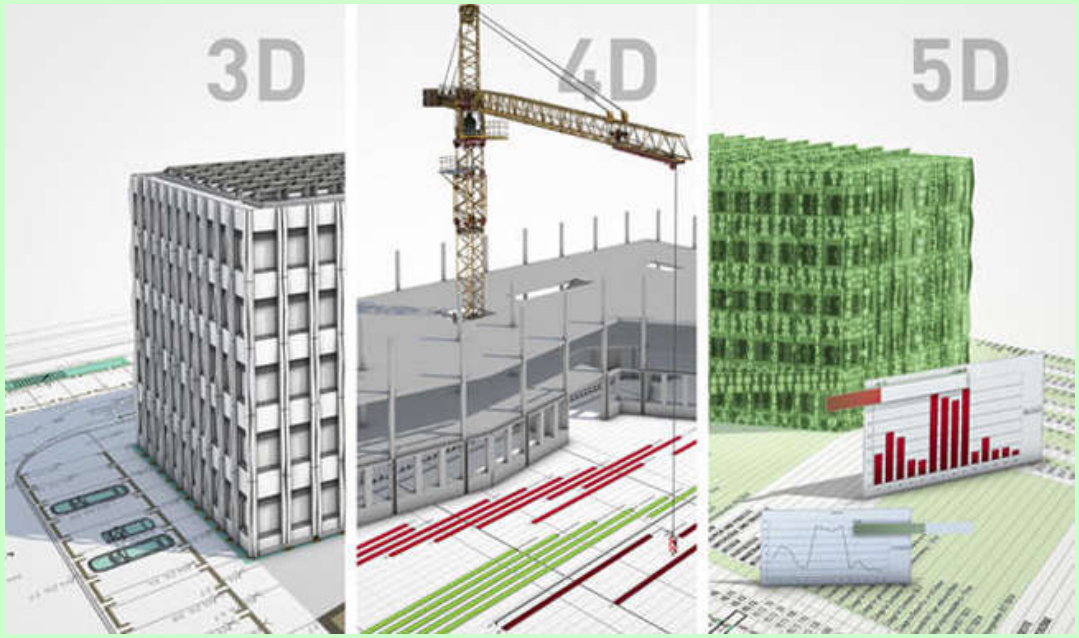
SBS5322 Basics of Building Information Modelling

http://ibse.hk/SBS5322/



BIM 5D model

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- Calculation & properties
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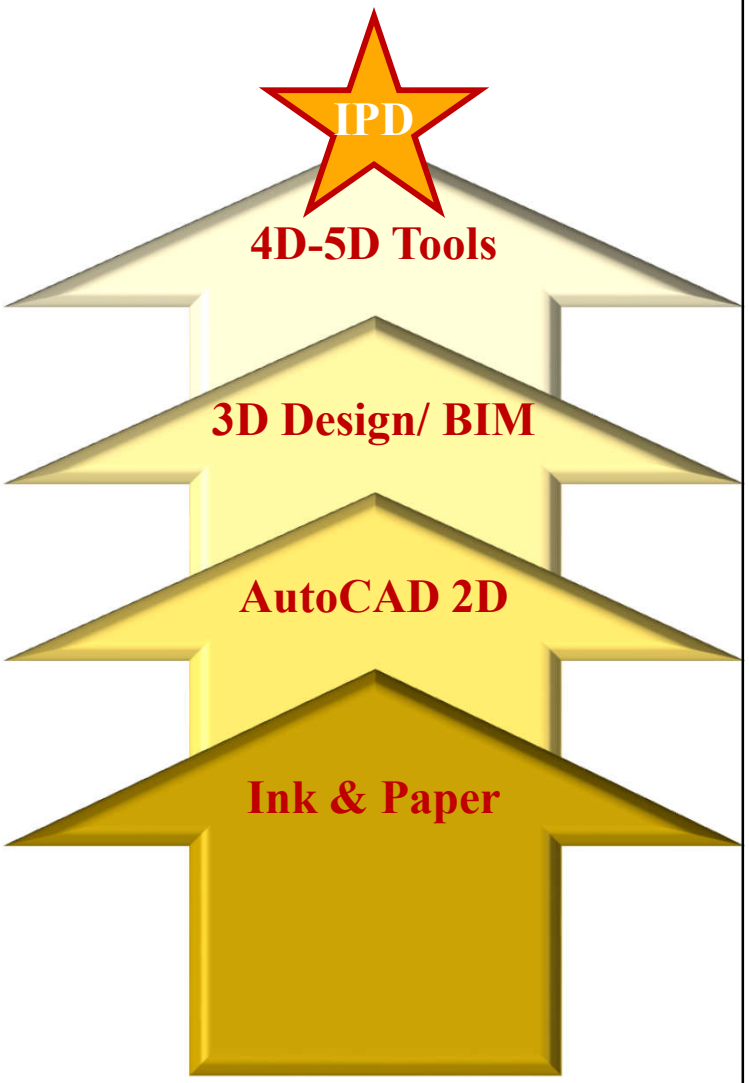
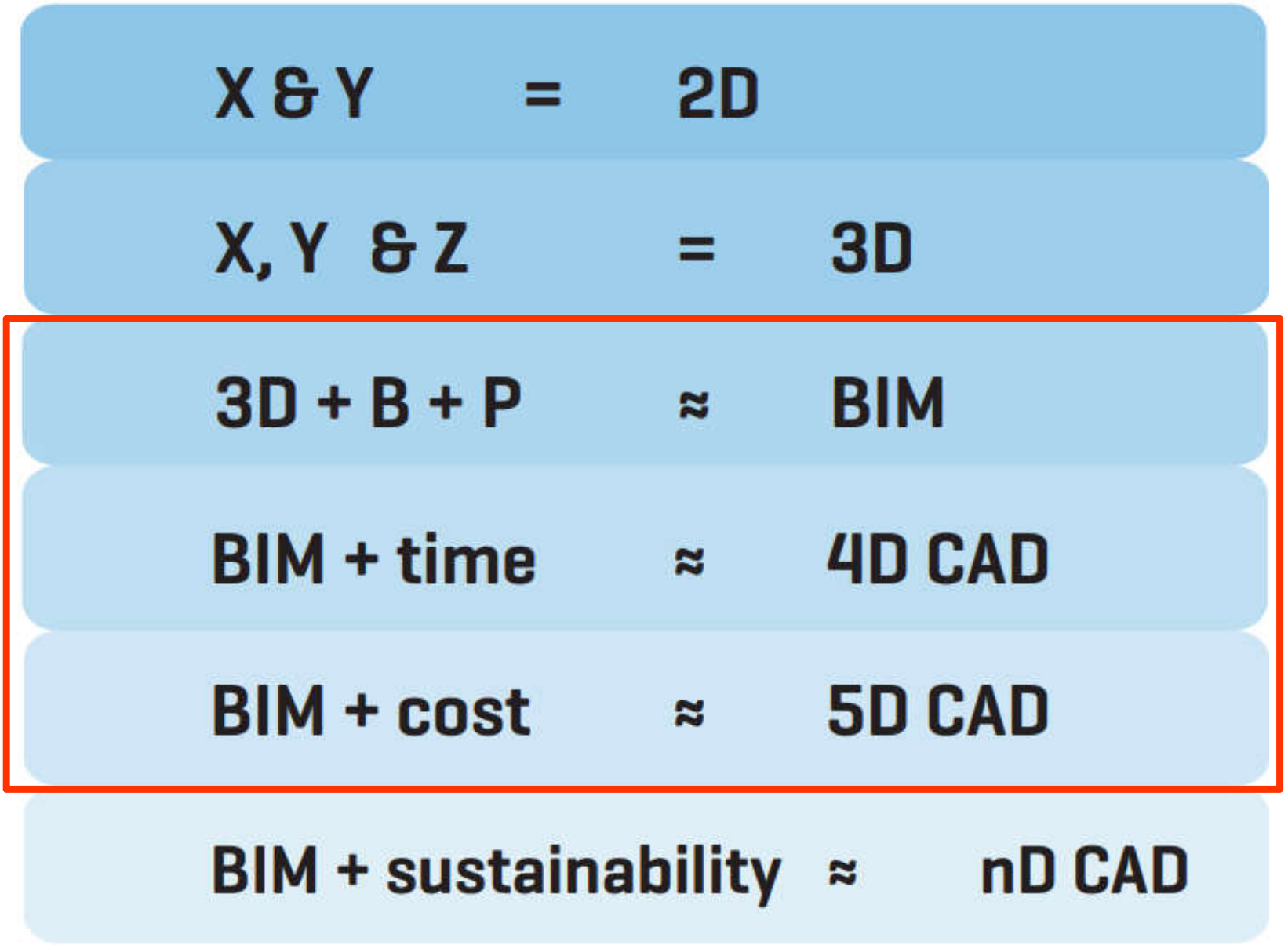
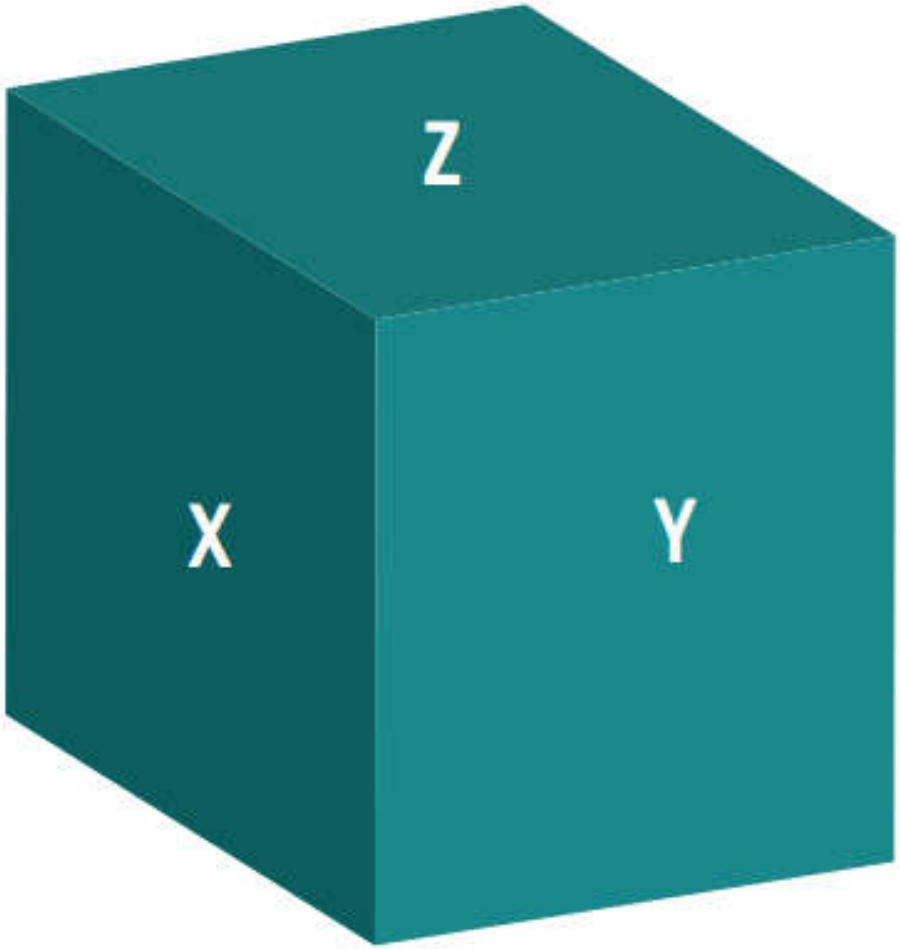


