Extending the enterprise to close the performance gap in the built environment

Seb Cox  M.Eng. M.Sc. MCIOB PMP
Nermeen Mahmoud  M.Sc. EIT

EllisDon Construction Services Inc

September 27, 2018
Seb Cox - Background

• 8 yrs Defense Aerospace O&M engineering (fast jet aircraft and support equipment)

• 8 yrs Project Management / O&M - Historic Buildings and Institutional Commercial and Industrial (ICI)

• M.Eng. (Mechanical Engineering) • M.Sc. (Construction Project Management) • MCIOB (Chartered Institute of Building) • PMP

• UK, Spain, Middle East and Canada

• Last 3 yrs in Calgary – consulting projects and some R&D with experts from EllisDon Corporation's diverse groups

• https://ca.linkedin.com/in/sebastianjcox
Nermeen Mahmoud - Background

- 8 yrs Engineering and Construction experience including 4 years in Virtual Design and Construction (VDC)
  - 15 projects in last 6 yrs including hospitals, airports, universities, commercial and residential buildings
- Leading the BIM team in EllisDon’s VDC Consulting service and building its capabilities
  - pre-construction coordination
  - as-built / reality capture
  - coordination drawings
  - BIM for facility management.
- Master’s in Civil Engineering / BIM management Diploma
Introduction

• Need for innovation in AECOO industry (Architecture Engineering Construction Owners and Operators)
  • Including cross over between project management and asset management
  • Knowledge and technologies from other industries (e.g. Defense Aerospace)

• Need for better systems integration as part of asset lifecycle capability development
  • increasing need for supply side integration / support across “extended enterprise”

• Need for collaboration (even between supply chain competitors)

• Case studies: 2 hospitals • 1 research facility • 1 utilities HQ • various healthcare use cases • some applicability to other sectors also

• Themes: Smart Building Technology • Building Information Modelling (BIM) / Virtual Design and Construction (VDC) • outsourcing of asset aftercare / technology support
AECO industry in need of change

• AECO Industry is a product of millennia of tradition so is resistant to change

• Second only to Agriculture and Hunting as the least digitized of industries in the USA (McKinsey & Company, 2017)

• Overall, productivity has been declining in recent years despite productivity gains in most other industries.

• Performance gaps are common place:
  • Expectations $\rightarrow$ design $\rightarrow$ as built/commissioned

• “Fragmentation” along multiple dimensions relating to: Organizational structure • IT systems • Process/workflow • Culture
Fragmentation of AECOO Industry

3 “dimensions” of fragmentation

- project/asset lifecycle ("vertical")
- trades / disciplines ("horizontal")
- between projects ("longitudinal")

Fragmentation of the Construction Industry (Sheffir, 2011).
Drivers of Change

• Complexity of systems (including digital technology)
• Sustainability goals
• Digital disruption
  • Enabling technologies increasingly capable / feasible
• Globalization of supply chain etc.

The above all demand / stimulate more integrated delivery of capital projects and sustainment services and convergence of digital technology
EllisDon’s Strategy

Such drivers have prompted the following response from EllisDon:

- Supporting assets *Cradle to Grave* with evolving services that deliver evolving *capability* (not just *product*)
  - no longer just construction (*product*) but focus on service
  - collaboration, innovation and technology addressing integration and performance gaps
  - asset management outsourcing (including finance / performance guarantees)
  - intelligent infrastructure and IT services, etc.
Main ‘lens’ for this presentation:

*Systems Integration & Capability Delivery*

*Systems integration is the composition of a capability by assembling elements in a way that allows them to work together to achieve an intended purpose.*

([www.mitre.org](http://www.mitre.org))

Under this definition, *capability* is synonymous with a *system* of elements or a *system of systems*. The elements can be both technical/physical as well as human, financial, knowledge, procedure etc.
Systems Integration and Capability

Discussion:

Compare lifecycle asset management of military aircraft versus hospitals

Obvious differences...less obvious similarities... (refer to white paper for more discussion)

• who are the systems integrators?
• nature of high level capabilities (relating to physical assets)?
• acquisition and support characteristics*

* Capability Delivery Model (Asset Management Council) on next slide is a resource for discussion
Case Studies

- Emera Global HQ Renewal, Halifax, NS
- Oakville Trafalgar Memorial Hospital
- Other Healthcare use cases
- DND Health Care Facility, Alberta
- Canadian High Arctic Research Centre (CHARS), Cambridge Bay, Nunavut
Emera HQ Renewal, Halifax, NS

- Ongoing alteration of 50 yr-old 125K ft² structure into a modern ‘Class A’ office space.
- Complete renewal of 7 floors
- New alternative energy generation
- New intelligent / converged building systems capabilities.
- Integration of adjacent 8-year old building’s legacy IT network
Emera HQ – Smart Building Capability Delivery and Support

- Design, Professional Services, and Support for integration of converged IT network
  - In-depth specification in collaboration with the owner’s IT teams.
  - Encompassing of many sub-system designs
    - Converged TCP/IP data network
    - IoT core/integration engine.
- Power over Ethernet (PoE) infrastructure at its core to power Building Automation System, Lighting System, CCTV System, Card Access
- Converged energy management network:
  - multi-tenant metering for both power and water systems
  - 60KW PV connected to TESLA Power Wall battery system
  - ability to sell energy back to grid.
Involvement in design and procurement ensured that the converged network design was optimized for:

- O&M and sustainability goals
- Security against evolving cyber threats
- Scalability and Adaptability
  - Open protocols
  - Platform agnostic
- Maximum utilization of converged network (no capability duplication)
Emera HQ – Smart Building Capability Delivery and Support

- EllisDon simultaneously performing Construction Management as well as a Master Technology Integrator role
- Allowed EllisDon to successfully deploy new processes and sequences for construction and commissioning
- Coordination of simultaneous mechanical, electrical, IT and communications systems installations and start-up
- Inherently complex systems interdependencies that do not exist with traditional non-converged building systems
- Systems require commissioning before building fully enclosed
- Complex contractual interfaces
- Reallocation of risk (especially to Master technology Integrator)
Emera HQ – Lessons & Future
Emera HQ – Lessons & Future

• Verified processes influencing best practice for future plans
  • E.g. procurement has to accommodate the smart building approach
    • sequencing of systems installations
    • work breakdown structure
    • roles and responsibilities and risks
    • transparency to manage the increased complexity of technology and service interfaces
    • need for interface management through Master Technology Integrator
  • Significant schedule and budget improvements in comparison with the adjacent 8-year-old building of similar size which also had a semi-converged network.
Emera HQ – Lessons & Future

• Importance of systems integration
  • “vertical” integration between design and construction and commissioning
  • “vertical integration” will continue through managed services for the IT infrastructure.
  • “horizontal integration” between trades
    • construction management PLUS master technology integrator
  • “horizontal” integration between consultants
    • interfaces with the converged building network through EllsiDon professional services
  • “longitudinal” integration between projects will be assisted through EllisDon’s continued role in managed services including campus fabric strategy
Oakville Trafalgar Memorial Hospital

This and all other OTMH images courtesy Halton Healthcare (Bill Bailey, VP Redevelopment - presentation to IFMA Toronto Chapter, 2017)
Oakville Trafalgar Memorial Hospital

- Design Build Finance and Maintain (DBFM) model

- EllisDon’s Facilities Services group and their partners worked together with the constructors to optimize design and to operate the hospital at risk for performance.

- Intelligent building solutions were designed, supplied, installed and are managed by EllisDon within this scope.

- The DBFM scope included the design and installation of systems furniture throughout the building for nursing communication stations and work stations.

