Integrating BIM and LEAN for Project Delivery

Construction of a Major Hospital in Jordan.
Introduction to CCC

Who We Are
- Top 22nd ENR int. Contractors
- High safety and environment consciousness.
- Operates in all continents mainly in MEA
- Around 6 B revenues
- Around 150K employees
- Around 1 B construction machineries.

Who We Serve
- Heavy Civil
- Process Plant
- Oil and Gas
- Infrastructure and Networks
- Road and Bridges
- Buildings
- Pipelines
Project Controls/ Room Completion System

King Hussein Cancer Centre Project
KHCC Scope of Work

The project includes Architectural Finishes and MEP Packages.

The project duration is 730 calendar days commencing 1st April 2014.

The current workforce is 850 persons and more than 40 sub-contractors.

The Hospital consists of 182 rooms and is comprised of two towers 10 and 12 floors above ground floor sharing the ground floor and three basement floors with an approximate total built-up area of 84,360 square metres.
Challenges

- Relatively small projects with high complexity
- A hospital by definition:
  - Many systems
  - Multiple room configurations
  - A lot of specialties and subcontract
- Utilize CCC Project Controls Strategy:
  - Hybrid system of BIM/AWP/Lean techniques
  - Fast track Finishing / Handover phase of hospital
Project Control Strategy

- Reliant Pull-Driven Technique optimize supply chain rather than sub optimization
  - Assure availability of resources before start of activity.
  - Emphasize productivity through the full work chain vs. individual activities
  - Prevent sub-optimization
  - Partnering
- Standardized Project Work Breakdown Structure
  - Project/Area/SubArea/Fragnet/Activity/Object/Operation
- Integrated EPC schedule with Emphasis on Handover and Construction Activities. (effective supply chain)
- 3D model built with WBS in mind and used as primary scope management tool.
- Early on Cooperation with the Partners/ EDI definition.
- 3 Month Look Ahead Schedule/ Material forward plan
- 3 week Look Ahead Schedule
Room completion system is based on integrated set of methodologies

- WBS
- BIM
- Invoice
- QC & Punch listing
- Work order
- Scope of work
- Fragnet templates
- 3 Week Look Ahead
- FEL
Work Breakdown Structure - WBS

It is a deliverable oriented hierarchy for a project that would organize the project’s team work into manageable sections.
Building project’s WBS

- **Level 1**: Project
- **Level 2**: Area 1, Area 2
  - Area 1: Sub-area 1, Sub-area 2
  - Area 2: Sub-area 3, Sub-area 4
- **Level 3**: Fragnet 1, Fragnet 2, Fragnet 3, Fragnet 4
- **Level 4**: Activity 1, Activity 2, Activity 3
- **Level 5**: Object 1, Object 2, Object 3, Object 4
- **Level 6**: Operation 1, Operation 2
- **Level 7**:
WBS Implementation

Level 1 - KHCC Construction

Level 2 - Area Location: Building1&2, Building Facades, Roof Works, External Works and Generator Building.

Level 3 - Zone Level: Floor Plans at specified Levels and Areas, Stairs, Shafts, Elevators, External areas.

Level 4 – Phase/Fragnet: Structural, Open space, finishing, building envelope, etc.

Level 5 - Activity: Unique Activity ID from Primavera

Level 6 - Object: Objects tagged as per BIM authoring

Level 7 - Operation: Operation templates as per object type and method statement (Work of One Crew)
Building Information Modelling - BIM

It is an intelligent 3D model based process that would provide a control tools for all project’s stakeholders during the project life.
Standardized BOQs as scope measurement

- Define BOQ, the basic way of measuring content of work
- Identify measurement methodology using any of the international standards such as SMM 7, RIC’s, etc...
- A BIM model is developed based on the tender documents and specification using BOQ and standardized WBS.
- Full MTO (Material Take-Off) is extracted from the BIM model detailed to the BOQ level. The MTO is linked to CCC estimation software where pricing is developed using crew-based estimation.
Object naming: WBS/naming conventions/asset tagging

![Diagram showing project WBS, BIM TAG, and Member Mark]

- **KHCC-B1-F9-HVAC-Dct001** Unique member mark

- **Project**
- **Building**
- **Floor**
- **Discipline**
- **P6-Activity**
- **Object s/n**
- **Operation**

- **Duct installation**
- **Dct001** fabrication

- **Project WBS** + **BIM TAG** = **Member Mark**
Required integrations using the modelled objects

- Primavera Activity / Activity ID
- BIM Authoring / Object Tag / Operation
- Estimation and Budgeting / Cost code
- Resources / Manhours / Equipments / Material
- BOQ / Qty & Specs. / BOQ code
- QC ITP / Category code
Room numbering
Room Type Colorization

The figure shows rooms located at Floor 9, Area 2. Rooms are colorized based on their type defined in the color legend.
Electrical systems identifications

The Cable Trays and Trunks are modeled as shown on the side figure.

