Aalto University

Cost estimating in construction

CIV-E1040 Construction Management

Lecture IIIb

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Previous 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

Agenda

- **Cost estimating methods**
  - Conceptual estimating
  - Element -based estimating
- **Cost estimation process**
- **Evolutionary estimating**
- **Use of parametrics and BIM**

Why budgeted costs are exceeded?

Olkiluodon uusi voimala on jo kalliimpi kuin yksikään pilvenpiirtäjä

Luksuskasinoiden ja pilvenpiirtäjien hinta kalpenee Olkiluodon uuden ydinvoimalan rinnalla

TALOUS 2.4.2014 2:00 Päivitetty: 2.4.2014 5:39

Juhani Saarinen HELSINGIN SANOMAT

JUSSI PARTANEN

Olkiluodon kolmatta voimalayksikköä rakentavan Arevan mukaan se on 86-prosenttisesti valmis.

Olkiluodon ydinvoimala kipuaa yhä korkeammalle maailman kalleimpien rakennusten listalla.

Alun perin Olkiluodon kolmannen ydinreaktorin piti maksaa noin 3 miljardia euroa, mutta rakentamisen lopullisen hinnan on arvioitu nousevan 8,5 miljardiin.

KOTIMAA

Länsimetro valmistuu elokuussa - kustannukset ylittyivät yli neljänneksellä

SAMI METELINEN 7.3.2016 klo 17:29 (päivitetty 7.3.2016 klo 20:16)

Länsimetron kahdeksan asemaa ja 14 kilometriä pitkä ratalinja Matinkylään aukeaa liikenteelle 15. elokuuta.

Tapiolan metroaseman rullaportaat. (Lehtikuva/Martti Kainulainen)

Länsimetron rakentaminen alkoi louhintatöillä marraskuussa 2009. Tunnelilouhinnat saatiin päätökseen helmikuussa 2014 ja kiskotus valmistui joulukuussa 2015. Nyt metrolinja on valmis testausta varten.

Länsimetro on työllistänyt louhintojen ja rakentamisen aikana noin 1 500 rakentajaa ja henkilötyövuosia kertyy noin 4 500. Hankkeen loppukustannusennuste on 1 088 miljoonaa euroa. Länsimetron hankesuunnitelmassa hankkeen kustannuksiksi arvioitiin 713,6 miljoonaa euroa (2007 hintatasossa). Indeksikorotus huomioiden kustannusarvio oli 848,0 miljoonaa euroa. Kustannukset ovat ylittymässä hankesuunnitelman mukaisesta laajuudesta 240 miljoonaa euroa eli 28,3 prosenttia.

Why are construction project costs exceeded?

- Project schedule is extended due to too optimistic original schedule or problems in execution, leading to cost inflation
- Customer changes his/her mind about the scope or quality during the project which leads to additional costs
- Risk is shifted to a party who is unable to control a specific risk, and project cost will likely increase
- Unforeseen events and conditions, such as weather-related incidents or bad soil conditions
- Human bias and optimism to underestimate costs in early phase of the project
- Poor cost estimating practices and processes

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Five things you should know about cost overrun☆

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ARTICLE INFO

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Cost underestimation
Cost forecasting
Root causes of cost overrun
Behavioral science
Optimism bias
Strategic misrepresentation
Delusion
Deception
Moral hazard
Agency
Reference class forecasting
De-biasing

ABSTRACT

This paper gives an overview of good and bad practice for understanding and curbing cost overrun in large capital investment projects, with a critique of Love and Ahiaga-Dagbui (2018) as point of departure. Good practice entails: (a) Consistent definition and measurement of overrun; in contrast to mixing inconsistent baselines, price levels, etc. (b) Data collection that includes all valid and reliable data; as opposed to including idiosyncratically sampled data, data with removed outliers, non-valid data from consultancies, etc. (c) Recognition that cost overrun is systemically fat-tailed; in contrast to understanding overrun in terms of error and randomness. (d) Acknowledgment that the root cause of cost overrun is behavioral bias; in contrast to explanations in terms of scope changes, complexity, etc. (e) De-biasing cost estimates with reference class forecasting or similar methods based in behavioral science; as opposed to conventional methods of estimation, with their century-long track record of inaccuracy and systemic bias. Bad practice is characterized by violating at least one of these five points. Love and Ahiaga-Dagbui violate all five. In so doing, they produce an exceptionally useful and comprehensive catalog of the many pitfalls that exist, and must be avoided, for properly understanding and curbing cost overrun.

