A Game-Theoretic Approach to Optimizing Behaviors in Acquisition

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Project Overview

Problem

"Government As The Integrator" (GATI) is now preferred approach

Incentives among contractors may not align with program objectives

Poor contractor cooperation causes delays, overruns, poor performance

Government is still learning how to "play" the "game" of GATI acquisition

~~*Research builds on prior work in:*~~

1. *Joint Program dynamic modelling*
2. *Signalling game cybersecurity modelling*
3. *Acquisition Archetypes*

Solution

Align contractor incentives using customized incentive mechanisms

Combine different incentive mechanisms to be more effective

Contractors acting in their interests also serves program interests

Approach

Describe & analyze GATI contractor incentives using game theory

Use agent-based modelling to quantify the game outcomes

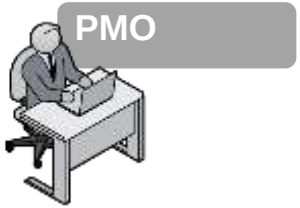
Simulate incentive mechanisms in context of a full acquisition program

Select the most promising combinations of mechanisms

2017 Work: *Interview acquisition program staff to gather empirical data*

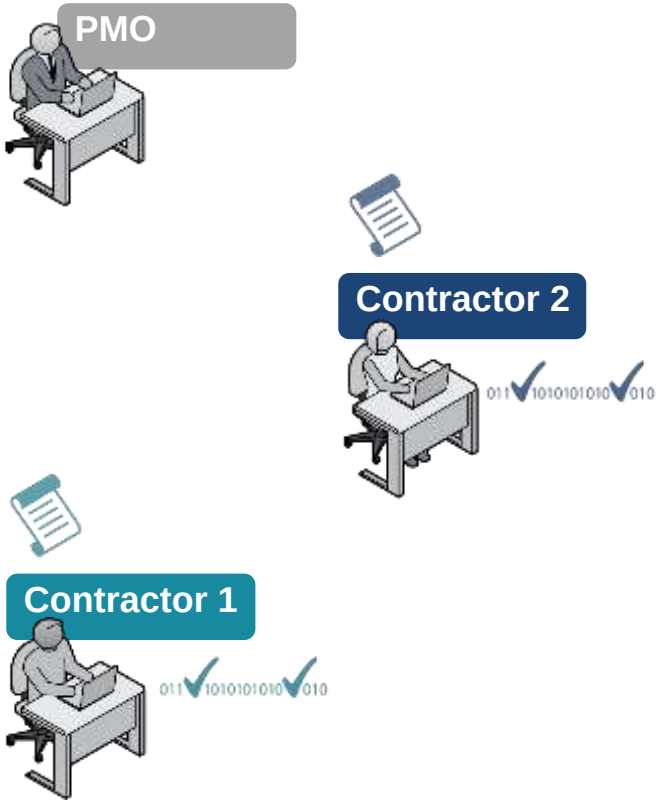
Future Work: *Pilot most promising mechanisms and measure results*

Research Approach



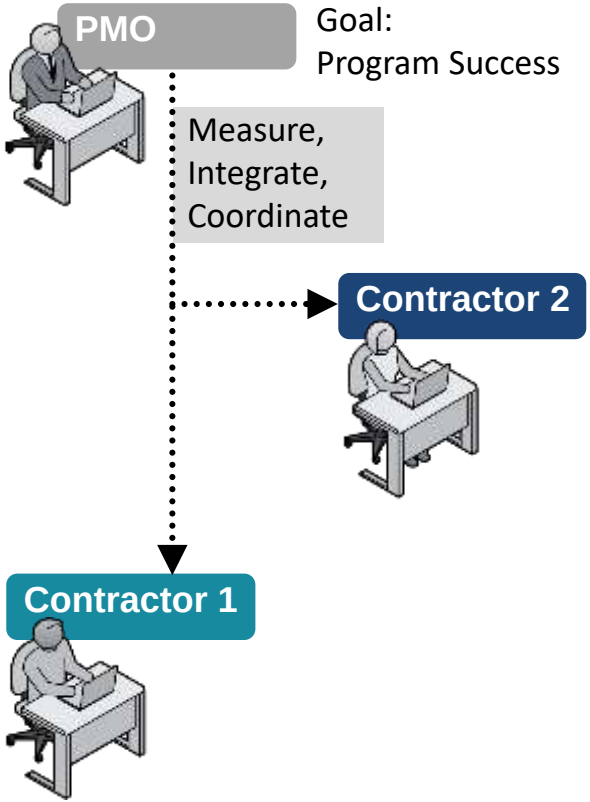
1 A GATI program has a CPAF contract with the ability to change the award fee structure every six months.

