Aalto University

Design management

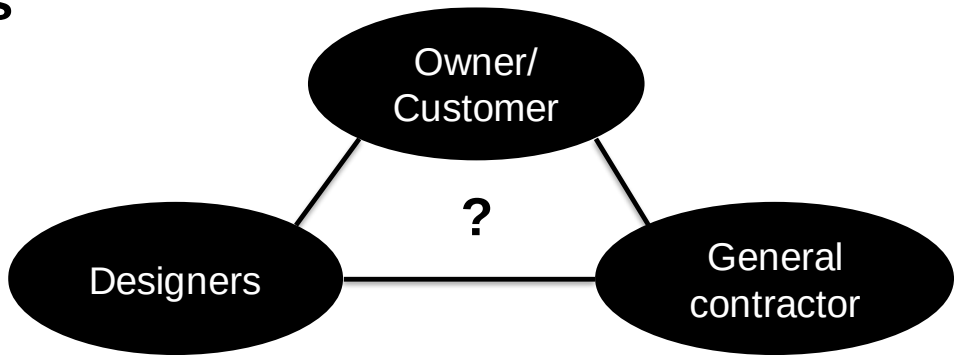
CIV-E1040 Construction Management

Lecture IIb

Antti Peltokorpi
Assistant Professor
Department of Civil Engineering, Aalto University
antti.peltokorpi@aalto.fi

Previous lecture

- **Project delivery methods**
  - DBB
  - DB
  - CM at Risk
  - Collaborative
  - Lifecycle



- **A tool to achieve customer's targets with manageable risks**

- **Introduction to a teamwork**

Agenda

- **Design management**
- **Target value design**
- **Design for flexibility**

The Nature of Design

- **Design problems are solved by exploring possible solutions**
- **Design problems can be reciprocally dependent, so that neither can be solved without solving the other**
- **Design best occurs through a set-based process in which alternatives are generated then progressively narrowed as they are further developed**
- **There is always a better solution possible, given time and money**

Architects' and engineers' approach to design

	Design Strategy	Constraints Management
Architects	Begin by generating solutions. Spend most time there.	Tend to maximize value within available cost and time.
Engineers	Begin by defining the problem. Spend most time there.	Tend to fix deliverables and try to minimize cost and time of delivery.

Lean Construction Institute 1999

Challenges / Research Issues in design

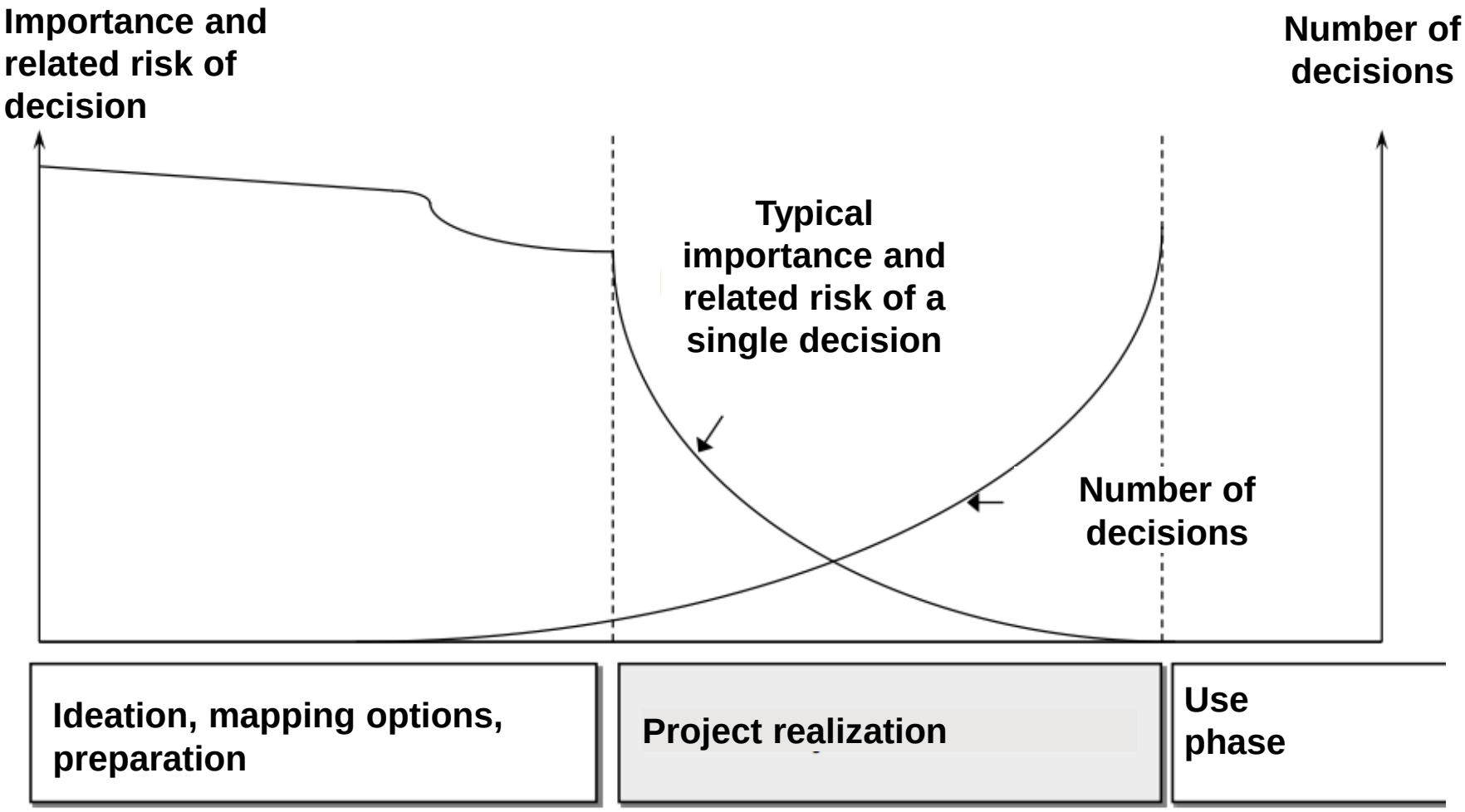
1. **How to incorporate the relevant specialists in the design process?**
   - *Both as regards knitting organizations together through contracts and effective processes for collaborative design*

2. **How to make tradeoff decisions between the characteristics?**

3. **How to drive design decision making to the targets?**

Design in siloes – redesign, changes, low constructability, cost surprises…

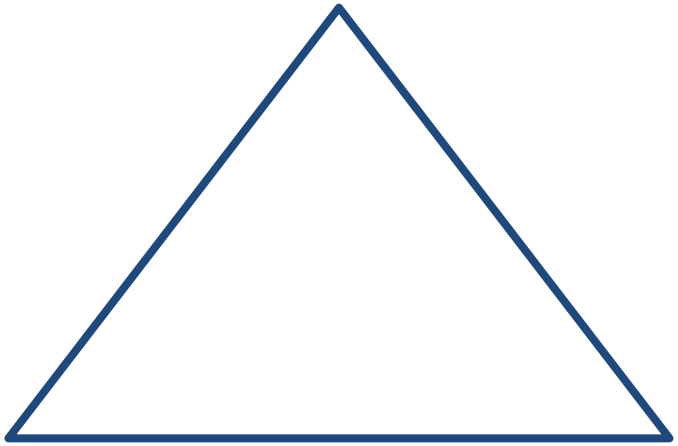
Project decisions and their importance



Source: Karlos Artto, Aalto University

Important decisions from cost perspective

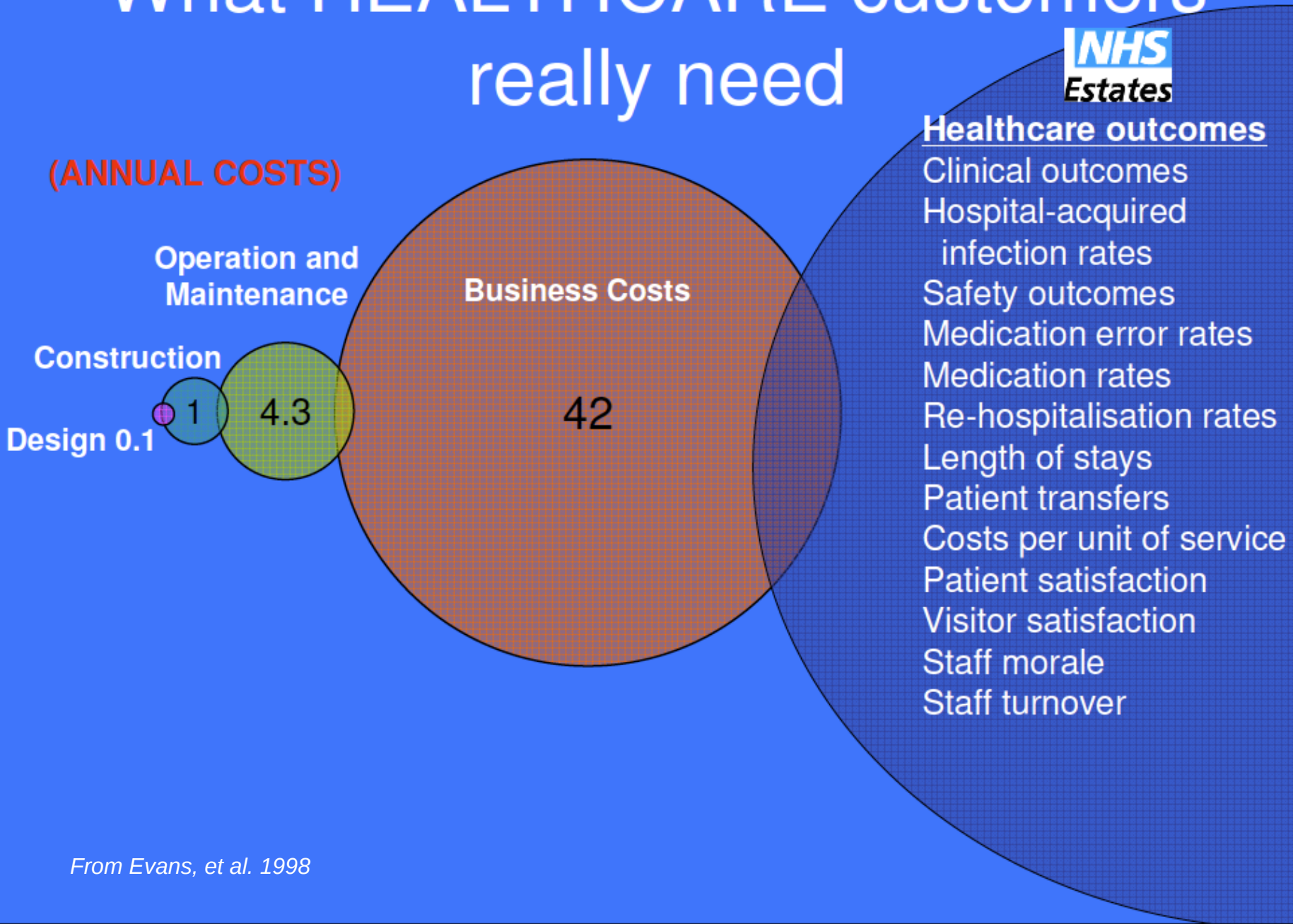
1. Needed functions and amount of spaces for them