Cost estimating: purpose and methods

Cost estimating during project lifecycle

1. Steering customer

2. Steering designers

3. Procurement & Contractor's tender

List and volume of functions

Room program

Massing

Structures

Materials

Contracts

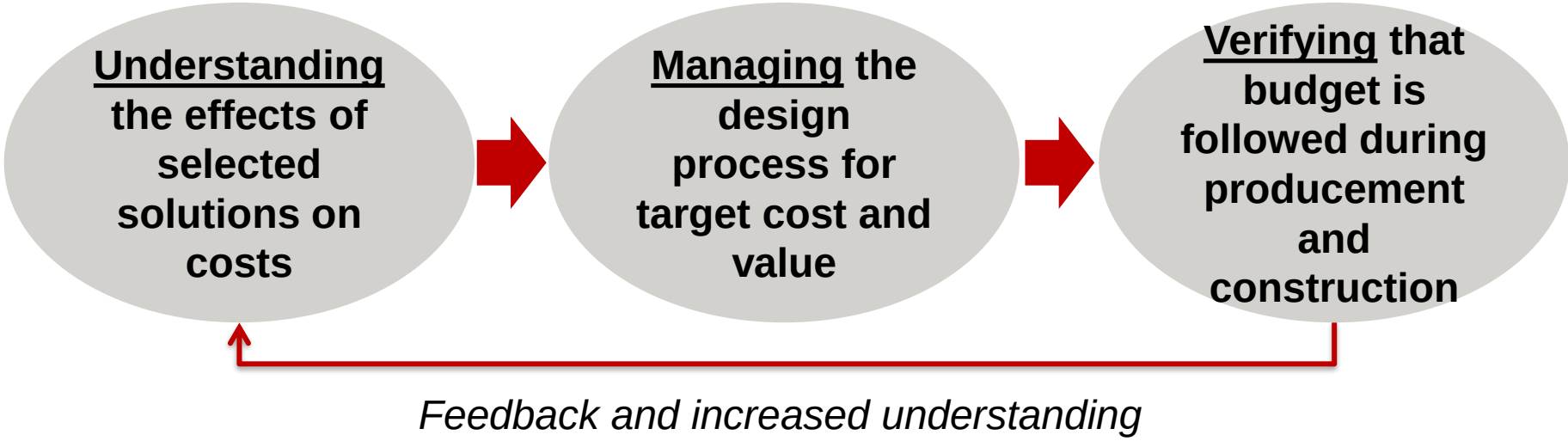
+ Cost control

***A. Conceptual estimating* for feasibility and target cost**

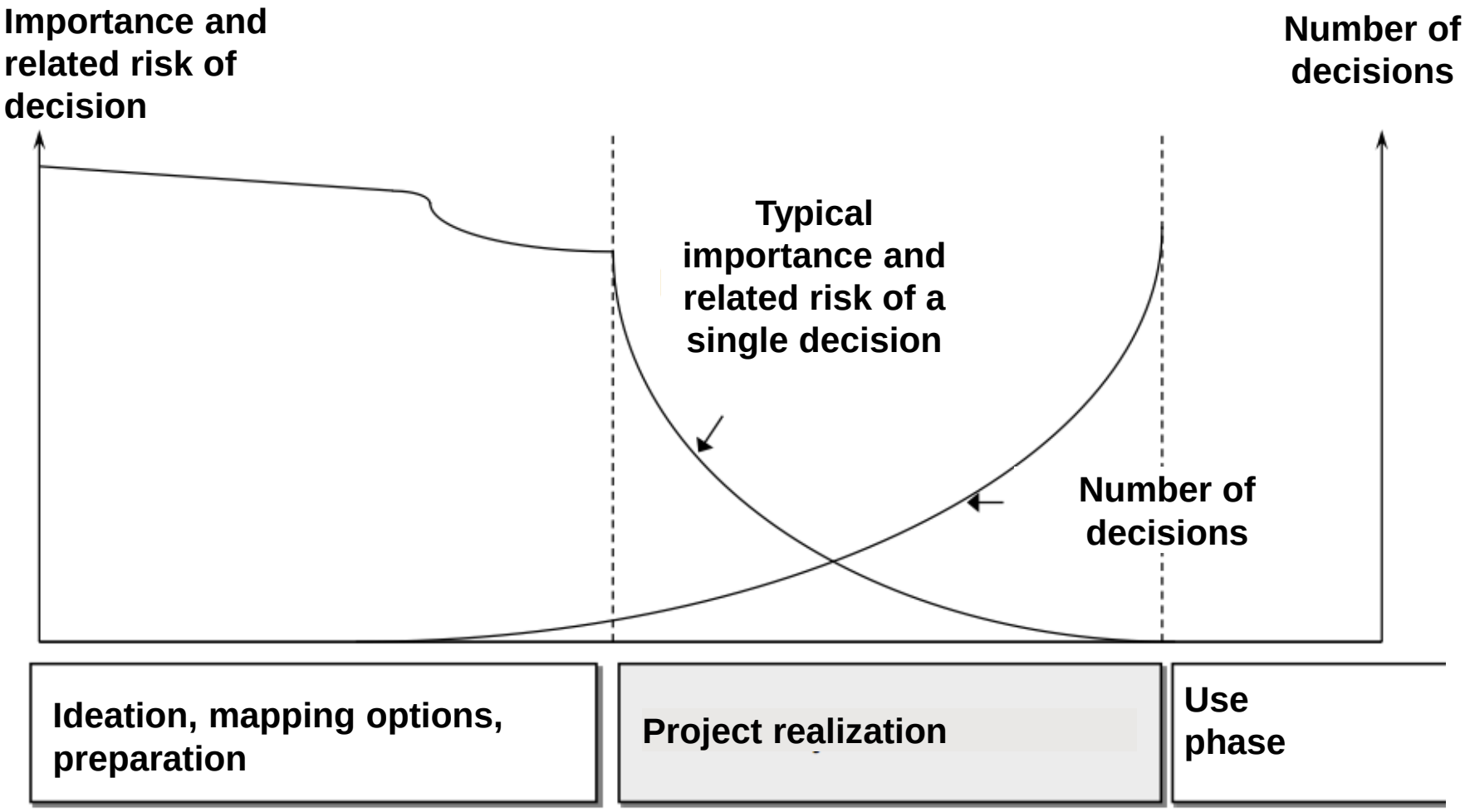
***B. Element -based estimating* using bill of quantities (BOQ)**

Cost management in construction

Mastering the three interrelated areas:

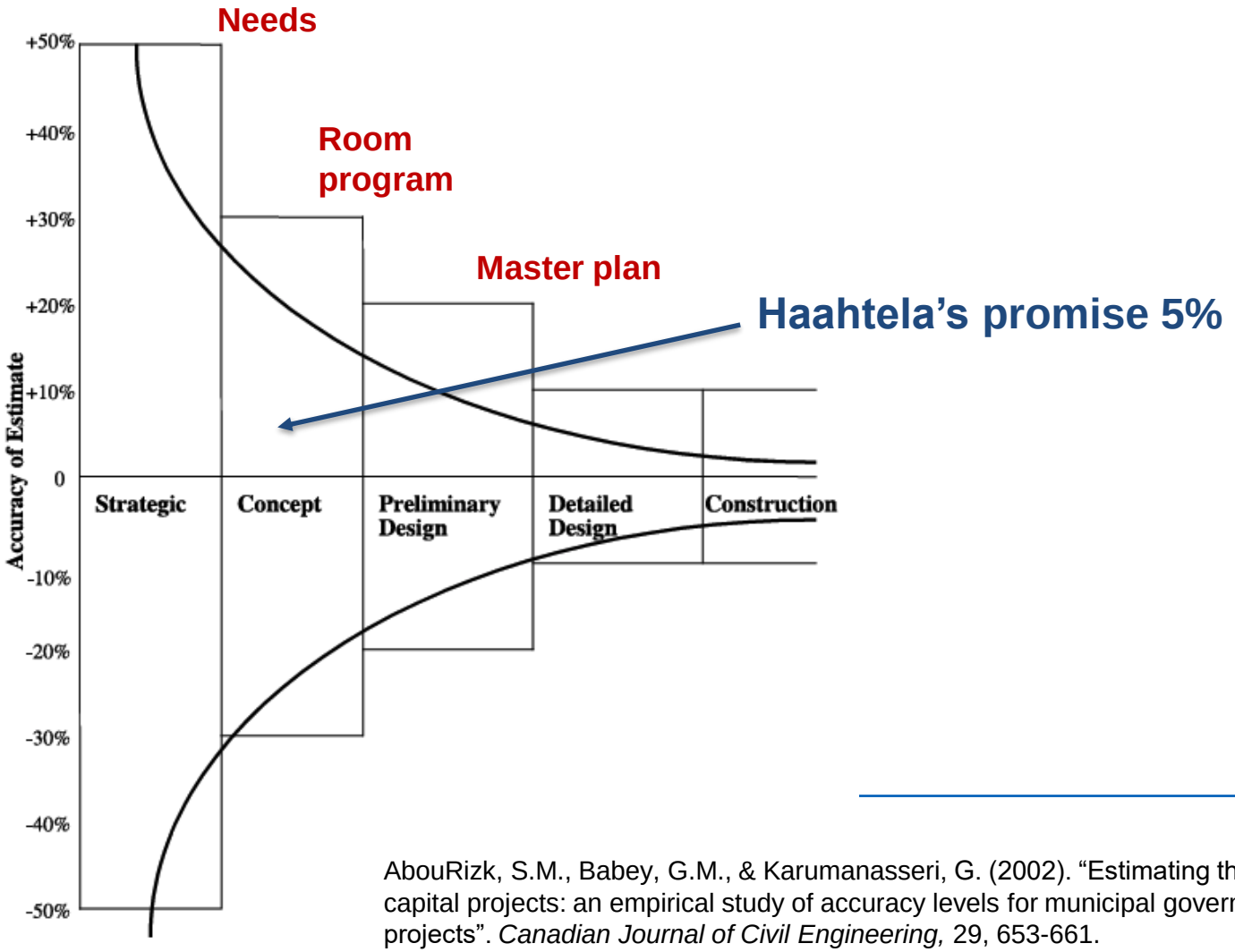


Project decisions and their importance



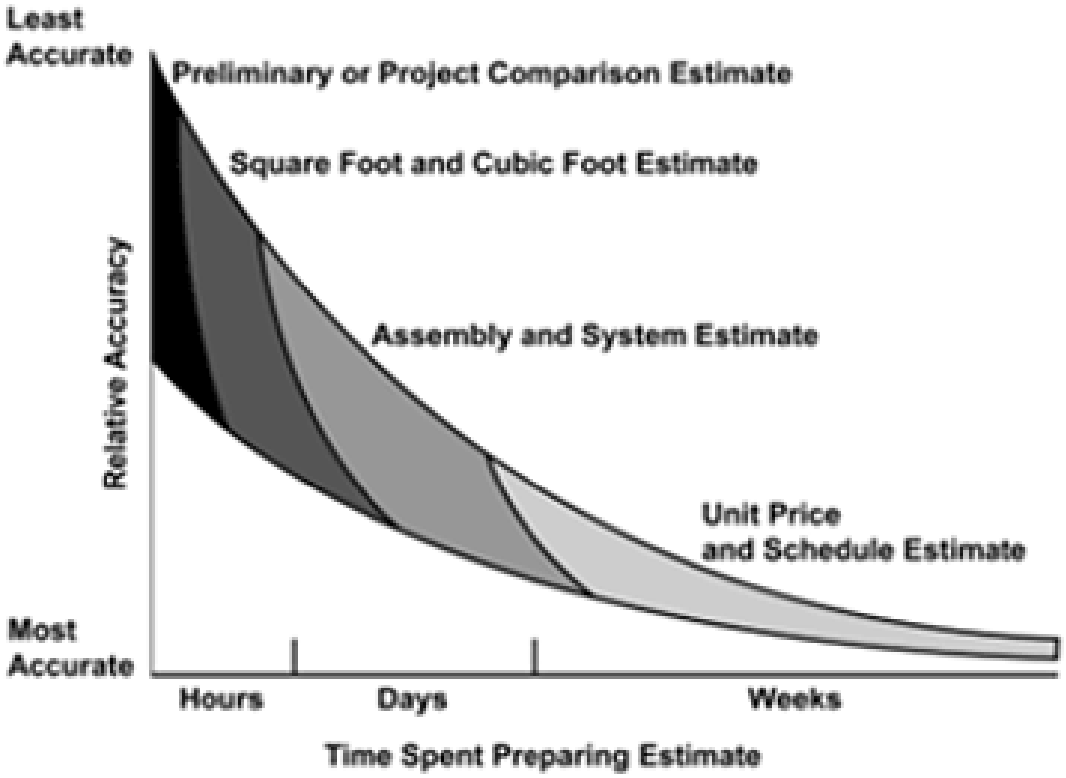
Source: Karlos Artto, Aalto University

Accuracy of cost estimates at different stages of the design



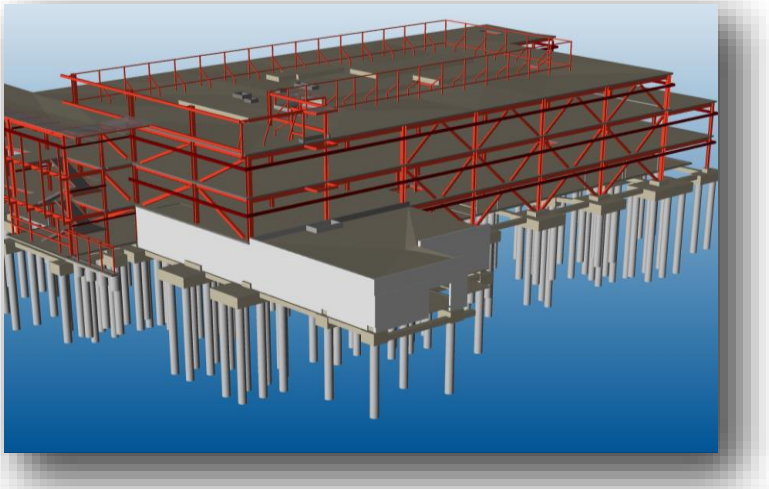
AbouRizk, S.M., Babey, G.M., & Karumanasseri, G. (2002). "Estimating the cost of capital projects: an empirical study of accuracy levels for municipal government projects". *Canadian Journal of Civil Engineering,* 29, 653-661.

