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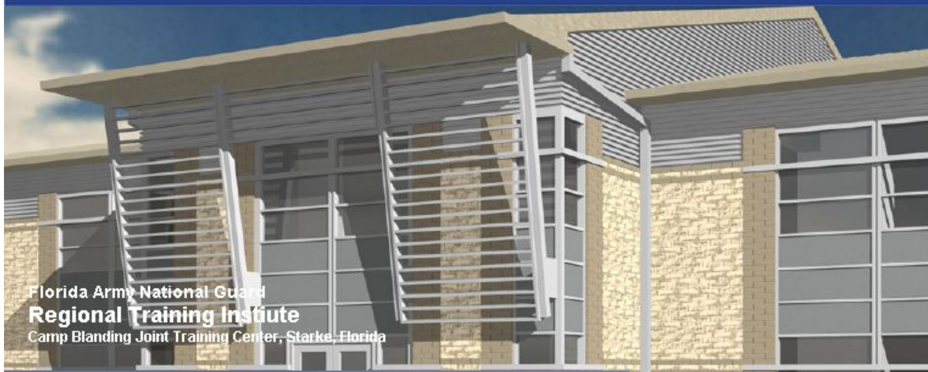

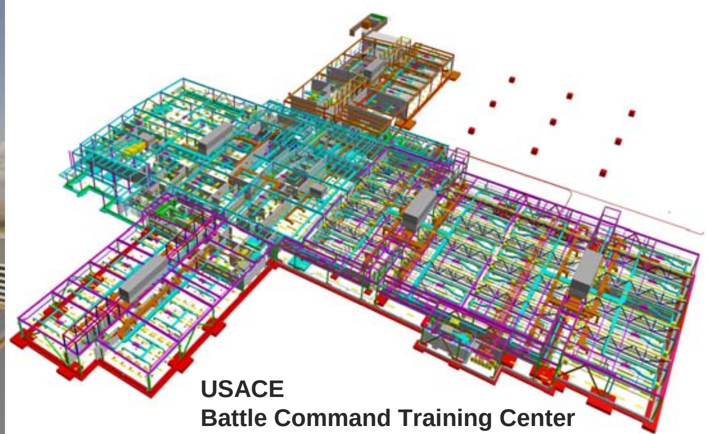

S500- BIM Best Practices
May 22, 2008

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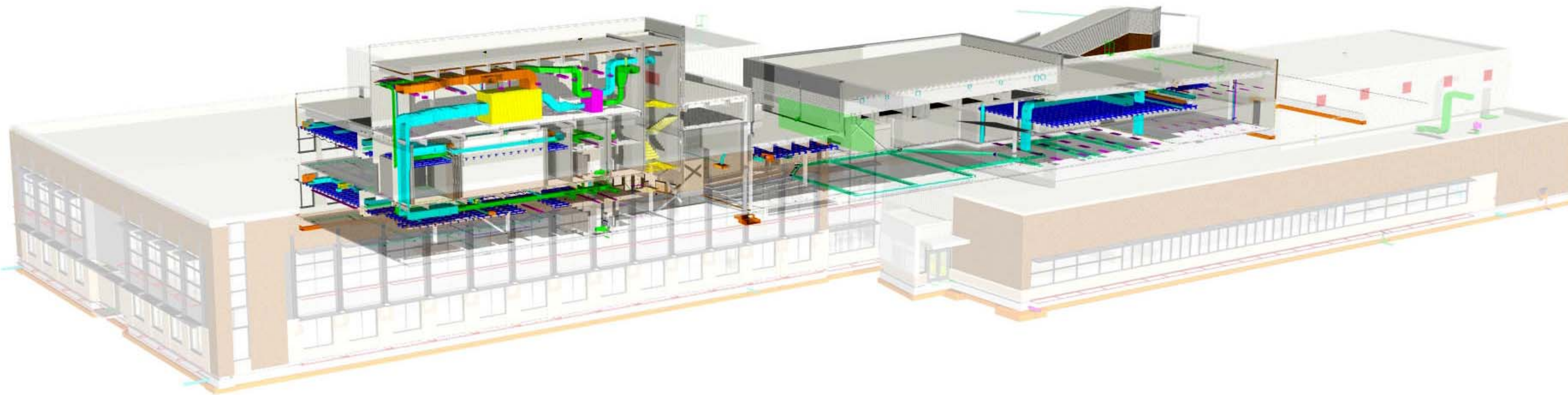
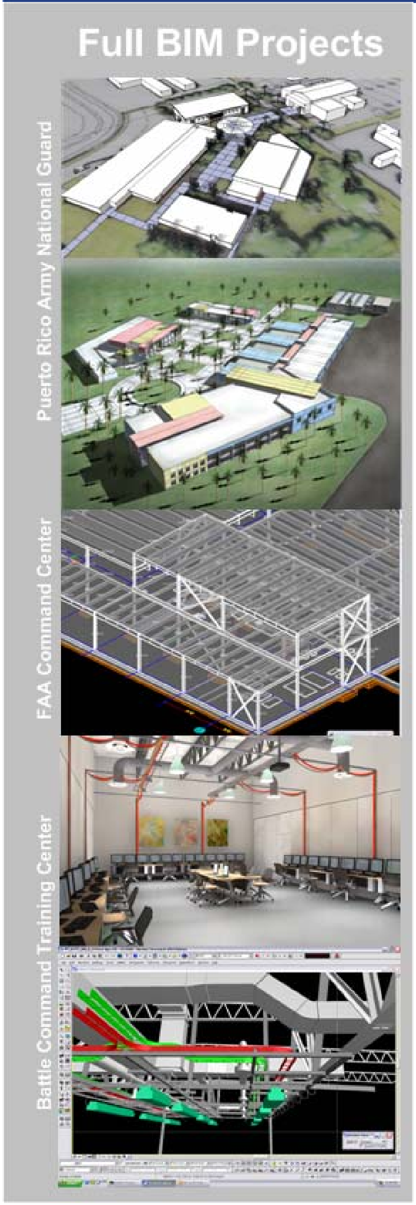
AEC–ST Science & Technology



Building Information Modeling

Implementation, Innovation, and Lessons Learned

BIM in Practice



BIM in Planning:

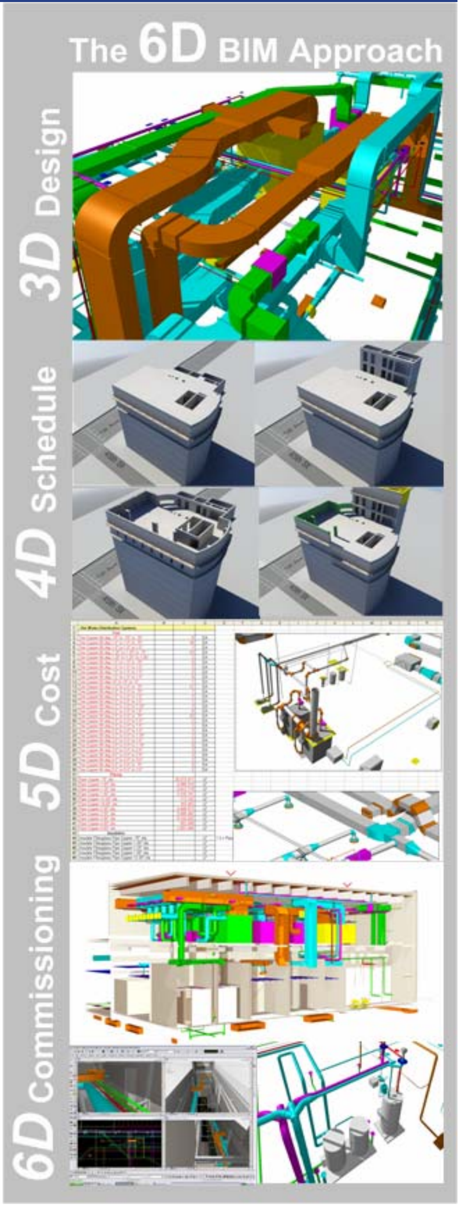
- Early Design Tool
- Links to Cost Model/ Program

BIM in Design:

- 35 Active Full BIM Designs
- All Disciplines, All Phases
- Coordinated Designs

BIM in Construction:

- 5 Full BIM Designs in Construction
- BIM Goes to the Field



Jacobs BIM Timeline:

BIM Implementation Timeline:

- 2000-2005 – Pockets on BIM/4D Inno
- November 2005 – Internal BIM and 4D
- January 2006 – Commissioned A BIM
- March 2006 – Best BIM Path Forward
- April 2006 – **First Full BIM Project (A**
- July 2006 – Committed to doing All Pr
- May 2007 – First three BIM Projects I
- August 2007 – Developed Integrated VDC Scope and Approach – Began VDC Dialog with Clients
- October 2007 – Began aggressively proposing Integrated VDC Delivery – 12 Active Projects with varying levels of VDC Application
- November 2007 – **22 BIM Projects/$1.4B Construction**

AIA

BIM: Transforming a Traditional Practice Model into a Technology-Enabled Integrated Practice Model

By H. Thomas McDuffie, AIA, RIBA

Like most design firms, we are continually driven by our clients' need for faster delivery and lower cost. And like most design firms, we continually strive for design excellence, increased production efficiencies and opportunities to provide added value for our clients. However, unlike most design firms, our business model includes not only architectural and engineering services, but also design-build, construction management, and facility O&M services. And it is these additional services that prompted us to look for ways to leverage BIM not just as a tool for design, but as an integral part of the entire project development life-cycle.

As we looked at our use of the traditional linear design process, two opportunities for improvement became evident. First is accelerated decision-making. Early decisions based on good data save time and money. Second, is to create a more collaborative concurrent process. Removing the stops and starts inherent in the linear model results in improved coordination. Individual phase activities are pulled forward into the "big picture" context. This not only increases interaction between disciplines, but importantly provides added opportunities for front-end involvement by stakeholders. Increased stakeholder involvement, particularly during early project activities, significantly enhances the ability to fully identify and address owner objectives and expectations, benefiting quality and functionality.

We were an early user of BIM tools and frequently applied BIM during the initial project phase efforts. However, while BIM was adding a visual dimension to our early architectural phases, it was not providing schedule compression nor was it significantly improving overall work efficiencies. We needed a solution that supported an integrated big picture…a solution that optimizes the use of BIM across all disciplines and activities from planning through design, construction, and occupancy.

Initial Actions

With this challenge in mind, we took three key actions.

1. Got informed. We asked hard questions of staff, vendors, and industry. How was BIM affecting quality control activities? How was it impacting schedule? What cost benefits were gained? What added value was provided to clients? While pockets of innovation and success were found, we concluded that the full value of BIM was not being realized. What was needed were new work processes that engaged BIM not only in visualization of design interferences, but also in understanding impacts of design decisions on construction, commissioning, close-out, and operation and maintenance activities.

