VDC and BIM

The use of Building Information Modeling in Virtual Design and Construction

Presented by Rex Tate

Model management

Part 2

Presented by ***Rex Tate***

Session 2 subjects

- Model management and the AIA G202 BIM protocol
- The concept of “parts”
- The dimensions from 2d to 7d
- Clash detection
- The right of reliance
- Change management and parametric modeling

A review of session 1 subjects

- Brief definitions of VDC and BIM
- What BIM is **not**
- Waste in the construction industry as compared to the manufacturing sector and the reasons for the difference
- Project delivery methods and VDC usage in IDP
- 3d models in the BIM process and LoD (**l**evel **o**f **d**evelopment)

The beginnings of BIM

The first ideas and theory on what would later be called BIM were developed by Charles Eastman at Georgia Tech in the late 1970's

In his papers he used "**Building Product Model**"

The actual term "**Building Information Modeling**" came from Phil Bernstein, an architect and AutoDesk strategist

The first implementation of BIM occurred in 1987

Simulation versus Depiction
5d versus 2d

2d paper plans are depictions

3d models are simulations of the projects

and with time added (5d), the simulations can be animated

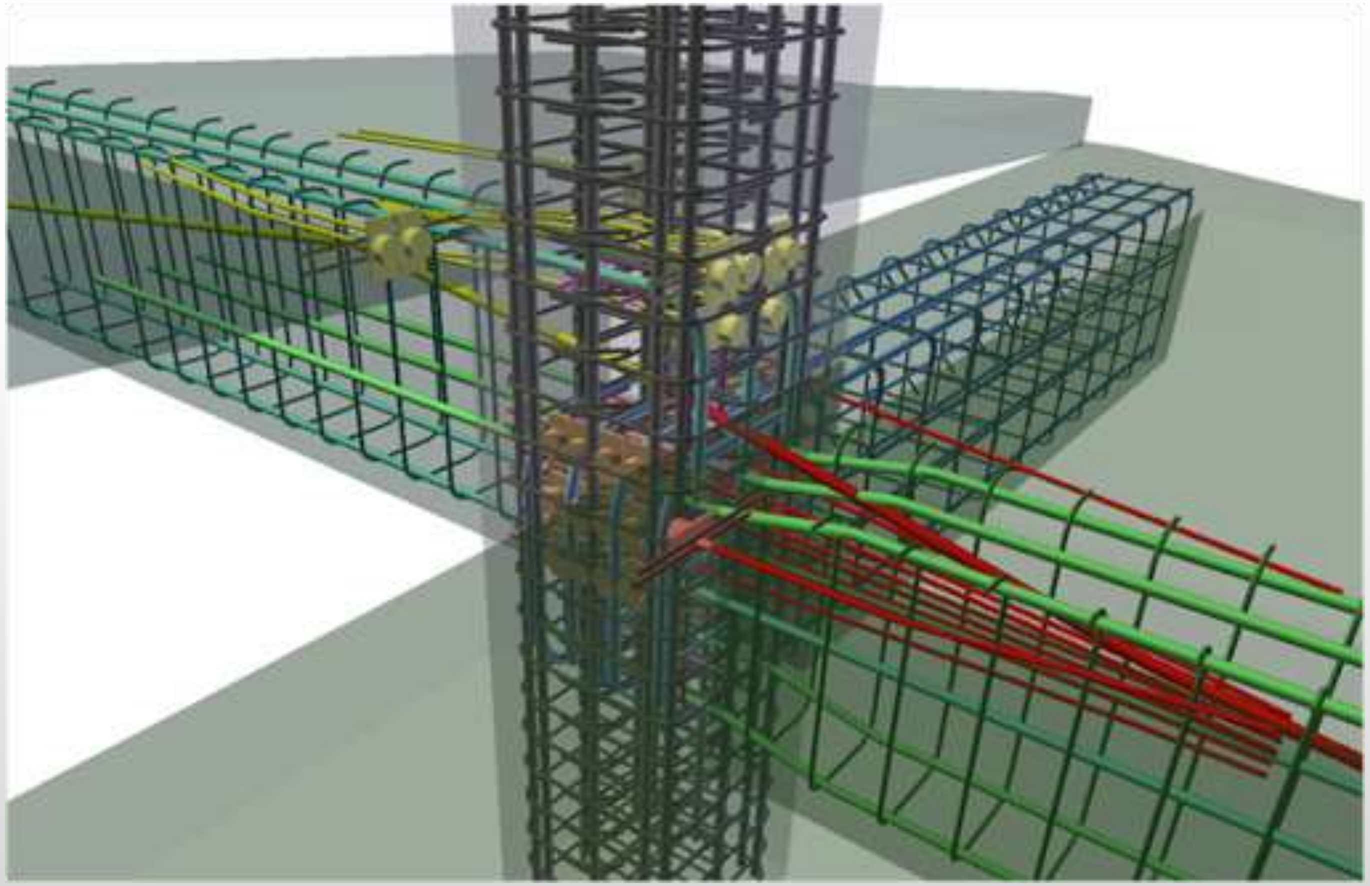
and show the progress and completion of the projects

3d versus 2d

Think about *modeling* versus *drafting*

The interior of concrete beams

Visualizing the reinforcing bars and connections inside
The spacing of the stirrups and the horizontal bar locations



It was the contractors who pushed the use of 3d models This forced changes in the design process