Accuracy and workload of estimation methods



Source: From Concept to Bid...Successful Estimating Methods by John D. Bledsoe

Evolutionary Estimating



Target € | € / M2 | € / SYS | € / Element | € / Activity | € / Unit

Conceptual estimating

- **Based on programmatic data *prior* to design**
- **Programmatic data includes what is wanted**
  - Functionalities, capacities, and features of the desired asset, where and when
- **Conceptual estimating:**
  1. Programming: defining what is to be estimated,
  2. Translation of the program into entities for which cost data is available (cost modeling)
  3. Applying that cost data

Ballard and Pennanen (2013) Conceptual estimating and target costing, IGLC.

Approaches to conceptual estimating

- Allowable cost / business case
- Space-based estimation
- Multi-parametric estimation models
- Reference project method
- Cost difference method (from reference project)
- Use of statistic data

Use of multi-parametric estimation models in early phase

$$P = \left(\sum_{i=0}^{n} (2 + 0.15i) f_i + \sum_{i=0}^{n} p_i s_i + 2 \sum_{j=0}^{m} f'_j + 2.5 \sum_{j=0}^{m} p'_j s'_j + r \right) \cdot R$$

where

P = the forecasted price;

R = the unit rate;

fi = the floor area at i storeys above ground;

pi = the perimeter of the external wall at i storeys above ground;

si = the storey height at i storeys above ground;

n = the total number of storeys above ground level;

m = the total number of floors below ground level;

f′j = the floor area at j floors below ground level;

p′j = the perimeter of the external wall at j storeys below ground level;

s′j = the storey height at j storeys below ground level;

and r = the roof area.

What is the optimal number of storeys above ground?

Source: Cheung and Skitmore, 2006. A modified storey enclosure model

Hospital building
Region: Finland, Uusimaa

Space-based estimation

Total: - €

		In English	In Finnish	Quantity	m2/a	total	Function / Space category	Price / m2	Total price
	1	LOBBY AND PUBLIC FACILITIES							
P	1	Lobby Office	Aulatoimisto	1	50	50			- €
P	2	Info	Info	1	30	30			- €
P	3	Walk-in lobby features	Walk-in-aulatoiminnot	1	300	300			- €
P	5	Recruitment	Työhönotto	3	7	21			- €
P	6	Quiet room	Hiljentymistila	1	60	60			- €
Y	1	Checkroom	Vaatesäilytys	1	50	50			- €
Y	2	Toilets	WC	2	4,5	9			- €
Y	3	Toilets	WC	1	6	6			- €
V	1	Entrance hall	Tuulikaappi	1	20	20			- €
A	1	Cleaning Rooms	Siivoushuone	1	15	15			- €
A	1	Kitchen	jakelukeittiö	1	20	20			- €
H	1	Job Lunch Restaurant Hall	Työpaikkalounasravintolasali	1	80	80			- €
H	1	Toilets	WC	2	4,5	9			- €
	2	COMMERCIAL SERVICE FACILITIES							
U	1	Business space	Liiketila	4	35	140			- €
U	2	Business space	Liiketila	1	80	80			- €
U	3	Social space	Sosiaalitila	7	3	21			- €
U	4	Storeroom	Varasto	7	3	21			- €
U	5	Cleaning room	Siivoustila	7	1	7			- €
	3	RESTAURANT							
U	1	Restaurant Hall	Ravintolasali	1	150	150			- €
U	3	Dry storage	Kuivavarasto	1	6	6			- €
U	4	Cold storage	Kylmävarastot	1	10	10			- €
U	5	Manufacture Space	Valmistus	1	30	30			- €
U	6	Presentation space	Esillepano	1	30	30			- €
U	7	Dishwashing	Astianpesu	1	25	25			- €
U	8	Office	Toimisto	1	10	10			- €
U	9	Waste room	Jätetila	1	3	3			- €
U	10	Equipment storage	Tarvikevarasto	1	3	3			- €
U	12	Cleaning room	Siivous	1	3	3			- €
U	11	Dressing Room	Puku-	2	3	6			- €
U	13	Toilets	HK-WC	2	2,5	5			- €

Example of Haahtela's price index for spaces

AVOITEHINNAT - TARGET PRICES

LAT - SPACES (€/m2)	Alueellinen hintataso - Local price index		
	71	77	81
huone, keittiö ja sauna - 1 room, kitchen and sauna (35-40 m2)	1450	1580	1690
huonetta, keittiö ja sauna - 2 rooms, kitchen and sauna (50-65 m2)	1260	1380	1470
huonetta, keittiö ja sauna - 3 rooms, kitchen and sauna (65-80 m2)	1240	1360	1440
huonetta, keittiö ja sauna - 4 rooms, kitchen and sauna (80-100 m2)	1200	1320	1400
huonetta, keittiö ja sauna - 5 rooms, kitchen and sauna (90-120 m2)	1200	1310	1390
ula - Hall	1820	1990	2110
einen - Hallway	1340	1470	1600
ittiö - Kitchen	1320	1440	1530
ylyhuone - Sauna	2060	2250	2390
akuuhuone - Bedroom	1070	1160	1240
lohuone - Livingroom	1120	1220	1310
suhuone - Bathroom	2150	2360	2520
havarasto - Garden storeroom	720	790	850
stysliikennetilat - Stairs	1450	1580	1690
c-huone - WC	2280	2510	2700
arastotila - Storeroom	900	970	1030

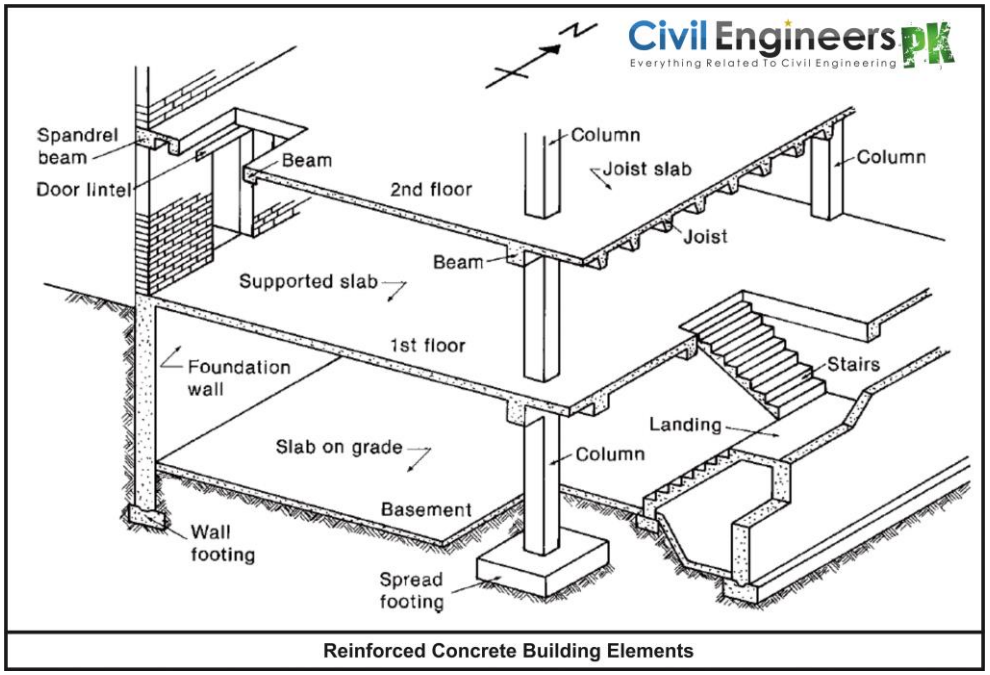
Element -based estimating – background

- **Goal is to estimate building's cost as a sum of costs of its *designed* elements (product components)**
  - Bottom-up method