2. Site circumstances and selected design solutions

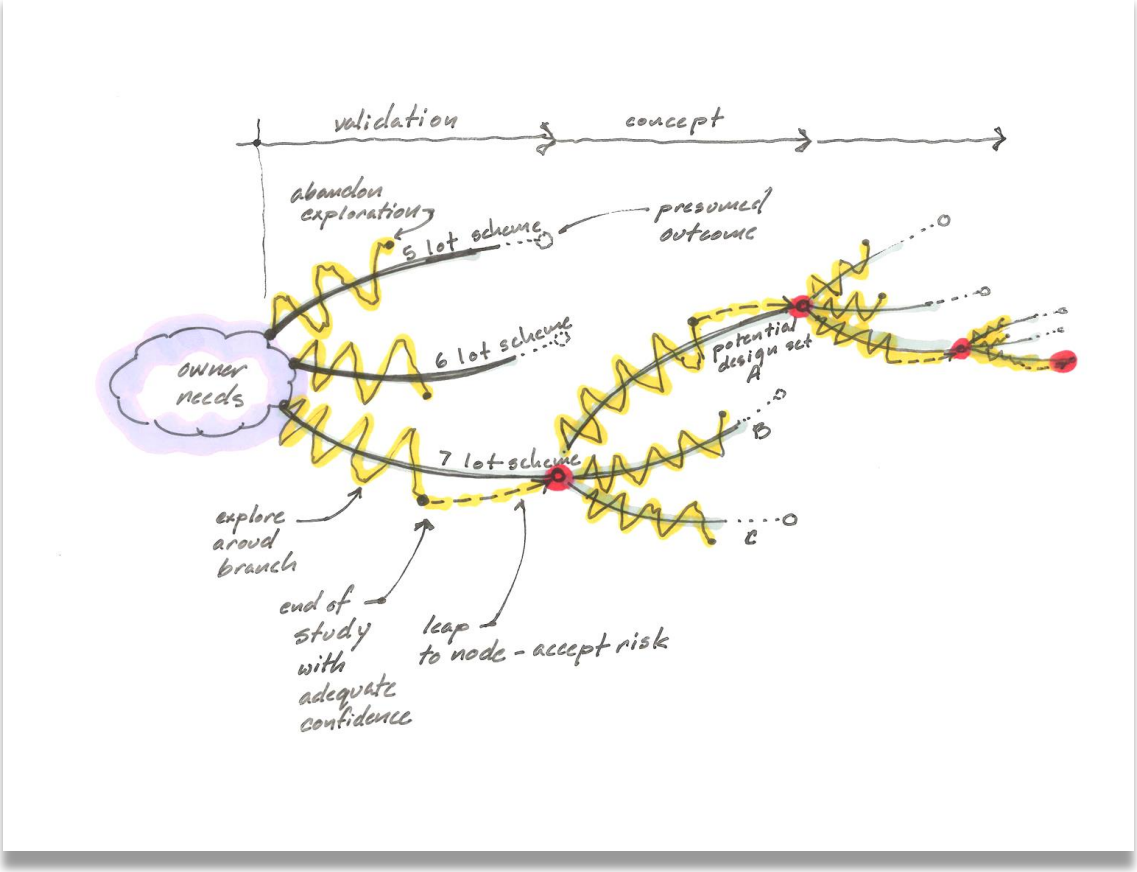
3. Economic situation, delivery method and schedule