- Outside of the DBFM scope, EllisDon also provided planning and procurement support for the remaining furniture fixtures and equipment (FF&E).
Oakville Trafalgar Memorial Hospital

**Outsourced Hard FM (EllisDon):**

- Operations and maintenance
  - plant
  - building systems
  - non-clinical equipment
  - structural / architectural
- Complete lifecycle responsibility for all building, plant and non-clinical equipment elements
- Utilities Management.

**Outsourced Soft FM (EllisDon):**

- Help Desk
- Roads and grounds maintenance
- Sustainability services
- Parking support
- Retail management services
Air Handling Units (1 of 37)

2.5mW Emergency Generator (1 of 6)

Oakville Trafalgar Memorial Hospital

Centrifugal Chillers (2 of 4)

Steam Boilers
Oakville Trafalgar Memorial Hospital

Intelligent Infrastructure (EllisDon):

Services:
Design – Supply – Installation - ongoing 24/7 management of performance with guarantees

Components:
- Core and Distribution Switches
- Access Switches
- Firewall, Servers, Operating System
- Wireless Controllers and Access Points
- Cisco Mobility Services Engine
- Cisco Prime and FirePOWER
- VMware ESXi and vSAN
- Master Clock

Automated Energy Optimization - pilot project funded by Sustainable Development Technology Canada and Emissions Reduction Alberta (EllisDon and SHIFT Energy)
Oakville Trafalgar Memorial Hospital

EllisDon provided and continues to provide supply-side project and service integration for Halton Healthcare:

- “Vertical” integration between design, construction and operations
  - Service integrated design, sustainable design (with design partners)
- “Horizontal” integration between trades, disciplines and technology systems
  - Lifecycle asset performance with penalties for performance failures
- “Extended Enterprise”
  - Embedded support personnel
  - Remote monitoring and support of IT systems
Oakville Trafalgar Memorial Hospital

Implementation and Lessons Learned

“Smart building infrastructure and support has transformed the way the hospital ensures patient safety and optimal care delivery”

More efficient and effective work flows through 120 different IT systems
Oakville Trafalgar Memorial Hospital

Smart Building End User Benefits
Oakville Trafalgar Memorial Hospital

A small handful of the smart building end-user benefits:

- Real Time Location Systems (RTLS) & wireless duress systems - better control risks of patient wondering, infant abduction and emergency response times.
- “Follow me printing” - printing paper consumption and printer inventories down 50%, better control of confidential documents.
- Persistent sign on - computer sessions remain active across dispersed workstations
- Mobile workflows improve efficiency by pushing information to the end user and reducing travel (e.g. mobile phones).
- Mobile telemetry improves effectiveness and safety where life-safety data such as cardiac wave-forms are pushed to end users.
- Asset tracking reduced inventories of critical fleet by eliminating hoarding (Maintenance and Biomed departments).
Oakville Trafalgar Memorial Hospital – Lessons

• Testing smart building use cases needs to happen in parallel with construction – i.e. before intelligent infrastructure is in place
  • Solution was to phase construction to enable “sampling” of full capability
• Software lifespans need careful consideration
  • E.g. 80 assets reached end of support life after only 3 yrs (obsolete driver)
• Strong owner leadership for collaboration and innovation is a key factor of success
• Strong supply-side systems integration key to promote transparency/convergence
• Balancing lifecycle costs risks and benefits is a perennial challenge/opportunity
  • greater complexity of systems
  • resources during front end pursuit stage – constraints / risk
  • exponential opportunities to innovate
Healthcare – Multi Trade Rack Prefabrication
Healthcare – Multi Trade Rack Prefabrication