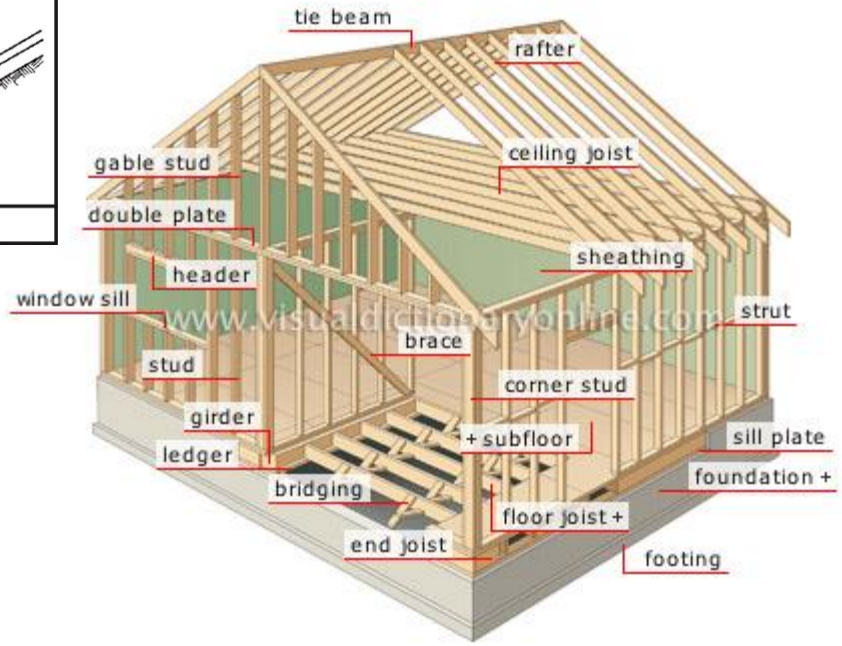
- **Defining the elements based on a certain classification system (product structure)**
  - e.g. Talo 80, Talo 2000, Uniformat, CSI Masterformat, often with a modeling software

- **Use:**
  - In the design phase: to give cost feedback to design proposals
  - In the procurement/tendering phase: to get commitment to a fixed price from a general contractor or sub-contractors

Building elements



Reinforced Concrete Building Elements



UNIFORMAT II Classification for Building Elements, USA

ASTM Uniformat II Classification for Building Elements (E1557-97)

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements
A SUBSTRUCTURE	A10 Foundations	A1010 Standard Foundations A1020 Special Foundations A1030 Slab on Grade
	A20 Basement Construction	A2010 Basement Excavation A2020 Basement Walls
B SHELL	B10 Superstructure	B1010 Floor Construction B1020 Roof Construction
	B20 Exterior Enclosure	B2010 Exterior Walls B2020 Exterior Windows B2030 Exterior Doors
	B30 Roofing	B3010 Roof Coverings B3020 Roof Openings
C INTERIORS	C10 Interior Construction	C1010 Partitions C1020 Interior Doors C1030 Fittings
	C20 Stairs	C2010 Stair Construction C2020 Stair Finishes
	C30 Interior Finishes	C3010 Wall Finishes C3020 Floor Finishes C3030 Ceiling Finishes
D SERVICES	D10 Conveying	D1010 Elevators & Lifts D1020 Escalators & Moving Walks D1090 Other Conveying Systems
	D20 Plumbing	D2010 Plumbing Fixtures D2020 Domestic Water Distribution D2030 Sanitary Waste D2040 Rain Water Drainage D2090 Other Plumbing Systems
	D30 HVAC	D3010 Energy Supply

Talo 2000 Building Project classification

12 Building elements

Building elements consist of foundations, the ground floor, the frame, the facades, the roof and external decks.

121 Foundations

Foundations consist of structures below the ground floor such as footings, enclosure walls, foundation columns and beams, and special foundation structures.

1211 Footings

Footings consist of the building's wall footings, column footings, pile footings and enclosure wall footings.

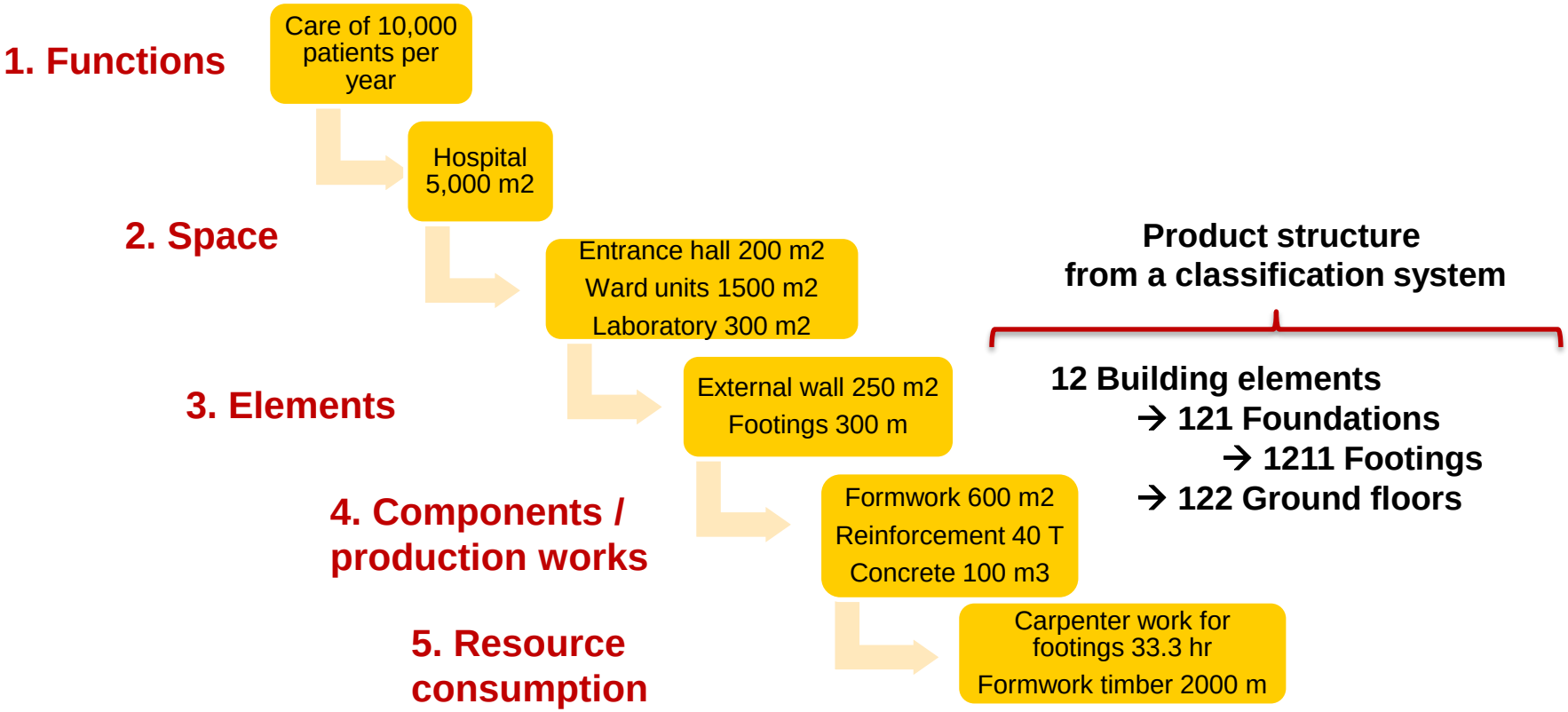
A footing is bounded by the underside of the footing and the enclosure wall, foundation column or framework; it never comes higher than the soffit of the bearing structure of the ground floor. Footings are measured in linear metres or in pieces specified by size.