- The growth of BIM is due to the unanticipated strength of interest by building contractors in the use of 3d models in construction
- The contractors immediately understood the power of models
- Architects and other designers have lagged in changing their flows and manners of designing and producing work (models versus drawings)
- Architects have had to develop new ways of thinking about the entire design process in order to work with the contractors' love of models
- Top performing owners now require BIM models from architects
- For architects to remain active and solvent, they must embrace the strange (get into this new stuff **now** or die)

Model objects and the concept of *parts*

- Note that an individual model object isn't just a single construction item. It consists of many *parts*
- Discrete manufacturers and aerospace use extensive parts lists and **Bills of Materials** (BoM) in their industries. AEC does not have an integrated information platform on the level of the manufacturers. This causes inefficiencies, rework and wasted resources at all stages of construction, from pre-design, conceptual planning, erection and installation and all of the way through facility operations and maintenance.
- At Stanford University, we are taking an initial step toward forming an integrated information platform for AEC by developing a formal concept of '**parts**'. Also, be aware that composite materials change the perception of a part.

Model objects and the concept of *parts*

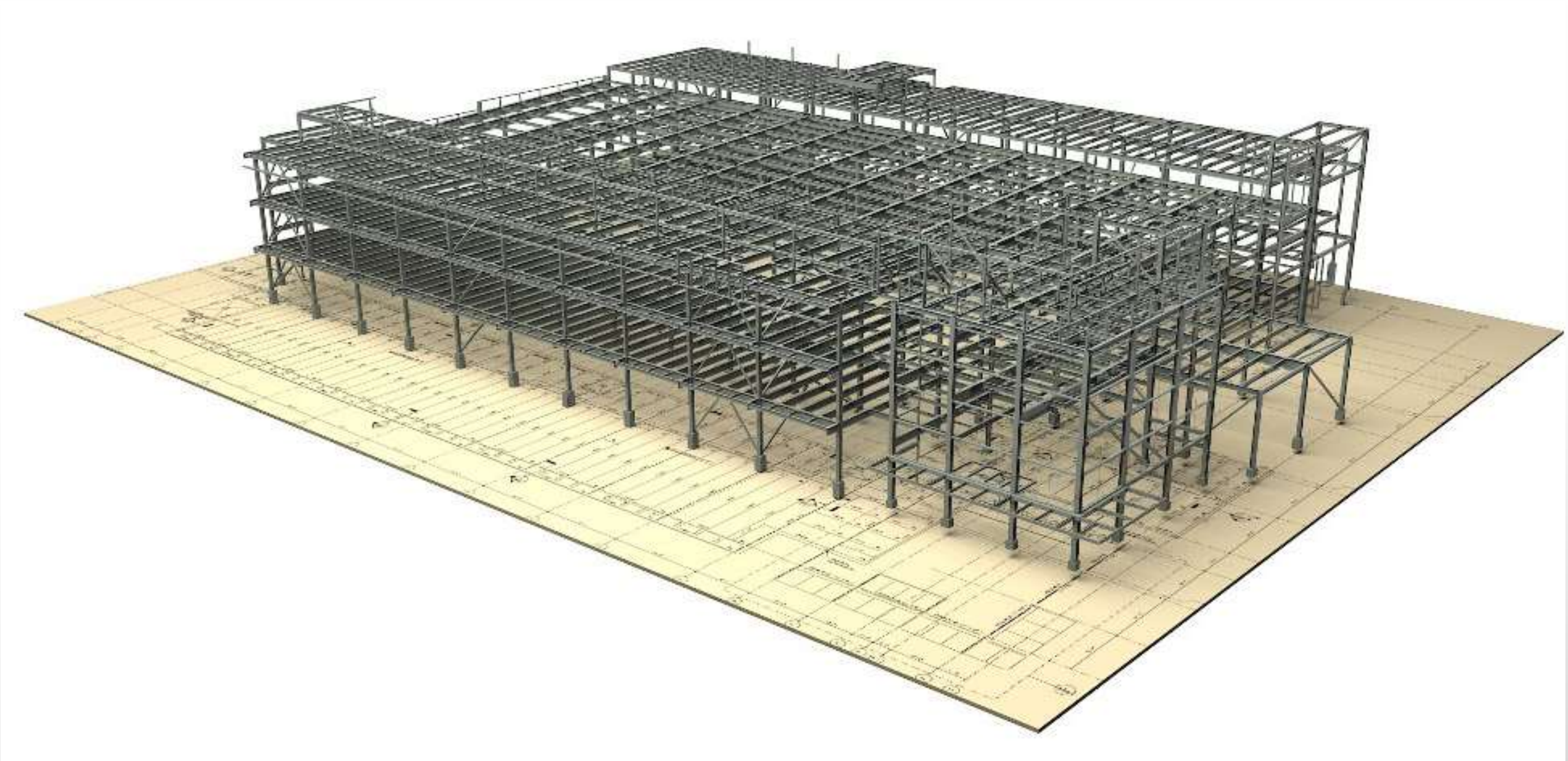
- Exactly what is a ‘part’? How is a ‘part’ defined?

- **A physical entity that is installed <u>on-site</u> by effort in an activity separate from any other item**. Off-site prefabrication reduces the number of parts. Also, the BIM objects in a 3d model are different from the defined ‘parts’. As an example, a construction project’s federated 3d model with 110,000 objects represents 6 million ‘parts’. Knowing the total no. of parts in a project gives you some insight.

