BIM Adoption by Public Construction Clients

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Thanks to…

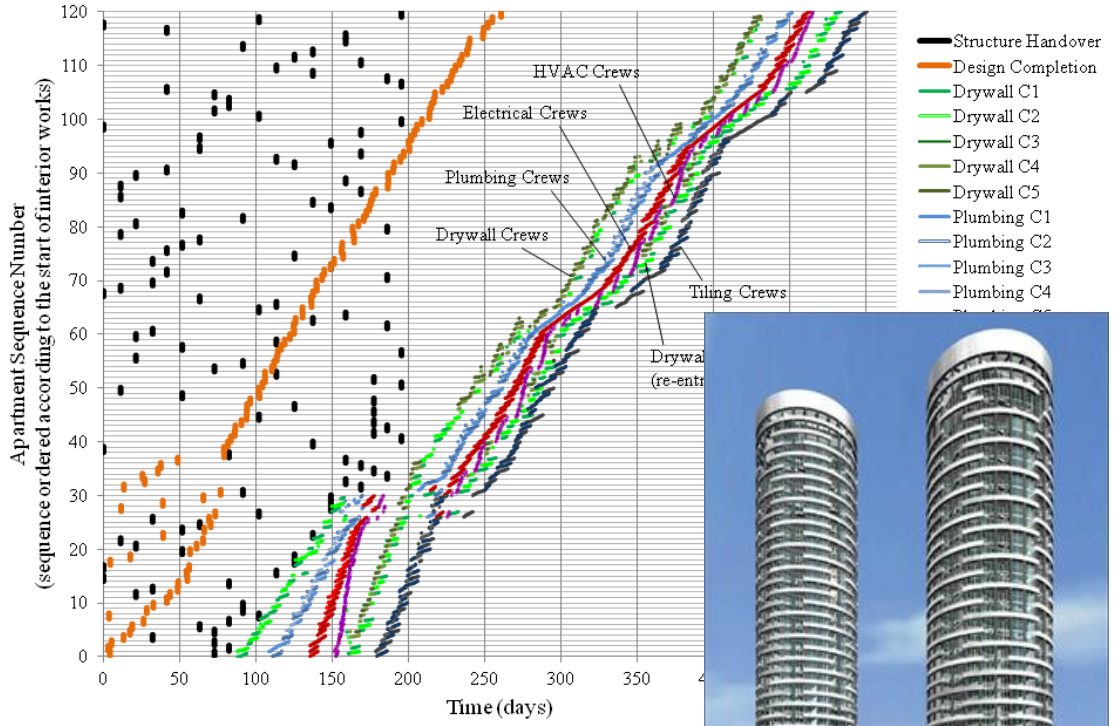
- Ury Gurevich,
  - PhD student who performed the action research
- SBTIC 2019, UNICAMPI
  - Departamento de Arquitetura e Construção,
    Faculdade de Engenharia Civil, Arquitetura e Urbanismo
    Universidade Estadual de Campinas
- Sinaenco

Research at the

VClab SeskinVirtual Construction Laboratory

- To study, model, experiment with and understand the flow of work and teams in complex construction projects: **Lean Construction**.

Observations, action research, process mapping and modeling, management games (LEAPCON), discrete event simulation, agent-based simulation (EPIC)

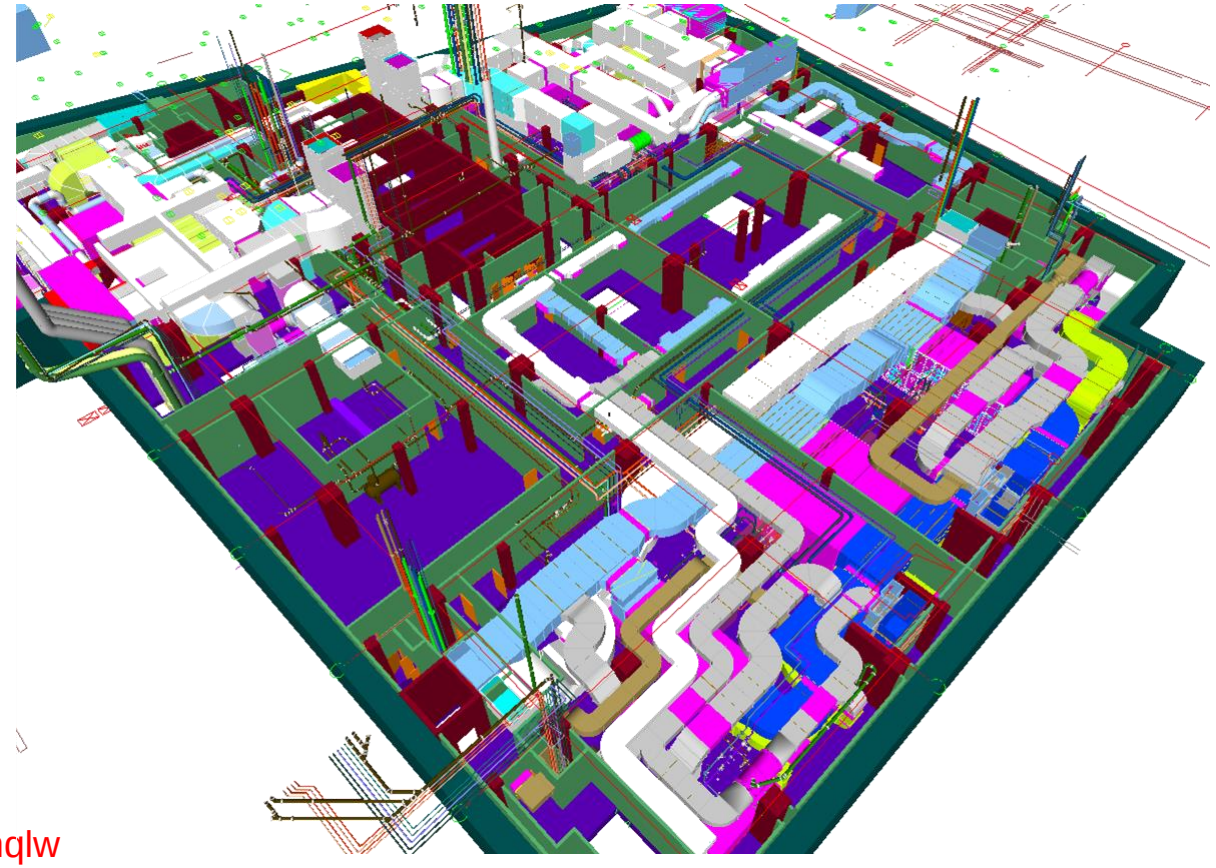


Research at the VCLab SeskinVirtual Construction Laboratory

- To study and develop **Building Information Modeling** (BIM)

IFC and BIM interoperability, BIM tools, virtual reality, BIM education

BIM & AI

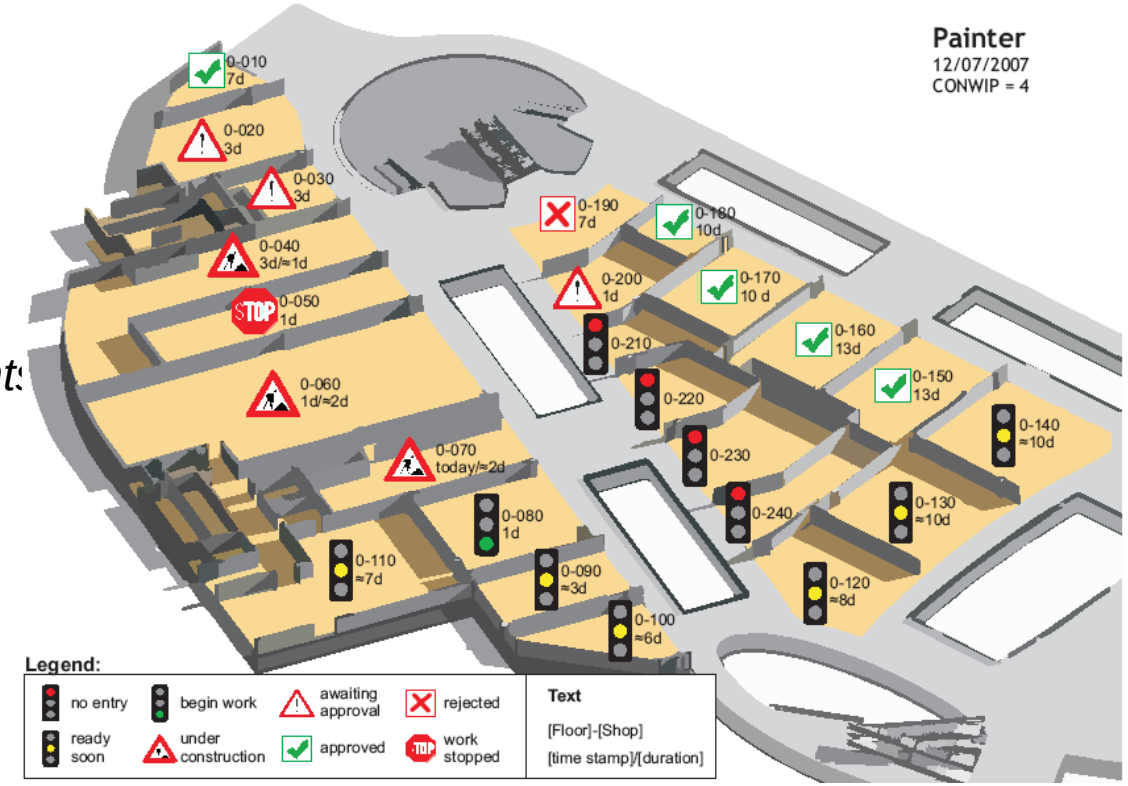


https://youtu.be/KJPnYKghqlw

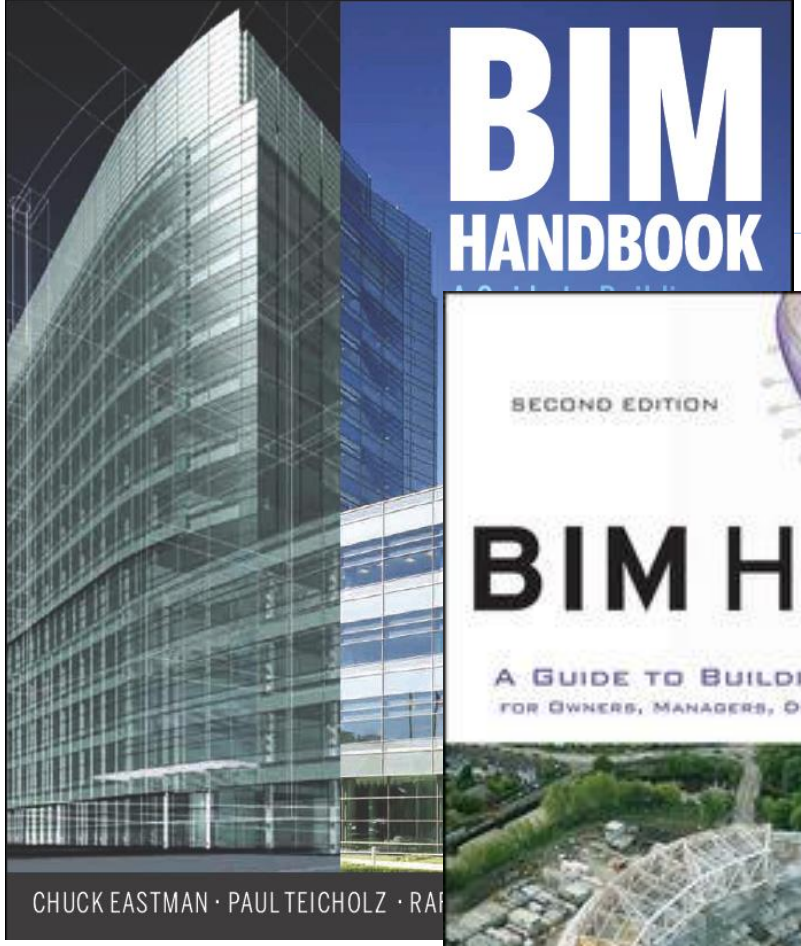
Research at the VCLab SeskinVirtual Construction Laboratory

- To propose, define, develop and test BIM-enabled systems to support production planning and day to day production control on construction sites: **Lean and BIM synergies**.

