

2018 Trimble Dimensions User Conference

November 5–7

The Venetian / Sands Expo Center – Las Vegas



Meditate with Metadata

Session ID: BCA-1579

The Zen of AEC data classification systems





"Without data
you're just another person
with an opinion."

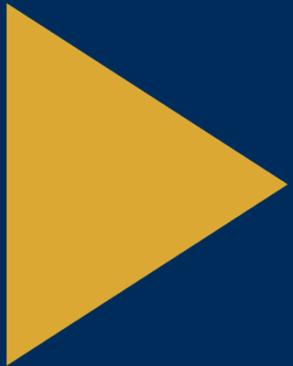
W. Edwards Deming

met·a·da·ta



a set of data that describes and gives information about other data

LET'S BEGIN



TADEH HAKOPIAN

BIM Coordinator at HKS

Eight years of experience in AEC industry with focus on Design Technologies including

- Estimating and Planning
- Concept design
- Construction Documents
- Field Operations,
- Research and Staff Training



Trammell Crow Company

UCLA

Disney

NADEL
ARCHITECTS

HKS

TYSONS
Partnership Building America's
Next Great City

UC San Diego

Simplot

CENTERCAL
PROPERTIES, LLC

Berkeley
UNIVERSITY OF CALIFORNIA

Caltrans

fold
THEATRE
FOUNDATION

HNTB

CommonWealth
partners

LAC+USC
HEALTH CARE NETWORK

Levi's®
STADIUM

SOM

Stantec

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WANDA GROUP

M

BCG

CLARK
CONSTRUCTION

Greenland USA
Always Innovating

LOS ANGELES
COMMUNITY COLLEGE DISTRICT

KAIER
PERMANENTE®

Richard Meier **Architect**

KILROY

gehry partners

OBJECTIVES



1. Become familiar with current industry Data Classification standards



2. How those standards are applied towards project lifecycles



3. Learn what Metadata is and how it is used in BIM models

DISCLAIMERS



1. Not an endorsement of any product

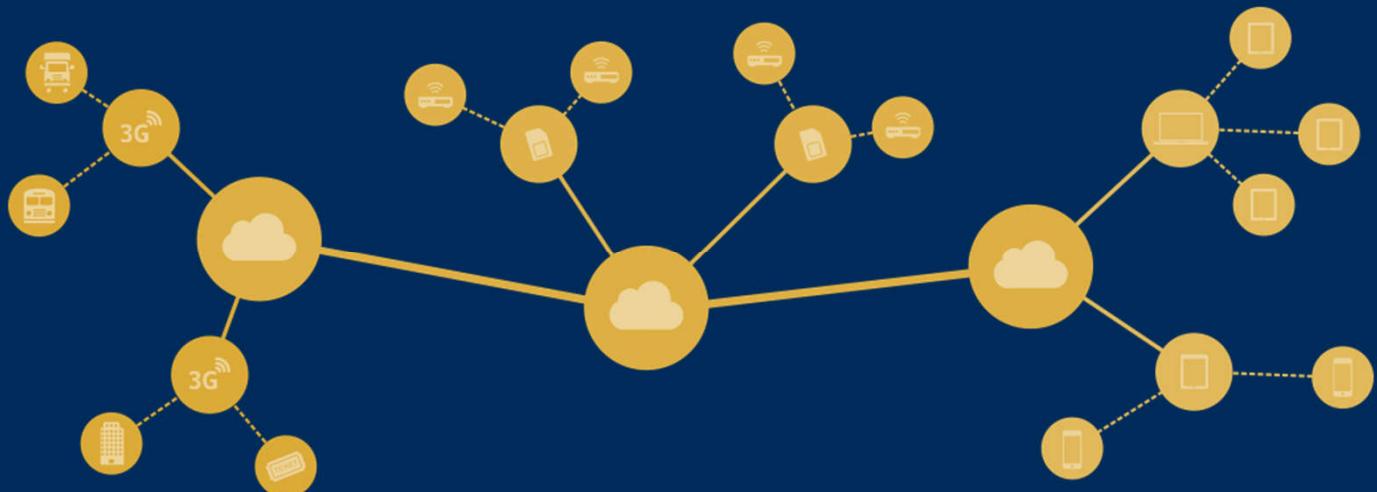


2. Key theme is the sharing and collaborating of information



3. Not an exhaustive description of all standards but we will go over the important stuff

DATA DRIVEN DECISIONS





METADATA IN AEC

Good Data

Good (Reliable) Information

Good (Useful) Decisions

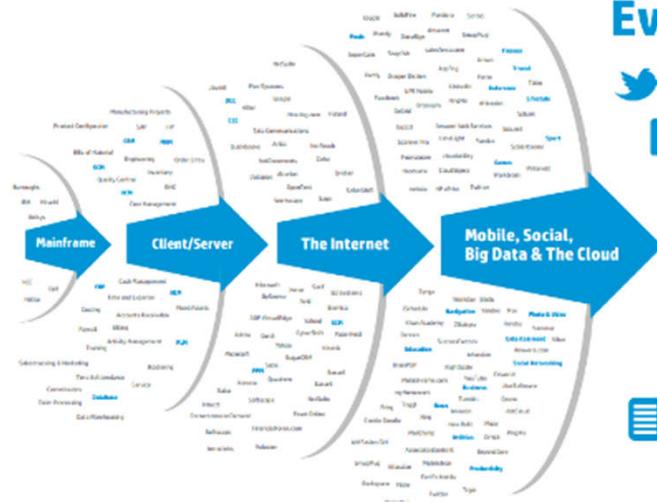
Data → Information → Decisions

Bad Data

Bad (Unreliable) Information

Bad (Poor) Decisions

METADATA



Every 60 seconds



98,000+ tweets



695,000 status updates



11million instant messages



698,445 Google searches



168 million+ emails sent



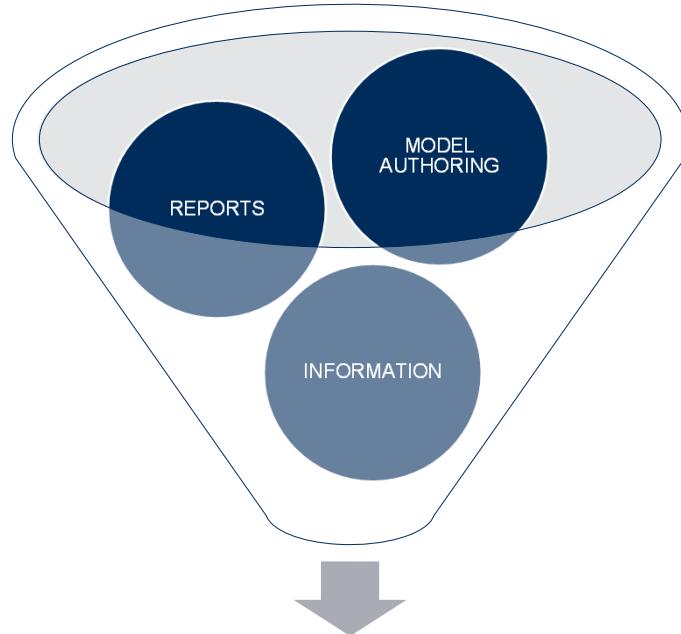
1,820TB of data created



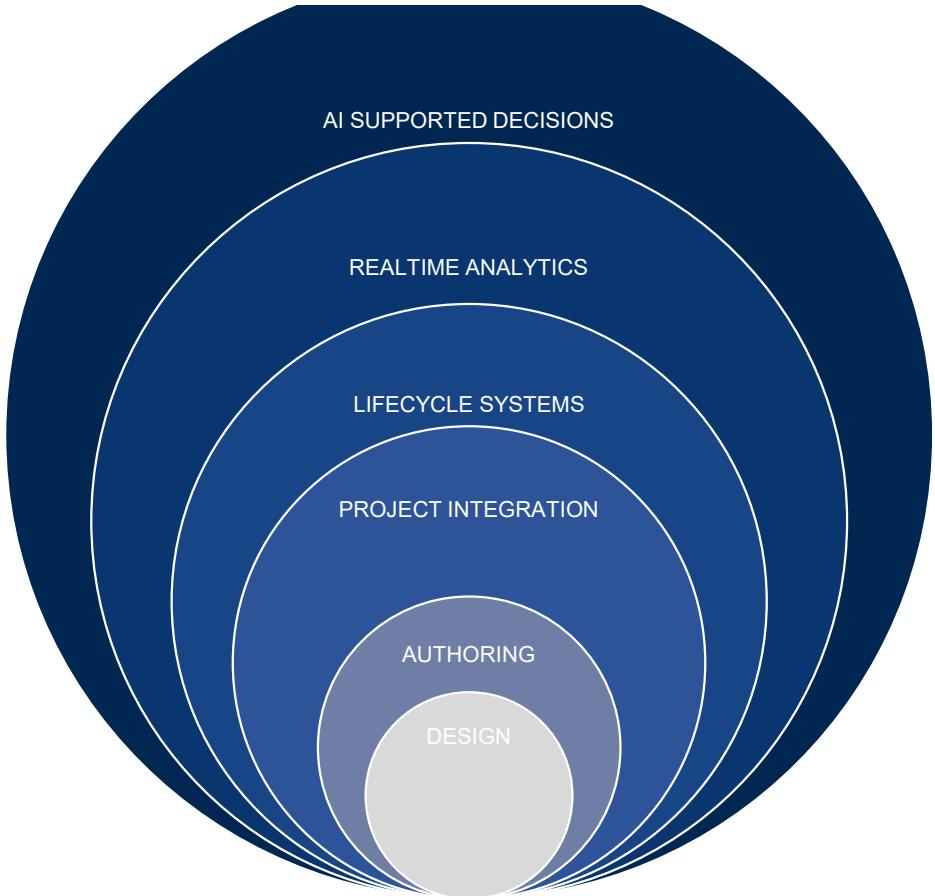
217 new mobile web users



COLLECTION



METADATA



DATA IN AEC

ACCURATE BUDGET ESTIMATES

Better schedule and plan

More accurate cost

Data wise, the more the better



KEEP TRACK AND BETTER MANAGEMENT

Use of geo location on machines

Better time estimation

Small saving - big difference



LOWER PROJECT RISK

Right data - better simulation

More insights

Small changes - big differences



METADATA DEVELOPMENT

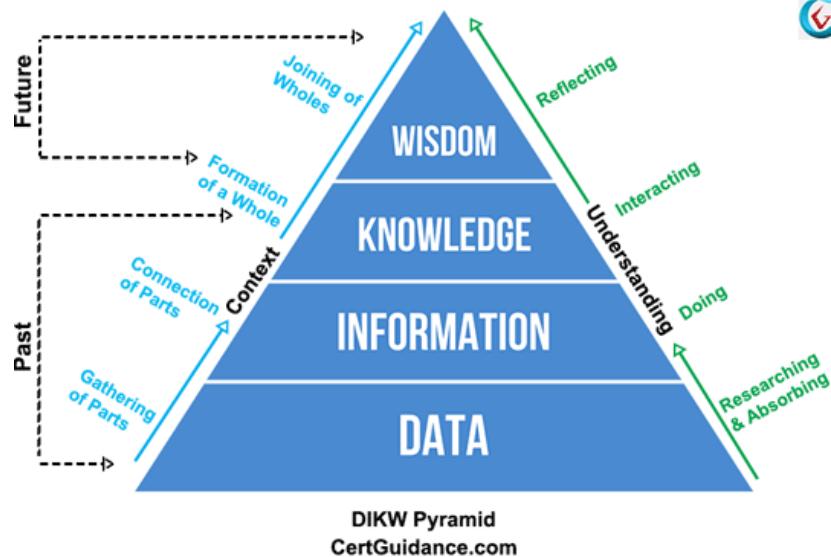
Where does it come from?

Digital Models

Project Accounting

Laser Scans

Connected Devices

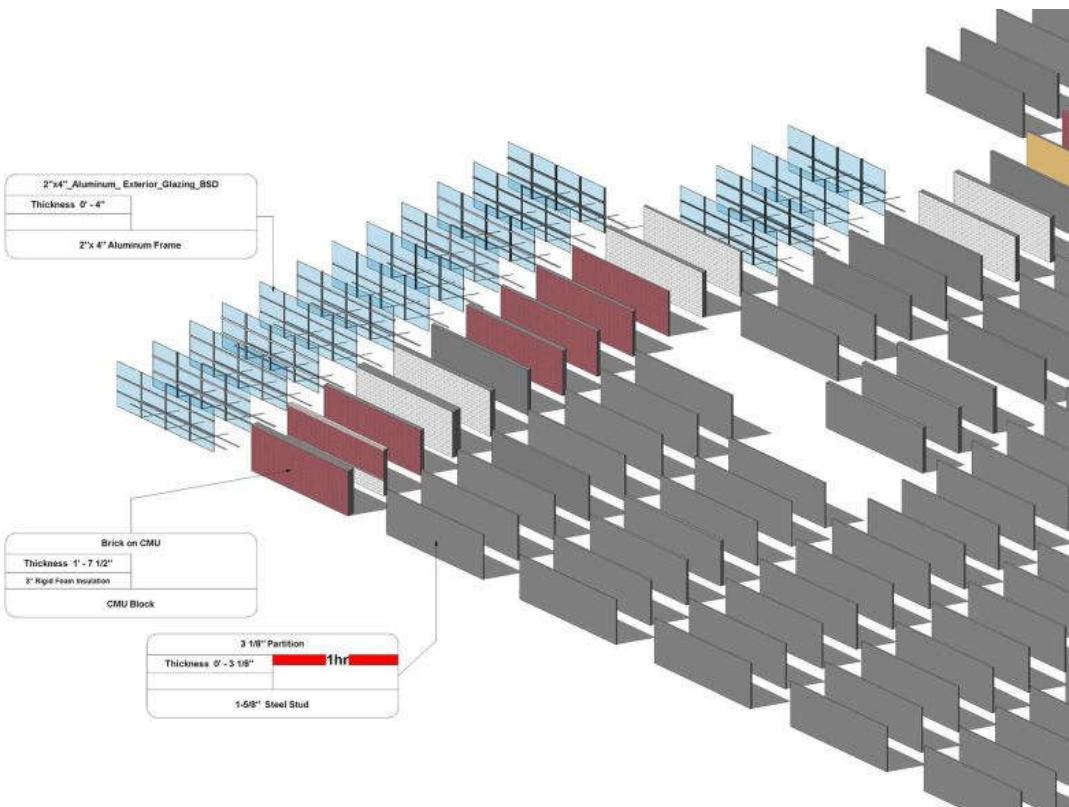


CURRENT USES



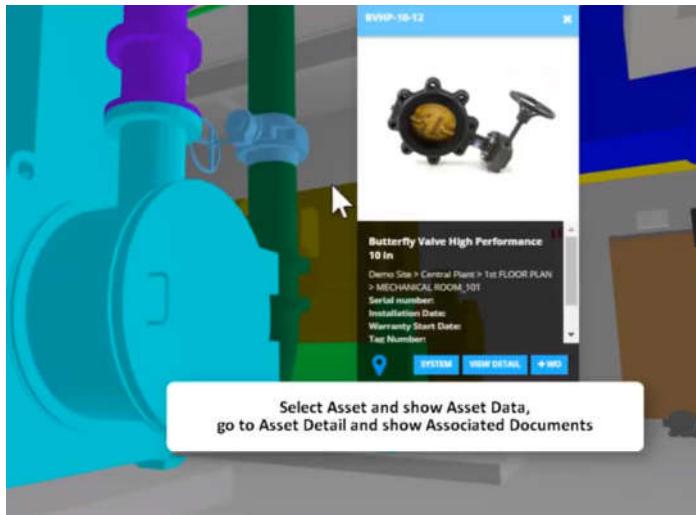
MODELS

- BIM platforms all allow metadata writing
- Can take the form of component sizes, position coordinates, manufacturer data and anything pertaining to the model



FACILITY MANAGEMENT

- Lifecycle As-built content
- Replaces binders and specifications



Edit Asset Data

Type	Valve-Butterfly-High_Performance-WNF_10"
Room	MECHANICAL ROOM_101
Description	Butterfly Valve High Performance 10 in
Serial number	1787287584518548
Installation Date	07/23/2017
Warranty Start Date	07/23/2017
Tag Number	lk23-3
Bar Code	
Asset Identifier	

PROJECT MANAGEMENT

- Project Data
- Shared Libraries

PROLOG ▶



ORACLE®
PRIMAVERA P6

PROCORE®

FIELD EQUIPMENT

- GPS Enable devices
- Drone Surveillance
- Laser Scan Point Clouds
- 360 Photos

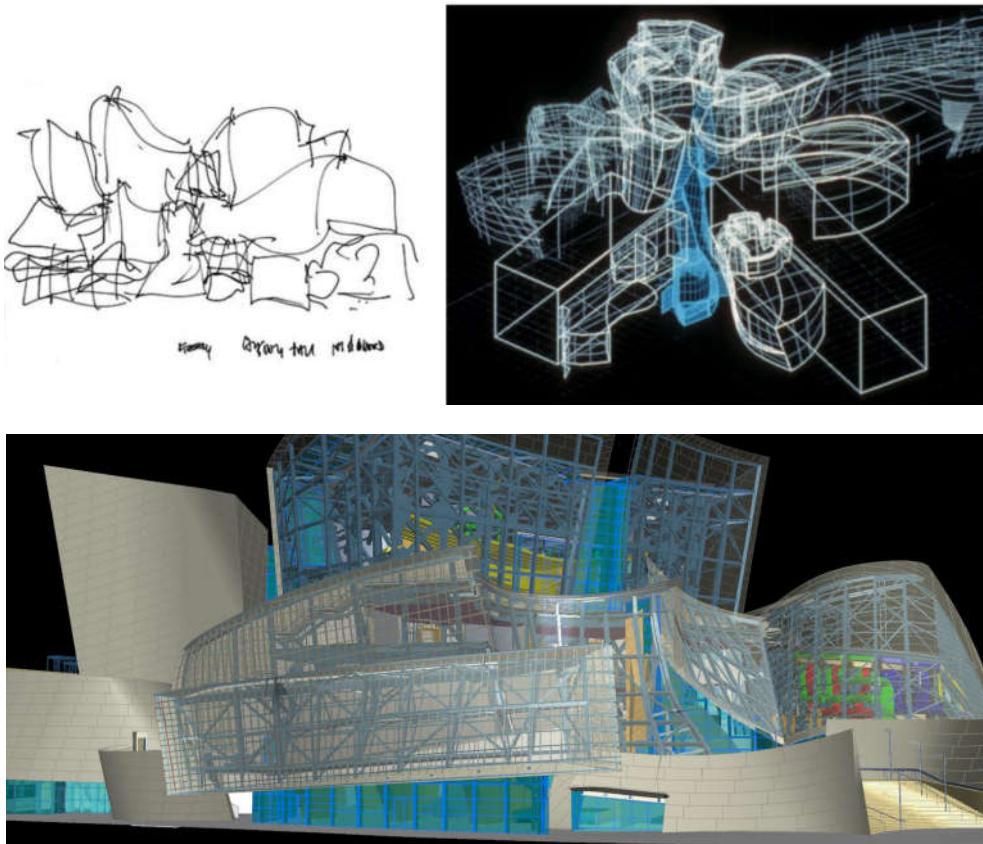


DATA IN AEC WORKFLOWS



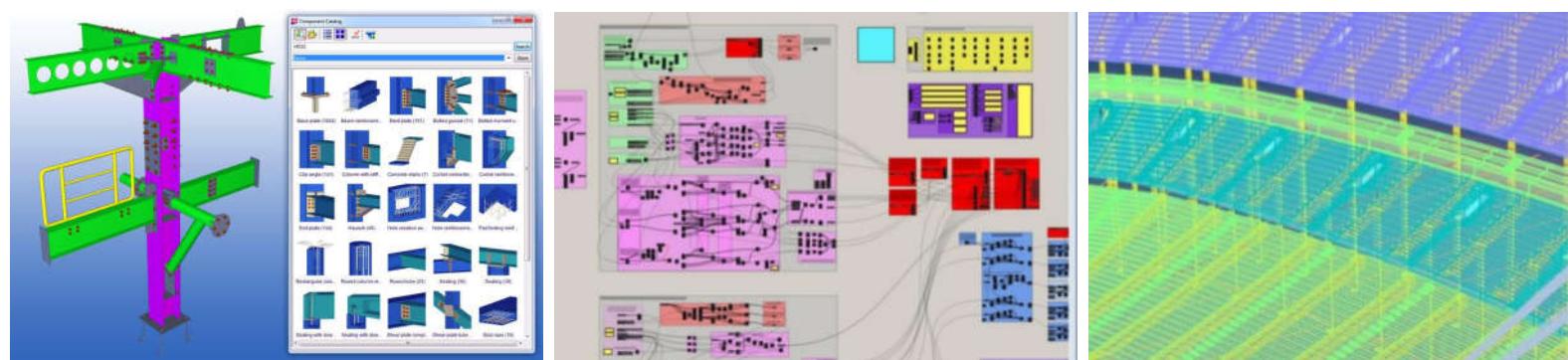
FABRICATION

- Concept design is tricky
- Lots of big moves but not enough to get you a finite level of information for fabrication