- Questions: How is a ‘part’ separate from a ‘component’.
  Is a component made of parts? or is a component a single part?

- Having an integrated information platform for AEC analogous to the manufacturers’ BoM’s will contribute towards the reduction of waste and rework.

Structural



From 2d to 5d and beyond

2D Common, traditional paper drawings (ink, pencil and CAD)

Plans, sections, elevations, details (by hand or computer)

3D Renderings and isometrics on paper, cardboard models, virtual 3D models, all express the 3 physical dimensions

4D The 3 physical dimensions + time

Scheduling, construction sequences, visual construction and animation

5D The 3 physical dimensions + costs

Estimating, accounting

6D The 3 physical dimensions + sustainability

Energy use monitoring and analysis, materials, LEED scoring

7D The 3 physical dimensions + product information

As-builts

A data rich virtual model, for O and M and many additional uses

nD Next ?

Why BIM is so useful in doing the job more efficiently and getting a higher quality building

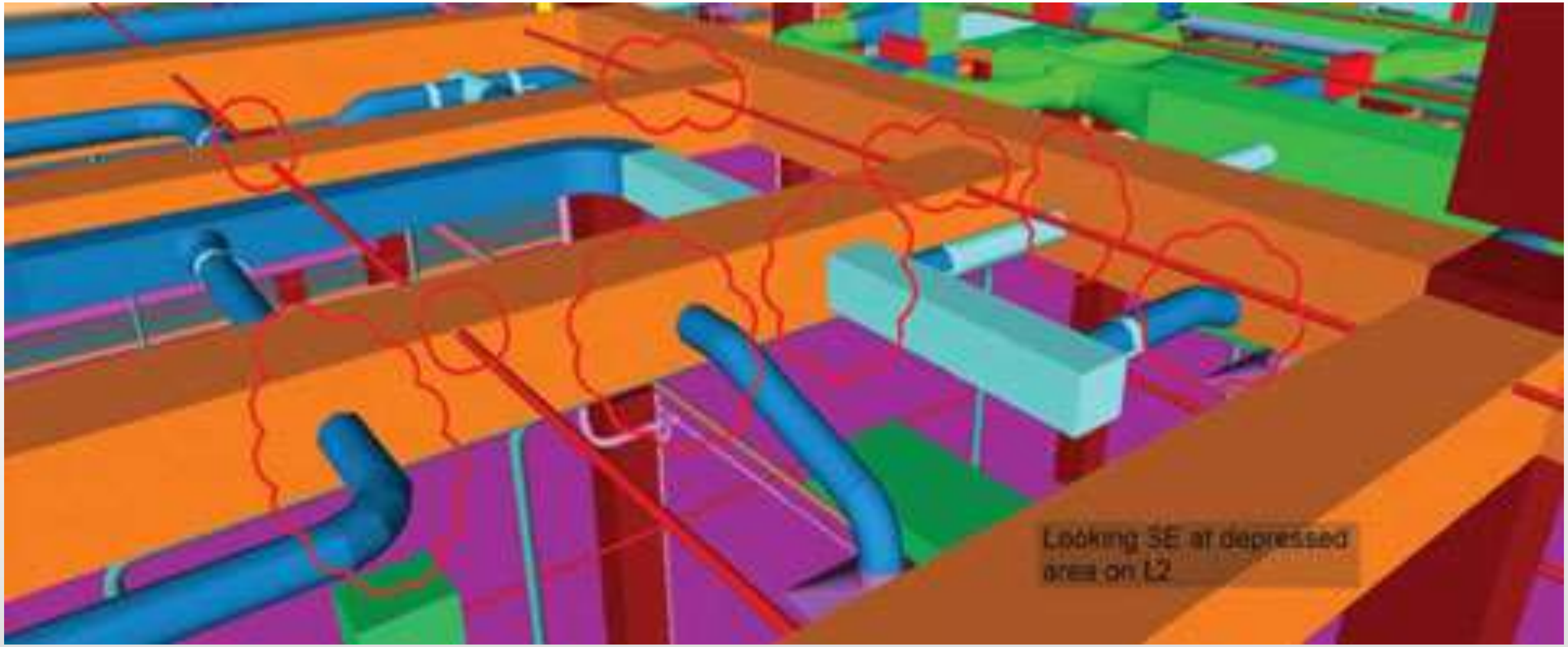
RIB running together

- overall visualization for clarity of intent
- design dissection (pulling apart the model) for review of details
- clash detection
- virtual tours (walk throughs and fly throughs)
- taking the information the last 100 feet to the workmen in the crews
- alternate materials on facades and interiors
- lighting conditions and shadows at different times of day and night
- cost estimating
- scheduling
- marketing and press releases
- product information
- facility operations and maintenance

