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BIM Collaboration

Design and Lifecycle Management

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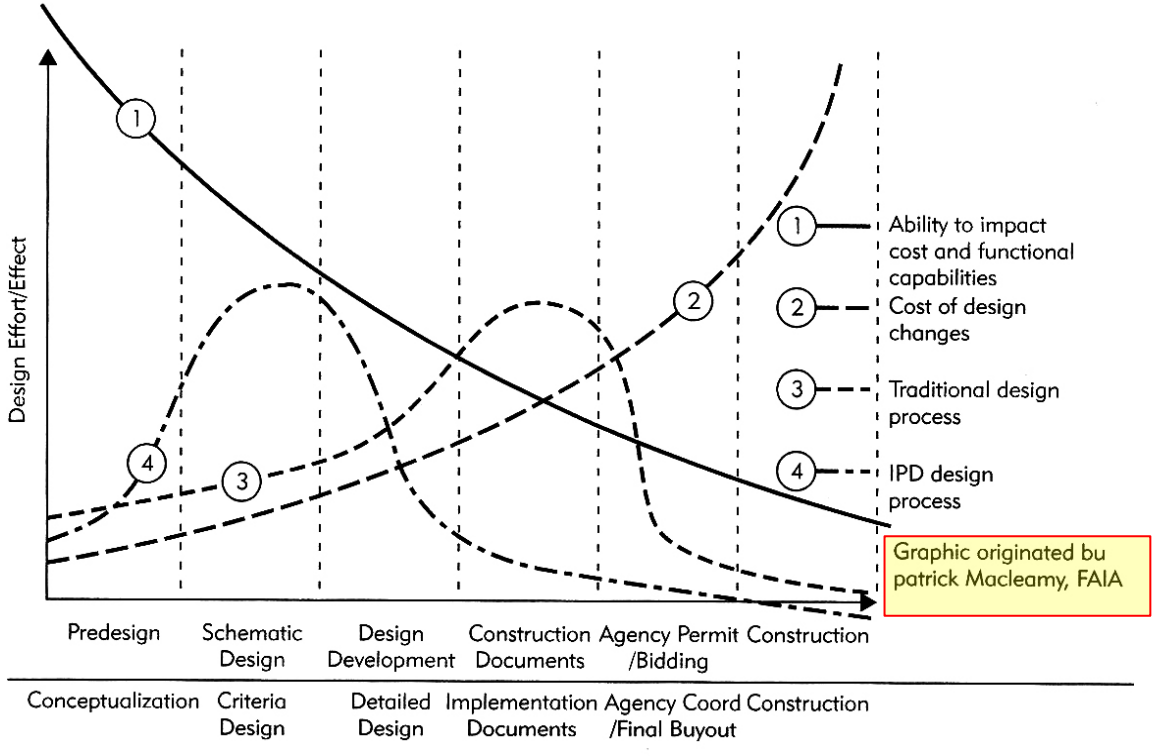
Aalto University, 14th March 2019

What is this session about?

- Design phase- decisions and processes and managing design teams
- Lifecycle considerations in early phase- Products, Processes and People
- Design for X [Safety, Manufacturing & Assembly- Prefabrication and Modularity…]
- Methodological approach- Design/ Dependency Structure Matrix
- Building handover
- Facility management and operations

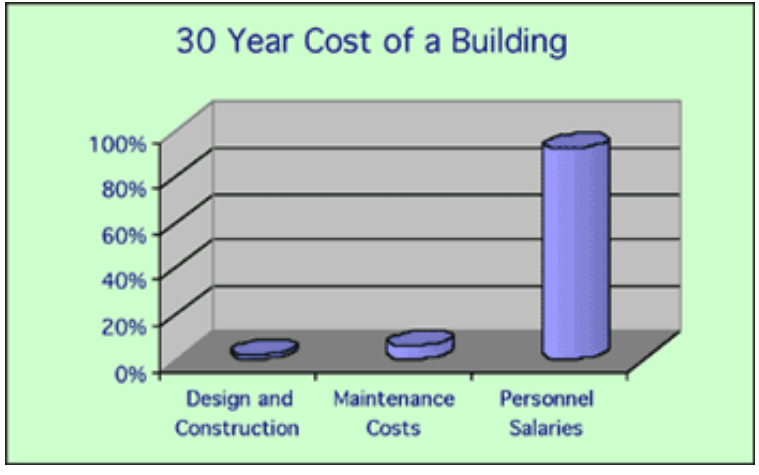
Design effort/ effect



- Most flexibility- design phase
- Low direct cost/resources, but most cost and resource committments

Lifecycle - broad themes

- Lifecycle cost (LCC)
  - Operations and maintenance
- Sustainability and environmental impact
- Design for lifecycle/ maintenance…



Source: https://www.wbdg.org/resources/life-cycle-cost-analysis-lcca

Lifecycle cost

- Initial Costs—Purchase, Acquisition, Construction Costs
- Utility Costs
- Operation, Maintenance, and Repair Costs
- Replacement Costs
- Residual Values—Resale or Salvage Values or Disposal Costs
- Finance Charges—Loan Interest Payments
- Non-Monetary Benefits or Costs

Online reference: https://www.wbdg.org/resources/life-cycle-cost-analysis-lcca

How do you account various types of lifecycle cost in the early design phase?

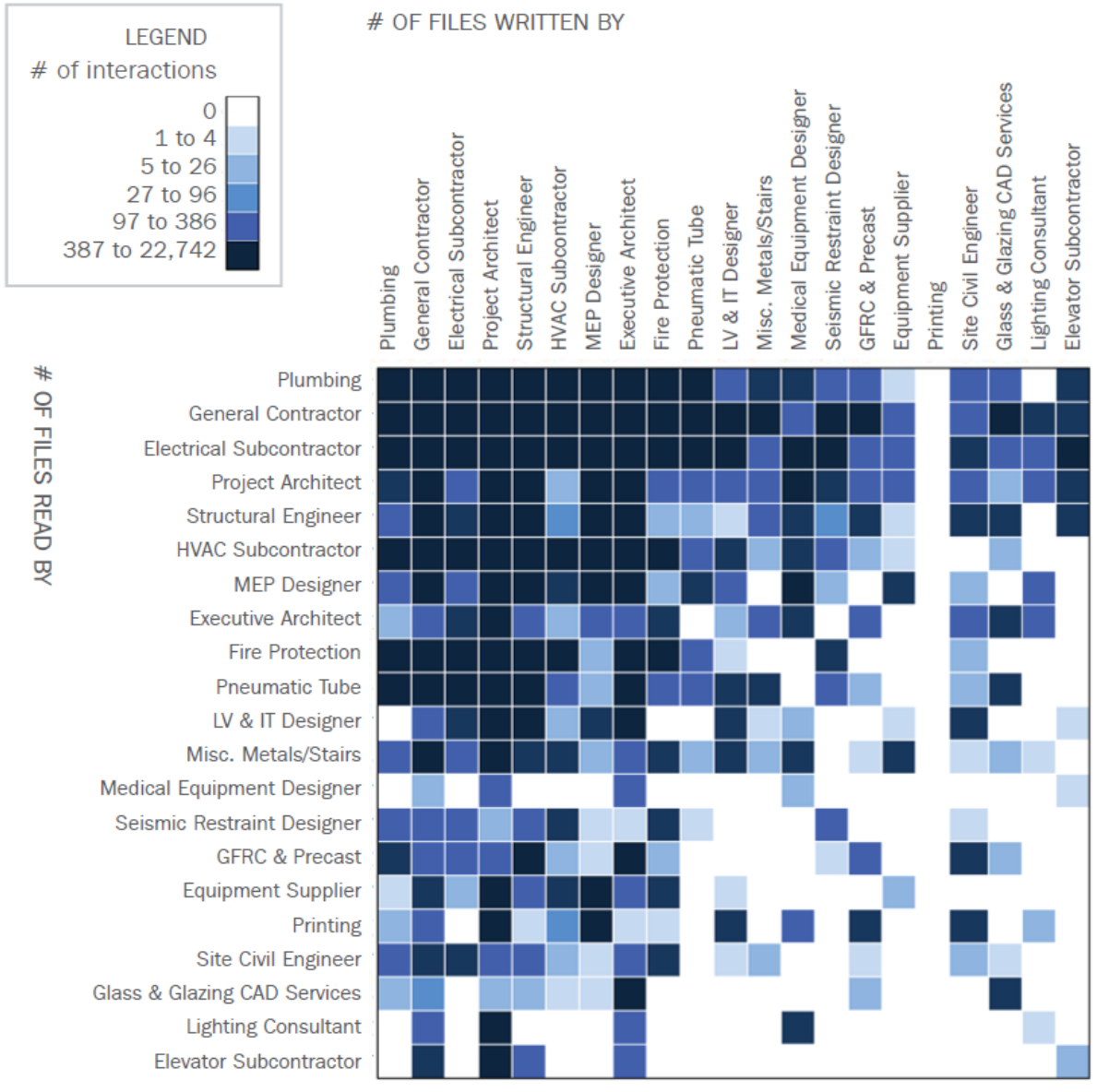
- Engage all stakeholders in the early design phase
- Develop methods for assessment
  - Lifecycle cost
  - Design for X
    - Lifecycle
    - Manufacturing and Assembly
    - Safety
    - Variety

Emerging best practices- Integrated approach

- **Collaboration**
  - Big Room
  - Knotworking
- **Contracting**
  - IPD (Integrated Project Delivery)
  - Strategic alliance

Changing ways of working- Big Room

Big Room



Ref: cife.stanford.edu/node/973

10 Insights from Big Room experience- DPR

- **Right technology:** (i.e., Smartboards, collaboration software, etc.)
- **Organize by clusters:** Arrange people not by company but by clusters
- **Well-planned meetings:** Detailed agendas and focus. Not everyone has to sit through every part of every meeting.
- **Time to work:** Schedule time for production work…no meeting time!
- Encourage and plan **integrated concurrent engineering (ICE)** sessions

10 Insights from Big Room experience- DPR

- **Daily huddle:** to address latency issues and adjust teams accordingly.