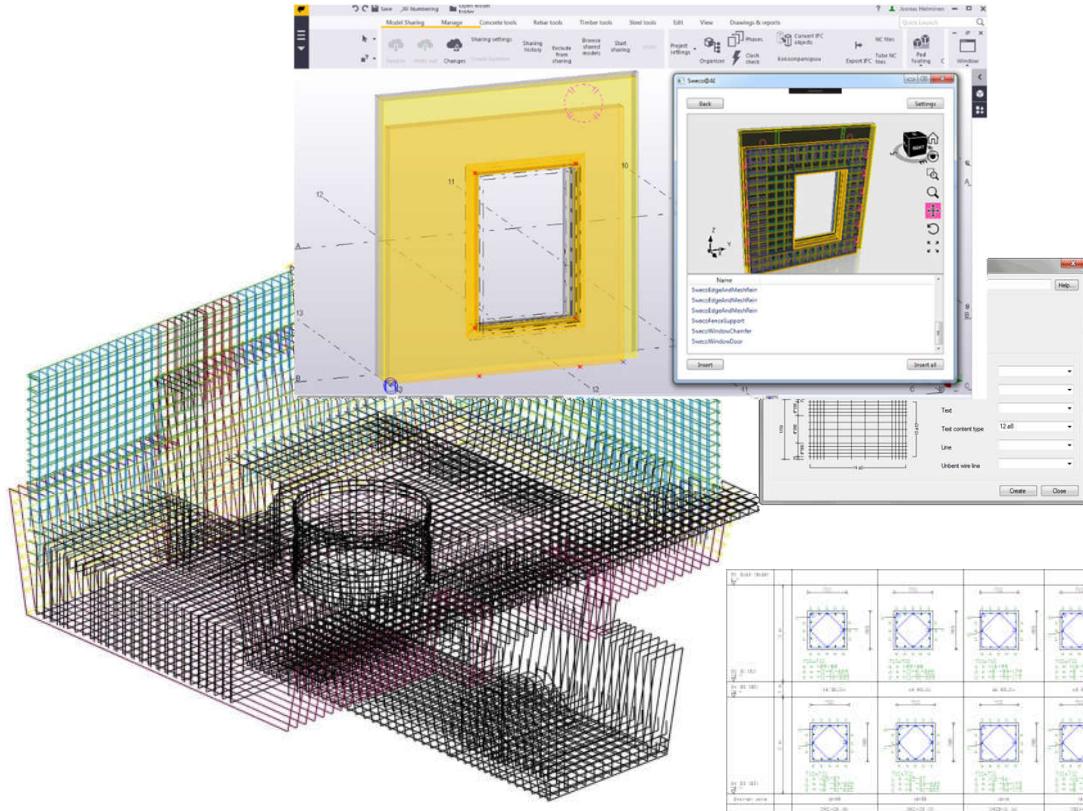
FABRICATION

- Be prepared with data ahead of time to get your content where it needs to be
- Designers can take it and run for complex plans

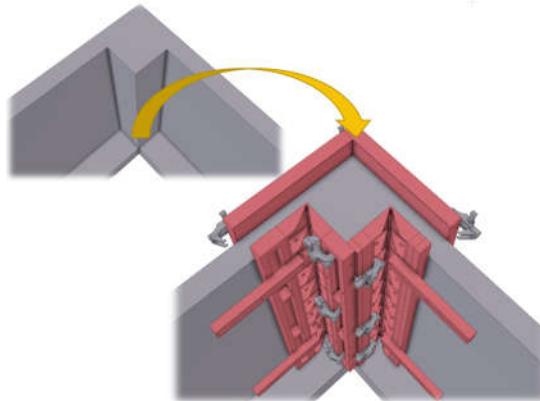
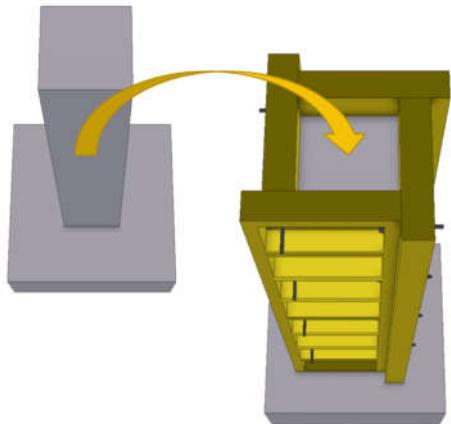


FABRICATION

- If design teams know about the data regarding the manufacturers' products and have the geometry of their products, then they are more likely to select those products and use them within buildings.
- process of delivering information to your clients
- everyone in the construction supply chain needs product information
- *Product Data Templates*

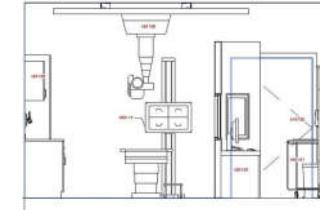
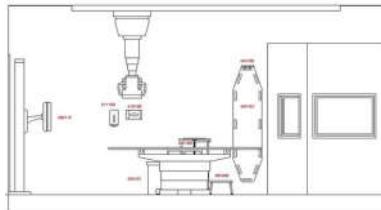
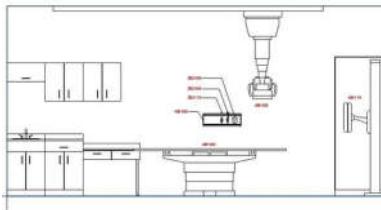
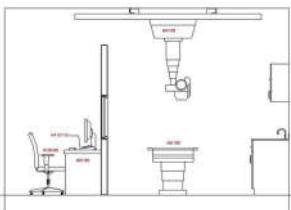


MANUFACTURER DATA



- Providing manufacturer data for assemblies and parts
- Creating content libraries for all fabricated parts of a building for record keeping in future renovations

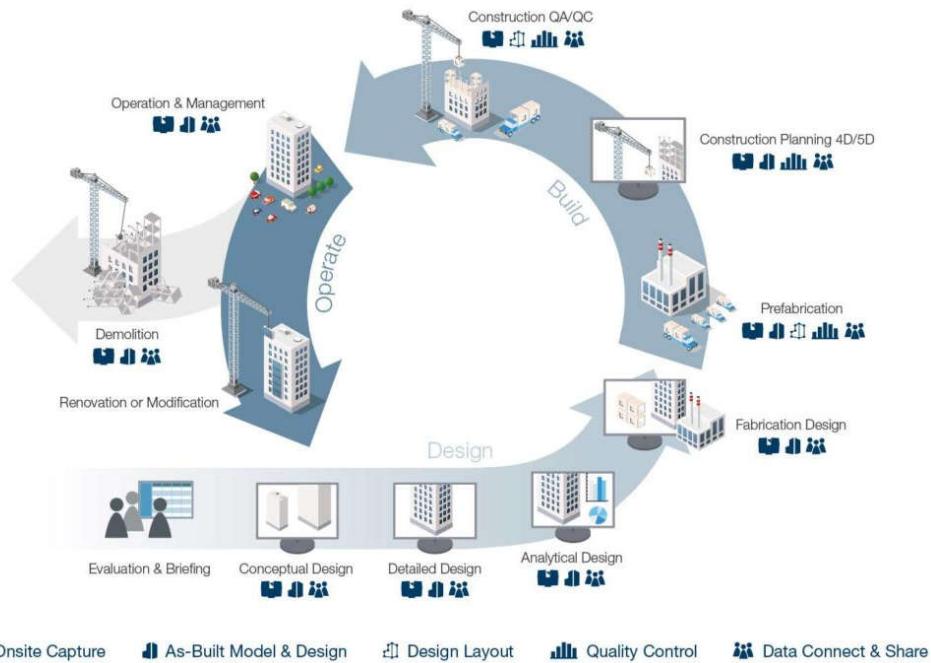
MANUFACTURER DATA



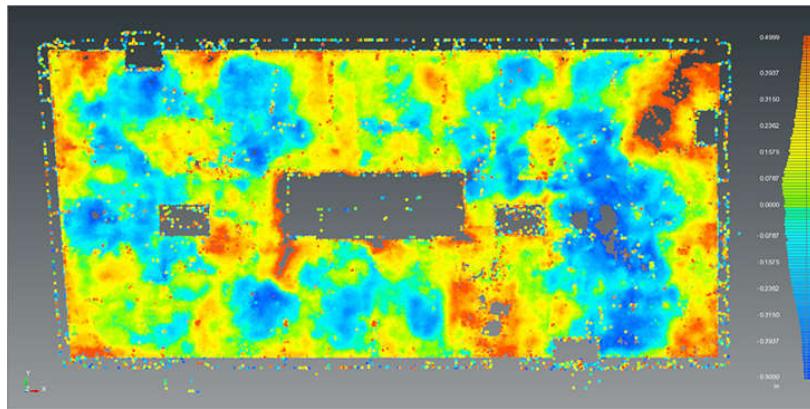
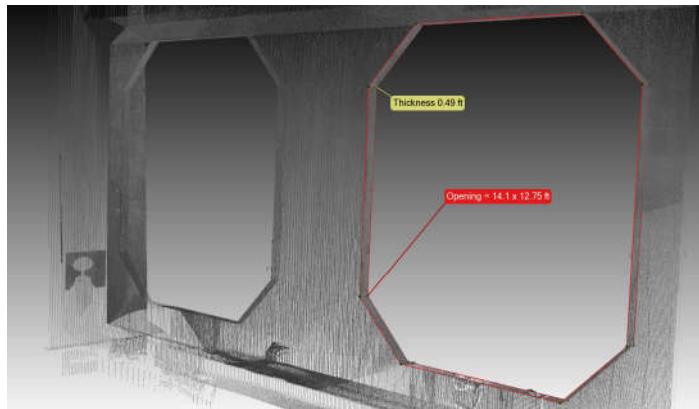
«Radiology Exam Room / Furniture Schedule»		
A	B	C
Family	Description	Count
105100	Services Console, 600mm	1
205200	Stool Step	1
212101	Hampers, Linen, Round, Tilt-Lid	1
303100	Medical Gas, Suction Regulator	1
303105	Medical Gas, Oxygen, Flowmeter	1
303110	Medical Gas, Air, Flowmeter	1
400115	X-Ray Unit, Detector Stand	1
405100	X-Ray Unit, General Radiography, Digital	1
405105	General Radiography, Control Console (Part of item 405100)	1
405106	General Radiography, Generator Cabinet (Part of item 405100)	1
495100	Transfer Board Wall Storage Rack	1
495102	Patient Transfer Boards, Radiology , Narrow	1
910100	Dispenser, Gloves, 1 Box	1
911100	Dispenser, Hand Sanitizer	1
950100	Base Cabinet, 600x600mm, with Sink and 2 Doors	1
950103	Base Cabinet, 600x600mm, with 2 Doors and 1 Drawer	1
951102	Wall Mount Desk, 900x600mm, with 2 Drawers	1
954101	Wall Cabinet, 600x300mm, 2 Doors	2
954104	Wall Cabinet Short, 600x300mm, 1 Doors	1
999101	Waste Containers, 8 Gallon	1
AR10110	Telephone	1
ID20100	Chair, Swivel, High Back	1
Grand total: 23		

LASER SCANS POINT CLOUD DATA

- Point Clouds from Laser scan equipment will become common place
- Higher resolution point clouds can become part of the model environment
- Continuous scan updates for projects can incorporate into life cycle asset management
- Scans can have built in data for elevation, GPS, range and other relevant information
- Terrain data
- Material information
- Scan content thicknesses
- Scanning informs the modeling and lifecycle management with real world content



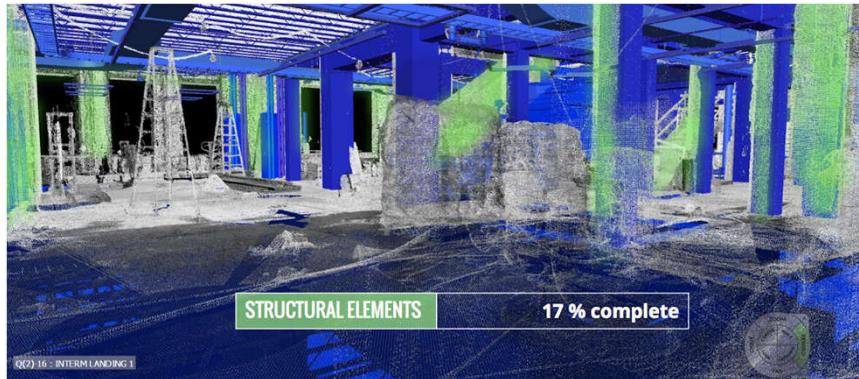
LASER SCANS POINT CLOUD DATA



- Sizing members
- Finish Floor flatness post pour and cured as built copy

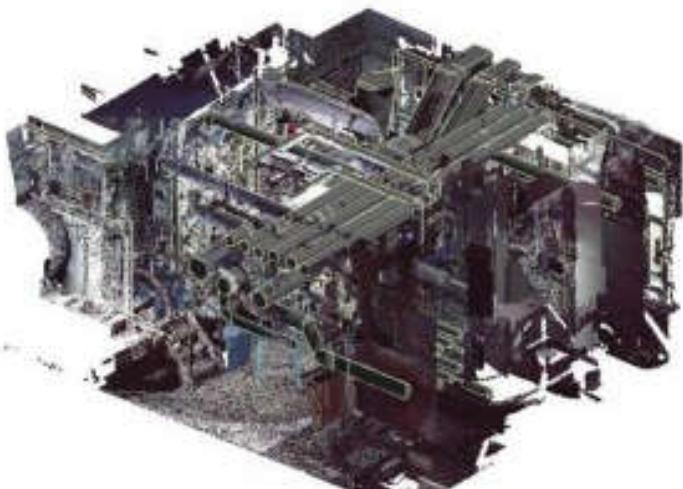
LASER SCANS

- Compare scans to federated models for construction progress
- Verify work progress matches the design



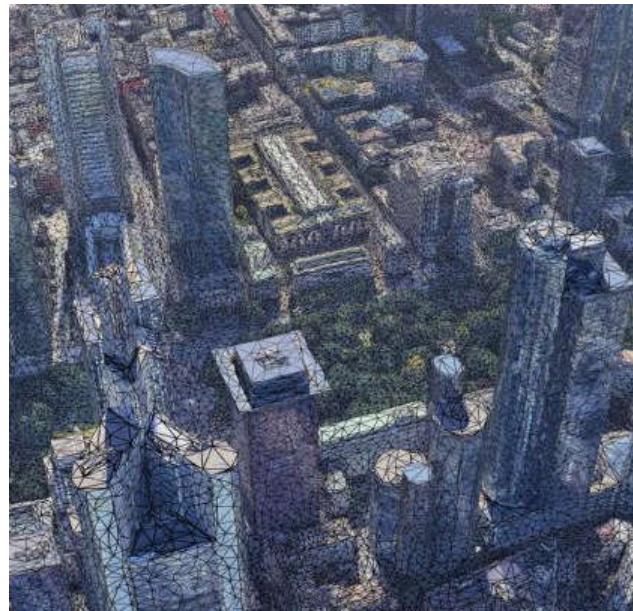
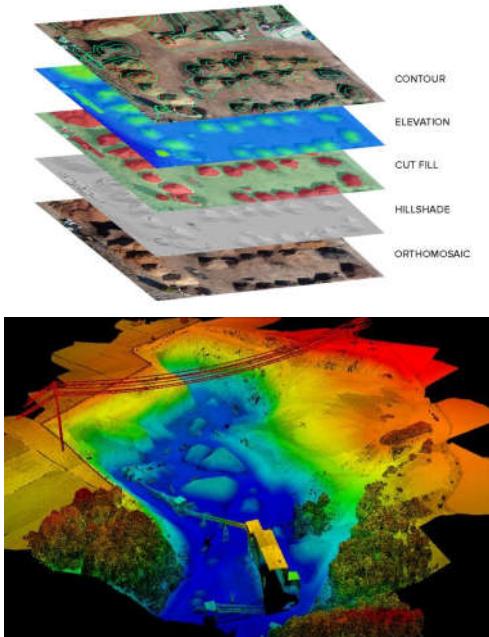
LASER SCANS

- Scan to BIM become more common
- GPS, Accuracy, Verification and common standards will be important data to avoid rework



LASER SCANS

- Large area laser scans
- Aerial Lidar
- Photogrammetry mesh
- Data can analyze urban infrastructure, water resources, terrain data
- Datasets can be analyzed by machine learning algorithms which can be trained to search for critical information that can be fed back to decision making



POINT CLOUD METADATA

point - constrained type

(2.1,4.7,1.0,9,...)



Point type = XML schema

X : float, offset, scale, description
Y : double, ...

patch (group of points) - compressed
- indexed



&

generalisations



pointclouds - 1 per table

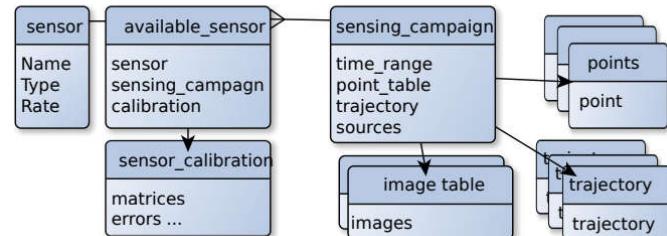
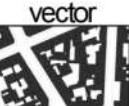
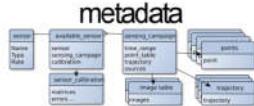
5	100011101...
6	1000101001...
7	1000001110...
...	...

