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DIVISION OF COST DEVIATIONS IN INTEGRATED PROJECT DELIVERY SYSTEMS USING COOPERATIVE GAME THEORY



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Weighted Average Player i marginal

Marginal Contribution Example

S: No. of Players in

SV: Shared Value

a coalition

t: milestone

TB: Target Band

TC: Target Cost

contribution

TCV: Total Cost

TTB: Total Target

 φ : Shapely Value

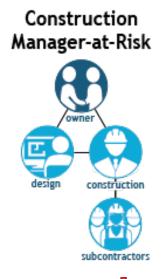
Variance

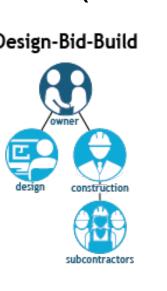
Band

INTRODUCTION

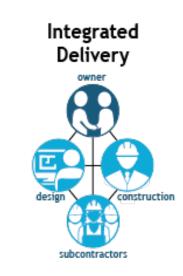
Definition

IPD is defined as a "project delivery method that integrates people," systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction," (AIA CC 2014).









Background

One of the main contractual issues faced in IPD projects under the two contract forms AIA-C191 & Consensus Docs 300 is the identification, management & allocation of cost deviations using well defined strategies and adequate plans (Ahmed et al. 2021 & Eissa et al. 2024).

An IPD project survival is difficult with an unreasonable distribution mechanism for risk & reward sharing (Guo et al. 2022).

GOAL & OBJECTIVES

Quantifying the IPD objectives based on monetary values



Determining cost deviation per project participant



Fairly distribute

cost deviations in IPD projects between the stakeholders

PROJECT METHODOLOGY

Modeling Earned Value Management

EVM is a "methodology that combines scope, schedule, and resource measurements to assess project performance and progress and forecast project outcome," (PMI 2019).



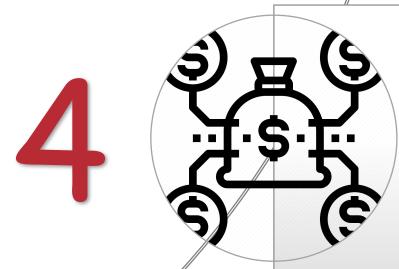
Dividing the Total Target Band

TTB is a certain sum of money determined at the beginning of the project to represent cost overruns and/or savings up to a certain limit.



Determining the Shared Value

SV is the sum of money that will be impartially shared among the core group members.



Distributing Shared Value by Cooperative Game

Game theory is "the study of mathematical modeling of strategic behavior of decision makers (players), in situations where one player's decisions may affect the other players," (Parrachino, I. et

IPD Project Information

o Project Name: Barrie-Simcoe Emergency Services Campus (BSESC) (Staub-French et al. 2022)