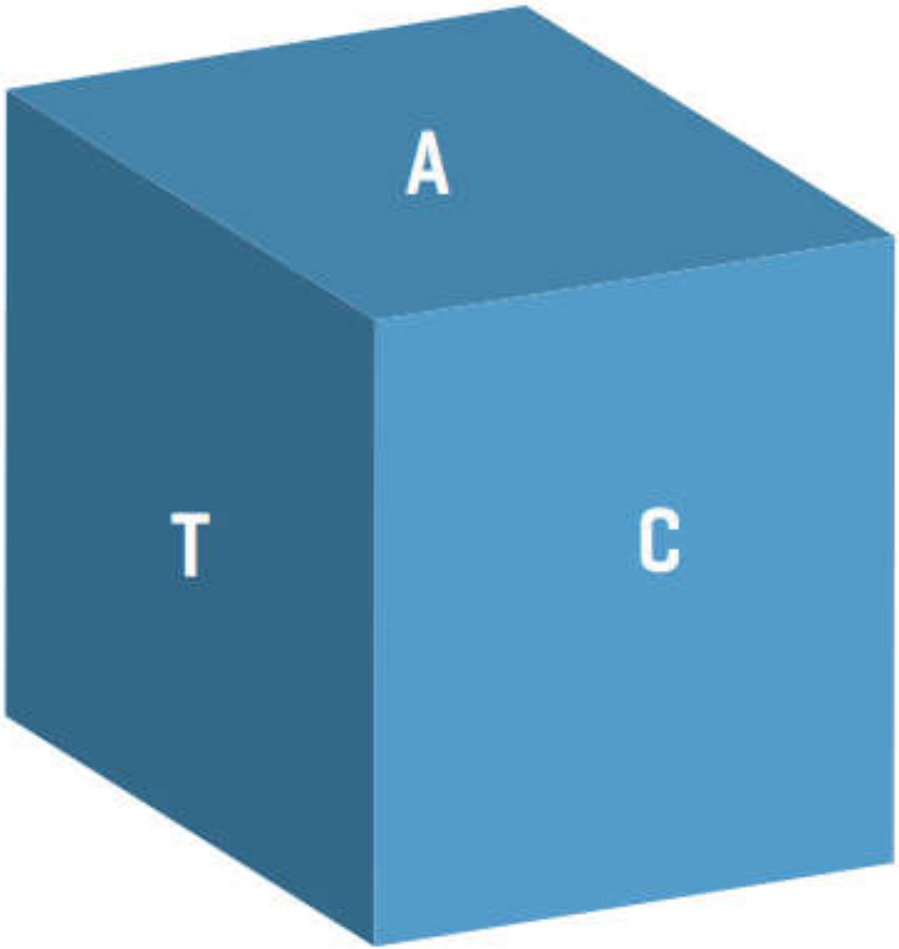
Dimensions of BIM



(Source: RICS, 2014. *International BIM Implementation Guide*)

Six dimensions of BIM





Key:
X, **Y**, **Z**: the three spatial dimensions
T: the time dimension, for construction sequencing
C: the cost dimension, quantities and rates
A: associated information, including specification

(Source: RICS, 2014. *International BIM Implementation Guide*)

The 5th dimension of BIM

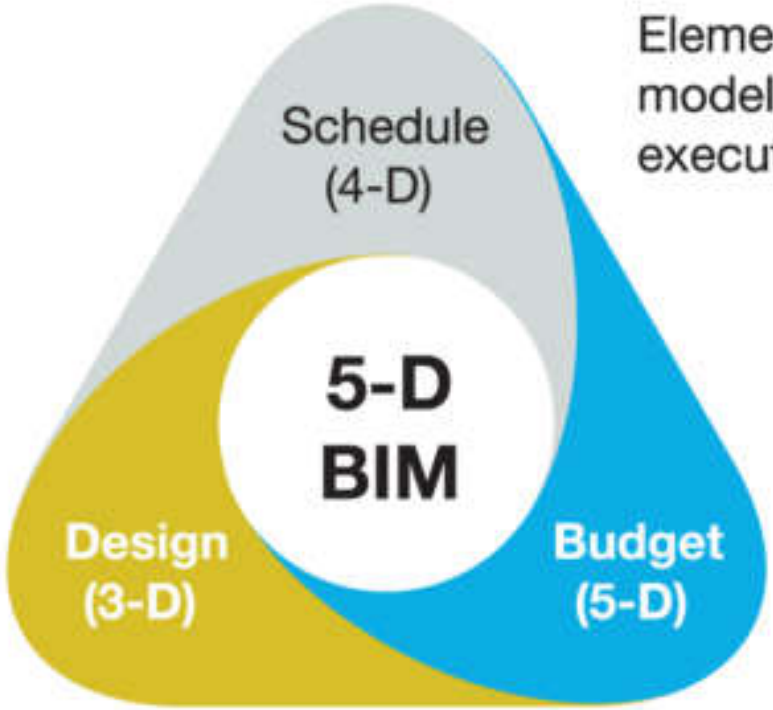
- **BIM 3D** = correct model 3D + properties and parameters of elements
  - What you see is what you build
- **BIM 4D** = BIM 3D + schedule of works, construction sequencing (virtual mock up)
  - What you see is how you build it
- **BIM 5D** = BIM 4D + cost estimation, quantity take-off (data & process management)
  - What you see is what you calculated

5-D functionality can integrate design, cost, and schedule in a 3-D output.

Building information modeling (BIM) is a digital representation of the physical and functional characteristics of a project, forming a reliable basis for decisions during the project's life cycle.

Information that can be embedded in 3-D model:

- Geometry
- Spatial data (from geographic information systems/lidar)
- Specifications
- Aesthetics (eg, color)
- Thermal properties
- Acoustic properties

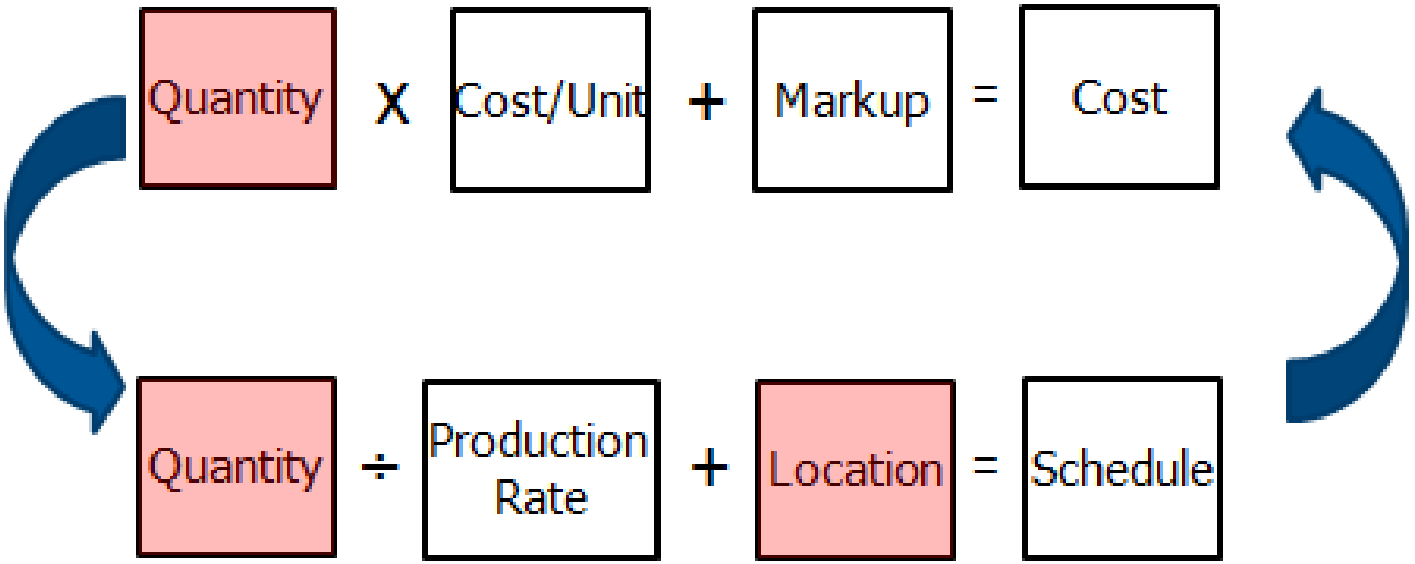


Elements of a 3-D model are linked to the execution schedule

Elements of the 3-D model are used to develop budget and linked to cost heads

(Source: McKinsey & Company)

5D BIM



(See also: What Is 5D BIM? http://www.vicosoftware.com/what-is-5D-BIM)

(Source: http://www.vicosoftware.com/bim-for-construction-software-products)

The 5th dimension of BIM

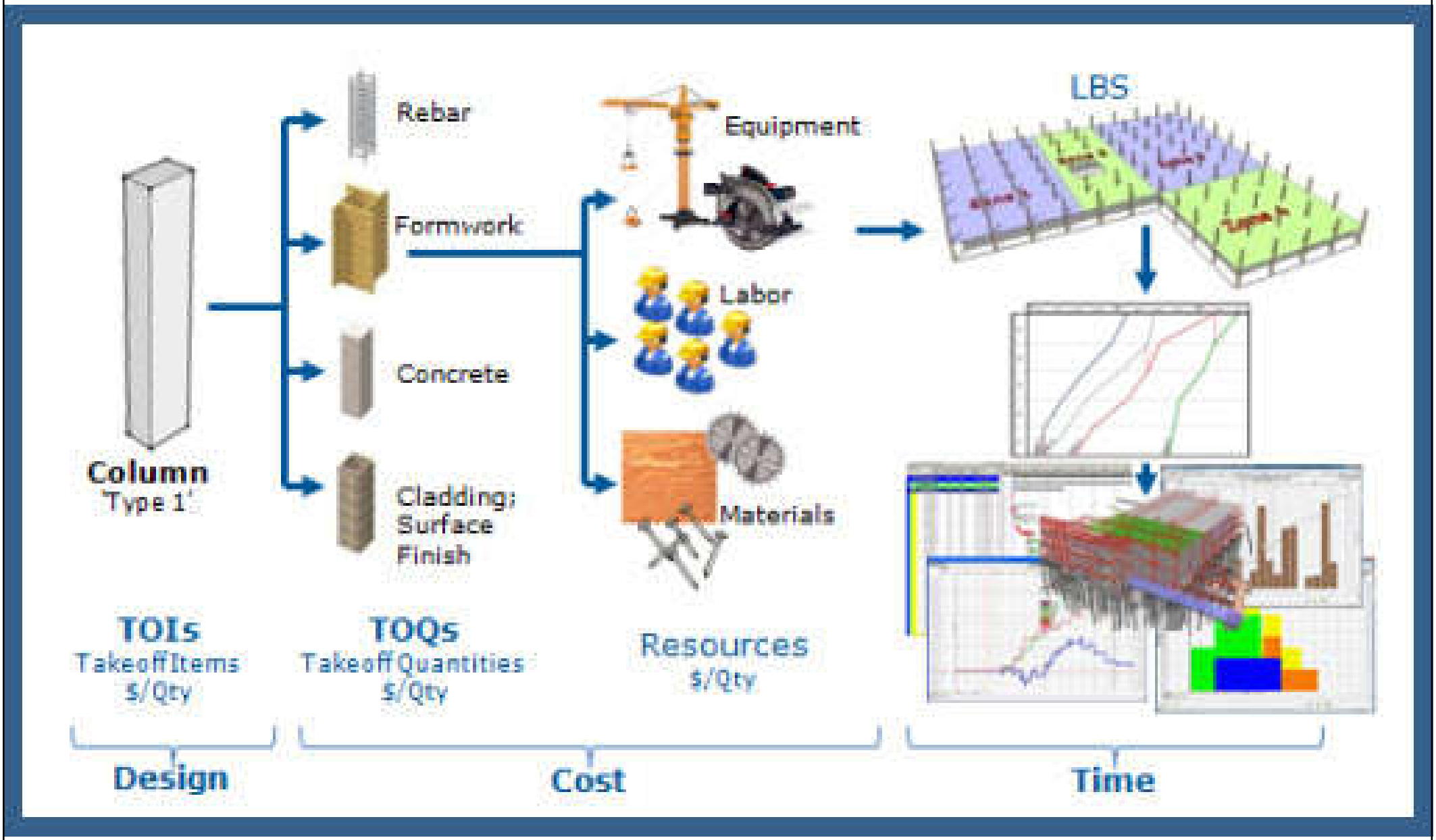
- 5D BIM capabilities
  - 1. Show an owner what happens to the schedule and budget when a change is made on the project
  - 2. Organize your own in-house database with cost and pricing information, labor productivity rates, crew composition data, and Sub KPIs
  - 3. Provide cost-loaded schedules for the owner
  - 4. Provide multiple, iterative (evolving) estimates for the owner which s/he can quickly compare to the target cost