What HEALTHCARE customers really need

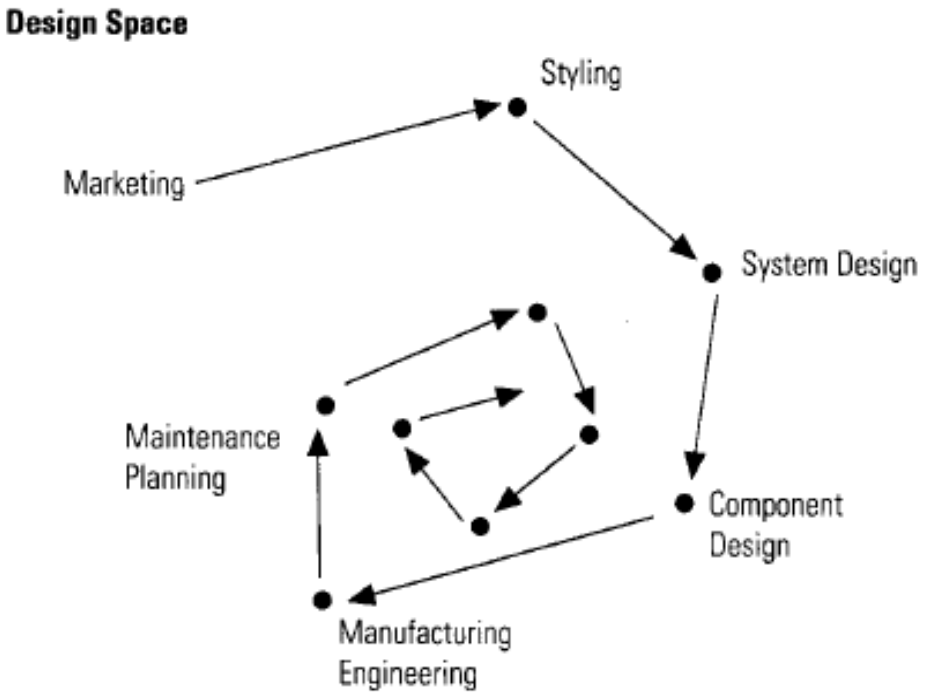


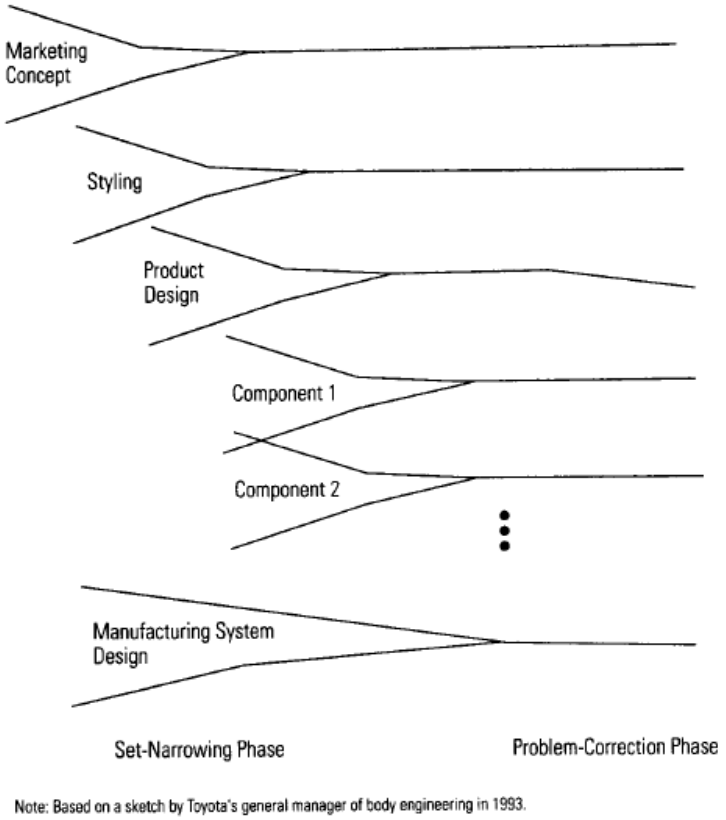
From Evans, et al. 1998

Working with design proposals: Set Based Design



Set-Based Design is not Point Based Design



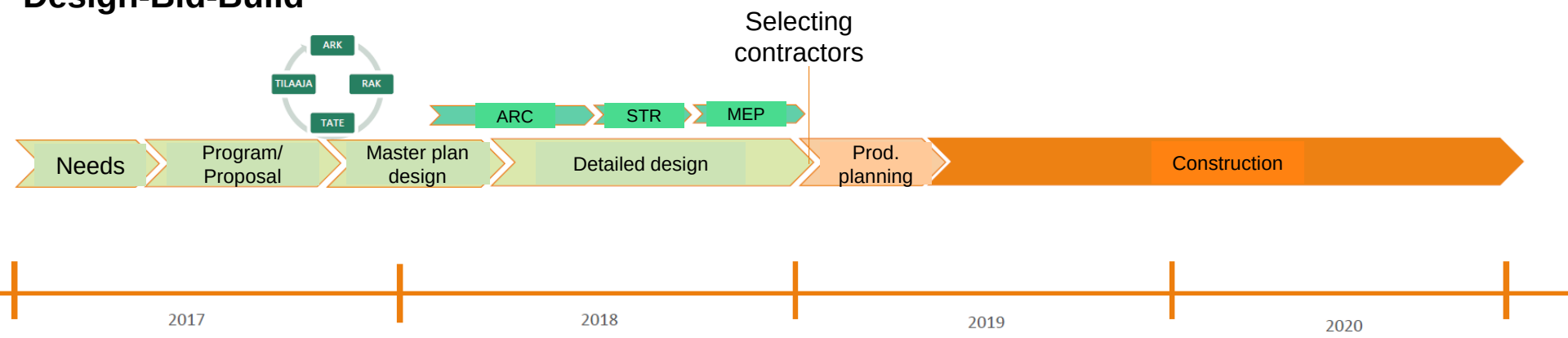


Point-Based Design **Set-Based Design**

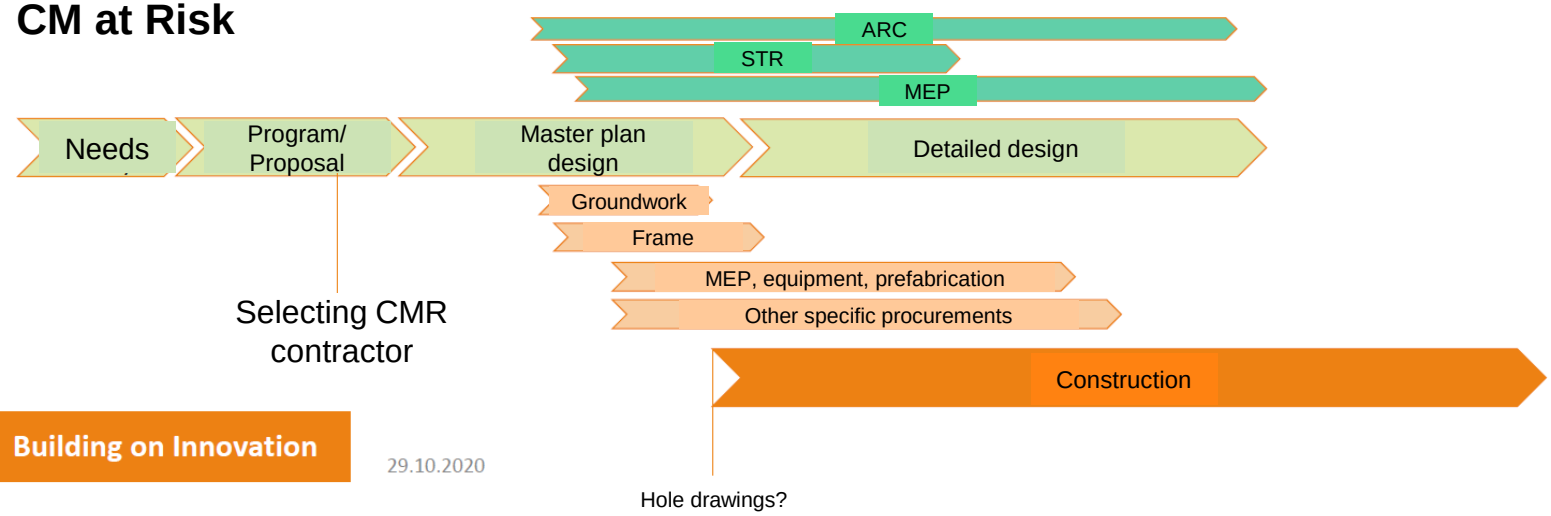
Figures from Ward et al. 1995

Design process in different projects

Design-Bid-Build



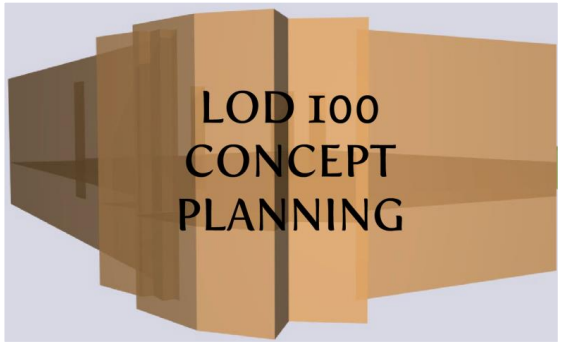
CM at Risk



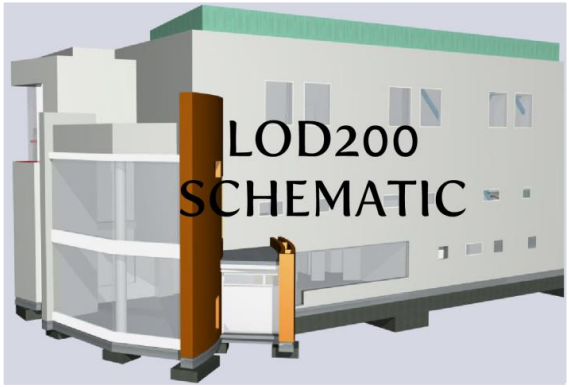
Granlund

Source: Juho Lepistö, Granlund

BIM - Level of Details (LOD*)



The building 3D model is developed to represent the information on basic level. Thereby, only conceptual model creation is possible in this stage. Parameters like area, height, volume, location and orientation are defined



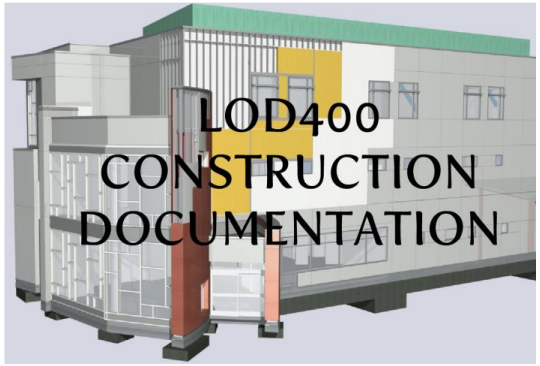
General model where elements are modeled with approximate quantities, size, shape, location and orientation. We can also attach non- geometric information to the model elements

**term Level of Development is also used*

BIM - Level of development (LOD)

LOD 300: Accurate modeling and shop drawings where elements are defined with specific assemblies, precise quantity, size, shape, location and orientation. Here too we can attach non- geometric information to the model elements

LOD 350: It includes model detail and element that represent how building elements interface with various systems and other building elements with graphics and written definitions



LOD 400: Model elements are modeled as specific assemblies, with complete fabrication, assembly, and detailing information in addition to precise quantity, size, shape, location and orientation. Non- geometric information to the model elements can also be attached

Linking the LODs with production

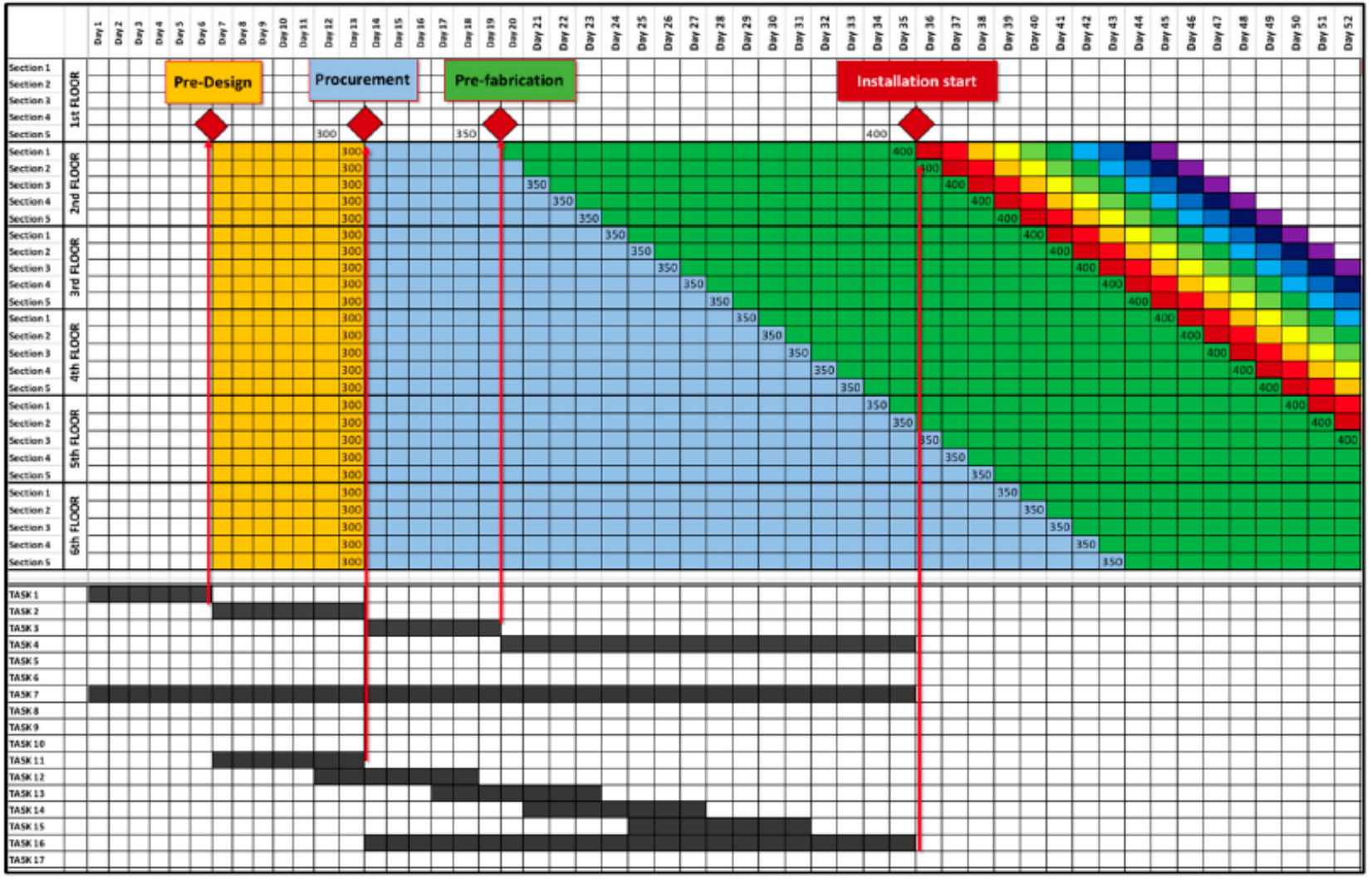


Figure 1. Linking the design LODs with the production takt time. Vertical axis presents locations and horizontal axis presents time.

