Project Delivery Performance:
Lessons Learned from Vertical Construction

AFH30:
Digital Project Delivery

Presented by:
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January 11th, 2014
Agenda

- Project motivation
- Background
- Limitations in the current BOK
- Goals and objectives
- Research methods
- Data collection
- Data analysis
- Conclusions
Observed problem:  
“The current project delivery decisions made by owners are on the basis of personal preference and comfort level.”

Reason:  
“Due to lack of experience and objective performance data.”

Solution:  
“There is a need for objective data and empirical evidence to support the performance of various project delivery methods.”
A research project conducted by Dr. V. Sanvido and Dr. M. Konchar of Penn State and CII Research Team 133

**Title:** “Project delivery systems: CM at risk, design-build, design-bid-build.”

**Goal:** “To improve delivery method selection by providing practical guidelines though empirical evidence.”

**Key performance metrics:** Cost, schedule, and quality

**Project delivery systems:** DB, DBB, and CM at risk

**Database:** 351 building projects

**Contribution:** “To provide guidance for owners on how to organize a successful project.”

**Findings:**
- The costs and schedule growth of DBB projects were higher than the other methods; and
- The construction and delivery speed of DB was faster than DBB.
### Summary of principal metrics studied by CII (1997)

<table>
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<tr>
<th>Performance metrics</th>
<th>DBB</th>
<th>DB</th>
<th>CM@R</th>
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</thead>
<tbody>
<tr>
<td>Cost growth (Median)</td>
<td>4.83</td>
<td>2.17</td>
<td>3.37</td>
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<tr>
<td>Schedule growth (Median)</td>
<td>4.4</td>
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<tr>
<td>Construction speed (Median-1000s SF/month)</td>
<td>5135</td>
<td>9091</td>
<td>8192</td>
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<tr>
<td>Design and construction speed (Median-1000s SF/month)</td>
<td>3250</td>
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<td>4712</td>
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<tr>
<td>Intensity (Median)</td>
<td>3.67</td>
<td>5.79</td>
<td>4.67</td>
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<tr>
<td>Quality (Aggregated scores)</td>
<td>43.14</td>
<td>45.9</td>
<td>39.14</td>
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</table>
The performance outcomes collected in the CII study was limited to cost, schedule, and quality;

The focus of CII was mainly on delivery methods while recent studies showed that team selection and contract methods can also considerably affect the project performance.
Goals and Objectives

Objective

✓ To determine the role of project delivery methods and team integration in project success.

Outcome

✓ A suite of empirical guides to successful owner practices regarding roles, team integration, team behavior, delivery method, procurement method, and project performance.

Impacts

✓ Providing a repeatable process for making key projects decisions.
✓ Allowing owners to select delivery methods, project teams and contracting methods that offer the greatest likelihood of success.
✓ Improving transparency of decision-making process regarding delivery method.
Research Methods

**Project Organization**

- **Delivery method**
  - (Design-Bid-Build, CM at Risk, Design-Build, IPD)
- **Contract terms**
  - (Lump Sum, Cost Plus, GMP)
- **Team selection**
  - (Low Bid, Prequalified Bid, Negotiated)

**Project Execution**

**Rank** | **Processes**              | **Technologies** | **Behaviors**                  |
---------|----------------------------|------------------|--------------------------------|
 1       | Prequalification of team   | BIM uses         | Open book accounting           |
 2       | BIM execution planning     | File sharing systems | Shared risk and reward       |
 3       | Partnering/team building   | Modularized designs | Joint project management    |
 4       | Co-location of team        | Communication latency | Communication formality  |
 5       | Lean decision-making tools | File to fabrication | Level of trust               |
 6       | Risk management            | BIM ownership     | Clarity of leadership         |
 7       | Process facilitator        | Facility management | Contingency management       |
 8       | Offsite prefabrication     | Last Planner      | Goal commitment               |
 9       | Decision-making procedure  | Electronic design reviews | Prior team relationship   |
10       | Design responsibility      | Visual management | Multi-trade prefabrication    |