(Source: What Is 5D BIM? http://www.vicosoftware.com/what-is-5D-BIM)

The 5th dimension of BIM

- Benefits of 5D estimating for BIM
  - Dramatically reduce measurement time
  - Elimination of errors and improved accuracy
  - Provide consistent and automated quantification
  - Definition of scope and cost is transparent to all project stakeholders
  - Continuous real-time updating of costs with design, reducing variability in cost estimates
  - Greater accountability in management of projects

Management of design, cost and time in building & construction



(Source: Vico Software http://www.vicosoftware.com/)

The 5th dimension of BIM

- Integrated 2D-3D-4D-5D BIM workflow
  - 2D-3D change management
  - 3D BIM for visualization
  - 3D BIM for clash detection
  - 3D BIM for layout
  - 3D BIM for quantity takeoff
  - 4D BIM for scheduling and production control
  - 5D BIM for estimating
  - Construction management reporting

(Source: The 5D BIM Workflow in Vico Office http://www.vicosoftware.com/5D-BIM-Workflow-in-Vico-Office)

The 5th dimension of BIM

- Work steps for BIM based time and cost planning of construction project
  - 1. Virtual design (3D)
  - 2. Publish/Link to 4D/5D BIM software
  - 3. Takeoff manager (for quantity takeoff)
  - 4. Cost planner (for cost estimation)
  - 5. LBS (location breakdown structure) manager
  - 6. Schedule planner (time & cost, cash flow)
  - 7. 4D simulation & visualization (sequential)

(Source: The 5D BIM Workflow in Vico Office http://www.vicosoftware.com/5D-BIM-Workflow-in-Vico-Office)

The 5th dimension of BIM

- Cost estimation, analysis and schedule
  - Automation of measurement & calculation
  - Element identification & visual cost planning
  - Quantity take-offs (QTOs)
  - Level of Detail/Development (LOD): model progression specification
  - Inventories
  - Cost estimation, analysis & control
  - Schedules (interactive) & scheduling (sequential)

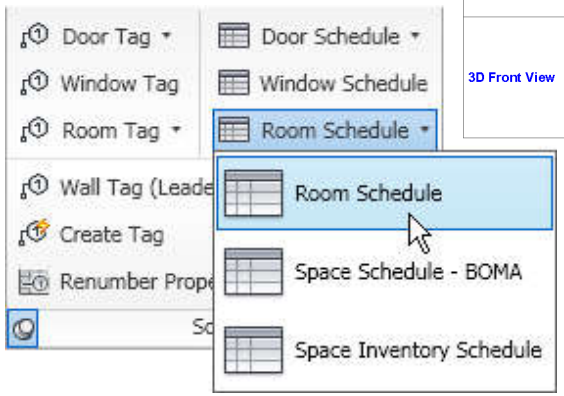
Calculation with BIM

The BIM concept supports a wide range of calculation and estimating activities:

- Quantity take-offs
- Door-window schedules
- Room inventories
- Cost estimations

Window List

Window Name	W Multiside Fix 13	W Triple Sash 13	W1 Casement 13
Quantity	1	1	1
From Room Number			
W x H Size	1,000x0,951	1,500x1,500	0,900x1,500
Orientation	R	L	L
Window sill height	0,900	0,900	0,900
Window head height	1,851	2,400	2,400
2D Symbol	1,000	1,500	0,900
3D Front View	1,000 / 0,951	1,500 / 1,500	0,900 / 1,500



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Element Identification

- Elements of the BIM model need to be identified by a unique identification number (ID) before the calculation process runs. Building components will be sorted by this number.

- Types of ID-s:
- Internal
  - ID is automatically assigned by the program
- User Defined
  - Users can create custom ID-s manually

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Quantity take-offs

The basic physical parameters of building components can be listed automatically from the BIM model:

- No. of elements
- Size
- Volume
- Surface
- Material

Wall List

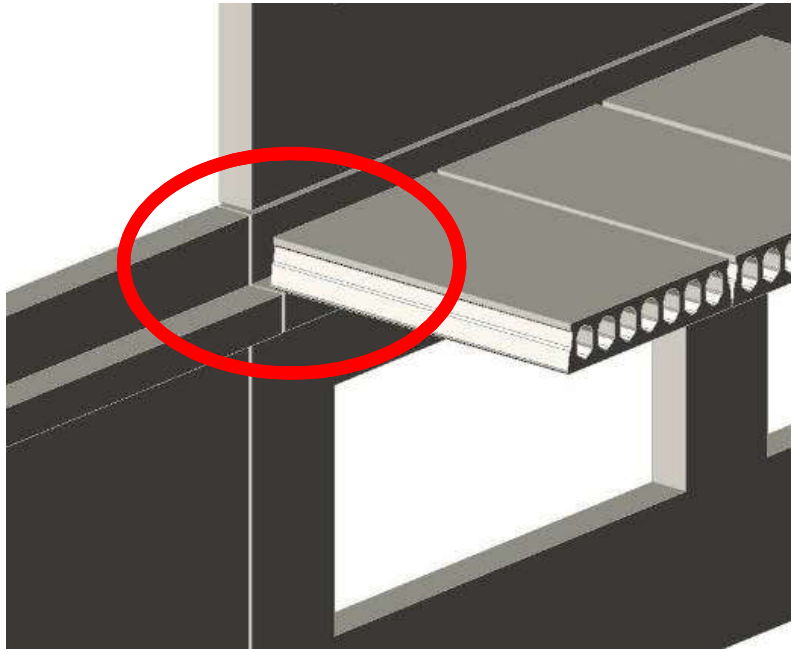
Wall Type	Volume ...	Thickness [m]	Height [m]	Area [m2]	Perimeter [m]	Length on Ref.Side [m]
block/block ...	2,26	0,353	0,700	3,23	18,986	9,140
block/block ...	2,27	0,353	1,125	2,02	12,162	5,728
block/block ...	1,31	0,353	3,800	0,68	4,551	1,922
block/block ...	1,34	0,353	3,800	0,35	2,711	1,002
block/block ...	1,50	0,353	3,800	0,39	2,936	1,115
block/block ...	3,90	0,353	3,800	1,03	6,522	2,908
block/block ...	6,65	0,353	3,375	2,17	13,104	6,007
block/block ...	10,46	0,353	3,375	5,18	30,081	14,729
block/block ...	14,36	0,353	3,375	6,00	34,707	17,000
block/cedar ...	0,08	0,200	1,125	0,07	1,119	0,359
block/cedar ...	0,15	0,200	1,200	0,12	1,641	0,620
block/cedar ...	0,20	0,200	1,125	0,18	2,204	0,902
block/cedar ...	0,22	0,200	1,200	0,18	2,204	0,902
brick/block 2...	0,79	0,278	1,125	0,71	5,816	2,712
brick/block 2...	1,16	0,278	1,125	1,03	8,122	3,893
brick/block 3...	0,21	0,353	0,806	0,56	3,885	1,590
brick/block 3...	0,29	0,353	3,100	0,10	1,391	0,446
brick/block 3...	0,36	0,353	0,825	0,83	5,432	2,363
brick/block 3...	0,36	0,353	0,874	0,84	5,440	2,367
brick/block 3...	0,37	0,353	1,125	0,33	2,644	0,800
brick/block 3...	0,77	0,353	1,125	0,68	4,562	1,928
brick/block 3...	0,86	0,353	3,100	0,28	2,504	0,833
brick/block 3...	0,94	0,353	1,125	0,83	5,556	2,492
brick/block 3...	0,97	0,353	3,375	0,29	2,485	0,993

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Accuracy

- Automatic quantity take-offs in BIM applications has the following limitations:

- Elements that are not modelled, will not be listed
- Accuracy of calculations largely depends on the elaboration of the BIM model (LOD)
- Clear intersections of structural elements are essential for correct results



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Level of Detail/Development (LOD)

The LOD of a BIM model increases as the project proceeds.

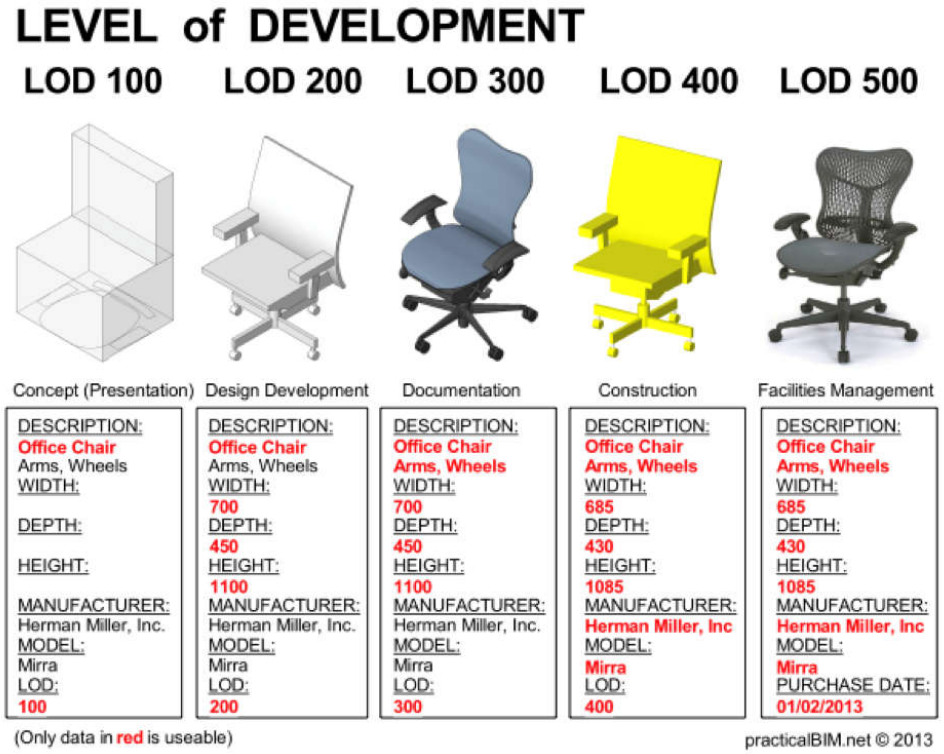
Based on a simple design intent model, through to a detailed virtual construction model, then an operational model.

It is important to define the level of detail that is required at each stage of development of the project.

LOD is a measure of how seriously you take the information represented by a BIM element.

LOD levels for a chair might go:

- LOD 100 = there is a chair
- LOD 200 = there is a chair that has nominal space requirement of 500x500
- LOD 300 = there is a chair with arm rests and wheels
- LOD 400 = manufacturer and model number.
- LOD 500 = manufacturer and model number, supplier, date purchased



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Properties

- Calculating complex building structures require either very detailed models or text based descriptions (properties) that are assigned to the model elements.

- **Property objects** are internal or external information assigned to the BIM elements. Property objects can contain the following data:

  - Calculation database descriptions (size, volume, price etc.)
  - Description of components included in a composite structure
  - Additional text based descriptions (e.g. Safety instructions)

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Benefits of using Properties

- Less physical modeling is required
- Additional information can be attched to BIM elements (e.g. Cost, instructions for construction etc.)
- Properties can be assigned automatically by various criterias (e.g. Layer names, pen colours etc.)
- Calculation information can be stored in external files

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Schedules

Construction documentation sets usually contain graphical list of special building elements. Most BIM applications allow automatic generation of various schedules:

- Window schedule
- Door schedule
- Curtain wall and storefront schedule
- Etc.