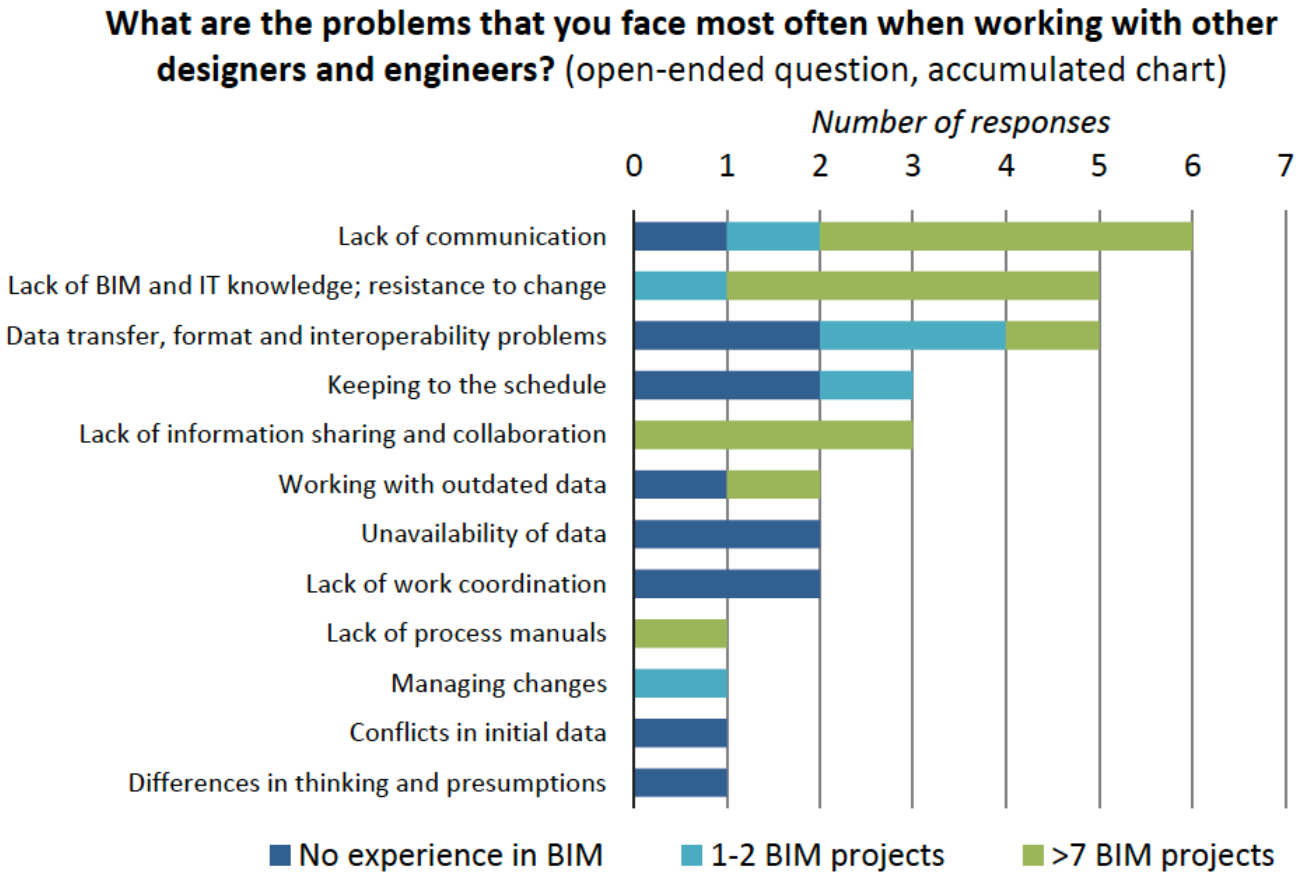
- **Respect time and expertise:** Value smaller roles. Align meetings to take advantage of their expertise when they are available

- **Be practical and tactical:** For example, stagger specific team meetings to give teams time for production work.

- **Use a parking lot:** Park items to stay on track and tackle later.

- **Plan the space:** Lots of open wall space for process planning and display of public metrics. Small and larger rooms for all types of meetings

Example- BIM in Finnish infrastructure design projects



Design tasks- Schedule VS Reality- Finnish case studies

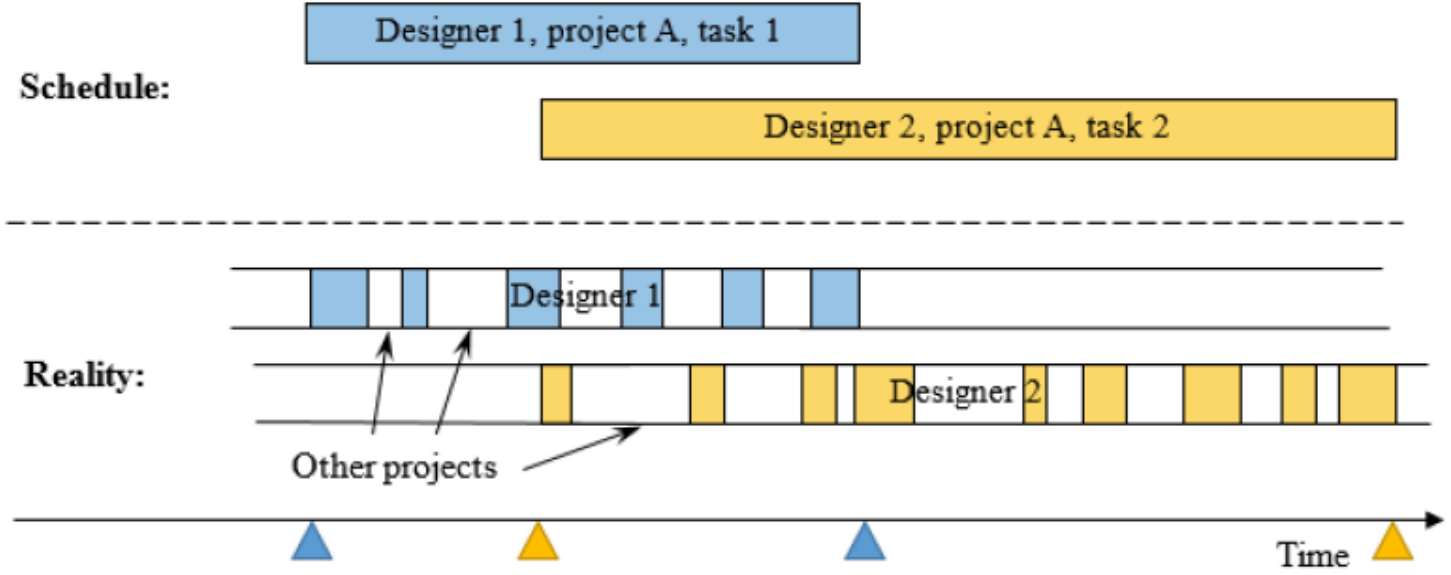
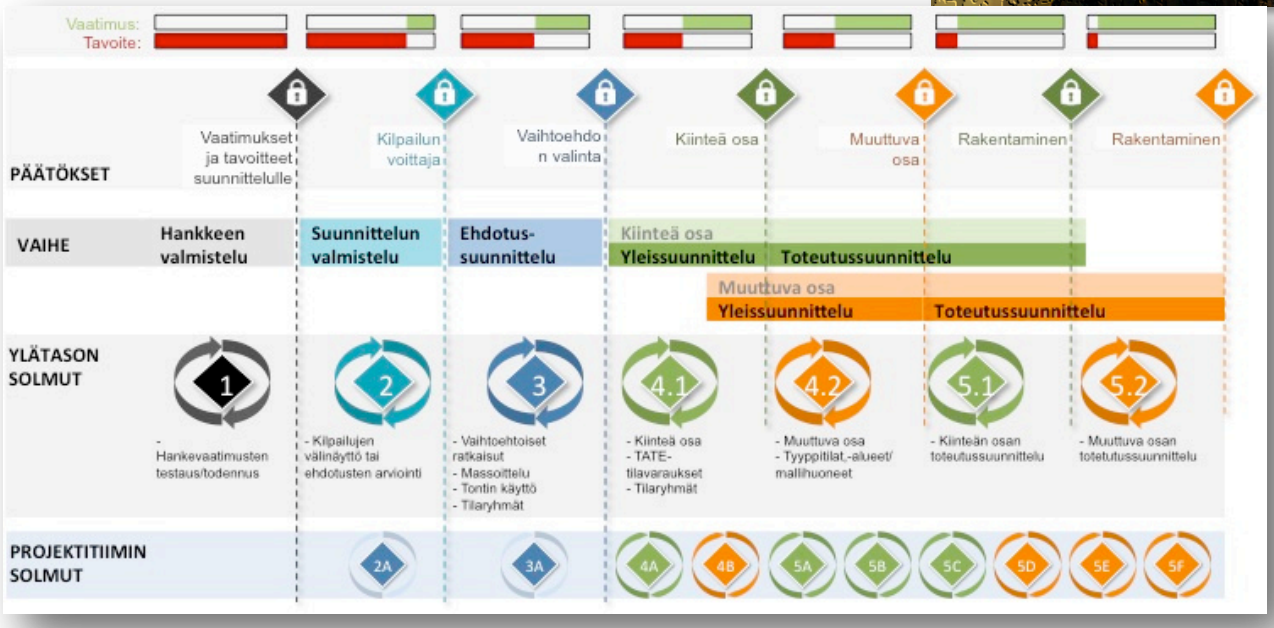


Figure 21: The design tasks as shown in project schedules; the schedule (on top) is an estimate and does not reflect the actual amount of hours spent on a project.

Knotworking



Lifecycle considerations- Products, Processes and People

Lifecycle factors to consider in terms of the product

- Product life
- Purpose and functionality: Use, Reuse
- Upgrade and changes, serviceability
- Depreciation in performance, quality, etc
- What can be recycled
- …

Several product characteristics determine these, for example

Material, technology, design, product architecture, environment…

Lifecycle factors to consider in terms of processes

- Terms and contracts
- Regulations and bylaws
- Archiving (documentation) and legal requirements
- Best practices and norms with operations and maintenance
- Prevalent business and operational processes
- …

Lifecycle factors to consider in terms of people

- Disintegrated phases have different people
  - Tracking who made what decisions and why?
- Customer or client's requirements
- Change of ownership
- Consideration of demographical factors
  - Cost and availability of labour
  - Skills and training, maturity of the FM industry
- …

Regular/ Non-volumetric prefab construction

Design phase?

Construction phase?

Operations phase?

Decommisioning?

Volumetric constr.