Source: Uusitalo et a. (2019) Applying Level of Detail in a BIM-Based Project: An Overall Process for Lean Design Management, Buildings.

Target Value Design (TVD)

“to make a client’s value (specific design criteria, cost, schedule, and constructability) a driver of design”

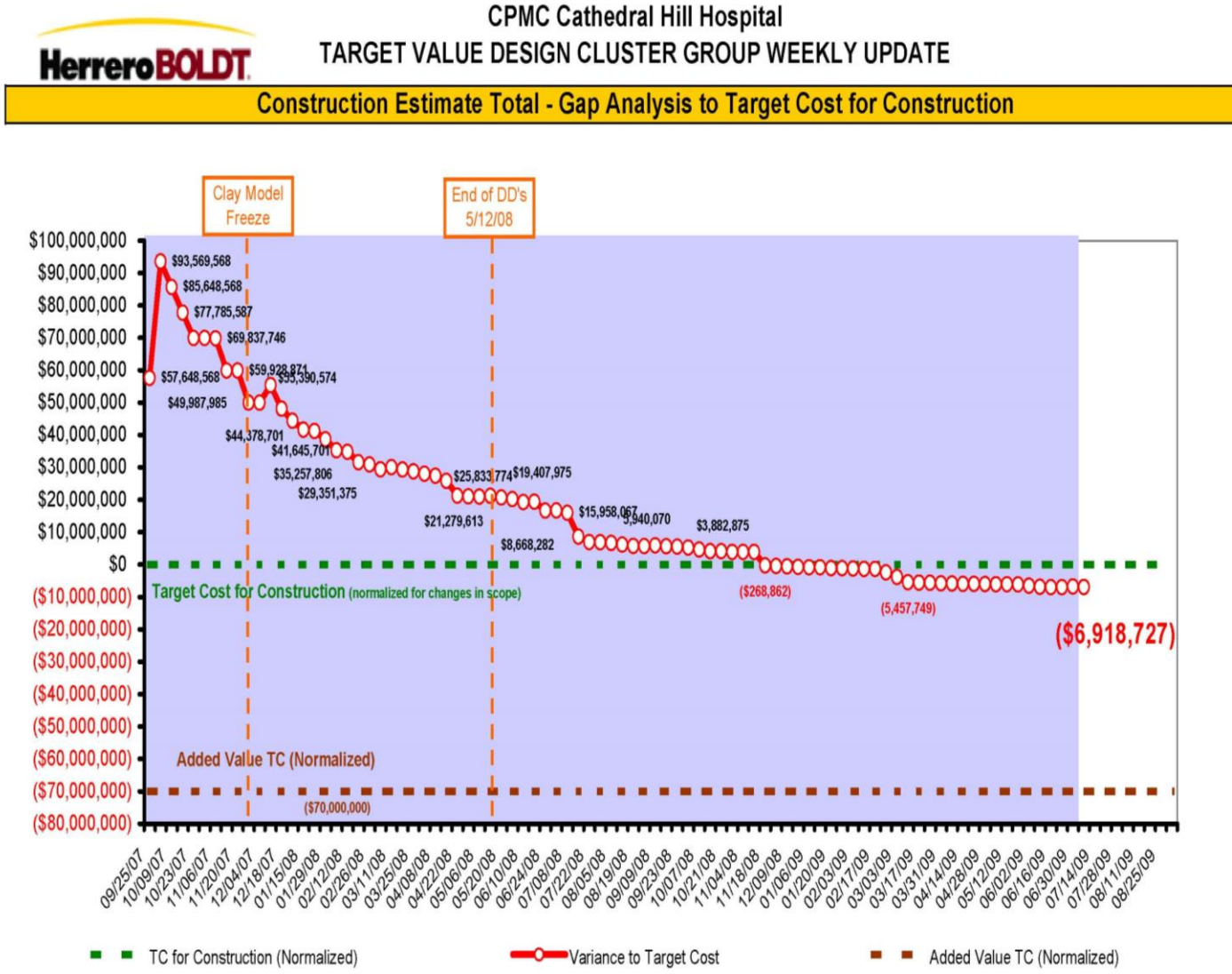
1. Setting project targets (not only costs!)
2. Aligning commercial interests
3. Bringing constructors onto the design team
4. Validating the business case
5. Governing the project
6. Steering design to target

In Finnish:
Target Value Design = Tilaajan tavoitteisiin suunnittelu

Target Value Design (TVD)

The cardinal rule: ***The Project's Target Cost shall never be exceeded without express approval of Owner.***

The budget becomes an influence on design and decision-making rather than an outcome of design.



Traditional vs. TVD

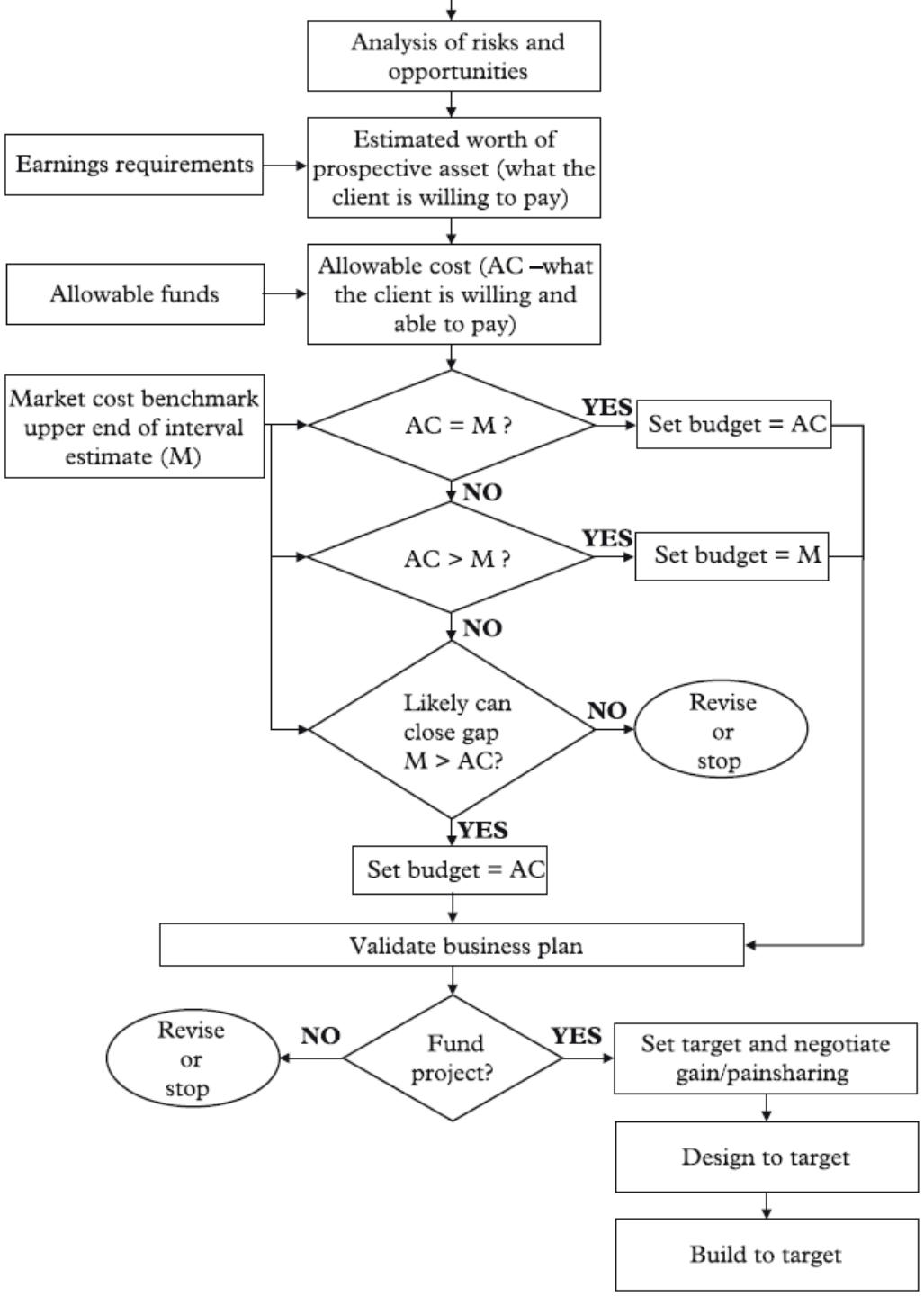
Traditional process

- Target set based on cost estimates (benchmarking)
- Cost target is for guessing the tender price
- Cost-based selection
- Designers design, Builders estimate and build
- Control cost with cost cutting measures
- Shift risks down the supply chain

TVD process

- Target set after a feasibility study (business case)
- Cost target is for final construction cost
- Value-based selection
- Design solutions developed with cost, schedule as design criteria
- Reduce price paid through gainsharing
- All-for-one, one-for-all, collaborative risk reduction