Intelligent scheduling solutions allow:

- Graphical editing of lists
- User editing of parameters listed
- Different graphical representations of elements (front,side, top, axonometric views)

Window List	
Window Name	W Casement 2 10
Quantity	1
From Room Number	
W x H Size	1500x1500
Orientation	L
Window sill height	0,900
Window head heig...	2,400
2D Symbol	
3D Front View	

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Inventories

Inventories are the list of building elements and/or furniture, equipment objects belonging to a certain space within the building. Inventories can also be used to calculate the floor plan area of different room categories.

- Typical inventory types are:
  - Furniture inventory
  - HVAC inventory
  - Room finishes
- The space definition for inventory calculation can be made:
  - by zones (e.g. Rooms)
  - by stories
- Inventories derived from the BIM model can be used effectively for facility management (FM) and cost estimation purpose.

Object Name	148MC Trame Gla...	27_Modus
Zone Name		Age Concern
Quantity	1	1
Length (A)	0,301	0,680
Width (B)	1,341	0,650
Height (Z Size)	1,691	1,000
2D Symbol		
3D Front Axonom...		

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Cost Estimation

Cost awerness can be a winning factor for the architects practicing in a competitive market. It is even more critical for construction companies in the bidding phase.

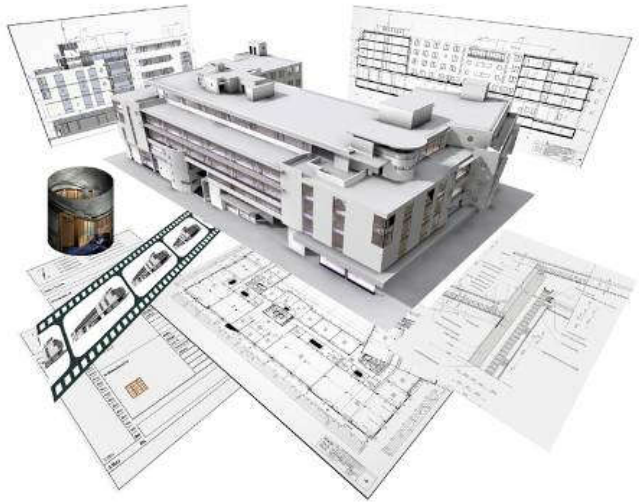
Assigning cost information to the BIM model allow automatic cost estimation of the building at any phase of the project life-cycle.

Advanced cost estimation solutions allow:

- Connection to standard cost estimation database
- Measuring of cost variances (design options)
- Output into different formats

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Cost Estimating with BIM



BIM Model

Linked Estimating Recipes

Code	Specification	Quantity	Unit	Min. unit price	Max. unit price	Unit price variance	Min. total price	Max. total price	Variance
B2010 B2010.0211	**Tiltup Wall Panel**	**29 409.44**	**sf**	**20.00**	**25.00**	**5.00**	**588 188.75**	**735 235.94**	**147 047.19**
B1020 B1020.1120	**Slab on Deck-RegMtl**	**35 147.62**	**sf**	**15.00**	**17.00**	**2.00**	**527 214.31**	**597 509.55**	**70 295.24**
A1010 A1010.0201	**Shallow Wall Footing**	**30.66**	**cy**	**310.00**	**320.00**	**10.00**	**9 505.57**	**9 812.20**	**306.63**
C1020 C1020.0100	**Intr HM Door**	**9.00**	**ea**	**730.00**	**750.00**	**20.00**	**6 570.00**	**6 750.00**	**180.00**
B2010 B2010.2100	EIFS Wall System	41.24	sf	15.29	15.29	0.00	630.76	630.76	0.00
B2010 B2010.0144	Expsd Agg Parapet	0.00	sf	0.00	0.00	0.00	0.00	0.00	0.00
B2010 B2010.0111	Precast Parapet	613.19	sf	20.20	20.20	0.00	12 385.00	12 385.00	0.00
B2010 B2010.3300	Alum Grating RoofScr	390.00	sf	16.77	16.77	0.00	6 539.10	6 539.10	0.00
Z2010 Z2010.5000	Preconstruction	1 000.00	sf	0.22	0.22	0.00	220.00	220.00	0.00
Z5040 Z5030 TEST	Precario	400.00	sf	200.00	200.00	0.00	80 000.00	80 000.00	0.00
A1030 A1030.0105	Cast Concrete Steps TEST	500.00	lf	143.03	143.03	0.00	71 516.00	71 516.00	0.00
A1010 A1010.0300	Grade Beams	20.00	ea	0.00	0.00	0.00	0.00	0.00	0.00
A2020 A2020.0100	Basemnt Foundtn Wall	133.22	cy	3 931.63	3 931.63	0.00	523 788.30	523 788.30	0.00
G2020 G2020.0400	Asphalt Parking Lot	2 025.00	sf	1.11	1.11	0.00	2 250.00	2 250.00	0.00
G2030 G2030.0100	Sidewalks	814.50	sf	2.90	2.90	0.00	2 362.05	2 362.05	0.00
C3030 C3030.1100	2x4 Acstc Clng	31 730.52	sf	1.44	1.44	0.00	45 744.84	45 744.84	0.00
A1030 A1030.0101	Slab on Grade	3 081.00	sf	5.85	5.85	0.00	18 017.94	18 017.94	0.00
B1030 B1030.1300	Roof Deck-ClsCell	3 512.76	sf	8.08	8.08	0.00	28 376.05	28 376.05	0.00
B2010 B2010.0228	SiteCast Tiltup Clmn	3 248.00	ft	0.00	0.00	0.00	0.00	0.00	0.00
A1010 A1010.0100	Pad Footings	24.44	cy	277.00	277.00	0.00	6 770.37	6 770.37	0.00
B1010 B1010.4100	Structrl Conc Core	277.73	cy	389.95	389.95	0.00	108 301.30	108 301.30	0.00
C1010 C1010.0055	IGypW 3-5/8 20GA NR	11 326.07	sf	6.32	6.32	0.00	71 589.29	71 589.29	0.00
	Listed structures in total						**2 109 969.62**	**2 327 798.68**	**217 829.06**

Cost Estimation

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Interactive Schedule

Since the schedules are derived from the BIM model any change in the building will have direct affect on calculations.

Some BIM applications also supports the editing of the BIM model from the calculation list dialog.

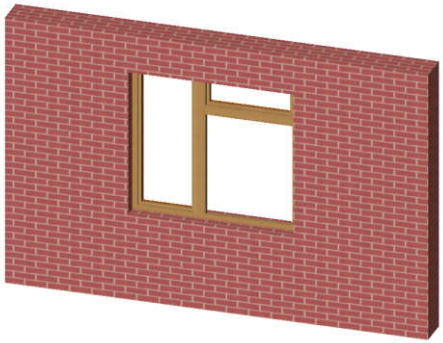
Typical example of this approach is the Interactive Schedule feature of ARCHICAD.

Interactive Schedule Features:

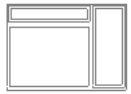
- Graphical editing of list form
- User defined parameters
- Changing of the most typical element properties (e.g. Size of a window) have result on the model
- Elements selected on the list will be selected on the floor plan as well

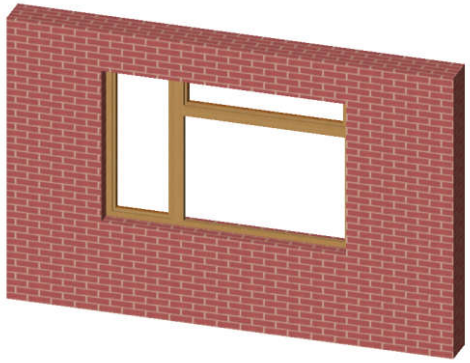
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Interactive Schedule



Window List	
Window Name	W Casement 2 10
Quantity	1
From Room Number	
Width	1,500
Height	1,500
Orientation	L
Window sill height	0,900
Window head heig...	2,400
2D Symbol	
3D Front View	

Window List	
Window Name	W Casement 2 10
Quantity	1
From Room Number	
Width	2,100
Height	1,500
Orientation	L
Window sill height	0,900
Window head height	2,400
2D Symbol	
3D Front View	



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

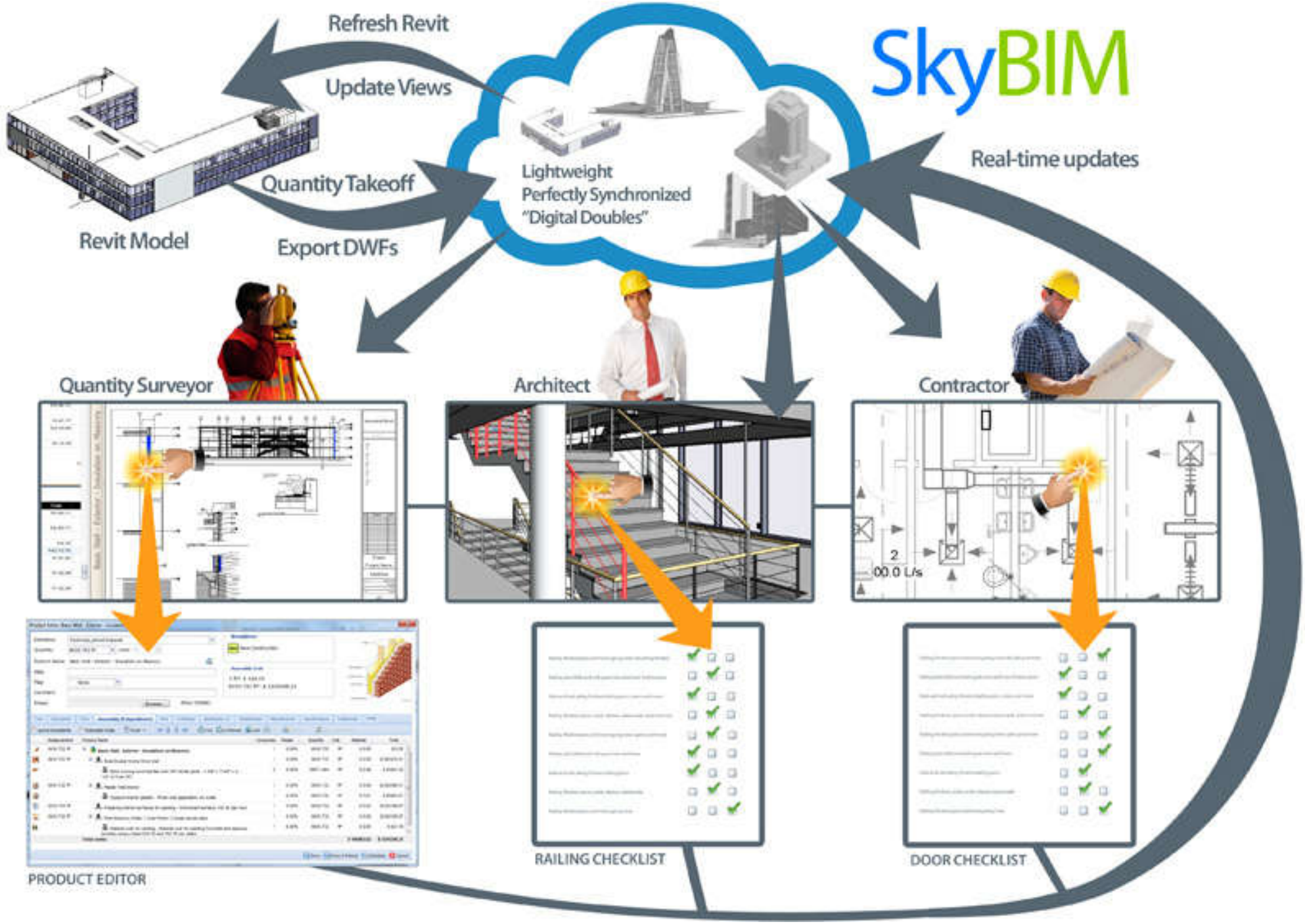
Calculation output

- Open BIM applications provides a wide range of calculation output formats that helps the architect to share the virtual building data with all the project stakeholders:

- Tabulated text
- Excel spreadsheets
- XML
- SQL
  - SQL (Structured Query Language) is the most popular computer language used to create, modify and retrieve data from relational database management systems.
- ODBC
  - Open Database Connectivity (ODBC) provides a standard software API method for using database management systems (DBMS).

