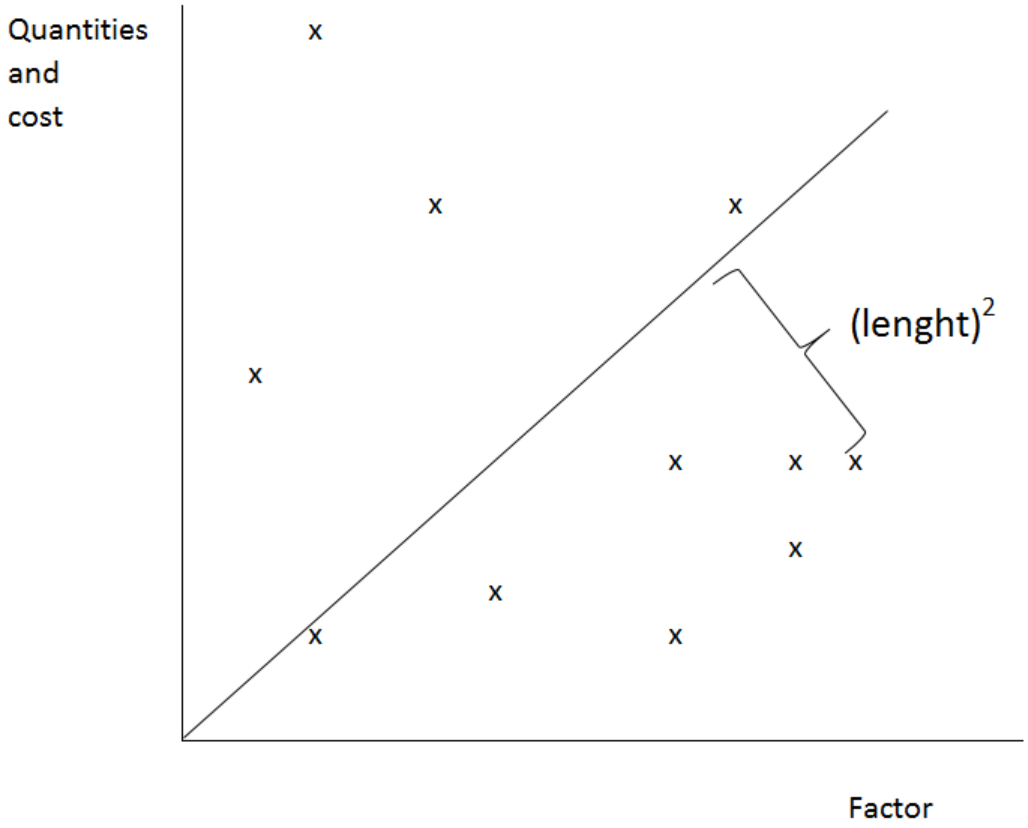
The client doesn’t know the extent of the building or the costs per squaremeter.

You can’t define the relation between activities and square-meters due to reference buildings as all buildings are unique.

You can't define the relation between costs per squaremeter due to statistics as all existing buildings have different activities, design solutions and they are constructed in different conditions.

Statistical average price

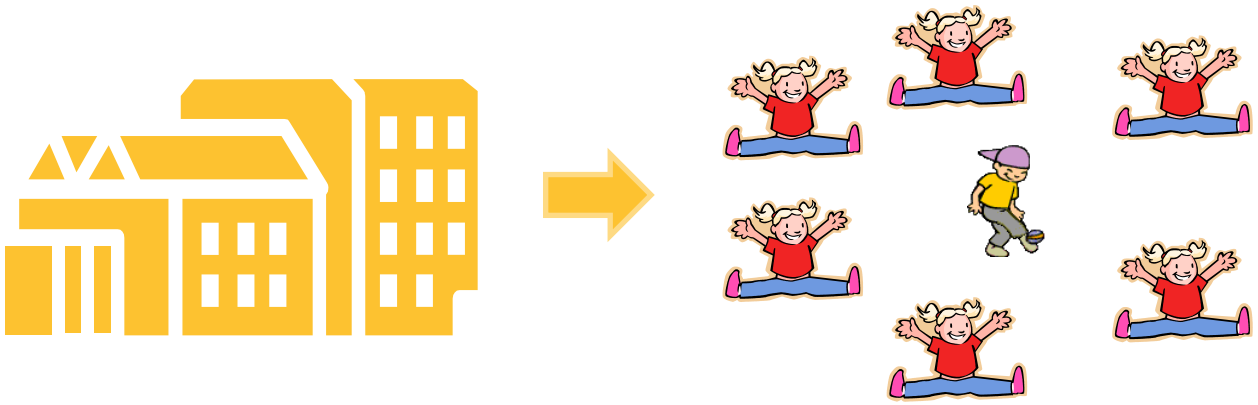
Office	3,500	€/m2	High quality, difficult site conditions
	2,500	€/m2	Small, difficult
	2,100	€/m2	”Standard”
	1,500	€/m2	Including car parking
School	3,300	€/m2	High requirements
	2,500	€/m2	To be piled
	2,300	€/m2	”Standard”
	1,800	€/m2	In low cost area, easy design solution
Appartment	5,800	€/m2	Top quality, arhitectural dream, incl. the lot in best place in the
	4,500	€/m2	town
	2,800	€/m2	Top quality, arhitectural dream
	1,950	€/m2	High quality, lots of details
	1,700	€/m2	”Standard”
			Lowest possible



Regression analysis

Statistical methods

”The more windows in the school, the more girls in school”

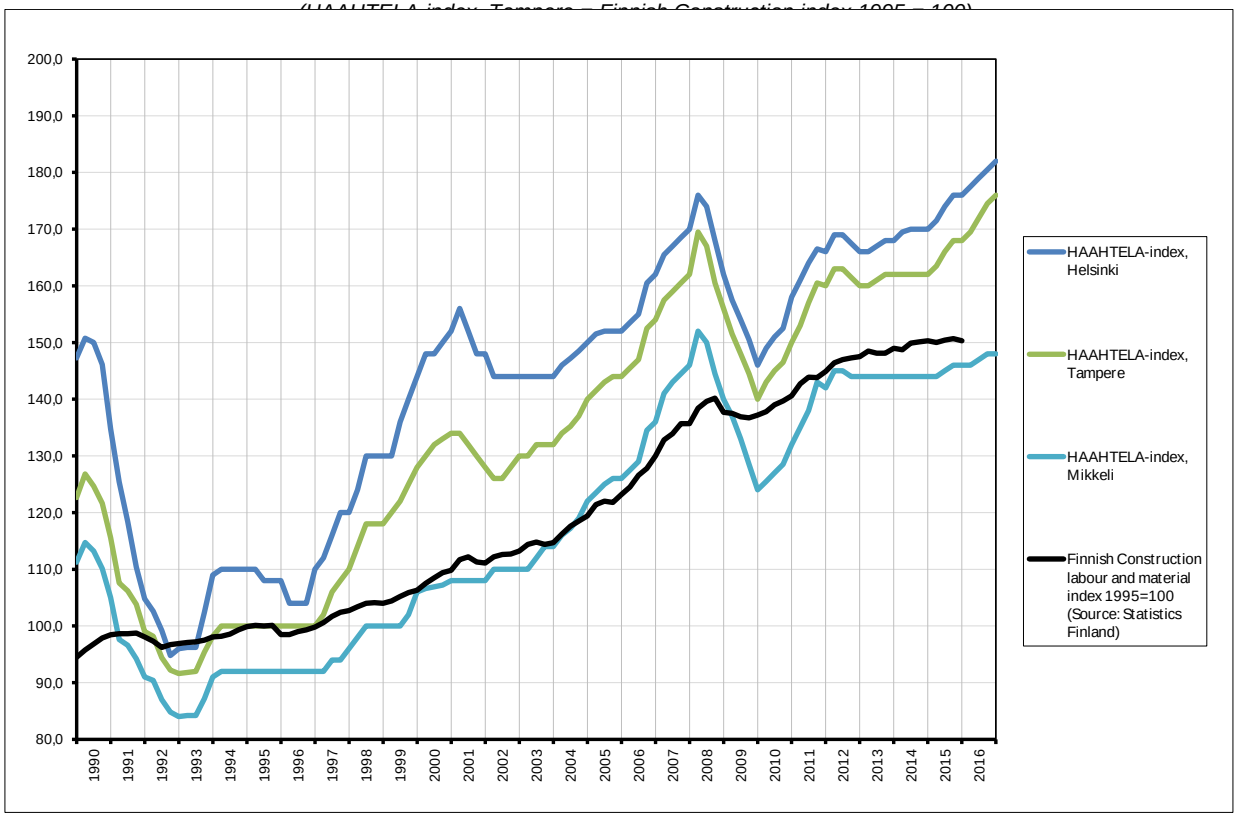


You have to customize the target towards for example:

- City plan
- Conditions
- Market

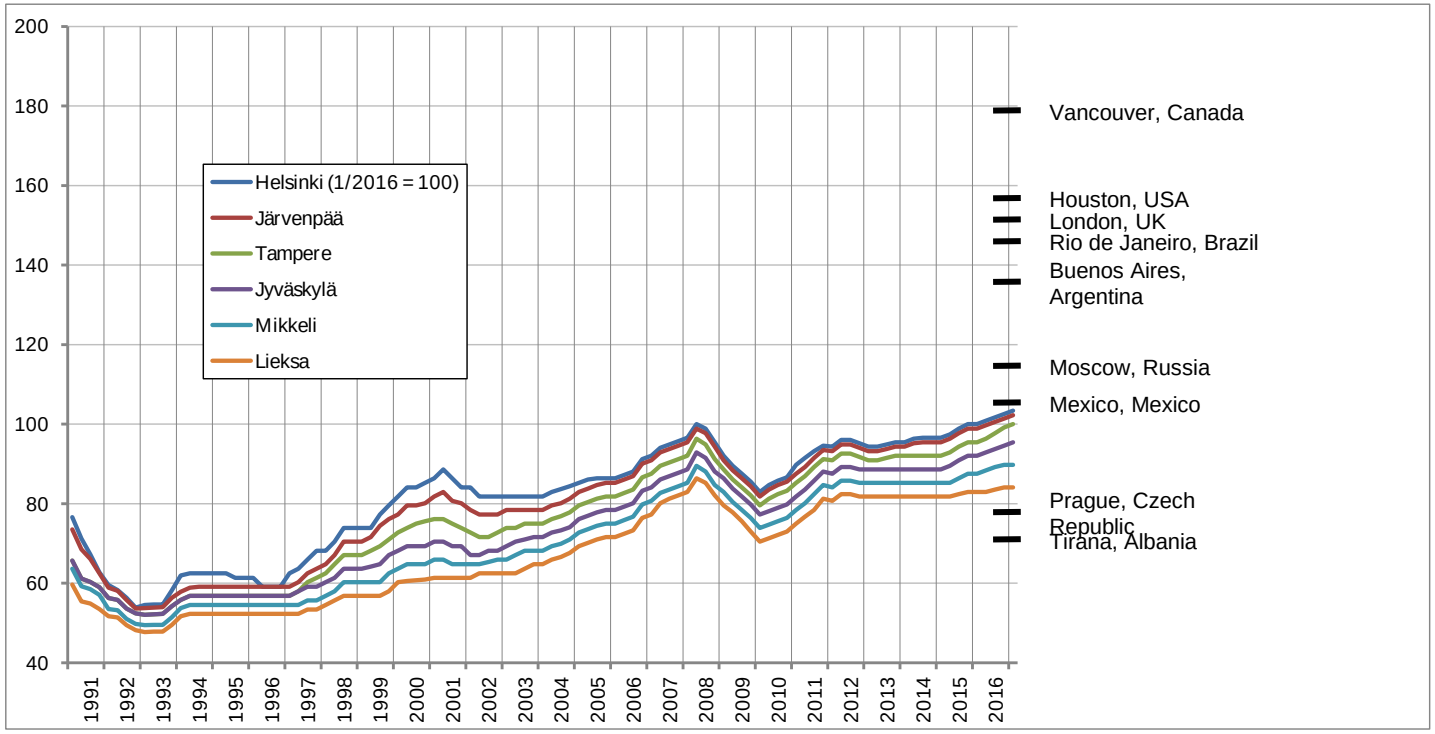
HAAHTELA-INDEX vs. FINNISH CONSTRUCTION LABOUR AND MATERIAL INDEX

(HAAHTELA-index, Tampere = Finnish Construction index 1995 = 100)



Haahtela

HAAHTELA-index



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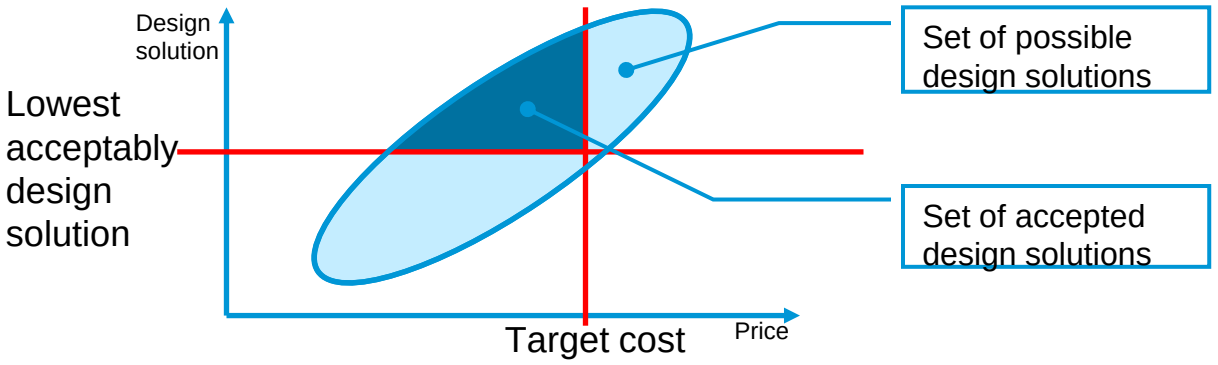
Price and design solution



- Set the target
- Supervise and measure it’s execution
- Plan, don’t let arise

Haahtela


They are going to build a 39 million building here

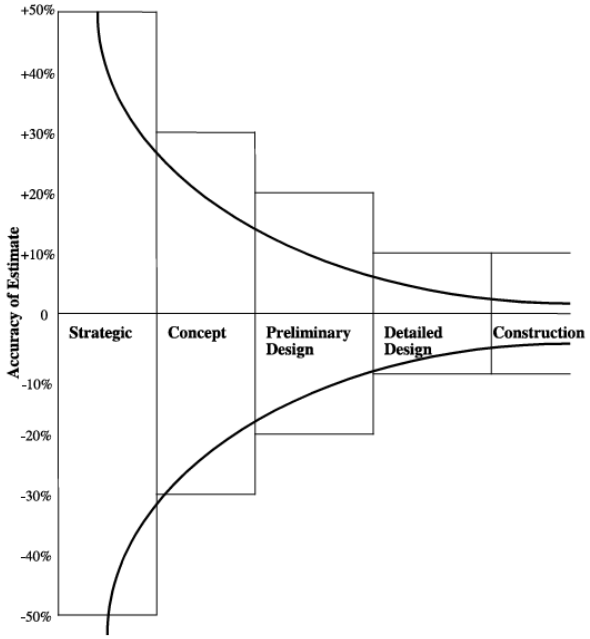
Increasing Accuracy of Conceptual Estimates

Conceptual estimating

(Ballard, Pennanen, International Group of Lean Construction, annual Conference of Lean Construction, Brasil 2013)

The Literature on cost:

- At stage prior design, almost nothing is likely to be known about the building except its general size, and therefore it is pointless to go into detail about cost before any designing has been done. The accuracy is +- 30 %.