&
coverage maps



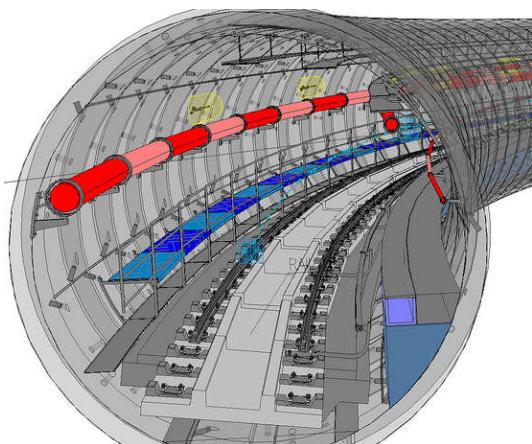
todo map

Metadata - relational
- classical / extended



CIVIL INFRASTRUCTURE

- Horizontal Civil models with embedded GPS information



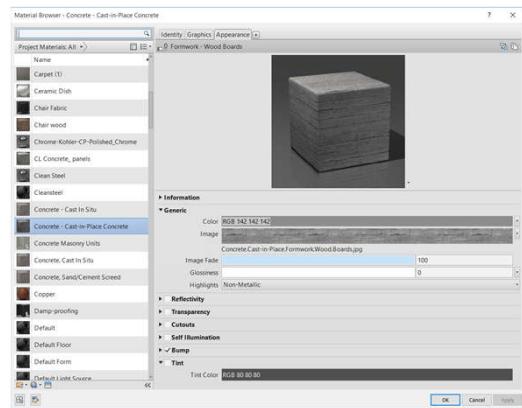
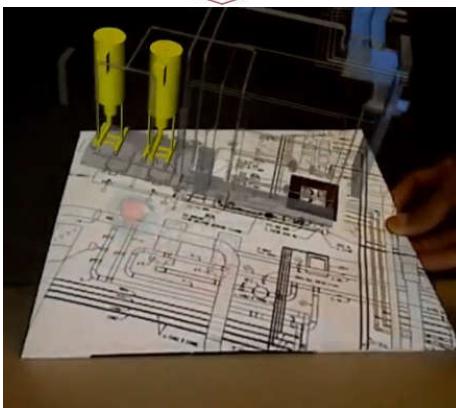
GIS

- Geographic Information Systems
- City planning and Large scale infrastructure can acquire larger data libraries as methods become standardized



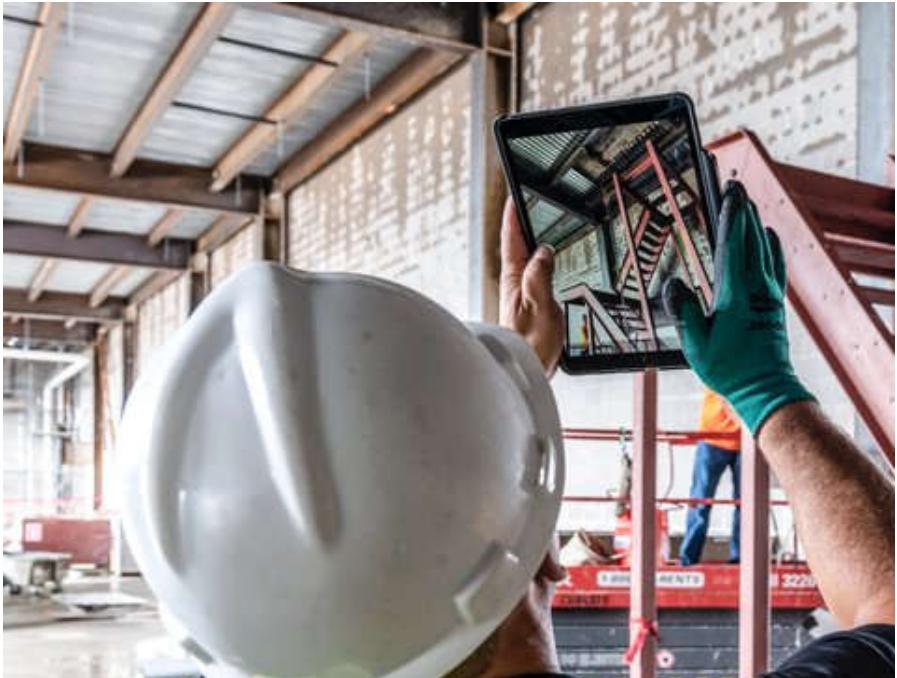
AR / VR / MR

- VR is used, for example, by builders for visibility on architectural designs and 3D ecosystems to carve out design flaws and ensure there are fewer errors on projects.
- Select content in real time overlaid with VR goggles
- Without metadata the VR environment lacks substance
- Connecting the VR experience with Data will make immersion informative not just visual



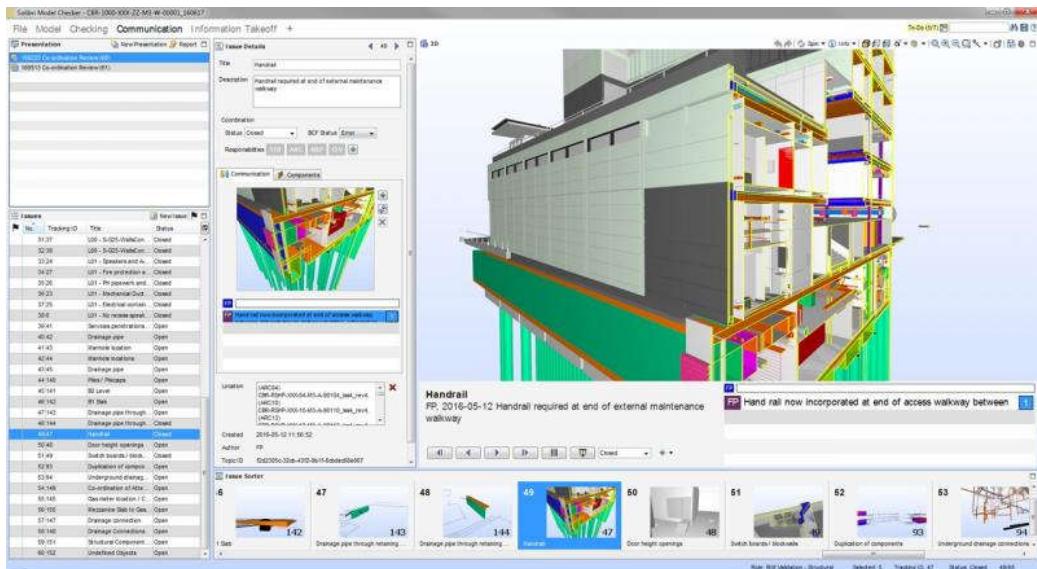
CONSTRUCTION MANAGEMENT

- Document Library
 - A Centralized, or Single, Source of Truth
 - Easier Team Handoffs
 - Improved Decision-Making
 - Controlled Information
-
- *A digital quality program improves operational excellence by enhancing a company internally from its people, processes, and relationships with third parties. The most important asset any construction company has is its people, along with their collective knowledge and experience. A digital quality program gives an organization the ability to capture best practices and expertise of its most experienced teammates in the form of a checklist that can be carried forward on future projects. To empower your third party relationships involve your trades and subcontractors when building out your checklist to improve alignment and set expectations. This will reduce the number of non-conformances and resultant re-inspection efforts required.*



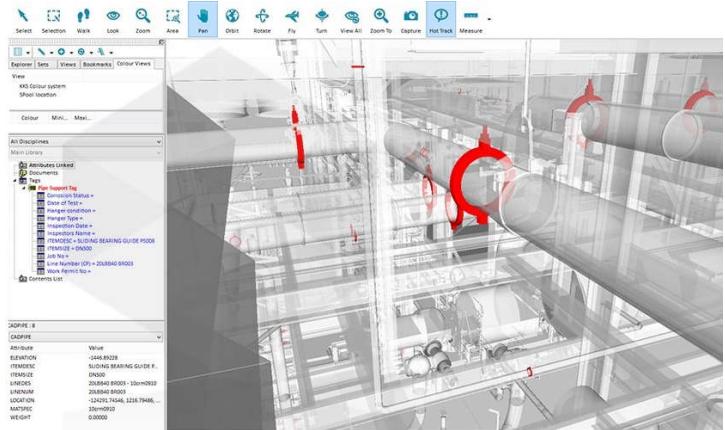
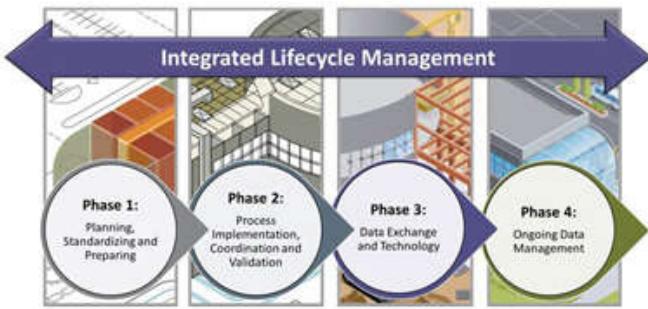
SAFETY

- Embed models early with safety information
- Fall safety data for federated models
- Project completion progress of scans vs models
- Usually input later in the process



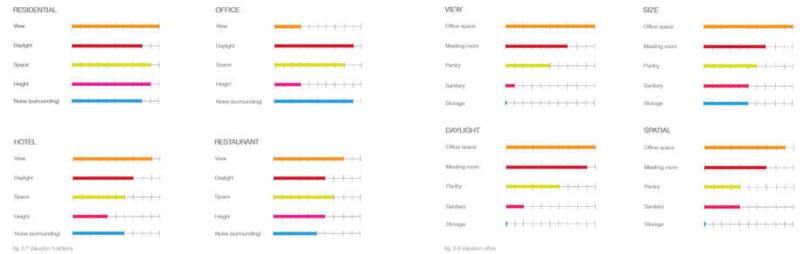
FACILITY MANAGEMENT

- Evaluate new capital projects
- Plan maintenance tasks
- Fast response to incidents
- Risk evaluation for unplanned work

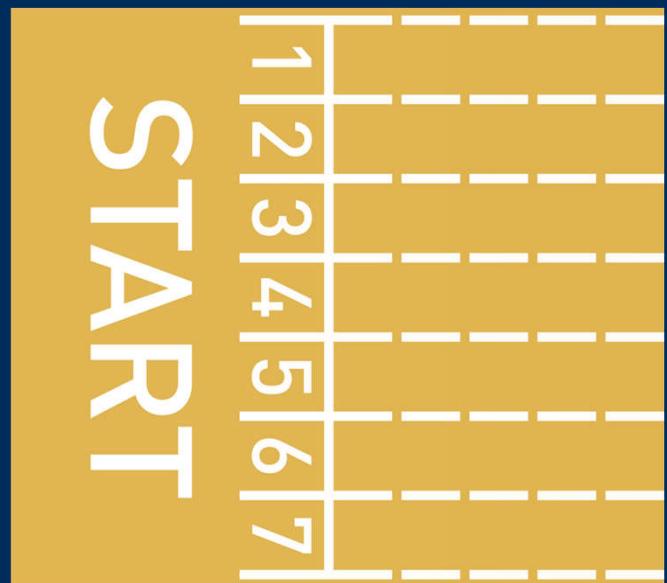


REPORTING AND ANALYTICS

- Model content can be sent directly to reporting platforms to gain insights
 - Boost communication between teams and organizations
 - Use data for AI systems
 - History of data can be used to make better informed decisions and avoid risk

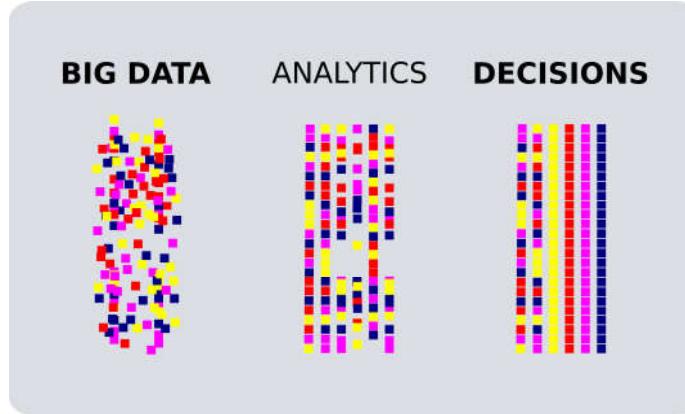


HOW TO GET STARTED



FIRST STEPS

- First, you need to select the model you would like to build.
- Collect your content & Understand how each part can be used. Learn about the characteristics: dimension, color, weight, shape.
- Start building small chunks until you've mastered all the uses.
- Finally, after you've built the model you've wanted, take all the pieces apart and start experimenting.



METADATA IN AEC

- Begin Discovering what are belonging to sets
- Create classes of those sets
- Process your data
- Create representations

Mapping
Maintenance

Mapping
Discovery



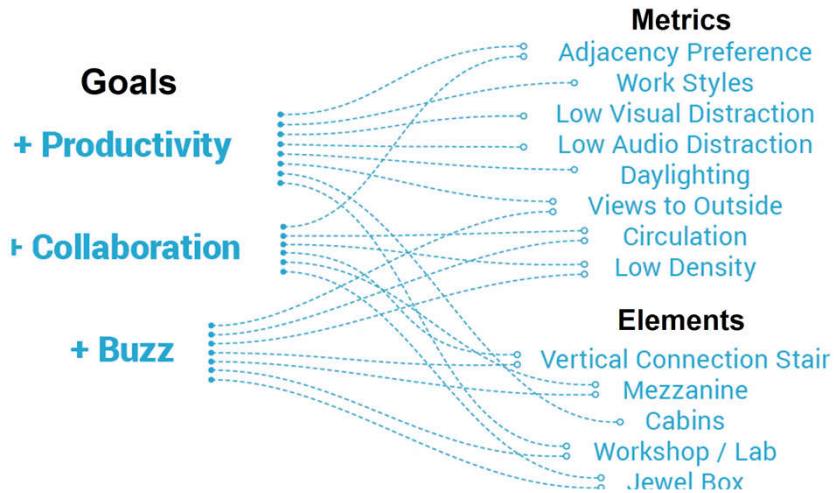
Mapping
Execution

Mapping
Representation



WORKFLOWS

- Analytics requires varieties of goals to be established before you can analyze
- Sometimes your goals can overlap
- So long as a relationship is established



DECISION HIERARCHY

- Goal of data cleaning, organizing and processing is to get some decisions making done
- Never in isolation but a part of the decisions making process to inform choices based on value from insights
- Raw data becomes more and more concentrated and organized until meaningful trends are established
- Decisions and insights are fed back into the organization process to improve upon each iteration

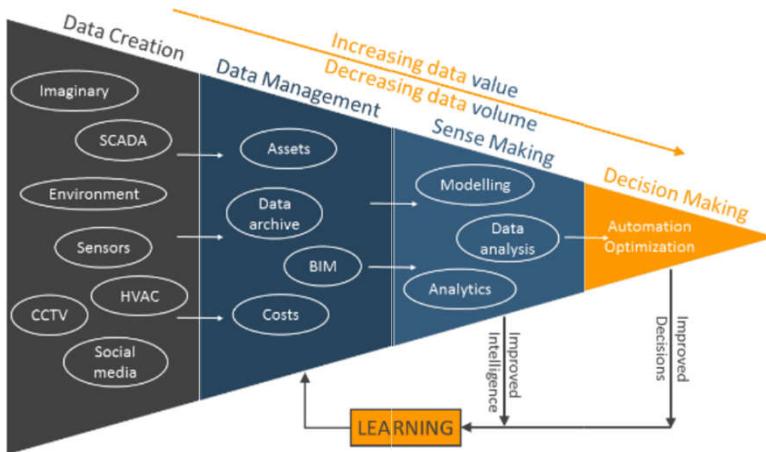


Figure 3: Smart Buildings: from data to information

INTERNATIONAL STANDARDS

A ● . . .
B
C
D
E ●
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G . . . : :
H
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J
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N . .
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U
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Z

1
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9
0

INDUSTRY STANDARDS

1 Bs BIM Strategy	BIM Strategy												2 Su Surveys and Reports	
3 Fr Framework	4 Cu Culture and behaviour	Strategy			Process			Standards			5 Bt BIM Toolkit	6 Lod Level of detail	7 Loi Level of Information	8 Vi Videos
9 Co Common methods	10 Po Process	11 As Assessment and need	12 Eir Employers info requirements	13 Cm Communication	14 In Investment	15 Sf Software	16 Cd Capital delivery phase	17 Cl Collaborative business relationships	18 Li Library objects	19 Cs Classification	20 An Analysis tools	21 Ev Events		
22 Pr Procurement route	23 Fo Forms of procurement	24 Ex Execution	25 Bep BIM execution plan	26 So Soft skills	27 Ch Change process	28 Ha Hardware	29 Op Operational phase	30 Po Protocol	31 Pe Prequalification questionnaires	32 Cafm Computer-Aided Facilities Management	33 Ct Cost tools	34 Fo Forums and user groups		
35 Ca Capability and capacity	36 Di Digital tools	37 De Delivery	38 Midp Master information delivery plan	39 Cp Cooperation	40 Sh Share success	41 Tr Training	42 Fm Facilities management	43 Qu Quality management systems	44 Bsdd buildingSMART data dictionary	45 Pg Programme tools	46 Ad Administration tool	47 Sc Social media		
48 St Standardisation and Interoperability	49 Ma Maintenance and use	50 Cde Common data environment	51 Ch Champion	52 Av Availability	53 Fi File storage	54 Dg Digital security	55 De Design management systems	56 Ifc Industry foundation classes	57 Au Authoring tools	58 Mo Model viewers and checkers	59 Bl Blog posts			
60 Dpow Digital Plan of Work	61 In Information exchange	62 Su Support	63 En Engage	64 In Infrastructure	65 Br Briefing	66 As Asset management	67 Idm Information delivery manual	68 Sp Specification tools	69 Fl File sharing and collaboration	70 Bo Books				

Digital Plan of Work stages

71 Sr Strategy	72 Bi Brief	73 De Definition	74 Ds Design	75 Bu Build and commission	76 Ha Handover and closeout	77 Oe Operation	78 En End of life
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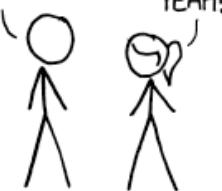
STANDARDS

HOW STANDARDS PROLIFERATE:

(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC.)