Prototyping (KanBIM, iKAN), field experiments, 'Virtual Construction Site' experiments

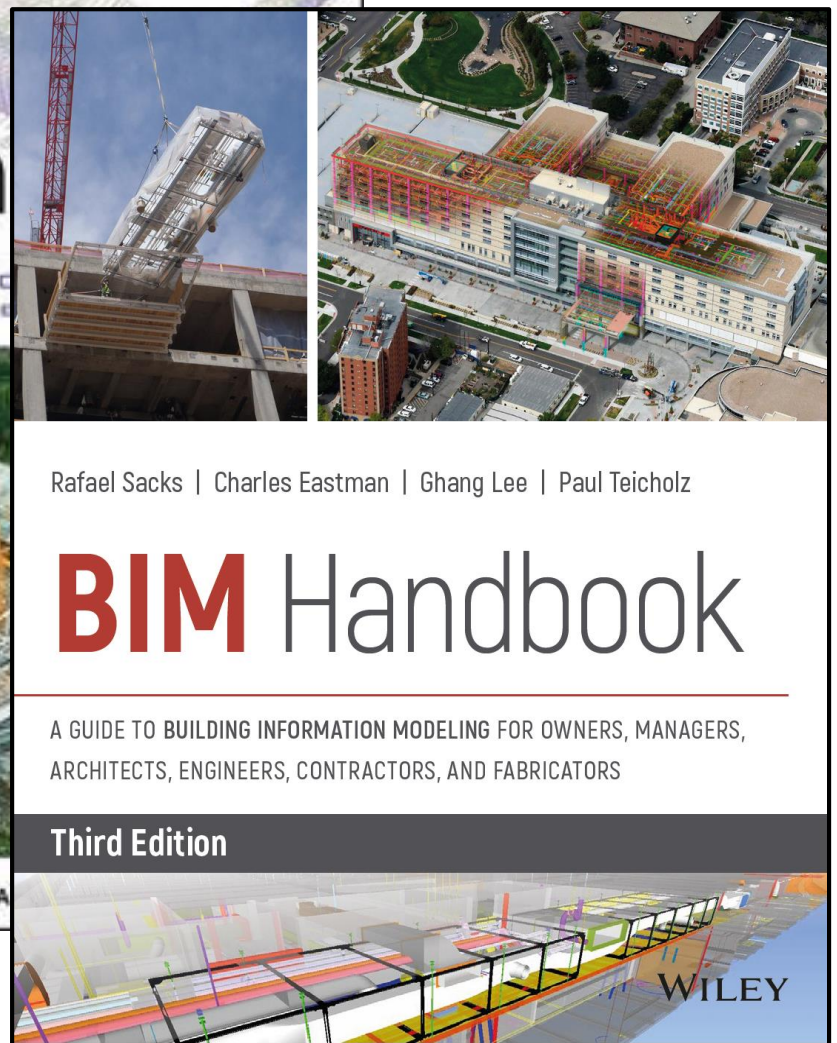


2008
1st Edition



2011
2nd Edition

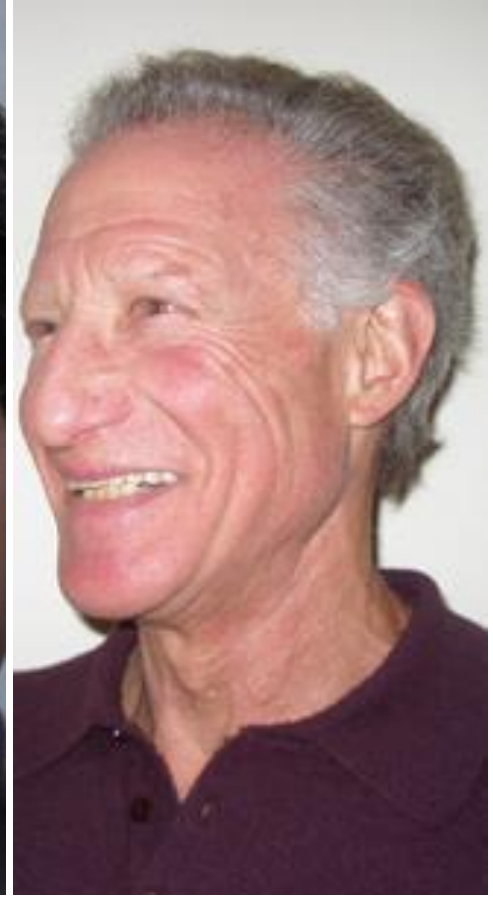
2018
3rd Edition



Rafael Sacks

Chuck Eastman

Ghang Lee



Paul Teicholz

BIM Handbook author team

2009
Korean
1st Edition

2014
Portuguese
1st Edition

2014
Korean
2nd Edition

2016
Italian
1st Edition

2017
Chinese
1st Edition

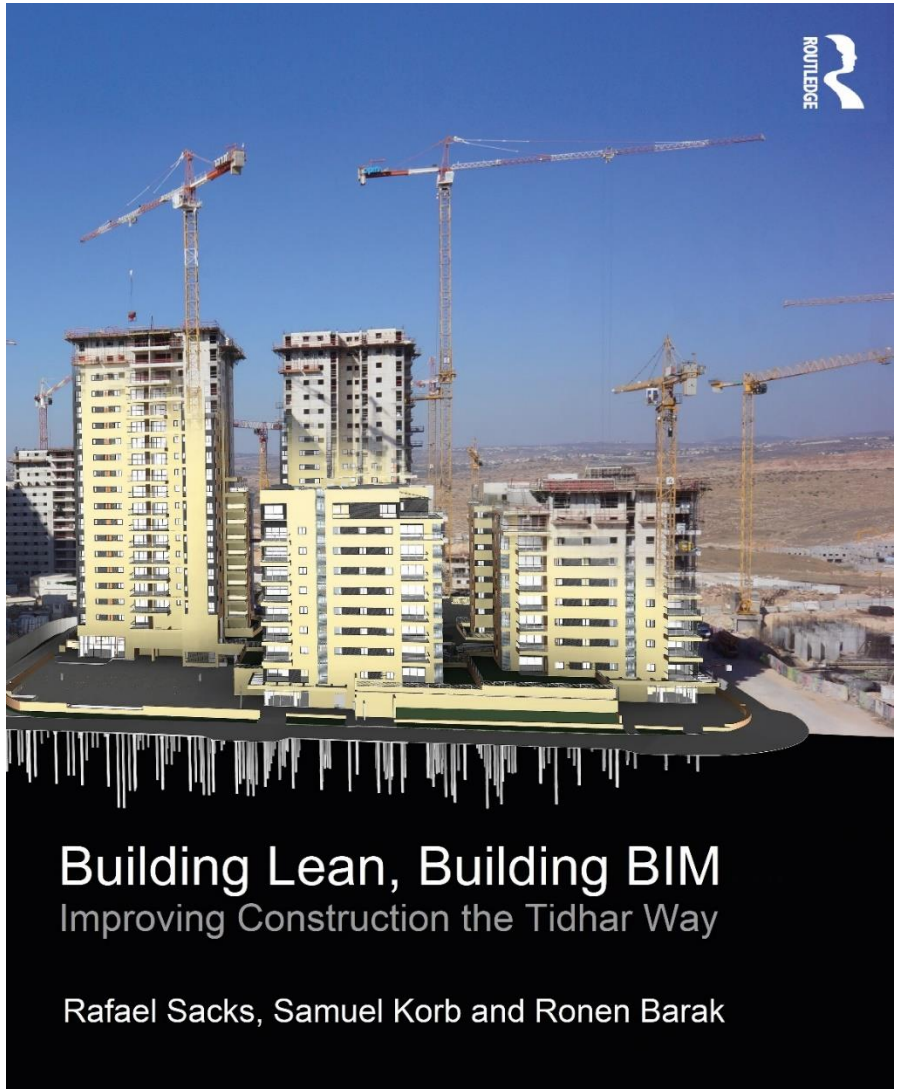
Building Lean, Building BIM

TIDHAR

SKANSKA

LEASE CRUTCHER LEWIS

Fira



Outline

- Public Clients
- What should we do?
- Research Method
- Review of BIM Documents
- Case studies
- Results
- Conclusions

Public construction clients

- **Government Construction Departments**

Defence, Education, Housing, Justice, Transport, Environment, Health…..

- **Government Agencies**

US Army COE, Veteran's Administration, GSA, TfL, CrossRail, Highways England

- **Universities**
- **Utilities**
- **Medical/health organizations**

Public construction clients

- Wide range of project types, scopes and sizes,
  (including very large projects with very big budgets)
- Subject to public review
- Strong influence on the construction sector
- Ability to demand and drive change in their supply chains
- Institutional Inertia

  Complex hierarchies and power structures

New Children's Hospital

BIM for Design with end user engagement

BIM Uses

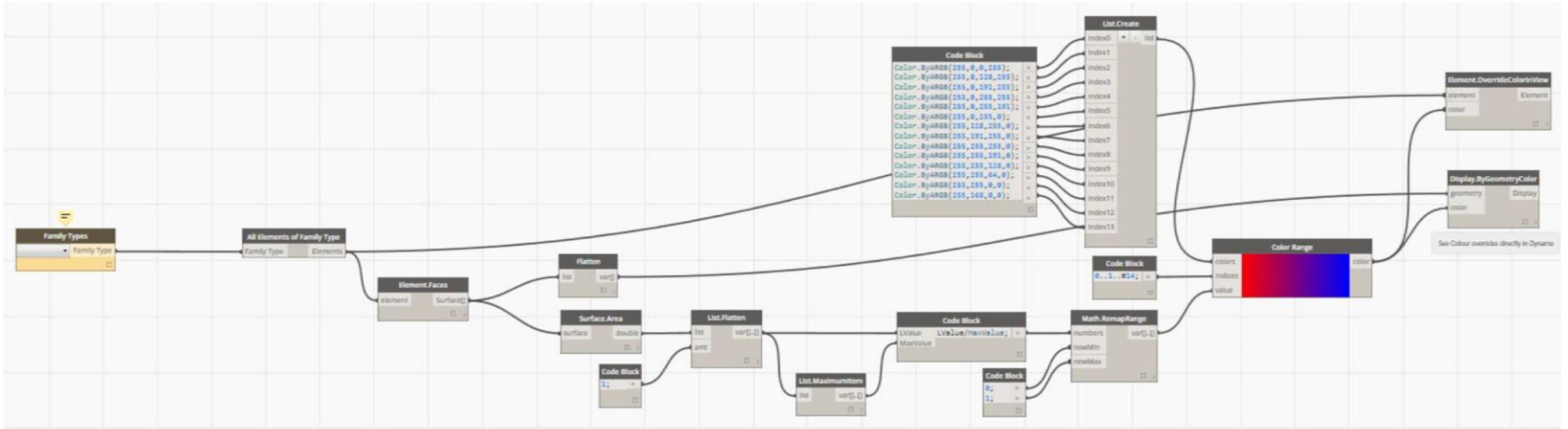
Phase	BIM Uses	Software	Technologies
Feasibility	Site Analysis	Revit, AutoCAD	Laser Scanning
	Phase Planning	Revit, AutoCAD	CAD
Design	Existing Conditions	Revit	Modeling
	Design Development, document authoring	Revit Dynamo NBS Create	Virtual Reality (VR), Augmented Reality (AR)
	3D Coordination	Navisworks	Clash detection
	Cost Estimation	CostX	Analysis
	Structural Analysis	Dynamo Tekla Structural Designer 2015 SCIA Engineer 16	Structural modeling and analysis
Pre-construction	3D Coordination	Navisworks	Virtual Reality (VR), Augmented Reality (AR), Laser Scanning
	Cost Estimation	CostX	Relational database
	Other Engineering Analysis	Dynamo, Tekla Structure, Designer 2015, SCIAEngineer16	Virtual Reality (VR), Augmented Reality (AR), Laser Scanning

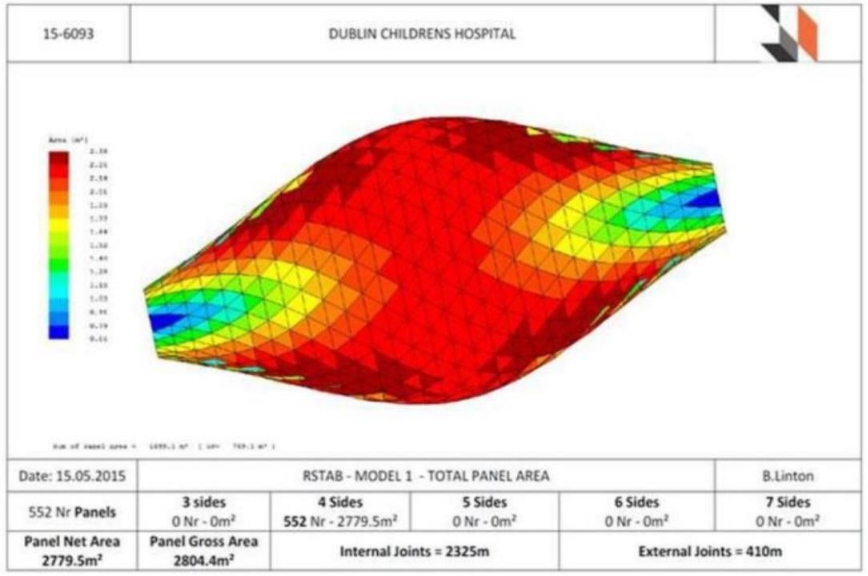
Design Development

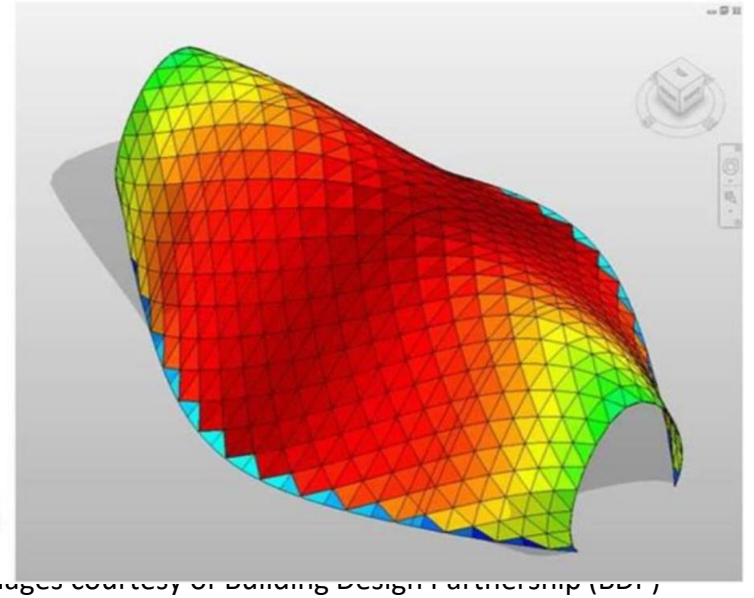
Google Cardboard, a visualisation tool where project stakeholders are placed 'inside' a virtual representation of their building.