1212 Enclosure walls, foundation columns, foundation beams

Enclosure walls and foundation columns and beams comprise the foundation columns, enclosure walls, well-ring foundations and foundation beams, with their thermal insulation and water and damp proofings anc finishings, that are located under the ground floor. Enclosure walls and foundation columns and beams are divided into structural elements as follows:

1 Surface of enclosure wall, foundation column, and foundation beam
2 External surface element
3 Enclosure wall, foundation column, or beam structure
4 Thermal insulation
5 Water and damp proofing

Information levels for cost estimating



From building elements to needed components and production works

- **Strip Foundations**
  - Excavation to foundations (excavate 20 % more) based on volume
  - Formwork – foundation system (both sides)
  - Reinforcement – 0.15 T / m3
  - Concrete – incl. waste 3.5%
  - Waterproofing – both sides and top

From building elements to model structures and their costs

Building element (rakennusosa)

1241 External walls

External walls consist of bearing, non-bearing, built-on-site and prefabricated external walls as well as curtain walling with sheathing and thermal insulation. Facade sections above the roofing deck are also parts of the external wall. External walls are divided into structural elements as follows:

1 External wall frame
2 Water and damp proofing
3 Thermal and acoustic insulation
4 Sheating
5 Curtain walling
6 Curtain walling finish

Structural elements (rakenneosa)

Model structures and costs

E.g. Wooden external wall 123 + 50 mm, wind protection board 25 mm, wood fiber insulator 175 mm, plasterboard: 1,68 hours/m2; 89,90 €/m2

Package of components and production works

Element based cost estimation – process

Process is divided into seven phases:

1. Defining types of element and measuring their quantities
2. Estimating production and assembly cost for each element type (cost data, e.g. Rakennustieto, Haahtela…)
3. Estimating cost for internal cladding, linings and building equipment (if not in elements!)
4. Estimating cost of building services
5. Estimating cost of project-related tasks
6. Estimating cost of connection charges and other costs relating to the site
7. Estimating the risk reserve

Estimating cost for each element

- **Calculation of dimensions of elements in needed units (e.g. amount, m2, m)**
  - Site elements, building elements, internal space elements, services elements…
- **Defining components and production works with quantities needed to build the element**
- **Defining resources and their quantities needed for components**
  - Quantities from standards (e.g. Ratu in Finland) or company's records
- **Using resource unit price lists for cost estimation**
  - Unit prices from material / work suppliers or work agreements

Components describe needed productions and procurements for elements

- **Formwork (m2)**

- **Reinforcement (T)**

- **Concrete (m3)**

Unit prices for formwork – example from Singapore

ITEM	DESCRIPTION	UNIT	2012Q1 MEAN
3	**FORMWORK**		
3.1	**Timber Formwork**		
	Timber formwork to in-situ concrete including strutting ne 3.50m high		
A	flat surface of suspended slab	m^2	32.65
B	vertical surface of pilecap, ground beam, etc.	m^2	33.00
C	vertical surface of column, walls	m^2	32.53
D	vertical curved surface of column, wall	m^2	38.39
E	sides and soffits of beams	m^2	33.78
F	slopping surfaces to soffit of slabs and staircases	m^2	34.15
G	vertical edge for each 100mm high	m	3.62
	Extra over formwork for strutting exceeding 3.50m		
H	each 1.50m high	m^2	2.38

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

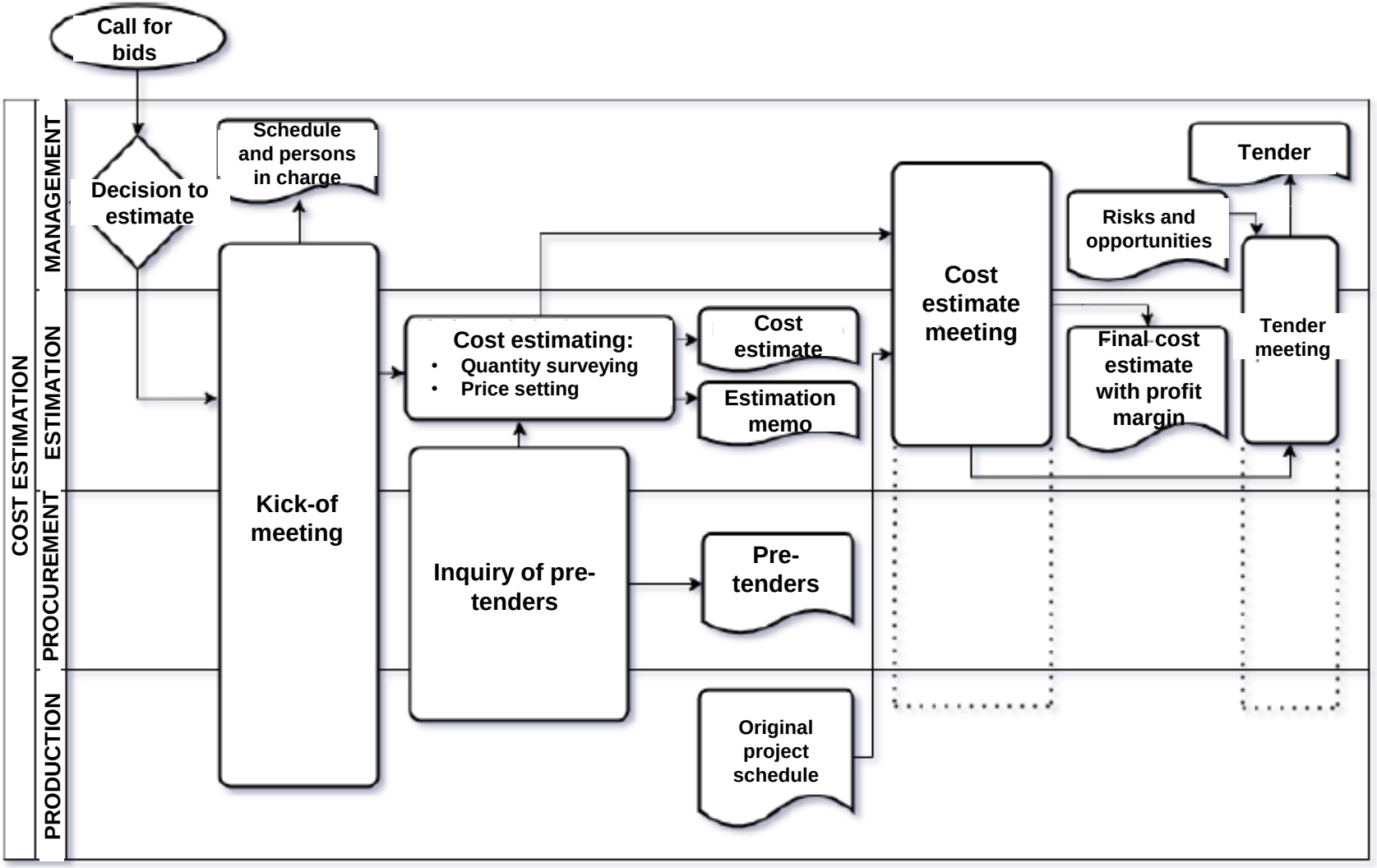
NOTES:
Bldg. Type: Recreational
Target (SQFT): 114,000
Floors: Single story plus mezzanines

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

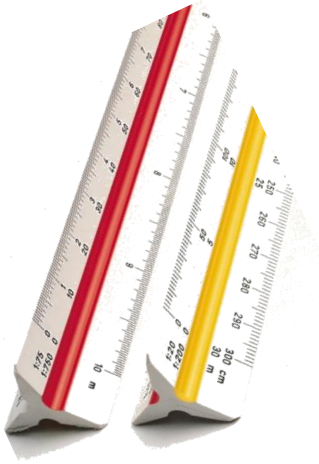
Elements and production works

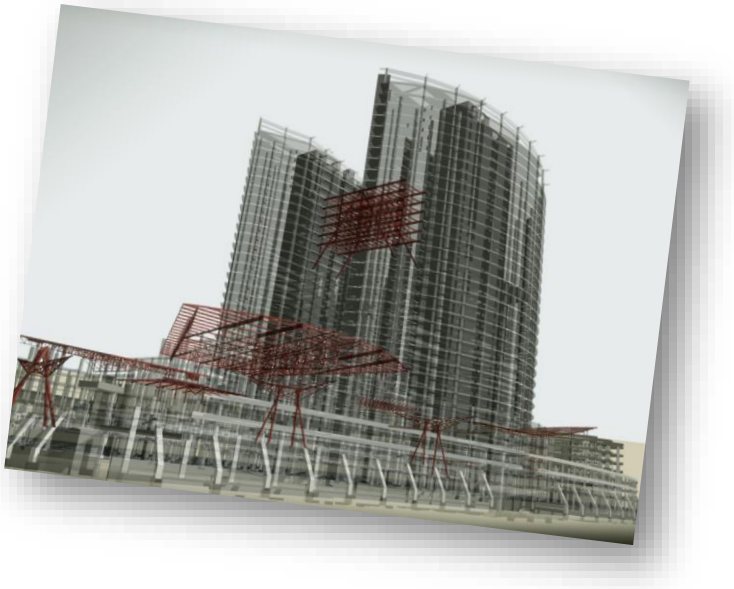
	Elements	Components / Production works
	Describe building as a product through sub-products	Describe production of building's elements through components
Main users	Designers, general contractor, module and element producers	General contractor, superintendent, foremen, sub-contractors
Needed for	Architectural design, structural design, MEP system design, procurements	Procurements, production control, scheduling

Tender cost estimating process of a construction company



BIM > another step change for estimating





As the technology continually improves, one thing does not change….

The need for an Estimator!

Why use BIM in estimating?