A Construction Project Tends To Fail

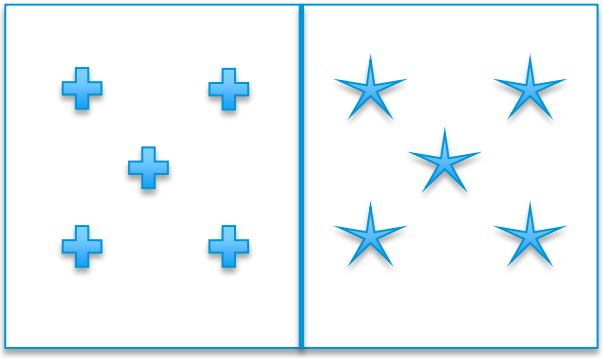
. It (the project) is not evil, the problem in in our mind

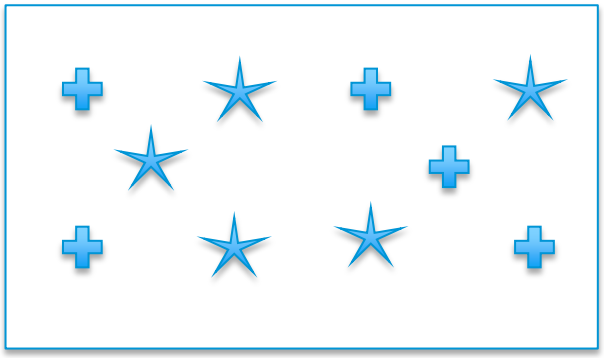
Why coffee turns to brown as you pour milk in the cup?

5! X 5! = 14 400 10! = 3 628 800

In random world all choices are as equally possible. “Order” our illusion.

Right lotto-numbers are considered to be rare. However, the numbers can be defined every week without difficulties.





A Succeeded Project. “Order in our mind”

- the customer (owners, users) know what they want
- the customer is satisfied with the investment and running costs budget
- the customer do not change his/her mind
- there is no wooden remnants between old double-deck-slab causing mold toxin emissions
- designers design within budget, of course
- the customer is satisfied with the design, of course
- we get the building permit on time (no public officers on sick leave)
- structural designer deliver the steel-beam-designs before the date of procurement, as agreed a month ago
- the beams are delivered to the site on Monday at 9.00 two months after.
- the beam-lifter-contractor is ready in the site on the same time, as agreed
- design has been done so well that the contractor has no reason to set claims
- the moisture of the floor concrete is low enough when linoleum floor coverings should be laid
- all the users are very happy with all the spaces
- the final costs are within the budget, naturally

Conceptual estimating

However, Estimates Prior Design (conceptual estimates) accuracy are proved to be within a standard deviation of +- 5%
(Ballard, Pennanen, International Group of Lean Construction, annual Conference of Lean Construction, Brasil 2013)

Accuracy in some degree is a misleading conceptualization. This Presentation aims to increase understanding on:

- Decision making in a project
- Steering the Customer and Commitment Making to create a Target Cost
- Steering Design to the Target Cost
- Leadership

and

- DATA QUALITY

that is a new concept for me but promising

DATA QUALITY

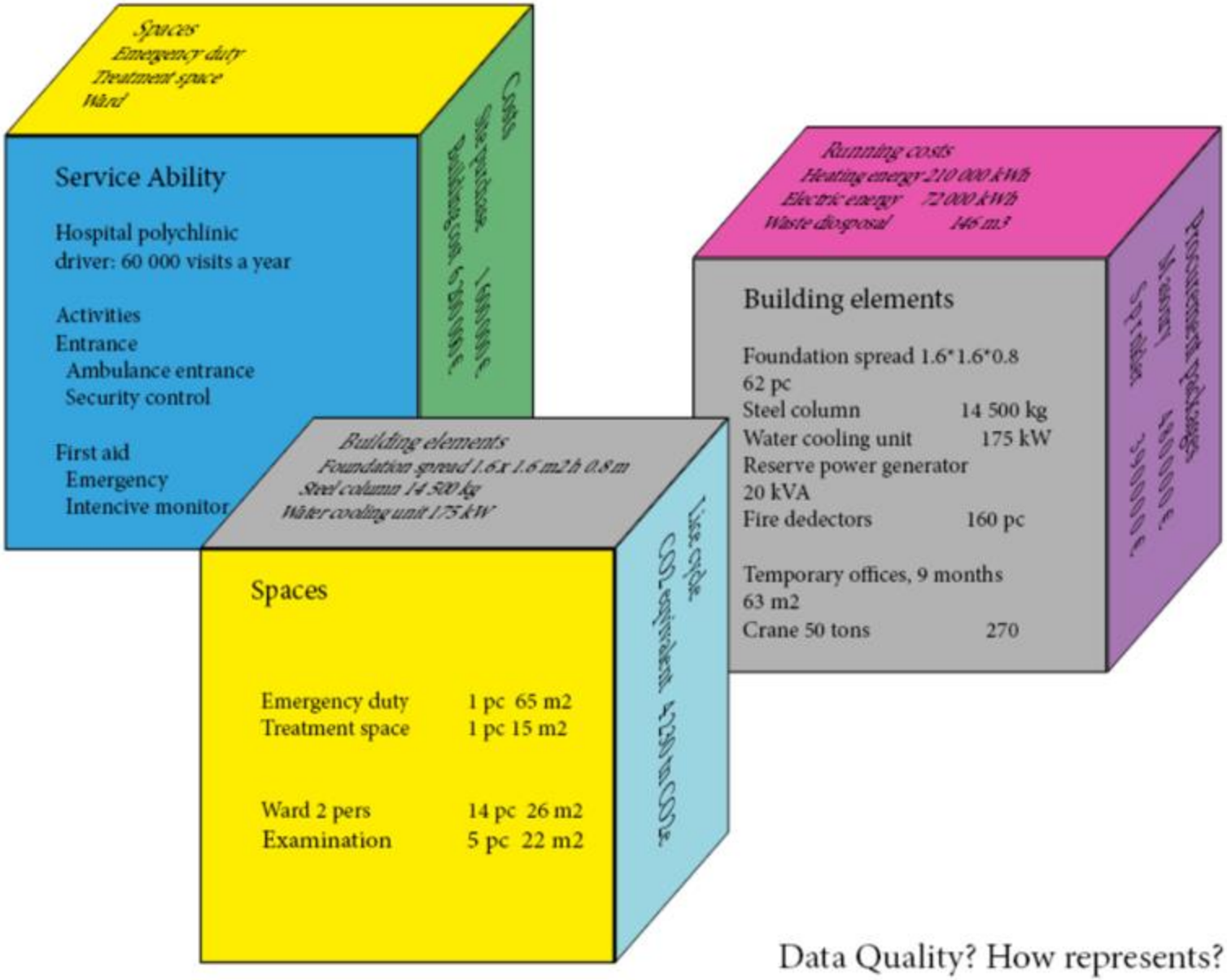
(e.g. Redman, T.C. 2008)

Semiotics, what kind of language.

- Data fits for its intended use in decision making
- Data represents correctly real world entities
- Data is complete
- Data is accurate

Building systems do not represent well the building for the user (partitions, cooling beams…)

User is interested what is between the systems; the space and performance (possibility to have meetings, warmth, height, light, fresh air…)

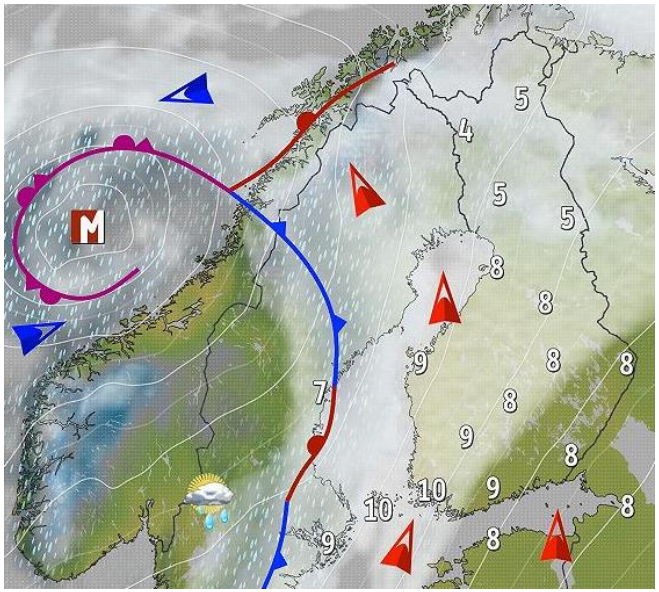


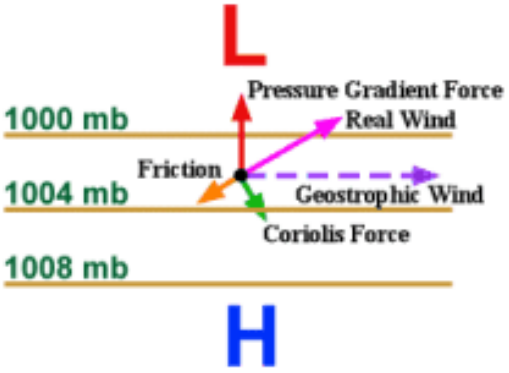
Data Quality? How represents? Accurant? Complete?

Deductive complexity

A correct answer to a problem exists. 2+2=4

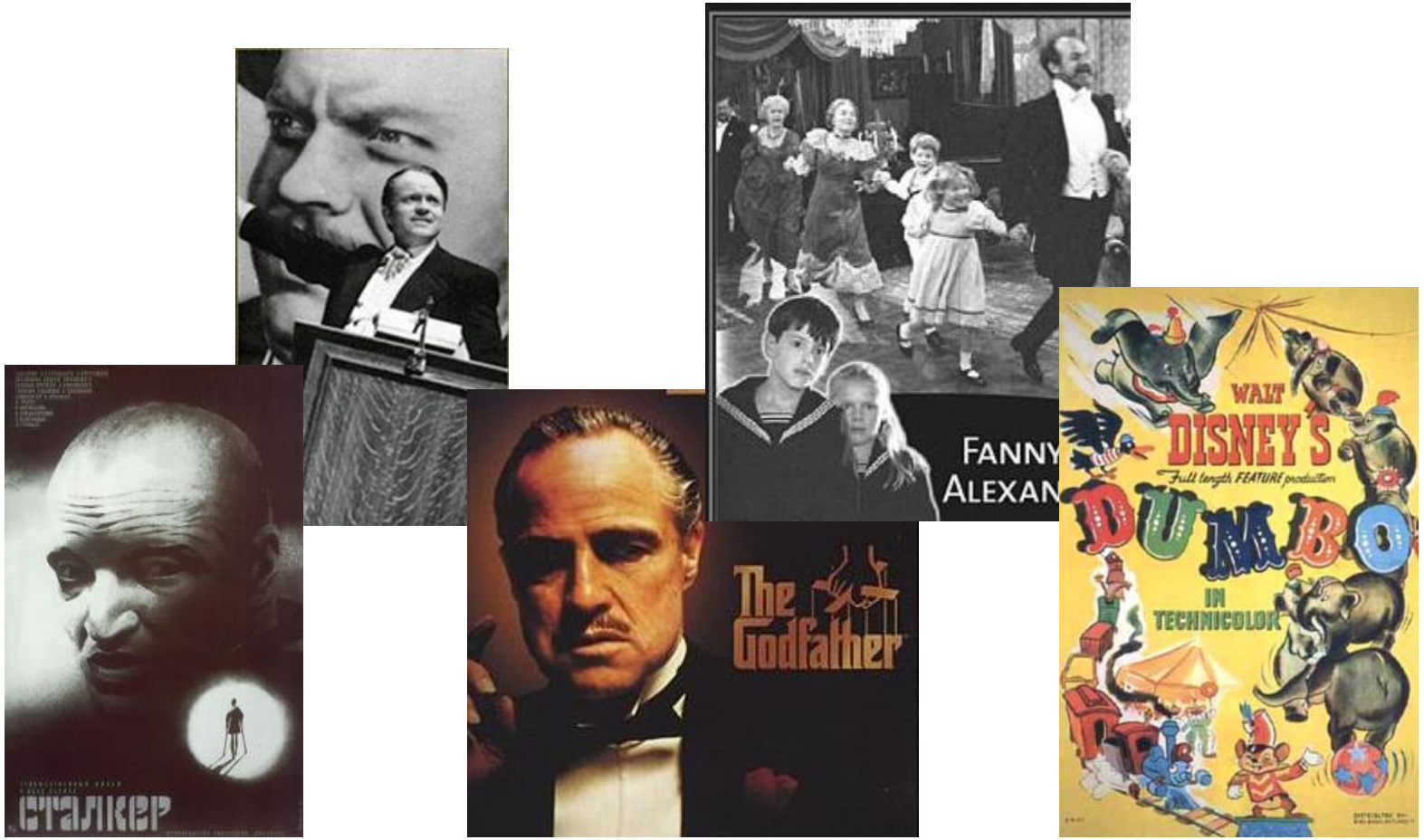
Problem might be complex in the meaning that it requires information that is hard to obtain





Inductive complexity

Best movie ever?



Social systems are complex
- “Inductive systems”, “Wicked problems”

Solutions to complex problems are not right or wrong…

…but good or poor

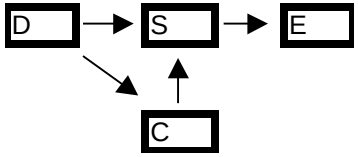
“Should we refurbishment the schools or should we repair the roads?”

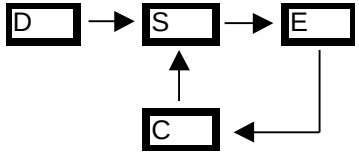
Making “good” is commitment making!