Images courtesy of Building Design Partnership (BDP)

Parametric Modeling

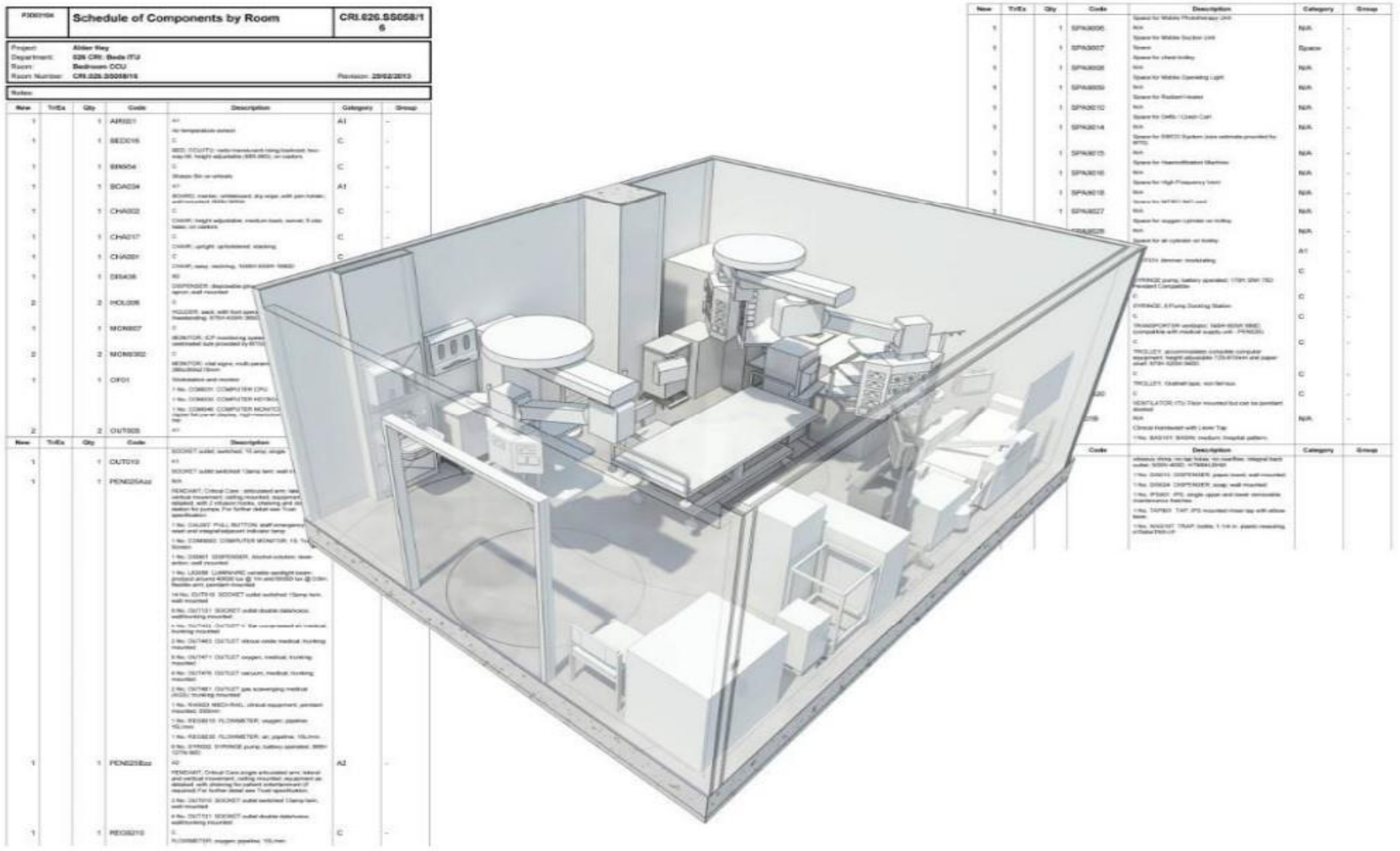






Images courtesy of Building Design Partnership (BDP)

Detailing and Schedules



Images courtesy of Building Design Partnership (BDP)

The question….

- What steps should public construction agencies take to promote adoption of BIM?
- What steps should they take to optimize the value from their adoption of BIM to improve:
  - business processes, and
  - buildings and other assets?
- Which activities:
  - are most effective?
  - generate value for the public client?
  - improve information flows?

Research Method

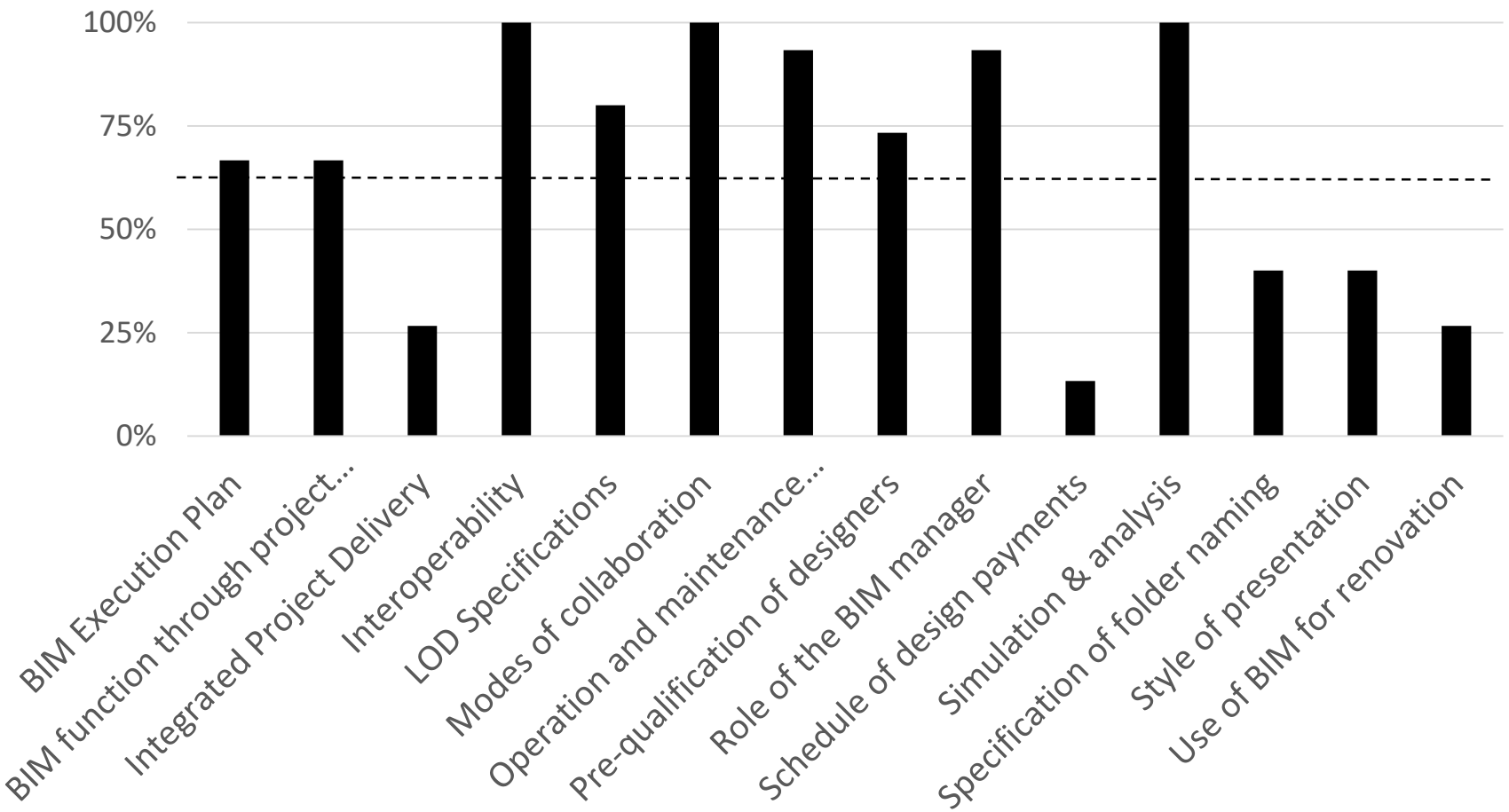
- Document review
  - Analysis of 15 BIM documents
- Case studies
  - Action research
  - Longitudinal study – follow organizations for three years
  - Measure organizations and projects
- Process Mapping
  - Compile a BIM Adoption Impact Map - BIM AIM

Document Review

1. Los Angeles Community College District
2. Georgia Institute of Technology
3. University of Southern California
4. Indiana University
5. Senate Properties, Finland
6. Statsbygg, Norway
7. New York District, U.S. Army Corp of Engineers
8. General Services Administration
9. Department of Veterans Affairs
10. State of Ohio General Services Division
11. NATSPEC
12. National Institute of Building Sciences - Buildsmart alliance
13. Building and Construction Authority, Singapore
14. CanBIM, Canada
15. BSI Standards Limited, UK

Sacks, R., Gurevich, U., and Shrestha, P., (2016). 'Review of National Standards and Organizational Guides for BIM Adoption', Journal of Information Technology in Construction (ITCon) Vol. 21, pp. 479-503.

BIM Document Topics



Case study organizations

Israel

- Israel Ministry of Defense

UK

- Highways England
- Environment Agency
- Transport for London/London Underground
- Defense Infrastructure Organization
- Ministry of Justice

Case study organizations

Israel

- Israel Ministry of Defence (IMOD)

UK

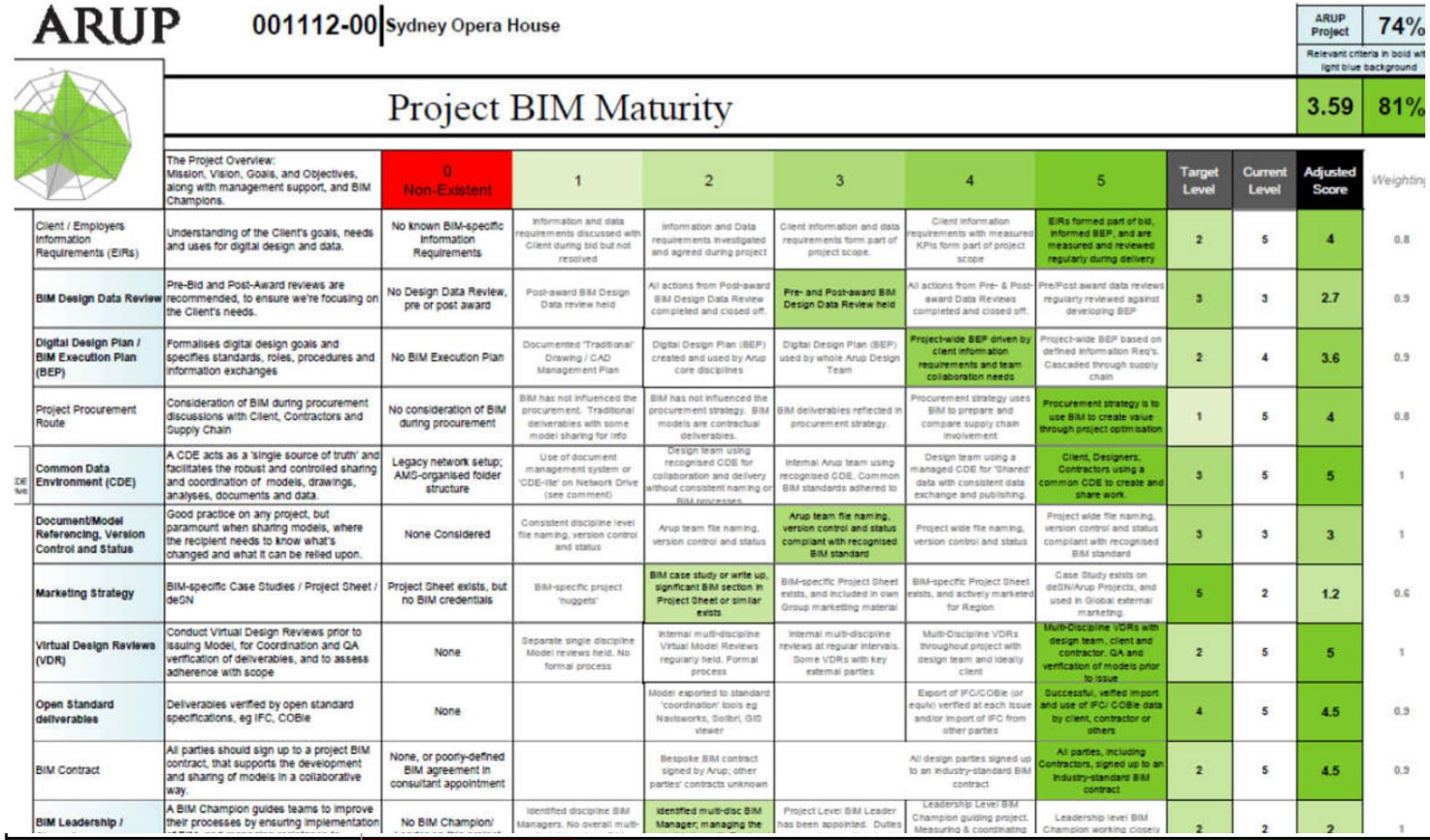
-
- Environment Agency (EA)
- Transport for London/London Underground (TfL)
-
-

Main BIM Adoption Actions

Action	Description
Adoption funding – intra-organization	Funding for training, creating data resources, outsourcing etc.
	Software and hardware purchase, training programs
Leadership	Senior managers directing themselves and their employees to invest time in training and developing BIM abilities
BIM object libraries	Creating organizational BIM object libraries to be used by others
Training	Train technicians and PMs for BIM understanding
Prepare BIM Guide	BIM Guides are the national, organizational or project level documents that establish common ways of working and the contents of BIM exchanges that are appropriate within the relevant contexts and along project timelines.
Motivate managers	Understanding potential benefits and the required actions needed to achieve the project goals, including preparation of contracts
BIM Execution Plan	Define desired modes of collaboration and information sharing, roles and responsibilities of partners, software and LOD of the different aspects of the model, model management, quality control procedures, object composition and naming conventions, etc.
Cash incentives	Align project design demands and payment