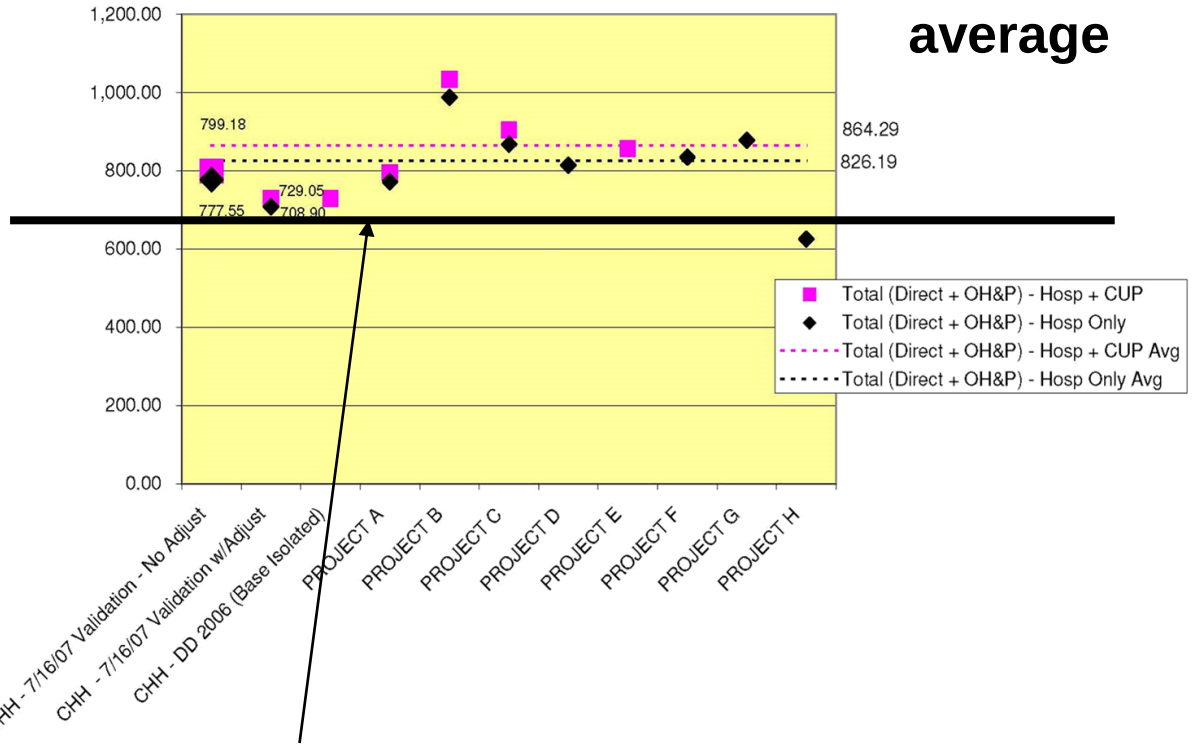
TVD process



Daria Zimina, Glenn Ballard & Christine Pasqure (2012) Target Value Design: using collaboration and a lean approach to reduce construction cost, Construction Management and Economics, 30:5, 383-398, DOI: 10.1080/01446193.2012.676658

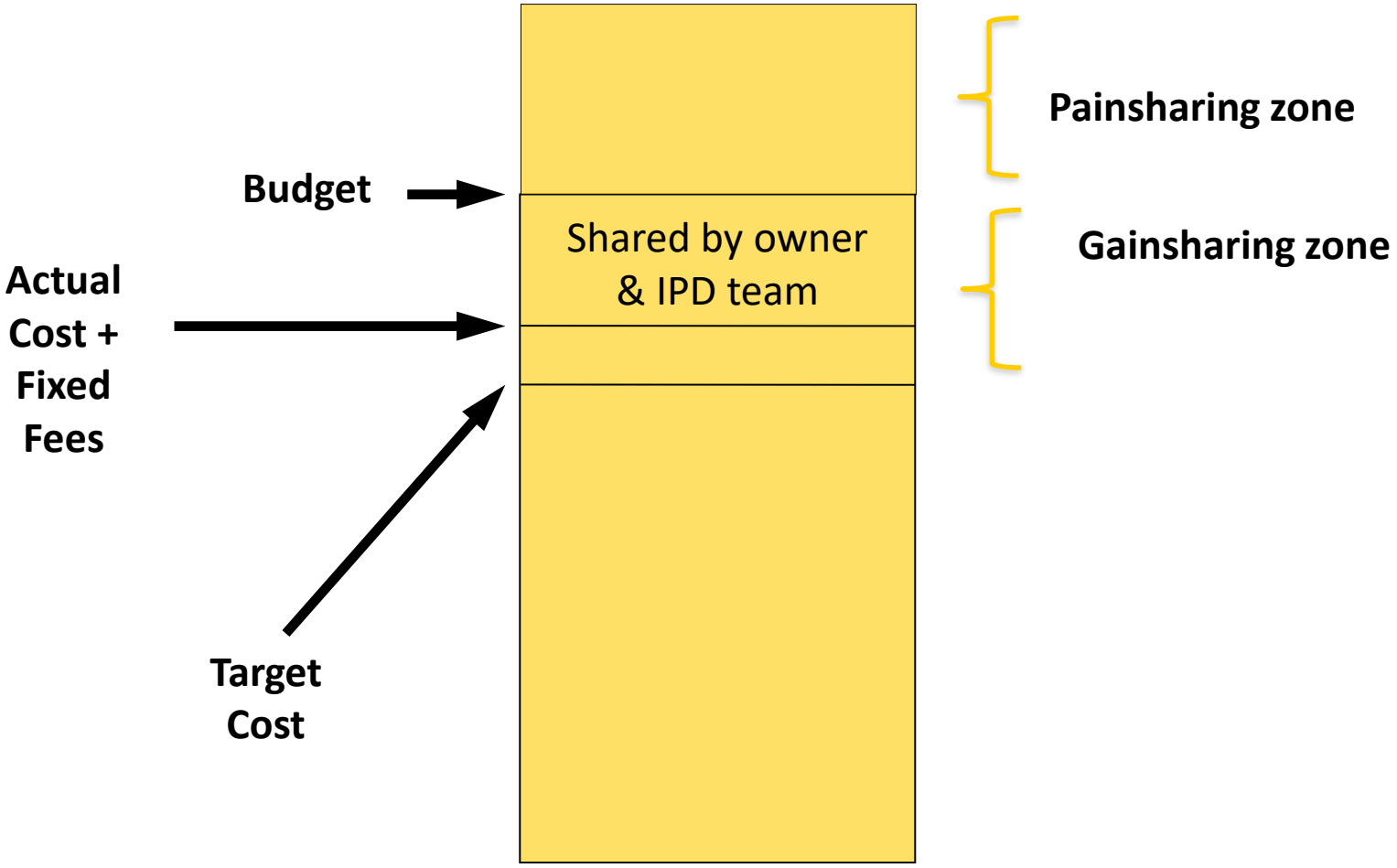
Setting the target cost and project schedule

Nine-project marketplace average



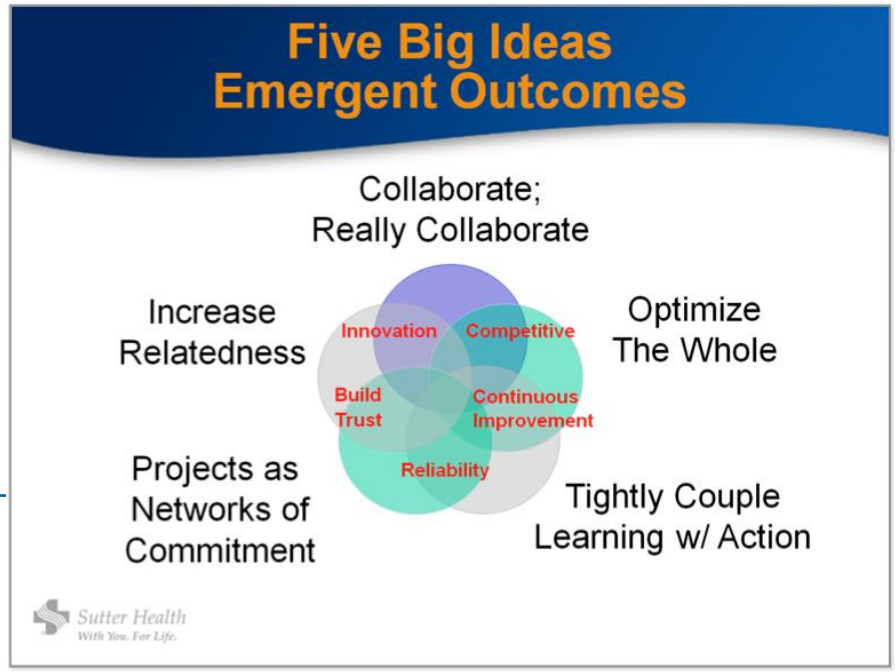
Target set 14% 'below' marketplace

Basic Commercial Model (IPD/Alliance)



Designing to the Target Cost

1. Allocate the target cost to systems, subsystems, components, …
2. Have cost modelers provide cost guidelines to designers up front, before design begins.
3. Incorporate value engineering/value management tools and techniques into the design process.
4. Use computer models to automate costing to the extent feasible.



