ICT in BUILDING
<table>
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<th>week</th>
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<tr>
<td>1</td>
<td>25/07/2017</td>
<td>Introduction</td>
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<td>History of ICT in the Construction Industry</td>
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<td>ICT use by Clients and Developers</td>
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<td>ICT use by Design Consultants</td>
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<td>ICT use by Head Contractors</td>
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<td>17/10/2017</td>
<td>Class Presentations</td>
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Understanding and Managing BIM in the Construction Industry

- Understanding the Supply Chain
- Managing Supply chain integration on projects
- PLM / ERP Integration at Hickory
Understanding Supply Chain Integration
Comparison with other industries

CONTINUING INNOVATION The automobile industry, like the aerospace industry, has seen tremendous paradigm shifts in production throughout its history. The movement from single craft assembly at the turn of the century to assembly-line production two decades later, and now to modular production has, led, at each shift, to significant improvements in the quality and cost of automobiles. (Images: from the collections of Henry Ford Museum & Greenfield Village.)
Comparison with other industries

Rethinking Building Lifecycle and Assembly

Image: Kieran/Timberlake - Refabricating Architecture

LOSING CONTROL. The last century witnessed an unprecedented development of new materials and improved environmental systems, as well as a new understanding of old topics, such as acoustics. This expansion of choices has added up to infinitely more complex and specialized buildings that require expertise in more subjects than one architect can master. The architect now coordinates the many diverse consultants who are able to master their own specialties.
Object Based Design & Assembly

Learning from others

Image: Kieran/Timberlake - Refabricating Architecture

Q = INTEGRATED COMPONENT CONSTRUCTION

IMPROVING THE SUPPLY CHAIN  The automotive industry has determined that expanding the supply chain into a few tiers has improved the quality of the final product and reduced its cost. Instead of having all parts arrive at the final point of assembly, the tiers gradually build up collections of parts to supply modules or integrated component assemblies to the original equipment manufacturer.
Professional Specificity – Spider Diagrams

Graphic mapping of varying priorities for the development of an office tower

- Average
- Fire Engineer 28.7 % off average
- Architect 12 % off average
- Structural Engineer 19.1 % off average
- Facade Engineer 24 % off average
- Acoustic Engineer 41.4 % off average
- ESD Consultant 27.5 % off average
- MEP Consultant 14.7 % off average
- Office Principals 15 % off average
Five fundamentally problematic aspects of contemporary PM:

... according to Li, Lu and Huang, 2009

1) using artificial tools and methods;
2) cannot try before build;
3) discontinuity in construction processes;
4) Ineffective information and knowledge management; and
5) creeping managerialism.
Building Systems Integration

Operational Islands across design stages

Source: (AIA, Richard Rush, 1991)
BIM - Focus on Policy, Process & People

- Interoperability
  "the ability to manage and communicate electronic product and project data between collaborating firms’ and within individual companies’ design, construction, maintenance, and business process systems”

Adoption of and alignment with preferred corporate systems

Ad-hoc Project ICT

Areas of duplicated information and manual transfer
Beyond BIM Information

Image: AEC Connect
Dassault Systèmes BIM/PLM Integration

AEC Delivery Challenges

No Data Integration
Consequence: Time delays & cost overruns

Disconnected Documents
Consequence: Throw-away work, rejected shop drawings and costly change orders

No Process Simulation
Consequence: Uncertain profit margin & delays due to injuries

Architect
Manufacturer
Builder

Permit Drawings
Shop Drawings
Sequence Drawings
The Need for Lifecycle Thinking

- 2/3 of costs due to a lack of interoperability are born by the owners/operators (avoidance, delay and mitigation)
- Estimated as £8.50 per ft$^2$ of development over a typical life-cycle
- Arising from productivity losses, manual re-entry, information verification...
- Costs during O&M phase regarded as being caused by a failure to manage upstream activities

Source: NIST Cost Analysis of Inadequate Interoperability
Comparison between traditional DBB paper-based process and collaborative BIM-based delivery process (Eastman, Teicholz, Sacks and Liston, 2011, p. 153)

**VALUE OF FACILITY DOCUMENTATION**
Joining the dots

Medial | Interior | Facades | Structure | MEP | QS

Visualisation | Physics | Acoustic | Wind | Fabrication | Construction

Integrated Planning

Integrated Planning
Supply chain integration in the Aerospace Industry

Product Lifecycle Management

a BOM-driven approach to implementation...