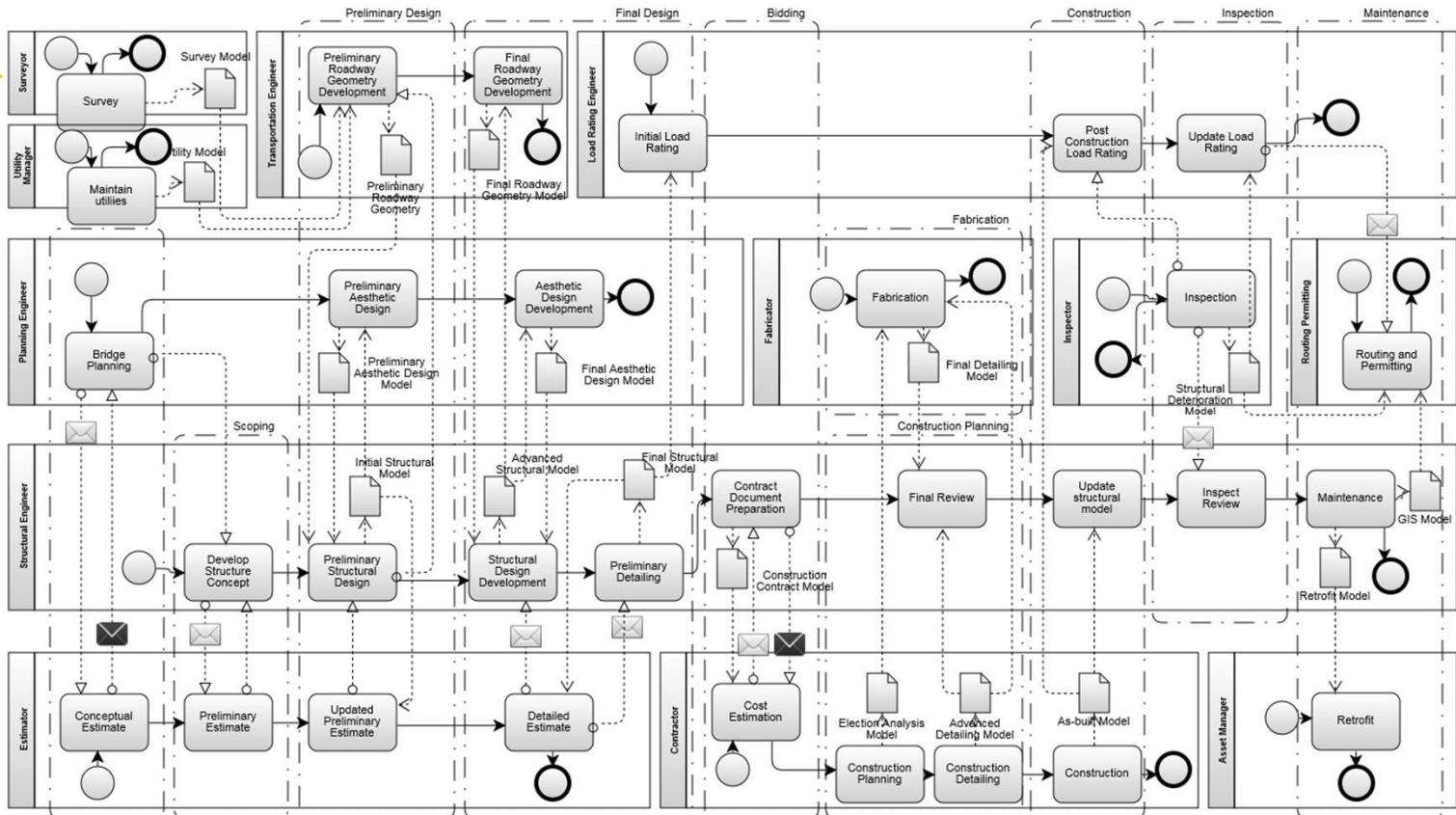
SITUATION:
THERE ARE
14 COMPETING
STANDARDS.

14?! RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE'S
USE CASES.



SOON:

SITUATION:
THERE ARE
15 COMPETING
STANDARDS.



ISO 9000

- International Organization for Standardization (ISO)
- In a nutshell gets everyone to agree on a standard
- ISO 9000 for quality management systems
- Hallmark is Plan, Do, Check, Act Cycle
- Quality management and quality assurance developed to help companies effectively document the quality system elements to be implemented to maintain an efficient quality system
- No BIM plans just standards for terminology and organization to bring all Quality Control in any business in line for comparable processes

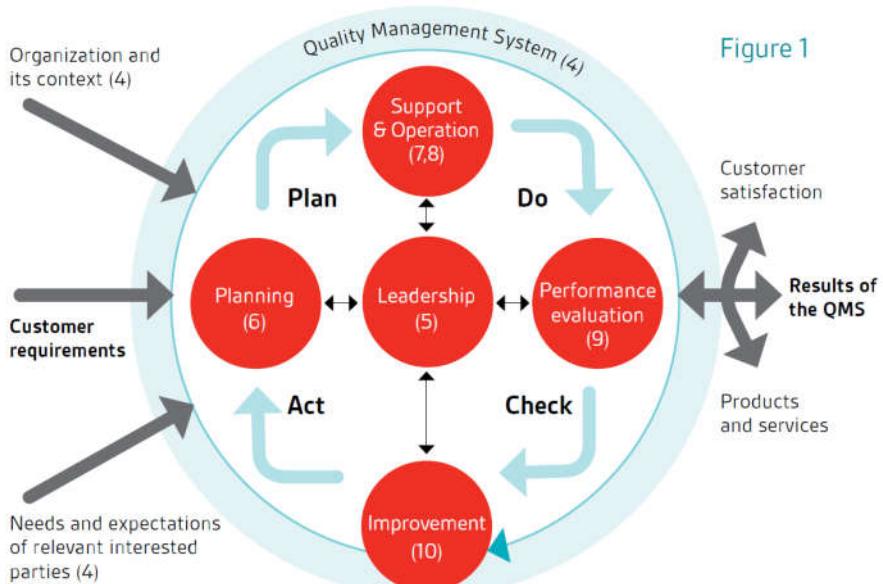


Figure 1



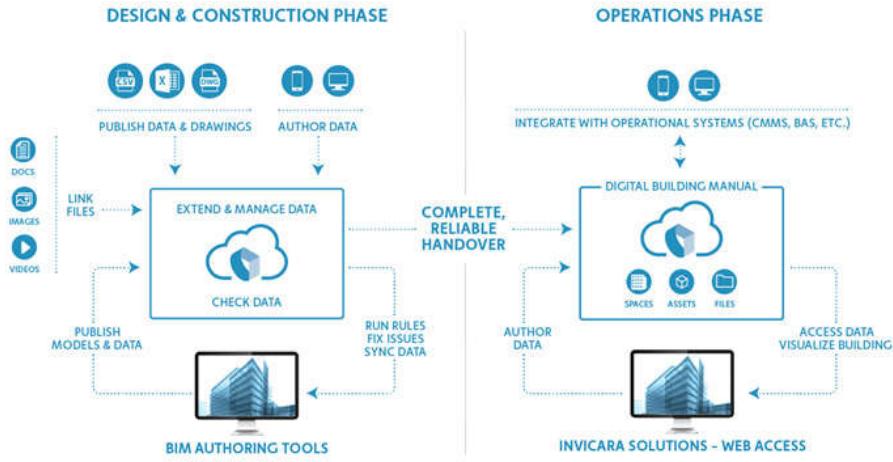
PAS 1192

- Publicly Available Specifications (PAS)
- Outgrowth of BS 1192
- UK Construction Industry Council (CIC) & British Standards Institute (BSI)
- Meant for UK BIM Level 2 (collaboration) requirements
- Provides clarity for BIM projects everyone in the UK AEC industry can follow
- All aspects combine to become an information model
- Contains several sub-sections
- 1192-2 information exchanged or managed in a BIM format
- 1192-3 for asset management



PAS 1192

- EIR – employer information requirements drives the BEP – BIM Execution plan not the other way around
- CDE – Common Data Environment is a Template for common naming conventions and approaches to collaborative working for use in architecture, engineering and construction. It also facilitates efficient data use in facilities management.
- Method for the development, organization and management of production information for the construction industry, using a disciplined process for collaboration and a specified naming policy.



PAS 1192

BIM mandate passed to "encourage the greater adoption of BIM within the UK domestic construction sector, to significantly improve sector productivity and to deliver benefits shareable between clients and their supply chains. A key element in supporting this ambition was to establish a partnership programme between government and industry to develop a comprehensive suite of 'enabling' standards and supporting documentation on which universal adoption could be based."

name :

project originator volume level type role number

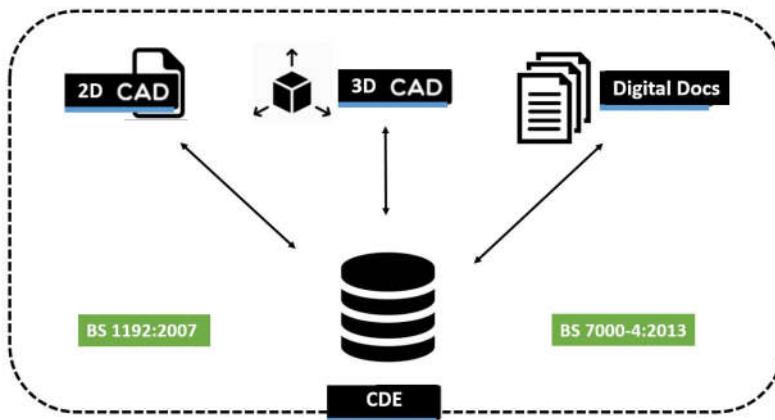
ABCDE - BBA - 00 - XX - DR - A - 0000

status : suitability description :

S2 **SUITABLE FOR INFORMATION**

revision : revision description :

P01 **PRELIMINARY**



NBS BIM CONTENT STANDARD

- NBS Standards for writing to objects in a BIM platform
- Specified for UK level 2 (PAS-1192) standards

NBS BIM OBJECT STANDARD



To be useful
objects need to
behave

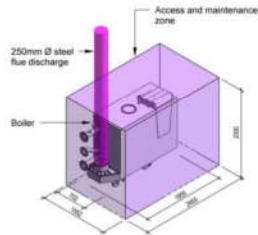
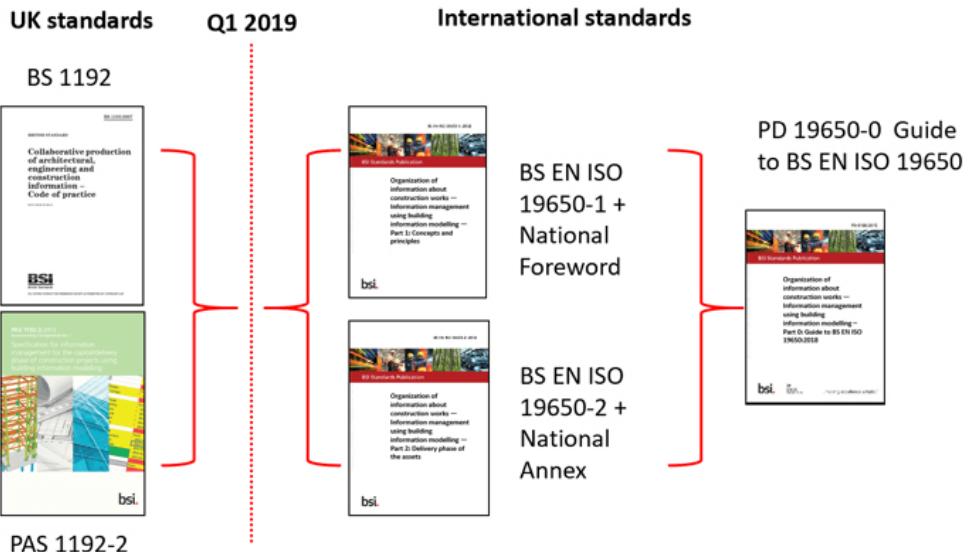


Table 4 - COBie Component Properties

Property name	Property requirements	Data type	Example
AssetIdentifier	An alphanumeric default value 'n/a'.	Alphanumeric	n/a
Barcode	An alphanumeric default value 'n/a'.	Alphanumeric	n/a
InstallationDate	The default value '1900-12-31T23:59:59'.	Alphanumeric	1900-12-31T23:59:59
SerialNumber	An alphanumeric default value 'n/a'.	Alphanumeric	n/a
TagNumber	An alphanumeric default value 'n/a'.	Alphanumeric	n/a
WarrantyStartDate	The default value '1900-12-31T23:59:59'.	Alphanumeric	1900-12-31T23:59:59

PAS into ISO

- BS and PAS 1192 will transition to ISO 19650 series for international quality management of BIM assets
- “BS EN” designation for UK projects
- BS EN ISO 19650-1 will replace BS 1192 for concept models
- BS EN ISO 19650-2 will Replace PAS 1192 for delivery assets
- All UK BIM Alliance efforts will go towards the ISO standards moving forward
- Release of ISO 19650 expected end of 2018



OTHER STANDARDS

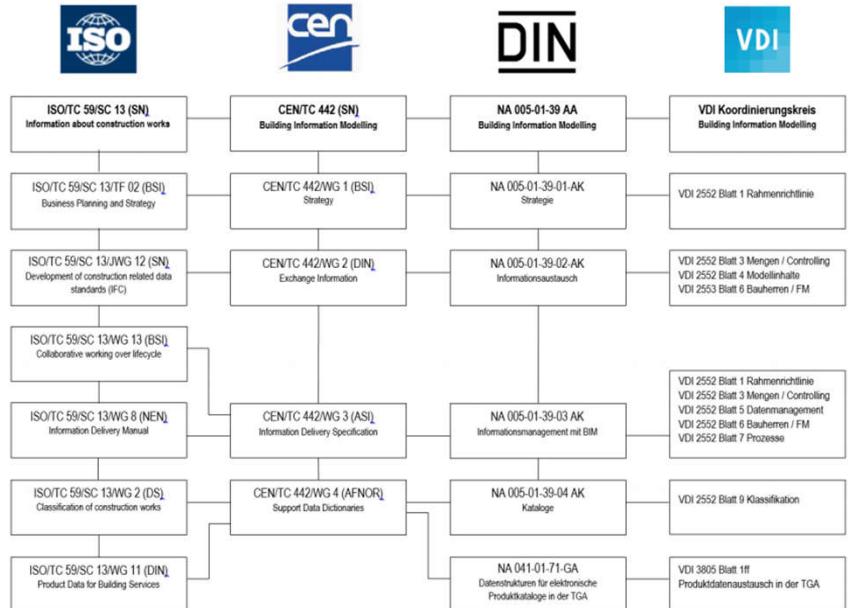
- VDI BIM guidelines in Germany
- DIN BIM guidelines in Germany
- CEN/TC 442 for EU BIM models
- Everything is being aligned to ISO



ISO 16739 ed.2

EN ISO 16739 ed.2

DIN EN ISO 16739 ed.2



CSI 50 MASTERFORMAT

- Construction Specifications Institute
- Organize specifications
- MasterFormat divisions and section numbers
- Hand in hand with Uniformat in North American specifications
- Oversees Omniclass

00 00 00	CSI Master Format
00 10 00	Procurement and Contracting Requirements
00 11 00	Solicitation
00 11 13	Advertisement and Invitations
00 11 16	Advertisement for Bid
00 11 19	Invitation to Bid
00 11 53	Request for Proposal
00 20 00	Request for Qualifications
00 21 13	Instructions for Procurement
00 24 13	Instruction to Bidders
00 24 13.13	Scope of Bids
00 41 00	Scope of Bids (Multiple Contracts)
00 41 14	Bid Forms
00 43 00	Bid Forms - Stipulated Sum (Multiple Prime Contract)
00 45 00	Procurement Form Supplement
00 45 13	Representations and Certifications
00 50 00	Bidders qualifications
00 51 00	Contracting Form and Supplements
	Notice to Award
00 52 00	Agreement Forms
00 52 16	Agreement Forms - Stipulated Sum (Multiple Prime Contract)
00 54 00	Agreement Form Supplements
00 55 00	Notice to Proceed

CLASS COMPARISONS

- Globalization of construction material and products, requires coordination of standards and systems
- Classification systems for specifications, structuring of documents, and cost estimation

ISO 12006-2: 2015	Uniclass 2015	OmniClass 2006-2013
A.2 - Construction Information	FI - Form of Information (Beta)	Table 36 - Information
A.3 - Construction Products	Pr - Products	Table 23 - Products
-	-	Table 41 - Materials
A.4 - Construction Agents	-	Table 33 - Disciplines
-	-	Table 34 - Organizational Roles
A.5 - Construction Aids	TE - Tools and Equipment	Table 35 - Tools
A.6 - Management	Pm - Project Management	Table 32 - Services
A.7 - Construction Process	-	Table 31 - Phases
A.8 - Construction Complexes	Co - Complexes	-
A.9 - Construction Entities	En - Entities	Table 11 - Construction Entities by Function
-	-	Table 12 - Construction Entities by Form
-	Ac - Activities	-
A.10 - Built Spaces	SL - Spaces/Locations	Table 13 - Spaces by Function
-	-	Table 14 - Spaces by Form
A.11 - Construction Elements	EF - Elements/ Functions	Table 21 - Elements (Includes Designed Elements) (Uniformat)
-	Ss - Systems	-
A.12 - Work Results	-	Table 22 - Work Results (MasterFormat)
A.13 - Construction Properties	-	Table 49 - Properties
-	Zz - CAD	-

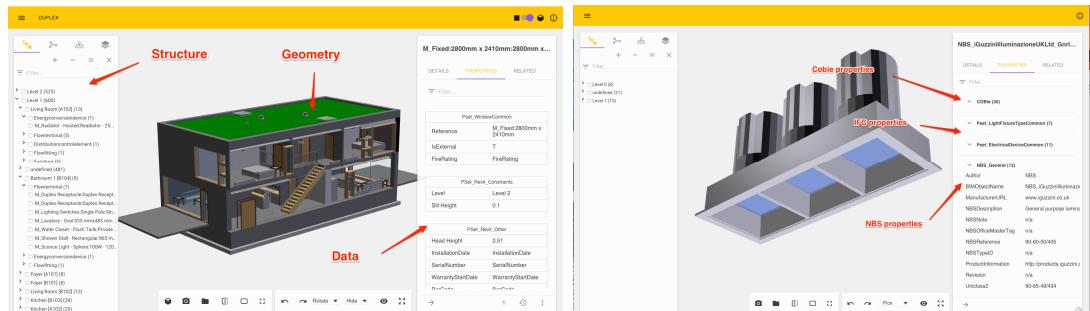
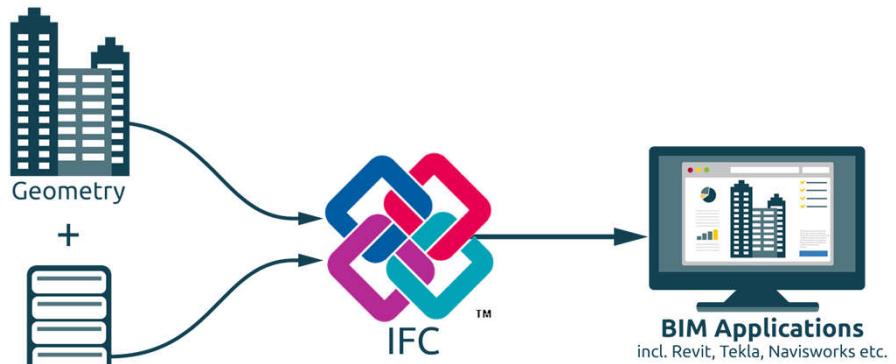
CLASS COMPARISONS

- Globalization of construction material and products, requires coordination of standards and systems
- Classification systems for specifications, structuring of documents, and cost estimation

Classification Systems	OmniClass	MasterFormat	UniFormat	Uniclass
Country of Origin	North America	North America	North America	UK
Produced By	CSI and CSC	CSI and CSC	CSI and CSC	CPIc and NBS
Language	English	English	English	English
Purpose and Properties	Organization, sorting, and retrieval of product information for all objects in the built environment in the project lifecycle.	A master list for organizing construction work results, requirements, products, and activities. Mostly used in bidding and specifications.	For arranging construction information, organized around the physical parts of a facility known as functional elements and mainly used for cost estimates.	For all aspects of the design and construction process. For organizing library materials and structuring product literature and project information.
Framework	ISO 12006-2, ISO 12006-3, MasterFormat, UniFormat, EPIC	Industry practice and gradual development	ISO 12006-2, Professional judgment	ISO 12006-2, SfB, CAWS, EPIC, CESMM
Grouping Principle	faceted	hierarchical	hierarchical	faceted
Organization and Taxonomies	15 inter-related tables categorized by number and name. A combination of Table 21, Table 22, and Table 23 allows for classifying a product precisely.	One table with a series of six numbers and name: Level one with 50 divisions (2004 version) each is made up of level two, level three, and sometimes level four numbers and titles for more detailed areas of work results.	One table with alphanumeric designations and titles in five levels: level one is in nine categories separated by their special function. Level 2 separates them into constituent parts, level 3, 4, and 5 further subdivide them.	The division among facets is based on the alphabet in 11 tables and within each facet by decimal scale up to 6 digits. Table G, J, K, and L can be used for classifying product models.