2. Commissioned a task force. This group was given a mandate to identify procedural changes needed to maximize the value of BIM within and across each phase of work. To facilitate this analysis, the task force identified a key project to serve as a case study and catalyst for change.

3. Set an internal expectation. A goal was set. All new projects will be executed through BIM by the end of 2007. By setting this expectation, we made BIM an operational requirement. We removed discretion for its use from that of project management and from client requirements.

Management by Outcome

We understood that BIM should be leveraged not just for design-related quality, schedule, and team coordination, but also for its potential to integrate post-design quality, schedule, cost, and coordination issues. With our stake planted firmly in the ground, it was critical to identify a means with which to measure results. Considering our two initial objectives (i.e., faster projects; increased project efficiencies), we identified two key metrics:

- **Schedule compression.** A goal was set to accomplish twice as much work within the same time frame and with the same number of staff. Our range of project size and complexity limited our ability to do this on all projects, but this provided an ambitious goal across all projects. Further, we expected BIM to assist in understanding impacts not only on design schedule, but also on subsequent project schedule for activities such as construction and commissioning. Success would be visible in our Rolling Workload Forecasts. If we met this objective, we would soon be in a position to tell our sales staff they needed to double their results in order to support current staff levels.

- **Team coordination.** This metric evolved over time. It began first with an objective to eliminate all construction-related change orders due to design-related coordination issues. Responding to our client focus, the metric quickly grew into the elimination of all client-generated review comments related to design coordination issues. It next progressed to the elimination of all internal quality control review comments related to design coordination issues. Ultimately, our goal is the real location of time budgeted for rework to investment in value adding design efforts.

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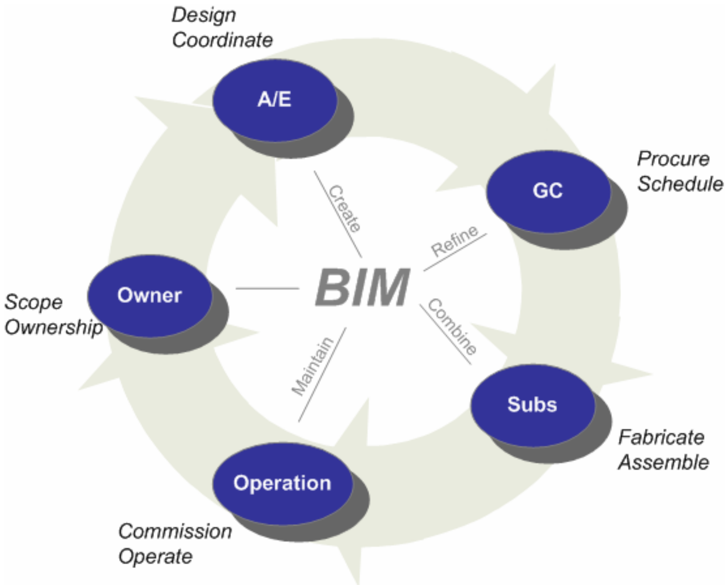
Why BIM/VDC At Jacobs?

- **In the Long-term View:**
  - The dissatisfaction of clients with the current performance of the design and construction industry is a critical factor.
  - Advent of the “Integrated Project Delivery” concepts and practices
  - The maturation of BIM technology, which enables continuous integration of design fabrication and assembly.
- **In the Short-term View:**
  - The escalation of construction costs, driven by material and labor inflation, and an increased level of construction activity taxing the industry’s capacity, is creating an urgent need for an alternative approach.



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Key Metrics For BIM/VDC:

1.) Schedule Compression and Utilization:

- Accomplish more work in shorter time-frame
- Focus more time on Design problem solving and project solutions

2.) Design Quality and Constructability:

- Eliminate design related change orders in construction
- Eliminate client review comments related to coordination

3.) Deliver Solutions for the Lifecycle:

- Apply 6D delivery across all projects linking 3D visualization with cost, schedule, commissioning, and O&M
- Exceed client expectations with an integrated practice model

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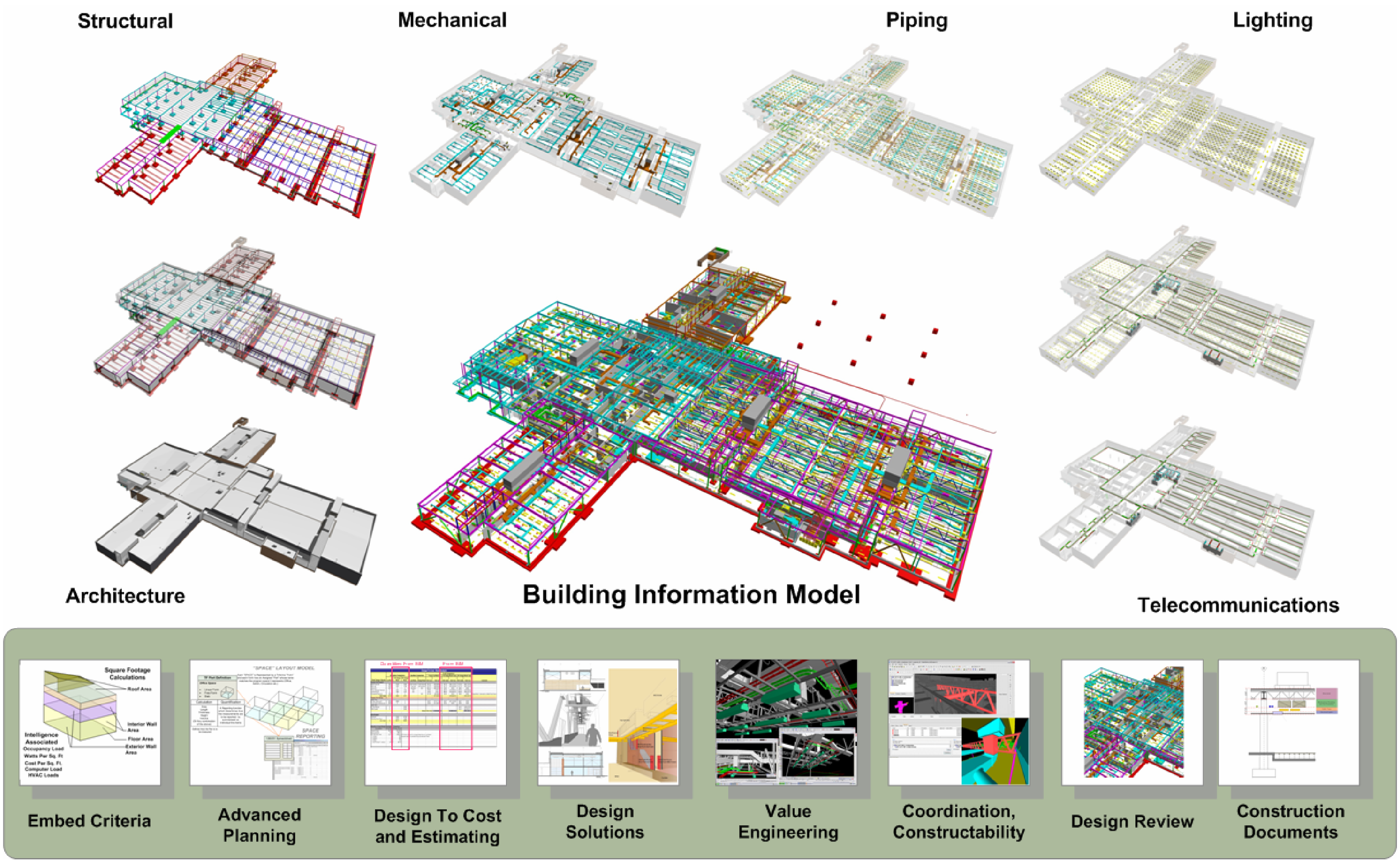
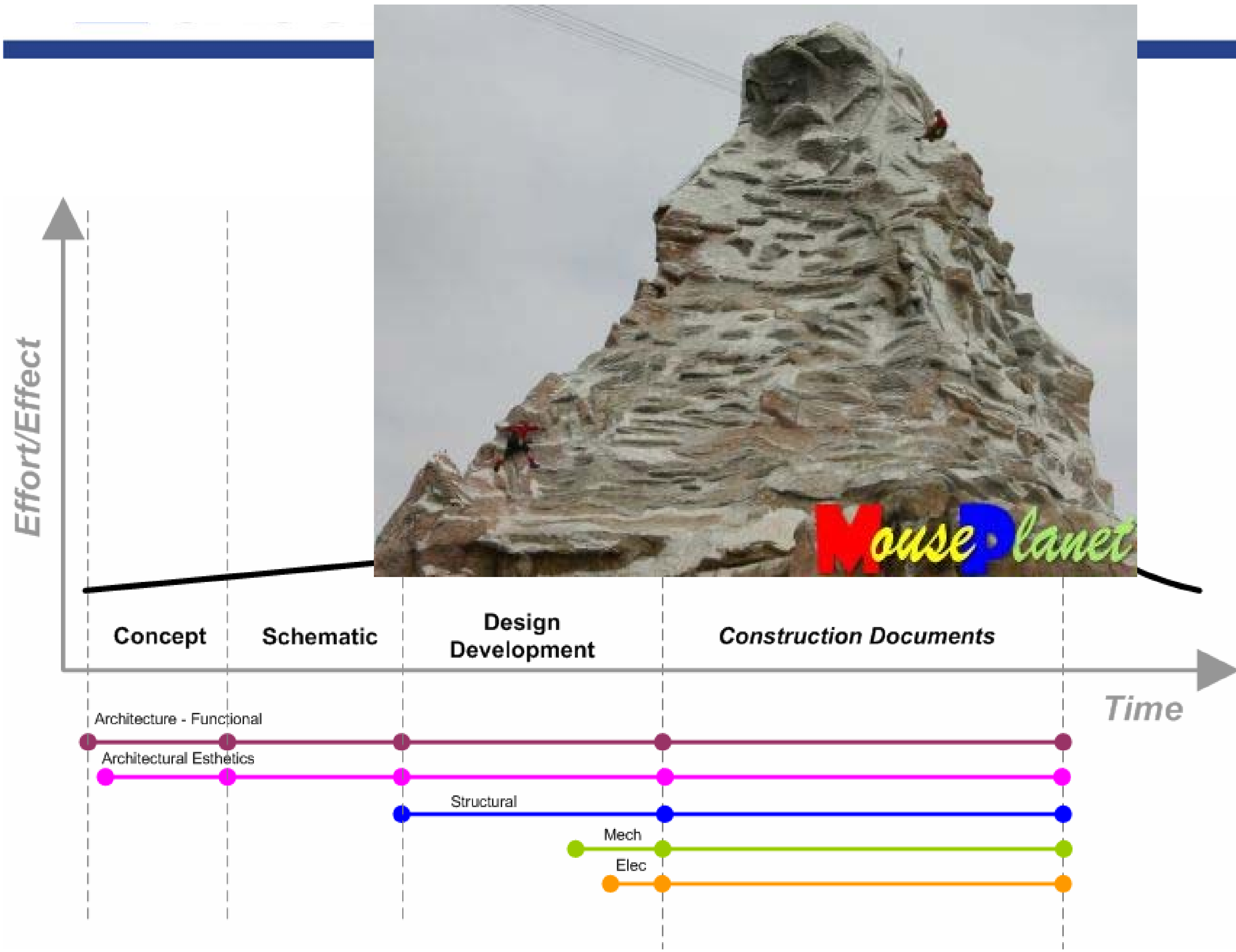
Scope of BIM In Design:




Effort/Effect
MousePlanet
Concept
Schematic
Design Development
Construction Documents
Time
Architecture - Functional
Architectural Esthetics
Structural
Mech
Elec

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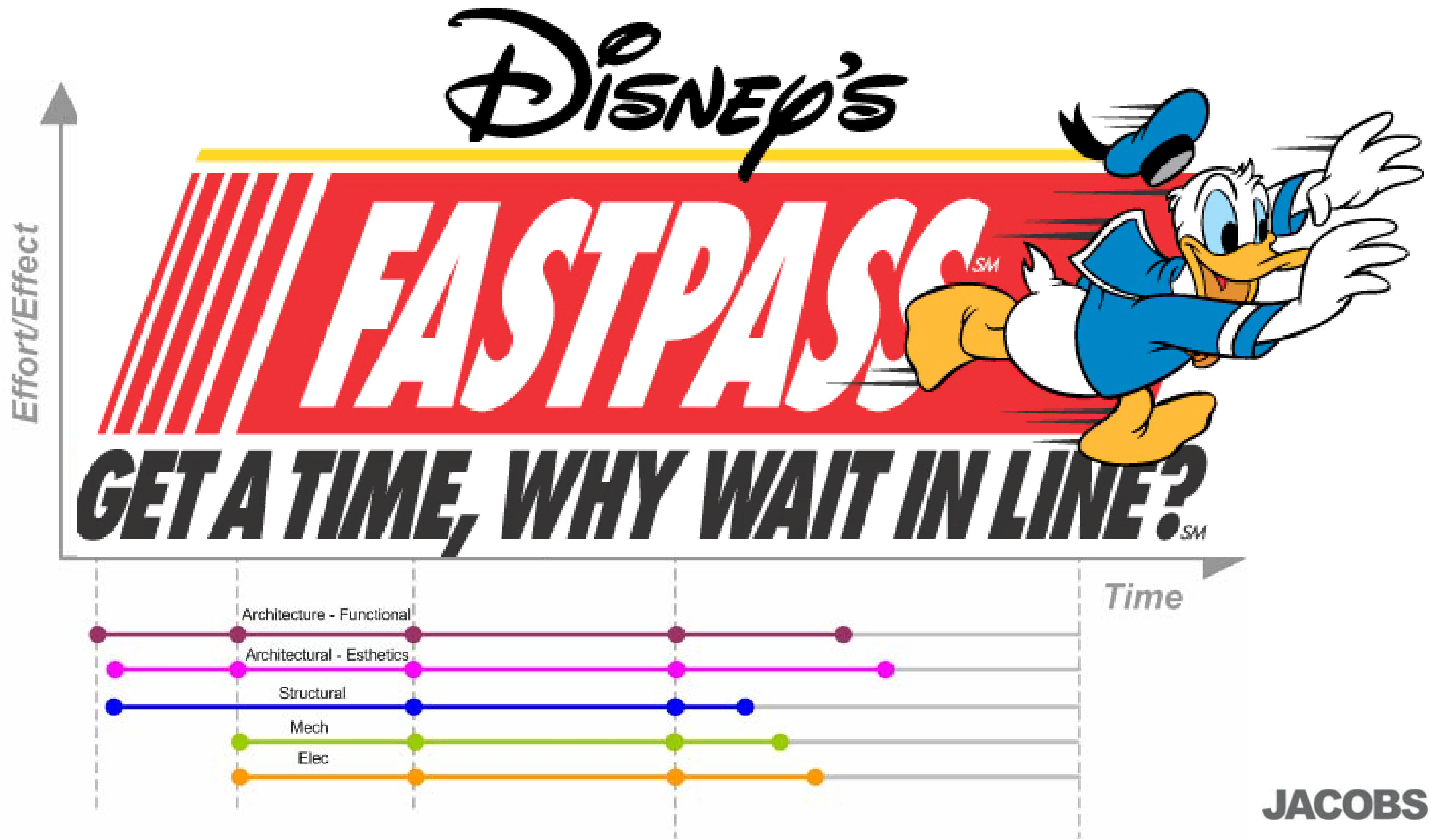
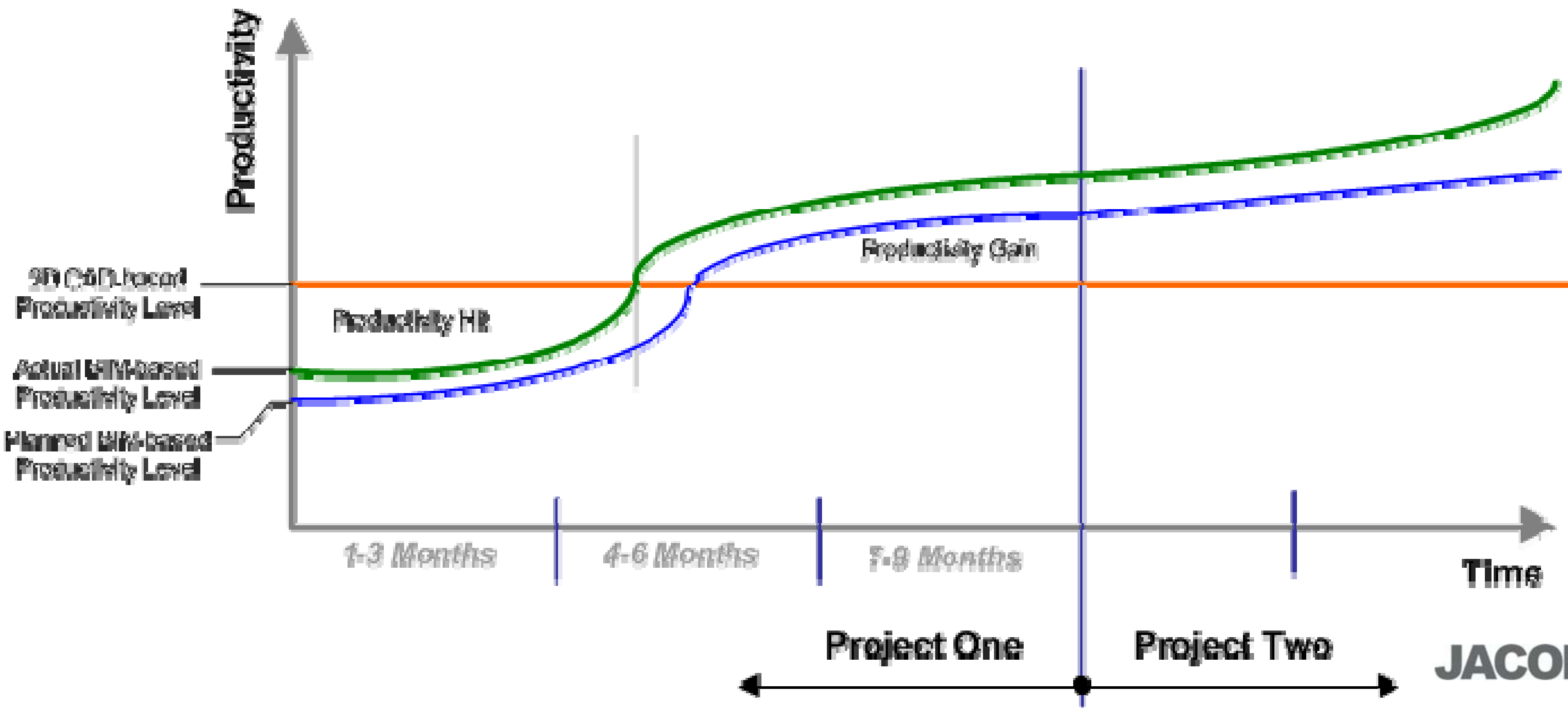
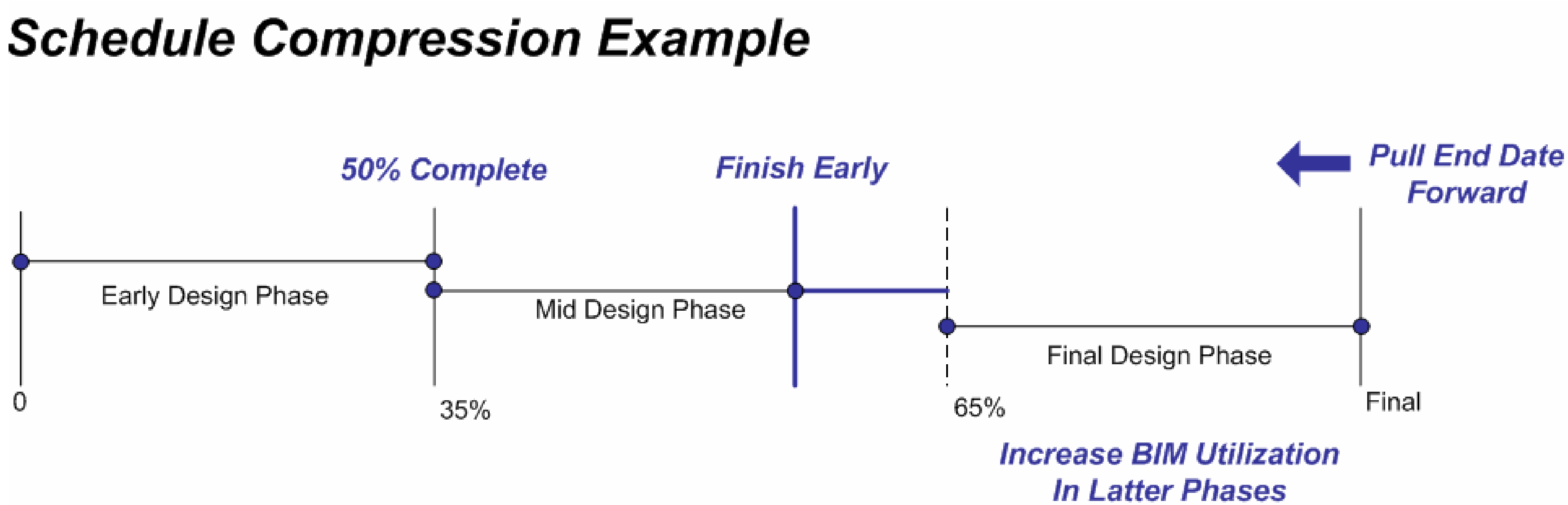