Slide by Julie Jupp, UTS
Boeing 777

- Bring example here
Goals of PLM

Product Lifecycle Management (PLM)

- Started with Product Data Management in car manufacture and aerospace, and ship-building
- Now going moving more and more into services and sustainability across many applications
- Shorten the time from concept to sales
- Reduce development costs.
- Ramp up production volumes to meet
- Manage and improve on product quality
- Reduce manufacturing costs as product moves from growth to maturity and into decline.
Goals of ERP

• avoiding data-duplication.
• location agnostic
• manage information across an enterprise in its totality
• web-based, centralised information storage
• accessed via cloud-based services
Characteristics of PLM, ERP & BIM

Product Lifecycle Management (PLM)
- Systems engineering
- Product and portfolio
- Product design
- Manufacturing process management
- Product Data Management

Enterprise Resource Planning (ERP)
- Resource planning
- Purchasing/Storage
- QA/Change Management
- Productivity management
- Finances/payroll, … and more

Building Information Modeling (BIM)
- Design authoring
- Design/Construction coordination
- Supply chain integration
- Construction Planning/Cost planning
- Life-cycle data integration for FM
The PLM/BIM/ERP nexus explained
Parallel development of PLM, ERP & BIM

• Little precedence about the PLM/ERP/BIM integration.

• Difficult alignment between BIM and ERP principles.

• ERP systems provide scalable solutions across an enterprise, whereas the construction industry is highly project-based.

• In construction, most inter-organisational stakeholders work on one-off projects, using disparate information-systems & formats.

• The effort for implementing PLM and ERP solutions is difficult to justify in smaller or medium sized organisations.

• Most likely beneficiaries are organisations with a large degree of off-site pre-fabrication, such as volume builders and equipment manufacturers with a high level of standardised components.
Complete integration of analysis and engineering documentation

**Figure 11. Building model supporting various engineering applications**

Image: Construction ICT Roadmap, Roadcon
Positioning the Sub-contractor

Design BIM

Construction BIM

Value!

As Maintained BIM
Increased convergence and data sharing

Figure 5. Benefits to key stakeholders

Image: Construction ICT Roadmap, Roadcon
Increased convergence and data sharing

Image: Autodesk
NATSPEC

- Clash detection/coordination
- Code checking
- Virtual testing and balancing
- Methods for showing functionality of occupants’ requirements
- Site analysis
- Space and equipment validation
- Modelling existing conditions
- Sustainability evaluation
- Quantity take-off and cost planning – 5D
- Other engineering analysis
- Communication of construction scheduling and sequencing – 4D
- Lift planning
- Facilities Management/As-built models
- Construction system design
- Design visualisation for functional analysis
- Structural modelling and analysis
- Design visualisation for communication
- Lighting analysis
- Energy analysis
- Digital fabrication
- Planning construction scheduling and sequencing – 4D
- Security assessment
- Site utilisation planning

Other engineering analysis

Dr Dominik Holzer, Semester 2, 2017
ICT changes the way we procure & operate assets
Global/Australian uptake of BIM in Construction

**Length of Time Using BIM**


- **Aus/NZ**
  - 1-2 Years: 39%
  - 3-5 Years: 28%
  - 6-10 Years: 50%
  - 11 or More Years: 47%

- **All Regions**
  - 1-2 Years: 28%
  - 3-5 Years: 18%
  - 6-10 Years: 9%
  - 11 or More Years: 2%

**BIM Expertise Level**


- **Aus/NZ**
  - Beginner: 26%
  - Moderate: 40%
  - Advanced: 27%
  - Expert: 7%

- **All Regions**
  - Beginner: 21%
  - Moderate: 37%
  - Advanced: 29%
  - Expert: 13%

**Current BIM Implementation Level**


- **Aus/NZ**
  - Light (Less Than 15% of Projects): 28%
  - Medium (15%-30% of Projects): 42%
  - Heavy (31%-60% of Projects): 22%

- **All Regions**
  - Light (Less Than 15% of Projects): 29%
  - Medium (15%-30% of Projects): 31%
  - Heavy (31%-60% of Projects): 22%