Case study orientation sessions

Project BIM Maturity



ARUP 001112-00 Sydney Opera House

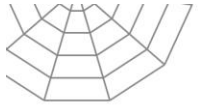
ARUP Project 74%

Relevant criteria in bold with light blue background

Project BIM Maturity

3.59 81%

	The Project Overview: Mission, Vision, Goals, and Objectives, along with management support, and BIM Champions.	0 Non-Existent	1	2	3	4	5	Target Level	Current Level	Adjusted Score	Weighting
	Client / Employers Information Requirements (EIRs)	Understanding of the Client's goals, needs and uses for digital design and data.	No known BIM-specific Information Requirements	Information and data requirements discussed with Client during bid but not resolved	Information and Data requirements investigated and agreed during project	Client information and data requirements form part of project scope.	Client information requirements with measured KPIs form part of project scope	EIRs formed part of bid, informed BEP, and are measured and reviewed regularly during delivery	2	5	4	0.8
	BIM Design Data Review	Pre-Bid and Post-Award reviews are recommended, to ensure we're focusing on the Client's needs.	No Design Data Review, pre or post award	Post-award BIM Design Data review held	All actions from Post-award BIM Design Data Review completed and closed off.	Pre- and Post-award BIM Design Data Review held	All actions from Pre- & Post-award Data Reviews completed and closed off.	Pre/Post award data reviews regularly reviewed against developing BEP	3	3	2.7	0.9
	Digital Design Plan / BIM Execution Plan (BEP)	Formalises digital design goals and specifies standards, roles, procedures and information exchanges	No BIM Execution Plan	Documented 'Traditional' Drawing / CAD Management Plan	Digital Design Plan (BEP) created and used by Arup core disciplines	Digital Design Plan (BEP) used by whole Arup Design Team	Project-wide BEP driven by client information requirements and team collaboration needs	Project-wide BEP based on defined Information Req's. Cascaded through supply chain	2	4	3.6	0.9
	Project Procurement Route	Consideration of BIM during procurement discussions with Client, Contractors and Supply Chain	No consideration of BIM during procurement	BIM has not influenced the procurement. Traditional deliverables with some model sharing for info	BIM has not influenced the procurement strategy. BIM models are contractual deliverables.	BIM deliverables reflected in procurement strategy.	Procurement strategy uses BIM to prepare and compare supply chain involvement	Procurement strategy is to use BIM to create value through project optimisation	1	5	4	0.8
CDE Info	Common Data Environment (CDE)	A CDE acts as a 'single source of truth' and facilitates the robust and controlled sharing and coordination of models, drawings, analyses, documents and data.	Legacy network setup; AMS-organised folder structure	Use of document management system or 'CDE-lite' on Network Drive (see comment)	Design team using recognised CDE for collaboration and delivery without consistent naming or BIM processes	Internal Arup team using recognised CDE. Common BIM standards adhered to	Design team using a managed CDE for 'Shared' data with consistent data exchange and publishing.	Client, Designers, Contractors using a common CDE to create and share work.	3	5	5	1
	Document/Model Referencing, Version Control and Status	Good practice on any project, but paramount when sharing models, where the recipient needs to know what's changed and what it can be relied upon.	None Considered	Consistent discipline level file naming, version control and status	Arup team file naming, version control and status	Arup team file naming, version control and status compliant with recognised BIM standard	Project wide file naming, version control and status	Project wide file naming, version control and status compliant with recognised BIM standard	3	3	3	1
	Marketing Strategy	BIM-specific Case Studies / Project Sheet / deSN	Project Sheet exists, but no BIM credentials	BIM-specific project 'nuggets'	BIM case study or write up, significant BIM section in Project Sheet or similar exists	BIM-specific Project Sheet exists, and included in own Group marketing material	BIM-specific Project Sheet exists, and actively marketed for Region	Case Study exists on deSN/Arup Projects, and used in Global external marketing.	5	2	1.2	0.6
	Virtual Design Reviews (VDR)	Conduct Virtual Design Reviews prior to issuing Model, for Coordination and QA verification of deliverables, and to assess adherence with scope	None	Separate single discipline Model reviews held. No formal process	Internal multi-discipline Virtual Model Reviews regularly held. Formal process	Internal multi-discipline reviews at regular intervals. Some VDRs with key external parties	Multi-Discipline VDRs throughout project with design team and ideally client	Multi-Discipline VDRs with design team, client and contractor. QA and verification of models prior to issue.	2	5	5	1
	Open Standard deliverables	Deliverables verified by open standard specifications, eg IFC, COBie	None		Model exported to standard 'coordination' tools eg Navisworks, Solibri, GIS viewer		Export of IFC/COBie (or equiv) verified at each issue and/or import of IFC from other parties	Successful, verified import and use of IFC/ COBie data by client, contractor or others	4	5	4.5	0.9
	BIM Contract	All parties should sign up to a project BIM contract, that supports the development and sharing of models in a collaborative way.	None, or poorly-defined BIM agreement in consultant appointment		Bespoke BIM contract signed by Arup; other parties' contracts unknown		All design parties signed up to an industry-standard BIM contract	All parties, including Contractors, signed up to an industry-standard BIM contract	2	5	4.5	0.9
	BIM Leadership /	A BIM Champion guides teams to improve their processes by ensuring implementation	No BIM Champion/	Identified discipline BIM Managers. No overall multi-	Identified multi-disc BIM Manager, managing the	Project Level BIM Leader has been appointed. Duties	Leadership Level BIM Champion guiding project. Measuring & coordinating	Leadership level BIM Champion working closely	2	2	2	1



	The Project Overview: Mission, Vision, Goals, and Objectives, along with management support, and BIM Champions.	0 Non-Existent	1 Initial	2 Managed	3 Defined	4 Measured	5 Optimizing
Open Standard deliverables	Deliverables verified by open standard specifications, eg IFC, COBie	None		Model exported to proprietary software (eg Navisworks, Solibri, GIS viewer)		Successful export/re-import of IFC / COBie verified at each Issue	Successful import of IFC / COBie into any package verified at each issue
BIM Contract	All parties should sign up to a project BIM contract, that allows for the sharing of models in a collaborative way.	None, or poorly-defined BIM agreement in consultant appointment		Bespoke BIM contract signed by Company; other parties' contracts unknown		All design parties signed up to an Industry-standard BIM contract	All parties, including Contractors, signed up to an Industry-standard BIM contract

Israel Ministry of Defense (IMOD)

IMOD – Typical Project

IMOD – Typical Project

Transport for London (TfL)

Victoria Underground Station Upgrade

BIM for infrastructure construction

BIM Uses

Phase	BIM Uses	Software	Technologies
Schematic Design	Feasibility	Bentley Triforma, Bentley AECOsim	Modeling
	Layout	Legion modeling	Crowd simulation
	Collaboration Archiving	Bentley ProjectWise	File sharing, cloud
Design Development	Design Authoring 3D coordination	Triforma AECOsim	Modeling
	Collaboration Archiving	ProjectWise	File sharing, cloud
	Structural Analysis	STAAD Hevacomp	Finite Element Method
Construction Documentation	Design Reviews	Triforma AECOsim	Modeling
	Drawing	Microstation	CAD
Construction	Existing Conditions	Triforma AECOsim	
	Collaboration	ProjectWise	
	Phase Planning	AECOsim	4D simulation

Victoria Station Upgrade

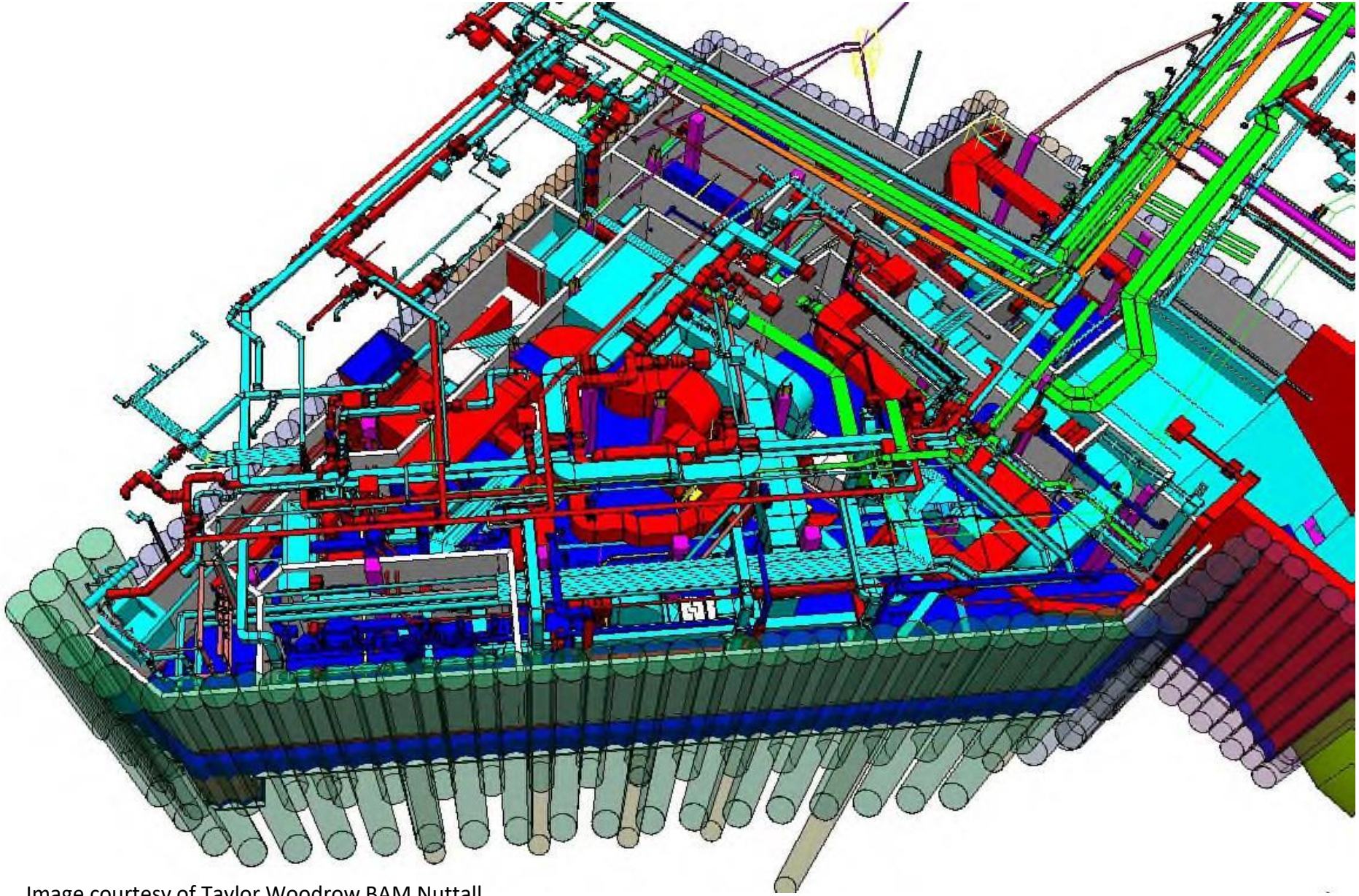
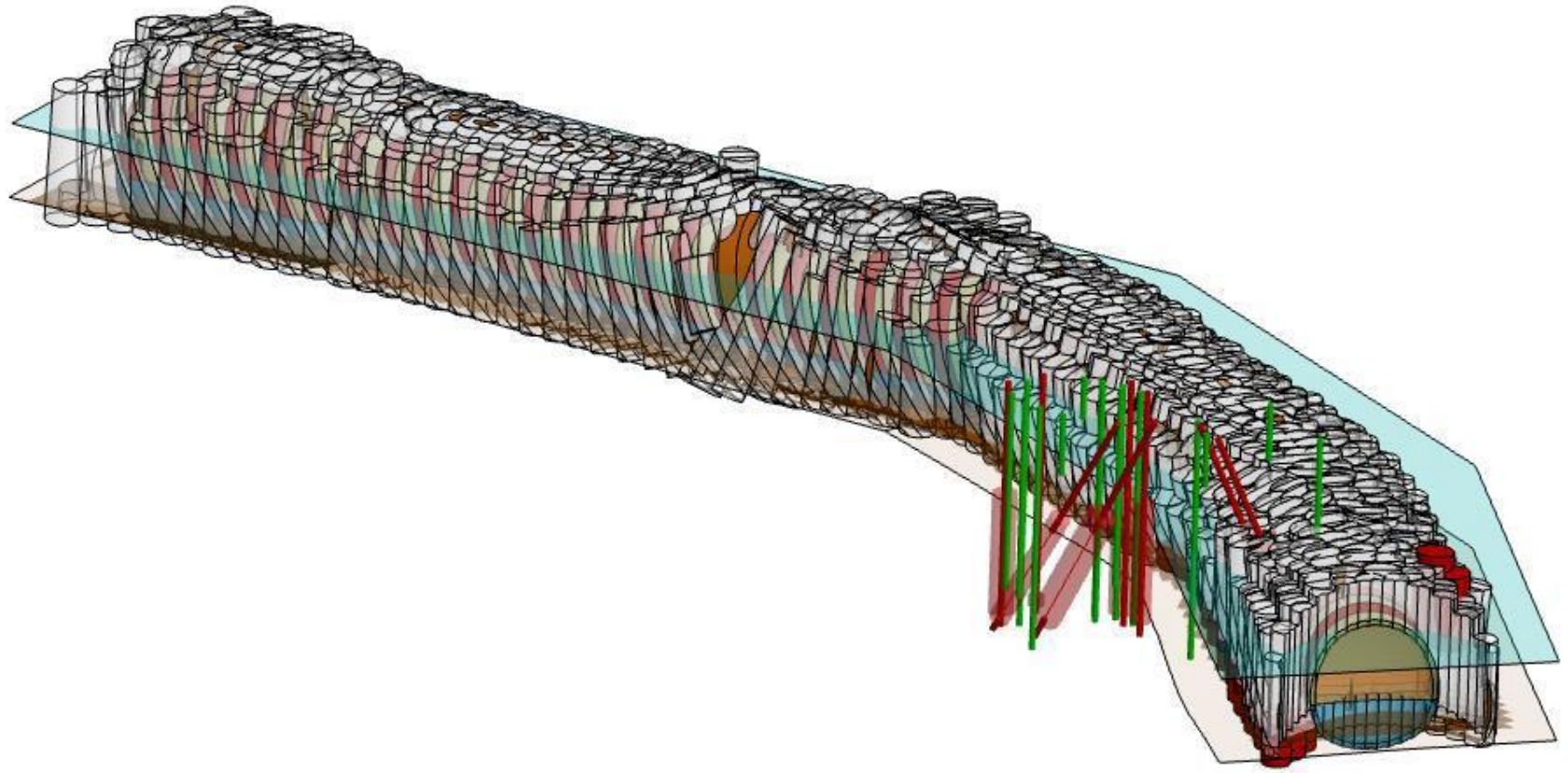
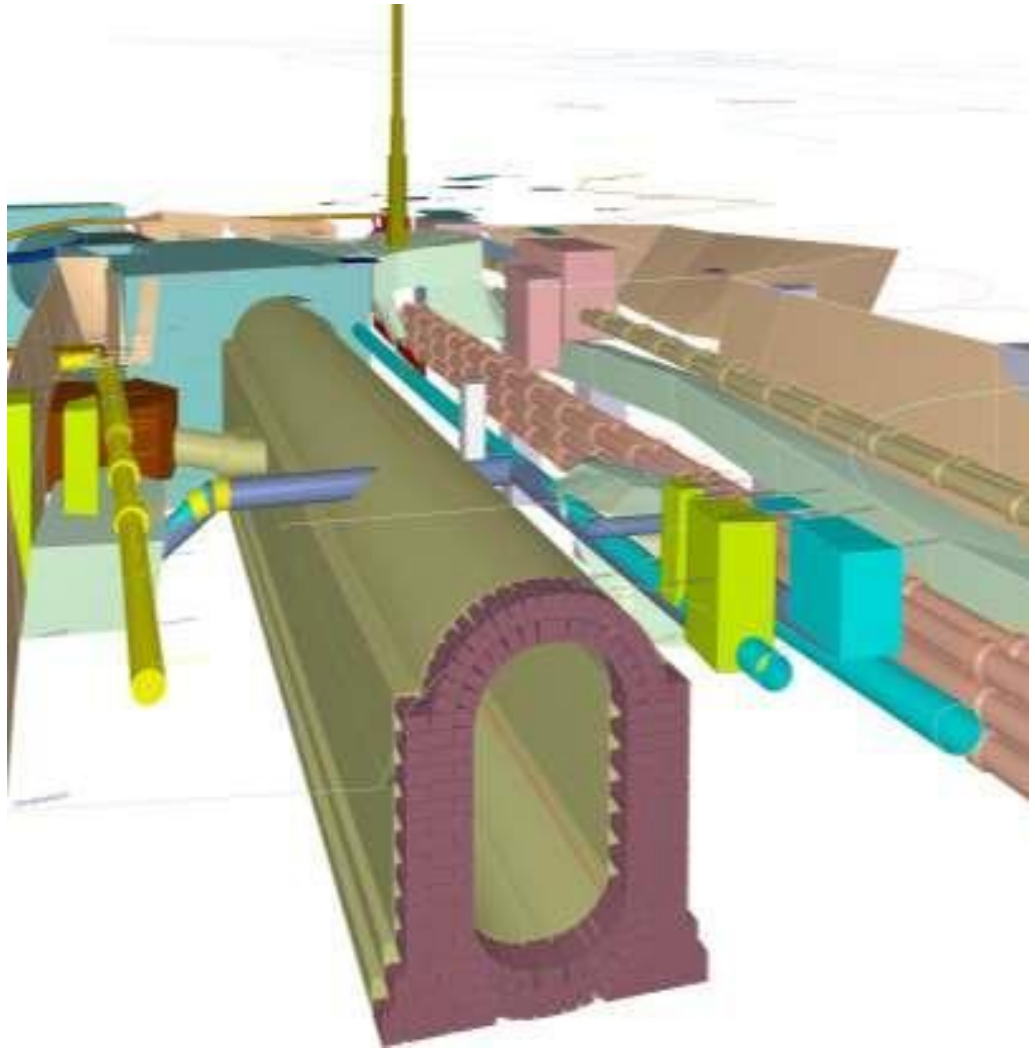