**Project Success**

- **Budget performance**
  - (Unit cost, Cost growth)
- **Schedule performance**
  - (Schedule growth, Delivery speed, Intensity)
- **Facility quality**
  - (System, Aesthetics, Functionality)
## Research Methods (*Outcomes*)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Data Collected</th>
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<tbody>
<tr>
<td>Project cost growth (%)</td>
<td>Final project cost (D+C)</td>
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<td>Awarded project cost (D+C)</td>
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<tr>
<td>Construction cost growth (%)</td>
<td>Final construction cost (C)</td>
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<td>Awarded construction cost (C)</td>
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<td>Final project unit cost ($/SF)</td>
<td>Final project cost (D+C)</td>
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<td>Gross square footage</td>
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<td>Project schedule growth (%)</td>
<td>Contracted and as-built design start</td>
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<td>Contracted and as-built substantial completion</td>
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*Full list in questionnaire*
SECTION 9: TEAM CHARACTERISTICS & BEHAVIOR

Indicate the owner’s type of relationship with the project team:

- Architect/Designer: □ First Time □ Repeat
- GC, CM/GC or DB: □ First Time □ Repeat

Evaluate each of the following attributes of your project team:

- Team’s prior experience as a unit ($1=Low$, $6=High$):
  - Low: □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 High
- Team chemistry ($1=Poor$, $6=Excellent$):
  - Poor: □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 Excellent

Relative to your expectations, denote the frequency of staff turnover within the project team ($1=Low$, $6=High$):

- Low: □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 High

When was end-user feedback provided to the project (check all that apply)?

- Inception
- Conceptual
- DD
- Construction
- Programming
- SD
- CD
- Operation
Specify when each project participant was **co-located** or sharing a workspace with other team members (*check all that apply)*:

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<thead>
<tr>
<th></th>
<th>Owner</th>
<th>Architect/Designer</th>
<th>CM/GC</th>
<th>MEP Contractors</th>
<th>Structural Contractors</th>
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<tr>
<td><strong>Design Phase</strong></td>
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<td><strong>Construction Phase</strong></td>
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</table>

Evaluate the communication among the project team:

**Formality of communication** (*1=Informal, 6=Formal*):

- Informal: 1  2  3  4  5  6 Formal

**Timeliness of communication** (*1=Never on time, 6=Always on time*):

- Never: 1  2  3  4  5  6 Always

How often did the project team compromise on project issues (*1=Never, 6=Frequently*)?

- Never: 1  2  3  4  5  6 Frequently

Did the project team manage a shared, internal contingency usable by both design and construction team members? **Yes** **No**

Who participated in setting goals for the project (*check all that apply*)?

- Owner
- Architect/Designer
- GC, CM/GC or DB
- MEP Contractors
- Structural Contractors
- Other: _____________________________

To what extent were all project team members committed to the same project goals (*1=Very Weakly, 6=Very Strongly*):

- Weakly: 1  2  3  4  5  6 Strongly
SECTION 10: PROCESS AND TECHNOLOGY

Number of design charrettes held by the project team:

Who was involved with the design charrettes (check all that apply)?
- Owner
- GC, CM/GC or DB
- Structural Contractors
- Architect/Designer
- MEP Contractors
- Other: ____________________________

How was Building Information Modeling (BIM) used (check all that apply)?
- BIM was not used
- MEP Coordination/Clash Detection
- Architectural Design
- 4D Scheduling
- Engineered Systems Design
- Facility Management

Who was involved in developing a BIM execution plan (check all that apply)?
- No BIM execution plan was developed for this project
- Owner
- GC, CM/GC or DB
- Structural Contractors
- Architect/Designer
- MEP Contractors
- Other: ____________________________

To what extent was electronic file and information sharing used by the project team (1=Primarily paper-based, 6=All electronic)?

**Paper-based**
- 1
- 2
- 3
- 4
- 5
- 6 **Electronic**

List any lean tools or approaches consistently used by the project team:

Evaluate the level of offsite fabrication and modularization used on the project (1=Entirely built onsite, 6=Entirely built offsite):

**Onsite**
- 1
- 2
- 3
- 4
- 5
- 6 **Offsite**

Did any prefabricated or modularized system on the project involve multiple trades?  Yes  No
Research Methods (Data Collection)

Questionnaire

- Call back contractor
- Call back owner
- Sharing screen
- Developing FAQ sheet
- Developing call-back guideline

Database

Owner's Guide to Maximizing Success in Integrated Projects

- Project ID: DE-003-G1
- Name of the Code: Defuald

1. Project Characteristics
2. Organization
3. Cost
4. Schedule
5. Quality
6. Safety
7. Sustainability

- Design start date (notice to proceed): 4/1/2004
- Construction start date (notice to proceed): 5/1/2004
- Construction End Date (substantial completion): 9/1/2006
- Facility operational date: 9/1/2006