Disney's
FASTPASS SM
GET A TIME, WHY WAIT IN LINE? SM
Effort/Effect
Time
Architecture - Functional
Architectural - Esthetics
Structural
Mech
Elec

The BIM Learning Curve:

- Early BIM Learning Curve – 25/35
- Gaining Efficiency in Latter Phases
- Second BIM Project is More Efficient than CAD



BIM Schedule Compression Metrics:



Project/Team Expectation Timeline:

- 1st Project – Build Coordinated Model – Create Drawings
- 2nd Project – Maximize Usage of all BIM Capabilities
- 3rd Project – BIM Potential is now Project/Client Value

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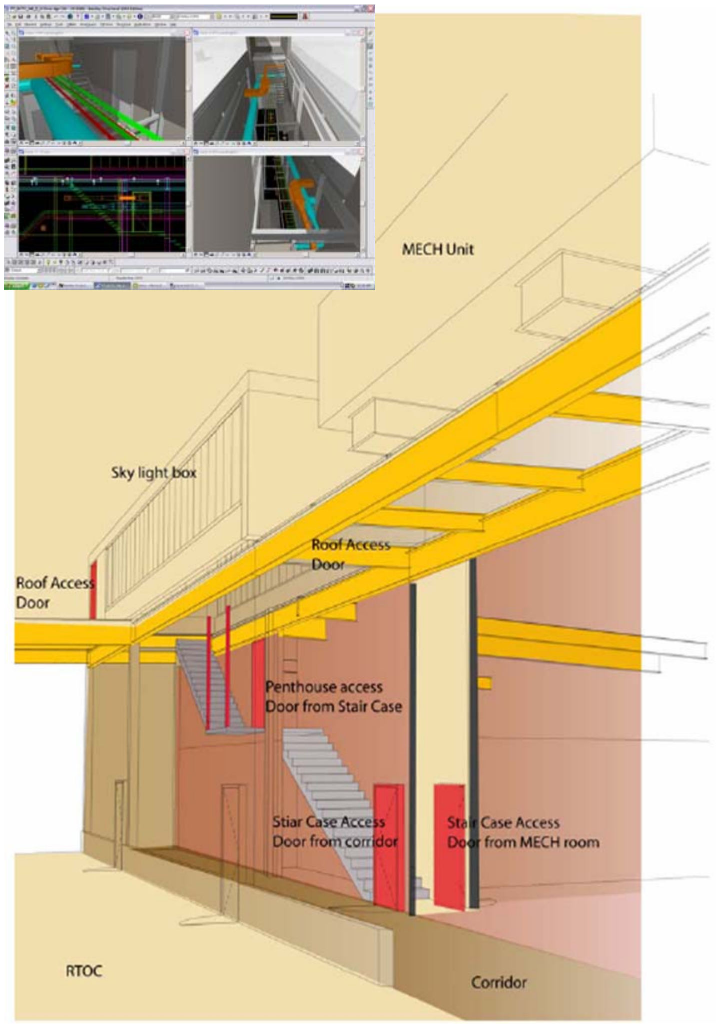
Typical Scope Of BIM On 1st Projects



- All Disciplines Involved in BIM
- BIM Used In All Phases Of Project
- Majority Of Drawings Will Come From The Model
- Use Interference Detection/Management
- Model Will Be Used To Develop Quantities
- Use 4D Scheduling to Evaluate Constructability
- Design Reviews Done In The Model
- Design Model Used In Construction

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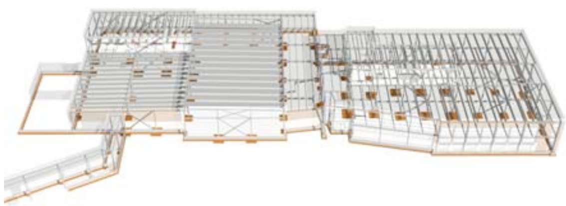
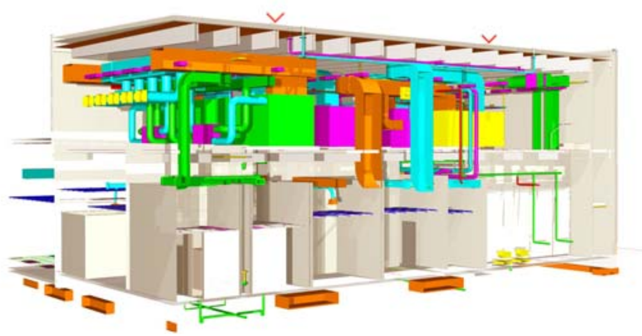
Typical Scope Of BIM On 2nd Projects





- Imbed Manufacturers Data
  - Schedules
  - Procurement
  - O&M Baseline
- Design Automation
  - Routing
  - Layouts
  - Connections
- BIM Integration with Analysis
  - Structural
  - Sustainability
  - Lighting
  - Power
  - Code Analysis

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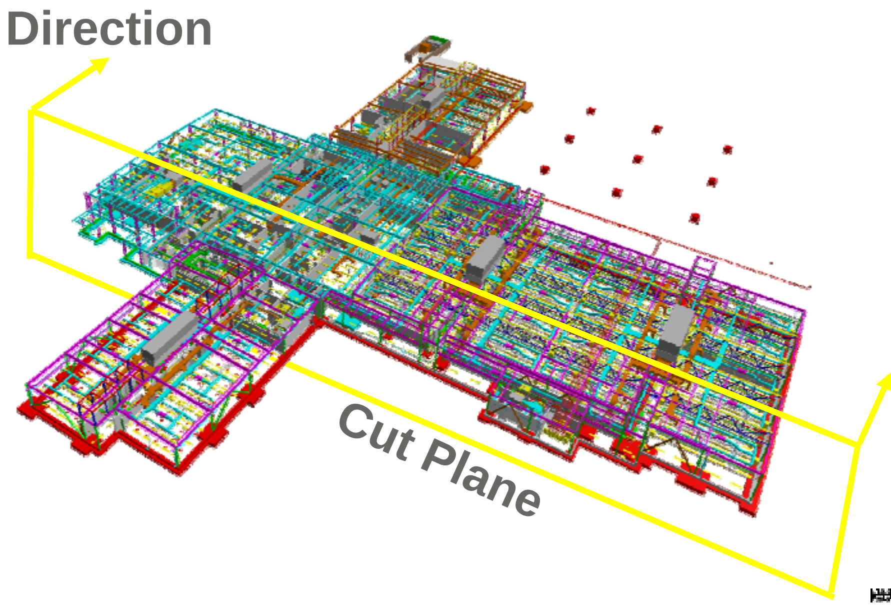
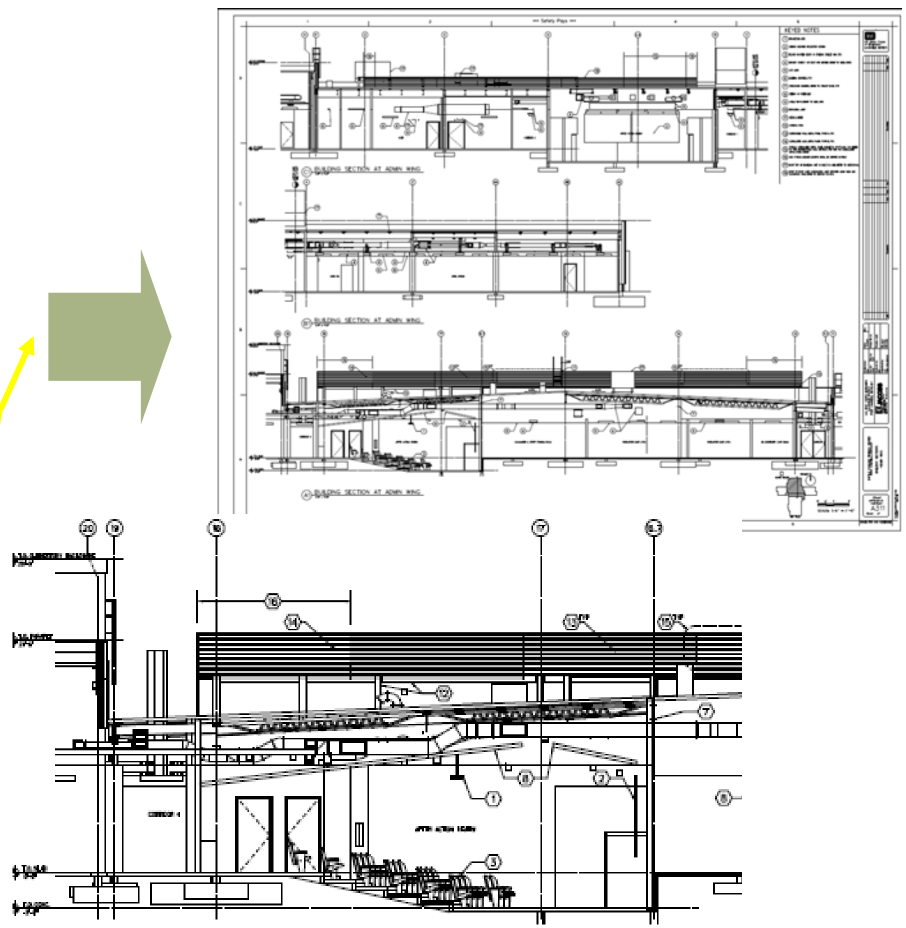
What About My Drawings?