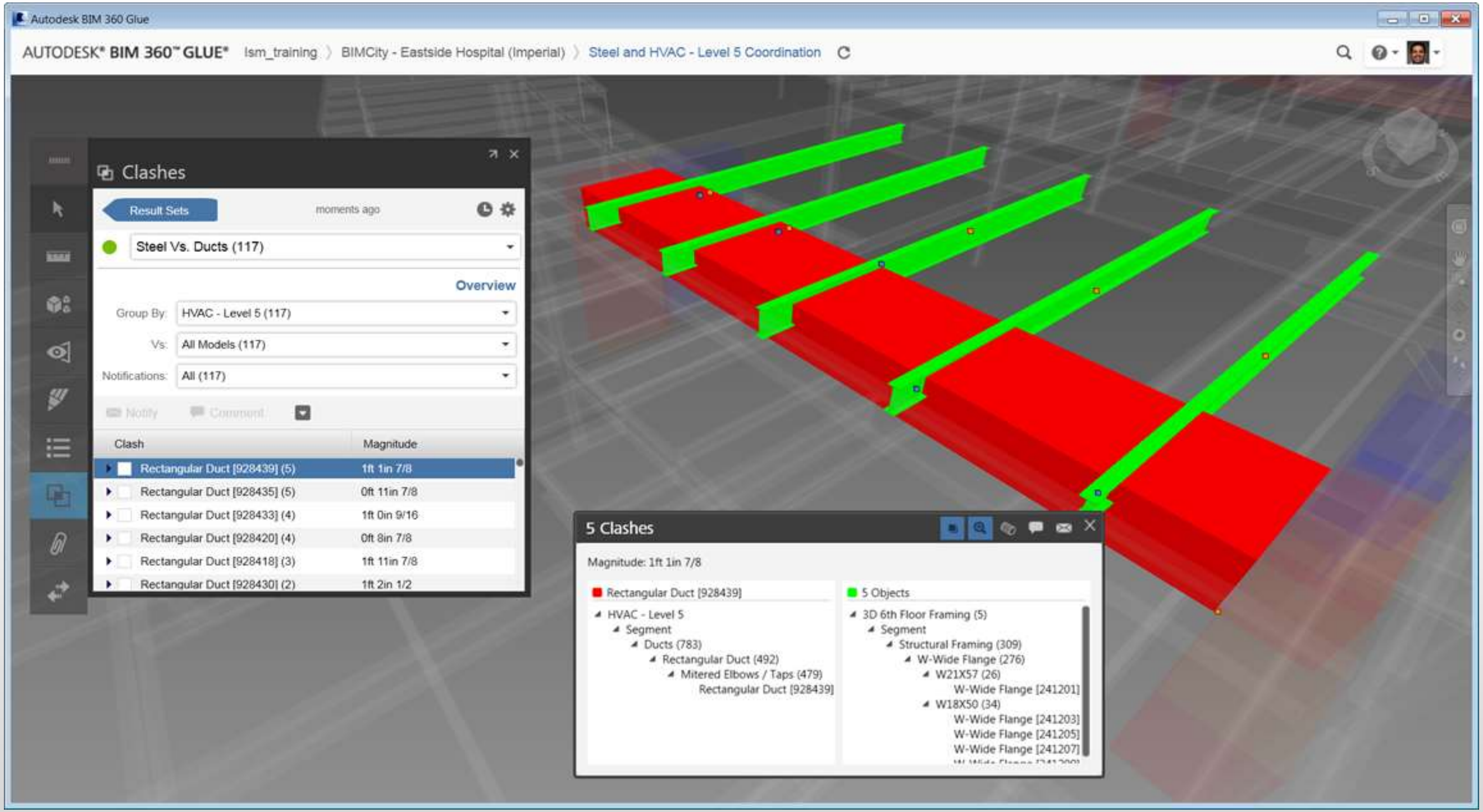
Spatial coordination and clash detection