Owner's Guide to Maximizing Success in Integrated Projects

- Project ID: DE-003-G1
- Name of the Code: Defuald

10. Team Characteristics
11. Team Behavior and Interactions
12. Process and Technology

- Q10-1: Individual experience of key team members with similar facilities:
  - Owner: 6 (High)
  - Designer: 6 (High)
  - Contractor: 5
  - Mechanical Contractor: 5
  - Electrical Contractor: 5
  - Structural Steel Contractor: 5
  - Concrete Contractor: 5

- Q10-2: Team experience of key members on your project's delivery system:
  - Owner: 7 (High)
  - Designer: 7 (High)
  - Contractor: 7
  - Mechanical Contractor: 7
  - Electrical Contractor: 7
  - Structural Steel Contractor: 7
  - Concrete Contractor: 7
Types of Data Collected

Categorical

- **Ordinal**: Naturally ordered as increasing or decreasing
  - Examples: 6pt rating scales, Level of LEED certification, Phase of involvement

- **Nominal**: Non-ordered
  - Examples: Delivery method, Contract terms, Owner type

Continuous

- Ordered with meaningful intervals
  - Examples: Cost growth, Schedule growth, Delivery speed
1. **Correlation**

*Tests for directional relationship between 2 variables*

*May be positive or negative*

**Examples:**
- Team chemistry with cost growth
- Number BIM uses with final project unit cost

2. **Difference in means**

*Tests for equal means*

**Examples:**
- Mean cost growth by owner type
- Final project unit cost by building type
Sample Demographics

By building type and building size:

- Recreation
- Municipal
- Hotel
- Office
- Educational
- Industrial
- Health Care
- Other

Building Size (ft²)

- < 50,000
- 50,000 - 150,000
- 150,000 - 350,000
- > 350,000

Percentage of Sample

Building Type

Private | Public
More Sample Demographics

By delivery method, builder selection process and builder payment terms:

Builder Selection Process

Builder Payment Terms

Delivery Method
### Bivariate Correlations, all variables

#### Spearman Rho: Size estimation and significance

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<tr>
<th>Variables</th>
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<td>7. Administrative burden</td>
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<td>11. Frequency of compromise</td>
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</table>

**Size estimation:**
- None (--): 0.0 to 0.09
- Small (S): 0.29 to 0.10
- Medium (M): 0.30 to 0.49
- Large (L): 0.50 to 1.0

**Significance (two-tailed):**
- *** $p < 0.001$
- ** $p < 0.01$
- * $p < 0.05$
### Bivariate Correlations, performance only

#### Spearman Rho: Size estimation and significance

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#### Significance (two-tailed):
- *** $p < 0.001$
- ** $p < 0.01$
- * $p < 0.05$
Case Study

**Characteristics:**

- One of the most advanced television studio in the country.
- The owner worked with a developer for 2 years, but did not get anywhere.
- Total cost of 71M

**Excellent budget and schedule performance!**

**Success factors**

- The mechanical, electrical, plumbing, glazing, concrete and earthwork were selected before the RFQ as DB assist.
- Revit was used from day 1 of programming, blocking & stacking throughout the entire design and construction process.
- During the design phase, the design team met (charrettes) with end users frequently (every Monday).
- Project schedule was updated daily and the BIM updated weekly.
- Last Planner was used from early phase of the project.
Case Study

➢ Characteristics:
  ▶ One of the most advance television studio in the country.
  ▶ The owner worked with a developer for 2 years, but did not get anywhere.
  ▶ Total cost of 71M

It was the right team.

➢ Success factors
  ▶ The mechanical, electrical, plumbing, glazing, concrete and earth work were selected before the RFQ as DB assist.
  ▶ Revit was used from day 1 of programming, blocking & stacking throughout the entire design and construction process.
  ▶ During the design phase, the design team met (charrettes) with end users frequently (every Monday).
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Conclusions

✓ Team environment is related to project success:
  1) **Communication timeliness** with construction cost growth;
  2) **Team chemistry** with overall schedule growth; and
  3) **Administrative burden** with construction cost growth and final unit cost.

✓ Team building
  1) **Personnel matters**
  2) **Team A vs. Team B**

✓ Avoiding bandwagon effect
Thank you for your time.