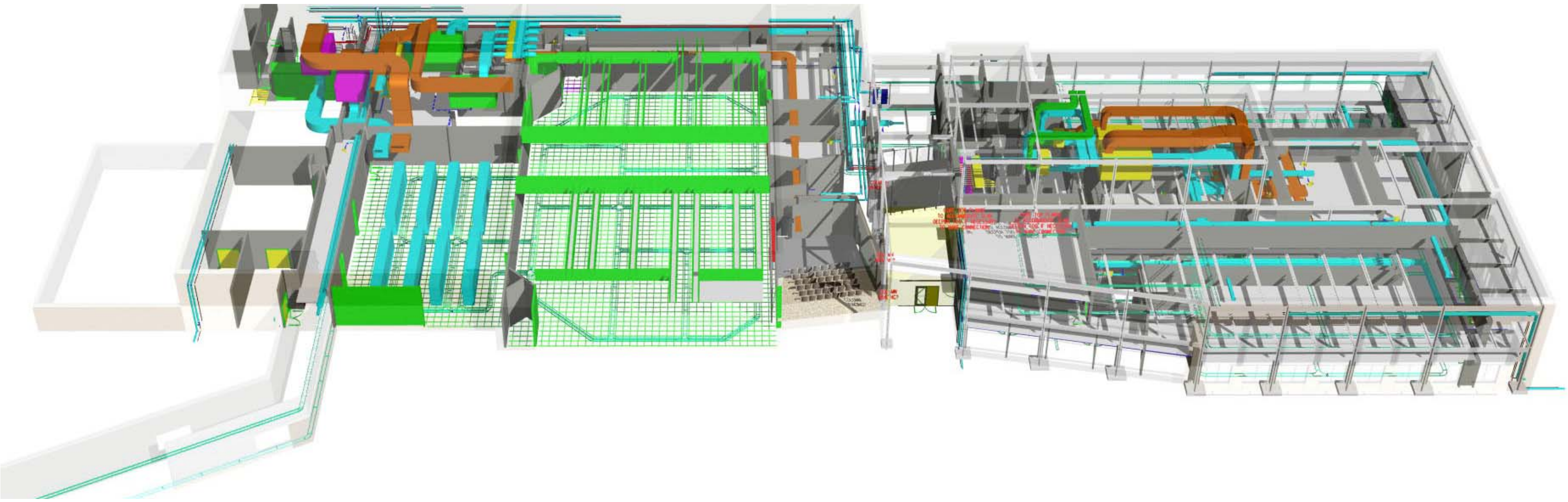
Design Model

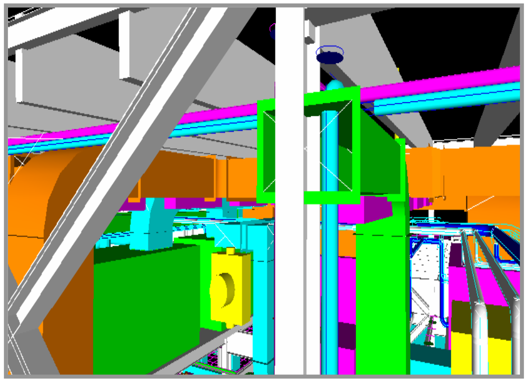


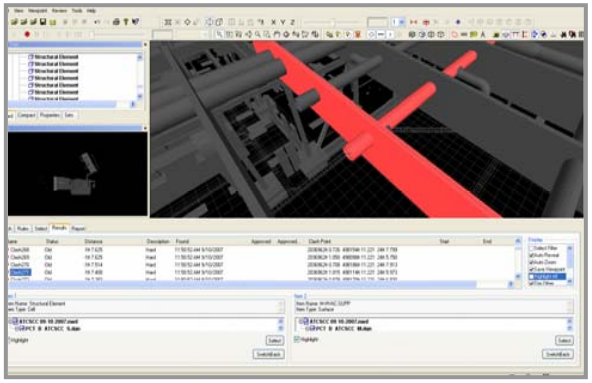
Drawings



Comprehensive Models:



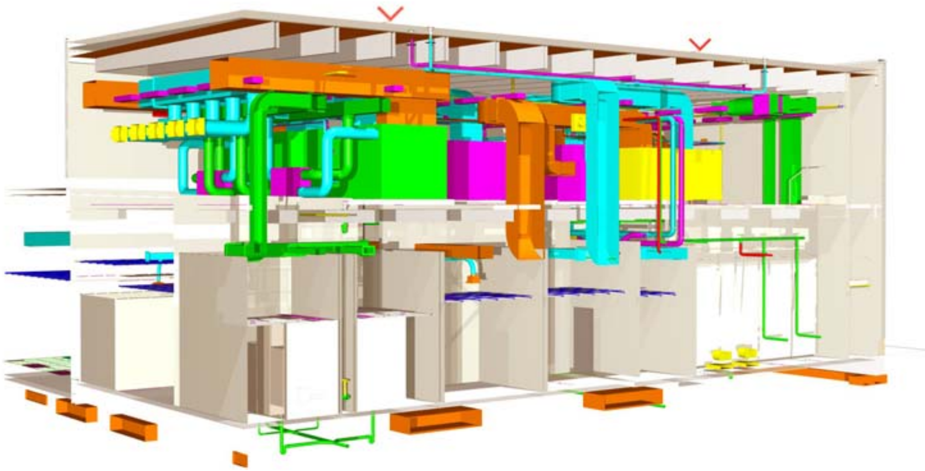


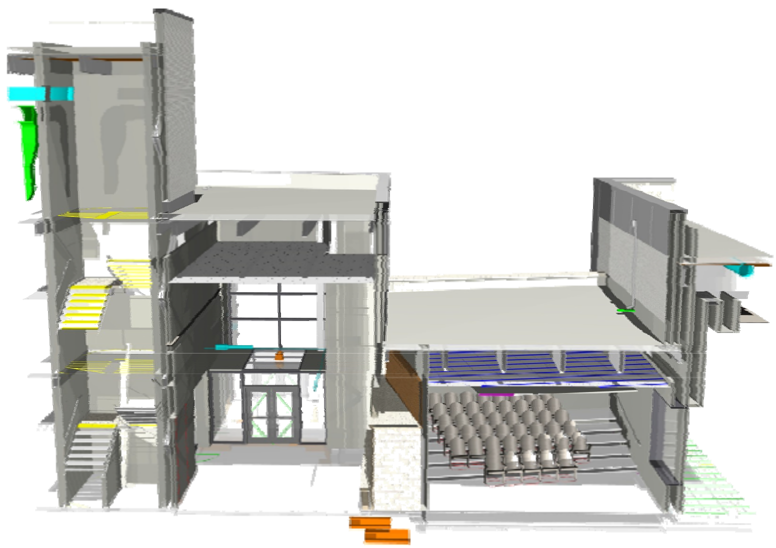


Comprehensive:

- Clash Detection
- Design Review
- Quantification
- 4D Constructability

Building Sections

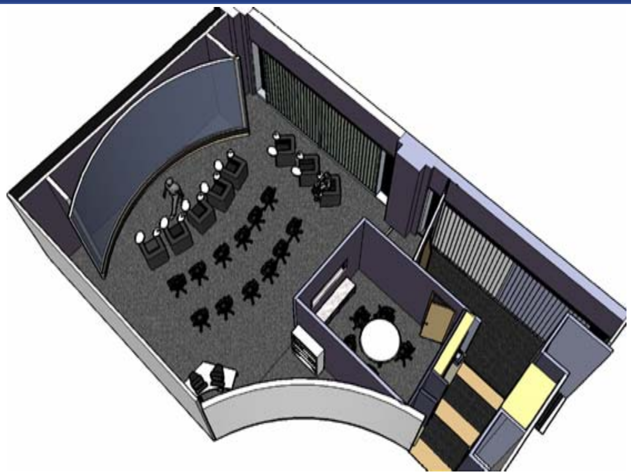




Viz Lab- Interactive Workspace Concept

Jacobs Viz Lab Technology

- Review and Evaluate the Design
- Reviews Enhanced thru Visualization
- 3D Printing for Virtual Prototyping



Manage Tenant Expectations – No Surprises

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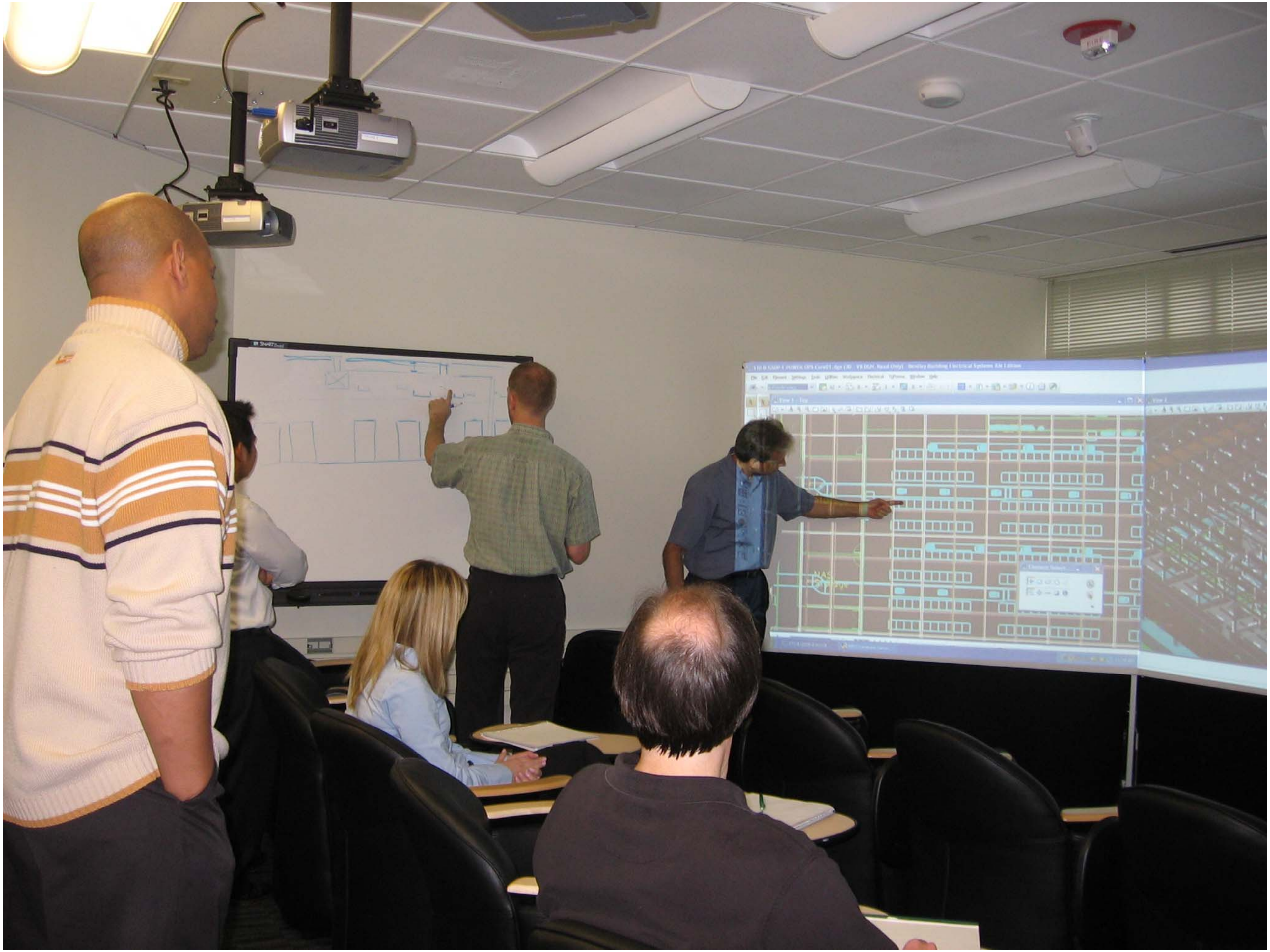