Image courtesy of Taylor Woodrow BAM Nuttall

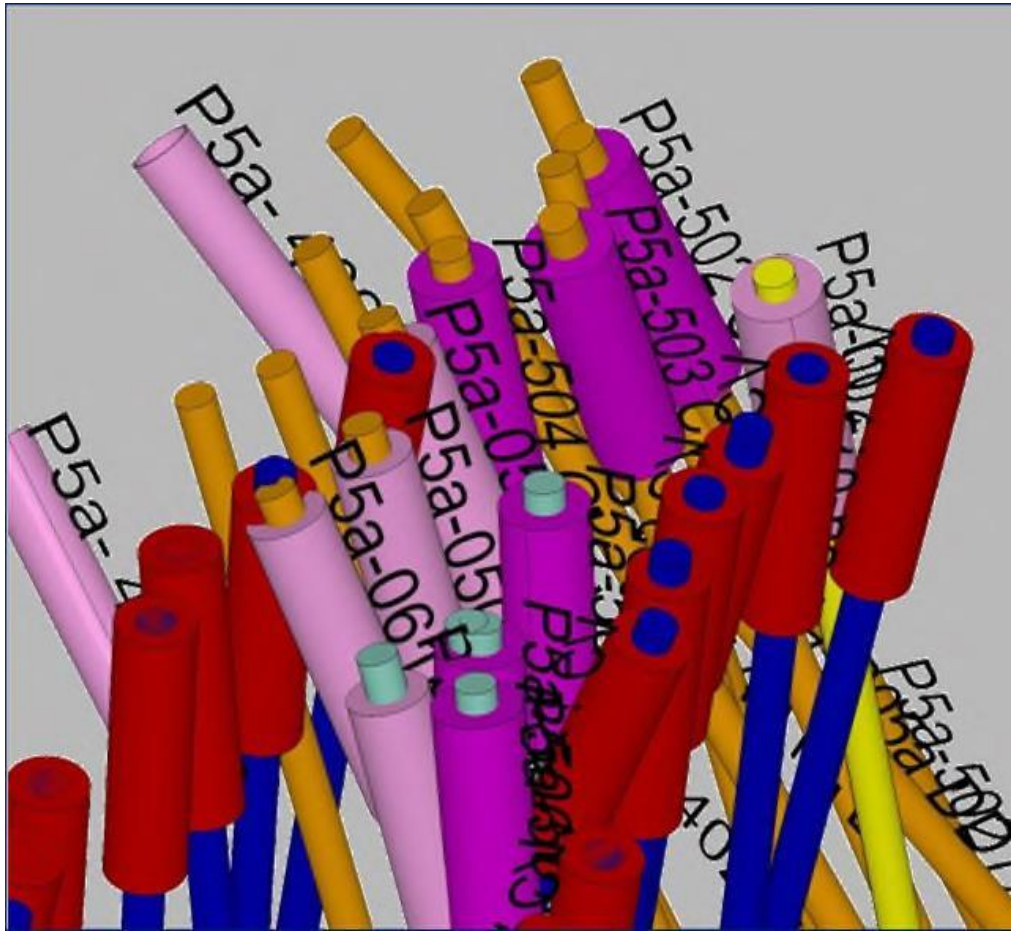
Victoria Station Upgrade



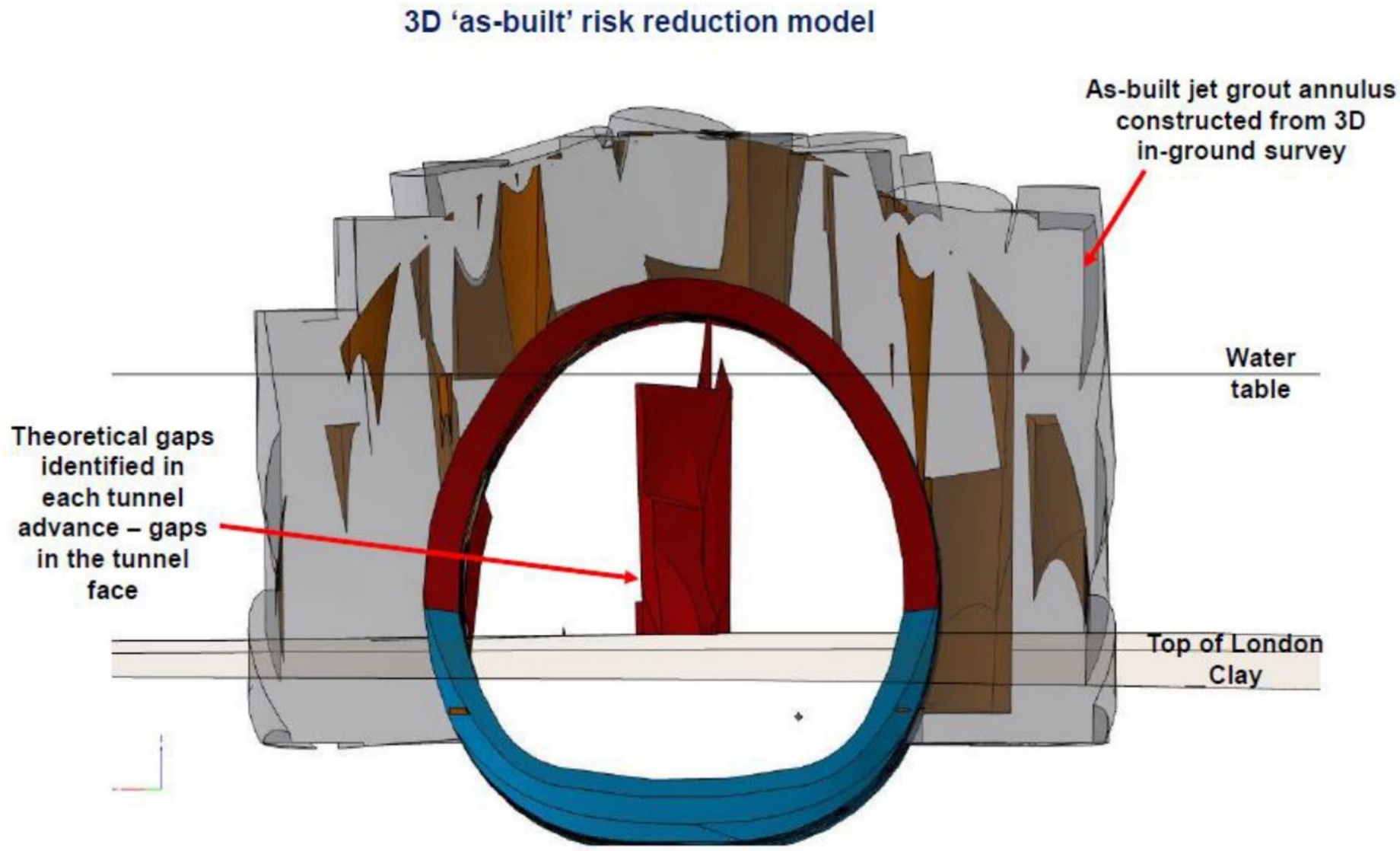
Victoria Station Upgrade



Victoria Station Upgrade



Victoria Station Upgrade



Victoria Station Upgrade

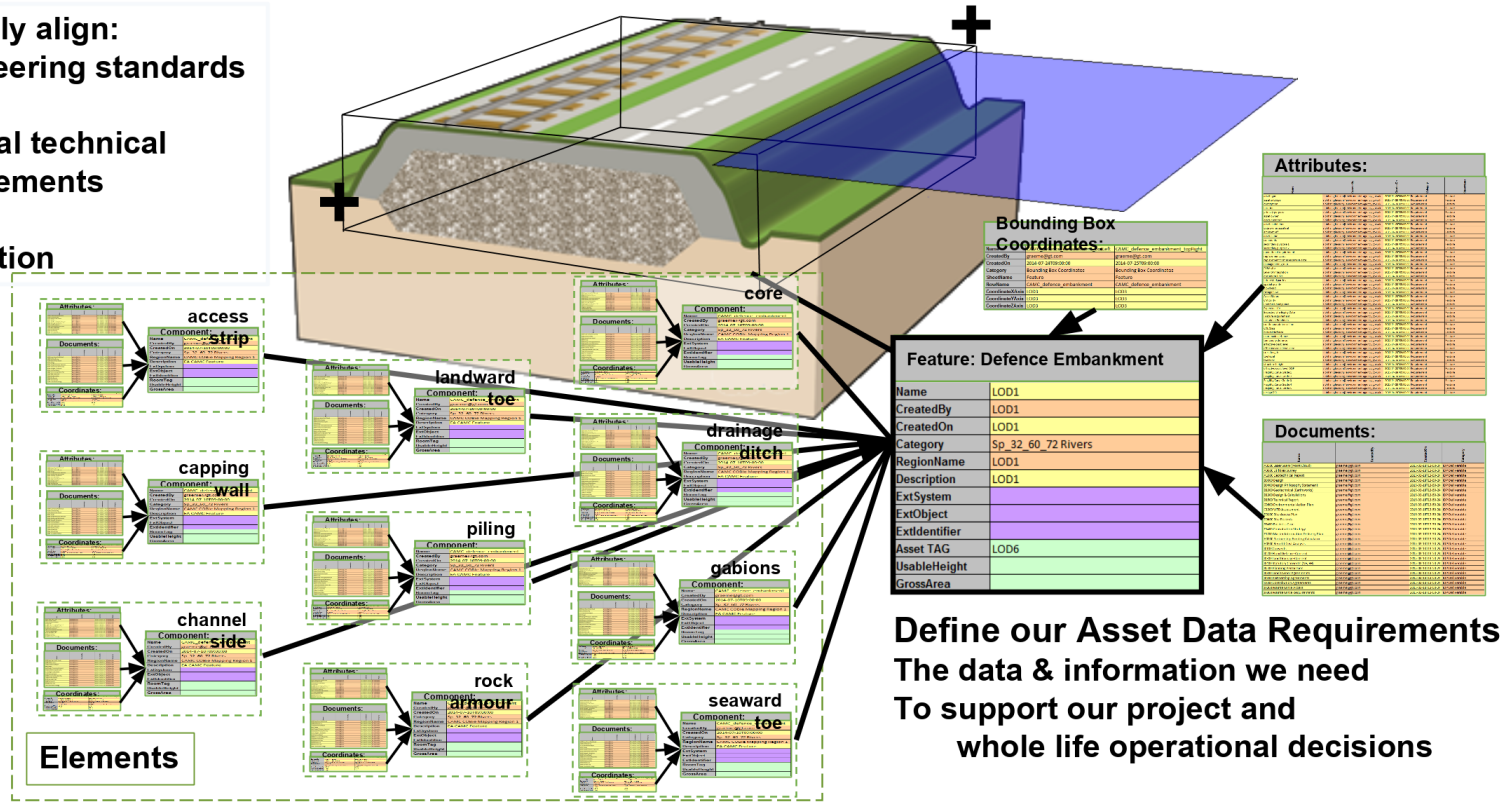
Environment Agency (EA)