Many items trying to be in the same place

Many things have to be moved

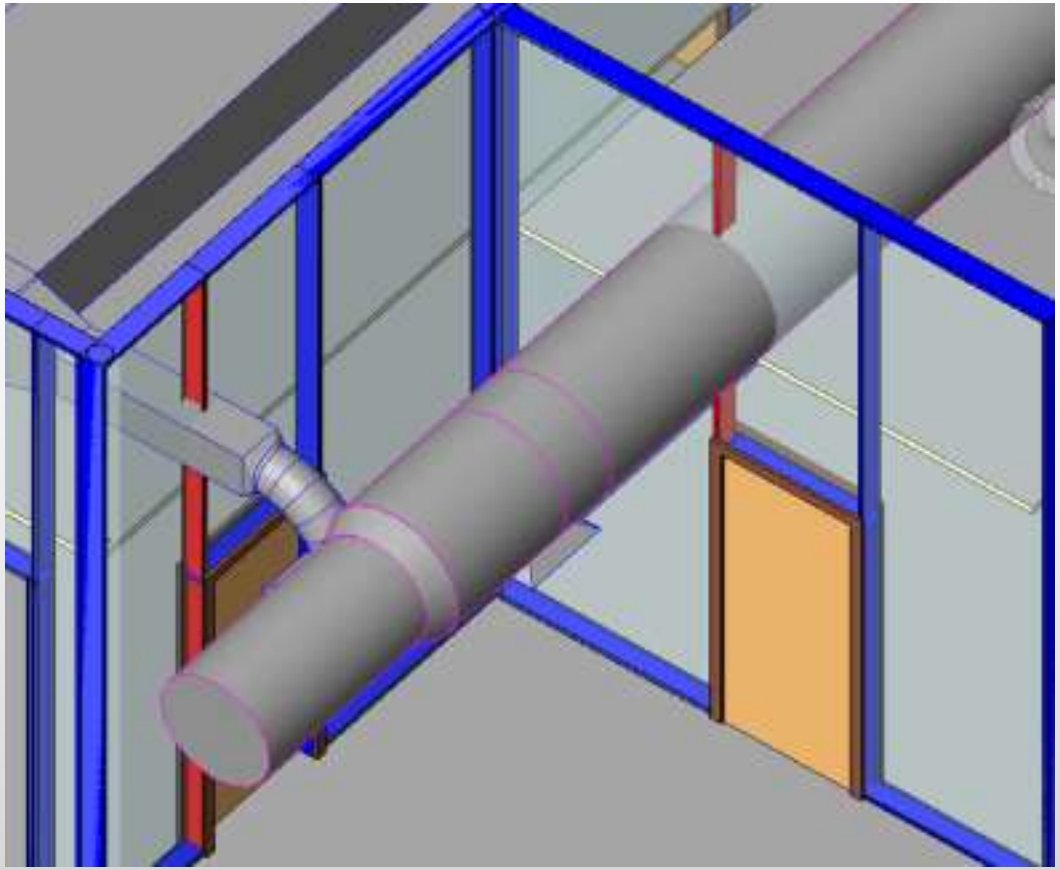


The clash of steel beams and ductwork
Steel wins!   The ductwork has to move   It's redesign time



More clashes

The metal studs are interfering with the ductwork in two places



Clash detection thoughts

Types:

- Geometric clashes between objects
  - Intersection clashes
  - Clearance clashes defined by distance settings
- Crew workspace clashes due to trade stacking by the CPM schedule

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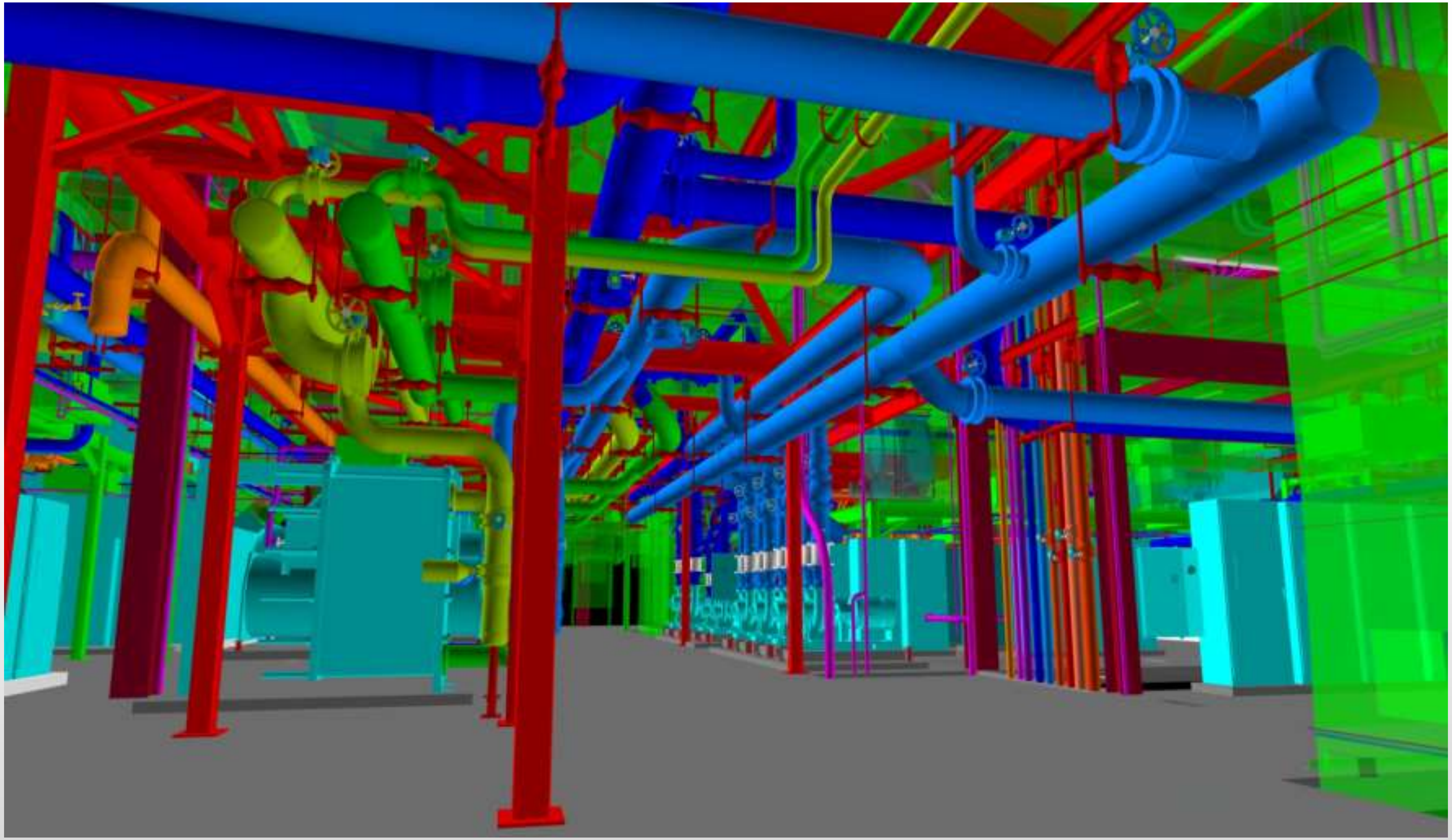
- Reducing false positives by using suppression rules

MEP model objects

At LoD 500, this model is very rich in data

It contains almost everything required for the operations and maintenance of the facility