Research Approach



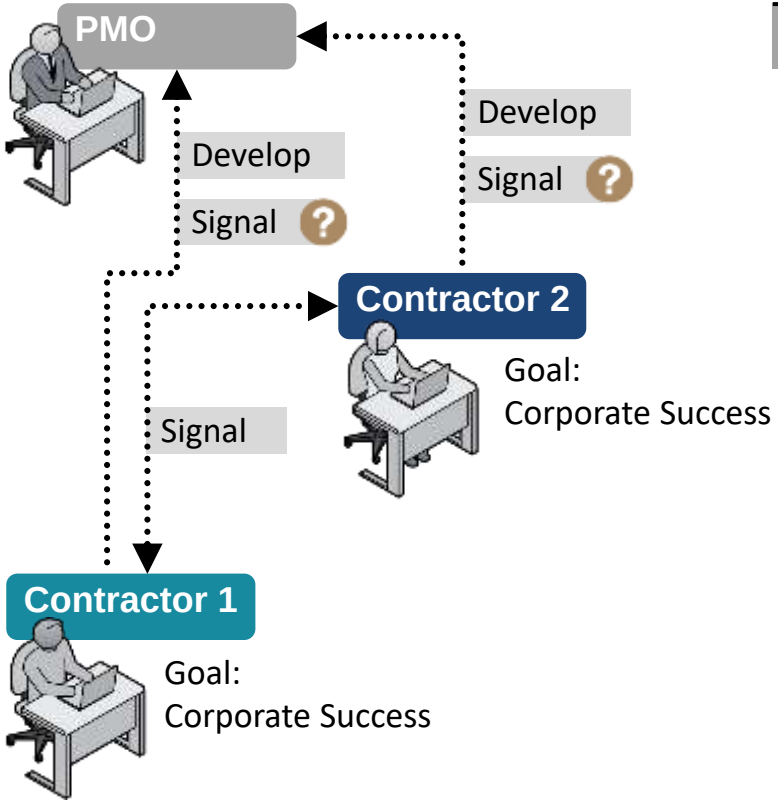
2 There are two contractors, each developing a subsystem, who must work cooperatively to produce the full system.
A "Giver/Receiver" list describes the schedule for the areas where the contractors must interface their subsystems.

Research Approach



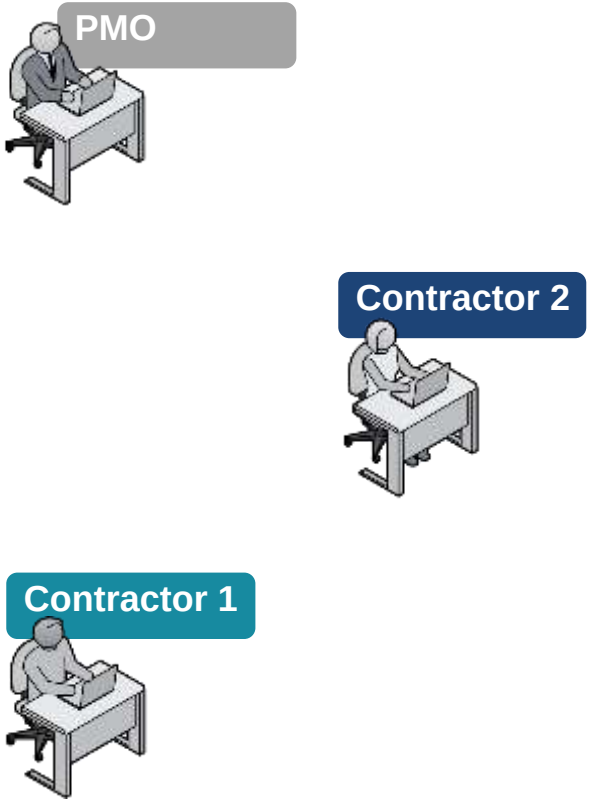
3 The PMO wants to successfully achieve the program's cost, schedule, & performance goals, and to do so can
a) measure the contractor's actions and performance,
b) perform some integration actions themselves, and
c) implement coordination actions to encourage contractor cooperation.

