Quantification of Cost, Benefits and Risk Associated with Alternate Contracting Methods and Accelerated Performance Specifications

AASHTO Subcommittee on Construction

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*University of Colorado*
## Alternative Contracting Methods (ACM)

<table>
<thead>
<tr>
<th>TRADITIONAL</th>
<th>ALTERNATIVE CONTRACTING METHODS</th>
</tr>
</thead>
</table>

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**August 16, 2016**
Research Objectives

• Document ACM benefits, costs, risks and lessons learned
• Quantify cost, schedule, and quality consequences of ACMs
• Update Transportation Construction Management Pooled Fund Project Delivery Selection Matrix
• Promote ACM lessons learned and best practices
Research Project Scope

- FHWA-funded, 2-1/2 year research study
- More than 15 investigators and research assistants
- Data collected from 291 completed projects
- Deliverables include data analysis and lessons learned
  - FHWA Tech Briefs
  - TRB and white papers
  - Conferences and webinars
FHWA Tech Brief of Empirical ACM Performance

• Introduction
• Data Collection
• Results and Discussion
  – Contracting Methods
  – Complexity
  – Project Risks
  – Procurement Methods
  – ATCs
  – Payment Methods
  – Project Costs
  – Project Duration
  – Schedule/Cost Certainty
  – Project Intensity
  – Award Growth
  – Cost Growth
  – Change Orders
  – Schedule Growth
• Project Delivery Selection
• Summary

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Data Collection

Data Collection Goals

• Collect the largest highway project delivery database
• Collect only *completed* projects
• Collect diverse sample of completed projects
  – Geographic
  – Project type
  – Project size
  – Project complexity
• Seek statistically significant results
Data Collection

• Two-step approach
  1. Contract admin databases
  2. Project manager questionnaires
• Follow-up calls for data validation
Data Collection

States with CM/GC Experience
Data Collection

States That Contributed D-B-B Projects
Data Collection

• 291 projects
  - 134 D-B-B projects
  - 34 CM/GC projects
  - 39 D-B/LB projects
  - 84 D-B/BV projects
• 28 agencies
• Completed 2004-2015

States That Contributed: D-B-B, CM/GC & D-B Projects
## Project Procurement Methods

<table>
<thead>
<tr>
<th>Procurement Procedure</th>
<th>D-B-B (n=134)</th>
<th>CM/GC (n=34)</th>
<th>D-B/LB (n=39)</th>
<th>D-B/BV (n=84)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Bid</td>
<td>80%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Best Value</td>
<td>14%</td>
<td>47%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Qualification-Based</td>
<td>1%</td>
<td>41%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Total of each column may not sum to 100% because of unclassified procurement procedures by respondents.*
## Project Complexity

<table>
<thead>
<tr>
<th>Most Complex (Major)</th>
<th>Moderately Complex</th>
<th>Non-complex (Minor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• New highways; major relocations</td>
<td>• 3R and 4R projects which do not add capacity</td>
<td>• Maintenance betterment projects</td>
</tr>
<tr>
<td>• New interchanges</td>
<td>• Minor roadway relocations</td>
<td>• Overlay projects, simple widening without right-of-way (or very minimum right-of-way take) little or no utility coordination</td>
</tr>
<tr>
<td>• Capacity adding/major widening</td>
<td>• Non-complex bridge replacements with minor roadway approach work</td>
<td>• Non-complex enhancement projects without new bridges (e.g. bike trails)</td>
</tr>
<tr>
<td>• Major reconstruction (4R; 3R with multi-phase traffic control)</td>
<td>• Categorical Exclusion or non-complex Environmental Assessment required</td>
<td>• Categorical Exclusion</td>
</tr>
<tr>
<td>• Congestion management studies are required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Environmental Impact Statement or complex Environmental Assessment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project Complexity

Most Complex (major) = 140 (48%)
Moderately Complex = 107 (37%)
Non-Complex (minor) = 42 (15%)
D-B-B Project Complexity

- Non Complex: 46%
- Moderately Complex: 39%
- Most Complex: 15%

D-B-B = 134 (46%)
CM/GC Project Complexity

- CM/GC = 34 (12%)
- Non Complex (3%)
- Moderately Complex (32%)
- Most Complex (65%)
D-B Project Complexity

D-B/BV = 84 (29%)

D-B/LB = 39 (13%)