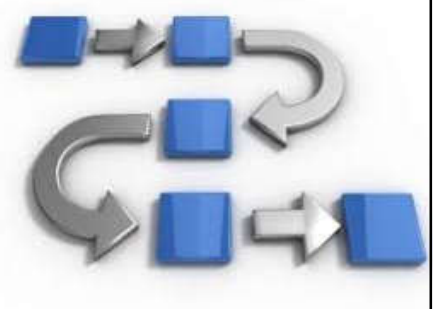
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Cloud-based management and real-time estimating using BIM

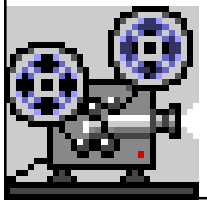


(Source: http://www.mosaicbim.com/)

4D scheduling

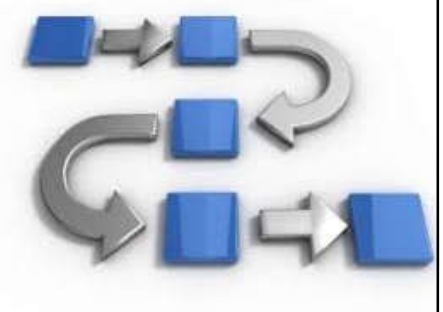


- 4D simulation : Provide different scenarios of animated construction sequences
- 4D scheduling : Perform a schedule and an animated construction sequence associated with a 3D BIM model
- 4D visualization : Perform an animated construction sequence of 3D BIM model
- >>> New jobs: 4D Planner & 4D Modeller



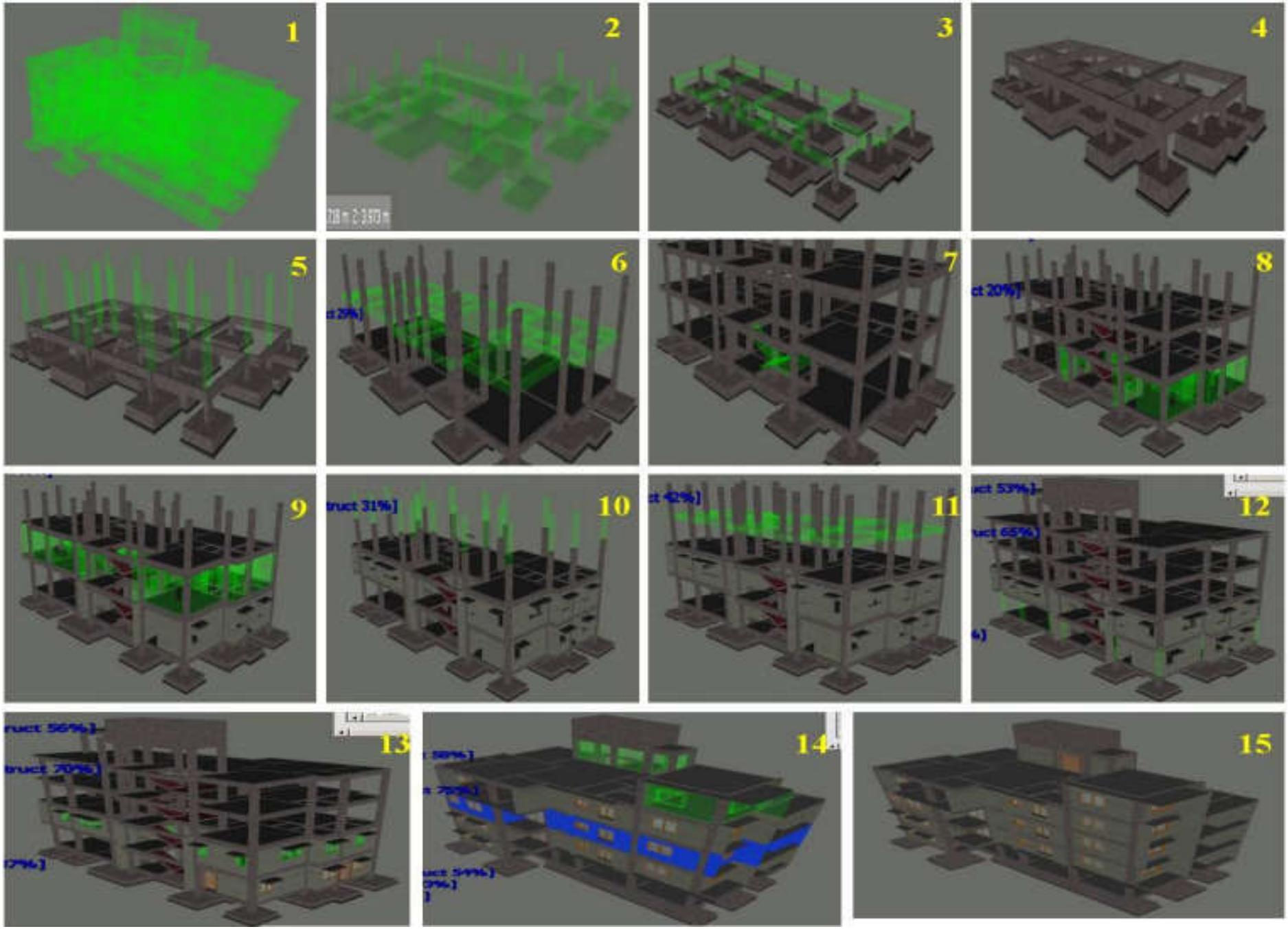
Video demon:
- Hotel Windsor 4D Construction Sequence Animation nm (3:26) https://youtu.be/pYDIsZwNl54
- 4d phasing, construction animation (3:31) https://youtu.be/5uHzLV3gf78

4D scheduling



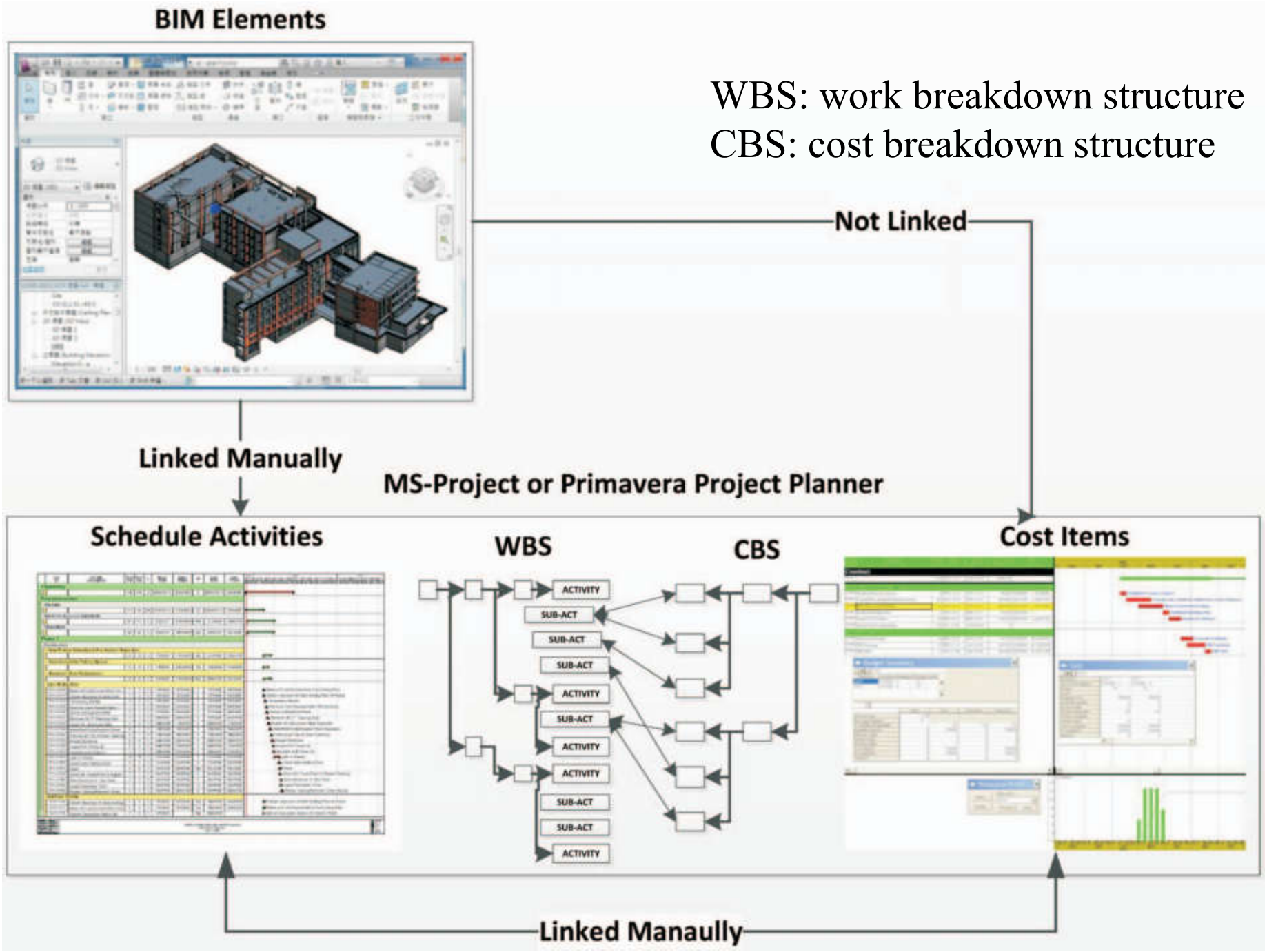
- 4D planning and scheduling
  - 1. Activity-based: deterministic, probabilistic
    - Such as critical path method (CPM) and program evaluation and review technique (PERT)
  - 2. Location-based: unit or location production
    - A hierarchical location breakdown of the structure
      - Location Breakdown Structure (LBS)
      - Location based quantities and tasks
      - Duration based on quantities, productivity and resources
      - A CPM network with buffers and lags

Sequential simulation of 5D model



(Source: Chowdary, M. A., Rajendra, S., Vijay, K. and Vidyashree, M., 2016. Modelling and project planning of a structure by implementing 5D BIM technique, *International Journal of Innovative Research in Computer and Communication Engineering*, 4 (4): 6969-6976. https://www.ijircce.com/upload/2016/april/100_MODELLING.pdf)