BIM Enhanced Design Reviews

Walkinside

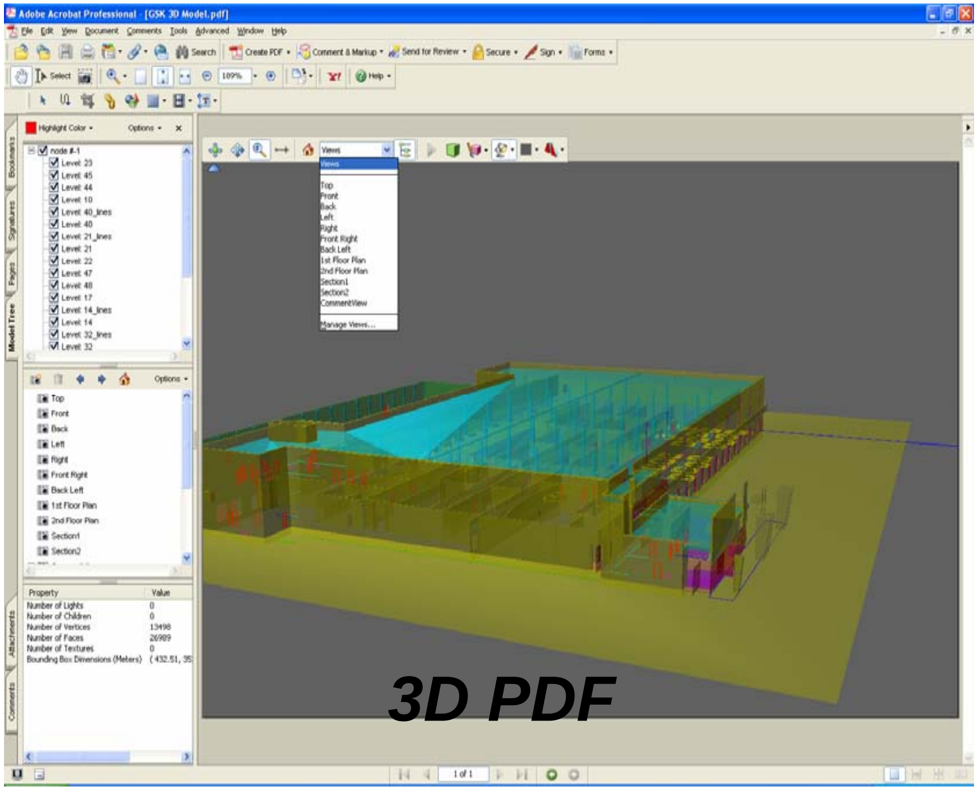
Quality Control of BIM

1.) QC Process Focused On Checking both the Model and the Extracted Drawings

2.) Coordination- Resolved System Interferences Prior to QC Checks

3.) Developed QC-Specific Extractions to aide Review Teams

4.) Focused on Evaluating the Design Model's Constructability and the Operational aspects of each System



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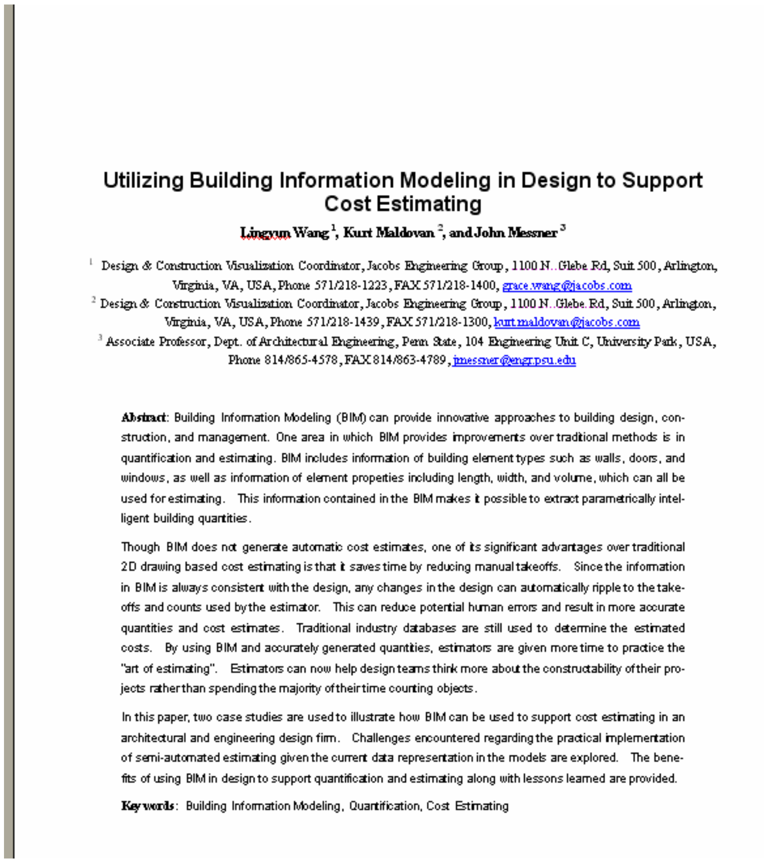
5D - BIM and Cost:

BIM + Quantities/Cost



Utilizing Building Information Modeling in Design to Support Cost Estimating

Lingyun Wang [1], Kurt Maldovan [2], and John Messner [3]

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[2] Design & Construction Visualization Coordinator, Jacobs Engineering Group, 1100 N. Glebe Rd, Suit 500, Arlington, Virginia, VA, USA, Phone 571/218-1439, FAX 571/218-1300, kurt.maldovan@jacobs.com

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Abstract: Building Information Modeling (BIM) can provide innovative approaches to building design, construction, and management. One area in which BIM provides improvements over traditional methods is in quantification and estimating. BIM includes information of building element types such as walls, doors, and windows, as well as information of element properties including length, width, and volume, which can all be used for estimating. This information contained in the BIM makes it possible to extract parametrically intelligent building quantities.

Though BIM does not generate automatic cost estimates, one of its significant advantages over traditional 2D drawing based cost estimating is that it saves time by reducing manual takeoffs. Since the information in BIM is always consistent with the design, any changes in the design can automatically ripple to the takeoffs and counts used by the estimator. This can reduce potential human errors and result in more accurate quantities and cost estimates. Traditional industry databases are still used to determine the estimated costs. By using BIM and accurately generated quantities, estimators are given more time to practice the "art of estimating". Estimators can now help design teams think more about the constructability of their projects rather than spending the majority of their time counting objects.

In this paper, two case studies are used to illustrate how BIM can be used to support cost estimating in an architectural and engineering design firm. Challenges encountered regarding the practical implementation of semi-automated estimating given the current data representation in the models are explored. The benefits of using BIM in design to support quantification and estimating along with lessons learned are provided.

Keywords: Building Information Modeling, Quantification, Cost Estimating

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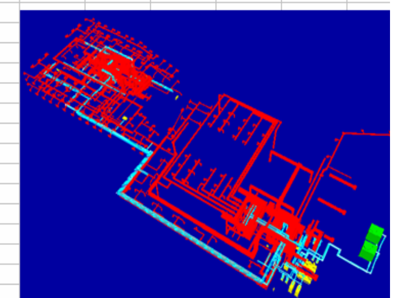
Quantities From BIM

From BIM

Air Flow	W1(")	D1(")	Length(")	SurfaceArea (Sqft)	Pressure Class
Supply	34	18	870	628	Low
Supply	36	16	159	115	Low
Supply	36	16	212	153	Low
Supply	38	32	115	112	Low
Supply	38	32	108	105	Low
Supply	38	32	230	224	Low
Supply	40	18	761	613	Low
Supply	40	18	41	33	Low
Supply	40	18	18	15	Low
Supply	40	24	484	430	Low
Supply	44	20	115	102	Low
Supply	44	20	241	214	Low
Supply	48	32	28	31	Low
Supply	48	32	77	85	Low
Supply	50	20	141	137	Low
Supply	50	20	95	93	Low
Supply	52	30	47	54	Low
Supply	60	24	72	84	Low
Supply	60	24	22	25	Low
Supply	60	24	30	35	Low
Supply	60	24	99	116	Low
Rectangular Duct Total				28524	



HVAC - Ductwork

Air Flow	W1(")	D1(")	Length(")	SurfaceArea (Sqft)	Pressure Class
Supply	34	18	870	628	Low
Supply	36	16	159	115	Low
Supply	36	16	212	153	Low
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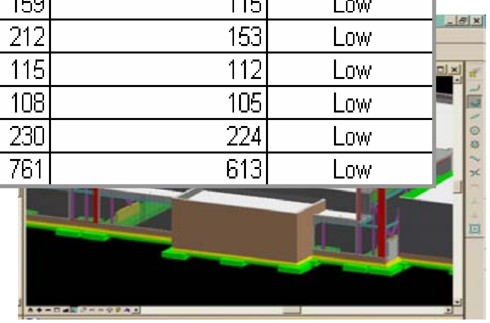

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6D - BIM for Commissioning and O&M:

The Key – Determining what data is needed (and when) for eventual facility operation

- O&M Data/Process Starts In Design Phase Model – Attributes for Spaces, Rooms, Components, and Materials
- **"As-Designed BIM"** Attributes Are Refined/Replaced in the Procurement, fabrication and assembly processes during Construction
- ***"As-Constructed BIM"*** Attributes in Digital Format usable by a Computerized Maintenance Management System (CMMS)