CONCRETE CORE

- Lateral load transferred to core through module.
- Gravity load taken by module.
- Low-mid rise buildings.

STACKABLE MODULAR UNITS

- Simple and easy to install.
- Load bearing modules.
- Poor in taking lateral load.
- Low rise buildings.
- Ex. Site offices made of shipping containers

STEEL FRAME

- Frames will take lateral as well as module load.
- Module has to take only its dead load.
- Flexibility in space design.
- High rise buildings.

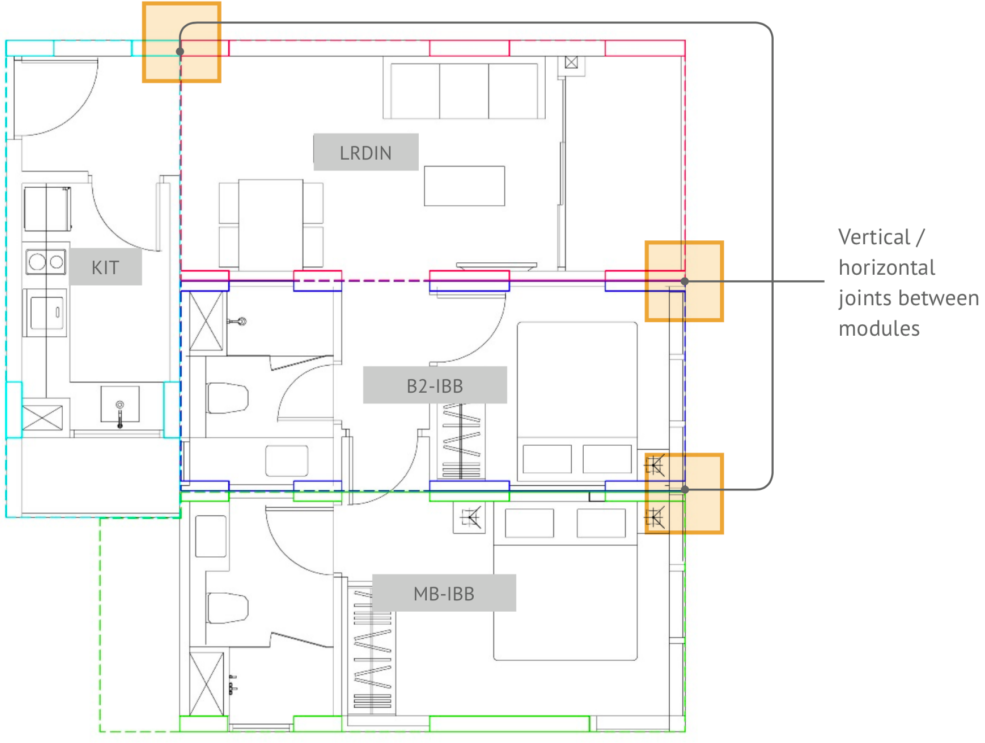
Design for lifecycle

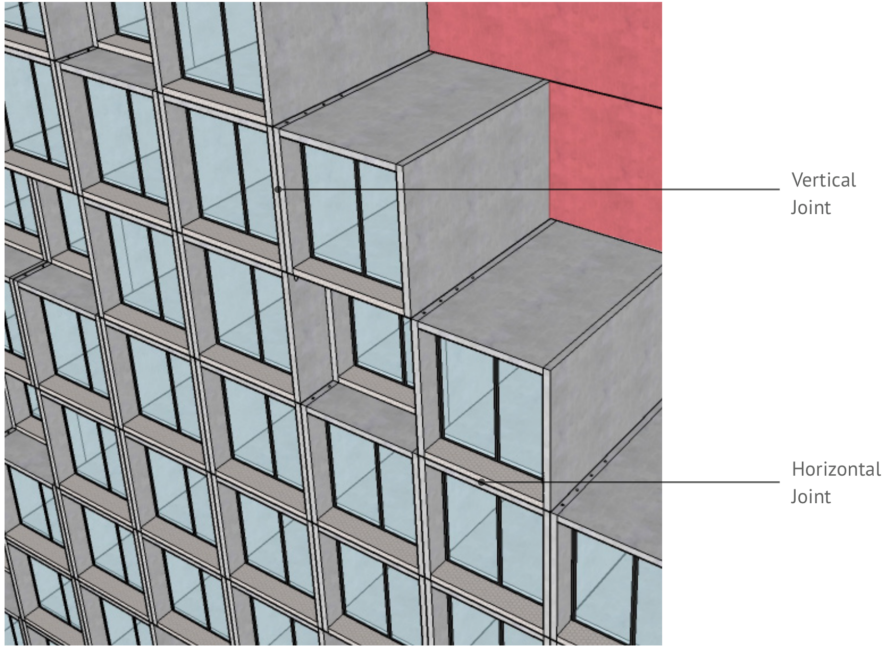
- Improve manufacturing and assembly- process and quality
  - Design for manufacturing and Assembly (DFMA)
  - Design for maintenance
  - Consider after life processes
  - …

https://www.bca.gov.sg/Professionals/Technology/others/PPVC_Guidebook.pdf

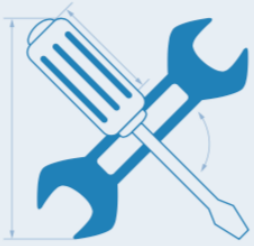
Water-Tightness Between Modules

To consider the water-tightness details on vertical and horizontal joints of modules





https://www.bca.gov.sg/Professionals/Technology/others/PPVC_Guidebook.pdf



ACCESSIBILITY FOR INSTALLATION AND MAINTENANCE

Means of installation shall enable ease of maintenance or future replacement when necessary. Space for installation, maintenance and future replacement shall be allocated. Pipework enclosures (e.g. ducts, castings, etc.) shall be of a suitable size. Sufficient and suitable ready access shall be provided for maintenance, inspection, testing and repairing / replacing of the enclosed pipework.

e.g. Periodic Structural Inspection (PSI)

10.5 Design for Safety

- PPVC supplier, designer, Qualified Person, Developer and Main Contractor are relevant stakeholders that shall be involved in the DfS review.
- Design for safety reviews should be carried out upstream, e.g. during the BIP application or at the concept and detailed design phases, to address risks that would manifest itself during:
  1. the construction stage,
  2. the building maintenance stage; and
  3. the demolition phase.

Things to note:

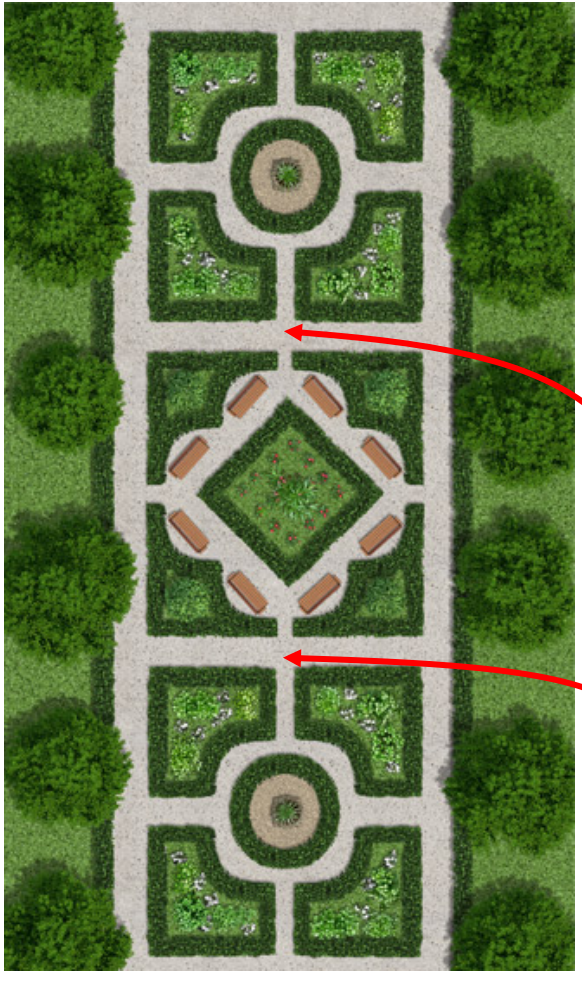
- For onsite installation, please pay special attention to activities related to Lifting, Access/Egress and Working at Height.
- The design should cater adequate provisions for safe PPVC building maintenance and repair.
- User/ installer manual should include safe demolition sequences and special precautions.
- PPVC suppliers/ designers shall control the design risks based on the Hierarchy of Control Measures.

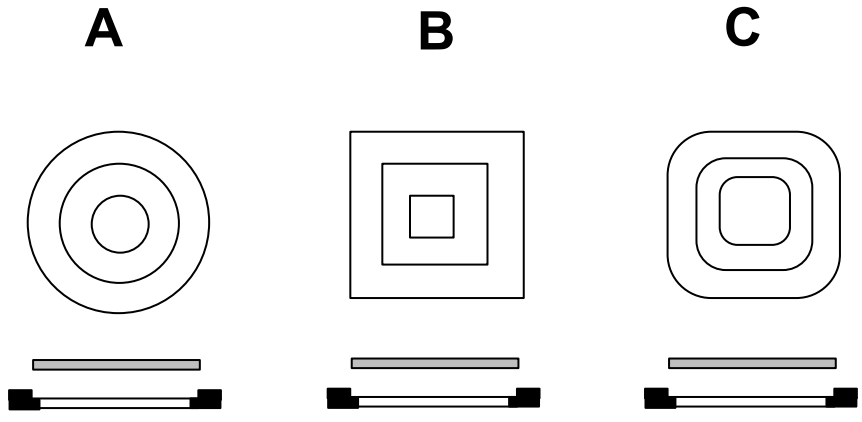
PPE shall be adopted as a last resort.