Target Cost Model

Legend:	Const TOTAL per SF	D-B TOTAL per SF
Worth (Target)		
Current Estimate	89.33	94.12

Project: Fieldhouse Expansion
Location: St. Olaf College Northfield MN
Phase of Design: Schematic Target
Date: June 21, 2001

Construction	+	Owner Reserves	+	Escalation	=	Construction TOTAL	Design-Build TOTAL
9,840,302		343,115				10,183,417	10,729,883

Incl Design at $504,886+41600

NOTES:
Bldg. Type: Recreational
Target (SQFT): 114,000
Floors: Single story plus mezzanines

SITE WORK	BUILDING	SHELL	INTERIOR	MECHANICAL	ELECTRICAL	SPECIAL	GENERAL
594,500	9,245,802	4,334,488	1,710,386	1,111,402	794,890	706,862	587,774
Site GC OH&P							
G10 Site Prep. Demo & Excav		A10 Foundation A20 Basement	C10 Interior Construction	D20 Plumbing	D5010 Service and Distribution	E10 Specialties & Equipment	Z1010 Project Administration
146,500		1,006,004	528,427	85,927	739,390	492,534	
G20 Site Improvements		B10 Superstructure	C20 Stairs	D30 HVAC	D5020 Lighting & Branch Wiring	E20 Furnishings Fixed/Movable	Z1030 General Conditions
373,000		1,218,797	62,639	824,160		34,000	
G30+40 All Utilities		B20 Exterior Closure	C30 Interior Finishes	D40 Fire Protection	D5030 Security Comm/Data	F10 Special Construction	Z1060 Fee
75,000		2,007,061	1,069,320	109,740		89,520	
G90 Other Site Structures		B30 Roofing	D10 Conveying	Testing and Special Mech	D5090 Other Electrical	F20 Selective Demolition	Z20 Risk and Contingency
		102,626	50,000	91,575	55,500	90,808	587,774

TVD Design methods

Designing and detailing in co-op with the users

- Maintain attention on what the customer will value
- Leads to the situation where focus can be targeted to right things

Work in small and diverse groups

- Innovation and learning arises
- Group will be more solid
- Communication and coordination is easier

Big Room

- Impromptu sessions
- Short co-design sessions are necessary
- Different specialist in same room

Meeting at the end of each design cycle

- Feedback and summarize the learning (plus/deltas)

Working in Big Rooms

Traditional vs. TVD – design practices

Rather than estimate based on a detailed design, design based on a detailed estimate

Rather than evaluate the constructibility of a design, design for what is constructible

Rather than design alone and then come together for group reviews and decisions, work together to define the issues and produce decisions then design to those decisions

Rather than narrow choices to proceed with design, carry solution sets far into the design process

Rather than work alone in separate rooms, work in pairs or a larger group face-to-face

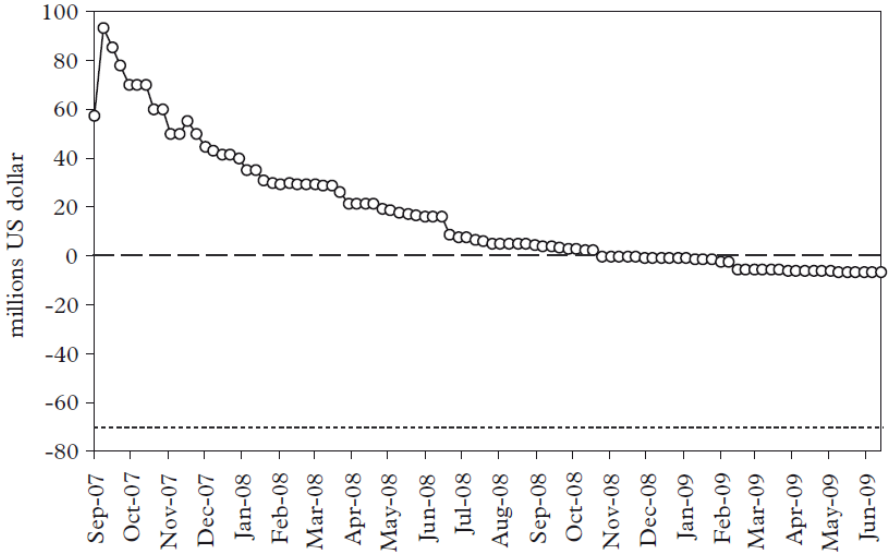
Macomber and Barberio 2007

Example – Cathedral Hill Project

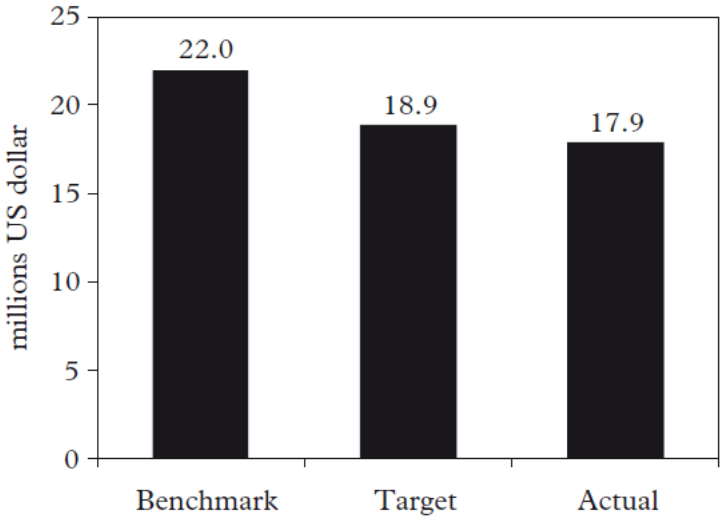
- **13-story, 274 bed acute care hospital**
- **Located in San Francisco, tight site surrounded by four main streets**
- **Originally $400 M over budget**
- **2006: new team selected using IPD / TVD**
- **Goal 90% of original scope in 70% of space**
- **LEED Silver certification**

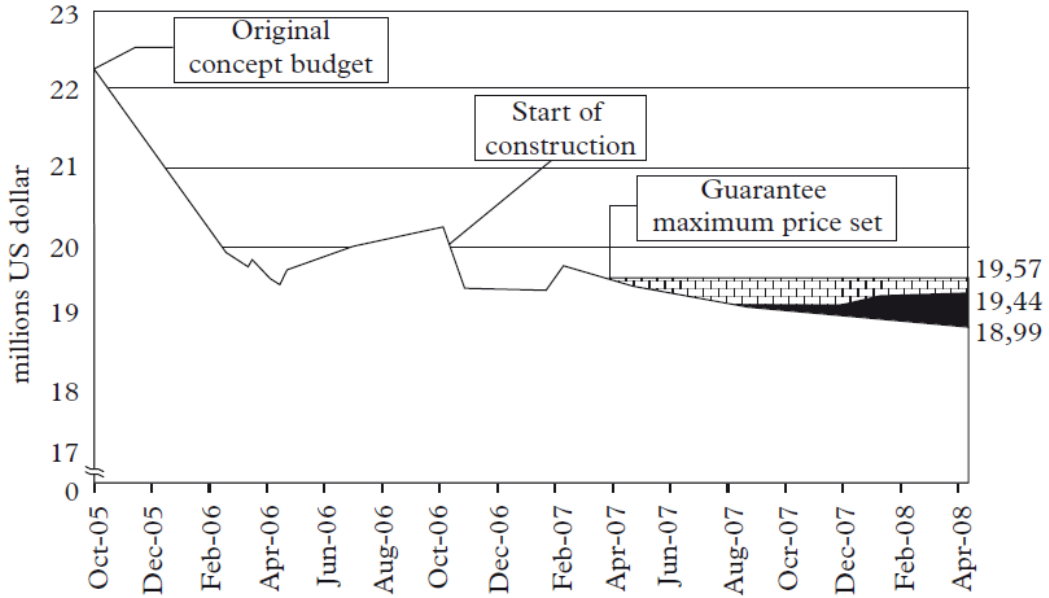
Cathedral Hill

- **Feasibility study - $60M over budget**
- **Team agreed to reduce the gap**
- **Gap eliminated in 14 months**
- **Target cost set $70M below the budget**
- **Finally estimated close to target**



Fairfield Medical Office Building





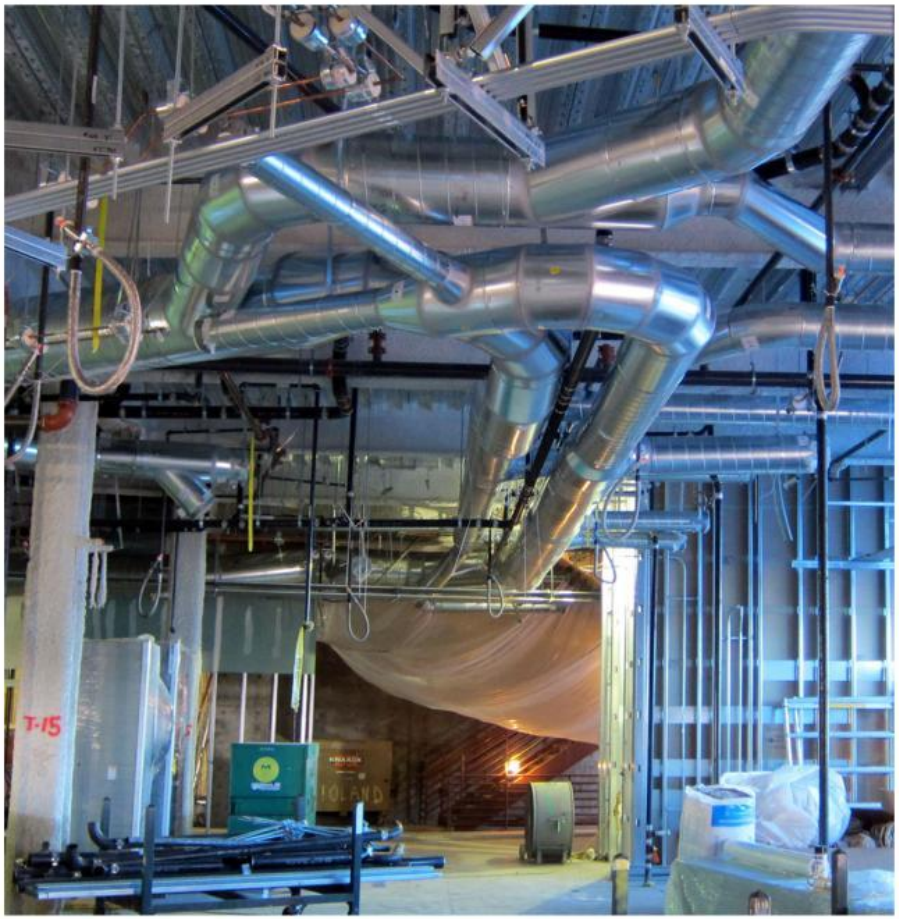
- **Black area – cost savings invested in value-adding features of the facility**