- Multi trade racks (MTRs) designed with service and maintenance in mind
  - Systems contained in the rack
    - e.g. serviceable Variable Air Volume (VAV) boxes kept to the perimeter
    - plumbing was installed in the mid layer with electrical systems easily accessible at the bottom.
    - racks not built out to the full width of corridors - for considerable access to either side.
  - Due to requirement for advanced coordination, design integration is proactive rather than reactive, allowing more effective trade-off analysis earlier in design
Healthcare – Multi Trade Rack Prefabrication
Healthcare – Multi Trade Rack Prefabrication
Healthcare – Benefits of Multi Trade Rack Prefabrication

- BIM allowed for the strategic placement of valves and electrical boxes to accommodate the access required during the life span of the facility.
- The 3D model illustrated the access and was easily communicated to all stakeholders prior to fabrication.
- Eliminated clashes in the MTR scope, site performed trade scopes and building structure obstructions to servicing areas.
Healthcare - Clash Detection

Earliest intervention is most effective:

- Clash detection can be done within the 3D model with clash spheres by running a clash test - e.g. between structural and mechanical - red spheres will be shown in the 3D model to identify clashes.

- Allows comment and assign clashes and track each clash until it gets solved, and walkthrough the model.

- Geometry intersect done with the 3D model using scripts.
Healthcare – Fabrication Models (traditional M&E install)

- Fabrication models can be created two months prior to installation.
  - Sub-trades involved at an early stage
- Using project specifications, standards and requirements to accurately represent M&E components from specific manufacturers
- This technology provides convergence between designers and manufacturing.
Healthcare – Medical Equipment Vendor Integration

• Extensive coordination between base building services and structure and medical equipment and its structural support and service connections.

• Challenge extends beyond constructability and logistics to the management of equipment access and maintenance requirements.

• EllisDon involve medical equipment vendors early on in the design process
  • Equipment geometry and support structure geometry provided by equipment vendors early on in design
Healthcare – Medical Equipment Vendor Integration

OR Booms
Healthcare – Medical Equipment Vendor Integration
Healthcare – Medical Equipment Vendor Integration
Healthcare – Benefits of Early Vendor/Sub-Trade Integration

• Owners, consultants and operators given transparency they need to accurately understand the “whole system” impact of different design options.

• Lays the foundation that enables the 3D model to be developed to more accurately record the as built condition of the facility.

• 3D as-built model can then contain structured asset data collected throughout the project lifecycle and directly feeding CMMS and other FM systems.
  • potentially spanning multiple scopes (e.g. main contract vs owner supplies)

• Enables strategic procurement of parts and sub-assemblies

• Earlier validation of design and install.

• Improved interaction with the facility management team.
Asset information Models can contain asset registries, shop drawings, O&M manuals etc. and be used to assist asset management decision making and mobile/field work including potential integrations with CMMS.
Summary – Other Healthcare Use Cases

• Various approaches to systems integration are improving project management (and to some extent asset management) performance:
  • Prefabrication
    • Traditional M&E systems
    • Multi-trade racks (modern methods of construction)
  • Early equipment vendor and sub-trade involvement in design / asset data collection
  • 3D coordination of design and installation including prefabrication, clash detection and as-built modelling
  • Asset Information Modelling
• These approaches need *early* systems integration scope for optimal input of sub-trades and equipment vendors
DND Health Care Facility, Alberta

VDC scope (as part of design build):

- Models set-up based on survey data to improve collaboration with all stakeholders.
- Facilitate BIM process for the trades and consultants through the project phases.
- Coordination drawings produced to assist mechanical trades (level of detail 400 of 500).
DND Health Care Facility, Alberta

Implementation

• EllisDon has fully integrated “horizontally” between design disciplines and sub-trades.

• On behalf of the sub trades, EllisDon delivered fabrication-level modelling of M&E systems simultaneously
  • “horizontal” integration between sub trades (who often model to this level of detail in isolation)
  • “vertical” integration between design and construction.