Managing complex systems

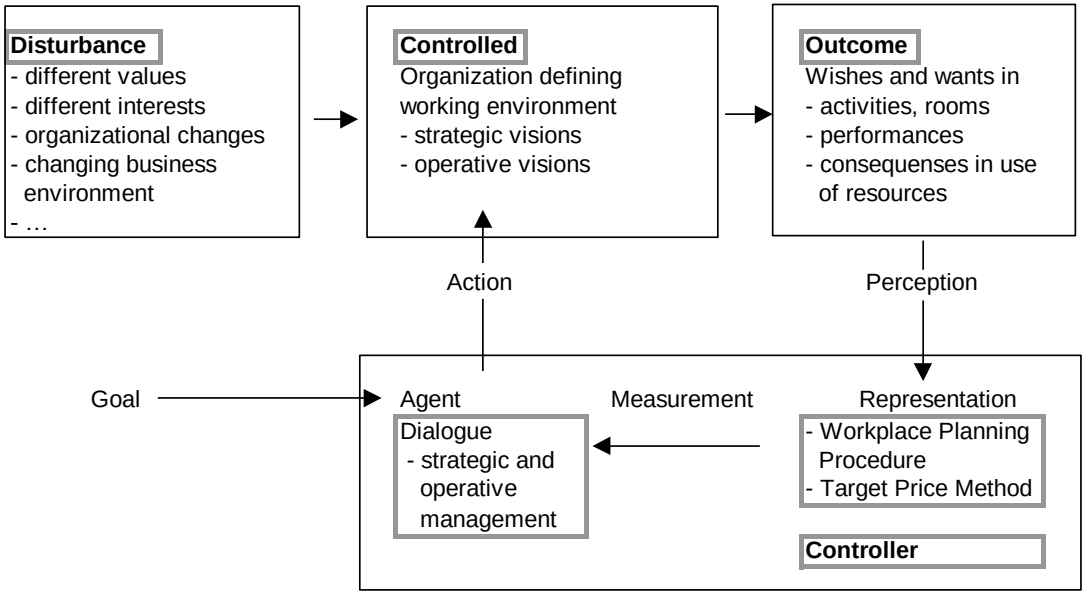
Perfect control versus Closed loop control

(Ashby 1956, an introduction to cybernetics)





A closed loop control is needed if the affect of disturbance to the system can not be predicted. “Thermostat control”



Managing complex systems

Target setting

Measurements

Feedback giving

Target value design

VALUE

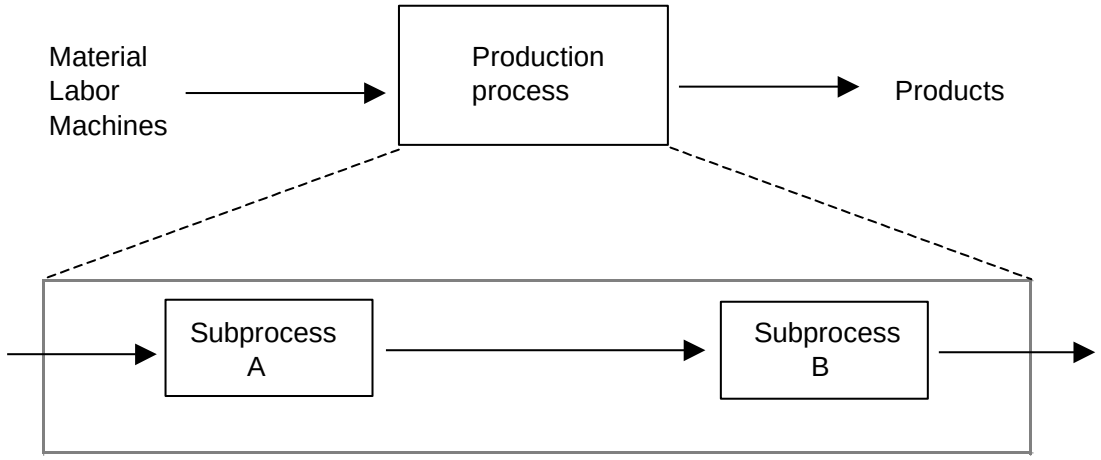
Value for the customer is not principally achieved by designing.

In customer business,
- a spatial investment competes for the same money than the other investments in operations
- the customer aims to balance with allocating resources to space-costs, salaries, raw-materials, machinery, educating the staff, marketing, R & D…

Value is ability to fulfill strategic goals of the organization.

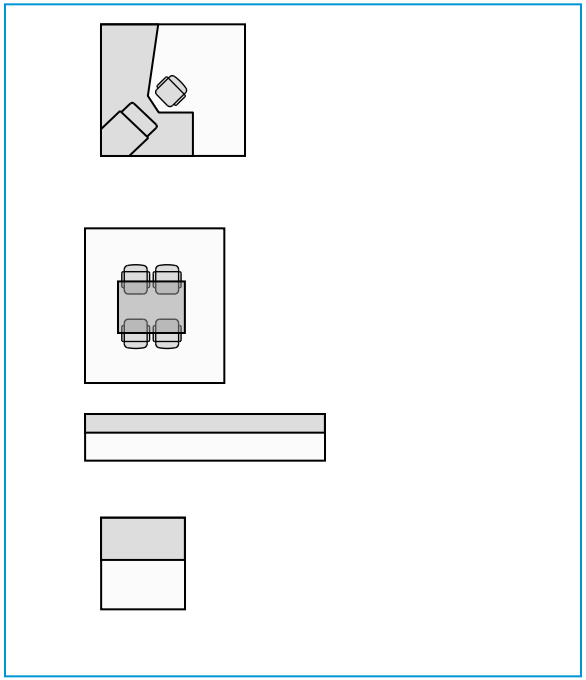
VALUE and PRODUCTION THEORIES

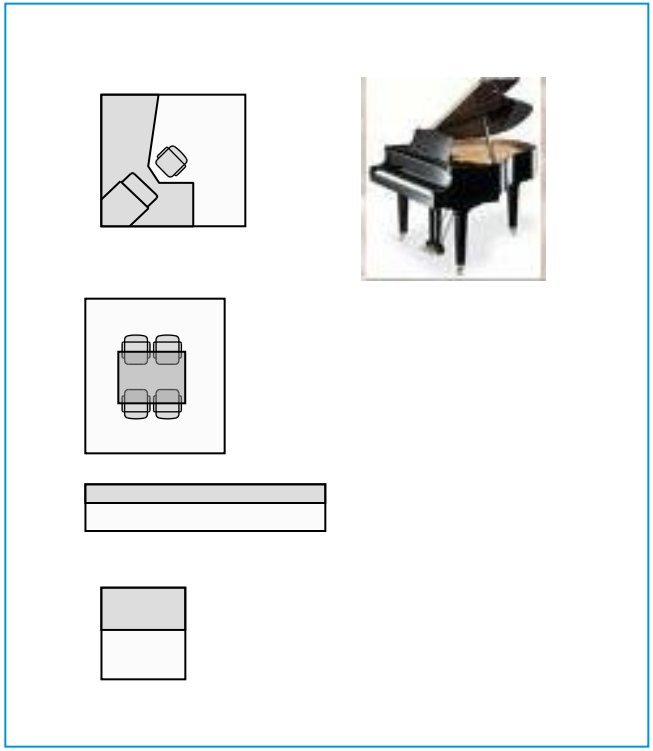
Transformation concept



Actions modeling of spaces

- The client do not say the size of the space but describes the functionality
- Information model defines the size and what kind of a space (bigger, better sound insulation…)
- Data quality; does it represent real life? Is it accurate? Is it complete?





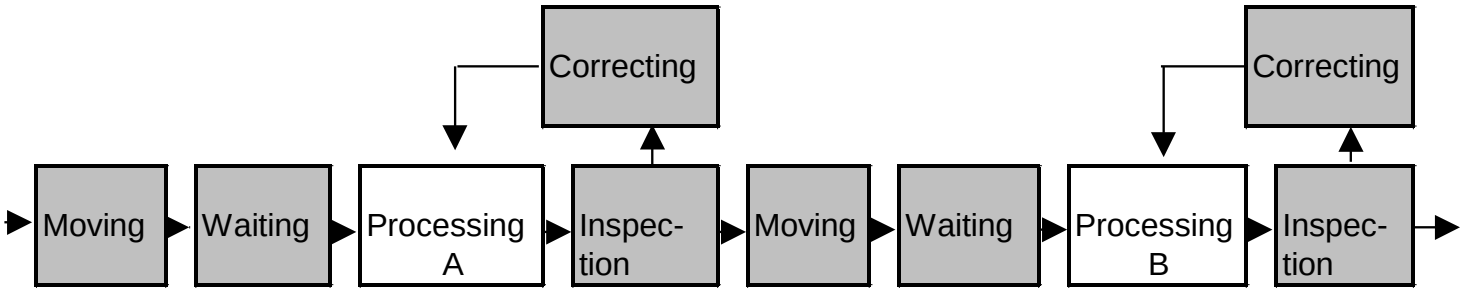
VALUE and PRODUCTION THEORIES

Flow concept

Value adding activities

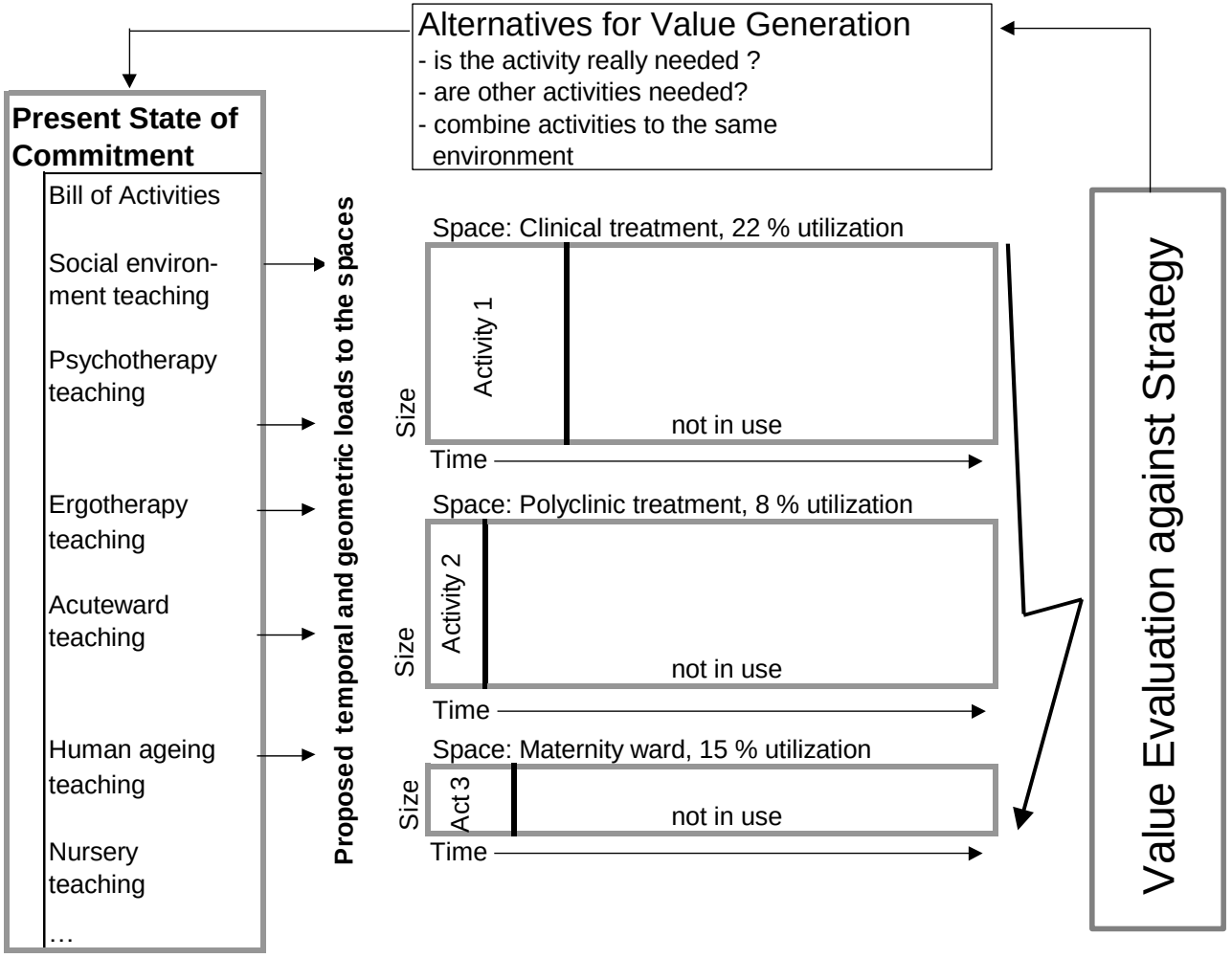
Waste

Time is a production factor

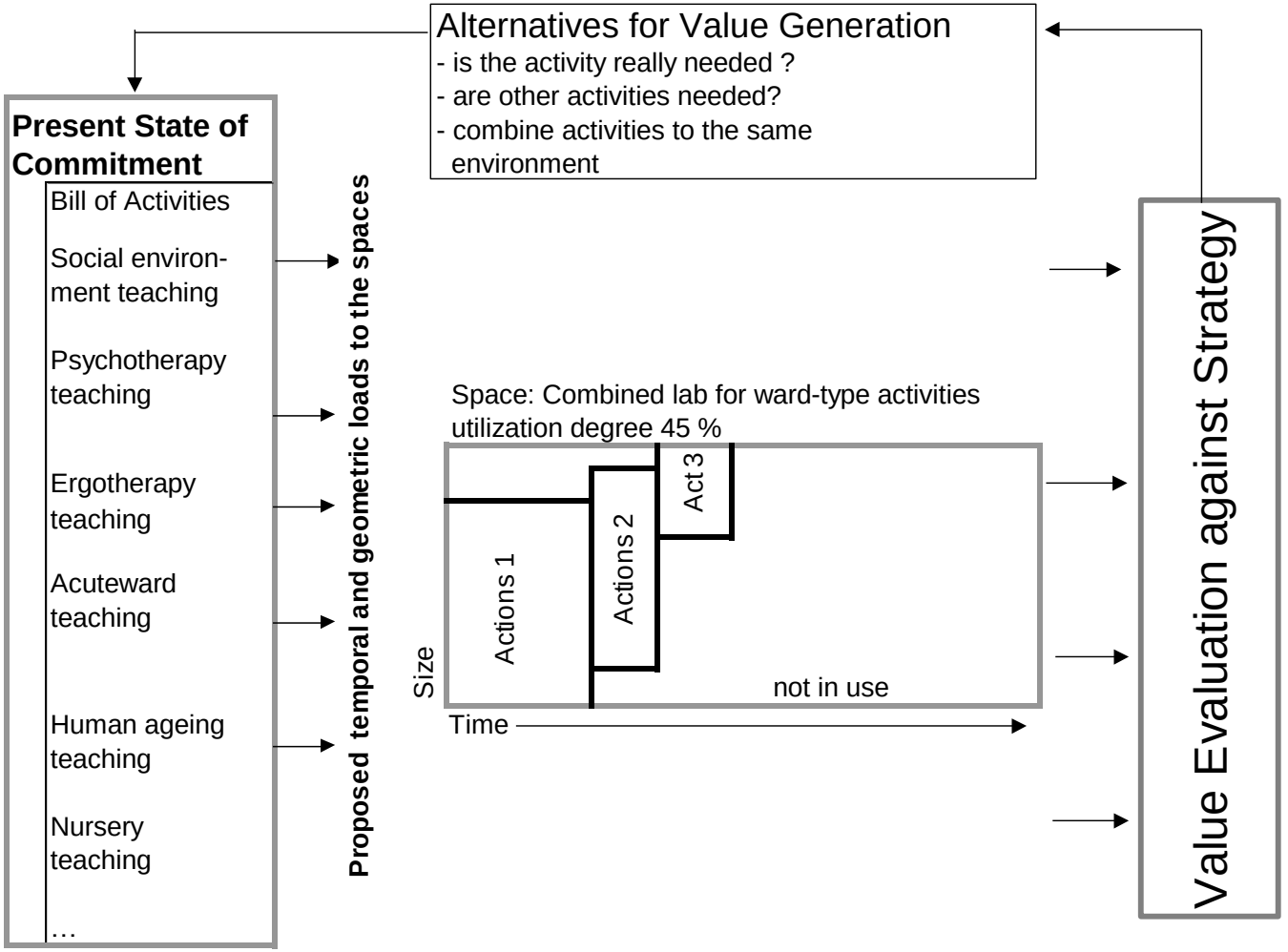


Activity modeling

Data quality; does it represent real world? Is it accurate? Is it complete?