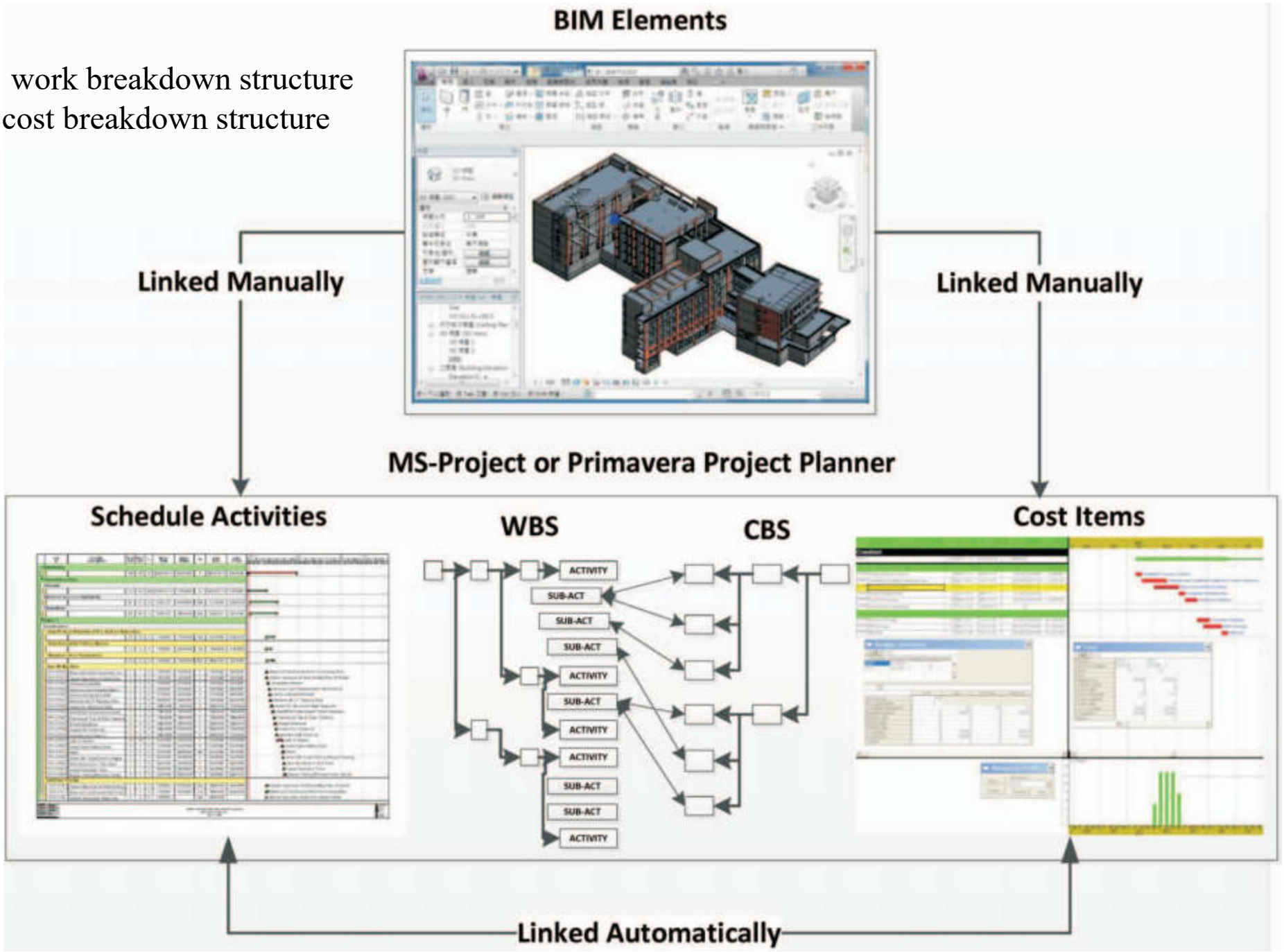
The current 5D modelling process for linking cost items to BIM



(Source: Fan, S.-L., Wu, C.-H. and Hun, C.-C., 2015. Integration of cost and schedule using BIM, *Journal of Applied Science and Engineering*, 18 (3): 223-232. http://www2.tku.edu.tw/~tkjse/18-3/02-CE10310_1368.pdf)

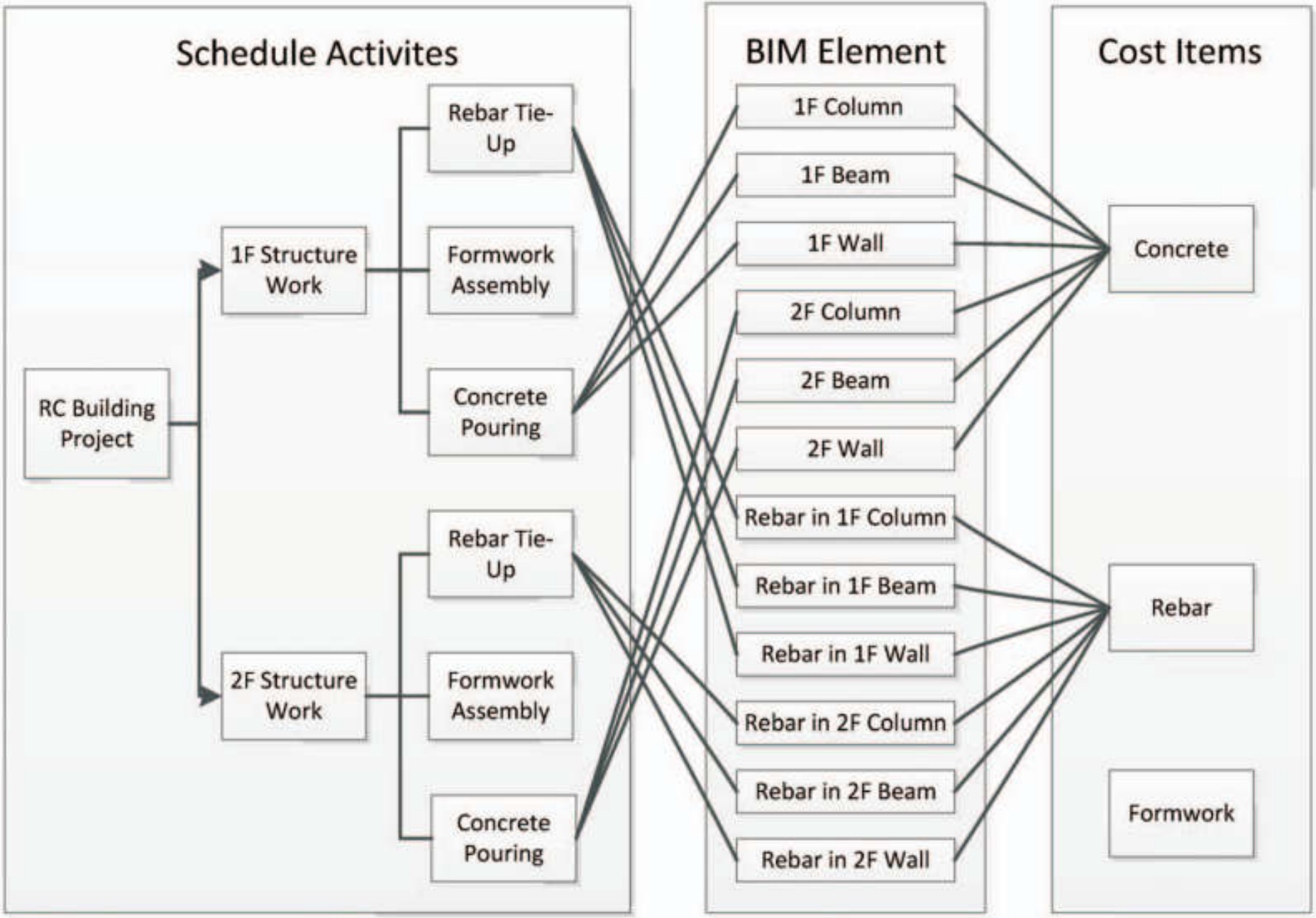
New 5D modelling process for linking cost items to BIM

WBS: work breakdown structure
CBS: cost breakdown structure



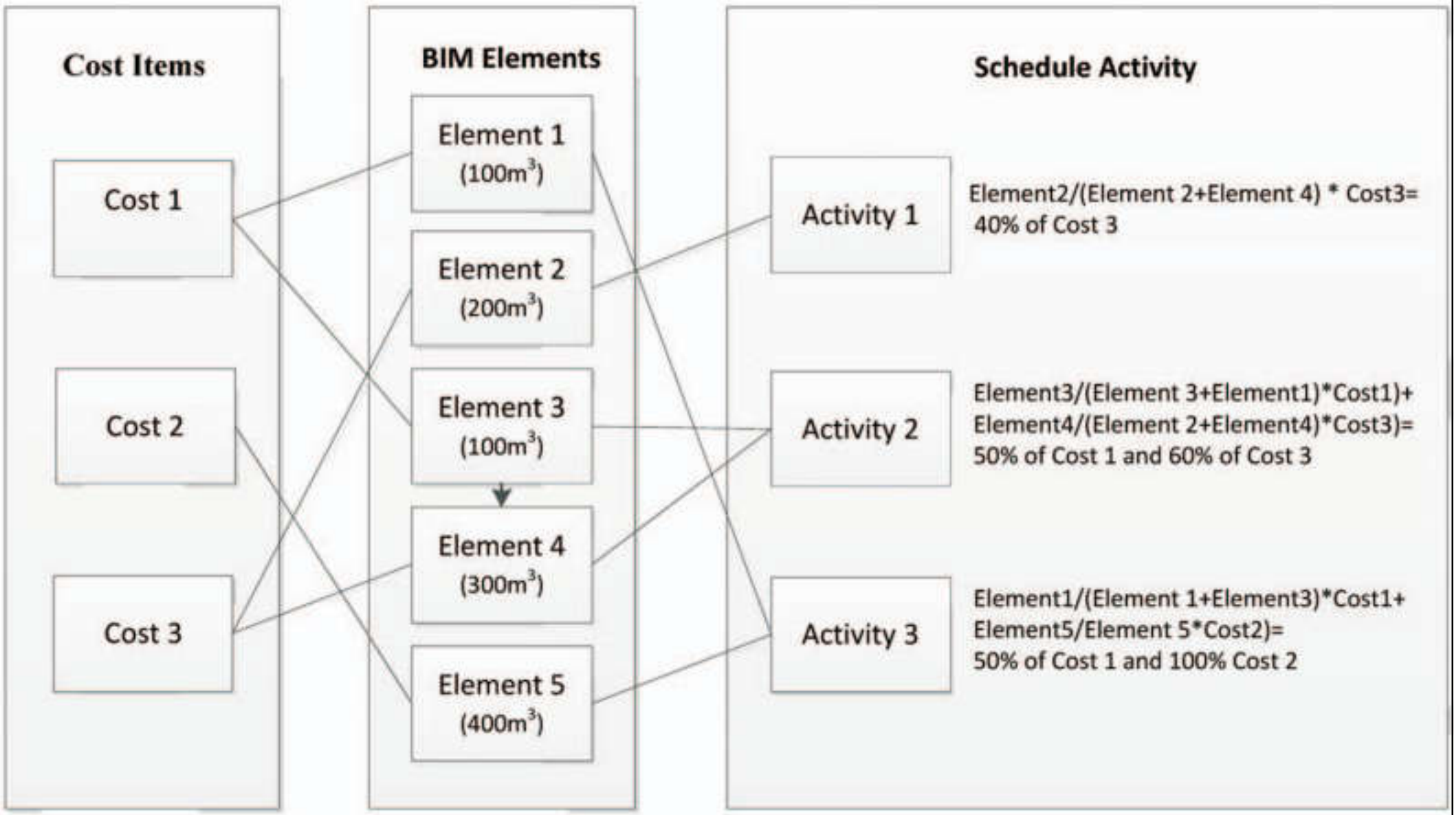
(Source: Fan, S.-L., Wu, C.-H. and Hun, C.-C., 2015. Integration of cost and schedule using BIM, *Journal of Applied Science and Engineering*, 18 (3): 223-232. http://www2.tku.edu.tw/~tkjse/18-3/02-CE10310_1368.pdf)

An example of the relationships between schedule activities, BIM elements, and cost items