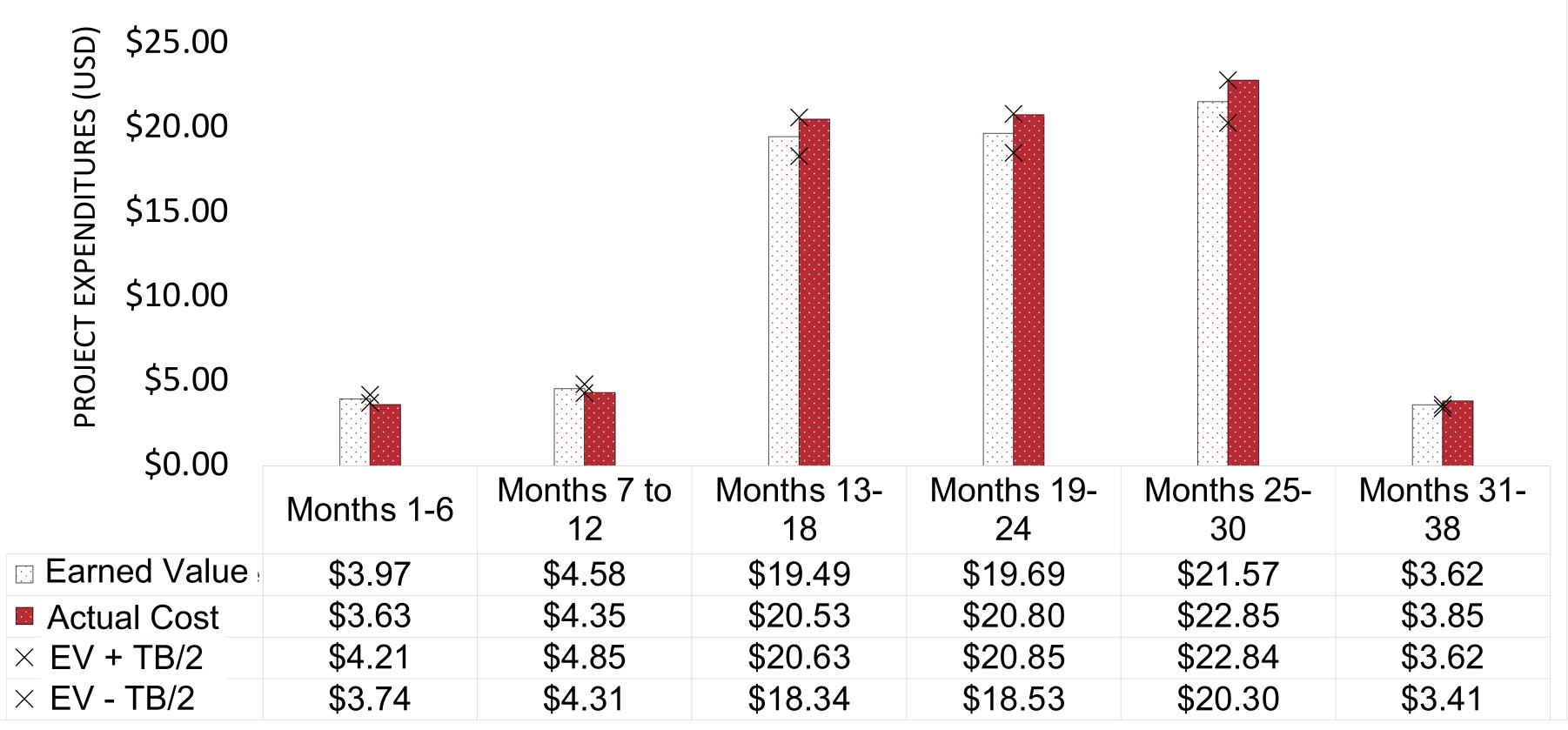
 $CV_i^t = EV_i^t - AC_i^t$

 $TB^{t} = \frac{\sum_{i=2 \text{ to } n} EV_{i}^{t}}{TB}$

- Budget: \$85,799,954
- Duration: 38 months
- Core Group Members: Owner, Architect, & Contractor

Assumptions

- Total Target Band (TTB): \$8,579,995
- Target Cost (TC): \$72,929,962
- Actual Cost (AC): \$76,000,313
- Project Milestones (T): 6
- Contractor Scope: 90% of TC



Note: All numbers are in Millions

Work Value at t for t = 1 to 6							
Months 1-6	Months 7 to 12	Months 13-18	Months 19-24	Months 25-30	Months 31-38		
\$0.0944	\$0.263	\$0.0197	\$0.0197	\$0.0197	\$0.007		
\$0.0164	-\$0.028	-\$1.065	-\$1.293	-\$1.293	-\$0.228		
\$0.345	\$0.235	\$1.046	-\$1.109	-\$1.273	-\$0.221		
\$0.468	\$0.539	\$2.293	\$2.317	\$2.538	\$0.426		
\$0.111	\$0.000	\$0.000	\$0.000	-\$0.004	-\$0.008		
	1-6 \$0.0944 \$0.0164 \$0.345 \$0.468	Months 1-6Months 7 to 12\$0.0944\$0.263\$0.0164-\$0.028\$0.345\$0.235\$0.468\$0.539	Months 1-6Months 7 to 12Months 13-18\$0.0944\$0.263\$0.0197\$0.0164-\$0.028-\$1.065\$0.345\$0.235\$1.046\$0.468\$0.539\$2.293	Months Months Months Months 1-6 7 to 12 13-18 19-24 \$0.0944 \$0.263 \$0.0197 \$0.0197 \$0.0164 -\$0.028 -\$1.065 -\$1.293 \$0.345 \$0.235 \$1.046 -\$1.109 \$0.468 \$0.539 \$2.293 \$2.317	Months Months Months Months Months 1-6 7 to 12 13-18 19-24 25-30 \$0.0944 \$0.263 \$0.0197 \$0.0197 \$0.0197 \$0.0164 -\$0.028 -\$1.065 -\$1.293 -\$1.293 \$0.345 \$0.235 \$1.046 -\$1.109 -\$1.273 \$0.468 \$0.539 \$2.293 \$2.317 \$2.538		

CASE STUDY

Cooperative Game

Theory

Shapely

Value

Core

MODEL DEVELOPMENT

Non-Cooperative

Game Theory

Nash

Equilibrium |

- Architect's Scope: 10% of TC

	Work Value at t for <i>t</i> = 1 to 6							
Value Description	Months 1-6	Months 7 to 12	Months 13-18	Months 19-24	Months 25-30	Months 31-38		
v(1), v(2), v(3)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000		
v(12)	\$0.094	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000		
v(13)	\$0.000	\$0.000	\$0.000	\$0.000	-\$0.0239	-\$0.0148		
v(23)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000		
v(123)	\$0.111	\$0.000	\$0.000	\$0.000	-\$0.004	-\$0.0083		
Owner's Shapley φ_1	\$0.0527	\$0.000	\$0.000	\$0.000	-\$0.0054	-\$0.0053		
Architect's Shapley φ_2	\$0.0527	\$0.000	\$0.000	\$0.000	\$0.0066	\$0.0022		
Contractor's Shapley ϕ_3	\$0.0055	\$0.000	\$0.000	\$0.000	-\$0.0054	-\$0.0053		

AC: Actual Cost

i: Player

v: Worth

CV: Cost Variance

EV: Earned Value

n: No. of players

Note: All numbers are in Millions

RESULTS & DISCUSSION

- The Owner's shapely value is always equal to that of the member responsible for the overrun/ saving.
- The model accounts for a player's positive contribution and incentivizes them accordingly, even if the overall performance of the project at that milestone is negative.
- The shares of each participant differed based on their contribution to a specific time window of the project.
- Distributing deviations along the project duration would either motivate the group members when incentivized or urge them to proactively avoid further overruns.

INDUSTRY CONTRIBUTION

gap 300 ConsensusDocs and AIA-C191.

- Promote collaboration in the booming construction industry.
- Ease IPD adoption worldwide.

DO NOT FORGET TO SCAN ME





POSTER



& videos



Help us improve & fill out the **SURVEY**

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