Most Complex 23%
Moderately Complex 35%
Non Complex 38%

Most Complex 39%
Moderately Complex 35%
Non Complex 7%
## Project Size

### Average Project Cost

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean</th>
<th>Median</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=134)</td>
<td>$20,286,637</td>
<td>$12,438,075</td>
<td>$183,202</td>
<td>$252,052,326</td>
</tr>
<tr>
<td>CM/GC (n=34)</td>
<td>$36,328,010</td>
<td>$19,167,399</td>
<td>$1,390,828</td>
<td>$235,936,099</td>
</tr>
<tr>
<td>D-B/LB (n=39)</td>
<td>$10,646,348</td>
<td>$4,384,177</td>
<td>$69,108</td>
<td>$68,826,264</td>
</tr>
<tr>
<td>D-B/BV (n=77)</td>
<td>$43,364,854</td>
<td>$22,127,526</td>
<td>$622,317</td>
<td>$357,760,287</td>
</tr>
</tbody>
</table>

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## Average Project Cost

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean</th>
<th>&lt; $20M</th>
<th>&lt; $10M</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=134)</td>
<td>$20,286,637</td>
<td>63%</td>
<td>39%</td>
</tr>
<tr>
<td>CM/GC (n=34)</td>
<td>$36,328,010</td>
<td>47%</td>
<td>29%</td>
</tr>
<tr>
<td>D-B/LB (n=39)</td>
<td>$10,646,348</td>
<td>82%</td>
<td>70%</td>
</tr>
<tr>
<td>D-B/BV (n=77)</td>
<td>$43,364,854</td>
<td>38%</td>
<td>27%</td>
</tr>
</tbody>
</table>
## Average Project Duration

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean Cost ($)</th>
<th>Mean Project Duration (Days)</th>
<th>Mean Agency Design Duration (Days)</th>
<th>Mean Construction Duration (Days)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=74)</td>
<td>$21,687,447</td>
<td>1,774</td>
<td>932</td>
<td>642</td>
</tr>
<tr>
<td>CM/GC (n=24)</td>
<td>$41,368,952</td>
<td>929</td>
<td>361</td>
<td>511</td>
</tr>
<tr>
<td>D-B/LB (n=18)</td>
<td>$12,249,585</td>
<td>889</td>
<td>268</td>
<td>435</td>
</tr>
<tr>
<td>D-B/BV (n=21)</td>
<td>$48,532,458</td>
<td>1,516</td>
<td>662</td>
<td>837</td>
</tr>
</tbody>
</table>

* Note “Construction Duration” for D-B projects includes design-builder design and construction (D-B contract duration).
### Tech Brief of Empirical ACM Performance

#### Ave Duration for D-B-B & D-B/LB projects between $2M-10M

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean Cost ($)</th>
<th>Mean Project Duration (Days)</th>
<th>Mean Agency Design Duration (Days)</th>
<th>Mean Construction Duration (Days)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=19)</td>
<td>$4,958,329</td>
<td>1,506</td>
<td>795</td>
<td>508</td>
</tr>
<tr>
<td>D-B/LB (n=10)</td>
<td>$4,745,533</td>
<td>773</td>
<td>181</td>
<td>380</td>
</tr>
</tbody>
</table>

* Note “Construction Duration” for D-B projects includes design-builder design and construction (D-B contract duration).
Tech Brief of Empirical ACM Performance

Timing of Award for D-B-B & D-B/LB projects between $2M-10M

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**Tech Brief of Empirical ACM Performance**

Ave Duration for **D-B-B, CM/GC and D-B/BV Projects between $10M-50M**

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean Cost ($)</th>
<th>Mean Project Duration (Days)</th>
<th>Mean Agency Design Duration (Days)</th>
<th>Mean Construction Duration (Days)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=34)</td>
<td>$21,188,585</td>
<td>2,130</td>
<td>1,139</td>
<td>818</td>
</tr>
<tr>
<td>CM/GC (n=10)</td>
<td>$23,912,981</td>
<td>662</td>
<td>281</td>
<td>349</td>
</tr>
<tr>
<td>D-B/BV (n=10)</td>
<td>$18,604,503</td>
<td>1,420</td>
<td>638</td>
<td>639</td>
</tr>
</tbody>
</table>

*Note “Construction Duration” for D-B projects includes design-builder design and construction (D-B contract duration).*
Tech Brief of Empirical ACM Performance

Timing of Award for D-B-B, CM/GC & D-B/LB Projects between $10M-50M
### Project Intensity

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean Cost ($)</th>
<th>Mean Project Intensity ($/Days)</th>
<th>Min. Project Intensity ($/Days)</th>
<th>Max. Project Intensity ($/Days)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=74)</td>
<td>$21,687,447</td>
<td>$12,802</td>
<td>$269</td>
<td>$123,566</td>
</tr>
<tr>
<td>CM/GC (n=24)</td>
<td>$41,368,952</td>
<td>$46,450</td>
<td>$3,618</td>
<td>$159,031</td>
</tr>
<tr>
<td>D-B/LB (n=18)</td>
<td>$12,249,585</td>
<td>$12,816</td>
<td>$894</td>
<td>$49,892</td>
</tr>
<tr>
<td>D-B/BV (n=21)</td>
<td>$48,532,458</td>
<td>$28,527</td>
<td>$1,930</td>
<td>$204,341</td>
</tr>
</tbody>
</table>