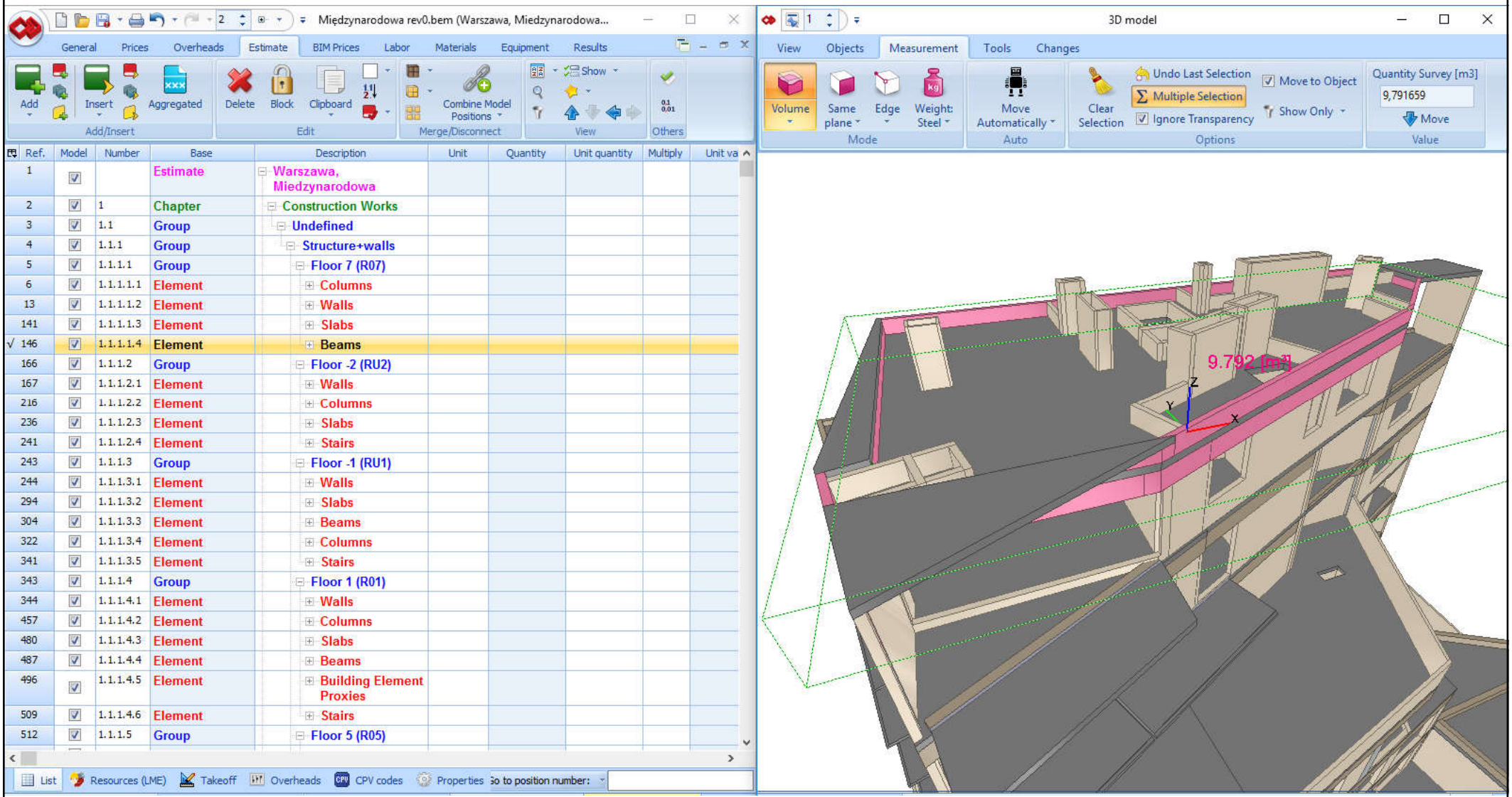
(Source: Fan, S.-L., Wu, C.-H. and Hun, C.-C., 2015. Integration of cost and schedule using BIM, *Journal of Applied Science and Engineering*, 18 (3): 223-232. http://www2.tku.edu.tw/~tkjse/18-3/02-CE10310_1368.pdf)

An example of the relationships between cost items, BIM elements, and schedule activities

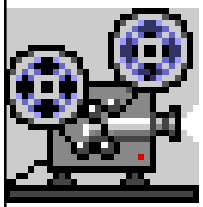


(Source: Fan, S.-L., Wu, C.-H. and Hun, C.-C., 2015. Integration of cost and schedule using BIM, *Journal of Applied Science and Engineering*, 18 (3): 223-232. http://www2.tku.edu.tw/~tkjse/18-3/02-CE10310_1368.pdf)

An example of BIM-based cost estimation software: BIMestiMate http://bimestimate.eu



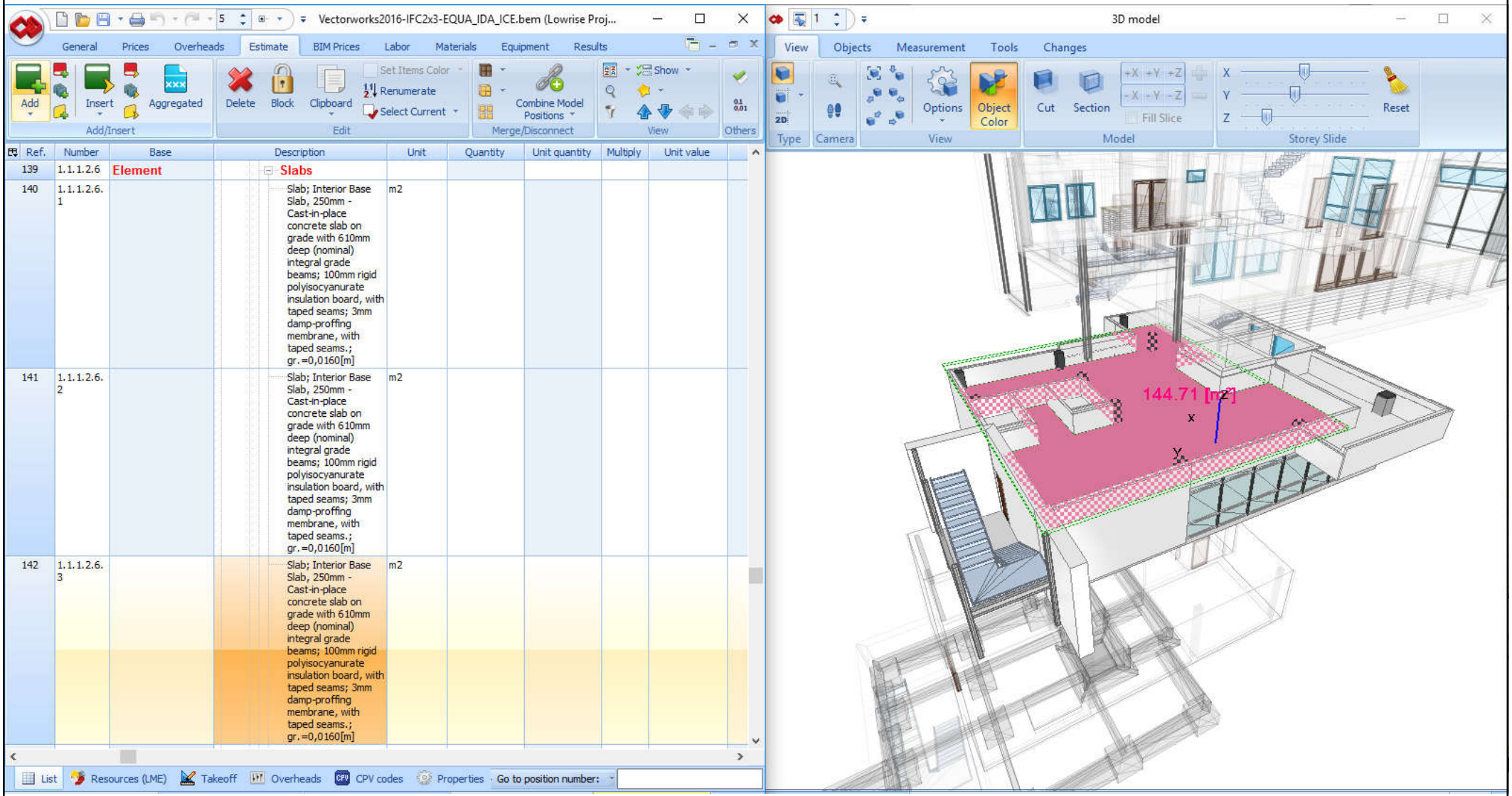
Automatic measurement of volume of all beams on a selected floor



Video: BIMestiMate - BIM-based Cost Estimation Software (5:07) https://youtu.be/tbmtjkSRc6I

(Source: http://bimestimate.eu/en/gallery/)

BIM-based cost estimation software: BIMestiMate http://bimestimate.eu

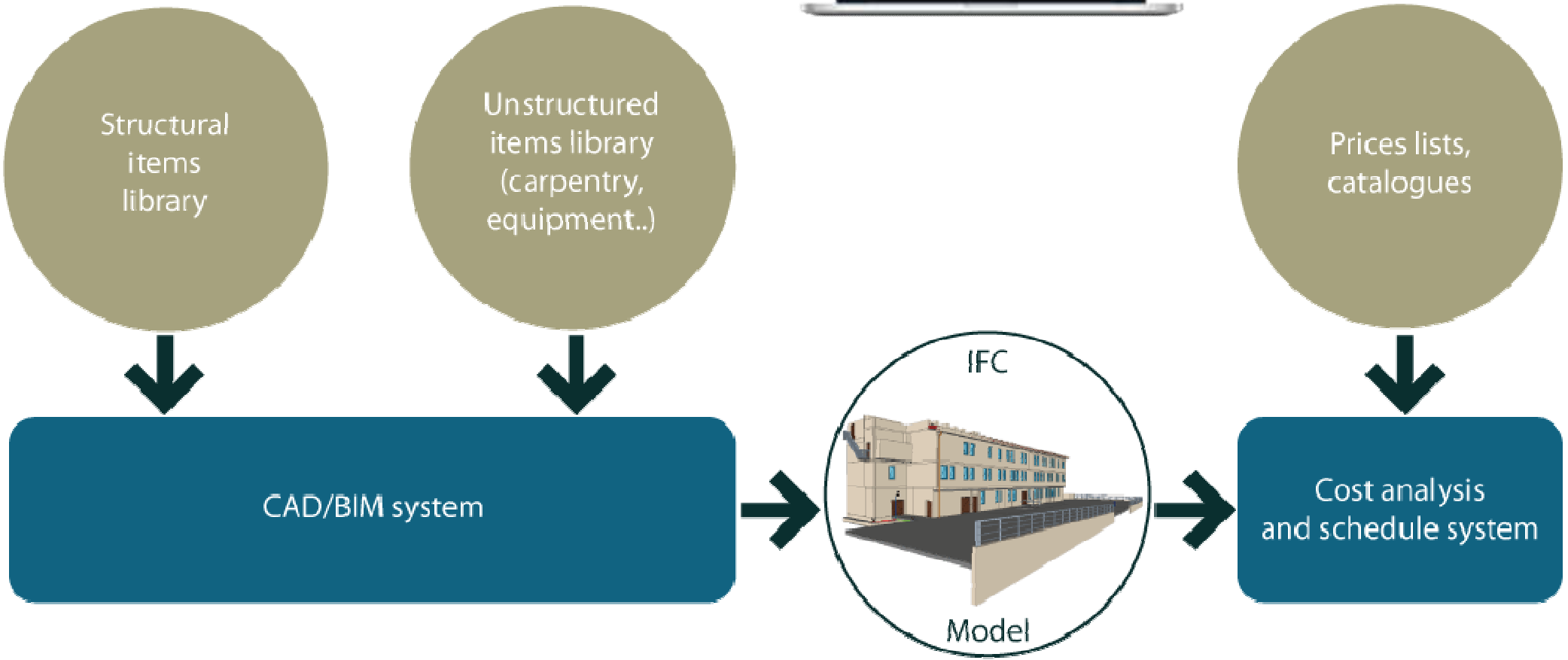


Displaying of a selected floor, storeys slide, area measurement, presentation of properties of an element.