IFC

- Industry Foundation Classes
- The basic 'operating system' that transports the information and the data.
- ISO 16739
- National Institute of Building Sciences (NIBS)
- IFC are non-proprietary exchange formats so you can share BIM models between different platforms
- Essentially a data exchange format



IFC

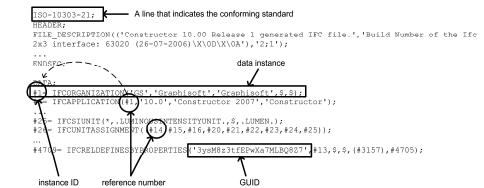
Data Mapping

Rooms (1)	<input type="button" value="New"/>	<input type="button" value="Edit"/>	<input type="button" value="Type"/>
Constraints			
Level	100 Ground Floor		
Upper Limit	100 Ground Floor		
Limit Offset	2400.0000		
Base Offset	0.0000		
Text			
SR_RoomZone			
SR_RoomNumber			
SR_RoomLevel			
Dimensions:			
Area	285.500 m ²		
Perimeter	6680.0000		
Unbounded Height	3400.0000		
Volume	Not Computed		
Computation Height	0.0000		
Identity Data			
Number	20		
Name	Room		
Image			
Comments	Comments		
Occupancy	Occupancy		
Department	Department		
Base Finish	Base Finish		
Ceiling Finish	Ceiling Finish		
Wall Finish	Wall Finish		
Floor Finish	Floor Finish		
Design Option	Main Model		
Phasing			
Phase	New Construction		
FCI Parameters			
#GUID	3u0GTc1v7WfMFCH-IMRanlk		

Space.0.1 - [Room]	
Base Overrides	
Space Boundary Areas	
Relations	Space Boundaries
Identification	Location Quantities Profile
Property	Value
Model	Project12
Discipline	Architectural
Name	Room
Number	20
Type	Room 20
Type Name	
Description	Comments
Occupant	
Layer	A-SL-M_Spaces
System	
Space Group Type	
Interior	True
Geometry	Extrusion
Application	Autodesk Revit 2017 (BIM)
GUID	3ubGTC16-7vNfPMdHRA...
BATID	

Space 0.1 : Room[20]	
Space Boundary Areas	Classification
Relations	Space Boundaries
Identification	Quantities
Location	Profile
<u>BaseQuantities</u>	
Peer_SpaceCommon	
Property	Value
Category	Rooms
CeilingCovering	Ceiling Finish
FloorCovering	Floor Finish
Reference:	Room 20
WallCovering	Wall Finish

Space,0.1:Room[20]					
Space Boundary Areas	Classification	Hyperlinks			
Relations	Space Boundaries				
Identification	Location	Quantities	Profile		
BaseQuantities		Part, SpaceCommon			
Property	Value				
GrossFloorArea	289.59 m ²				
GrossPerimeter	68.80 m				
GrossVolume	695.016.00 m ³				
Height	2.40 m				
NetFloorArea	289.59 m ²				



IFC Parameter Name	Override Shared Parameter
Name	IfcName or NameOverride
LongName	IfcLongName or LongNameOverride
ObjectType	IfcObjectType or ObjectTypeOverride
Description	IfcDescription
Element Tag	IfcTag

IFC

- Classes are industry definitions of geometry and attribute data, enabling a BIM system to reconstitute an object, such as walls, doors and windows, from one system to another despite their many core differences. COBie is based on IFC's definitions, mapping the asset data to its rows and columns.
- Basis is XML with GUID tracking instance IDs

ISO-10303-21; ← A line that indicates the conforming standard

```

HEADER;
FILE_DESCRIPTION(('Constructor 10.00 Release 1 generated IFC file.', 'Build Number of the Ifc
2x3 interface: 63020 (26-07-2006)\X\OD\X\0A'), '2;1');

...
ENDSEC;

#1= IFCORGANIZATION('GS', 'Graphisoft', 'Graphisoft', $, $);
#1= IFCAPPLICATION(#1, '10.0', 'Constructor 2007', 'Constructor');
...
#2= IFCSUNIT(*..LUMINOSITYINTENSITYUNIT., $, LUMEN.);
#2= IFCUNITASSIGNMENT((#14, #15, #16, #20, #21, #22, #23, #24, #25));
...
#4709= IFCRELDEFINESBYPROPERTIES('3y3M8z3tfEPwXa7MLBQ8Z7', #13, $, $(#3157), #4705);

#145= IFCARBITRARYOPENPROFILEDEFI(.CURVE., $, #1144);
#146= IFCAXISPLACEMENTDEFI($, $, $);
#147= IFCSURFACEOFLINEAREXTRUSION(#1145, #146, #9, 2.6);
#148= IFCCONNECTIONSURFACEGEOMETRY(#1347, $);
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#150= IFCARTESIANPOINT((6.3560000000000001,-11.04200000000001));
#151= IFCPOLYLINE((#1149, #150));
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#158= IFCPROPERTYSINGLEVALUE('WallCovering', $, IFLABEL('WallCovering'), $);
#159= IFCPROPERTYSINGLEVALUE('FloorCovering', $, IFLABEL('FloorCovering'), $);
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#161= IFCPROPERTYSINGLEVALUE('Vertical', $, IFLABEL('Vertical'), $);
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#167= IFCPROPERTYSINGLEVALUE('Area', $, IFCAREAMASURE(5.415919401311199), $);
#168= IFCPROPERTYSINGLEVALUE('Perimeter', $, IFLENGTHMEASURE(9.84123152985701), $);
#169= IFCPROPERTYSINGLEVALUE('Compound Height', $, IFLENGTHMEASURE(5.000000000000001), $);
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#172= IFCPROPERTYSINGLEVALUE('Omcilable Table 33 Category', $, IFLABEL('Omcilable'), $);
#173= IFCPROPERTYSINGLEVALUE('CeilingCovering', $, IFLABEL('CeilingCovering'), $);
#174= IFCPROPERTYSINGLEVALUE('FloorCovering', $, IFLABEL('FloorCovering'), $);