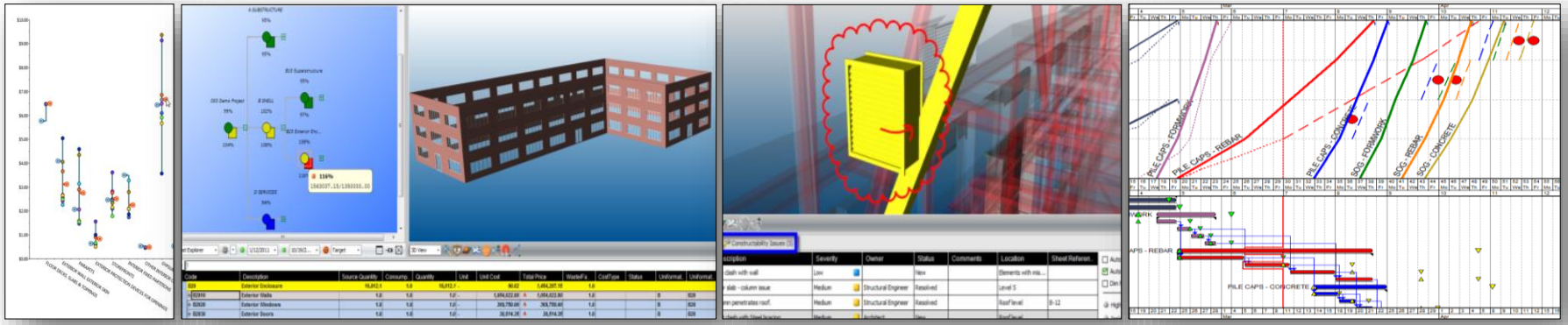
Win Business
+
Reduce Risk

Make Life Easy for **Owners/Designers**

Make Life Easy for **GCs / Subs**

Decision Support & Superior Interaction

Improve Efficiency & Reduce Design, Cost & Schedule Risk



BIM ties disciplines together: Quality-Schedule-Cost

Cost Planning — 5D — Cost Control

Schedule Planning — 4D — Production Control

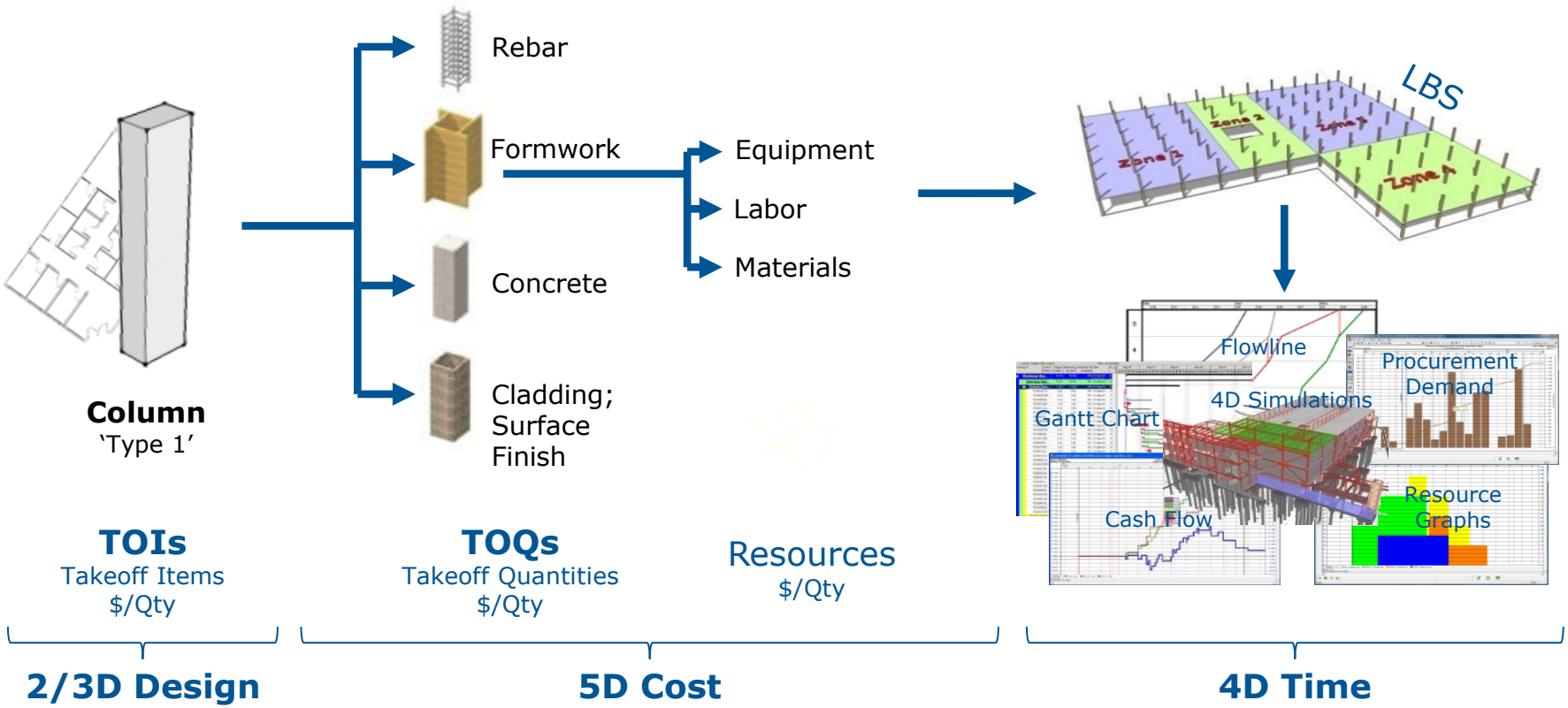
Design to Build — 2D/3D — Build to Design

CAD/BIM | Biz Dev | Preconstruction | Operations | ENTERPRISE

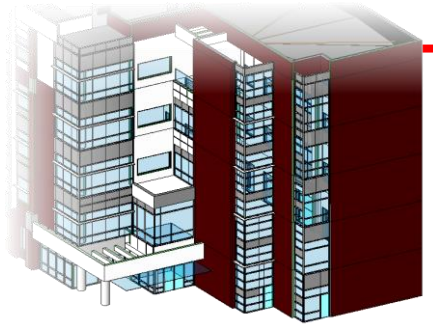
2D/3D Design | Visual Prez | Change Mgmt | Constructability Analysis | Quantity Takeoff | Cost Estimating | Project Scheduling | Bid Mgmt | BIM to Field Integration | Production Control | Cost Control | Project Accounting