Information capture in design phase

- Can we capture design rationale?
- Can we trace the history of design decisions?
- What are the benefits of tracing history of design decisions?
  - Identifying responsiblities
  - Documentation for IPR and sharing benefits

Example- capturing design rationale

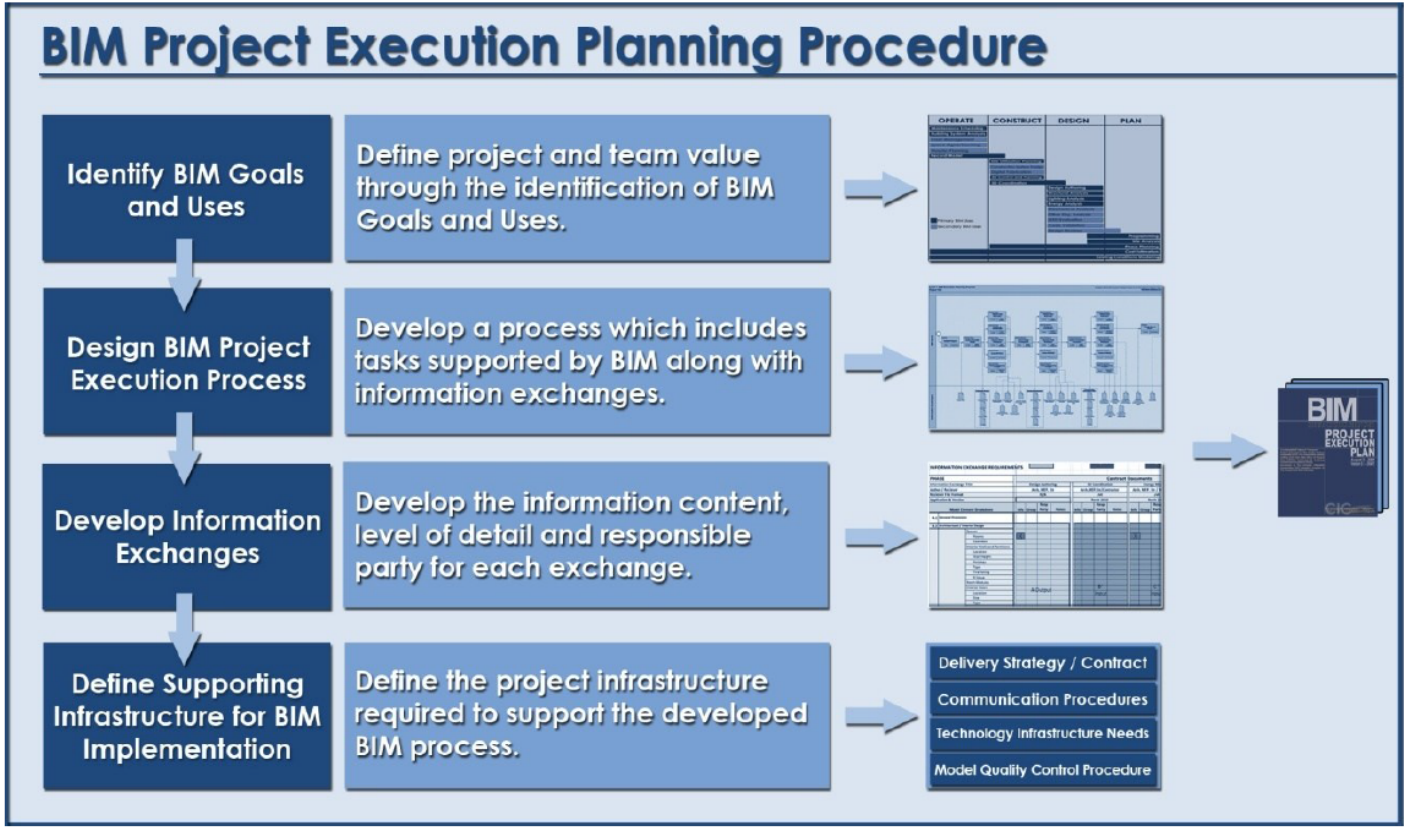


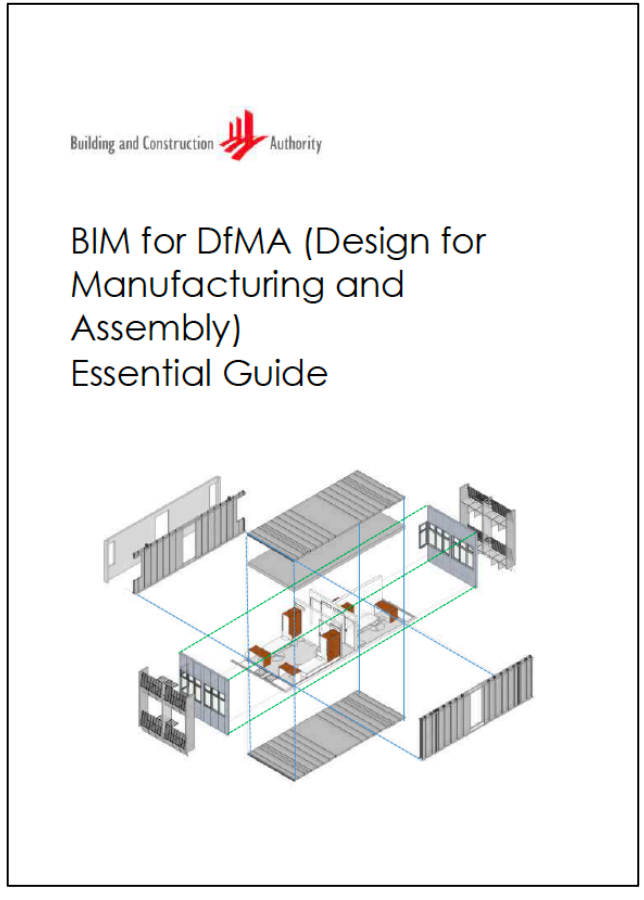


All covers (not fastened) have same cost, same strength, same material, similar details…

Which option would you pick?

BIM execution plans





https://www.corenet.gov.sg/media/2032999/bim_essential_guide_dfma.pdf

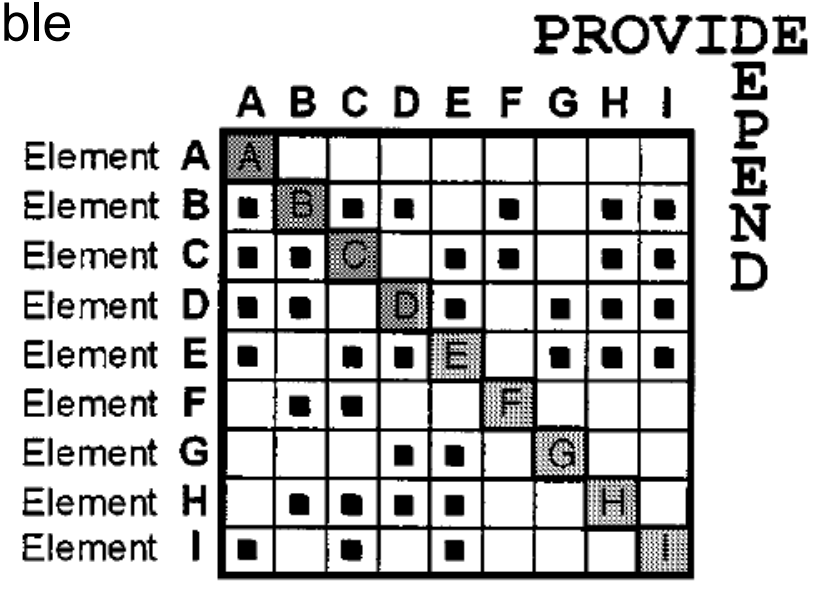
BIM execution plans

1. Evaluate BIM requirement (specific to project)
2. Determine purpose of BIM (possibilities)
3. Understand work process within and across the organizations
4. Knowledge of available tools
5. Understand project partner capability (current/ potential)
6. Evaluate current status (overall)
7. Assess the gap
8. Conduct what-if: Iterate

Methodological approach- decision tool

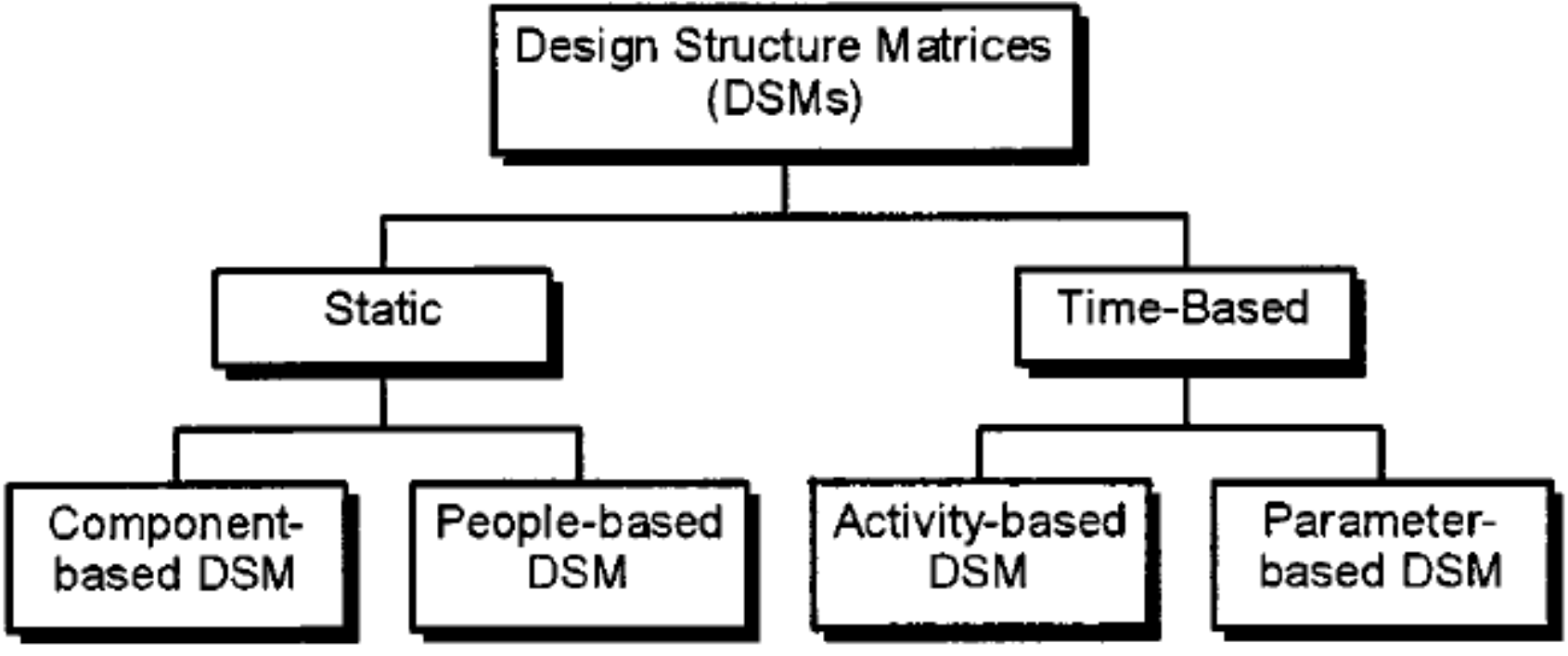
Design/Dependency Structure Matrix

- Adjacency matrix
- Dependencies/ relationships
- Human readable, Machine readable
- Various types
- Data gathering, data analysis