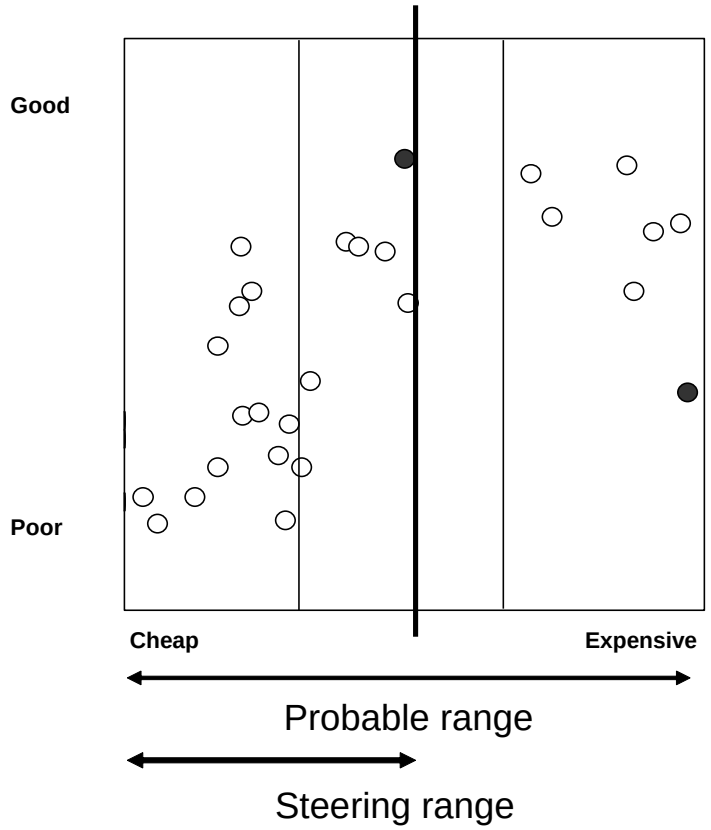


Activity modeling



Functionality, Cost and Quality

- Define customer's functional performance
- Set final investment and maintenance costs by pricing the performance criteria
- Steer the design to target cost and good quality
- Cost is a fixed parameter and quality is steered. Cost is known before design.



IMPACT OF COST CONSTRAINTS ON AESTHETIC RANKING FOLLOWING TARGET VALUE DESIGN EXERCISES

Zofia K. Rybkowski[1], Manish Munankami[2], Udaya Gottipati[3], Jose Fernández-Solís [4], and Sarel Lavy[5]

STEERING THE CUSTOMER

Building Information Model prior Design

- Representation of Functionality
- Allowable cost vs. Expected cost
- Feedback

Building Information Model prior Design

Building types do not exist anymore.

My nearby shop that I use in Helsinki:

- a Retail Center in the earth level
- a Restaurant in the earth level
- a Pharmacy in the earth level
- A Health center in the earth level
- Residences from floors 2 to 8
- Four storeys of car parking in the cellar

Is it a shop? Or parking hall? Or a residence building?

Data Quality?

A statistical Building Type does not represent real life, it is not accurate or complete

Good quality data is to represent functionalities.

Customizing Functions Inside Spaces:

A Highschool

Customizing Process Times and Targets on temporal Utilization

A Highschool
An Office for Activity Based Working

Customizing Functionality in Activities level

”Service Ability of the Building”

- Hotel
- Conference Center
- Parking
- Office for Activity Based Working
- a Tennis Court

Customizing Service Ability of the Building

- a extra WC to business suite

- Balconies to business suite

Customizing Space Performance

a Surgical Operations Unit
- internal climate
- medical instrument air
- safety, security
- lighting

Customizing to Cityplan

STEERING THE CUSTOMER

CASE

Haahtela

The new Childrens's Hospital in Helsinki

Haahtela

The new Children's Hospital

Owner
a Private Foundation of New Children’s Hospital. Wanted to have a Children’s Hospital earlier than scheduled. Put in order a fundraising and succeeded to get one third of investment money in a year.

User
Helsinki University Hospital leases the spaces.

Service ability
Surgery, Imaging, Rehabilitation, Laboratories, Mortuary, Outpatient clinic, Intensive care, Children’s psychiatry, Bedrooms, Catering…

Target Cost
175 million euros. Based on the Users willingness to pay rent. The Helsinki University Hospital has an investment schedule (Trauma-hospital, Cancer-hospital…). The rent has to fit to schedule.

Project’s state in summer 2014

Conceptual design was completed and designers prepared to start design for construction.

The Owner realized that they are failing with their targets. Costs were exceeding 15 %. Tenant would not be prepared to pay more.

The owner wanted to keep targets and asked for Target Value Design.

Haahtela inc. was hired to be a Project Manager.

Activity modeling and Process modeling

Project manager wanted to find out weather the project is in the Steering Range. Ilkka Niukkanen and Ari Pennanen from Haahtela performed a Building Information Modeling prior design.

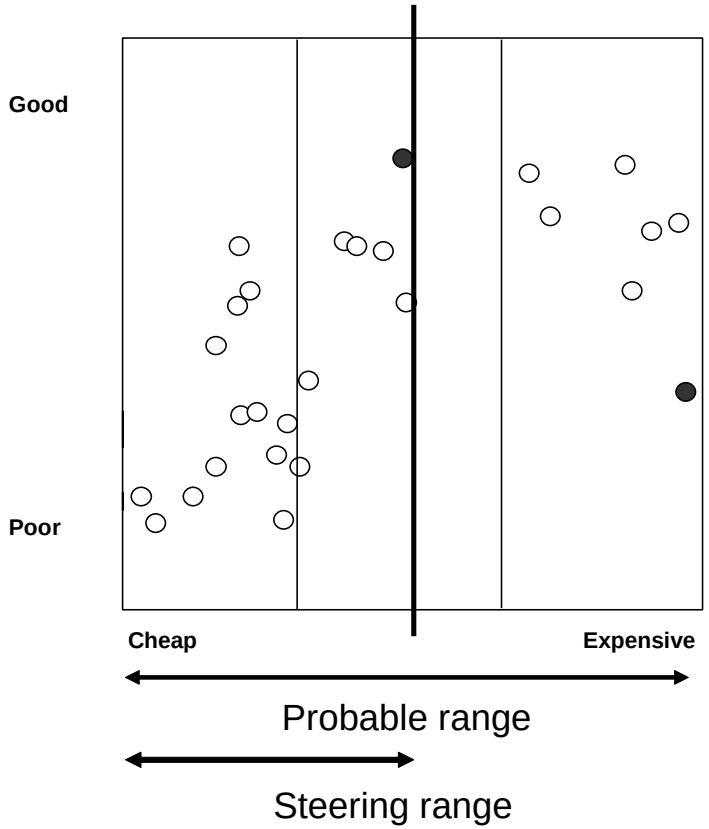
Modeling included
- activities
- process times and utilization degrees
- spaces
- performance of the spaces

The result was that it is possible to achieve Target Cost of 175 million euros

But…

Design of that functionality should not exceed 48 000 gross-m2.

The present design was 53 000 gross-m2.



Next steps in fall 2014

It was obvious that the architect cannot take off 5 000 gross-m2 in very short time without sacrificing functionality. The architect needed help.

Design was ceased for 3 months.

Project manager concentrated to steer the user to balance functionality and usable area. Most of the operations were modeled by BIM prior design to get instant feedback information for decision making.

Intensive work was done with help of doctors and other experts of the user (Helsinki University Hospital). They were supported by a hospital consultant NHG.

Utilization degree of recovery places was low

Utilization degree of post-surgical recovery beds was low (45 %) and thus there were too many beds in design proposal.

Doctors explained that because recovery-rooms / preparation- rooms are separated in two zones, they need more temporal buffers (also staff is working in separated locations). If recovery- rooms were in one zone, they could be planned to 55-60 % utilization

Utilization degree of recovery places was low

Before

After

htela

Utilization degree of outpatient clinic consultancy rooms was low

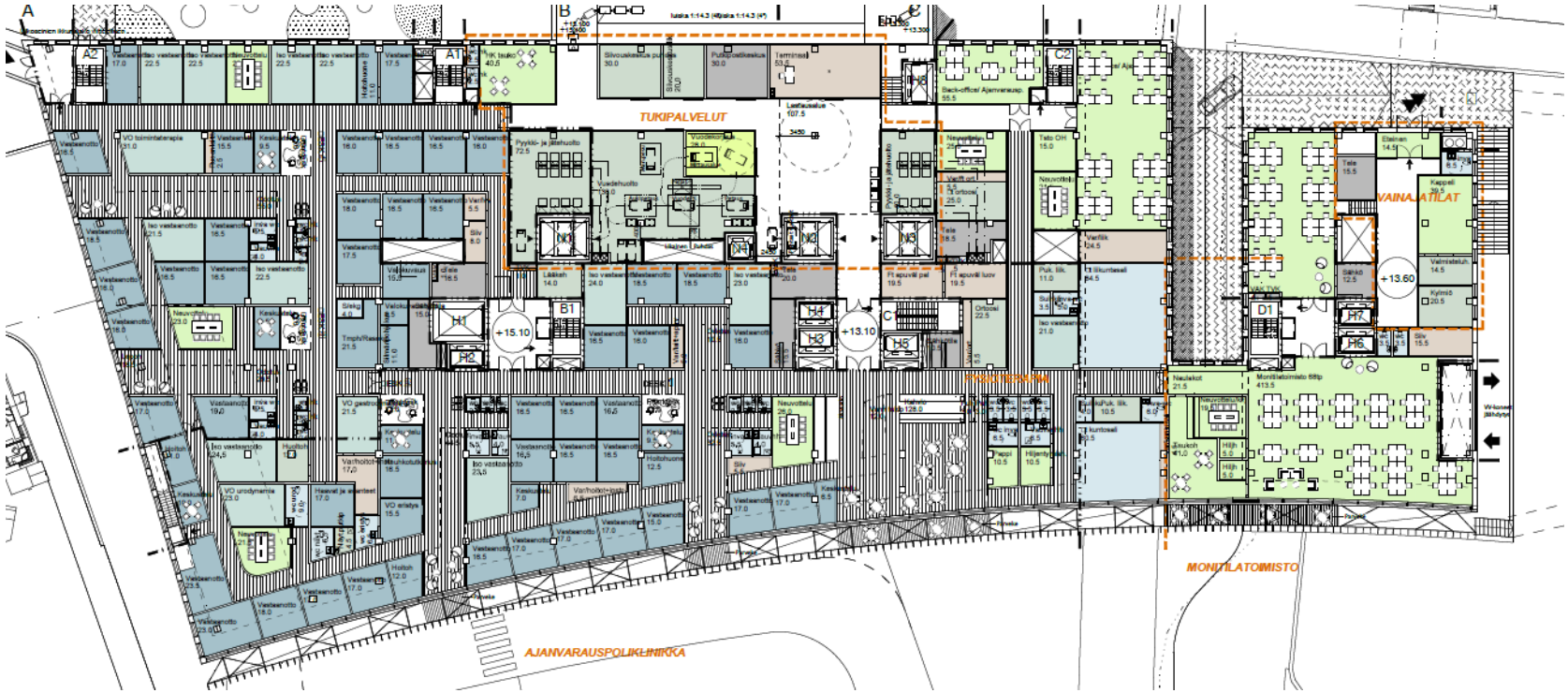
Utilization degree of consultancy rooms was 53 % with proposed design. It means 6 patiens / day (8 hours).

Many doctors also work in the University as professors, researchers… They have used to do, but patient consultancy, also research in the rooms.

Consultancy rooms were decided to plan with 75 % utilization (8 patients / day or 6 hours / day).

Back-office workstations were placed to same floor as the consultancy rooms.

Utilization degree of outpatient clinic consultancy rooms was low



Haahtela

Utilization degree of ward bedrooms was low

Ward bedrooms were estimated with ”gross days”. It means that if a patient is in the room in the morning, the room will be reserved for whole day.

In older hospitals cleaning the room is normally done in the evenings.
New Children’s hospital is provided by robot- elevators. The staff can put whole bed after use in the robot and it will fetch a new one from cellar.

Programming was decided to do with ”Net days”. If a patient leaves in the morning, a new one can come in the evening.

Ward could be programmed 15 % more efficient (from 130 bedrooms to 111 bedrooms)

At November of 2014

Steering the User reduced the gross area from 53 000 m2 to 48 000 m2 (10 %).

No sacrifices were done with the service ability of the building.

The architect was asked to collect design team and perform conceptual design again.