```

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#145= IFCARBITRARYOPENPROFILEDEFI(.CURVE., $, #1144);
#146= IFCAXISPLACEMENTDEFI($, $, $);
#147= IFCSURFACEOFLINEAREXTRUSION(#1145, #146, #9, 2.6);
#148= IFCCONNECTIONSURFACEGEOMETRY(#1347, $);
#149= IFCARTESIANPOINT((4.69399999999983,-11.04200000000001));
#150= IFCARTESIANPOINT((6.3560000000000001,-11.04200000000001));
#151= IFCPOLYLINE((#1149, #150));
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#174= IFCPROPERTYSINGLEVALUE('FloorCovering', $, IFLABEL('FloorCovering'), $);

```

ISO-IFC Alignments

- ISO will align all the standards into one system
- IFC4 Will take over from existing IFC formats
- Between ISO Quality Management and IFC information management a true international BIM exchange and management format is possible

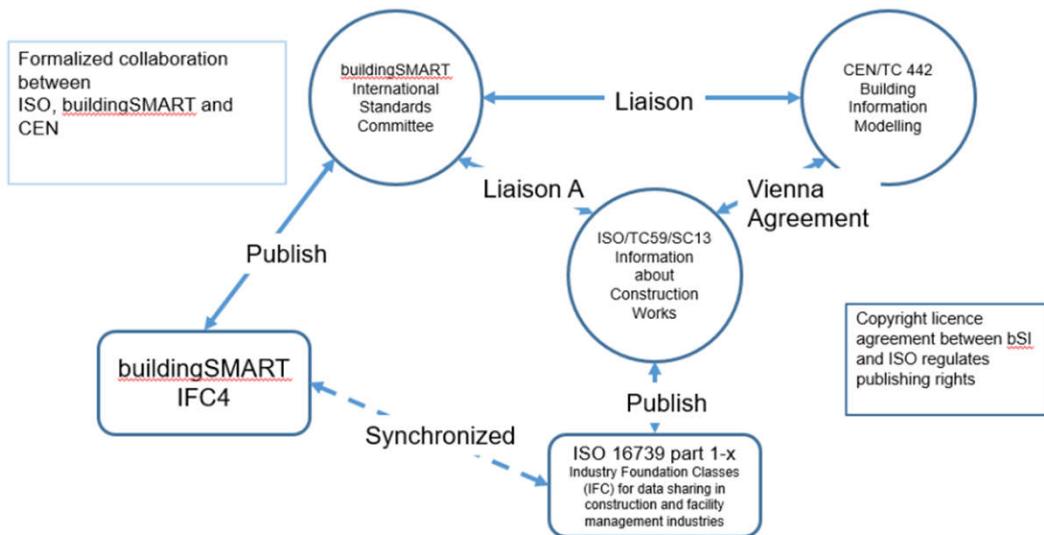
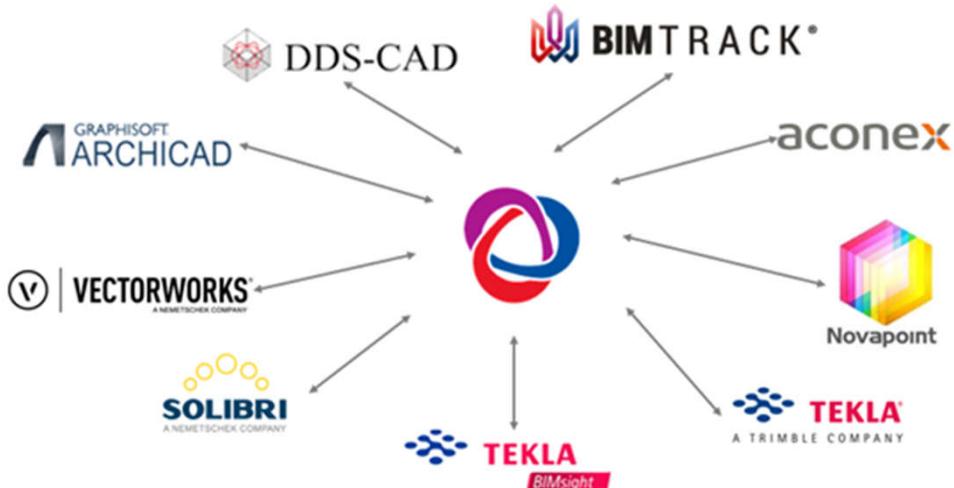


Figure 7: IFC development coordination

BCF

- BIM Collaboration format
- In 2010, Tekla and Solibri came up with an initial XML schema, called "bcfXML v1", to encode messages containing BIM-topics
- buildingSMART standard
- Keeps record of changes in a BIM project in XML format with additional comments and model content during collaboration
- IFC can't be edited so this was the solution
- For 3rd party vendors this format will become more useful managing many different BIM formats



COBIE

- Construction-Operations Building information exchange
- Internationally agreed information exchange schema for exchanging facility information between the employer and the supply chain.
- Based on standard ISO: 10303
- National Institute of Building Sciences (NIBS) Facility Maintenance and Operations Committee
- Created by US Army Corps of Engineers
- This code of practice defines expectations for the exchange of information throughout the lifecycle of a Facility.
- Typically looks like a spreadsheet with categorical information in rows and columns

	A Name	B CreatedBy	C CreatedOn	D Category	E sheetName	F rowName	G value	H Unit	I extSystem	J extObject	K extIdentifier	L Description	M allowedValues
1													
8327	Threshold	rich.mitre	2012-12-1	Requirement	Component	Door 2A05	T	n/a	Autodesk	Autodesk	485517	n/a	n/a
8328	DoorFrame	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	ALUMINIU	n/a	Autodesk	Autodesk	485503	n/a	n/a
8329	HardwareSet	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	109	n/a	Autodesk	Autodesk	485511	n/a	n/a
8330	WeatherStripping	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	n/a	n/a	Autodesk	Autodesk	485505	n/a	n/a
8331	JambNumber	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	J11, J10	n/a	Autodesk	Autodesk	485513	n/a	n/a
8332	SoundProof	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	n/a	n/a	Autodesk	Autodesk	485507	n/a	n/a
8333	DoorThickness	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	45 mm	n/a	Autodesk	Autodesk	485501	n/a	n/a
8334	DoorWidth	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	915 mm	n/a	Autodesk	Autodesk	485497	n/a	n/a
8335	HeadNumber	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	H8	n/a	Autodesk	Autodesk	485515	n/a	n/a

LEVEL OF DEVELOPMENT

- BIM forum specifies the examples for different components during a project lifecycle phases
- Organized by CSI Uniformat 2010
- Determines extent of detail and information in a model and parts of a model
- AIA and other AEC organizations recommend using BIM forum definitions
- In UK referred to as Level of Detail