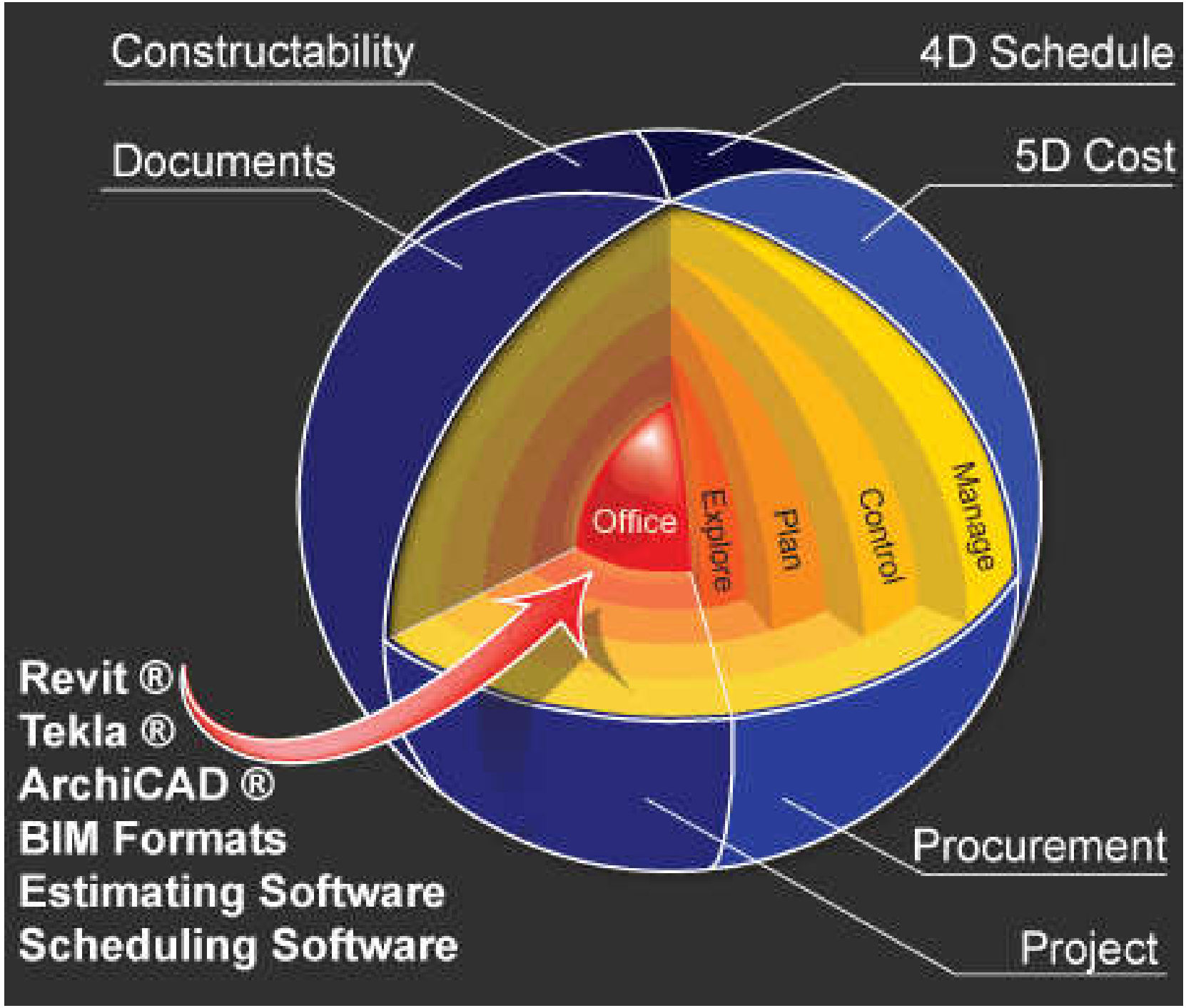
Gallery: http://bimestimate.eu/en/gallery/
Video: http://bimestimate.eu/en/video-2/
BIMestiMate Demo https://store-datacomp.eu/BIMestiMate/Home/Demo

(Source: http://bimestimate.eu/en/gallery/)

Download BIMestiMate Demo and try the software:
https://store-datacomp.eu/BIMestiMate/Home/Demo



Vico Office Suite: a construction-oriented 5D BIM environment

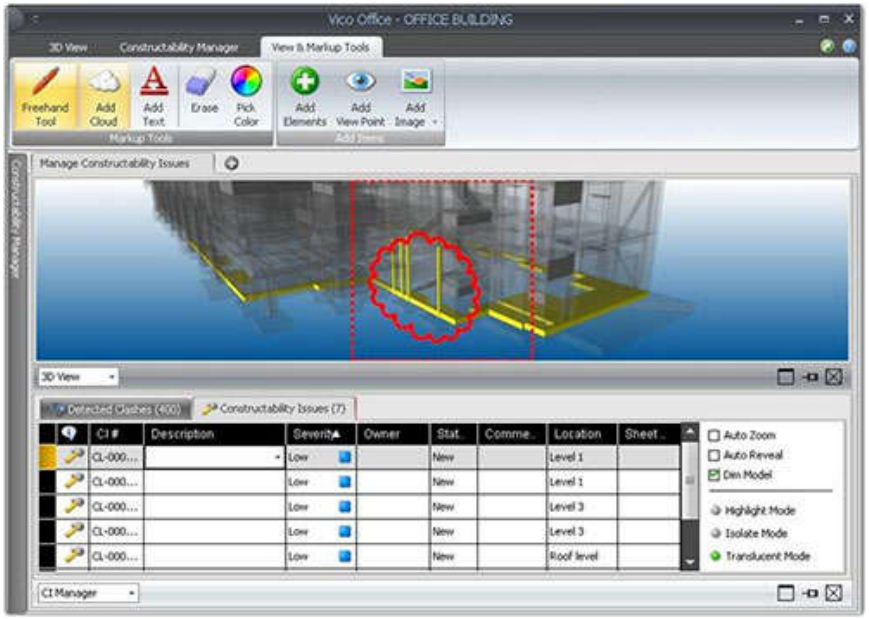


(Source: http://www.vicosoftware.com/products/Vico-Office)

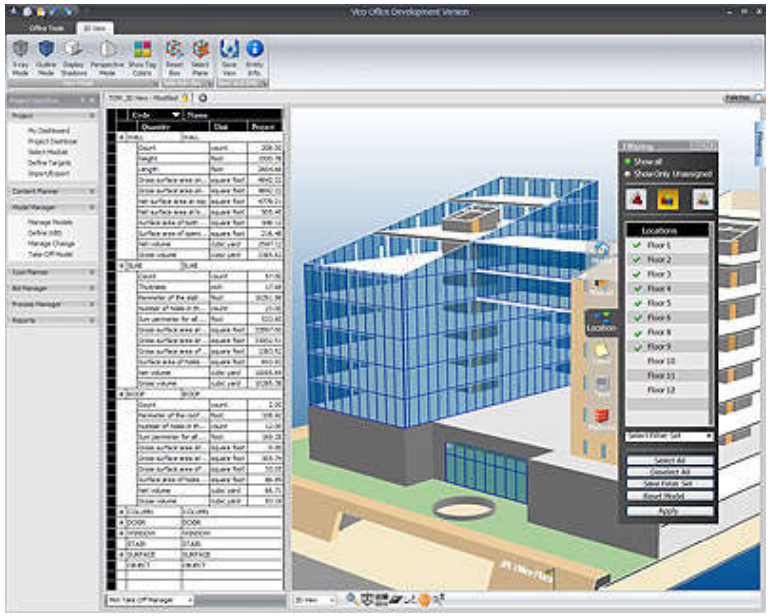
Examples of 5D BIM software

- The 5D BIM Workflow in Vico Office
  - http://www.vicosoftware.com/5D-BIM-Workflow-in-Vico-Office
  - Vico Office Client
  - Constructability Manager
  - Document Controller
  - Layout Manager
  - Takeoff Manager
  - Cost Planner and Cost Explorer
  - LBS (location breakdown structure) Manager
  - Schedule Planner
  - 4D Manager and Production Controller

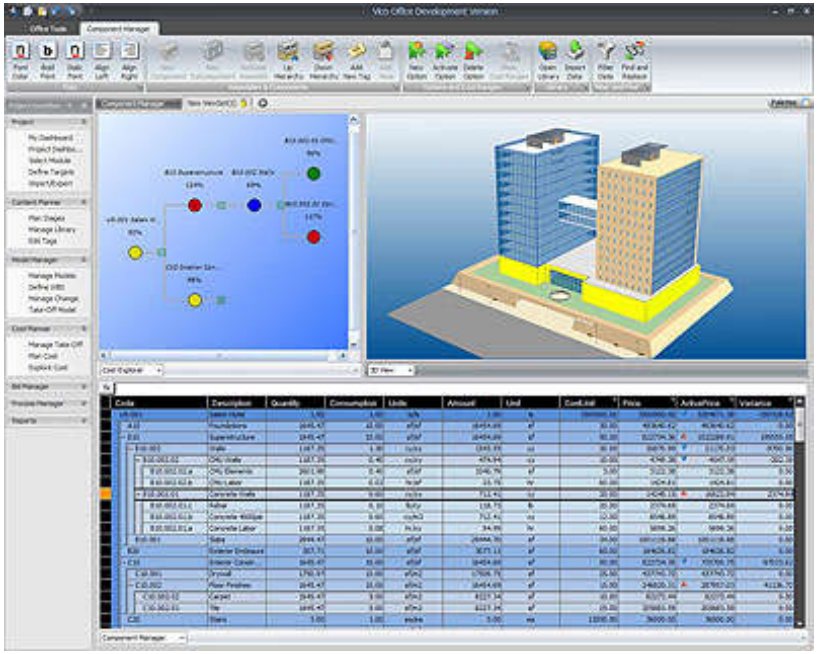
Examples of tools in Vico Office



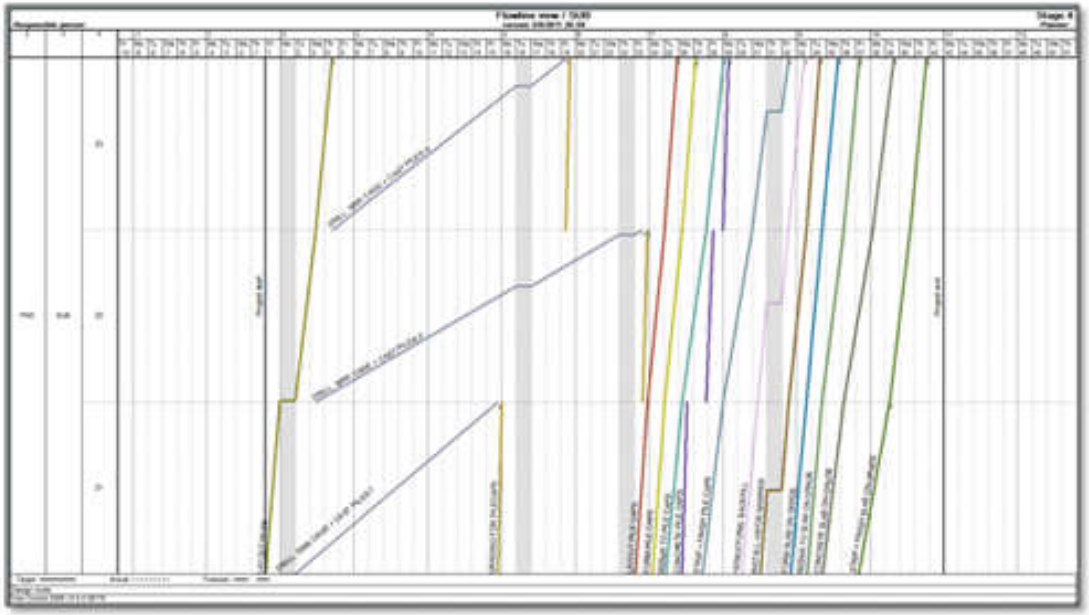
Constructability Manager



Takeoff Manager



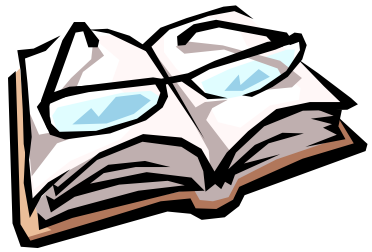
Cost Explorer



Schedule Planner

(Source: Vico Software http://www.vicosoftware.com/)

Further reading



- 5D BIM - Wikipedia
  - https://en.wikipedia.org/wiki/5D_BIM
- BIM dimensions - 3D, 4D, 5D, 6D BIM explained
  - https://www.thenbs.com/knowledge/bim-dimensions-3d-4d-5d-6d-bim-explained
- CS123778: Vico Workflow—5D BIM Case Study for a Hospital Project from Estimator's Perspective (Duration 54:07)
  - http://au.autodesk.com/au-online/classes-on-demand/class-catalog/classes/year-2017/revit/cs123778