Source: Browning, 2001

DSM types and applications

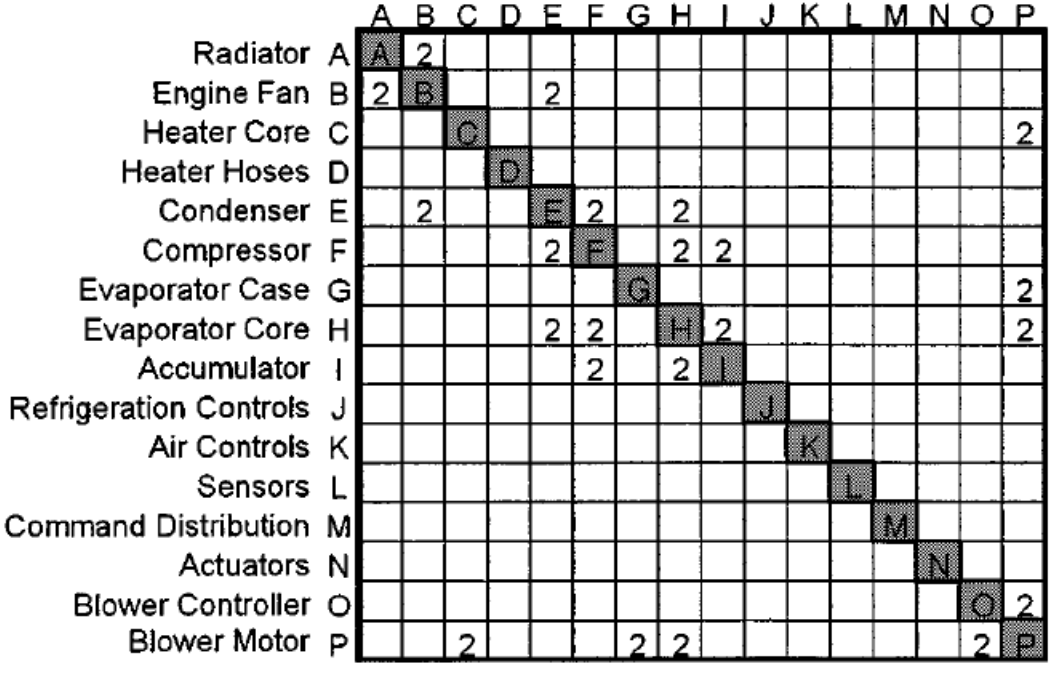


Source: Browning, 2001

DSM applications and purposes

DSM application	For modelling	Analysis
Component-Based or Architecture DSM	system architectures; mapping subsystems relationships	Clustering
Team-Based or Organization DSM	organization structures based on people and/or groups and their interactions	
Activity-Based or Schedule DSM	Processes and activities based on information flow and other dependencies	Sequencing
Parameter-Based (or Low-Level Schedule) DSM	low-level relationships between design decisions and parameters, subroutines, etc	

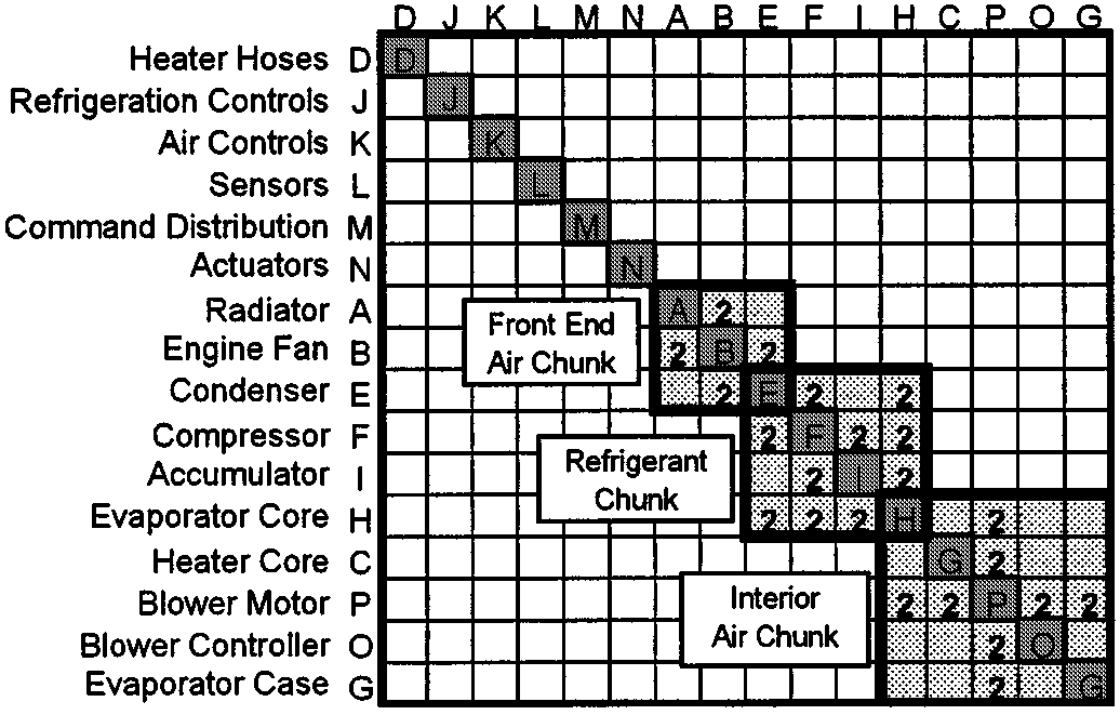
Product configuration



+2= Required interaction
+1= Desired
0 = Indifferent
-1= Undesired
-2= Detrimental

Component-based DSM showing materials interactions for climate control system

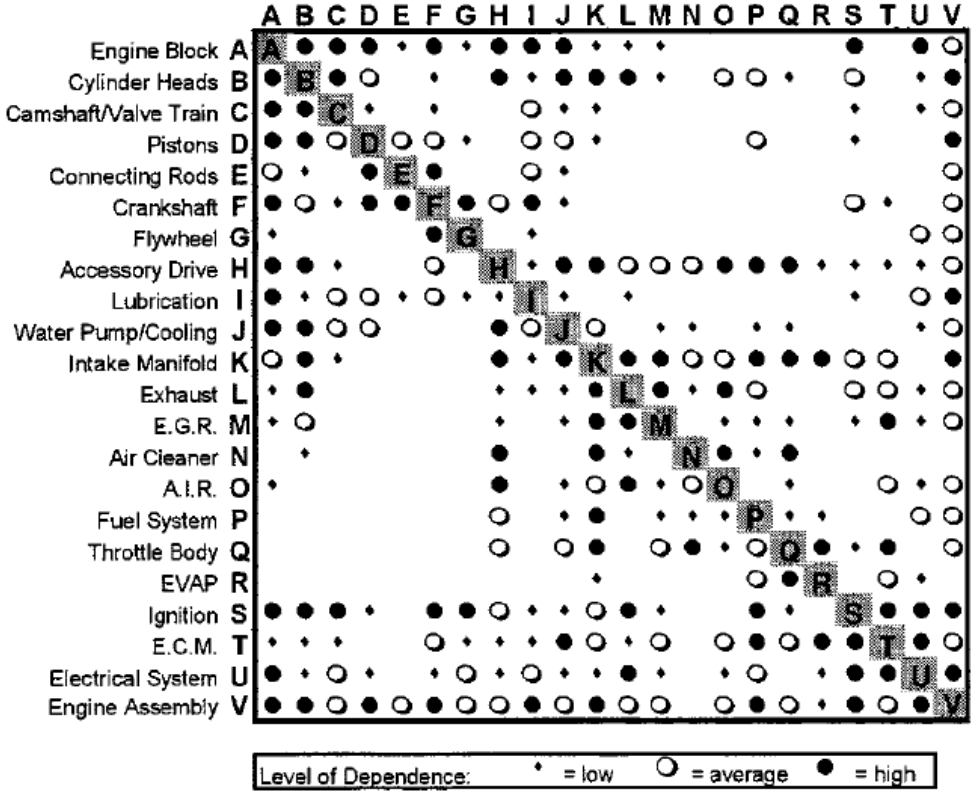
Clustering dependent components



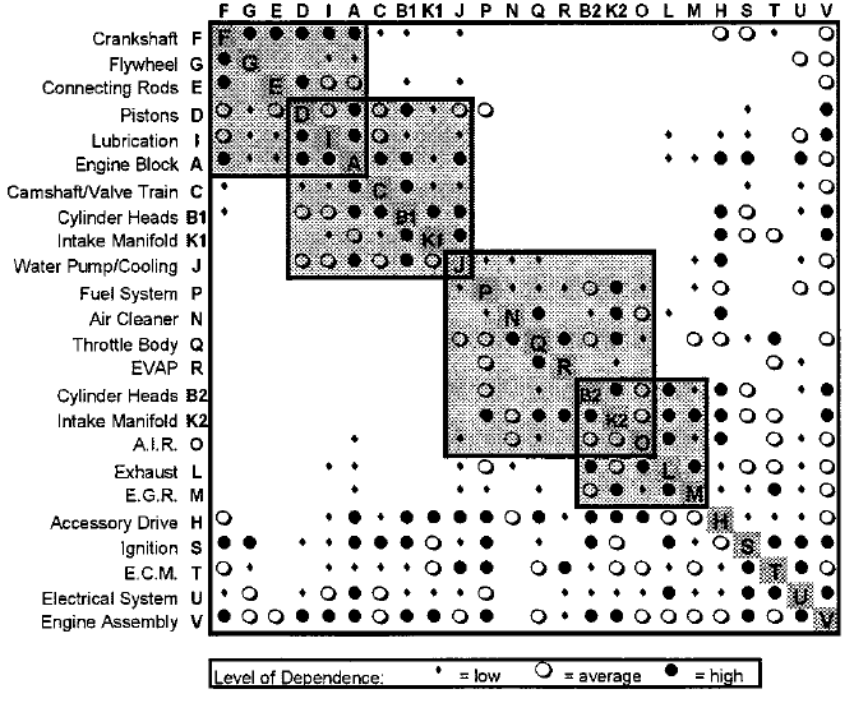
Clustering of materials interactions in component-based DSM