**BIM Engagement Level**


- **Aus/NZ**
  - Low BIM Engagement: 42%
  - Medium BIM Engagement: 36%
  - High BIM Engagement: 12%

- **All Regions**
  - Low BIM Engagement: 36%
  - Medium BIM Engagement: 36%
  - High BIM Engagement: 17%

**Planned BIM Investments Over Next Two Years**


- **Developing External Collaborative BIM Processes**
  - **Aus/NZ**: 43%
  - **All Regions**: 46%

- **New/Upgraded Desktop Machines**
  - **Aus/NZ**: 50%
  - **All Regions**: 50%

- **Developing Internal Collaborative BIM Processes**
  - **Aus/NZ**: 34%
  - **All Regions**: 34%

- **Developing Custom 3D Libraries**
  - **Aus/NZ**: 49%
  - **All Regions**: 49%

- **Software Customization/Interoperability Solutions**
  - **Aus/NZ**: 32%
  - **All Regions**: 34%

- **BIM Training**
  - **Aus/NZ**: 39%
  - **All Regions**: 39%

- **BIM Software**
  - **Aus/NZ**: 45%
  - **All Regions**: 41%

- **New/Upgraded Tablets/Mobile Devices**
  - **Aus/NZ**: 31%
  - **All Regions**: 38%
BIM under various procurement types
### BIM under various procurement types

<table>
<thead>
<tr>
<th>Procurement Type</th>
<th>Design BIM as Template for Tender</th>
<th>Design to Construction BIM</th>
<th>Early Sub-Contractor Involvement</th>
<th>Lifecycle BIM (incl. Asset Management)</th>
<th>Risk-Sharing Project-Insurance</th>
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*People don’t resist change – they resist risk*

Dawn Naney The State of BIM and IPD: an Owner’s Perspective, 2012
Managing Supply Chain Integration
BIM Management Plans
Regulating the collaborative effort
BIM Management Plans and more

Regulating the collaborative effort
BIM Management Plans and more
Regulating the collaborative effort
BIM – Integrated Project Delivery
Connecting project procurement to design technology

Keys to Integrated Project Delivery

- Involve all team members in design meetings, including contractors.
- Facilitate collaboration.
- Create a culture of trust and sharing.
- Check for and manage interferences between trades, digitally.

Images: Autodesk and California AIA
BIM – Integrated Project Delivery
Connecting project procurement to design technology
BIM – Integrated Project Delivery

Connecting project procurement to design technology
BIM Management Plans
What is it and why should we use one?

A good BIM Management Plan should address:

• Who and what the document is for?
• Who is involved, and in what capacity?
• What is sought for the project?
• What approach will be taken?
• How will the project be designed/built/managed?
• How will the project information be developed, exchanged, validated, used and re-used and over what period?
• What tools (software) and processes (BIM uses) will be used toward this purpose?
• How will those tools/processes be employed, by whom and when?
Integration with ‘existing building’ information

Figure 3-9 AAM point cloud scan—Revit Café sample.
Industry Challenges with BIM Implementation

- Perceived to be too complex and too difficult to use.
- Lack of standardization / Model Sizes & Management.
- Industry shortage of people with BIM skills and expertise.
- Divergence in rate of adoption of BIM.
- Industry going in many different directions.
- Lack of clarity in the contract responsibilities, obligations and deliverables.
- Expensive with no return on investment
BIM-MEP\textsuperscript{AUS} Workflows

Design Model (BIM-MEP\textsuperscript{AUS})

BIM-MEP\textsuperscript{AUS} Execution Plan / BIM Model Management

Online BIM-MEP\textsuperscript{AUS}

Commissioning

Site Positioning

Scheduling

BIM-MEP\textsuperscript{AUS} Shop Detailing, Prefabrication Setup

D&P Fabrication

B2B Procurement

Pre-Fabrication

Commissioned As-Built Model

BIM-MEP\textsuperscript{AUS} Execution Plan / BIM Model Management
BIM data embedded in 3D objects
Industry Example Project
Industry Example Project
Impact on PLM

From design intent – utilising non industry standard content leading to question not just around constructability but maintainability from a PLM standpoint BIM and industry standards go hand in hand for a full FM / PLM solution across the industry – future exchange or maintenance on the heat exchanges / valves / plate removal and replacement all aspects to be leveraged and adopted now to provide solutions for buildings in the future once all the construction teams have long forgotten the project.