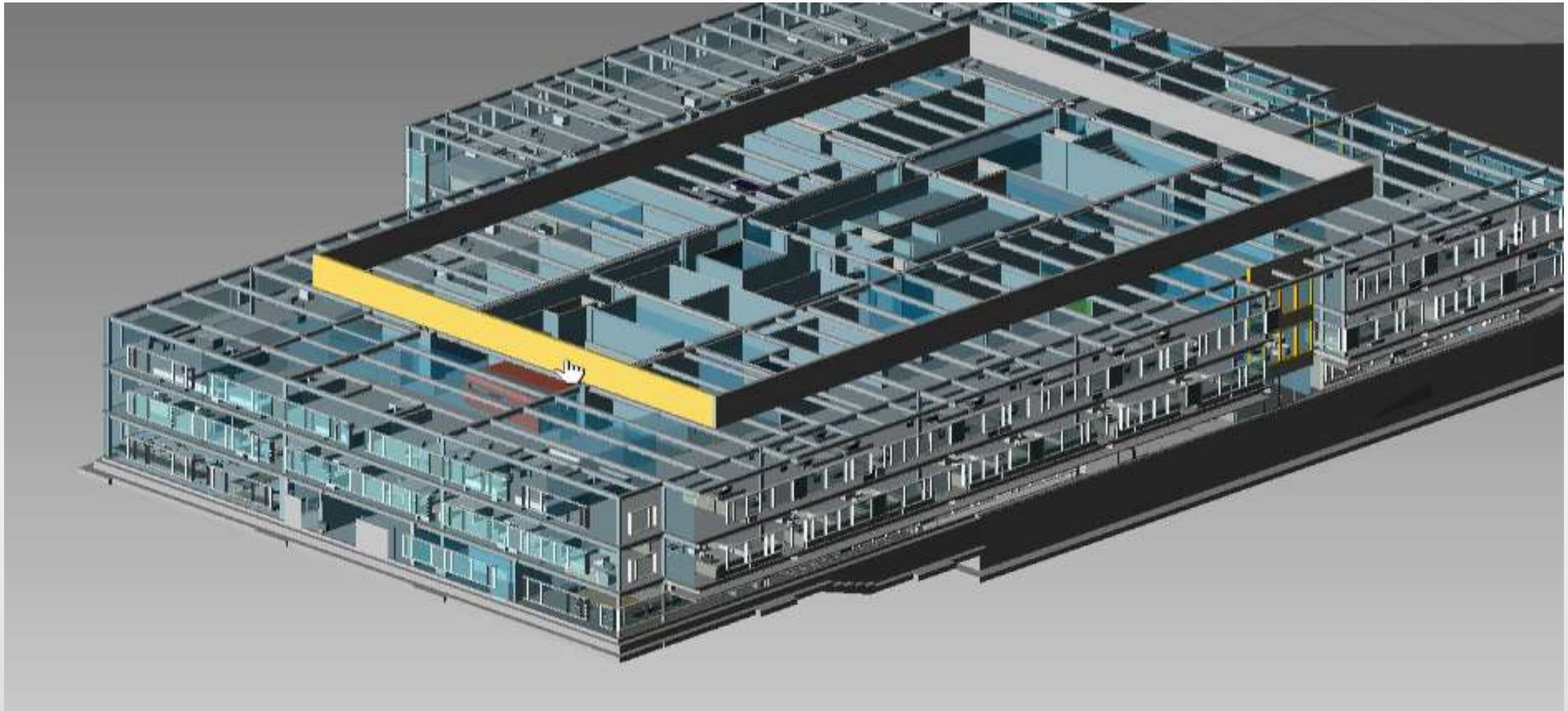


Model management

- Model ownership and intellectual property
- The model's manager changes as the project progresses
- MEA's (**m**odel **e**lement **a**uthors) and contributions and the identity of the designer
- Access to the model
- The AIA G202 protocol and contractual structure
- The right of reliance and gaining the benefits of BIM

Project and model management

Who is responsible for what in this thing ?



Use the AIA G202 BIM protocol to help bring VDC/BIM data into the world of construction contracts and legal items

Standards for 3d models set by the contractor

- Quality contractors have a set of BIM standards for the models in their projects
- All of the subcontractors and others contributing models to the project understand and adhere to these standards so that the models are accurate and at the right level of development as work progresses
- The main manager of the model changes through successive project phases (example: first the GC, then the structural steel subcontractor, back to the GC, then to the electrical subcontractor, the HVAC subcontractor gets it, now the GC is the main manager again)
- The nature of models in BIM blurs the concepts of model ownership, designing and authoring versus contributing, intellectual property rights and who is in responsible charge
- The AIA G202 BIM protocol is a further attempt at defining BIM processes and determining model ownership and management and the responsibilities of model makers at various points in the project A 2013 revision of the 2008 E202 protocol

The Federated model

There is no single, all encompassing, comprehensive model in a construction project using BIM processes, but there is a total model that is made of linked models from all of the different construction contributors to the project (structural, site, MEP, masonry, lighting, furnishings, finishes, equipment).

This model of multiple linked models is called the “**federated**” model. No separate linked model is affected by changes made to other linked models. Each one retains its own identity, data and values separate from the others.

Even though the data from each model is linked to all of the others through the model “federation” process, they do not affect one another’s data.

Each of the separated ones can be classified as “component” models of the “federated” model. And unless the project is comprised of but one model, there is no “master” model. Only a very small project using BIM methods would have but a single model.