Team-based DSM example

DSM showing information flow between Product Development Teams

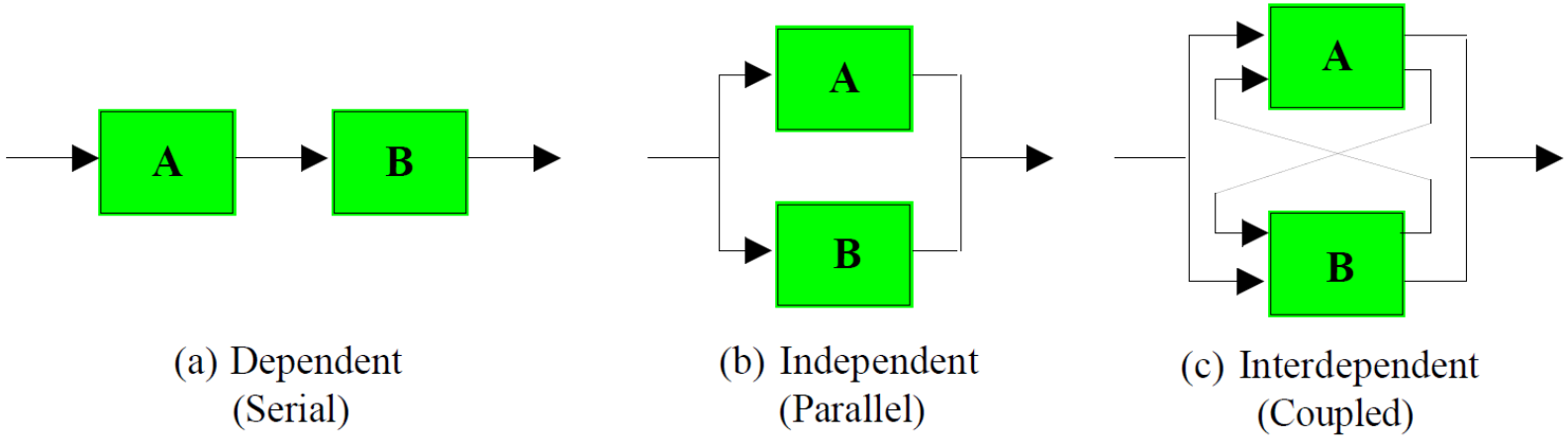


Team-based clustering: example

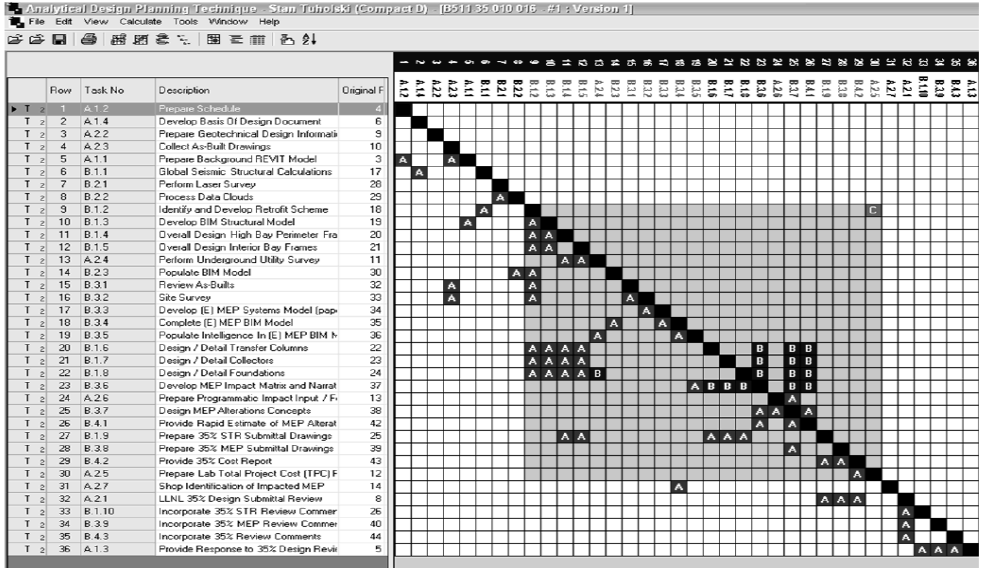


Restructured, team-based DSM shows proposed “metateam” organization design

Activity (task)-based DSM: dependencies

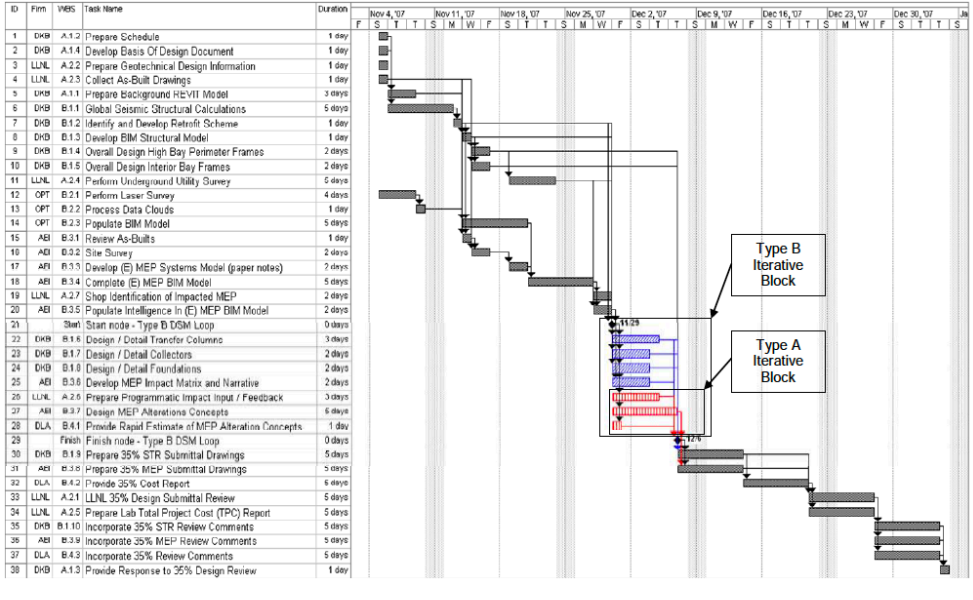


Activity networks and DSM equivalents



Design Structure Matrix (DSM) Implementation on a Seismic Retrofit Stan

(2008) J. Tuholski and Iris D. Tommelein



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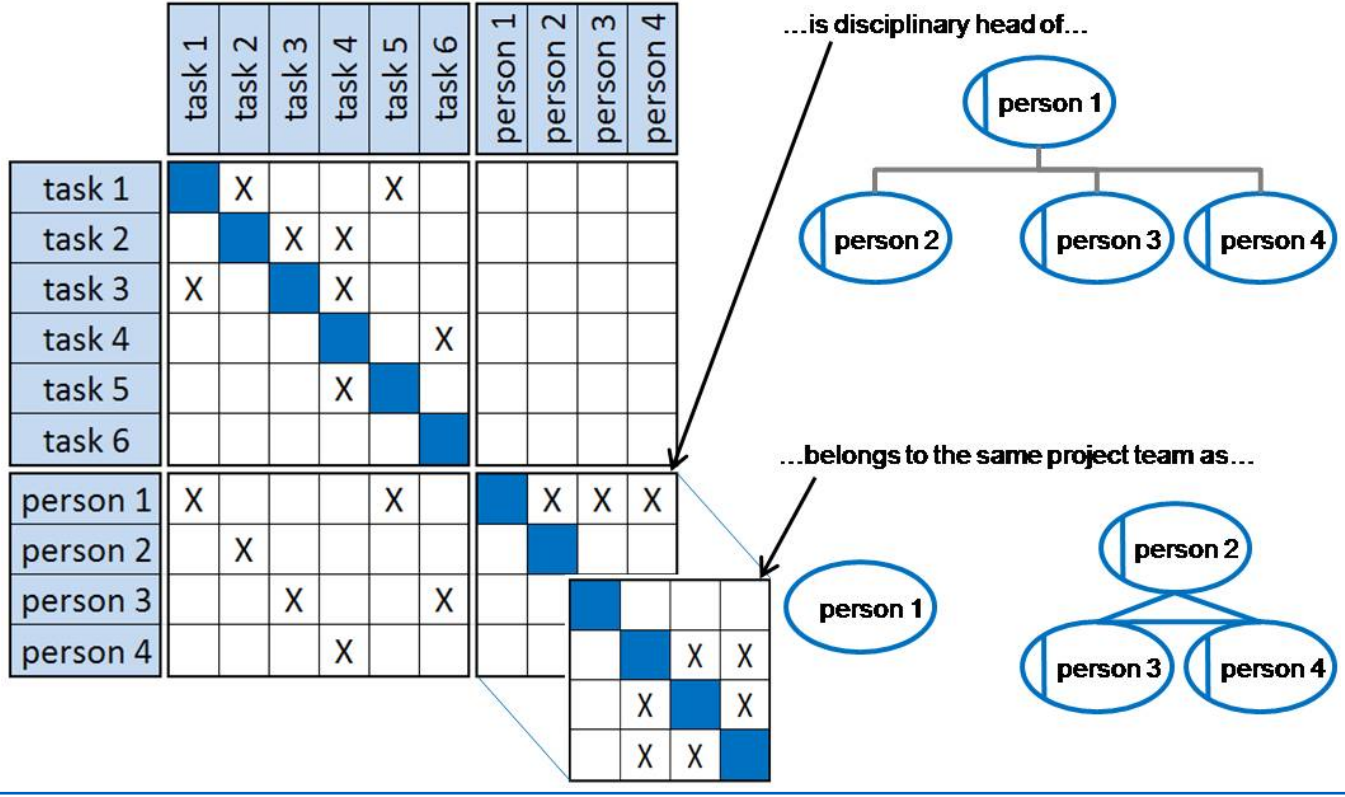
Multi-Dimensional Matrix



Post construction- Lifecycle management

Asset management over lifecycle

Six crucial questions [Vanier 2001]

- What assets do you own?
- What is the value of these assets?
- What is the condition of these assets?
- What tasks are required to maintain asset serviceability?
- What and how long will the assets effectively operate?
- What is the plan for maintenance of all assets?