Milestones shown here are examples only -> Reference to attribute sheets

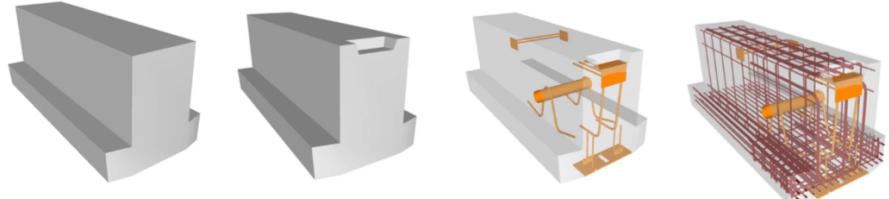
Model elements/ building systems	Relevant Attribute Tables			SD			DD			CD		
	Date	Date	Date	LOD	MEA	Notes	LOD	MEA	Notes	LOD	MEA	Notes
SUBSTRUCTURE												
Foundations												
Standard Foundations												
Wall Foundations												
Column Foundations												
Standard Foundation Supplementary Components												
Special Foundations												
Driven Piles												
Bored Piles												
Caissons												
Special Foundation Walls												
Foundation Anchors												
Underpinning												
raft Foundations												
Pile Caps												
Grade Beams												
Subgrade Enclosures												
Walls for Subgrade Enclosures												
Subgrade Enclosure Wall Construction												
subgrade Enclosure Wall Interior Skin												
subgrade Enclosure Wall Supplementary Components												
Slabs-on-Grade												
Standard Slabs-on-Grade												

Standard milestones

Project specific milestones

LOD - Level of Development requirement at this milestone for this element

MEA - Model element; author (responsible for this element at this milestone)



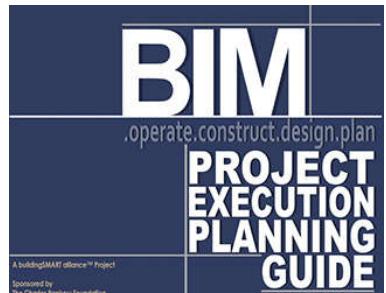


WHAT SHOULD YOU DO?

1. Review Your BIM standards
2. Align definitions and processes to global norms
3. Create templates for models and documents that meet ISO & IFC guidelines
4. Use visual examples and data sets as exhibits

GOVERNING DOCUMENTS

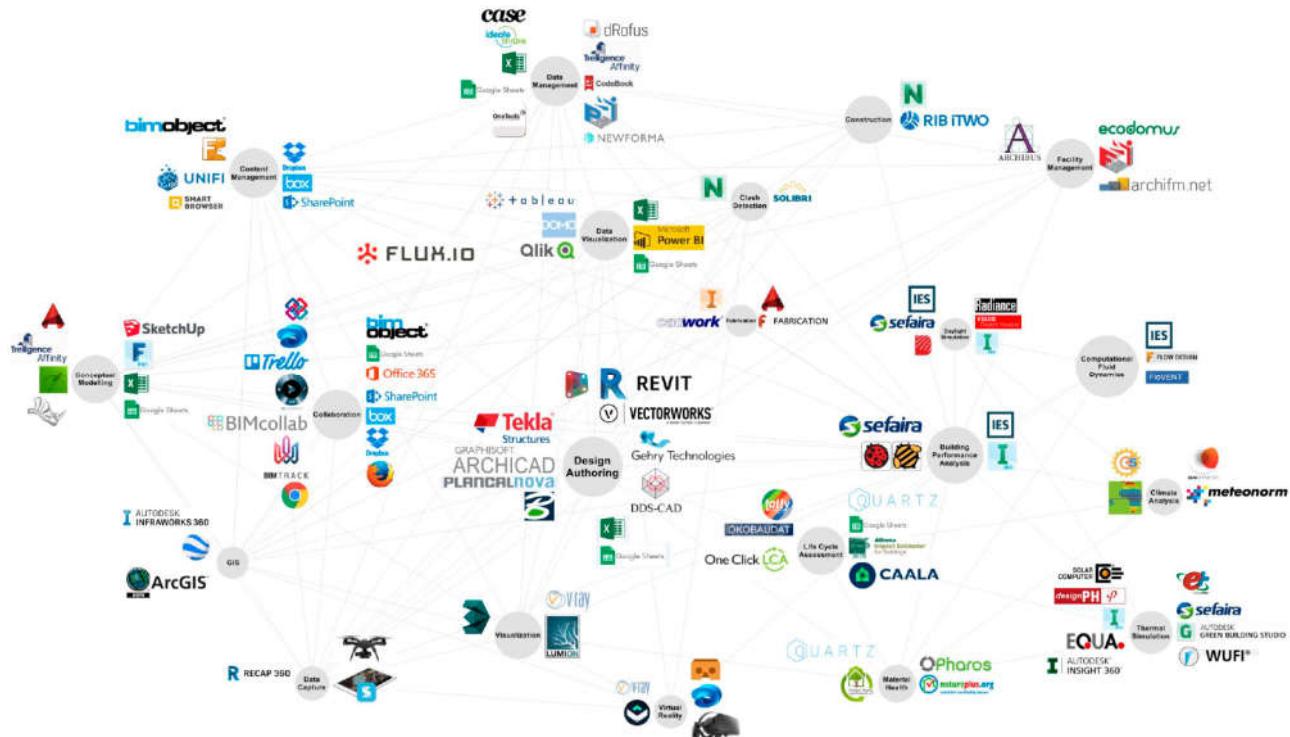
- PAS 1192
- PENN STATE BIM PROJECT PLANNING GUIDE
- CSI 50
- IFC
- NATIONAL BIM GUIDE FOR OWNERS
- BIM FORUM LOD



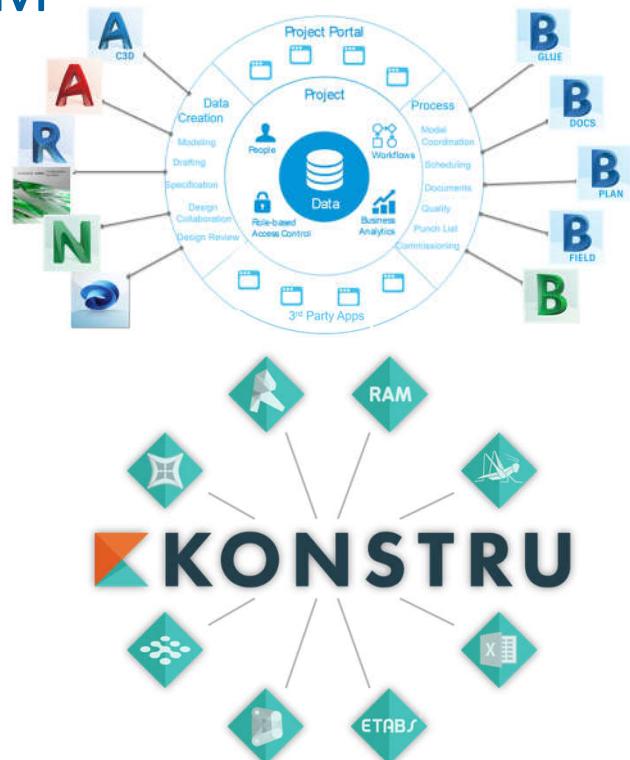
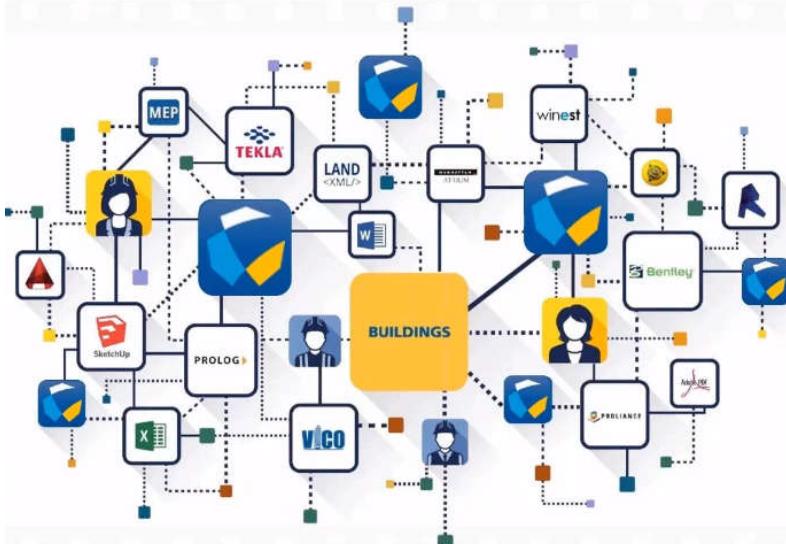
AUTHORING TOOLS



BIM SOFTWARE ECOSYSTEM

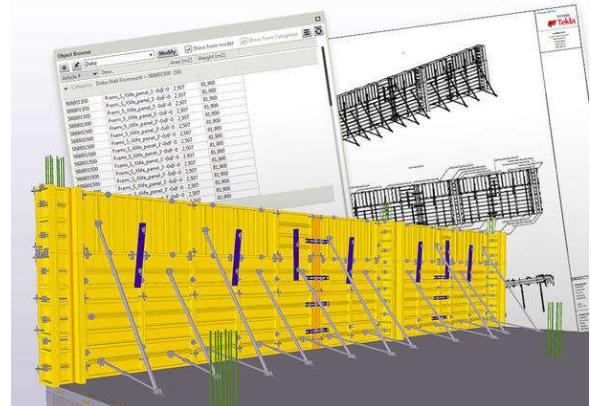
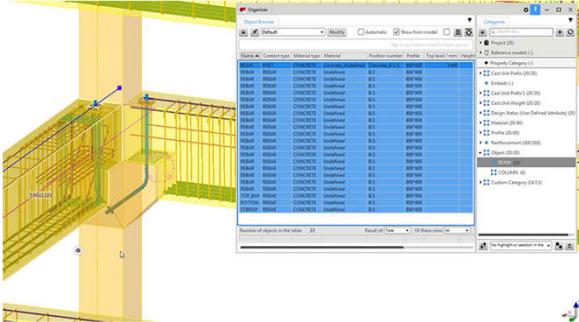
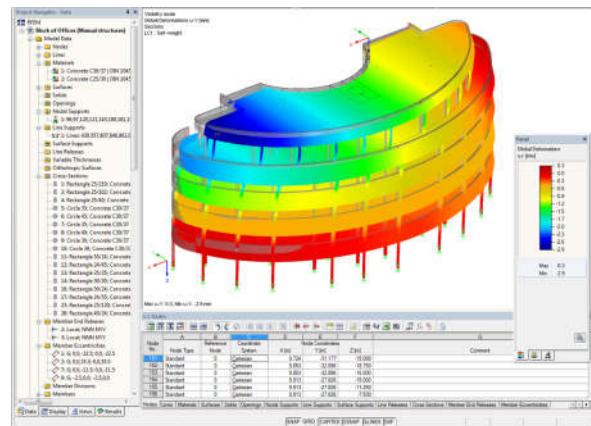
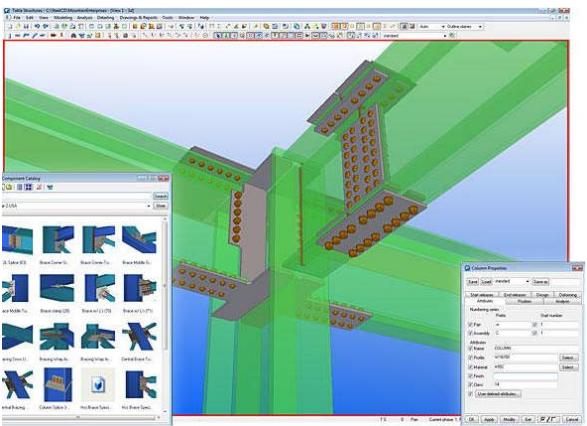


BIM SOFTWARE ECOSYSTEM



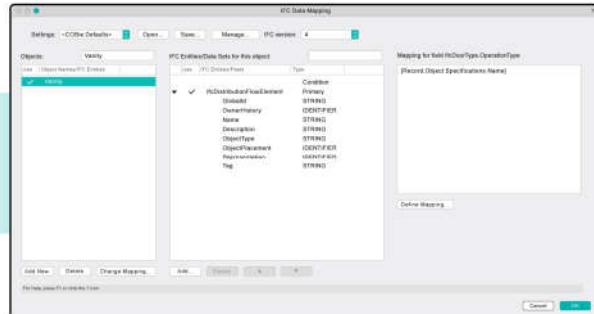
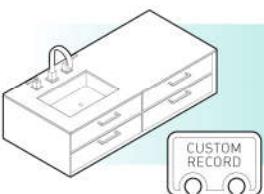
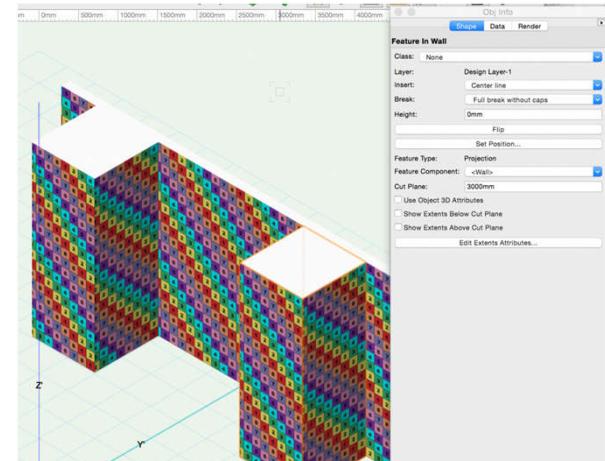
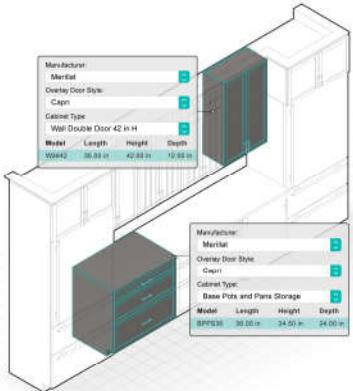
TEKLA

- Tekla can embed a lot of information to each part for estimating and fabrication
 - Schedules, Details, Prints, Analysis and data exchange all possible



VECTORWORKS

- Catalog Components
- Custom IFC export



COBIE

IFC 4

ARCHICAD

- 3D views for IFC components
- Schedules with Cobie content

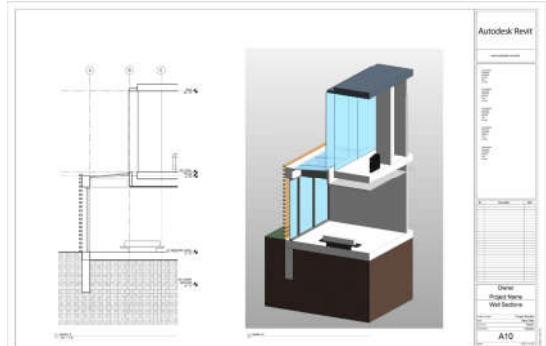
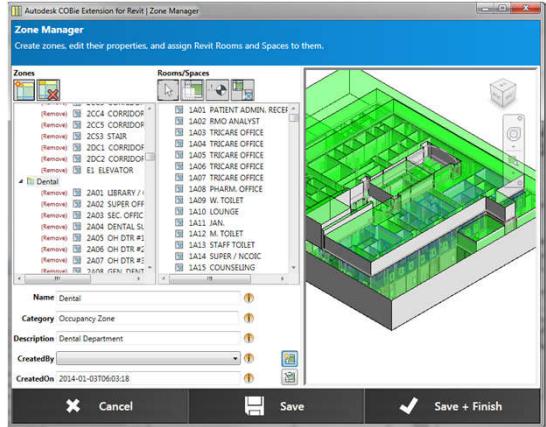
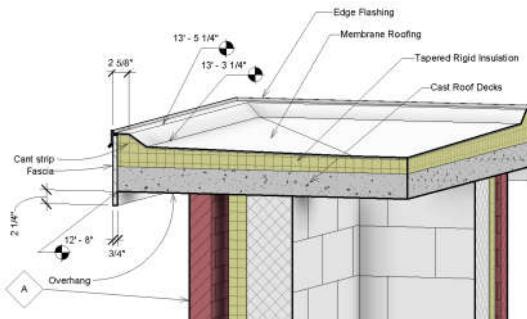
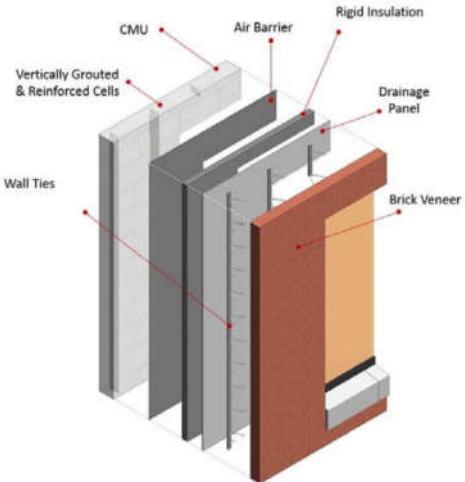


Outputs



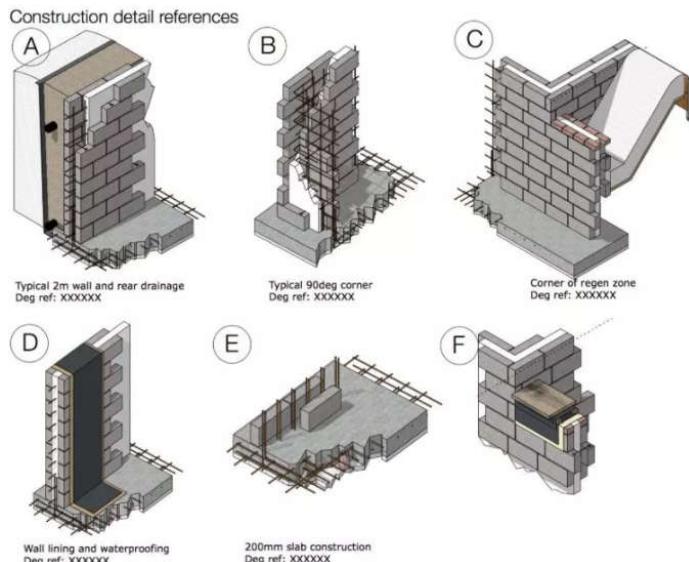
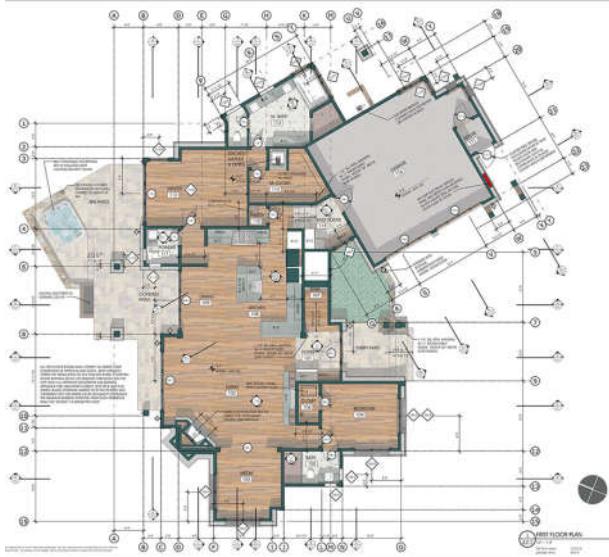
REVIT

- Can export IFC but limited to proprietary formats
- Cobie extension for Revit can export and import data into families and model spaces



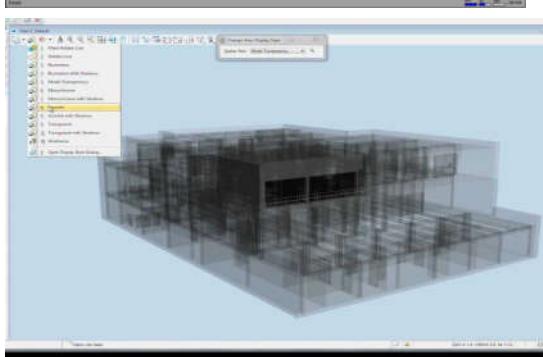
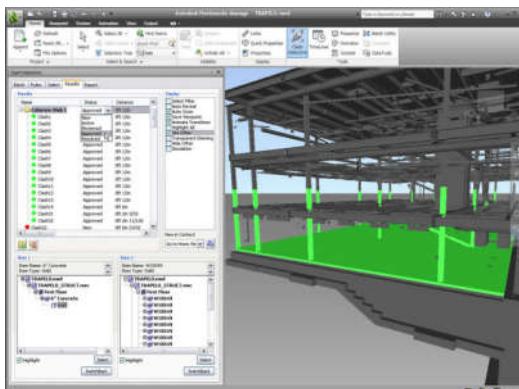
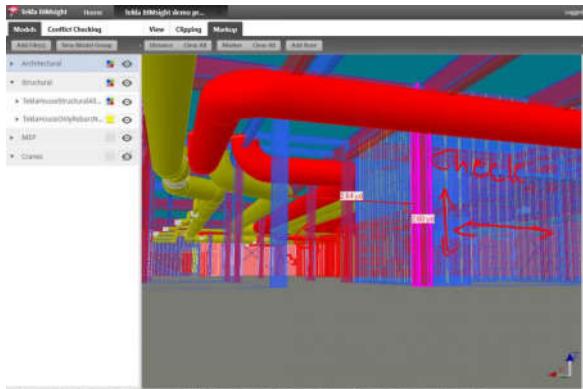
SKETCHUP

- Groups can have information
- Floorplans and details can be drawn



CLASH DETECTION

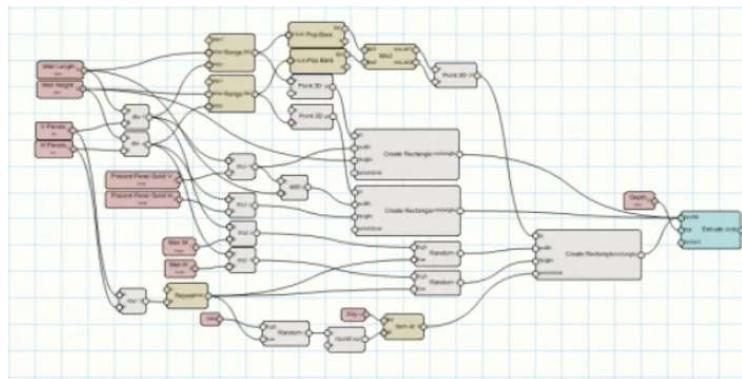
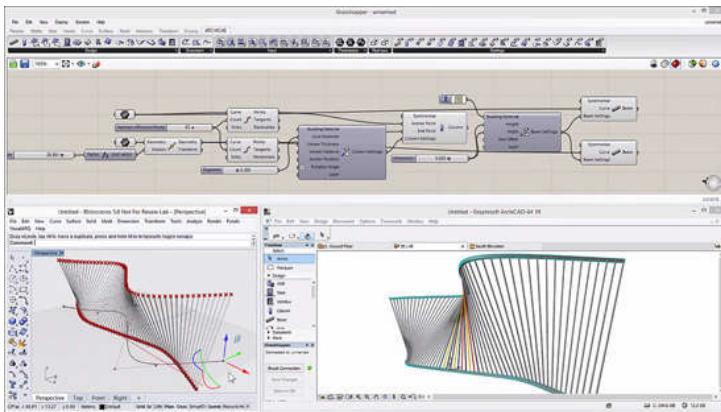
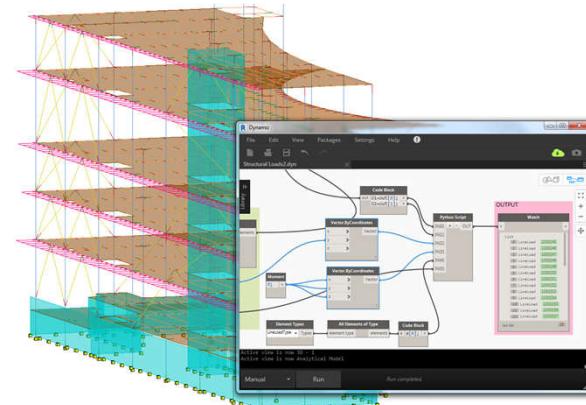
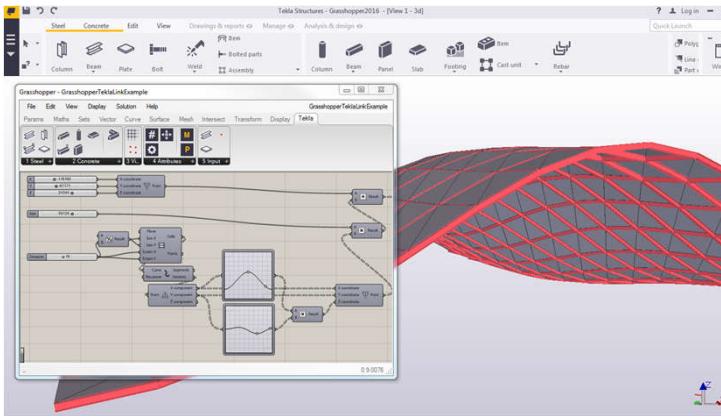
- Combine models and see the problems
- Tekla BIMsight
- Autodesk Navisworks
- Bentley Navigator
- Solibri

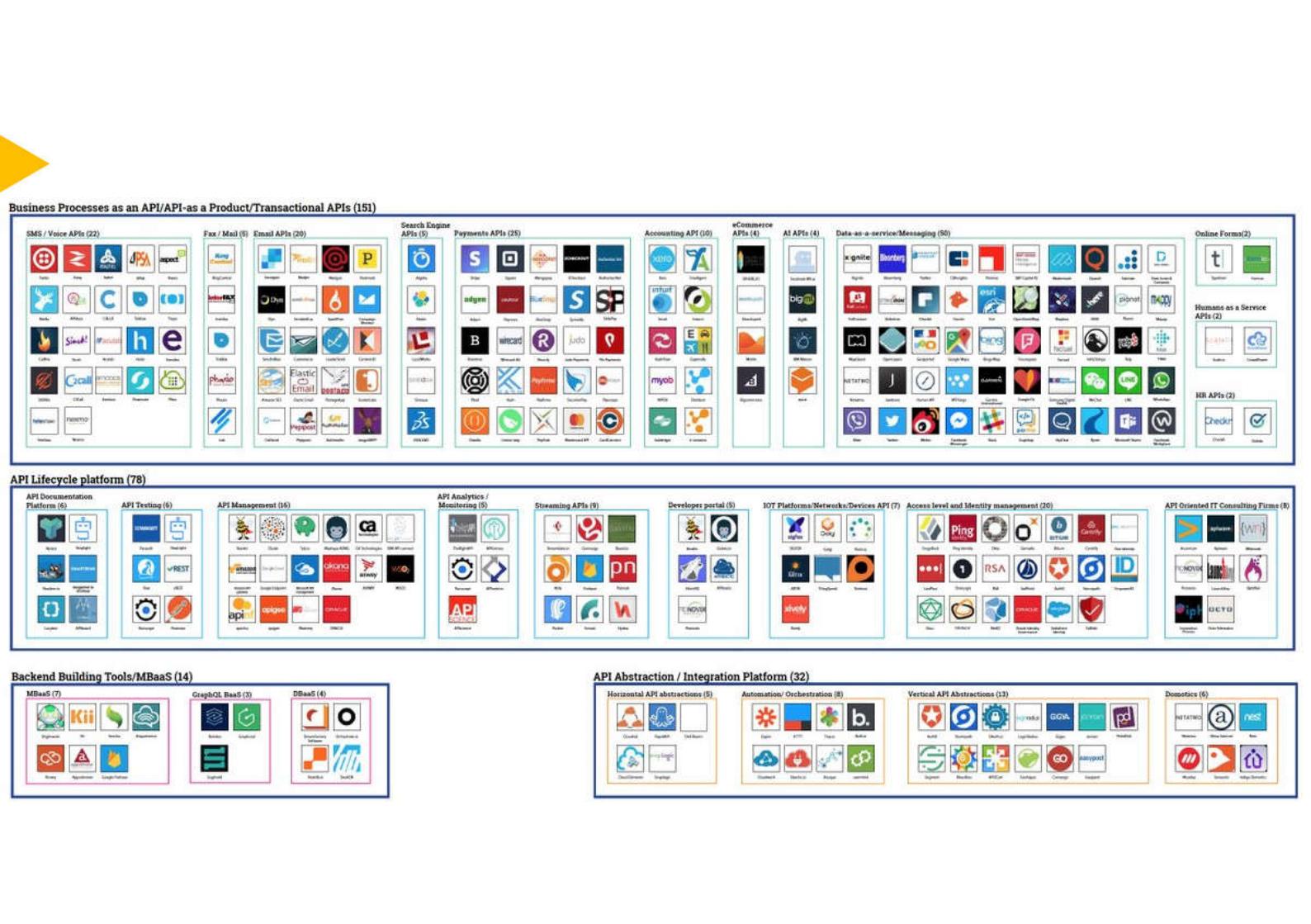




GETTING THE DATA

1. AUTOMATE
2. AUTOMATE
3. AUTOMATE