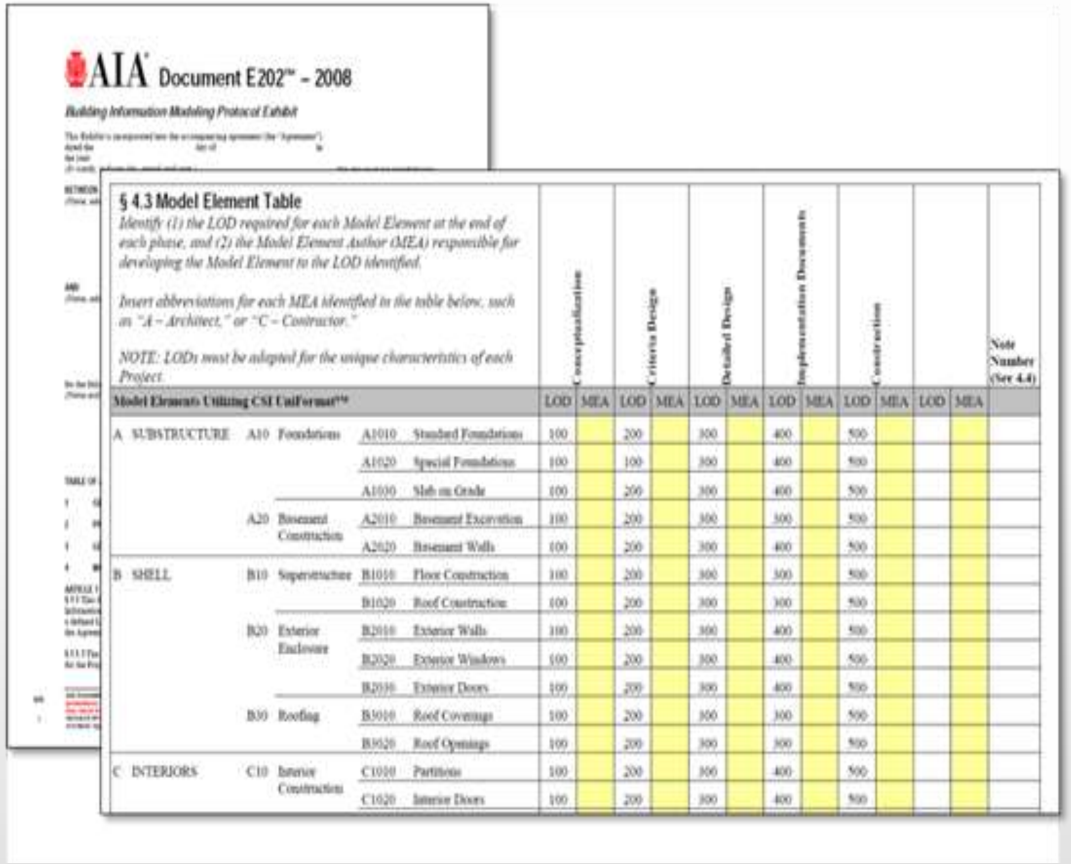
The AIA G202 BIM protocol

This is an attempt at helping to bring BIM data into the world of legal contracts and advances the initial steps of the E202 protocol released in 2008

It defines different levels of models and the content of each level and the authorized use of each level

The protocol allows procedures for determining model ownership, the management of data within the models and the responsibilities of the model makers

The protocol uses a 2 dimensional matrix of ***UniFormat*** (the building's components) and LoD/MEA columns to organize the parts of the model


AIA Document E202™ – 2008

Building Information Modeling Protocol Exhibit

§ 4.3 Model Element Table

Identify (1) the LOD required for each Model Element at the end of each phase, and (2) the Model Element Author (MEA) responsible for developing the Model Element to the LOD identified.

Insert abbreviations for each MEA identified in the table below, such as "A – Architect," or "C – Contractor."

NOTE: LODs must be adapted for the unique characteristics of each Project.

Model Elements Utilizing CSI UniFormat™					Conceptualization LOD	MEA	Criteria Design LOD	MEA	Detailed Design LOD	MEA	Implementation Documents LOD	MEA	Construction LOD	MEA	LOD	MEA	Note Number (See 4.4)
A SUBSTRUCTURE	A10	Foundations	A1010	Standard Foundations	100		200		300		400		500				
			A1020	Special Foundations	100		100		300		400		500				
			A1030	Slab on Grade	100		200		300		400		500				
	A20	Basement Construction	A2010	Basement Excavation	100		200		300		300		500				
			A2020	Basement Walls	100		200		300		400		500				
B SHELL	B10	Superstructure	B1010	Floor Construction	100		200		300		300		500				
			B1020	Roof Construction	100		200		300		300		500				
	B20	Exterior Enclosure	B2010	Exterior Walls	100		200		300		400		500				
			B2020	Exterior Windows	100		200		300		400		500				
			B2030	Exterior Doors	100		200		300		400		500				
	B30	Roofing	B3010	Roof Coverings	100		200		300		300		500				
			B3020	Roof Openings	100		200		300		300		500				
C INTERIORS	C10	Interior Construction	C1010	Partitions	100		200		300		400		500				
			C1020	Interior Doors	100		200		300		400		500				

The G202 and contractual structure

The AIA BIM protocol gives a contractual structure for working with BIM throughout construction projects