Building Handover process

Contractor’s responsibilities in handover

- Quality control/ audit
  - Does it meet the standards set out in the contract?
- Prepare (with consultants) ‘snagging’ lists, to be resolved
- Arrange training and familiarization
- Hand over documentation
  - Health and safety file
  - All ‘as built’ data
  - Log book
  - Manuals and instructions as agreed in the contract

Typical contents of the log book

- Summary of the facility and purpose of the building services
- Zoning arrangements
- Location and features of the relevant plant and equipment
- Schedule of the building's energy supply meters
- Description of the energy-consuming services
- Instructions on how to achieve the specified performance

Typical O&M manuals

- Makes and model numbers, with manufacturers' contact details
- Manufacturers' instructions, with clear indications of the equipment actually installed, and all maintenance and servicing schedules and requirements
- Schematic diagrams of the building services
- Commissioning records, including demonstration of compliance with specified energy efficiency standards

Client’s role in handover

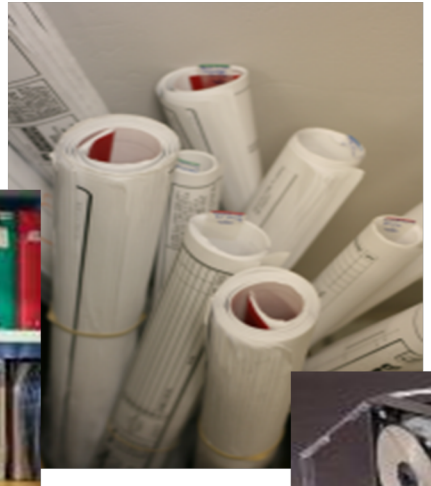
- Monitor and record problems within Defect Liability Period
- Arrange for contractor’s briefing on the building's systems
- Check the project against the brief, the design and the contract
- Be aware of possible future problems: building systems for HVAC are likely to need fine-tuning once in use
- Collect during handover
  - Certificate of practical Completion
  - Certificates of compliance with regulations
  - Construction record information

Client’s role in handover (Contd.)

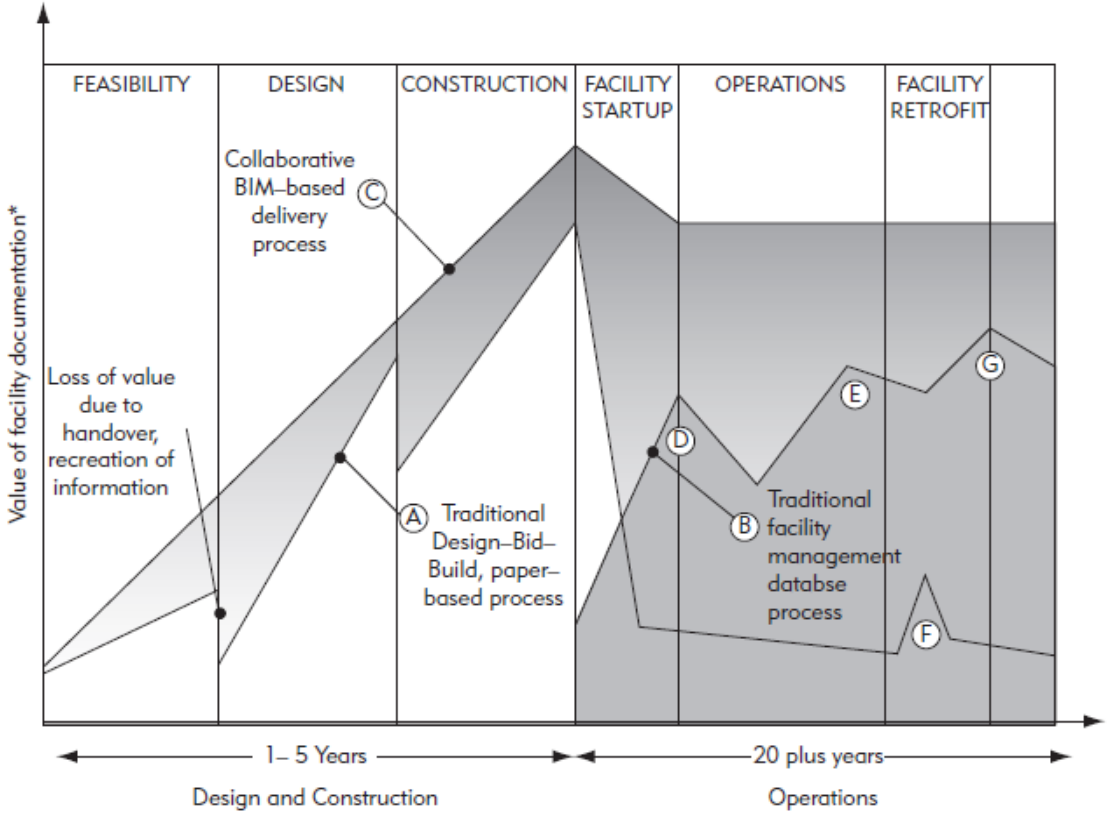
Checklist

- O&M of all systems and relevant instructions
- Insurance for building, equipment, contents, etc
- Transfer of meters to the new owner after final reading
- Guarantees and warranties
- Taking over loose equipment including keys
- Health and safety files
- Security and any policing of open space as required

What we often get during handover!!