STEERING DESIGN

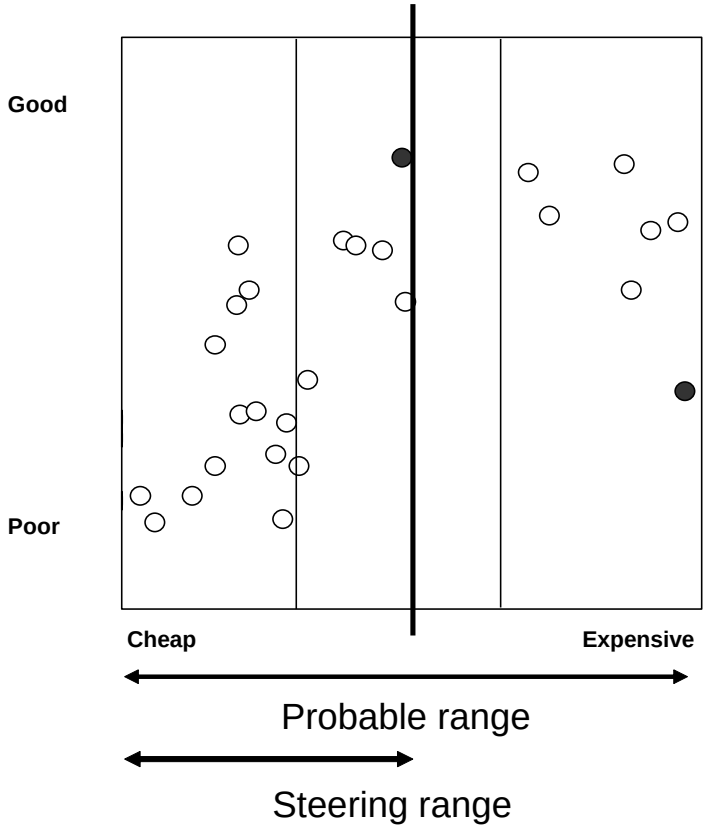
Component level modeling

Component level target costing

Activity modeling and Process modeling

Now, Target Cost is in steering range.

But are the designers able to meet the goal



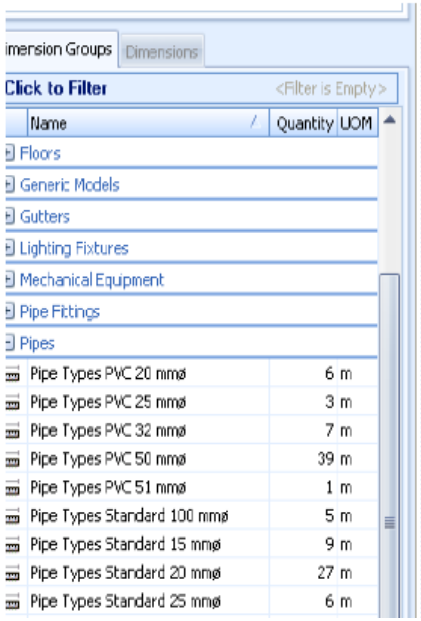
Claims of BIM picked from internet…

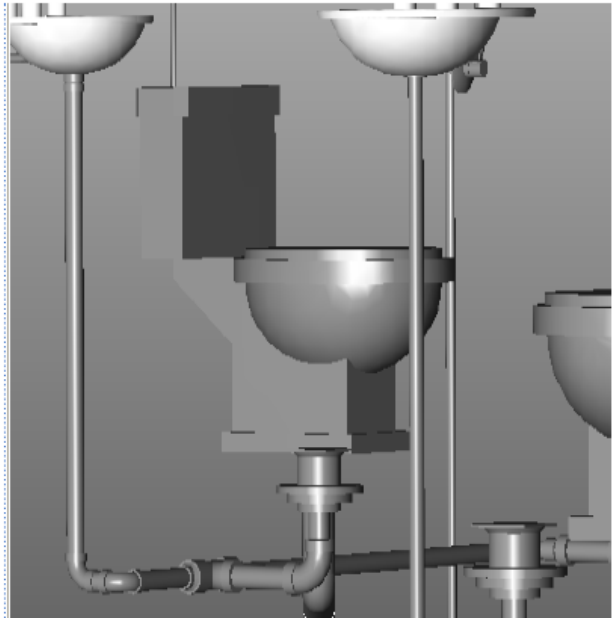
Building information model…used to support cost estimating
…a wall, for example, ”knows” what it is…

Bim is intended to improve… productivity with

- accurate and
- complete

information.



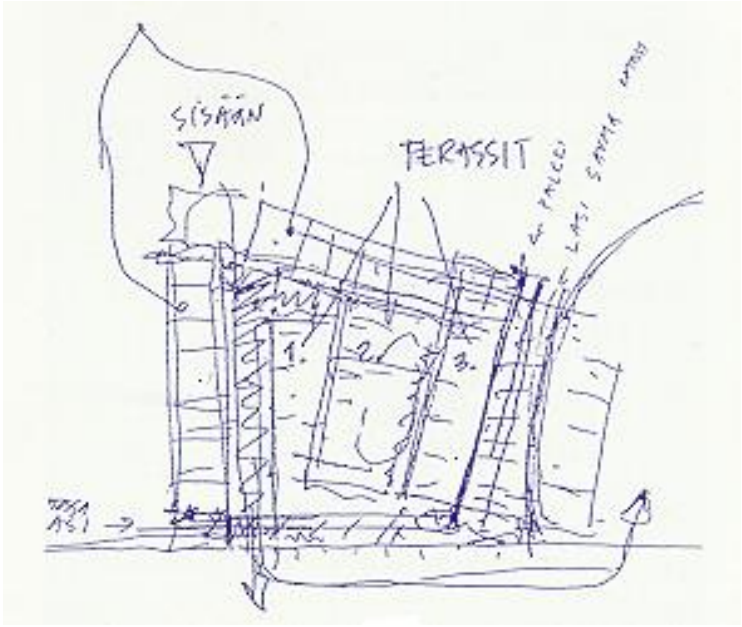


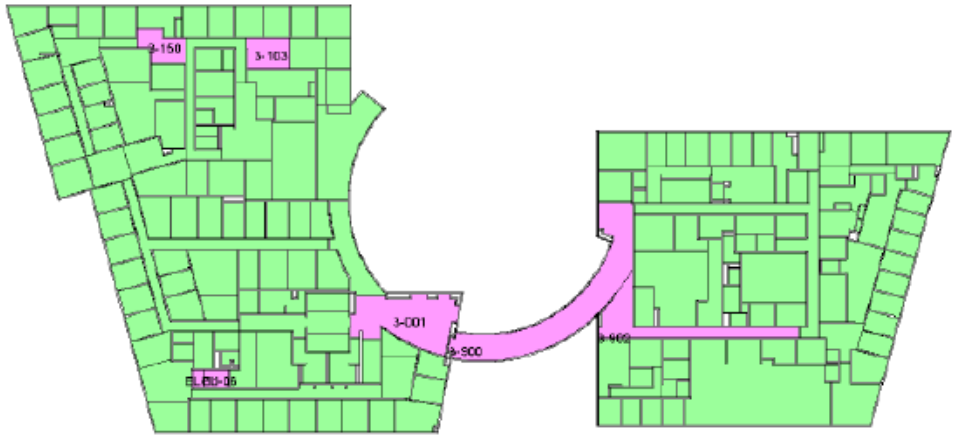
Actually…
for customer value generation in strategic meaning,
Present Cad BIMs are always

- inaccurate and
- incomplete

design is cumulative by its nature

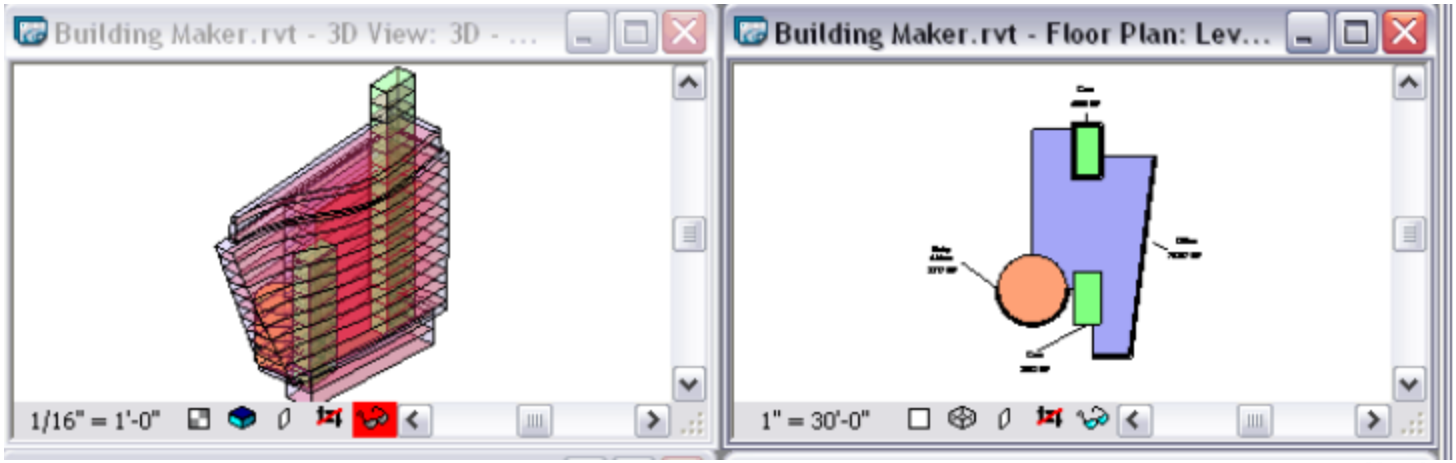
BIM



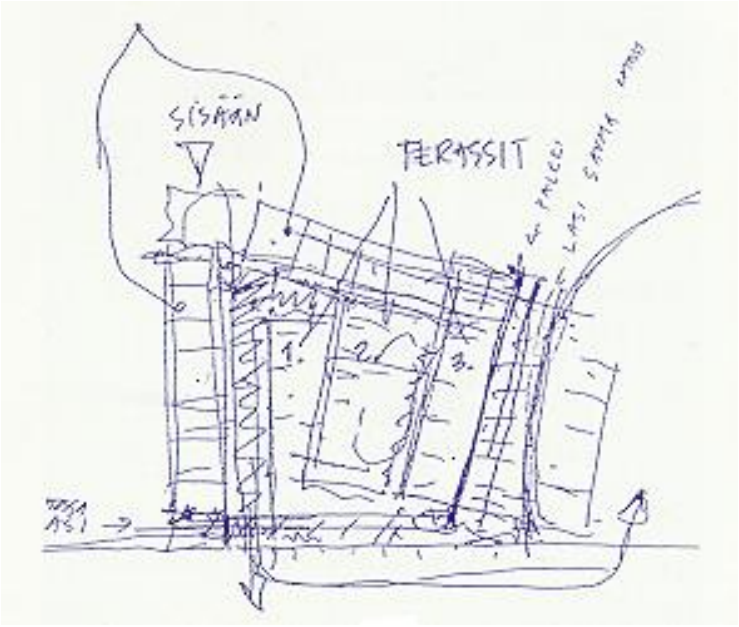


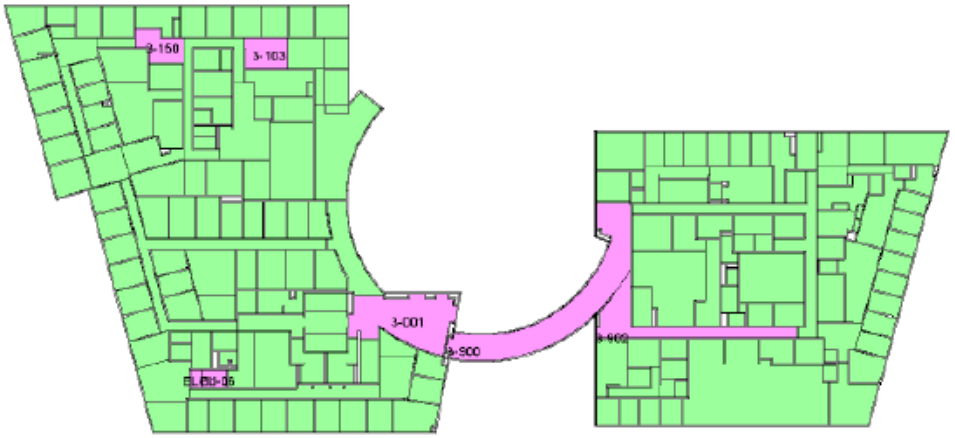
Information content

- Shape and form in urban environment
- Connections of the activities defined in programming



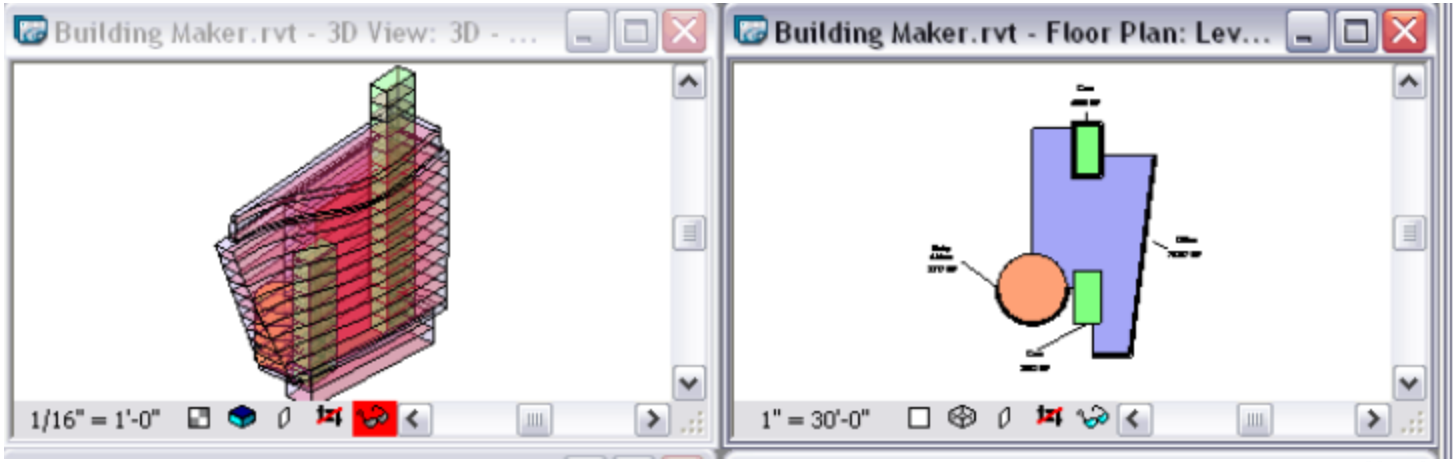
BIM





Information content

- No piles, beams or lifts
- No taps, cooling units or inlet fans
- No luminaires, switchboards or nurse call



Haahtela

Value generation

BIM should inform functionality for operations and final costs immediately, after two weeks design…

Value generation

After four weeks design…

Haahtela

After four months design

The final content of components (and costs) will be completed a little after the construction has been completed (after latest fixed furniture, that has been designed by supplier, has been added to the model)

To serve our customers in strategic level…
We have to know all the components, unit costs and life cycle costs before the start of design

As CAD BIMs start from 0% content of quantities,
BIM prior design starts from 100 % content of quantities.