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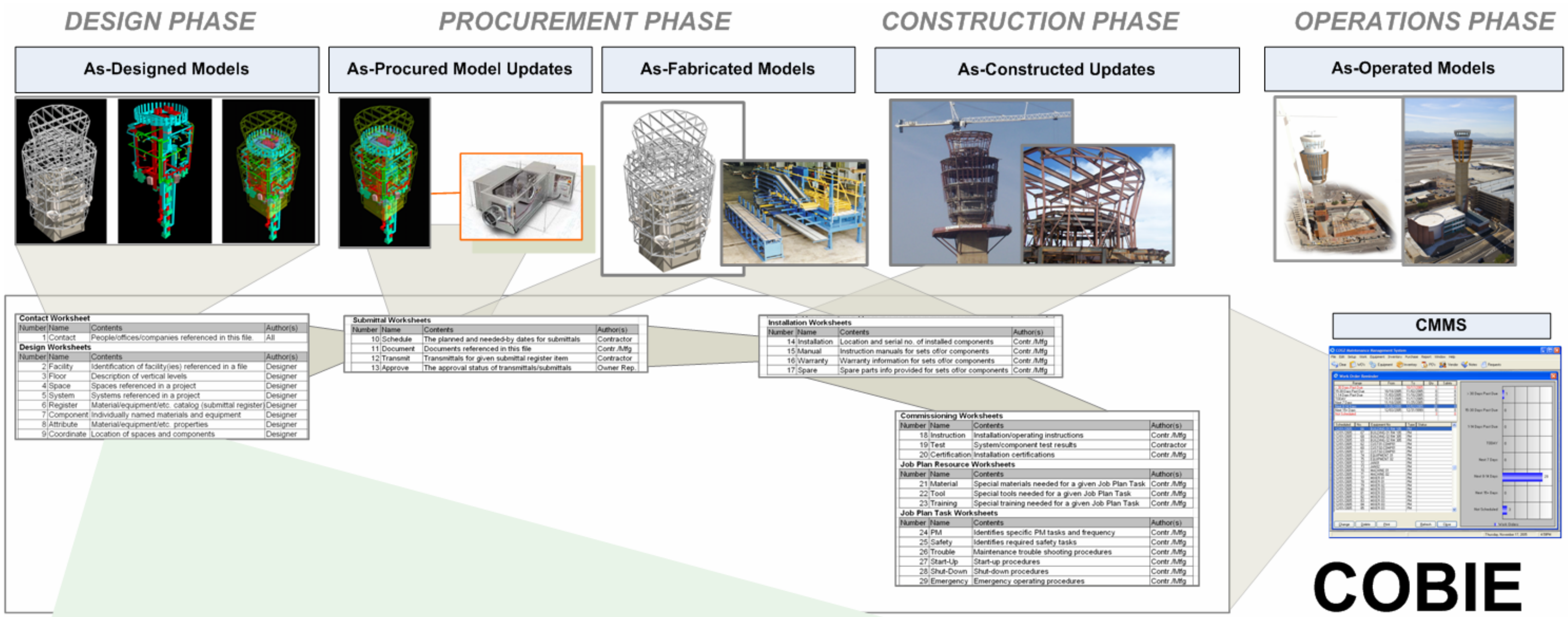
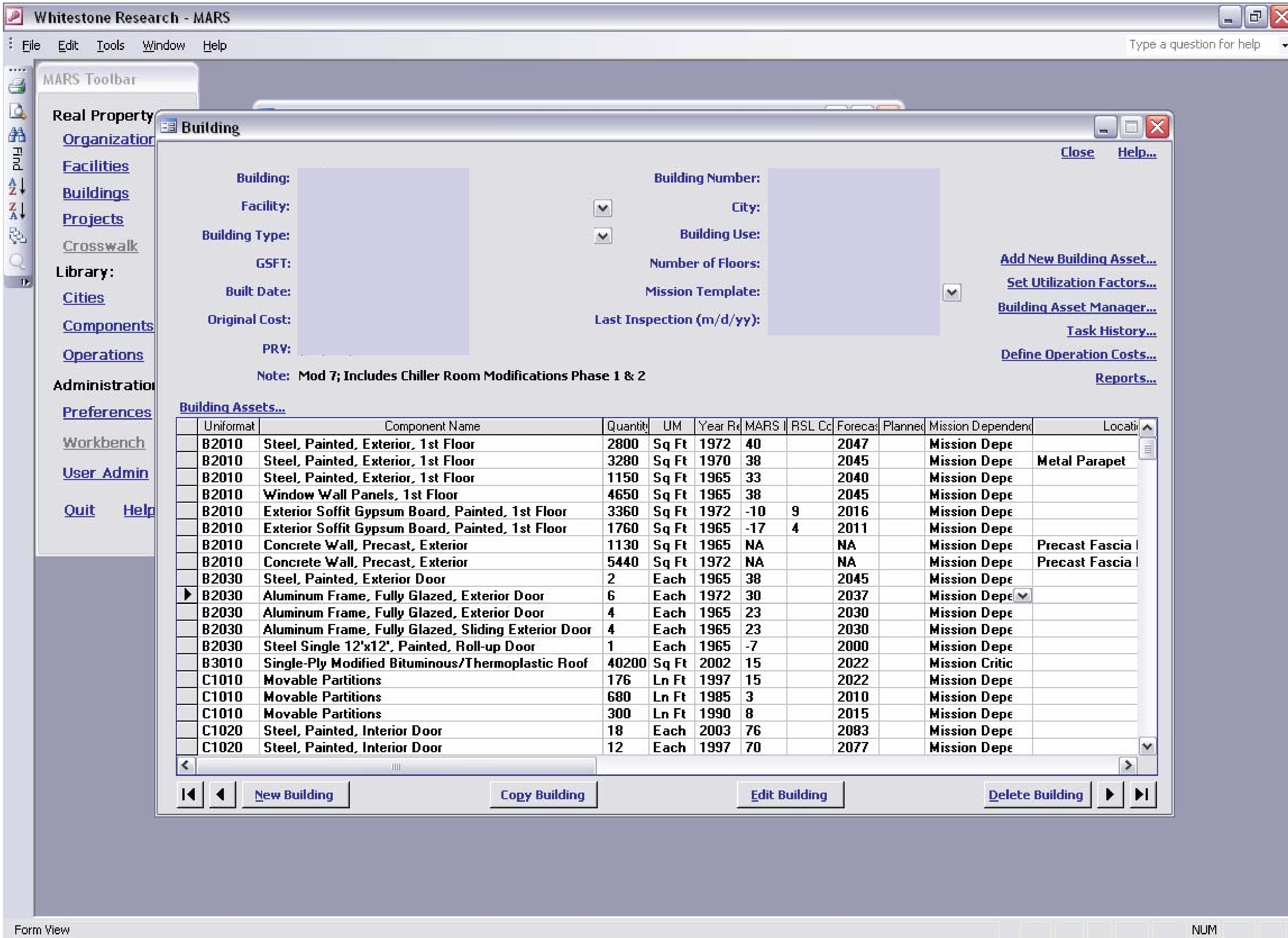


COBIE

BIM and Facilities Management

Contact Worksheet			
Number	Name	Contents	Author(s)
1	Contact	People/offices/companies referenced in this file.	All
Design Worksheets			
Number	Name	Contents	Author(s)
2	Facility	Identification of facility(ies) referenced in a file	Designer
3	Floor	Description of vertical levels	Designer
4	Space	Spaces referenced in a project	Designer
5	System	Systems referenced in a project	Designer
6	Register	Material/equipment/etc. catalog (submittal register)	Designer
7	Component	Individually named materials and equipment	Designer
8	Attribute	Material/equipment/etc. properties	Designer
9	Coordinate	Location of spaces and components	Designer

The objective of the Construction-Operations Building Information Exchange (COBIE) project is to create an open-standard through which information created during design and construction can be transferred directly to facility operators, maintainers, and managers in useable electronic format.