Asset Data Requirements including H&S

Digitally align:
Engineering standards

Minimal technical requirements

Validation

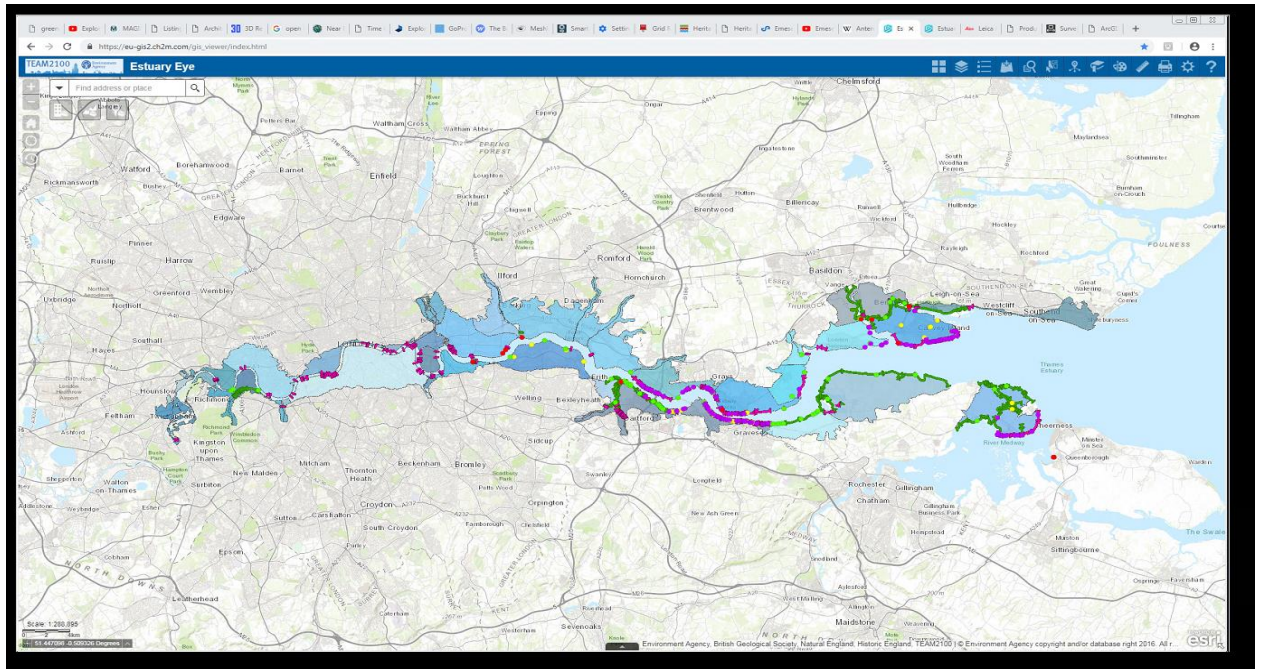


Define our Asset Data Requirements
The data & information we need
To support our project and whole life operational decisions

Environment Agency (EA)

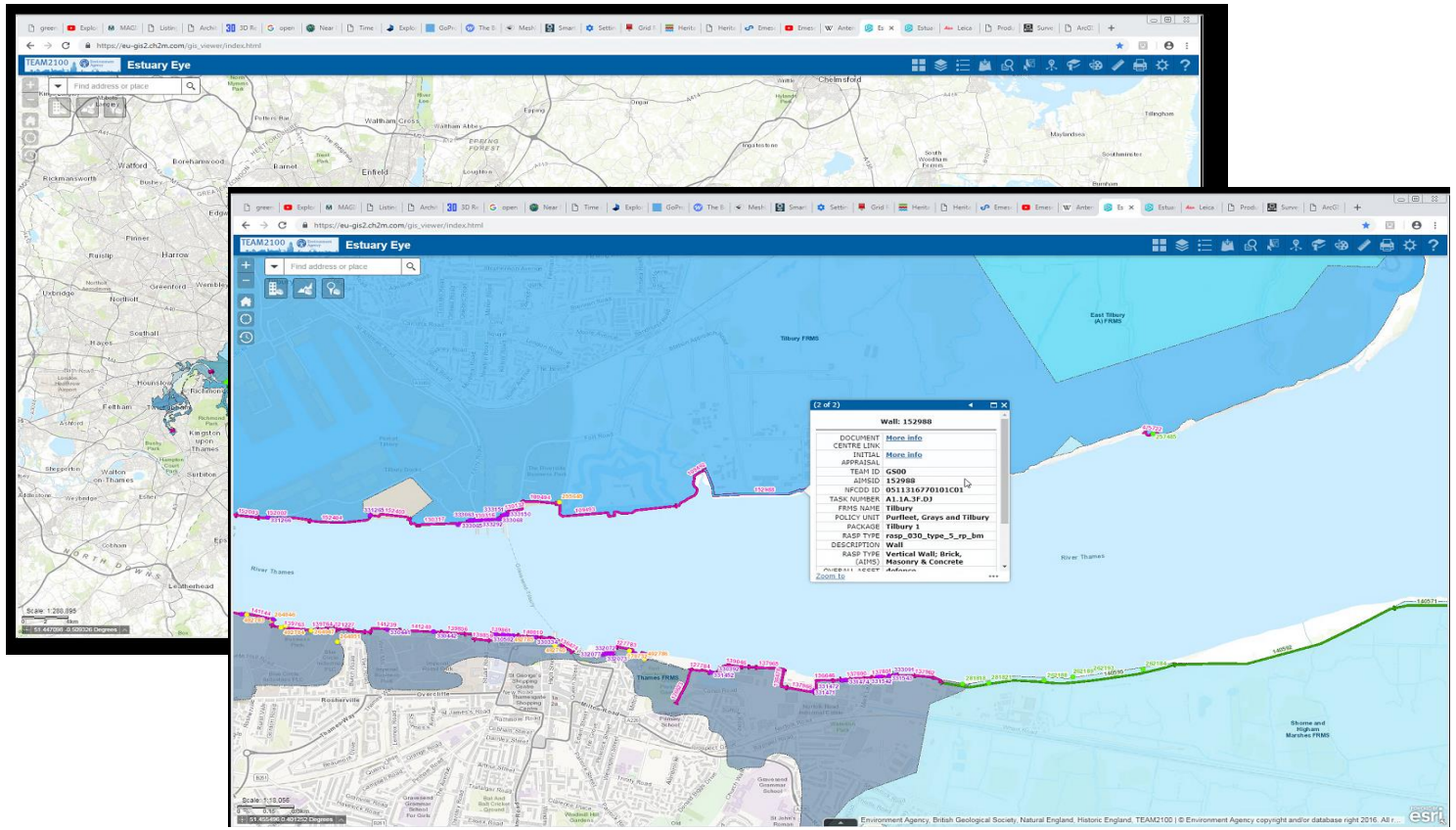
Environment Agency (EA)

Network information – system of flood control projects



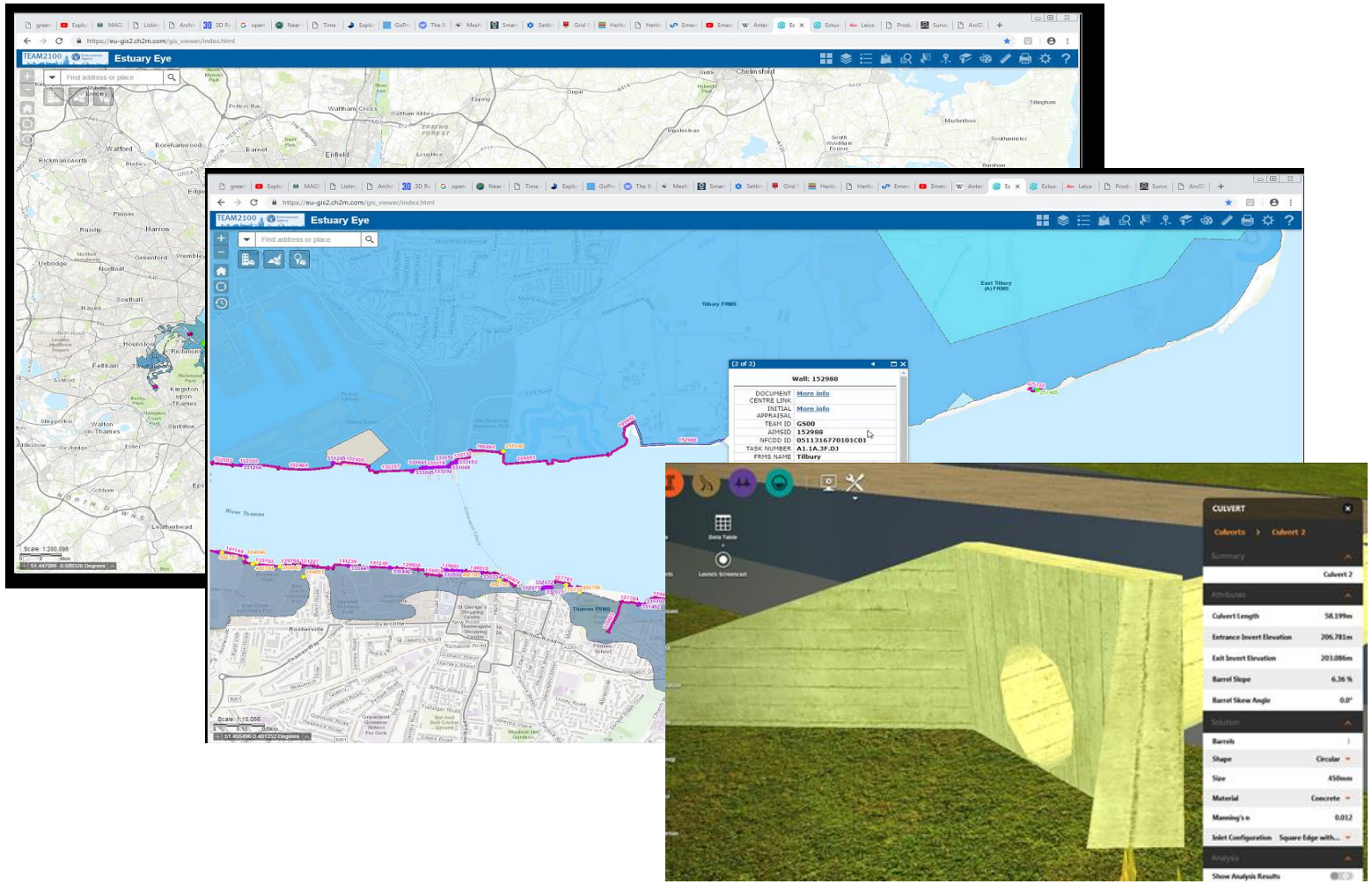
Environment Agency (EA)

Network information – system of flood control projects



Environment Agency (EA)