The cables are identified and colorized based on the feeding system as given in the legend.
Mechanical systems identification

Mechanical Systems are identified and given a color based on their type.
System identification per room

Intersection between room and systems are identified:

- Duct Accessories
- Duct Fittings
- Ducts
- Flexible Ducts
- Mechanical Equipment's, such as FCU, TU, FSD, VD, ..etc.
- Pipes (Includes Drain Pipes, HVAC Pipes, Medical Pipes). The Tag Name can classify the pipes subsystem.
- Pipe Fittings
Coordination between Subcontractors

WBS

BIM

S/C scope of work
Subcontractor Scope Management

- Have an EDI agreement with the sub-contractor
- List the subcontractors and their BOQ items
- Analyze the subcontracted scope of work related to a section or volume of the model
- Link in between the drawings/documents and the sub-contractors scope of work
- Visualize the construction schedule of one or more subcontractors in a Gantt Chart
- Link the sub-contractors operations to fragnets and clearance forms for coordination
- Provide QC inspections, and punch listing for S/C work
- Provide clearance forms to control the relation of the S/C with others
- Subcontractor Invoice checking based on Earned value
EDI agreement with the sub-contractor

Electronic Data Interface meetings are to be done with the sub-contractor to agree on:

1- Model format coming from the S/C
2- Model Level of detail (LOD)
2- Naming conventions and tagging
3- Data and documents related to the objects/model
4- Update frequency for the data and change management
Defining sub-contractors’ scope graphically and their related BOQ

- Adding/removing subcontractors
- Assigned Objects per subcontractor
- BOQ per Subcontractor
Fragnets:
Templates of operations in sequence to complete a room
Sequence of Works (finishing & MEP systems within rooms)

Building the sequence of work as a **Fragnet per room type**. The sequence of work rely on:

**Lean Principles**
List of 26 operations for different disciplines within a room
Level 7 Operation link to QC Form
Front End Loading - FEL

- WBS
- BIM
- S/C scope of work
- Fragnet templates
- FEL
FEL (Front End Loading): is the process of checking and preparing of the execution elements that are required to consider a work front as an open front (Usually on the Zone/Fragnet Level)

The check list should include the following:
- Material
- Engineering
- PMV
- HSE
- QCPs
- Accessibility
- HR
- etc..

FEL main topics per different disciplines within the work front
- service departments
- Flag as 3M or 3W
- ETA dates
- Status
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Identify the open front

The subcontractor is allowed to start work at the selected green area which are designated as Open Front. The highlighted boundaries in brown are still not ready to start works.
To be ready for the 3 Week Look Ahead Schedule

- Target Progress from Schedule
- Objects/Operations and their relative weights per Activity with their MTO
- Crew Availability and their capacities
- Required QC Forms at completion of operations
- FEL to assure availability of drawings, material, procedures, etc.
- Weekly Meetings on Site to validate progress and plan the next 3 weeks (Generate Workorders)

Weekly Assignment per Crew
Site Planning – 3 weeks Look Ahead (Old)
Lean Site Planner
### Weekly Three Week Look-Ahead Report (Sample on Period 86)

**JV/CCC & HEC - King Hussein Cancer Centre Project**

Weekly Look Ahead Status Report for Period (86) Dated: 29 Dec 2015

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**Grand Total**

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Crew Availability
Work order and progress registry

- **WBS**
- **BIM**
- **S/C scope of work**
- **Fragnet templates**
- **FEL**
- **3 Week Look Ahead**
- **Work order**
## Digital Pen form

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<th>Description</th>
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*Note: The form is being filled out using a digital pen, and the user has indicated that some tasks are on hold.*
## Daily Foremen Report