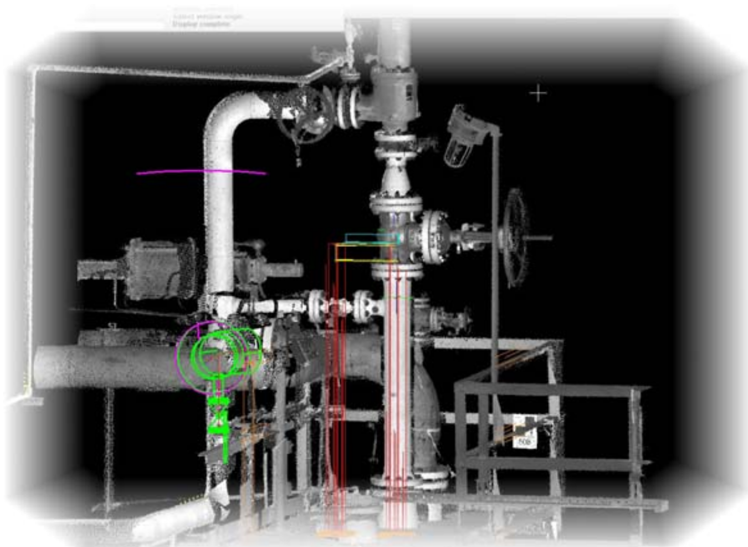


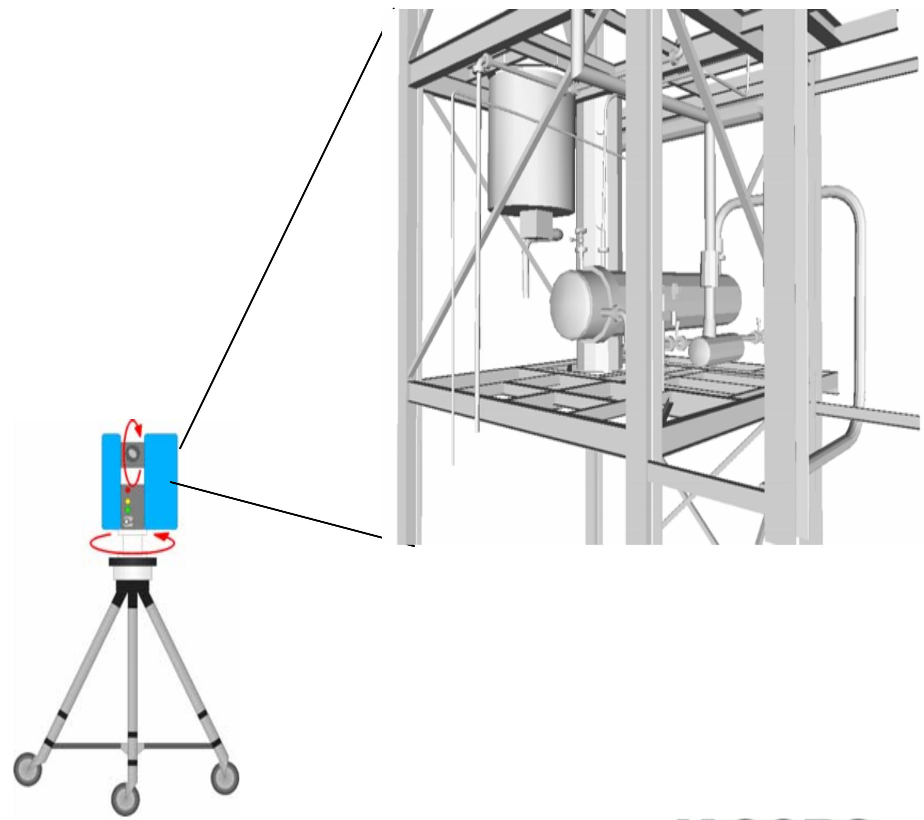
Uniformat	Component Name	Quantit	UM	Year Re	MARS I	RSL Cc	Forecas	Planned	Mission Dependenc	Locati
B2010	Steel, Painted, Exterior, 1st Floor	2800	Sq Ft	1972	40		2047		Mission Depe	
B2010	Steel, Painted, Exterior, 1st Floor	3280	Sq Ft	1970	38		2045		Mission Depe	Metal Parapet
B2010	Steel, Painted, Exterior, 1st Floor	1150	Sq Ft	1965	33		2040		Mission Depe	
B2010	Window Wall Panels, 1st Floor	4650	Sq Ft	1965	38		2045		Mission Depe	
B2010	Exterior Soffit Gypsum Board, Painted, 1st Floor	3360	Sq Ft	1972	-10	9	2016		Mission Depe	
B2010	Exterior Soffit Gypsum Board, Painted, 1st Floor	1760	Sq Ft	1965	-17	4	2011		Mission Depe	
B2010	Concrete Wall, Precast, Exterior	1130	Sq Ft	1965	NA		NA		Mission Depe	Precast Fascia I
B2010	Concrete Wall, Precast, Exterior	5440	Sq Ft	1972	NA		NA		Mission Depe	Precast Fascia I
B2030	Steel, Painted, Exterior Door	2	Each	1965	38		2045		Mission Depe	
B2030	Aluminum Frame, Fully Glazed, Exterior Door	6	Each	1972	30		2037		Mission Depe	
B2030	Aluminum Frame, Fully Glazed, Exterior Door	4	Each	1965	23		2030		Mission Depe	
B2030	Aluminum Frame, Fully Glazed, Sliding Exterior Door	4	Each	1965	23		2030		Mission Depe	
B2030	Steel Single 12'x12', Painted, Roll-up Door	1	Each	1965	-7		2000		Mission Depe	
B3010	Single-Ply Modified Bituminous/Thermoplastic Roof	40200	Sq Ft	2002	15		2022		Mission Critic	
C1010	Movable Partitions	176	Ln Ft	1997	15		2022		Mission Depe	
C1010	Movable Partitions	680	Ln Ft	1985	3		2010		Mission Depe	
C1010	Movable Partitions	300	Ln Ft	1990	8		2015		Mission Depe	
C1020	Steel, Painted, Interior Door	18	Each	2003	76		2083		Mission Depe	
C1020	Steel, Painted, Interior Door	12	Each	1997	70		2077		Mission Depe	

VDC: Capturing Existing Facilities in BIM

Laser Scan for Existing Conditions

- Survey Effort is Reduced
- BIM is Used for New Design
- Coordinate thru Interference Management
- Eliminates Field Rework





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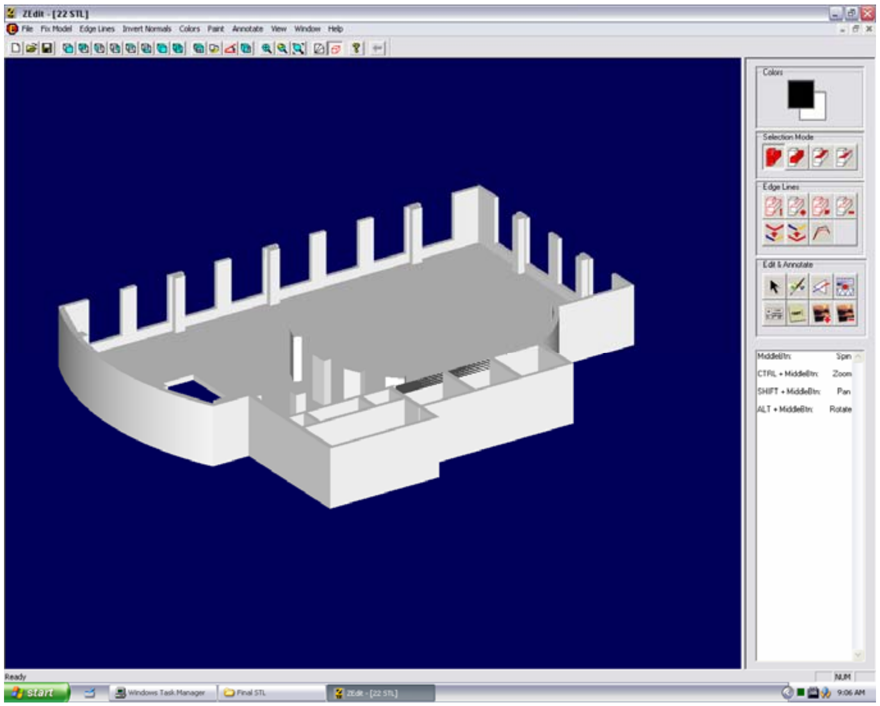
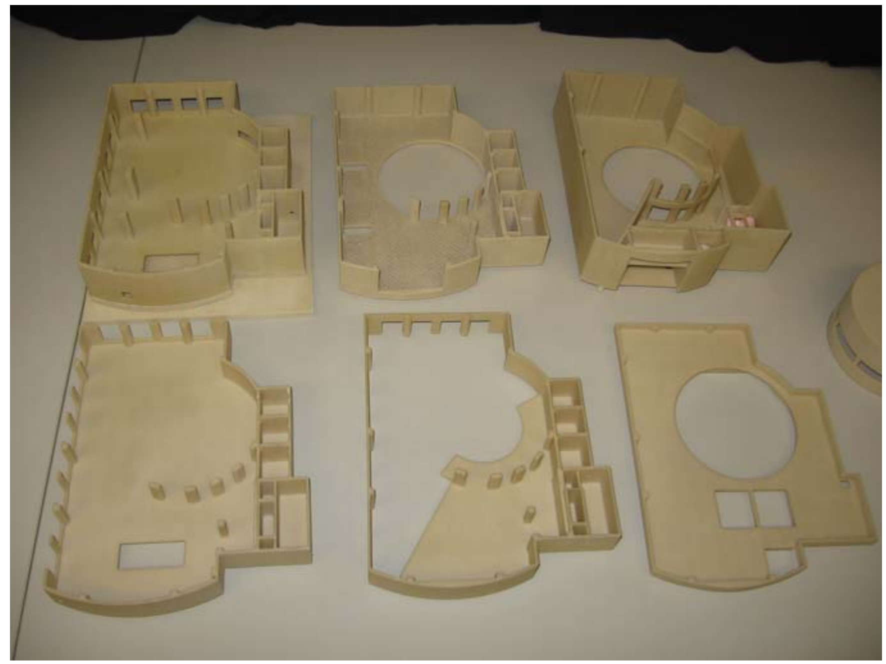
Technology in the Trailer:






Created by: Gary Koah / Jacobs Facilities Inc
Registered to: Gary Koah / Jacobs Facilities Inc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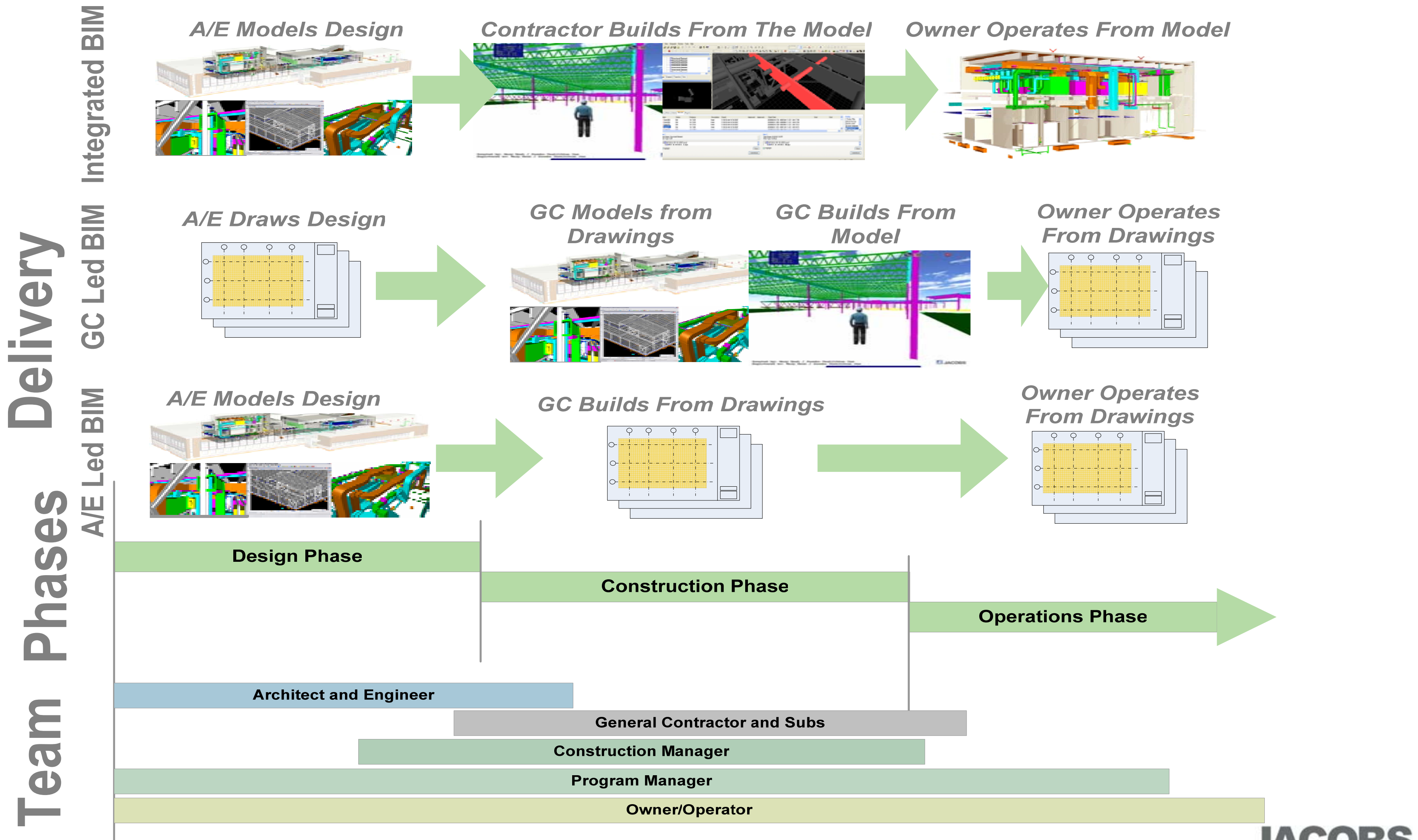
Integrated Team Approach



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Discussion

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