```
# Create lists to store the matching and unmatching elements.
# The two lists are to match the convention in the FilterByBoolMask node.
matchingElements = []
nonMatchingElements = []

# Iterate through the input Elements to compare the Element's Workset
for elem in elements:
    # A Revit Element within Dynamo is wrapped into a Revit.Elements.Element class
    # that contains the Autodesk.Revit.DB.Element object so we need to use the
    # UnwrapElement method to get the DB element we can actually get properties from.
    rElem = UnwrapElement(elem)

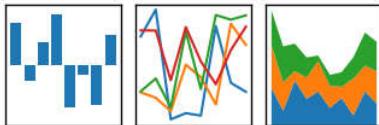
    # Get the WorksetId from the Revit Element's Id property
    wsId = doc.GetWorksetId(rElem.Id)

    # Get the Workset from the WorksetTable using the WorksetId
    workset = worksetTable.GetWorkset(wsId)

    # check the name of the workset against the input name
    if workset.Name == worksetName:
        # Add the wrapped elem to the matching list.
        matchingElements.append(elem)
    else:
        # add the wrapped elem to the non-matching list.
        nonMatchingElements.append(elem)
```

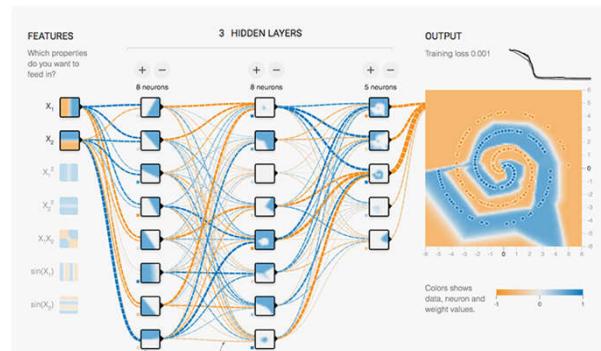
pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$

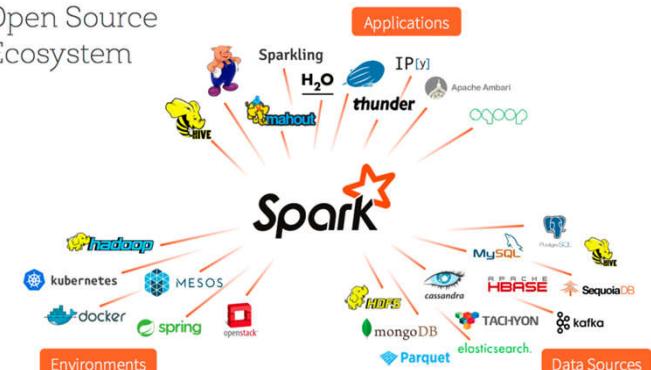


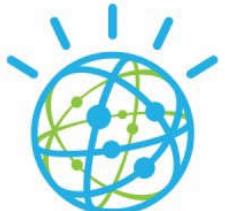
ANACONDA DISTRIBUTION

Python & R distribution with 1000+ curated packages that makes it easy to get started with Data Science



Open Source Ecosystem





IBM **Watson**



Amazon
Machine
Learning



Cloud ML Engine



Azure Machine Learning

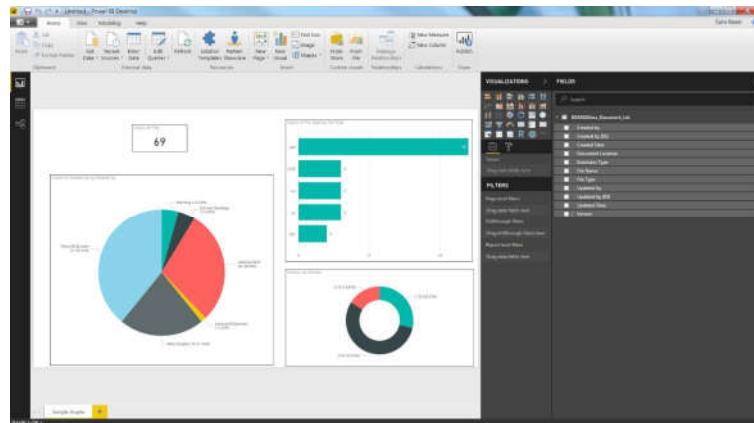


GETTING THE DATA

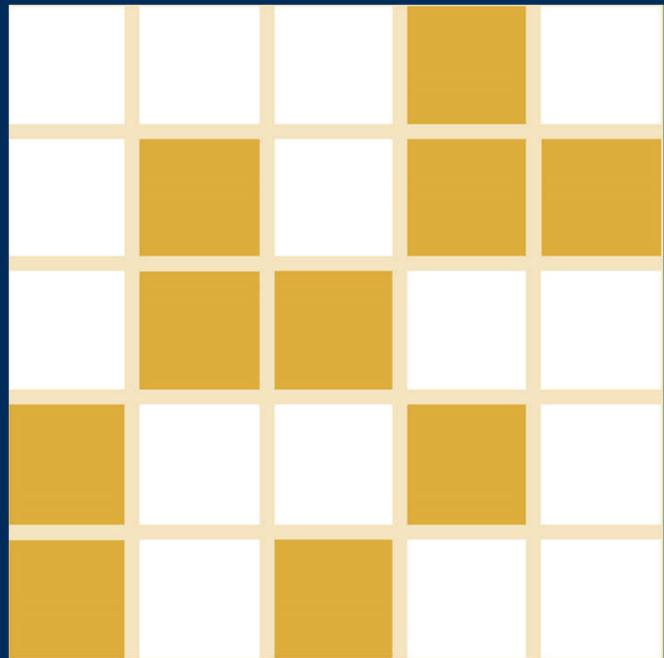
1. CREATE DATA TABLES
2. WRITE TO YOUR MODELS
3. EXPORT YOUR MODEL CONTENT
4. CREATE DATA SETS FOR
STATISTICAL PLATFORMS
5. STUDY INSIGHTS FROM DATA
6. SHARE YOUR INFORMATION

USING THE DATA

- Power BI by Microsoft is a common industry tool
 - Take exported content from your project models and schedules to get analysis and insights
 - Can be shared as dashboards on websites for any device
 - Tableau and SAP are also popular tools for similar analysis



PROJECTS

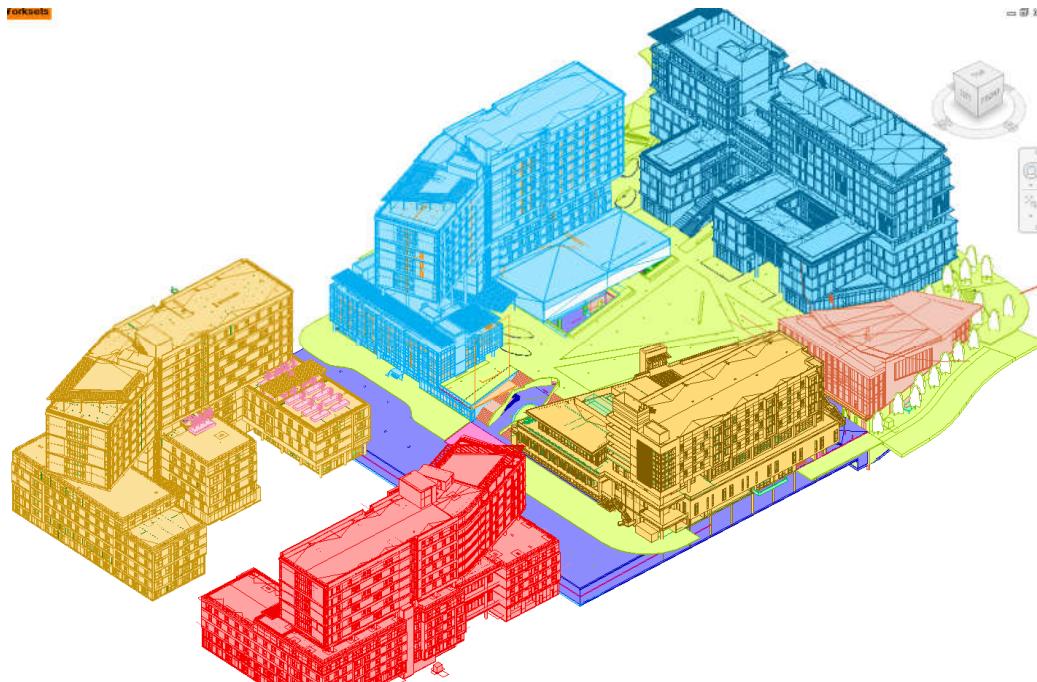


UCSD NORTH TORREY PINES CENTER



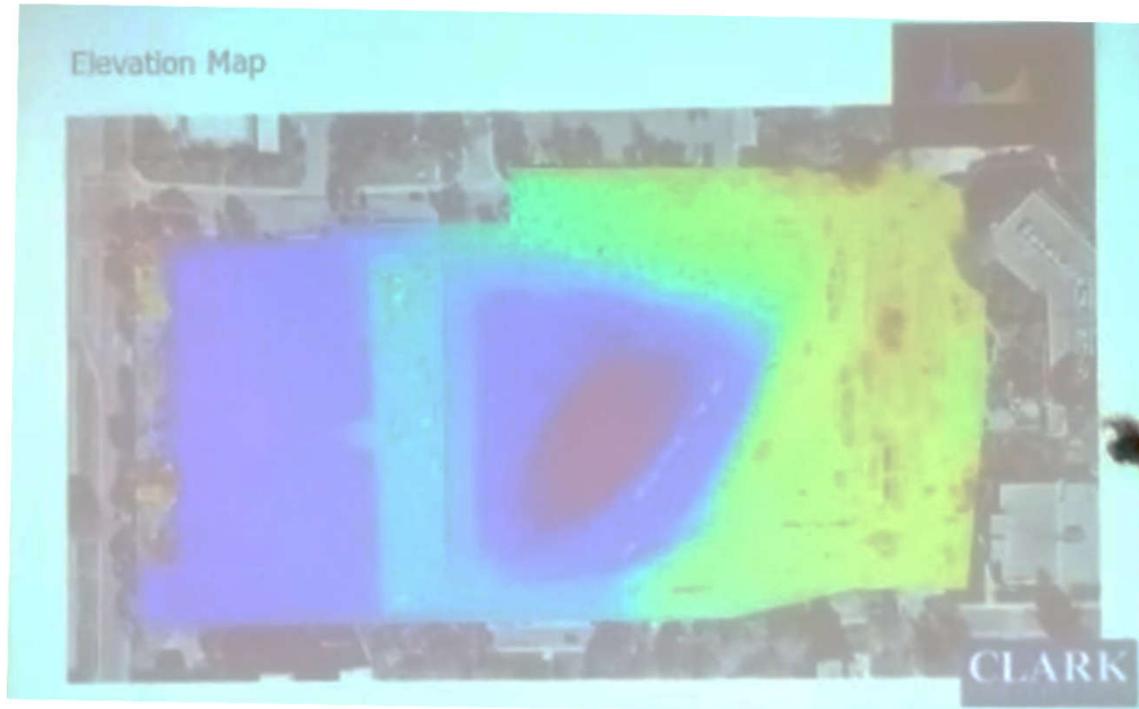
DESIGN

- Design Build Project by HKS and Clark Construction
- 500,000 SF (46,000 SM) project with 6 buildings and a parking structure
- Concept in November 2016
- 100% Construction Documents by June 2018
- Turn key completion by August 2020
- Client pushes to get best practices implemented
- Multiple models (55) live on cloud accessible to anyone on the project team
- Effectively all the data in the project – Plans, details, schedules, parts, counts, etc



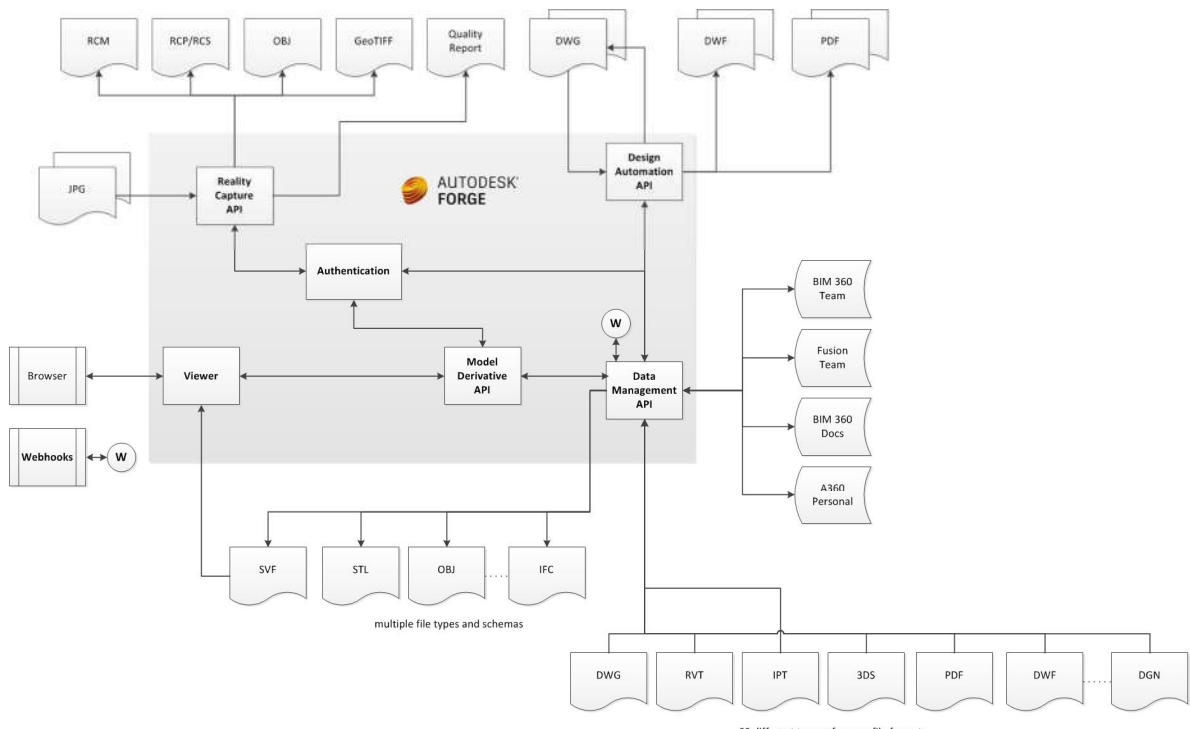
CONSTRUCTION

- Construction site has an Elevation map from Aerial analysis using drones



FACILITY MANAGEMENT

- UCSD Facility Management went from CAD to BIM Life Cycle Management with the Torrey Pines project
- New requirements came onboard during CA phase for a Data Asset BIM model deliverable
- Cobie, Omniclass, Specifications and manufacturer data are requirements for the deliverable
- Entire FM system will be powered by IBM Maximo

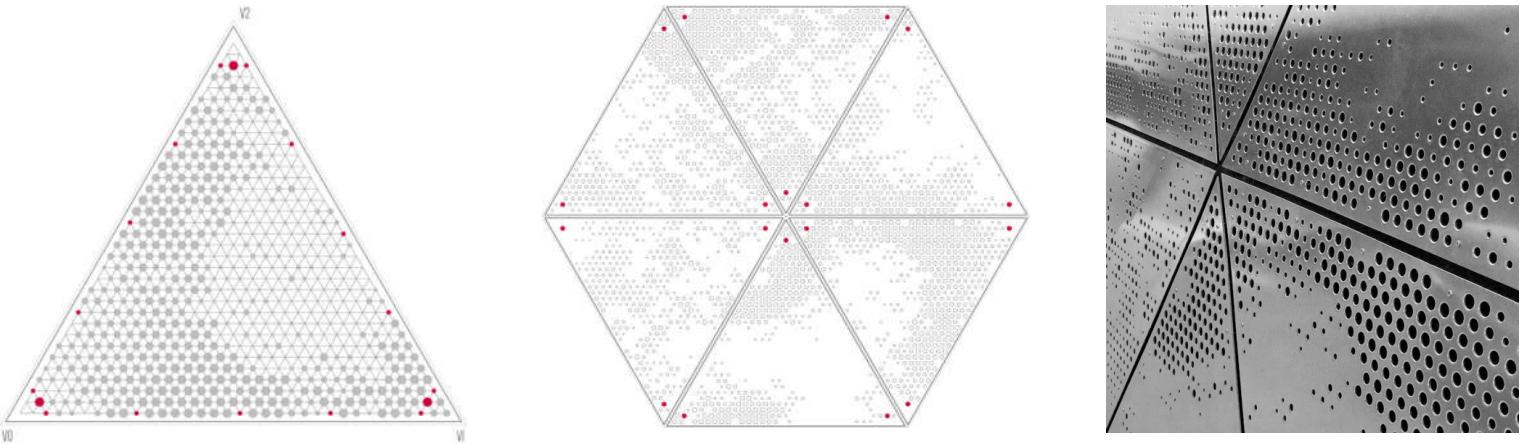


LA STADIUM



- Canopy has 36,000 panels with 20 million perforations punched into them
- Data points from meshes can be exported for fabrication

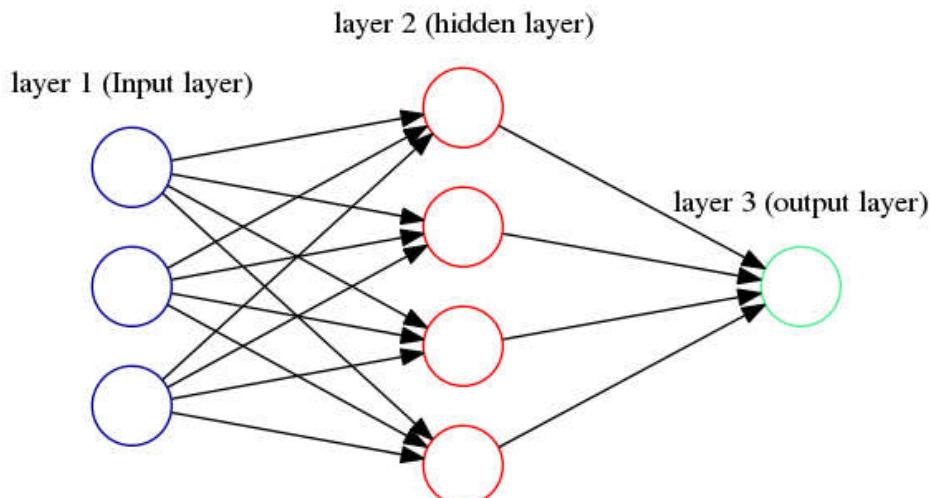
GENETIC ALGORITHMIC DESIGN



- Standardized $\frac{1}{2}$ " circle diameter increments mapped onto a triangle
- Data points from meshes can be exported for fabrication

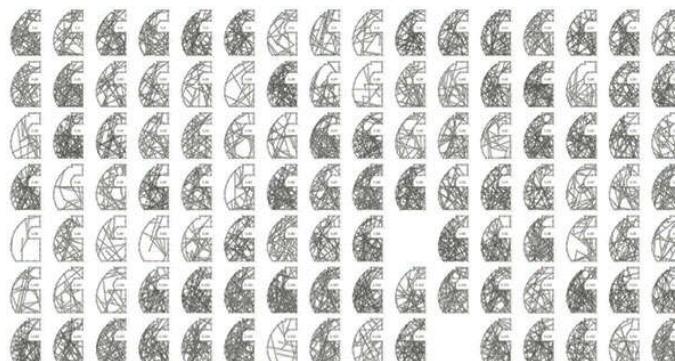
GENERATIVE DESIGN

- Create initial population
- Evaluate Fitness
- Removed unfit
- Reproduce population
- Create next generation and repeat
- Process leads to design optimization from data fed into the layers

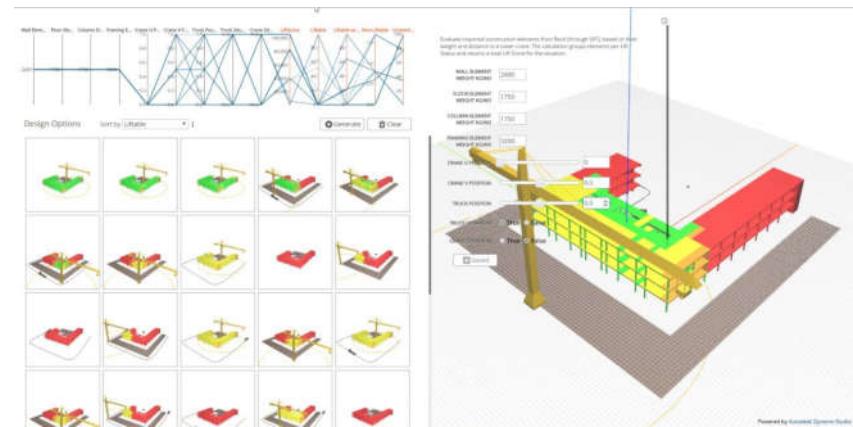
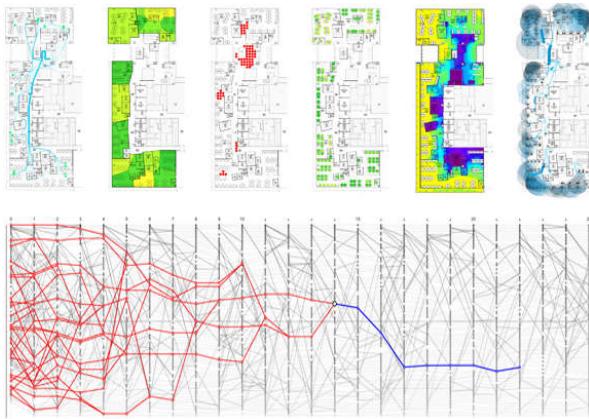


GENERATIVE DESIGN

- Design optimization can begin with using inputs with higher or lower priorities
- Inputs feed into an algorithm displaying multiple scenarios for design configuration
- Based on future choices you can refine the process for results closer to the project requirements
- Automating this process is Machine learning – training a computer program to find patterns and create outcomes you find useful
- Currently we manually do this process which depending on the scenario can take a while and doesn't offer the same level of value or analysis
- Applications can be for design, scheduling, cost estimating, flow analysis - anything requiring choices to be made

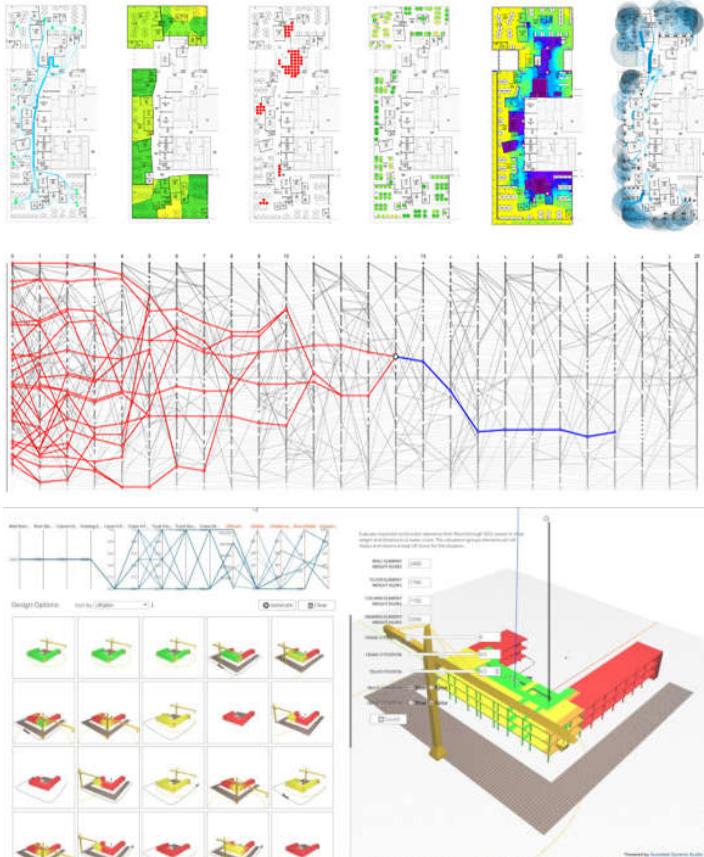
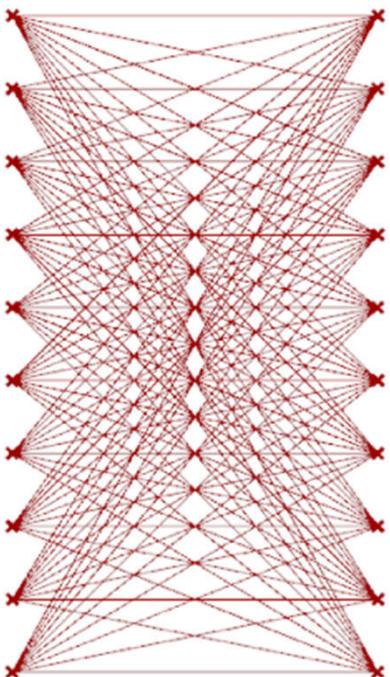


GENERATIVE DESIGN



GENERATIVE DESIGN

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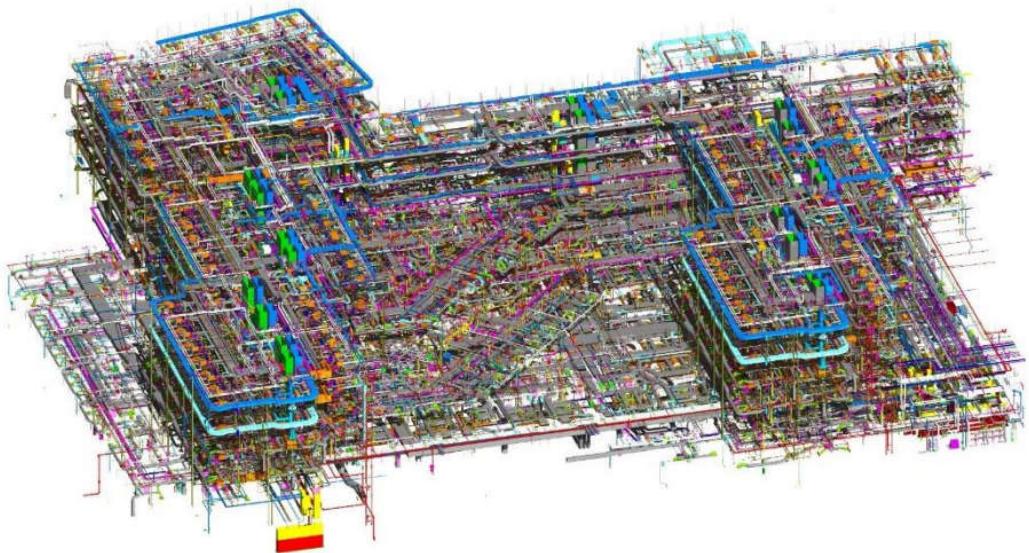


UCSF Mission Bay Master Plan

- Value added Data for large campuses
- 120 buildings and four hospitals
- Integrated project delivery (IPD) approach to the building delivery consolidated by its use of a Building Information Modeling for Facilities Management (BIM4FM) system.
- Designated LOD 400 to 500
- IBM Maximo is a computerized maintenance management system that tracks the work history and the repair history for information surrounding the 60,000 assets
- Large data volumes are shifted for the granular content like life safety systems which are critical to maintain



UCSF Health Precision Cancer Medicine Building



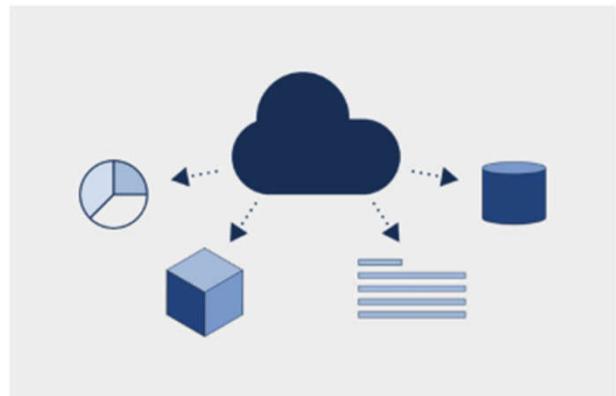
FUTURE

Live Building Catalogues

- Software and consultants from manufacturers with up-to-date information on a given building available from databases

The screenshot shows the Assemble software interface. On the left, there's a sidebar with sections for 'Components' (Architectural and Structure), 'Comparing Models' (listing 'Architecture' and 'Structure' components), and 'Showing Changes' (with checkboxes for 'Added', 'Deleted', 'Changed', 'Type Only', 'Type and Quantity Only', and 'Unchanged'). The main area displays a 3D model of a building structure with various components highlighted in different colors (green, red, yellow, blue). To the right of the 3D model is a table titled 'Comparing Models' with columns for 'Name', 'Model Name', 'Quantity', 'Variance', 'Unit', 'Length (ft)', and 'Variance'. The table lists numerous cabinet components with their respective dimensions and quantities.

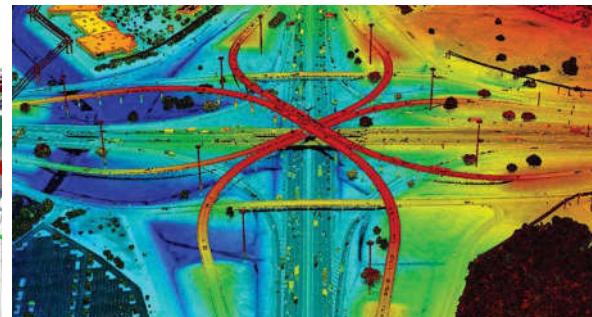
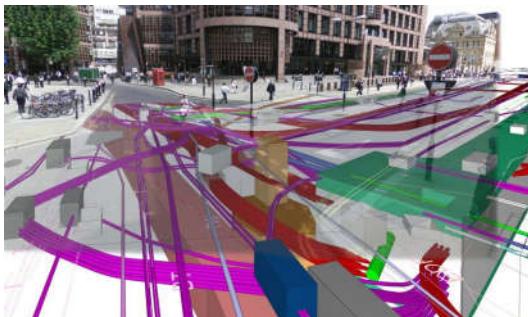
Name	Model Name	A	B	Variance	Unit	A	B	Variance
+	Cabinet C100 - Vanity - Counter Top-Apron	79.39	84.24	(4.85)	sf	25.12	27.10	(1.98)
+	Cabinet C200 - Base Cabinet Open 1 shelf	0	1	(1.00)	ea	0.00	0.00	0.00
+	Cabinet C200 - Base Cabinet Single Door	0	2	(2.00)	ea	0.00	0.00	0.00
+	Cabinet C200 - Base Cabinet Single Draw	12.29	13.21	(0.92)	sf	0.00	0.00	0.00
+	Cabinet C200 - Base Cabinet Single Draw	10.65	13.54	(2.89)	sf	0.00	0.00	0.00
+	Cabinet C200 - Base Cabinet Single Draw	37.21	54.40	(17.19)	sf	0.00	0.00	0.00
+	Cabinet C200 - Counter Top - 24' Depth	103.22	103.48	(0.26)	sf	53.11	53.48	(0.37)
+	Cabinet C200 - Counter Top L-Shaped - 3'x	31.79	30.32	1.47	sf	0.00	0.00	0.00
+	Cabinet C200 - Microwave Cabinet - Micro	30.66	30.66	0.00	sf	0.00	0.00	0.00
+	Cabinet C200 - Upper Cabinet Double Draw	0	1	(1.00)	ea	0.00	0.00	0.00
+	Cabinet C200 - Base Cabinet Double Draw -	0	3	(3.00)	ea	0.00	0.00	0.00



FUTURE

Smart Cities

- Everything in smart city concept has to be catalogued and organized or it won't be very useful
- IOT utilities will make an impact on how cities are planned
- Data –embedded models can help planners and developers make decisions
- Aerial Lidar can fill in the gaps of modeling data



SMART CITIES

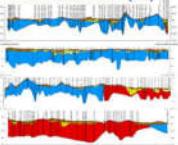
- Singapore's Smart City initiative is a pioneer for others to follow
- Assessing geology, traffic, infrastructure, population dynamics, energy utility monitoring, telecom and other city resources with a single system
- Flow is 'Data River' into a 'Data Lake' which can be used to intelligently assess city-wide planning by government officials



M3: Establishment of 3D Geo-models

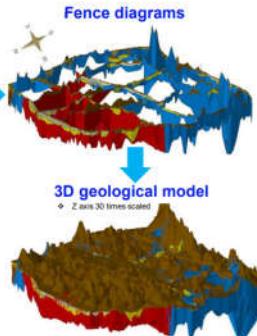
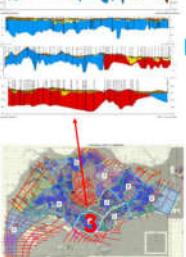
2 Geological modelling-zone 3

Cross-sections (10)



Fence diagrams

3D geological model



TAKEAWAYS



THEMES



METADATA IS
GROWING



OWNERS WANT MORE
OF IT

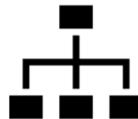


DON'T GET LEFT
BEHIND

AEC INDUSTRY TRENDS



- Construction Technology investment is increasing
- Over \$1 Billion in funding has been allocated to construction startups in 2018 alone
- The largest portion is collaboration software
- Connected devices will increase the requirements of BIM MetaData immensely
- Data Analysis and Content Sharing in AEC will become the norm not the exception



- Clients requiring Metadata as part of the deliverable
- Models reporting more data every year
- Regulating bodies can require projects to be submitted with metadata in the models for compliance review



- Facility management systems will use data in their regular operations
- Insights from the Model data will be used for analytics by building engineers and designers
- All BIM projects will become more integrated by all parties requiring common standards and interoperability workflows from the start

KEYPOINTS – WHERE TO GET STARTED



- Data won't be a writeable content it will become an asset



- Model interoperability will become the norm – no platform is dominant with everyone sharing content consistently



- Solutions will be built within an ecosystem of domain expertise not platform expertise



- Create model templates with parameters writeable to IFC files and other open platforms



- Have your own Roadmap for Data Asset Management and Data Analysis to get the most value out of every project



- Study your data with analytical platforms to get the most value out of your project



- Don't let perfect be the enemy of the good



"Without data
you're just another person
with an opinion."

W. Edwards Deming



*“The best way to predict the future
is to create it”*

— Abraham Lincoln

REFERENCES

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- USIBD - <http://www.usibd.org/>



Trimble

DIMENSIONS