Data quality
Does it represent real world? Is it complete? Is it accurate?

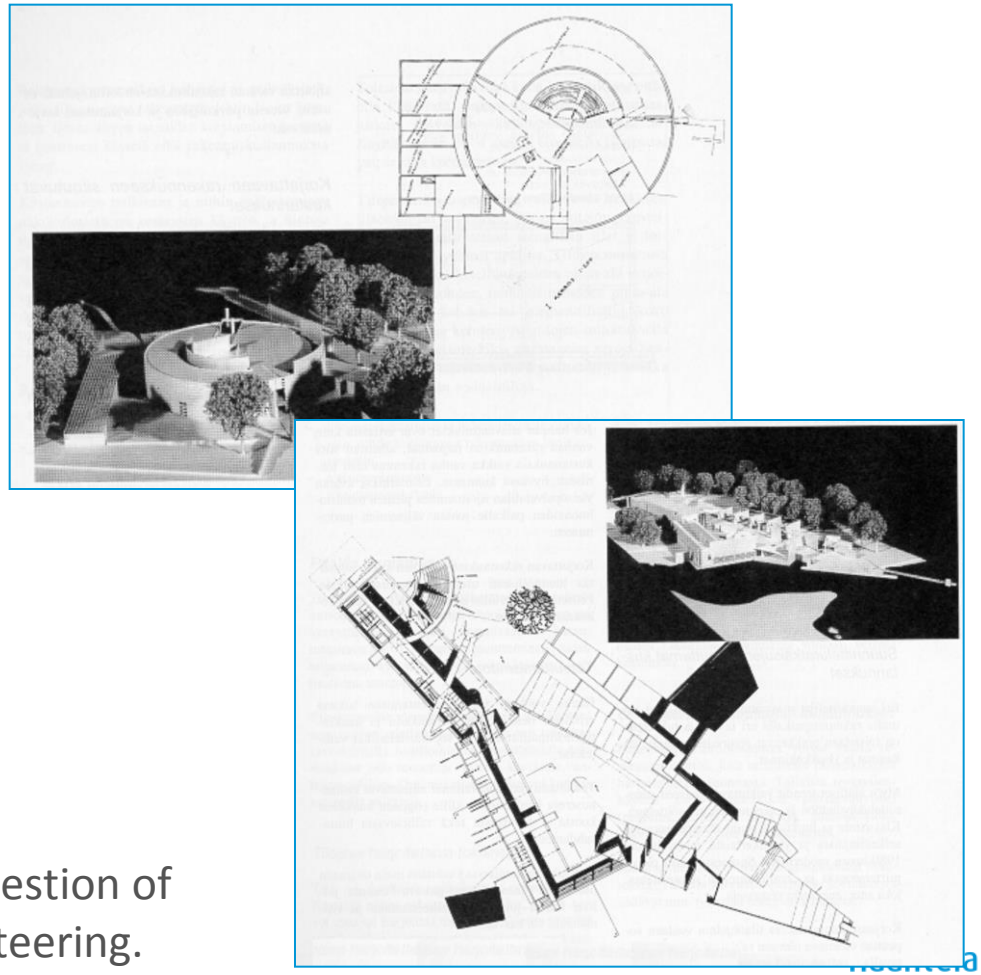
Project Level Target Costing vs. Component level target costing

Simulates design process

Examples
Customizing

“Real Quantities and Real Costs ?”
Like in quantum mechanics, they all are true at the same time

Scope of the elements		Unit price (€)
…		
Piling, 30 * 30	5300 m	30
…		
Foundation bases		
- framework	1630 m2	25
- reinforcing	65000 kg	2
- concretework	820 m3	120
…		
Beams		
- steelbeam, 90 kg/m	36500 kg	2
…		
Slabs		
hollow core slabs 400	19915 m2	80
…		
Cooling apparatus	800 kW	300
Taps	430 pc	800
Air inlet fans (4 m3/s)	13 pc	20000
…		
Luminaires		
Switchboards		
…		



It is not a question of accuracy. It is a question of decision making during design. Design steering.

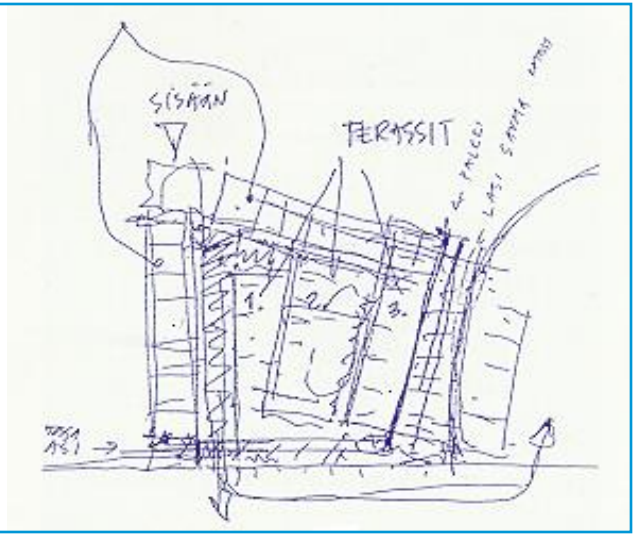
DESIGN STEERING

Fast feedback

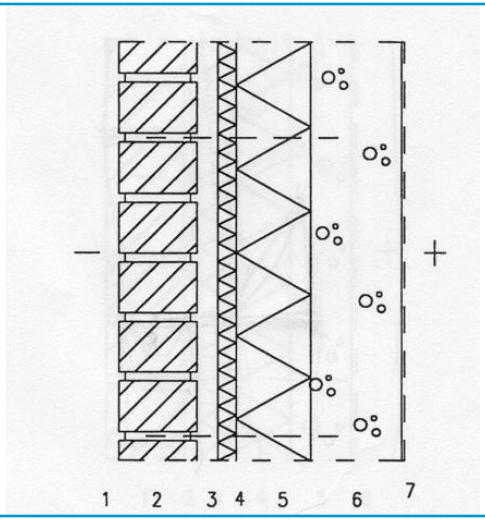
It seems that traditional estimating (measure quantities and price them) can not produce fast economic feedback to the architect (week or two from starting the design)

Two orthogonal perspectives to design

Shape and connections



Components



DESIGN STEERING

Fast feedback

- Dialogue with Component Level Target Costing (BIM prior design) and designer's CadBIM builds up the fast feedback loop
- Enables designing shape-and-connections perspective and components perspective at the same time
- BIM prior design is a Defending Champion. It is right until it is proved to be wrong

- At the end of the steering process (at he end of design) both models are equal (CadBim has substituted all the elemets in the Haahtela model.
- Costs are estimated constantly during design

Customizing to shape and form of the first sketch

Design Model

- add a storey
- projecting 3rd floor
    - frame, arcade
- adjust to form and shape of the design proposal (perimeter, floor-height)
    - frame, exterior wall

Customizing to building elements

- Cooling unit (kW)

- etc

STEERING DESIGN

Cases

The new children's hospital in Helsinki; a new building

OP headquarters in Vallila, office and banking; rehabilitation and extension

Forum commercial center in Kamppi; rehabilitation

The new children's hospital in Helsinki

After steering the user, the design was still exceeding the target cost

Feedback to the architect:

- in design proposal there is 1 100 m2 more circulation area (corridors, stairs) than in the Haahtela model based on usable area

- exterior wall is very expensive

- slabs are expensive

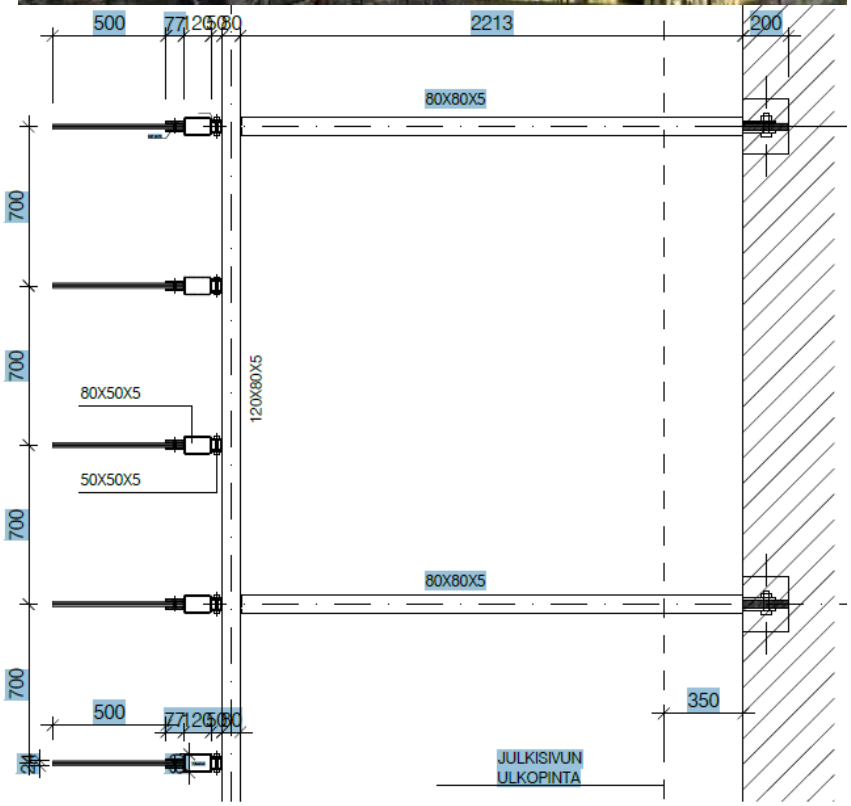
Ward bedroom floor

Architect's Proposals

Before

Now

Haahtela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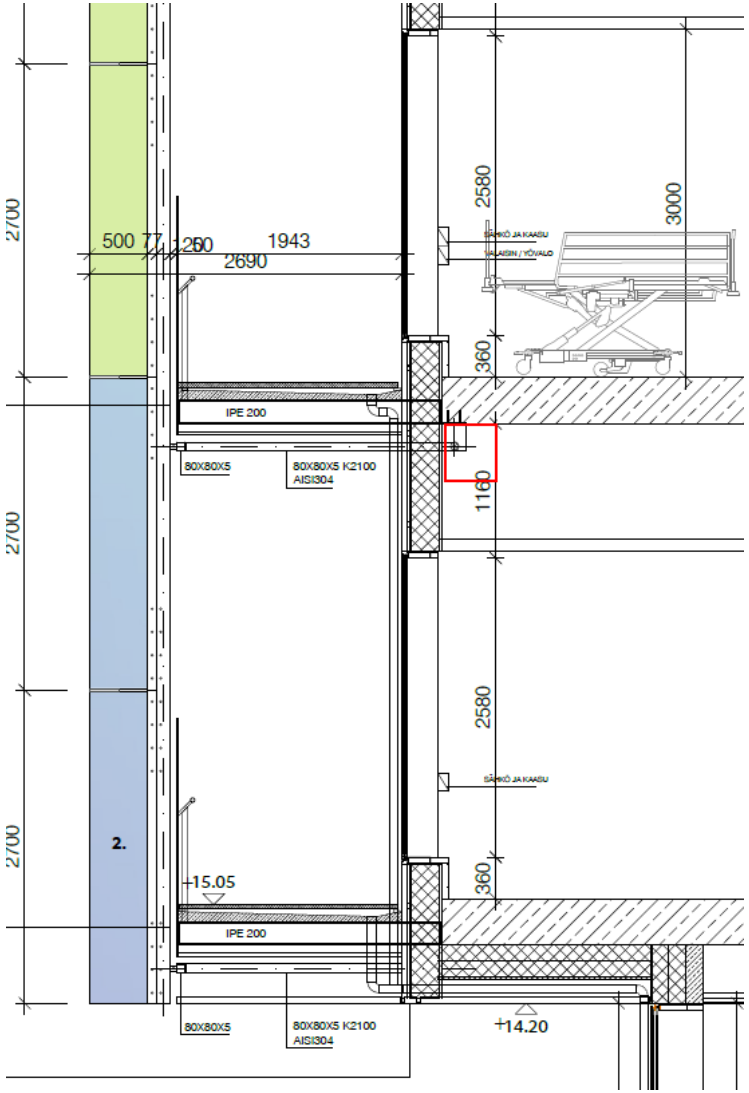
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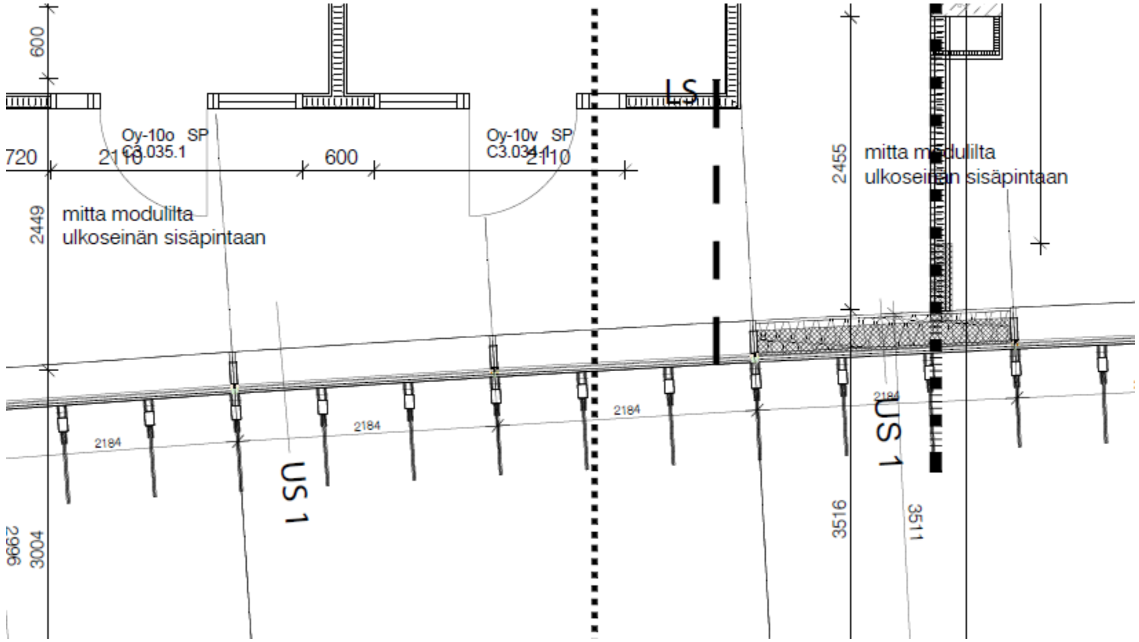
Haahtela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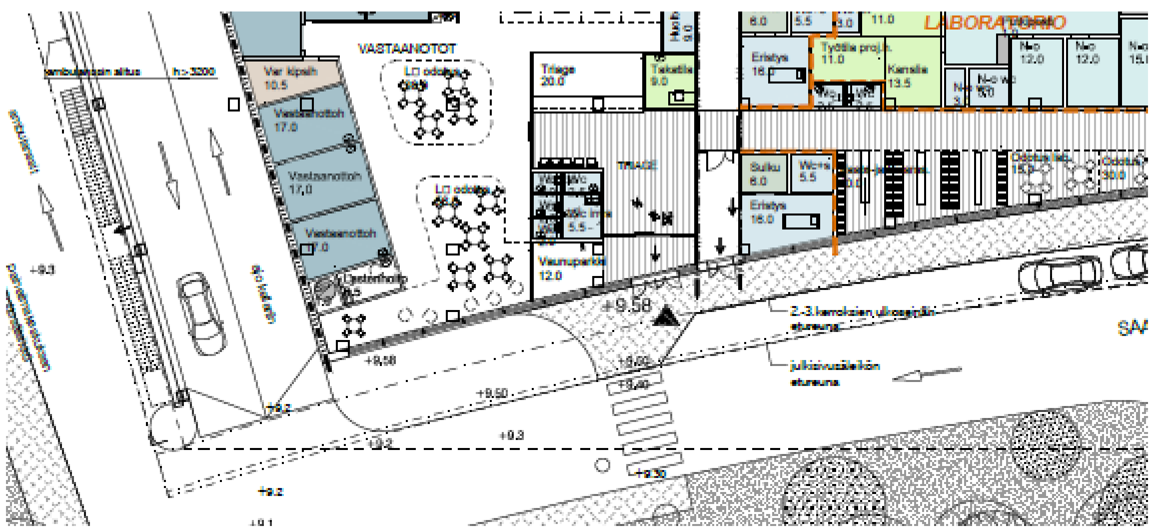
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Eristys
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Sulku
6.0
Kanslia
13.5
+9.58
+9.50
+9.3