Actual Cost, Quantity & Production **data mining**

Integrated BIM+Estimating+Scheduling



Cost Planning Integrated Workflow



Model Elements

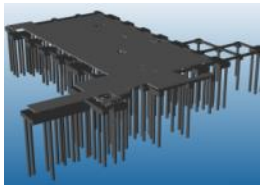
Element Properties

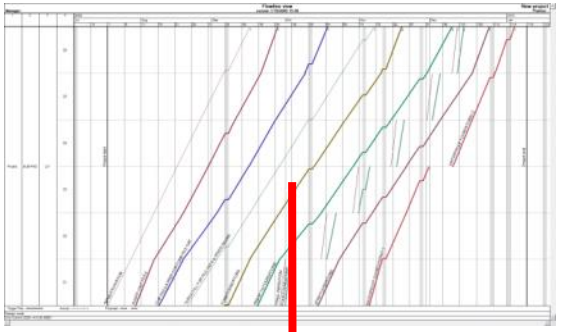
Takeoff Items

Formula

Cost Components

Cost Assemblies



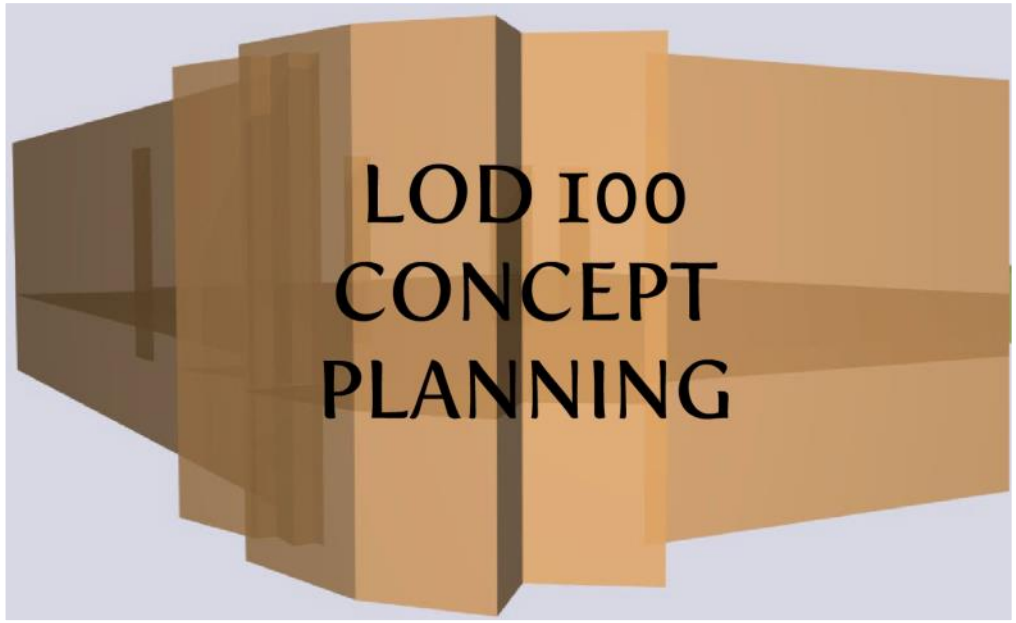


Co..	Description	Type
Quantity	Unit	Value
	_B1021_Membrane Roof 2.ARC	(11)
	_B1021_Membrane Roof.ARC	(17)
	_B1021_Vestibule Roof Deck_0-5 1/8.STR	(1)
	_B2011_CMU Wall_0'-8".STR	(6)
	_B2011_Exterior Stud Wall_Brick Type 1.ARC	(466)
Count	count	466.00
Length	feet and inches	2559'-4 ...
Reference Side Surface Area	square foot	27289.79
Opposite Reference Side Surface Area	square foot	27289.79
Top Surface Area	square foot	2550.07
Bottom Surface Area	square foot	2542.50
Ends Surface Area	square foot	12022.77
Reference Side Opening Surface Area	square foot	2169.07
Opposite Reference Side Opening S...	square foot	2169.07
Net Volume	cubic yard	940.09
Gross Volume	cubic yard	948.81
	_B2011_Exterior Stud Wall_Brick Type 2.ARC	(42)
	_B2011_Exterior Stud Wall_Metal Panel Sof...	(5)
	_B2011_Exterior Stud Wall_Metal Panel.ARC	(152)
	_B2011_Exterior Stud Wall_Metal Panel.AR...	(5)
	_B2011_Exterior Stud Wall_Precast Concre...	(51)
	_B2011_Exterior Stud Wall_Roof Parapet ...	(14)
	_B2011_Extruded Alu Tube.ARC	(11)

Code	Description	CostUnit	Price	Variance
000	Cost Planning with Vico Office	50,000,000.00	49,650,000.00	-350,000.00
A	Substructure	700,000.00	700,000.00	0.00
A10	Foundation	40.00	749,895.01	47,171.74
A1012.300.001	Pad Footing	250.00	74,902.61	7,050.77
03 11 00.03.11.0...	Erect Forms to CIP Concrete - CIP Pad...	10.00	31,547.47	0.00
1.LCON003	Formwork Carpenter	0.00	0.00	0.00
2.03.11.00.040	Erect Forms - CIP Pad Footing - Materials	0.00	0.00	0.00
03 11 00.03.11.0...	Strip Forms to CIP Concrete - CIP Pad ...	4.00	12,618.99	0.00
1.LCON003	Formwork Carpenter	0.00	0.00	0.00
2.03.11.00.041	Strip Forms - CIP Pad Footing - Materials	0.00	0.00	0.00
03 21 00.03.21.0...	Reinforcement Steel to - CIP Pad Footing	200.00	10,856.30	0.00
1.LCON004	Rodman	0.00	0.00	0.00
2.03.21.00.040	Re Steel - CIP Pad Footing - Materials	0.00	0.00	0.00
03 31 00.03.31.0...	Casting Concrete in place to - CIP Pad ...	50.00	13,570.37	0.00
1.LCON001	Concrete Pourer	0.00	0.00	0.00
2.03.31.00.040	Concrete - CIP Pad Footing - Materials	0.00	0.00	0.00
03 35 00.03.35.0...	Concrete finishing to - CIP Pad Footing	2.00	6,309.49	0.00
1.LCON001	Concrete Pourer	0.00	0.00	0.00
2.03.35.00.040	Finishing to - CIP Pad Footing - Materials	0.00	0.00	0.00
A1011.300.001	Continuous Footing	6.00	21,782.75	-9,075.76
03 11 00.03.11.0...	Erect Forms to CIP Concrete - Continu...	0.00	3,479.12	3,479.12
1.LCON003	Formwork Carpenter	0.00	0.00	0.00
2.03.11.00.010	Erect Forms - Continuous Footing - Mat...	2.00	3,479.12	0.00
03 11 00.03.11.0...	Strip Forms to CIP Concrete - Continuo...	0.00	3,479.12	3,479.12
1.LCON003	Formwork Carpenter	0.00	0.00	0.00

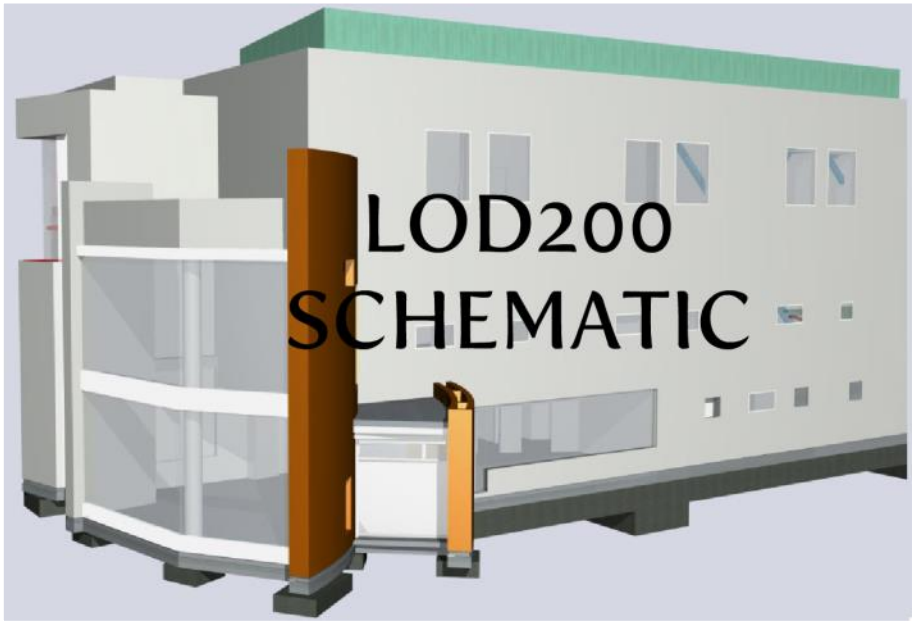
Estimate Progression - 1

	Code	Description	Quantity	Unit	Unit Cost	Total Price
		Project	**50,000.0**	**sf**	***379.36***	***18,967,938.60***
	A10	Foundations/Substructure	10,000.0	sf	17.67	176,700.00
	B10	Superstructure	50,000.0	sf	52.73	2,636,623.14
	B20	Exterior Closure	42,500.0	sf	49.86	2,119,029.31
	B30	Roofing & Sheet Metal	50,000.0	sf	5.41	270,605.73
	C10	Interior Construction	50,000.0	sf	69.27	3,463,500.00
	C30	Interior Finishes	50,000.0	sf	15.74	787,186.42
	D10	Conveying Systems	50,000.0	sf	9.62	481,054.02
	D20	Plumbing				
	D30	H.V.A.C.				
	D40	Fire Protection				
	D50	Electical Systems				
	E10	Equipment				
	F10	Special Construction				
	Z10	General Requirements				



Estimate Progression - 2

	Code	Description	Quantity	Unit	Unit Cost	Total Price
		Project	**50,000.0**	**sf**	***384.50***	***19,225,131.33***
	A10	Foundations/Substructure	10,000.0	sf	17.67	176,679.15
	A1010.01	Continuous Footings	500.0	lf	100.00	50,000.00
	A1011.01	Spread Footings	30.0	ea	2,500.00	75,000.00
	A1032.01	Slab On Grade	10,000.0	sf	4.00	40,000.00
	B10	Superstructure	50,000.0	sf	52.73	2,636,623.14
	B20	Exterior Closure	42,500.0	sf	49.86	2,119,029.31
	B30	Roofing & Sheet Metal				
	C10	Interior Construction				
	C30	**Interior Finishes**				
	D10	Conveying Systems				
	D20	Plumbing				
	D30	H.V.A.C.				