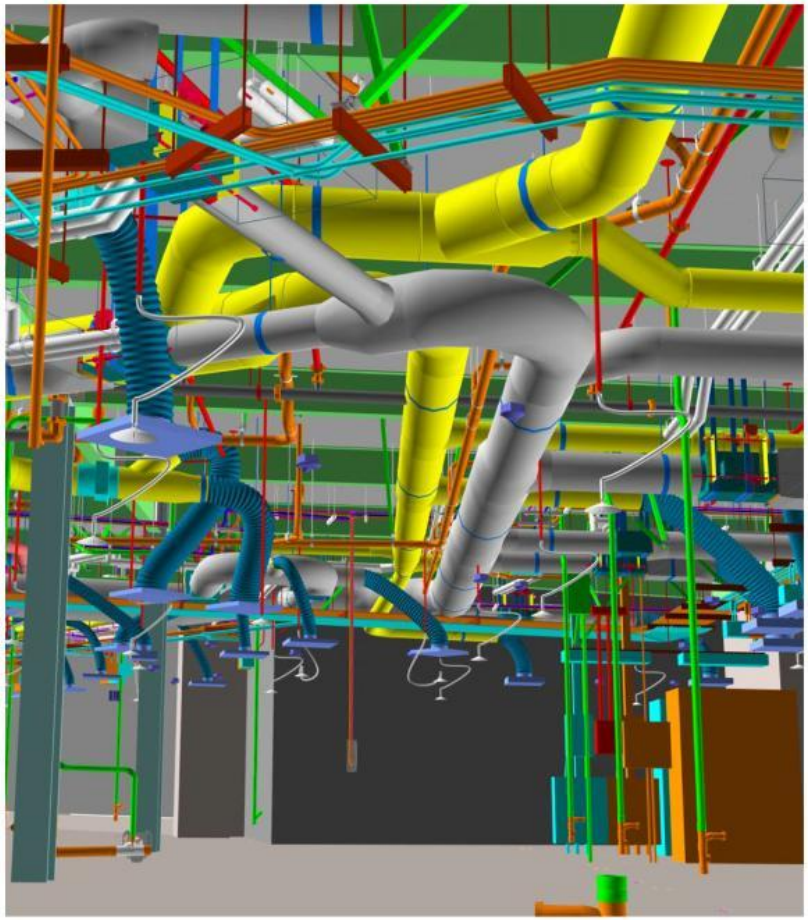
Source: Daria Zimina, Glenn Ballard & Christine Pasquire (2012) Target value design: using collaboration and a lean approach to reduce construction cost. Construction Management and Economics, 30:5, 383-398.

Performance – Eden Medical Center

- Ahead of schedule and under budget
- No compromise to space program or sustainability goals
- Construction rework 15-80% less than trade baselines
- Productivity 5-20% greater than trade baselines
- Mechanical/Plumbing installed exactly to the model 99% of the time
- Electrical installed exactly to the model 71% of the time
- Framing installed exactly to the model 79% of the time
- Fewer RFI's, Change Orders and failed inspections than Sutter 'legacy' projects
- 'Tool time' significantly higher than industry standards

Eden Medical Center – adherence to the model





Examples of successes

- **Normal result = 15% decrease (Zimina et al. 2012)**

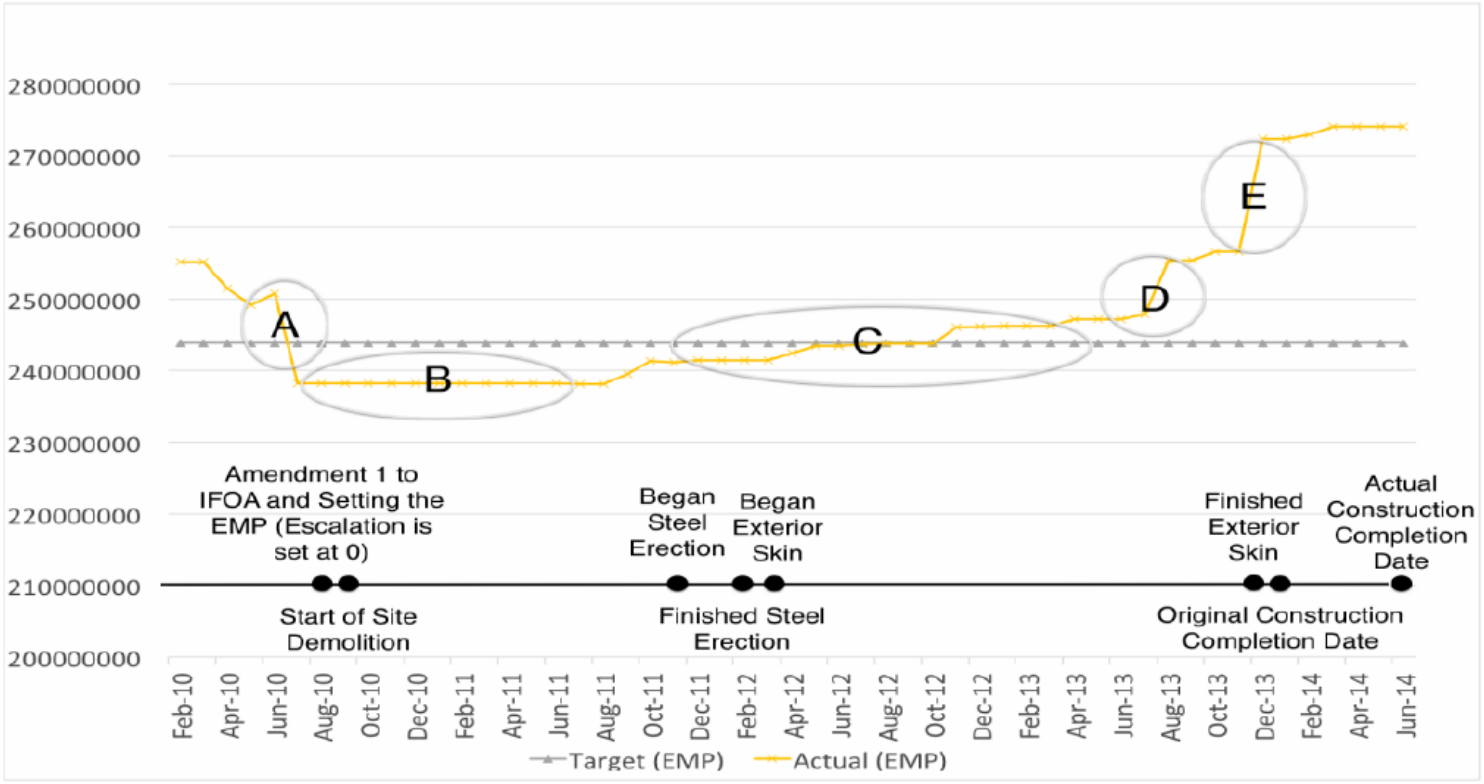
#	Project size, 000 SF (Square Feet)	Stage	Market unit cost (benchmarked or expected), doll. per SF	Target unit cost set for designing, doll. per SF	Final unit cost (current estimate if below target), doll. per SF	Improvement in % (realized or targeted)
1	114.0	Completed	119.0	n/a	103.0	13
2	230.0	Completed	96.0	n/a	78.0	19
3	75.4	Completed	180.0	n/a	149.0	18
4	477.0	Construction documents	440.0	n/a	393.0	11
5	368.9	Completed	266.0	n/a	242.0	9
6	30.0	Completed	483.0	n/a	457.0	6
7	231.9	Construction	1332.0	989.0	n/a	26
8	925.0	Construction documents	1200.0	1039.0	n/a	13
9	869.0	Construction documents	2085.0	1825.0	n/a	12
10	233.1	Design development	1342.0	1268.0	n/a	6
11	107.0	Design development	2626.0	2336.0	n/a	11
12	101.9	Construction	1601.0	1062.0	n/a	34

However, 15% of IPD/TVD projects fail

- **Example, 25,000 m2 patient care pavilion**
  - An addition to an operating hospital
  - 238 medical beds with 11 floors above grade and 2 floors below grade
  - Estimated Maximum Price was $251 M
  - Project completed 6.4% over budget, no profits for risk pool members

- Source: Ballard, G., Dilsworth B., Do D., Mobley J., Phillips P., Reed D., Sargent Z., Tillman P., Wood N. (2015) How to Make Shared Risk & Reward Sustainable. In: *Proc. 23rd Ann. Conf of the Int'l Group for Lean Construction. Perth, Australia, July 29-31, pp. 257-266, available at www.iglc.net*

Failed project – construction phase



Countermeasures?

- **Share allowable cost**
- **Revalidate when the scope changes**
- **Involve the right people at the earlier responsible moment**
- **Require the same level of evidence for cost decreases as for cost increases**
- **Shared governance**
- **Transparent productivity monitoring**
- **Reduce future cost by spending wisely now**

- Source: Ballard, G., Dilsworth B., Do D., Mobley J., Phillips P., Reed D., Sargent Z., Tillman P., Wood N. (2015) How to Make Shared Risk & Reward Sustainable. In: *Proc. 23rd Ann. Conf of the Int'l Group for Lean Construction. Perth, Australia, July 29-31, pp. 257-266, available at www.iglc.net*