Design intent - Fully coordinated Consultants model (3D View)
Impact on PLM

Constructible Review – Workshop detail (taken into consideration / service / access / future removal / replacement)
Impact on PLM

Commissioning / As-built BIM keeping PLM in mind
Summary

- Mechanical Contractors typically take the lead in site-coordination; they are also the ones who service & maintain equipment post delivery.

- Mechanical Contractors are empowered to provide essential value-add to life-cycle BIM as they close the gap between design intent by consultants, construction scheduling and costing.

- Specialist Mechanical Contractors are increasingly opting to link BIM to a construction model and leveraging benefits of offsite fabrication.

- BIM-MEP\textsuperscript{AUS} has provided an industry standard protocol for generic models and how manufacturers and suppliers can respond for procurement.

- BIM-MEP\textsuperscript{AUS} workflows demonstrate how information can progressively developed and data exchanged.

- The BIM-MEP\textsuperscript{AUS} initiative ultimately facilitates productivity improvements throughout the life-cycle from design to FM.
Determining predicted and actual use

Supply Chain Visibility
- Search and report across multiple projects

Field worker with tablet PC
- viewing either
  2D or 3D
  DWF sheets

- STATUS
  - Back order
  - In transit
  - On site
  - % Complete
  - Installed

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From BIM to TCO – getting the information you need

Tenant Service Request Trends by

Performance trends by work type
From BIM to TCO – getting the information you need

Building Analytics Model Harvester

Multiple Clients
The Hickory Example
Prefab Residential / Assembly on the Factory Floor
Unitised Building
Steps for transformation required at Hickory

• Consolidating separate information systems across the business into a centralised system for data storage & management

• Strong focus on frontloading the design effort in order to identify & validate detailed assembly requirements early on

• Logical naming conventions that allow for fluent data transfer between PLM, BIM and ERP.

• Knowledge engineering based on detailed analysis of prototypes & knowledge transfer down the supply-chain.

• Revised tool ecology with detailed specification of data-transfer and management.

• Introducing detailed process plans with clearly defined hold-points & identification of high-risk items.
Steps for transformation required at Hickory

1. Architectural Plan
2. Structural Mapping
3. Units Identified
4. Componentry identified
5. Bill of Materials produced
6. Shop Drawings
7. Module Manufacture
8. Fit Out
9. Dispatched
10. Installation
11. Commissioning
12. Final Completion
Prefab Residential / Assembly on the Factory Floor

Unitised Building
Steps for transformation required at Hickory
Prefab Healthcare Pods/ Structure & Mechanical

PREFabricated construction in healthcare
Prefab Healthcare Pods/ Structure & Mechanical
Comparison btw. traditional & systematised approach

![Comparison Chart]

- **Little Hero**: Hickory Building System - 9 months, Traditional Construction - 18 months
- **The Nicholson**: Hickory Building System - 12 months, Traditional Construction - 22 months
- **Pegasus**: Hickory Building System - 7 months, Traditional Construction - 16 months
- **Centvm**: Hickory Building System - 10 months, Traditional Construction - 18 months
- **3:East**: Hickory Building System - 11 months, Traditional Construction - 18 months

**Legend**:
- **Blue**: Hickory Building System
- **Gray**: Traditional Construction
Steps for transformation required at Hickory

- **Design & Planning**
  - Architect
  - BIM 3D Model
  - Shop Drawing
  - Bill of Materials

- **Procurement**
  - Supply Chain
  - Inventory Management

- **Manufacture**
  - Manufacture
  - Unit Assembly
  - Factory Finished

- **Supply & Install**
  - Dispatched
  - Transported into Position
  - Installed on Site
  - Finished Product

Epicor ERP System automates activity and facilitates information flow
Key Findings

• The construction industry aims to find a closer match between virtual representations of building components & their physical counterparts.

• BIM has reached a level of maturity where data fidelity is sufficiently resolved for interaction with PLM systems via well established BOMs.

• The Bill of Materials can feed into ERP processes and help to drive the production line as well as to manage other organisational aspects.

• Changing the mentality from a traditional mindset towards highly engineered manufacturing and production does not occur overnight.

• Once established, a well structured ‘PLM/ERP/BIM system’ should be transferrable geographically in order to minimise production cost.