Estimate Progression - 3

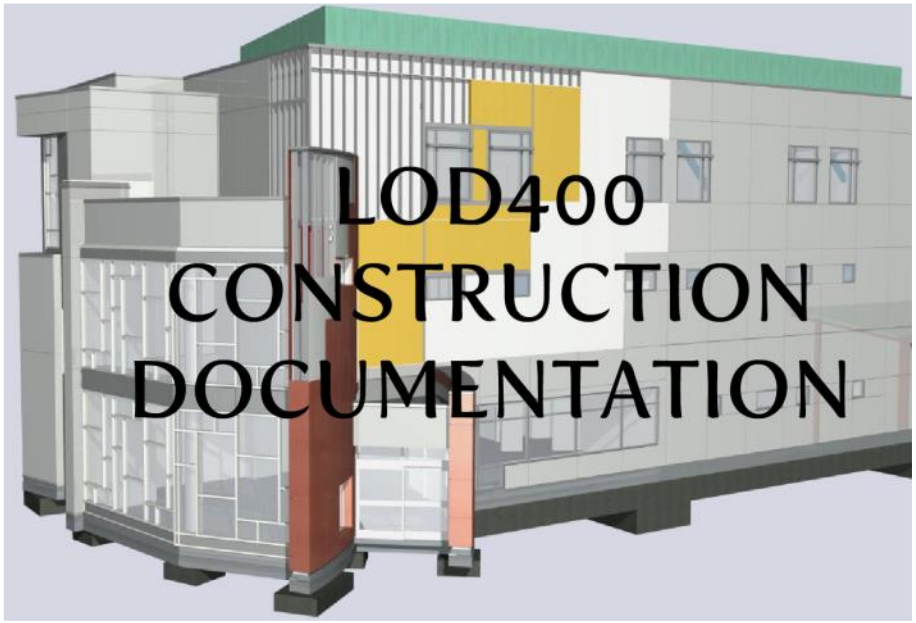
fx **A1010.01 Contuous Footings.**Reference Side Surface Area * 2

Code	Description	Quantity	Unit	Unit Cost	Total Price
	Project	50,000.0	sf	*384.27*	*19,213,452.18*
A10	**Foundations/Substructure**	10,000.0	sf	*16.50*	*165,000.00*
A1010.01	Continuous Footings	500.0	lf	100.00	50,000.00
03 01 10.01	Formwork Continous Footings	1,000.0	sf	10.00	10,000.00
03 01 20.01	Reinforcement Continuous Footings	60.0	ton	300.00	18,000.00
03 01 30.01	Cast In Place Concrete	1,000.0	cy	20.00	20,000.00
A1011.01	Spread Footings	30.0	ea	2,500.00	75,000.00
A1032.01	Slab On Grade	10,000.0	sf	4.00	40,000.00
B10	Superstructure	50			
B20	Exterior Closure	42			
B30	Roofing & Sheet Metal	50			
C10	Interior Construction	50			
C30	**Interior Finishes**	50			
D10	Conveying Systems	50			
D20	Plumbing	50			
D30	H.V.A.C.	50			
D40	Fire Protection	50			
D50	Electical Systems	50			
E10	Equipment	50			
F10	Special Construction	50			

Estimate Progression - 4

fx Parent.Quantity

Code	Description	Quantity	Unit	Unit Cost	Total Price
	Project	**50,000.0**	**sf**	***384.27***	***19,213,452.18***
A10	**Foundations/Substructure**	**10,000.0**	**sf**	***16.50***	***165,000.00***
A1010.01	**Continuous Footings**	**500.0**	**lf**	**100.00**	**50,000.00**
03 01 10.01	Formwork Continous Footings	1,000.0	sf	10.00	10,000.00
L-001	Carpenter	33.3	hr	60.00	2,000.00
F-001	Formwork Material	1,050.0	sf	6.00	6,300.00
03 01 20.01	Reinforcement Continuous Footings	60.0	ton	300.00	18,000.00
03 01 30.01	Cast In Place Concrete	1,000.0	cv	20.00	20,000.00
A1011.01	Spread Footings				
A1032.01	Slab On Grade	10,0			
B10	Superstructure	50,0			
B20	Exterior Closure	42,5			
B30	Roofing & Sheet Metal	50,0			
C10	Interior Construction	50,0			
C30	**Interior Finishes**	**50,0**			
D10	Conveying Systems	50,0			
D20	Plumbing	50,0			
D30	H.V.A.C.	50,0			
D40	Fire Protection	50,0			
D50	Electical Systems	50,0			

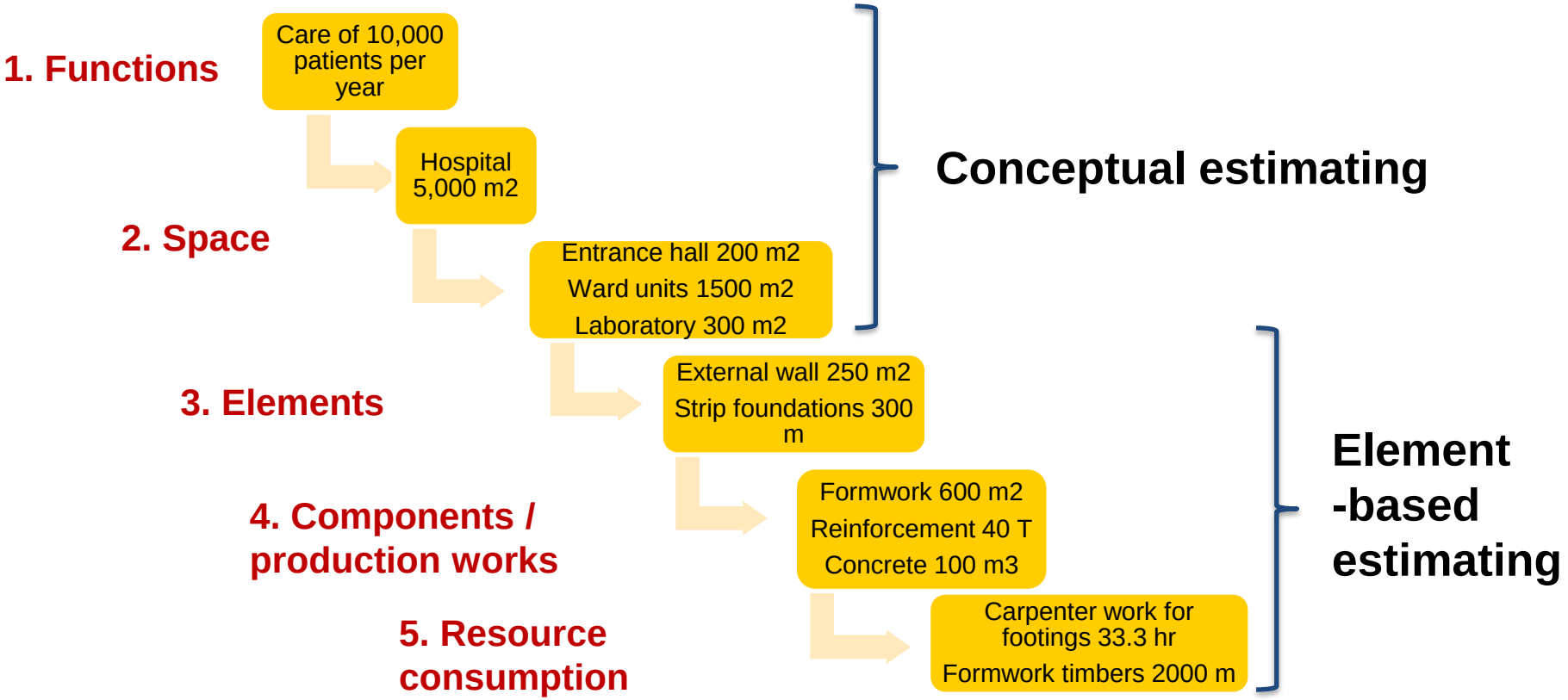


Estimate Progression - 5

fx Parent.Quantity

Code	Description	Quantity	Unit	Unit Cost	Total Price
	Project	**50,000.0**	**sf**	***384.27***	***19,213,452.18***
A10	**Foundations/Substructure**	**10,000.0**	**sf**	***16.50***	***165,000.00***
A1010.01	**Continuous Footings**	**500.0**	**lf**	**100.00**	**50,000.00**
03 01 10.01	Formwork Continous Footings	1,000.0	sf	10.00	10,000.00
L-001	Carpenter	33.3	hr	60.00	2,000.00
F-001	Formwork Material	1,050.0	sf	6.00	6,300.00
03 01 20.01	**Reinforcement Continuous Footings**	**60.0**	**ton**	***307.60***	***18,456.22***
L-012	Rodman	82.0	hr	65.00	5,330.00
L-090	Laborer	90.0	hr	40.00	3,600.00
R-008	Reinforcement #8	21.2	ton	155.20	3,290.24
R-012	Reinforcement #12				
R-016	Reinforcement #16				
03 01 30.01	Cast In Place Concrete				
A1011.01	Spread Footings				
A1032.01	Slab On Grade				
B10	Superstructure				
B20	Exterior Closure				
B30	Roofing & Sheet Metal				
C10	Interior Construction				
C30	**Interior Finishes**				

Information levels for cost estimation



Individual thinking:

Disadvantages of the presented cost estimation methods

Summary of the lecture

- **Cost estimation methods**
  - Conceptual estimating
  - Element based estimating
- **Cost estimation process**
- **Evolutionary estimating**
- **Use of parametrics and BIM**