The new children's hospital in Helsinki

Slabs expensive: tenders were asked for

- column – massive slab

- column – beam – pre-tensed thin slab + in-site casted concrete

- hollow core slab

The new children's hospital in Helsinki

at the moment (1/2016)

- cost monitoring in component level

Project management: Haahtela Group

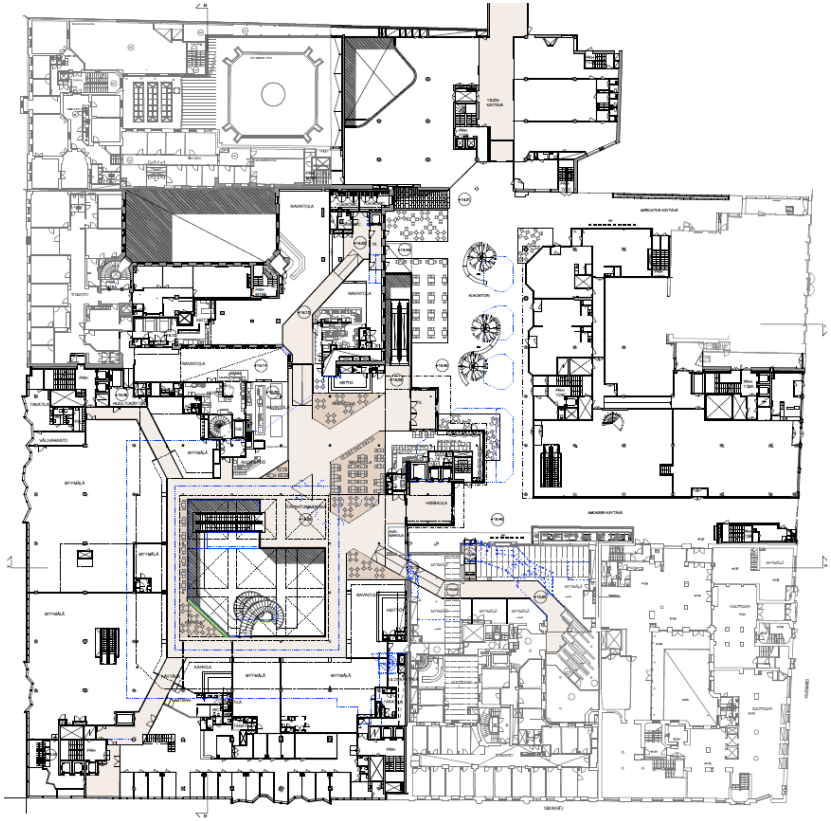
Architecture: SARC Architects

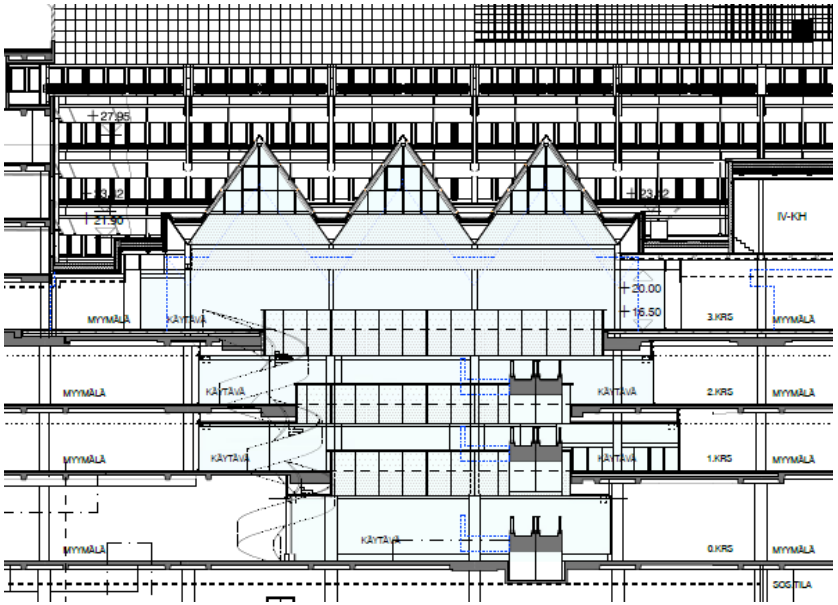
Haahtela

Forum commercial center rehabilitation

Project and construction management; Haahtela Group

Architecture; SARC Architects

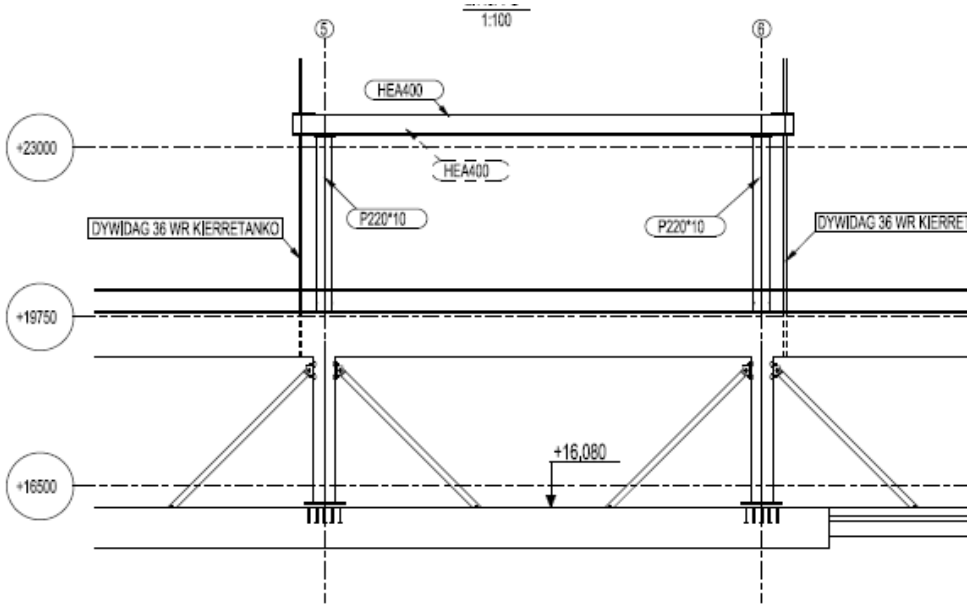


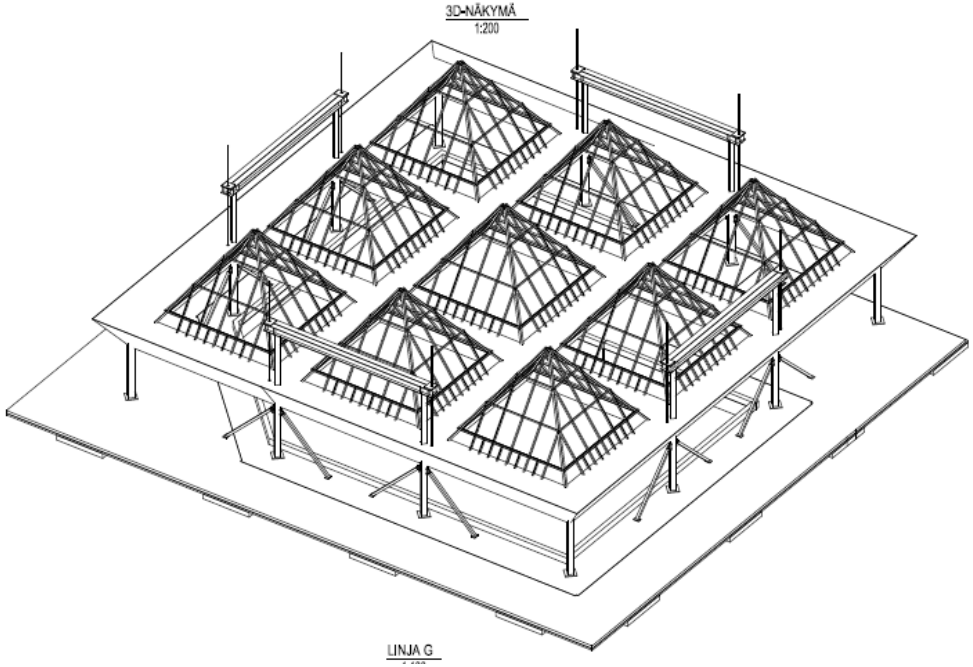


Haahtela

Skylight was about to be demolished

Instead, it was recycled

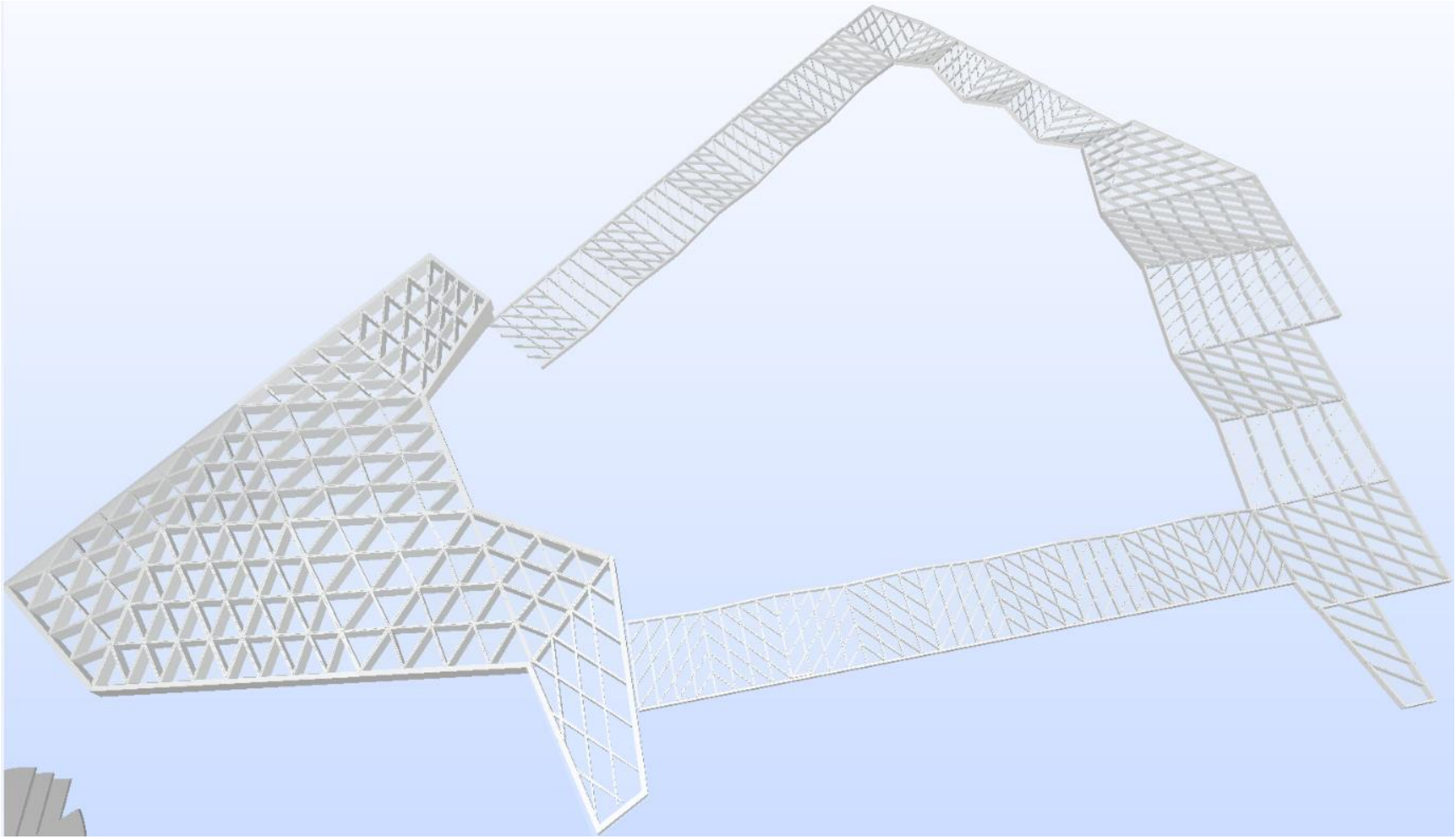


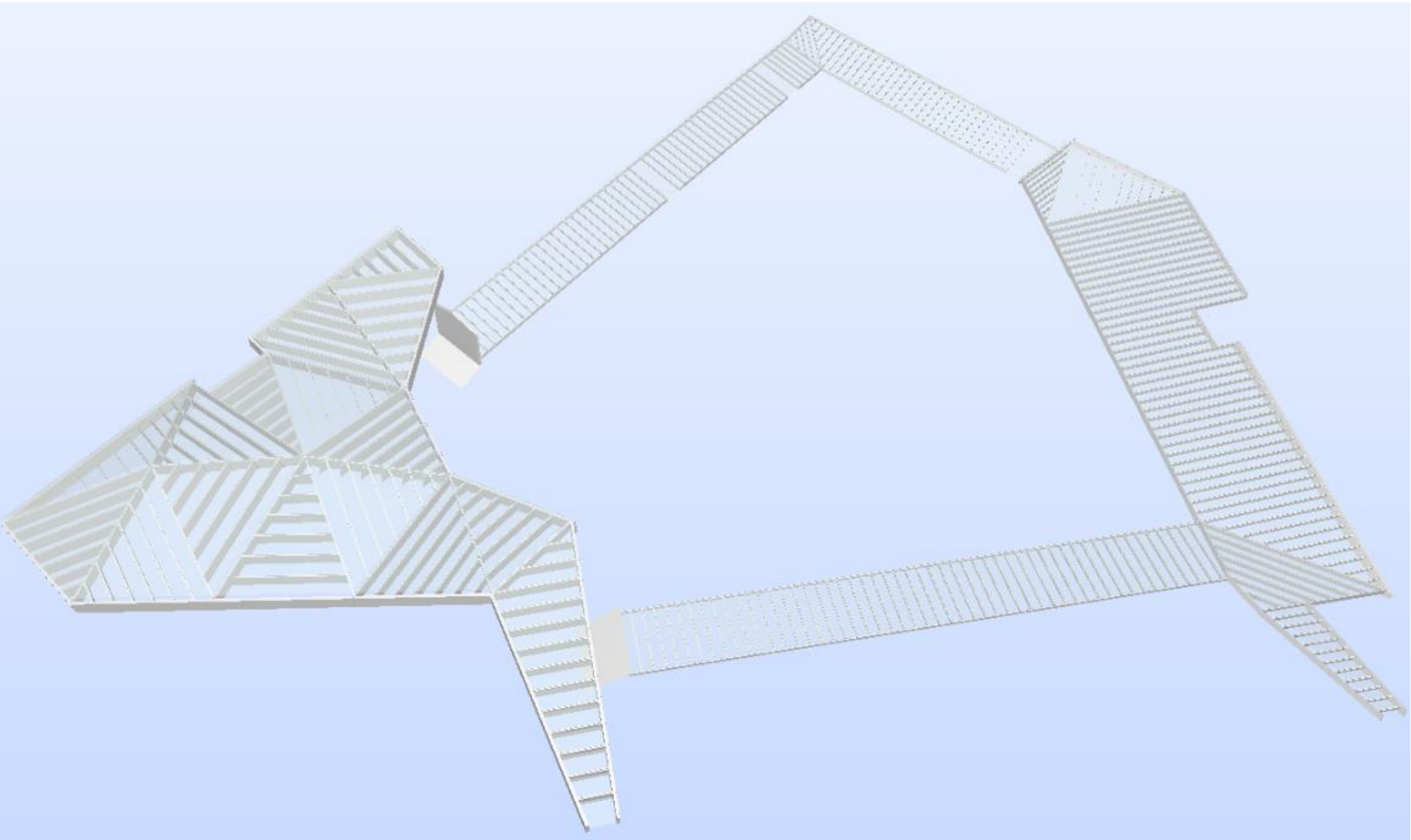


OP – headquartes in Vallila (Helsinki)

Skylight frame of atrium was very difficult to assemble

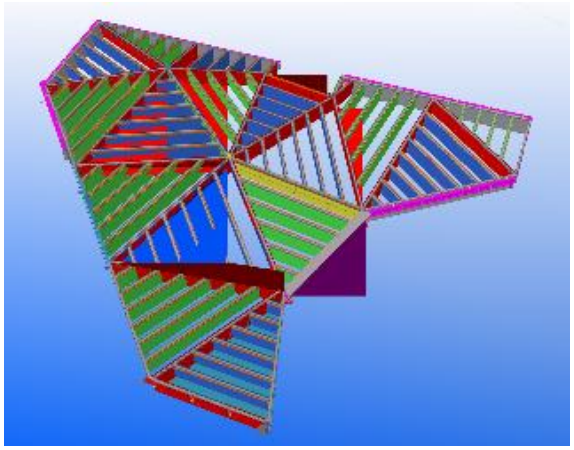
Haahtela





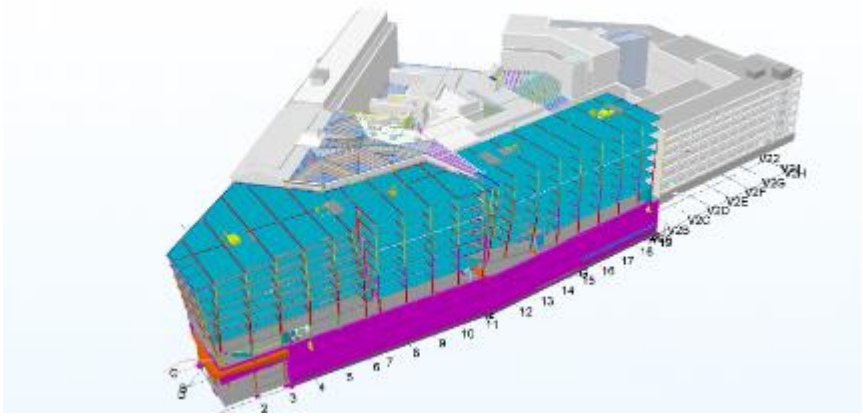
Project and construction management
Haahtela- Group

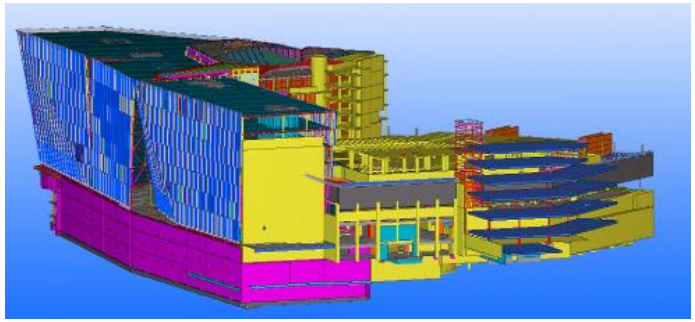
Architecture
JMKK Architects



OP- headquarters rehabilitation and extension 1 / 2016

- Construction is almost completed
- In Target Cost (250 million euros) and time schedule
- Nominaded Tekla Total BIM Qlobal winner 2014
- Finalist in Finlandia Prize for Architecture 2015





Haahtela

References







- About 100 construction projects (1993 – 2015)
- Almost all within the budget and on time
- Project values of between 10, 000, 000 € – 250, 000, 000 €

Target Costing Information Model
Component level Target Cost

Number of luminaries needed is based on illuminance required

N= ExA/(FxnxUfxMf)
where
E is illuminance required