- It lays out exactly who is the author of each specific component in each construction phase (versus others who act as contributors to model objects)
- It tells how and in what fashion subsequent model users can depend on it for fabrication, critical path and other forms of scheduling, estimating and actual construction
- It delegates exactly who takes care of the model during specific and discrete phases of the project

Model element authors versus model contributors

The identity of the originating designer as separate from those who contribute information to it

- Once a model object is authored, that act defines the MEA
- If the design process and model building provides for the adding of information to advance an object’s LoD, that is a contribution to it, not the authoring of the object
- The use of 3d models and VDC processes are introducing a great number of new legal areas, issues and risks, both real and imagined, whose approaches are currently evolving
- 3d models, libraries and contributed object information as intellectual property

The Model Element Table in G202

This area of the protocol tells you who is responsible for making the content of the different areas of the 3D model

It is a matrix of the various parts of the building (using **UniFormat** to describe the building's components) combined with the assignments of who is the MEA at each given model level (LoD 100 through 500)

AIA BIM Protocol Exhibit E202-2008.)

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B SHELL	B10 Superstructure	B1010	Floor Construction													
		B1020	Roof Construction													
	B20 Exterior Enclosure	B2010	Exterior Walls													
		B2020	Exterior Windows													
		B2030	Exterior Doors													
	B30 Roofing	B3010	Roof Coverings													
		B3020	Roof Openings													

An example of a contractor's LoD structure

Official AIA fundamental LoD's

Level 100	Conceptual design	Conceptual geometry
Level 200	Schematic design	Approximate geometry
Level 300	Design development	Precise geometry
Level 350	Pre-construction	
Level 400	Construction documents	Construction and fabrication ready
Level 500	As-built model	Current conditions

Note that the AIA numbering for LoD's is to three positions (Nnn)

This allows for an individual firm to develop its own sub-levels and additional details for particular jobs using the Nnn structure

Be aware that the AIA **official** LoD stance is that there is **no** strict correspondence between the LoD's and the design documents

An example of a project's LoD structure

A contractor's in-house expanded LoD 1st and 2nd positions

Level 100	Conceptual design	Conceptual geometry
Level 150	Space planning	
Level 200	Schematic design	Approximate geometry
Level 300	Design development	Precise geometry
Level 350	Pre-construction	
Level 400	Construction documents	Construction and fabrication ready
Level 450	Construction administration	
Level 500	As-built model	Current conditions
Level 600	Operations and management	Facility management

An example of an individual project's LoD structure use

A contractor's LoD structure to the 3rd position

100 Initial concept

- 110
- 120
  - 121
  - 125
- 150 Space planning
- 160

200 Schematic design

- 220
- 225

300 Design development

- 310
  - 311
  - 312
  - 316
- 330
- 350 Pre-construction
  - 355
  - 357
- 380

400 Construction documents

- 420
- 440
- 450 Site ready
  - 460

500 As-built model

- 510
- 520
- 540
  - 542
  - 545
- 570

600 Facility management model

- 610
- 680

The contractor may devise his structure to have the individual LoD numbers mean exactly the information and geometry all objects at a particular level must possess in order to be tagged at that level

Access to models

Shared information and collaboration

In order for BIM to exist, there must be access by all of the design and construction members to all the rich data found in a good quality model. The members must be able to provide input and receive output of any data they wish during any stage of the process: design and construction.

For the team members to make the construction process as efficient (in time and in money) as BIM can make possible, access **cannot be denied**. There can be no private project information if the benefits of BIM are to be realized.

This is one of the fundamentals of collaboration, and collaboration is one of the fundamentals of BIM and VDC.

The right of reliance
Benefits and efficiencies

Unless there is universal confidence in the models, you destroy all of the benefits of BIM if you continuously check and recheck the work of others as you access the model for accuracy and veracity. The reduction in activity latency is negated by this checking. A project must have a "**right of reliance**" if it is to provide the efficiencies and positive outcomes of BIM. Good BIM processes remove the need for duplicate efforts among team members so that time is used for actual productive work. Project contracts can define the beneficial "rights of reliance". The reliance is also based on your confidence in the absolute competency of the modeling teams that worked on the models before you. Total team competence plus contract defined reliance rights lead to efficiencies.

Parametric modeling

- Parametric model data is a relationship built into the model where different objects are connected to one another
- This form of connection is the *data parameter*
- Here are some examples of parameter connections:

Columns are spaced evenly across an area. You change the length of the area. The equal spacing of the columns is maintained. In this circumstance, the data parameter is *proportional*.

A junction box is on a wall. You move the wall within the model. The box remains connected to the wall in its same position. Here, the data parameter is *connection*.

Some more parameters

RIB running together

An interior partition has metal studs spaced at 16". You increase the length of the wall. The 16" spacing of the studs is maintained and additional studs are automatically placed within the partition. In this situation, the data parameter is *additive*. If you decreased the length of wall, the parameter would be *subtractive* and studs are removed to reflect the less lengthy partition.

Conversely, the parameter could be to maintain the number of studs and alter the spacing based on the wall's length.

There is a room with a door. You add a partition within the room, dividing it but maintaining the overall length and width of the original room. The newly added partition strikes the position of the door. The door automatically moves sideways, away from being hit by the new partition. Here, the data parameter is *obstruction*.

Change management

- *Change management* is having the all of the related objects parametrically connected correctly so that when a change is made to the model, all of the corresponding objects are automatically changed properly.

  This is valuable in working with the model in that it increases accuracy, reduces the time required to work with the model and decreases the introduction of errors.

Thank you