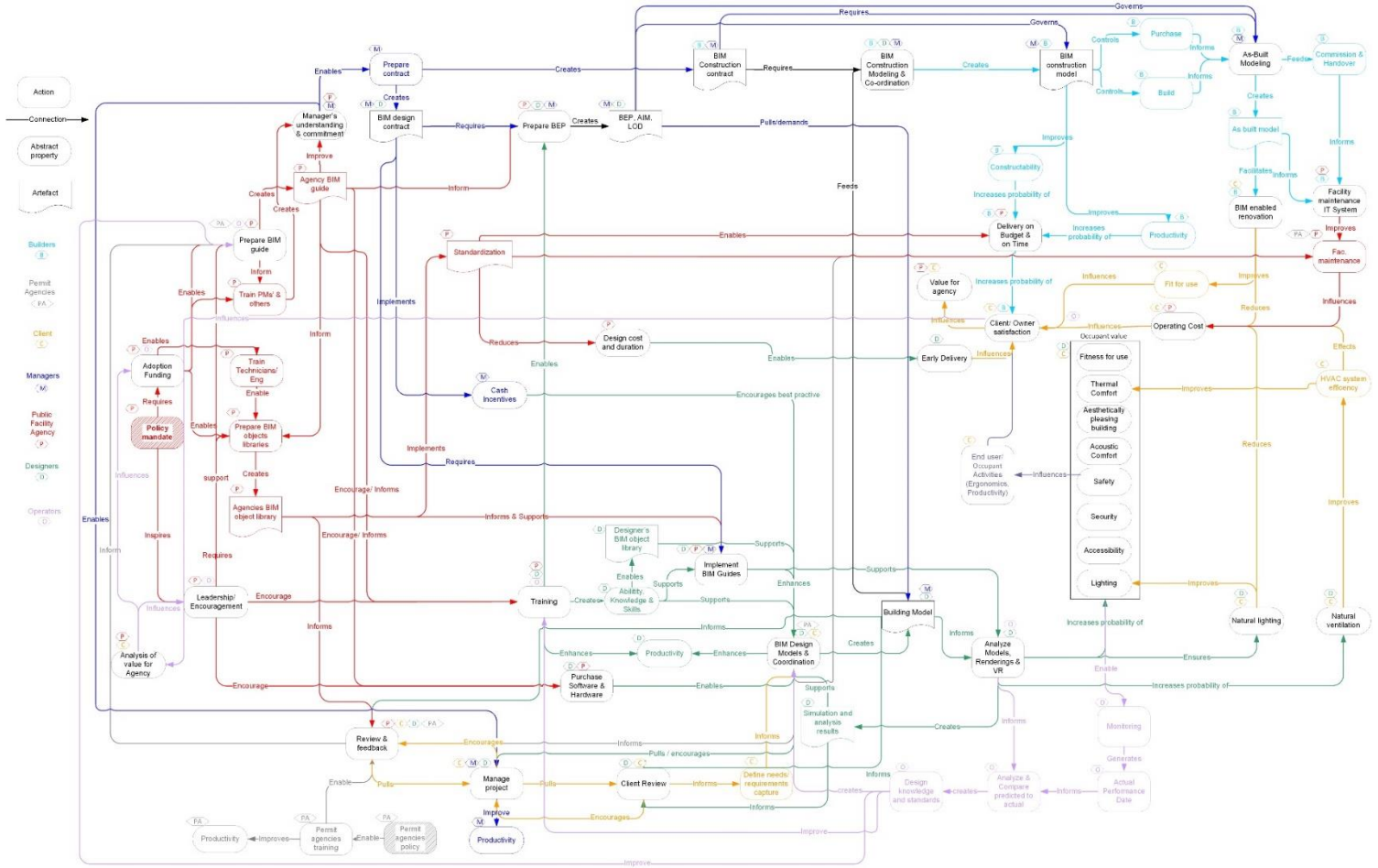
Network information – system of flood control projects



Process mapping method

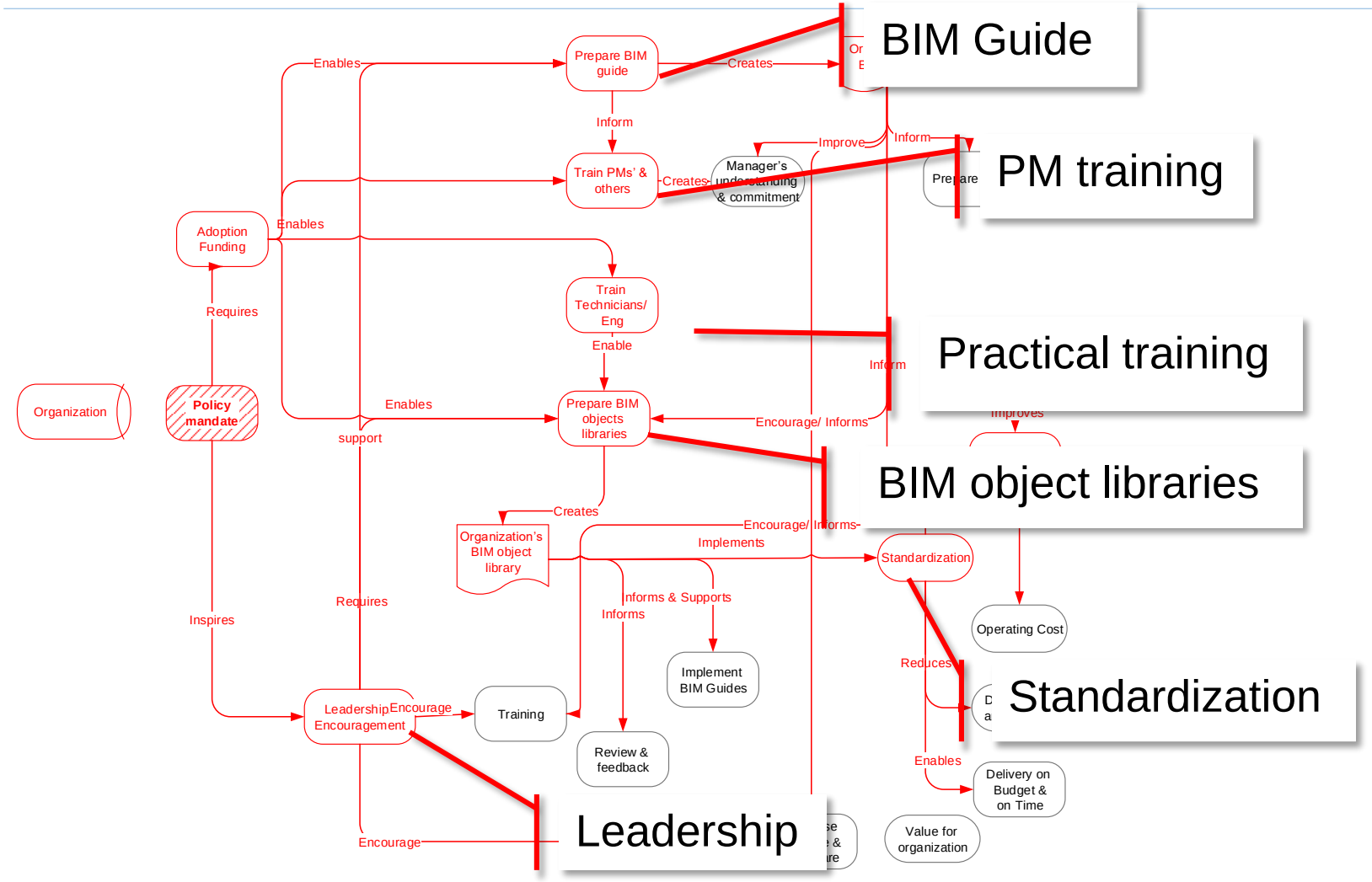
- Prepare an initial process map
  - Actors: public clients, project managers, designers, contractors, permit agencies, end users, facility managers
  - Four aspects: Technology, Process, People, Information
  - **Result – BIM AIM 1.0**
- Review with case study participants to identify:
  - Missing activities
  - Activities that have not been done by any client
  - Activities that have amplified impact
- Revise and redraw
  - **Result – BIM AIM 2.0**

BIM Adoption Impact Map v1.0



Gurevich, U., Sacks, R. and Shrestha, P., (2017). '[Mapping the Impact of BIM Adoption Efforts on Occupant Value](), Building Research and Information, Vol. 49, No. 6, pp. 610-630.

BIM AIM v1.0 – client actions

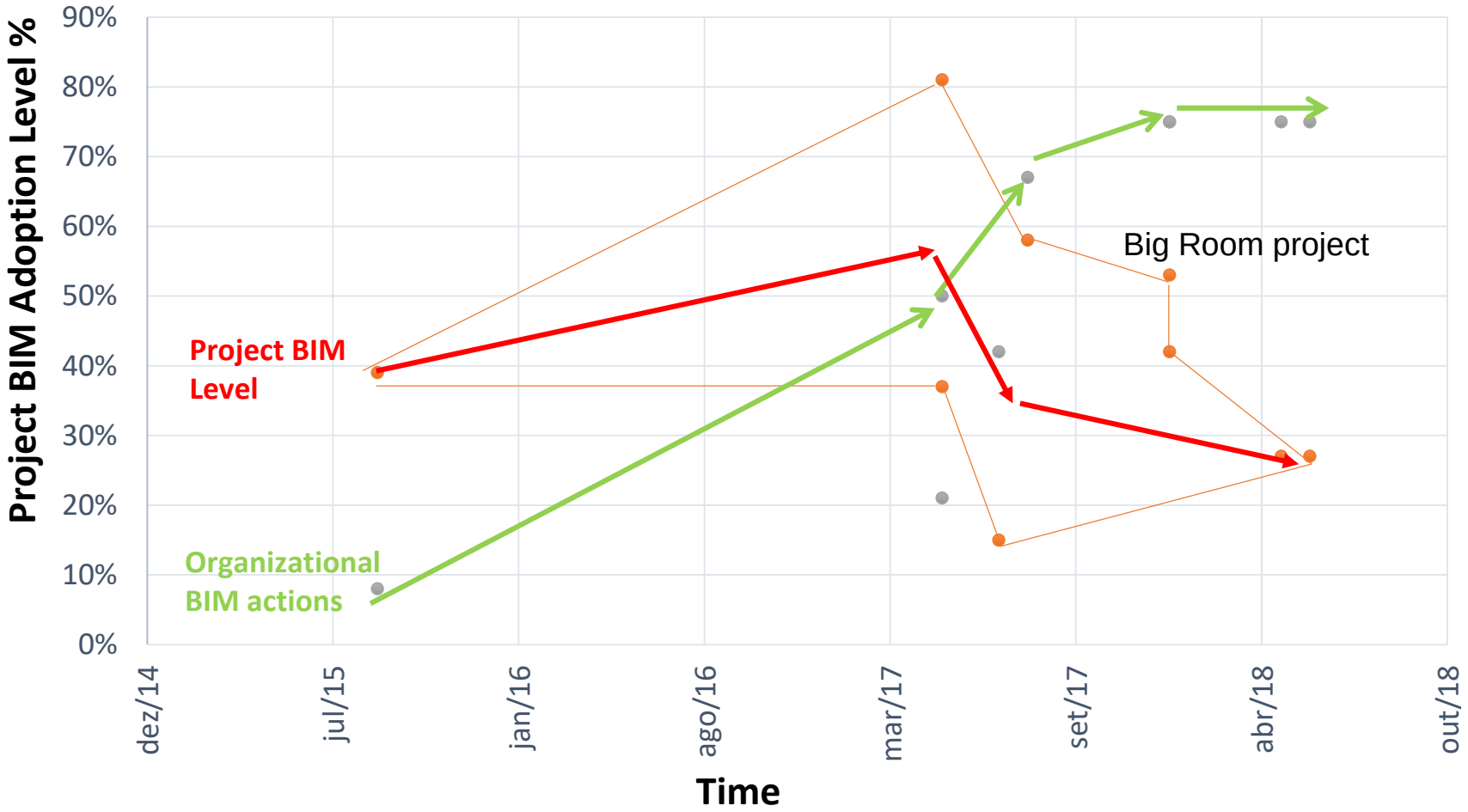


Results

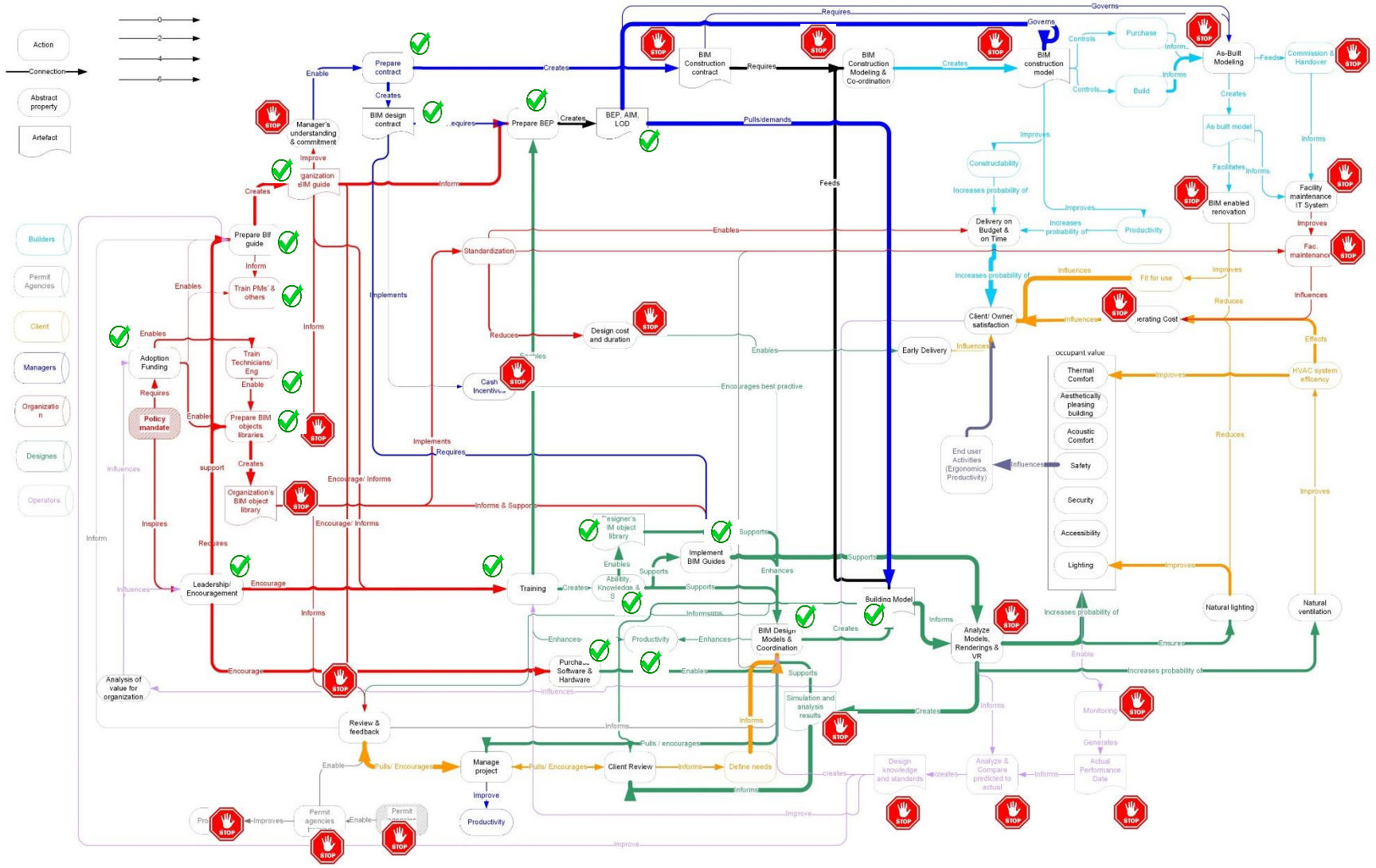
- Measure over three years….
  - Organization BIM adoption actions
  - Organization BIM maturity
  - Projects BIM maturity

- Map organization BIM actions

IMOD – Project BIM level progression



IMOD – Analysis using BIM AIM



Observations

- The organization continued to actively pursue its adoption actions, but….