**Date**: Aug 23, 2015  
**Start**: 2013-05-11 00:00:00  
**End**: 2013-05-17 00:00:00

### Activity ID | Object ID | Operation Code | Plan % | Act % | 100 | A-Z | Flex | Comments |
--- | --- | --- | --- | --- | --- | --- | --- | --- |
01-3030 | 02-3030 | MTB DUP1_MV_STR-SST-F | 000 | 000 | 000 | 000 | 000 | 000 |
02-3030 | 02-3030 | MTB DUP1_MV_STR-SST-F | 000 | 000 | 000 | 000 | 000 | 000 |
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06-3030 | 02-3030 | MTB DUP1_MV_STR-SST-F | 000 | 000 | 000 | 000 | 000 | 000 |
07-3030 | 02-3030 | MTB DUP1_MV_STR-SST-F | 000 | 000 | 000 | 000 | 000 | 000 |
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20-3030 | 02-3030 | MTB DUP1_MV_STR-SST-F | 000 | 000 | 000 | 000 | 000 | 000 |
Room Type Progress Colorization

The Room types are colorized based on their progress. The colors in the legend give the range of progress percentages.
C3D Progress Colorization By System

C3D colorization method can visualize the actual progress percentage on each system.
C3D and Subcontractor Progress (per system)

A list of subcontractors with systems related and percentage of progress in colors
C3D and Subcontractor Progress (Per room finishing)

The Floor Finishes are illustrated in the figure presenting overall progress on each room type.

We can allocate the responsibilities of each subcontractor on each floor and observe actual progress.
Standard progress reports

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Click on Sign to add text and place signatures on a PDF file.
QC forms and RFI tracking

WBS
BIM
S/C scope of work
Fragnet templates
FEL

Work order

QC & Punch listing

3 Week Look Ahead
C3D Atlas - Room Completion

Room QC check list

Atlas allow:

- Tracking the AFI
- Building QC scope
- Document progress
- Handing over dossier
C3D Atlas - System Progress Tracking

The selected system on each floor are tracked and followed depending on their ITP’s and form status. This will allow better operational sequence for the Testing and Commissioning Plan.
Punch list forms per rooms and subcontractors
Subcontractors Progress and Invoice checking

- WBS
- BIM
- S/C scope of work
- Fragnet templates
- FEL
- 3 Week Look Ahead
- Work order
- QC & Punch listing
- Invoice
<table>
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<th>DESCRIPTION</th>
<th>UNIT</th>
<th>Qty</th>
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Earned Value Calculations

1. Plan + Budget + contract
2. C3D Planner
   - Activity Percentage Completion
3. Cost Loading
   - Budgeted Cost & rules of credits per Operations
4. Total Earned Value for Activity
5. EV Reporting per WBS
<table>
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<th>ACTIVITY ID</th>
<th>ZONE LEVEL</th>
<th>DISCIPLINE (SYSTEM/ SUBSYSTEM)</th>
<th>ACTIVITY ID DESCRIPTION</th>
<th>SUB-CONTRACTOR</th>
<th>ACTUAL START</th>
<th>ACTUAL FINISH</th>
<th>BUDGETED UNITS % COMPLETE</th>
<th>COST % COMPLETE</th>
<th>UNITS DONE THIS PERIOD</th>
<th>ACTUAL LABOUR UNITS</th>
<th>BUDGETED LABOUR UNITS</th>
<th>ACTUAL COST</th>
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<th>PRIORIT Y ORDER</th>
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<td>2-Sep-15</td>
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## Weekly Budgeted Cost Progress Report (Sample on Period 87)

**JV/ CCC & HEC - King Hussein Cancer Centre Project**

Weekly Budgeted Cost Progress Report for Period (87) Dated: 29 Dec 2015

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
<th>Budgeted Cost (JOD)</th>
<th>Cost Progress - Last Period</th>
<th>Cost Progress - Original Plan</th>
<th>Cost Progress - Actual This Period</th>
<th>Difference Between Periods</th>
<th>Variance</th>
<th>Cost Progress - Last Period %</th>
<th>Cost Progress - Original Plan %</th>
<th>Cost Progress - Actual This Period %</th>
<th>Difference Between Periods %</th>
<th>Variance %</th>
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<td>-15.96%</td>
<td>-15.96%</td>
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<td>-15.96%</td>
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</tbody>
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### Budgeted Cost Progress (%)

- **Cost Progress - Last Period %**
- **Cost Progress - Original Plan %**
- **Cost Progress - Actual This Period %**
- **Difference Between Periods**
- **Variance %**

### Budgeted Cost Progress (JOD)

- **Cost Progress - Last Period**
- **Cost Progress - Original Plan**
- **Cost Progress - Actual This Period**
- **Difference Between Periods**
- **Variance**
Thank you
Zuhair Haddad
zuhair@ccc.me
CCT – Booth 8