* Note “Construction Duration” for D-B projects includes design-builder design and construction (D-B contract duration).
## Relationship between ACMs and Award Growth

### Project Award Growth per Delivery Method

<table>
<thead>
<tr>
<th>Contract Method</th>
<th>Mean (%)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-B-B (n=129)</td>
<td>-9%</td>
<td>18%</td>
</tr>
<tr>
<td>CM/GC (n=31)</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>D-B/LB (n=37)</td>
<td>-5%</td>
<td>32%</td>
</tr>
<tr>
<td>D-B/BV (n=78)</td>
<td>-7%</td>
<td>22%</td>
</tr>
</tbody>
</table>

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### Relationship between ACMs and Change Orders

<table>
<thead>
<tr>
<th>Change Orders</th>
<th>D-B-B (n = 65)</th>
<th>CM/GC (n = 19)</th>
<th>D-B/LB (n = 21)</th>
<th>D-B/BV (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency Directed</td>
<td>1.2%</td>
<td>0.7%</td>
<td>1.6%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Plan Quantity Changes</td>
<td>1.1%</td>
<td>0.3%</td>
<td>0.6%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Unforeseen Conditions</td>
<td>2.4%</td>
<td>1.5%</td>
<td>1.8%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Plan Errors and Omissions</td>
<td>0.9%</td>
<td>0.6%</td>
<td>0.1%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Other</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.8%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Total</td>
<td>5.8%</td>
<td>3.4%</td>
<td>5.0%</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

Average Impact (% of cost growth) of Change Order Categories

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Selecting Project Delivery Methods

• Project Delivery Selection Matrix
  – Colorado Department of Transportation
  – Next Generation Transportation Construction Management Pooled Fund Study

http://www.colorado.edu/tcm
Selecting Project Delivery Methods

- Create project description checklist
- Develop project goals and identify project constraints
- Evaluate the primary factors
  - 1. Delivery schedule
  - 2. Complexity and innovation
  - 3. Level of design
  - 4. Cost
  - 5. Initial project risk assessment
- Evaluate the secondary factors
  - 6. Staff experience / availability
  - 7. Level of oversight and control
  - 8. Competition and contractor experience
Tech Brief of Empirical ACM Performance

• Summary
  – Agencies using ACMs on all project sizes
  – ACMs delivered 40-60% time savings on projects studied
  – ACM cost certainty was significantly earlier
  – ACM project intensity was significantly higher
  – Award growth, cost growth and schedule growth were comparable to traditional methods
Research Objectives

✓ Document ACM benefits, costs, risks and lessons learned
✓ Quantify cost, schedule, and quality consequences of ACMs
✓ Update Transportation Construction Management Pooled Fund Project Delivery Selection Matrix

• Promote ACM lessons learned and best practices
ACM Lessons Learned Research

Short Titles
A. ACMs and Change Orders
B. ACMs on Small Projects
C. QBS and Best-Value for CM/GC
D. Role of the ICE in CM/GC
E. CM/GC Contract Packaging
F. ACM Engineer’s Estimates
G. Effective Use of D-B Stipends
H. Procurement Duration and Performance
I. ATC State-of-Practice
J. ATCs Confidentiality and Innovation
K. ACM QA/QC Effectiveness
Role of Independent Cost Estimator in CM/GC

• 25 project surveys and six interviews

• Roles of ICE
  1. 100% independent estimate
  2. 57% attend design meetings
  3. 30% consult on initial procurement
  4. “Other”
     1. Change Order Negotiation
     2. Constructability Consultant

• Cost of ICE – Avg. 0.9%

• ICE hired
  – 40% same time as contractor
  – 36% after contractor
  – Typically at ~30% design

• ICE Best Practices
  – Construction experience
  – Local area knowledge
  – Include ICE in “team”
Effective Use of Stipends on D-B Projects

- **Stipend Value & Use**
  - 123 projects
  - Use of stipends
    - 84% of D-B/BV
    - 16% of D-B/LB
  - Stipend value
    - 62% less than 0.25% of award
    - Average 0.30% of award

- **Stipend Interviews**
  - No correlation w/amount-innovation
  - Required to ensure
    - D-B firms propose
    - Adequate competition
Quantification of Cost, Benefits and Risk Associated with Alternate Contracting Methods and Accelerated Performance Specifications

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