- Project managers were not sufficiently informed of the purpose and value of BIM use, because…

1. The organization failed to identify the value of information for:
   - Facility operation and maintenance
   - Future development of the system
2. The organization failed to monitor and support its own in-house project managers

Observations

What is the real value for public clients?

- Short term value
  - Reduce project construction costs
  - Reduce project durations
  - Improve project quality
- Long term value
  - Asset information
  - Visualization
  - Asset management
  - Maintenance
  - A basis for operational information
  - Managing staff

} the ***Digital Twin***

Conclusions

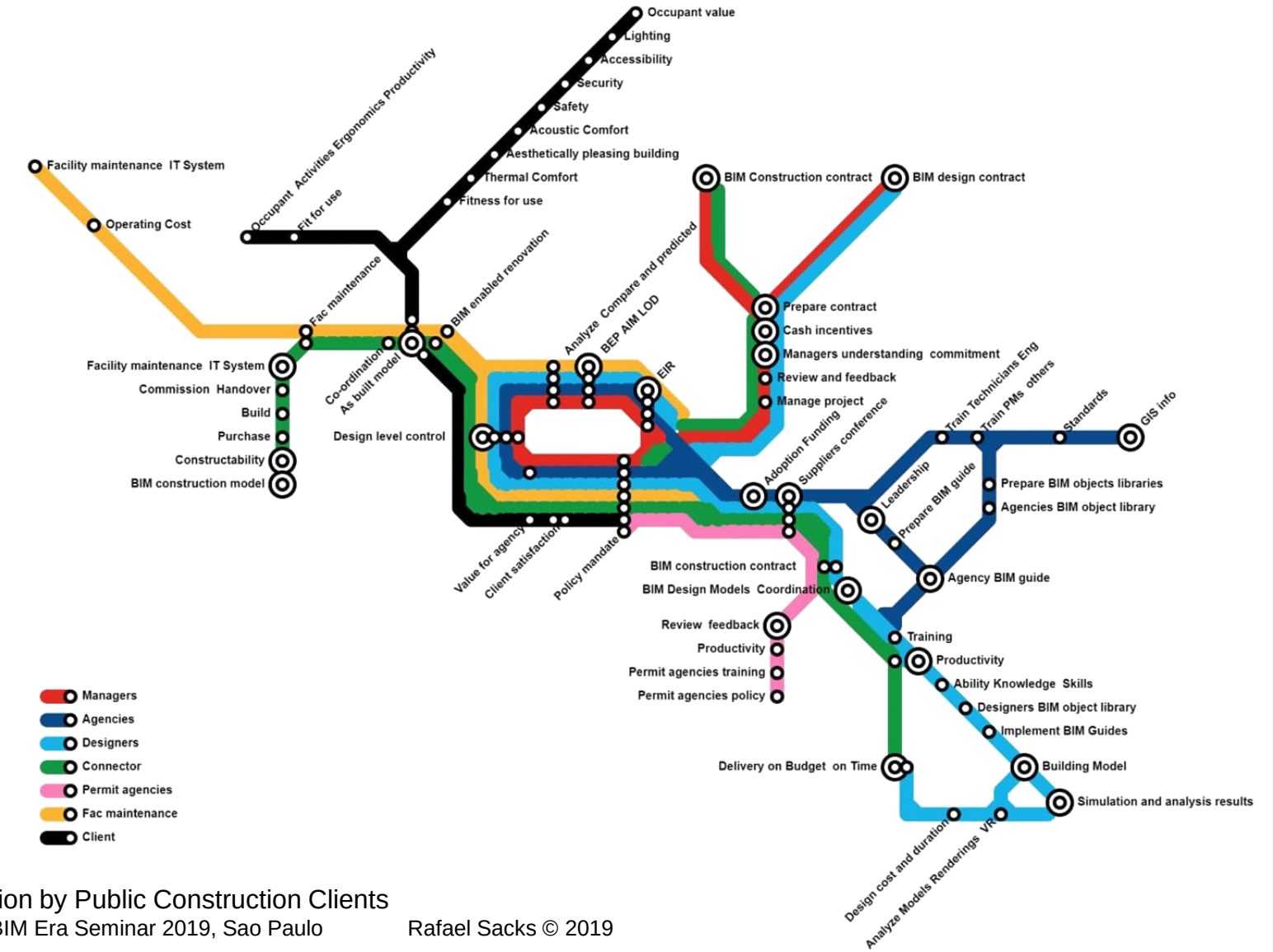
- The hypothesis:
  - "The more actions the organization implements to promote and support BIM adoption on its portfolio of projects, the better the BIM level of the organization will be"

  …. is wrong.
- There is a strong relationship between an organization's actions and the BIM level achieved in projects
- Some actions have amplified effect while others have limited or no effect

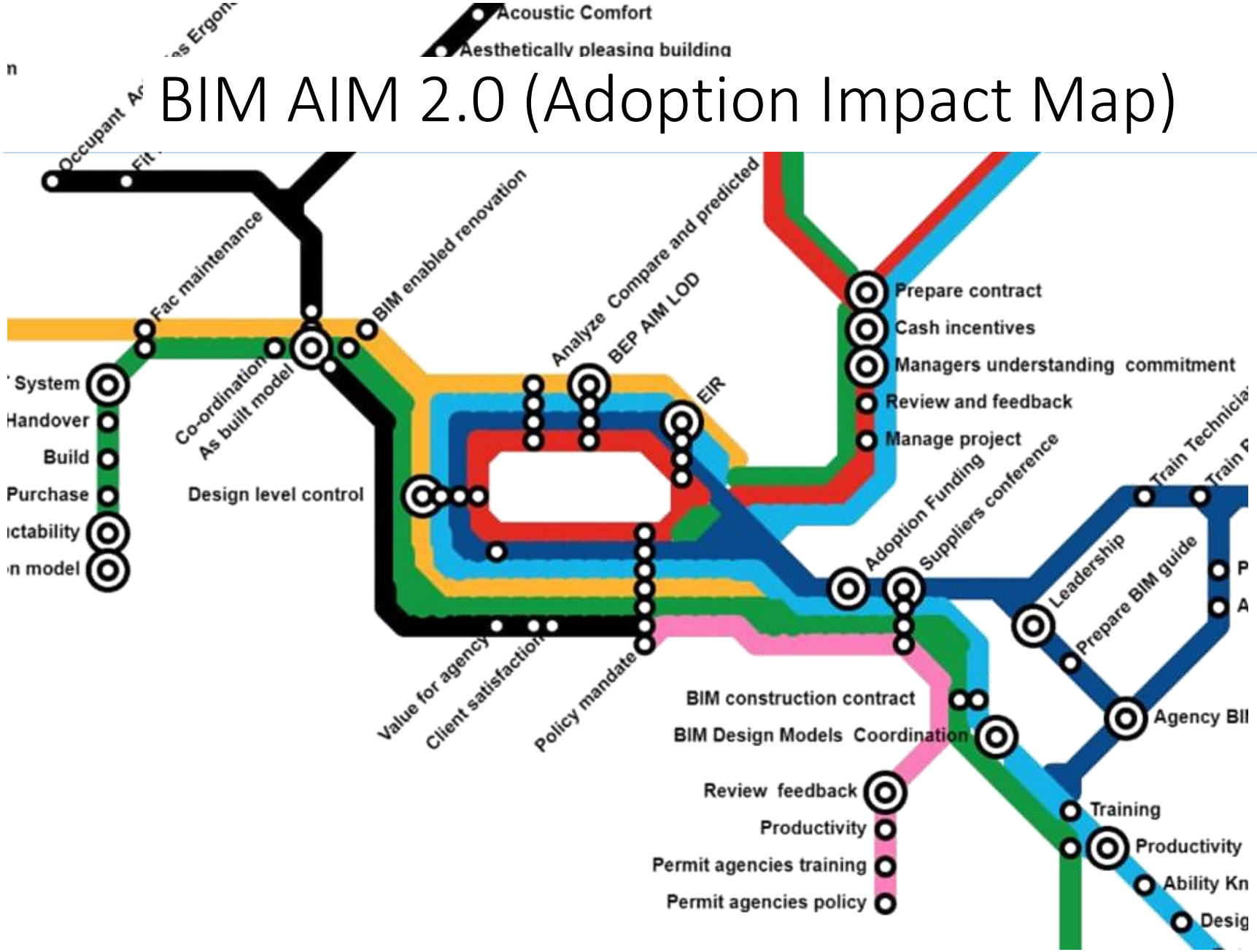
Most valuable adoption actions

- **Leadership**, **guidance**, and **control** by senior management
- Involve and motivate suppliers (designers and contractors)
- Education and training
- Define **Asset Information Requirements** (AIR)
- Monitor and control in-house project managers
- Pay designers properly for BIM
- Manage expectations and collaboration – at both organizational and project levels

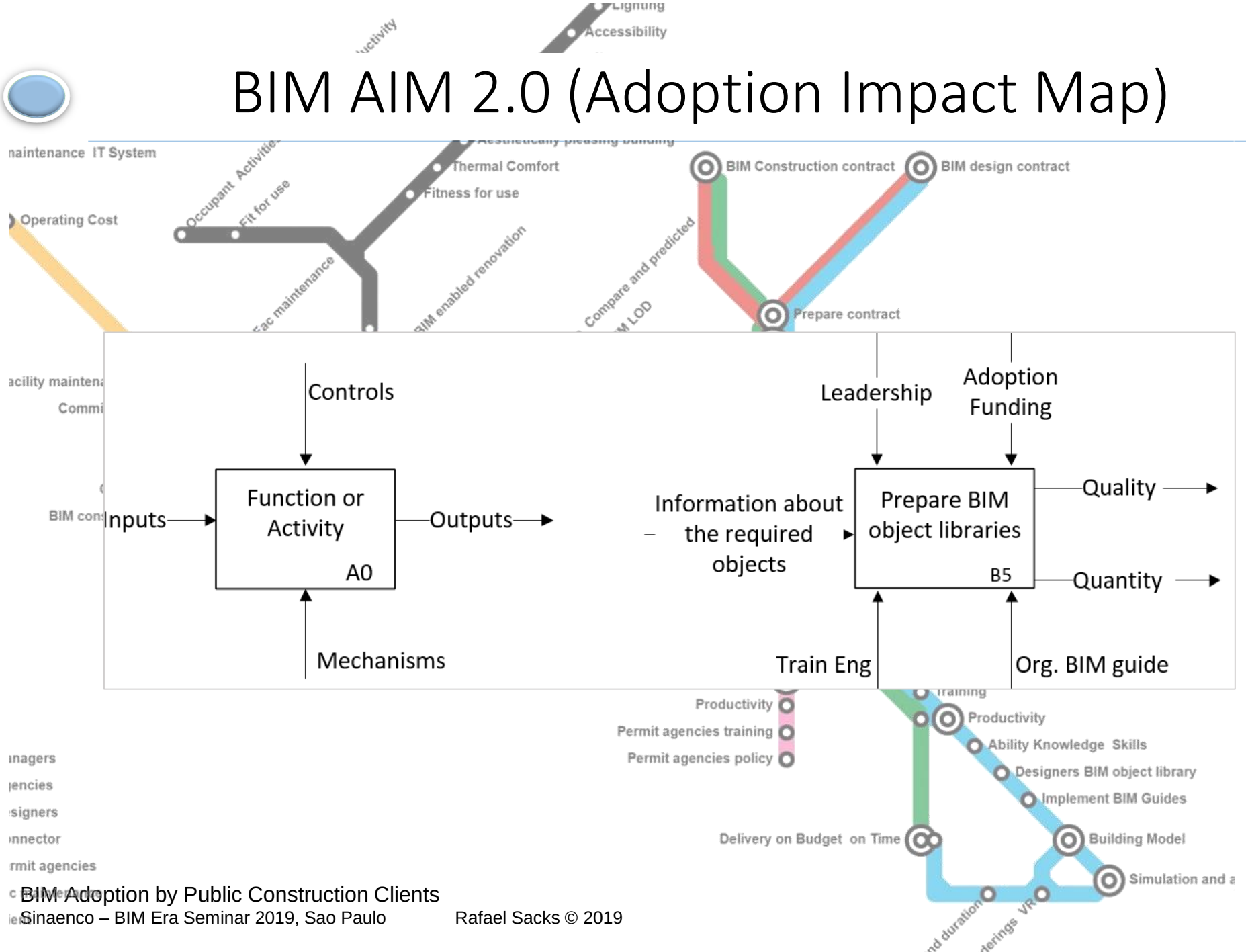
BIM AIM 2.0 (Adoption Impact Map)



BIM AIM 2.0 (Adoption Impact Map)



BIM AIM 2.0 (Adoption Impact Map)



Value of BIM AIM 2.0

- Supports planning of adoption actions
- Identifies which actions amplify other actions
- Reflects extensive experience, grounded in case studies
- Identifies actions that have not been tried in practice
- Represents all aspects:
  - Technology
  - People
  - Process
  - Information

Thanks for listening!

BIM Adoption by Public Construction Clients

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