• Allowed for design optimization for future O&M considerations avoiding costly rework on site (“vertical” integration between project and operations)
Implementation:

- Optimizing Coordination between the Mechanical models and all other disciplines
- Re-routing of Mechanical components to avoid clashes
- Supporting responses to requests for information and assisting change orders

Mechanical Penthouse – Coordination of AHU’s and of ducts through the shaft space.
Lessons / Future Steps:

- Assisted standardization of parts
  - to assist accuracy of installation pre-planning
  - to simplify the client’s procurement process downstream
  - to open up procurement options across multiple facilities (“longitudinal” integration).
- Fully detailed as-built model will be completed in a subsequent phase (“vertical” integration between construction and operations)
  - can be used to auto-populate the family types of shared assets and components in future facilities (“longitudinal” integration between projects)
- Design-build simplifies workflows but all procurement models can benefit.
Canadian High Arctic Research Station (CHARS)
Cambridge Bay, Nunavut

Facilities:
- Main Research Building
- Field Maintenance Building
- Two Triplex Accommodation Buildings

Services:
- Construction Management
- BIM/VDC Consulting
- FM Consulting
CHARS – Asset Management Readiness

Mapping parameters and bi-directional workflow between 3D model and Excel (horizontal and vertical convergence between systems)
CHARS – Asset Management Readiness

Maintainable asset data in 3D model - “vertical” convergence of BIM with FM asset information during construction
Cloud-based software used to create views for asset elements

- Coordination of latest BIM files from consultants and sub-trades (“horizontal” integration)
- Modifying the architectural, structural, mechanical, electrical, fire protection and infrastructure utilities models referencing as-built drawings (“horizontal” integration)
CHARS – Asset Management Readiness

Diesel Generator part of asset information model with location, sub-location, unique ID and flag for synchronization with CMMS etc.

BIM data synchronization with CMMS. >600 assets. Fields such as asset code, location, description, manufacturer, model and serial no. etc. (“horizontal” integration).
CHARS – Asset Management Readiness

• BAS set up for the field maintenance and residential buildings and integration with CMMS for alarms and notifications (“horizontal” integration)

• BIM/Asset Information Model updates so that it can be relied upon for collaborative decision support across a highly dispersed project team (“horizontal” integration)

• Establish asset management policies and procedures for the majority of the assets as follows (“vertical” integration):
  • Establish recommended maintenance strategies/schedules
  • Establish FM performance management system and reporting
  • Establish FM policies and procedures
  • Provide training to local and remote staff to utilize BIM models and CMMS and other procedures
  • Execute initial / phase 1 facilities management services (“vertical” integration)
CHARS - Implementation

- Challenges due to remoteness
  - specialist staffing at site for mandatory compliance issues
  - minimal site visits
  - bulk orders of consumables & replacement equipment as contingency
- Collaboration between remote support staff and the local Inuit workforce
- Requirements for asset information and the intended use cases for the geospatial model downstream of construction
- EllisDon acted as integrator and QA/QC lead
CHARS - Lessons Learned

• Informed best practice for future projects
  • guiding owner-specified Asset Information Requirements
  • establishing optimal workflows.
  • BIM/asset information model available to easily inform future renewal and alteration options and projects.
• “BIM for FM” requirements still unfamiliar territory for some project partners
• Requirement for early design stage involvement of contractors
  • to optimize the data model structure and workflows
  • to avoid unnecessary rework or sub-optimal outcomes downstream.
• Model / data quality only ever as good as the human input
Any Questions?

- The need for innovation in AECOO industry
- Knowledge and technologies from other industries (e.g. Defense Aerospace)
- Need for systems integration as part of capability development
- The need for collaboration

**Case studies:** Emera HQ Renewal, Halifax, NS • Oakville Trafalgar Memorial Hospital • Other Healthcare use cases • DND Health Care Facility, Alberta • Canadian High Arctic Research Centre (CHARS), Cambridge Bay, Nunavut

**Themes:** Smart Building Technology • Building Information Modelling / Virtual Design and Construction • Outsourcing of asset aftercare (including IT)