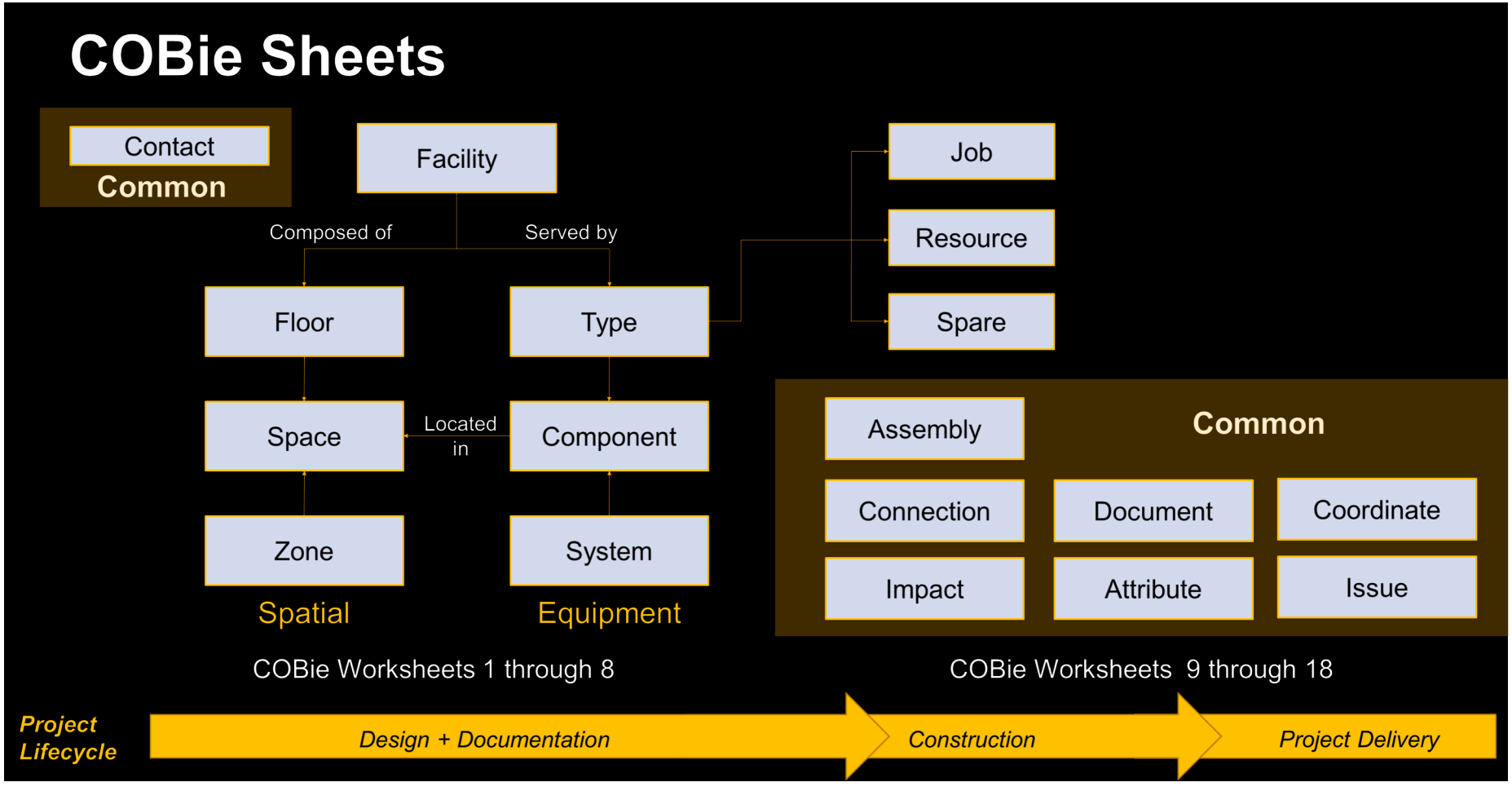


Value from different documentation methods



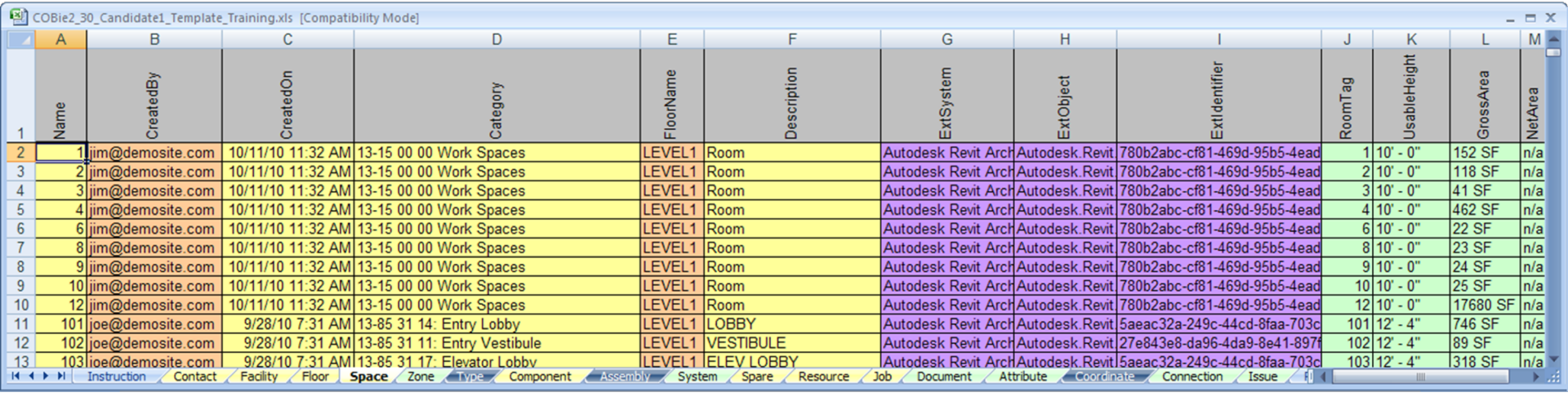
(A) Traditional single-stage drawing-based deliverables, (B) traditional facility management database system, (C) BIM-based deliverables throughout the project delivery and operation process, (D) setup of facility management (FM) database, (E) integration of FM with back-office systems, (F) use of "as-built" drawings for retrofit, and (G) update of FM database.

COBie- Construction Operations Building Information Exchange



COBie- data collection (4 ways)

- Manual data entry
- Extracting attribute data into a COBie compliant file
- Direct use of COBie compliant software, and
- Exporting via Industry Foundation Classes (IFC) standard with correctly structured property sets.



COBie2_30_Candidate1_Template_Training.xls [Compatibility Mode]

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Name	CreatedBy	CreatedOn	Category	FloorName	Description	ExtSystem	ExtObject	ExtIdentifier	RoomTag	UsableHeight	GrossArea	NetArea
2	1	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	1	10' - 0"	152 SF	n/a
3	2	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	2	10' - 0"	118 SF	n/a
4	3	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	3	10' - 0"	41 SF	n/a
5	4	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	4	10' - 0"	462 SF	n/a
6	6	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	6	10' - 0"	22 SF	n/a
7	8	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	8	10' - 0"	23 SF	n/a
8	9	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	9	10' - 0"	24 SF	n/a
9	10	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	10	10' - 0"	25 SF	n/a
10	12	jim@demosite.com	10/11/10 11:32 AM	13-15 00 00 Work Spaces	LEVEL1	Room	Autodesk Revit Arch	Autodesk.Revit	780b2abc-cf81-469d-95b5-4ead	12	10' - 0"	17680 SF	n/a
11	101	joe@demosite.com	9/28/10 7:31 AM	13-85 31 14: Entry Lobby	LEVEL1	LOBBY	Autodesk Revit Arch	Autodesk.Revit	5aeac32a-249c-44cd-8faa-703c	101	12' - 4"	746 SF	n/a
12	102	joe@demosite.com	9/28/10 7:31 AM	13-85 31 11: Entry Vestibule	LEVEL1	VESTIBULE	Autodesk Revit Arch	Autodesk.Revit	27e843e8-da96-4da9-8e41-897f	102	12' - 4"	89 SF	n/a
13	103	joe@demosite.com	9/28/10 7:31 AM	13-85 31 17: Elevator Lobby	LEVEL1	ELEV LOBBY	Autodesk Revit Arch	Autodesk.Revit	5aeac32a-249c-44cd-8faa-703c	103	12' - 4"	318 SF	n/a

Instruction | Contact | Facility | Floor | Space | Zone | Type | Component | Assembly | System | Spare | Resource | Job | Document | Attribute | Coordinate | Connection | Issue

COBie data drop

COBie 'Data Drops' throughout a project's lifecycle

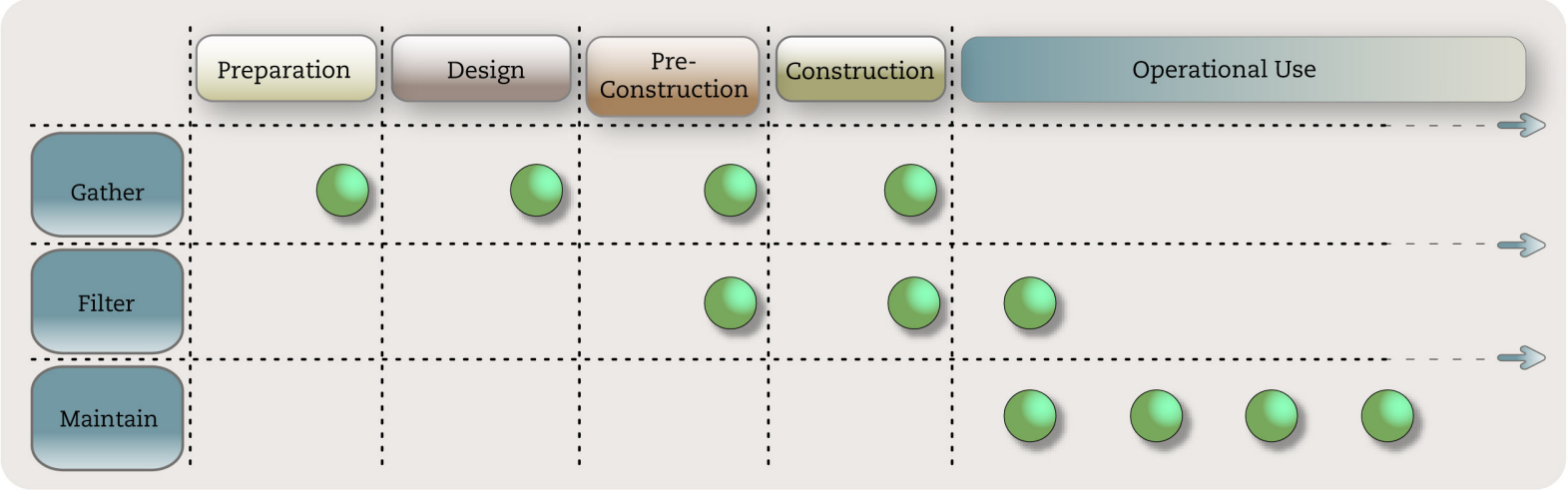


Image Source: AEC Connect, based on the UK Strategy Paper for the Government Construction Client Group

Also see: https://www.thenbs.com/knowledge/what-is-cobie

Conclusions

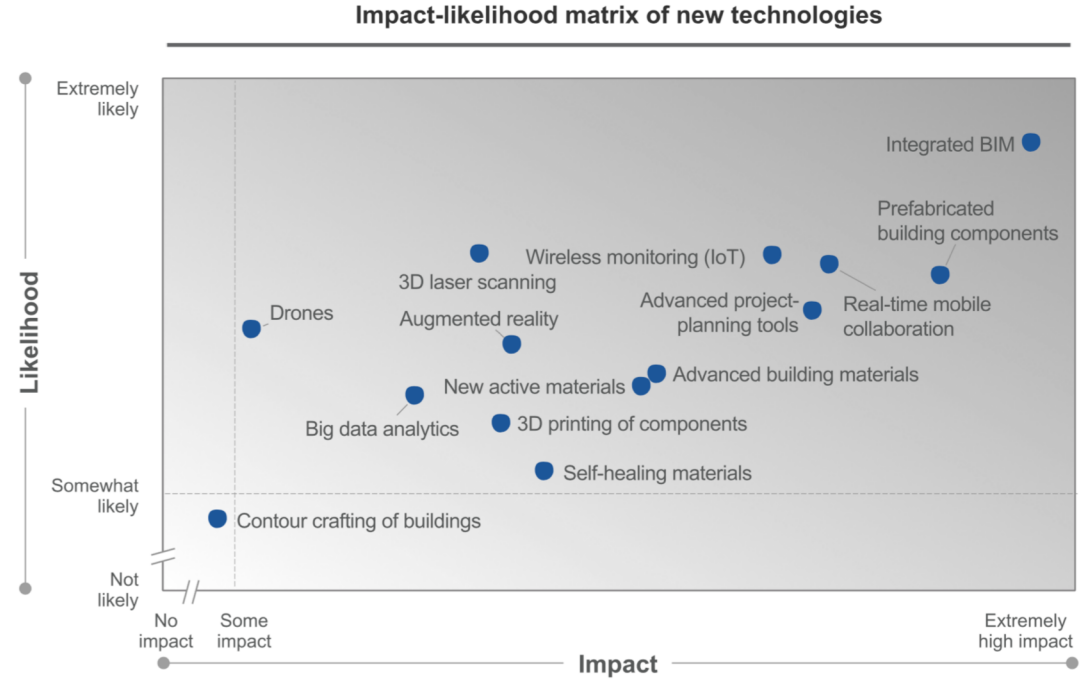
- Design decisions critically influence lifecycle management
- Early engagement of diverse experts is critical
- Mapping long term data and information requirements is important
- Familiarity with best practices and guidelines, e.g. DFMA is useful
- Structured methods like DSM should be used in the decision process

Quick run through sample assignment topics

Technological approach	+ Specific theme
Volumetric/ Non-vol. construction	- BIM execution plans
Volumetric/ Non-vol. construction	- Safety on site
Volumetric/ Non-vol. construction	- Fabrication and installation on site
Volumetric/ Non-vol. construction	- Coordinating different disciplines
Volumetric/ Non-vol. construction	- Logistics- factory to site
Volumetric/ Non-vol. construction	- Lifecycle considerations

Quick run through sample assignment topics

Figure 20: Future Impact and Likelihood of New Technologies



Source: Future of Construction Survey

Technological approach + Specific theme

Reading

https://www.bca.gov.sg/Professionals/Technology/others/PPVC_Guidebook.pdf

https://www.corenet.gov.sg/media/2032999/bim_essential_guide_dfma.pdf

Browning, T (2001) Applying The Design Structure Matrix To System Decomposition And Integration Problems: A Review And New Directions, IEEE Transactions on Engineering Management 48(3):292 - 306 · September 2001

Thank You!

Questions?