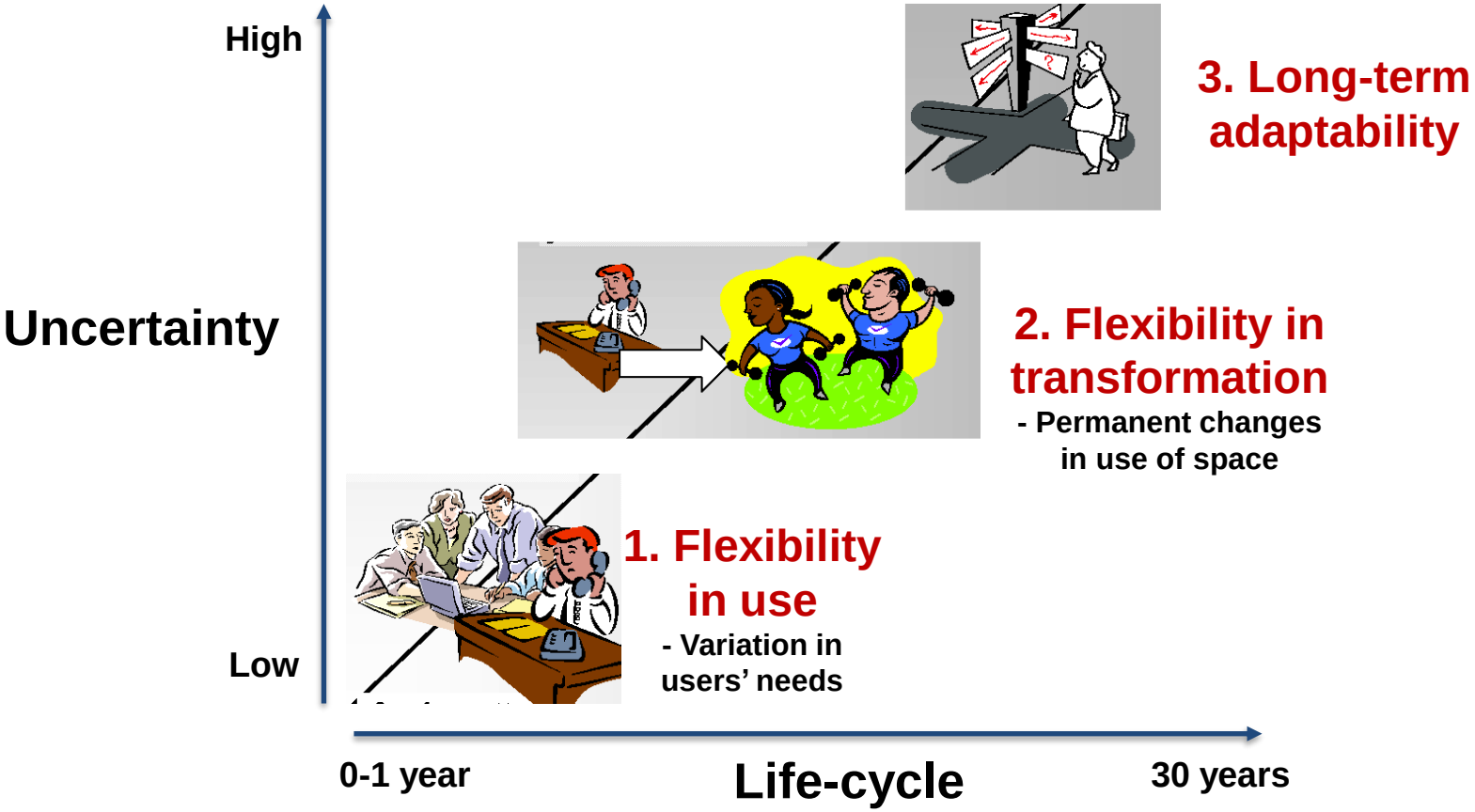
Further readings

- **Zimina et al. (2012) Target value design: using collaboration and a lean approach to reduce construction cost. Construction Management and Economics (May 2012) 30, 383–398.**

- **TVD in Finnish:**
  - http://lci.fi/blog/menetelmakortti/tilaajan-tavoitteisiin-suunnittelu-target-value-design-tvd/

Design for flexibility

Building life-cycle and flexibility



Flexibility should be taken into account in a very early stage of design

- **Flexibility in use; Flexibility in technology**

- **Multi-functional buildings and spaces**
  - School, daycare, library…
  - Office, dwelling…

- **Can some functions be located in other buildings or be outsourced?**
- **Can some spaces be used by other users? → Future reserve**

- **Flexibilities should be defined according to anticipated needs**

Open building philosophy: Fixed structure, flexible space

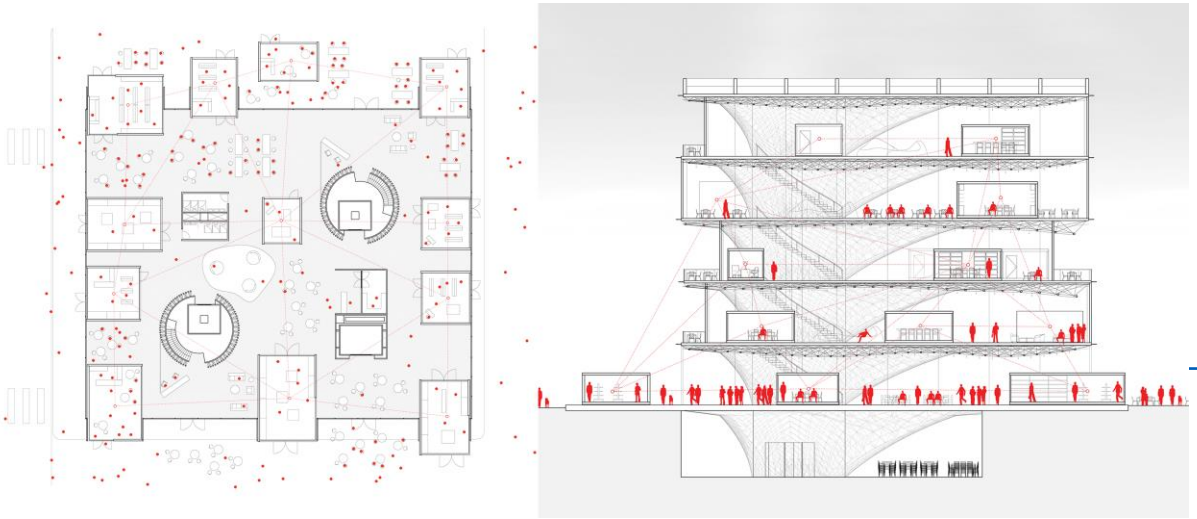
- **The idea that**
  - Built environment is in constant transformation, and that, as a consequence, change must be recognized
  - Built environment is the product of an ongoing, never ending design process in which environment transforms part by part
- **The idea of**
  - Distinct levels of intervention in the built environment, such as those represented by 'support' (or 'base building'), and 'infill' (or 'fit-out')
  - Users/inhabitants may make design decisions in their sphere of control, as well as professionals
  - The interface between technical systems allows the replacement of one system with another performing the same function (e.g. from different suppliers)

Base building and fit-out

- **Fixed base building**
  - Fixed spaces
  - Fixed structure:
    - *spans, loading capacity, room height…*
  - Fixed technical building services

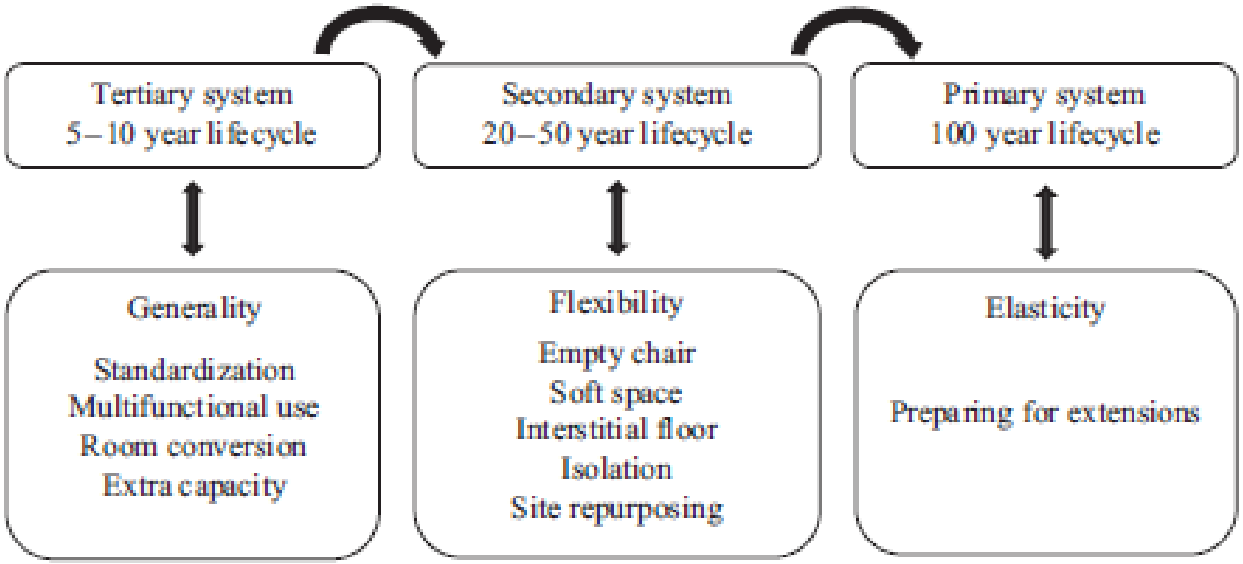
- **Flexible fit-out**
  - Dividend to separable spaces
  - Space characteristics: use and conditions

- **Flexible fit-out spaces can be modified without changes in the fixed base building**



Source: https://medium.com/built-horizons/metabolism-s-spatial-flexibility-in-the-21st-century-d7cef8aaaf84

Framework of adaptability strategies: Generality, Flexibility, Elasticity



Source: Riikka Kyrö, Antti Peltokorpi, Lauri Luoma-Halkola, (2019) "Connecting adaptability strategies to building system lifecycles in hospital retrofits", *Engineering, Construction and Architectural Management*, https://doi.org/10.1108/ECAM-10-2017-0217

Summary of the lecture

- **Nature of design**
- **Design process in different projects**
- **Target value design:**
  - The budget becomes an influence on design and decision-making rather than an outcome of design
- **Design for flexibility**
  - Improving lifecycle value of buildings through use and technical flexibility

Weekly assignment II

- **Work independently**
- **Read Uusitalo et al. (2017) article "Review of Lean Design Management: Processes, Methods and Technologies"**
  - Uusitalo, P. , Olivieri, H. , Seppänen, O. , Pikas, E. & Peltokorpi, A. 2017, 'Review of Lean Design Management: Processes, Methods and Technologies' In:, *25th Annual Conference of the International Group for Lean Construction*. Heraklion, Greece, 9-12 Jul 2017. pp 571-578
- **Familiarize with the presented 16 attributes of Lean Design Management and write an individual max 500 word report on your own reflections about the three most potential attributes to solve design management problems:**
  - Why these three are the most potential?
  - What design management problems they could solve and how?
  - What challenges there are to apply those attributes?
- **Return your assignment as word/pdf report through MyCourses no later than 17.11**