A is size of the space
F is efficiency of the lamp
n is number of lamps in the luminaire
Uf is a certain factor (dealing with the absorption of surfaces)
Mf is a factor (dealing with probability that lamps work)

It is not necessary to produce first a design solution to count out the number of luminaries (or size of main switchboard, or…) as the designers use the same formula to determine the number of luminaries

Target Costing Information Model

Number of lifts needed and performance of the lifts is based on waiting time

Round-Trip Time= Travel time + Stopping time + Transfer time
Travel time = (2 x Storeys x height of the floor) / Velocity
Stopping time = etc

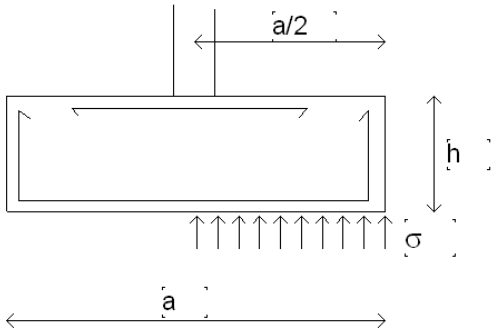
Waiting time = (Round trip time) / (2*number of lifts)

Recommended waiting intervals
-Offices 30 sec
-Hotels 60 sec
-etc

Result: Four lifts, 13 persons cars, 2 m/s

Target Costing Information Model

Need of foundation bases is due to the total weight of th e building and performance of ground



Cooling beams needed is based on thermal load and requirements on the control of internal climate

Cooling by air:

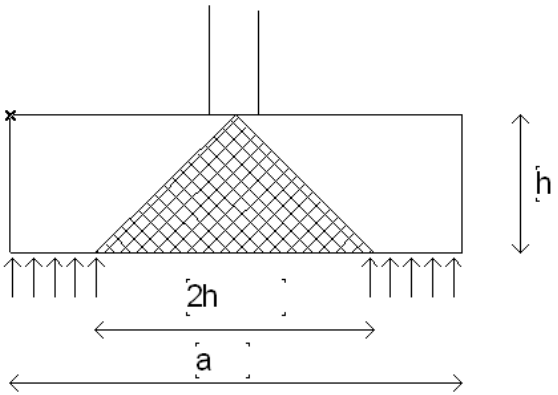
$Q = \zeta^* V * \Delta H$ (kW)

H = entalpy

Etc

Rest by cooling beams

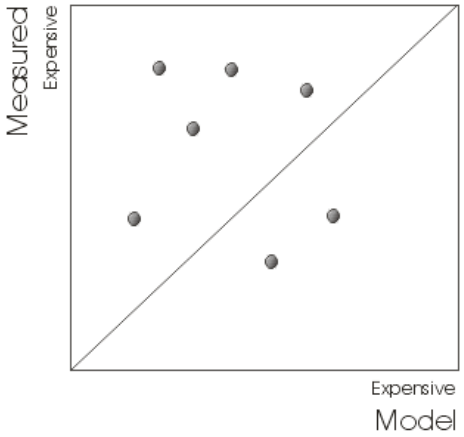
Number of beams = Qrest / 350W

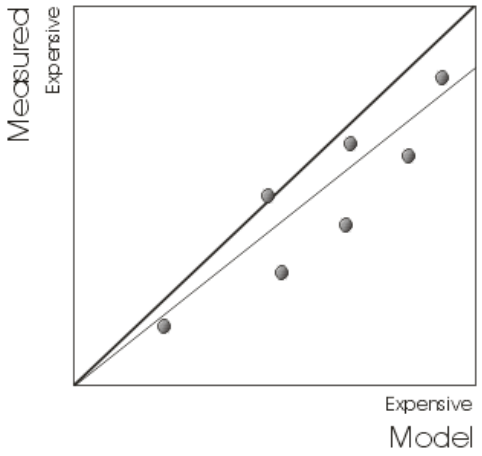


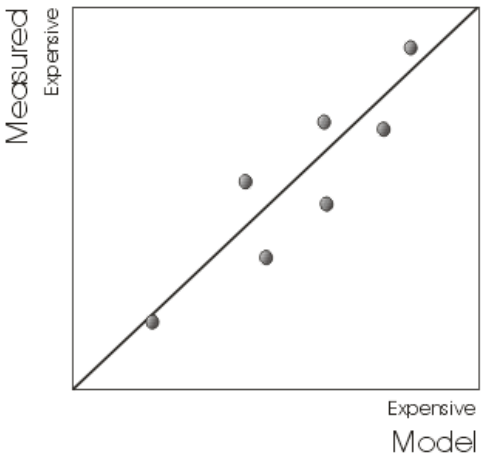
Target costing information model

Black Box Calibrating (Cybernetic feedback loop control)

Emergent features



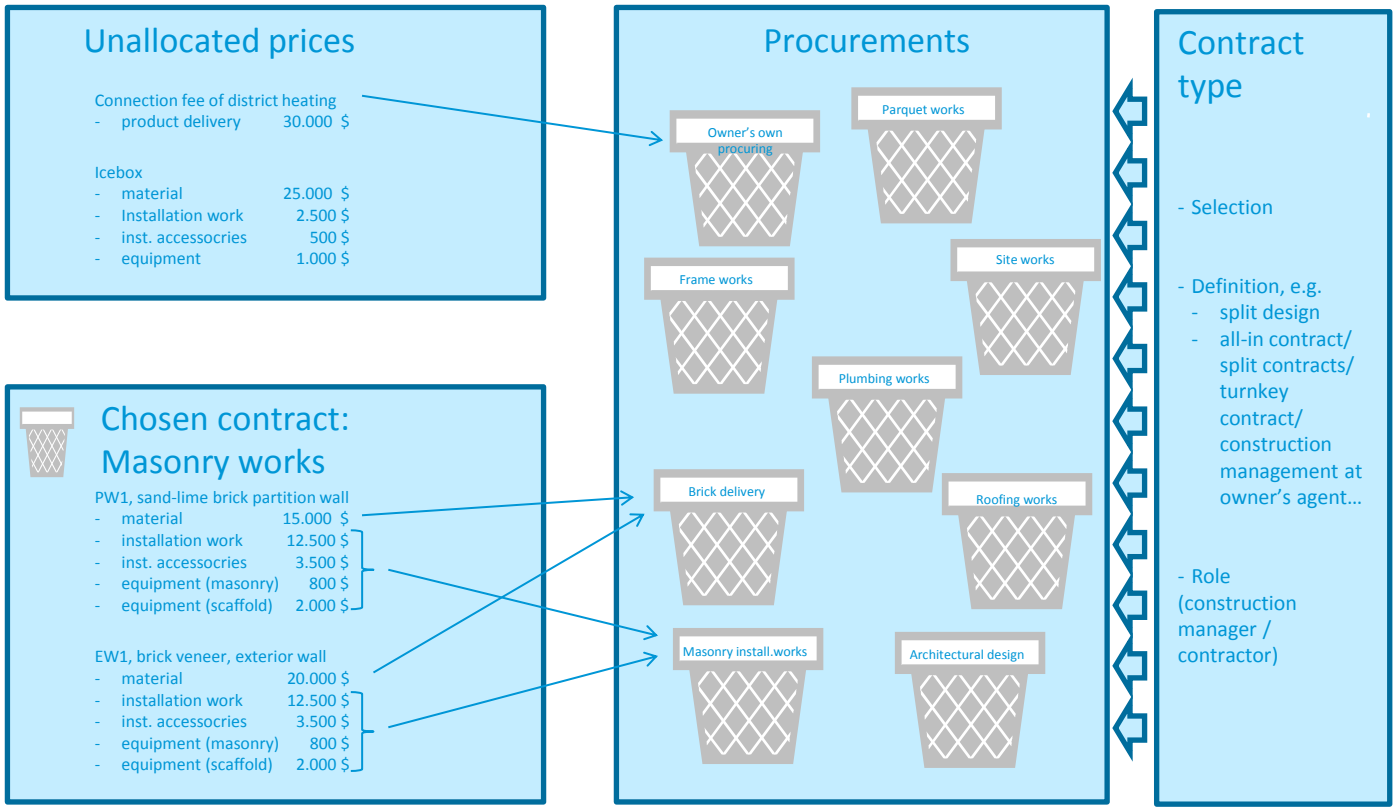




Component level

Product level

Procurement estimate



This concludes The American Institute of Architects
Continuing Education Systems Course

Lean Construction Institute

info@leanconstruction.org