Research Approach



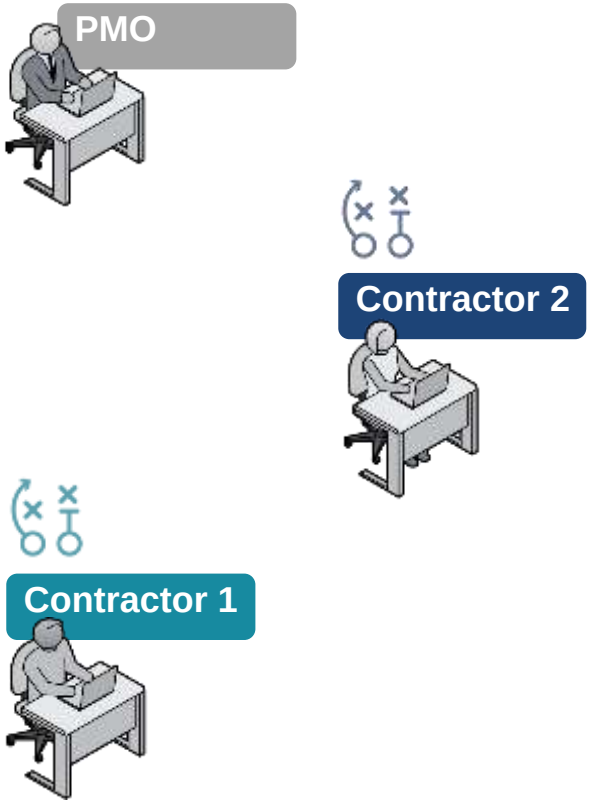
4 The contractors want to maximize their own goals, and in doing so they both
a) perform various development activities, and
b) send (possibly deceptive) performance "signals" to the PMO about what they're doing.

Research Approach



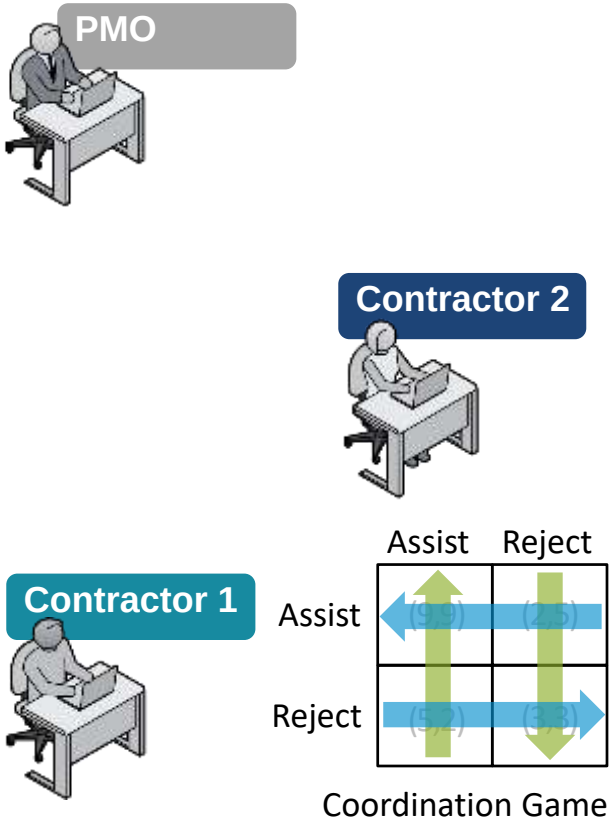
5 While the contractors may want the program to succeed, they also have individual incentives to not cooperate with each other, such as concerns about disclosing proprietary information to a competitor, providing costly technical support, or agreeing on an interface that might simplify the other contractor's work, while making their own more difficult.

Research Approach



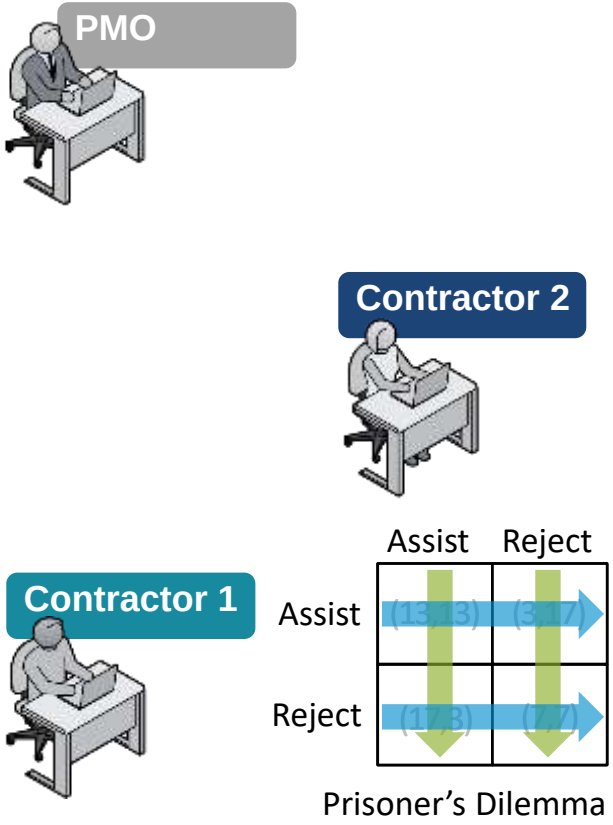
6 If a contractor doesn't cooperate, they may
a) delay work and desynchronize the schedule,
b) refuse to provide the data they should provide to the other contractor, or
c) choose an interface that undermines the other—but they will manipulate the PMO's measurements to avoid detection, and conceal their motives to avoid penalties for being uncooperative.

Research Approach



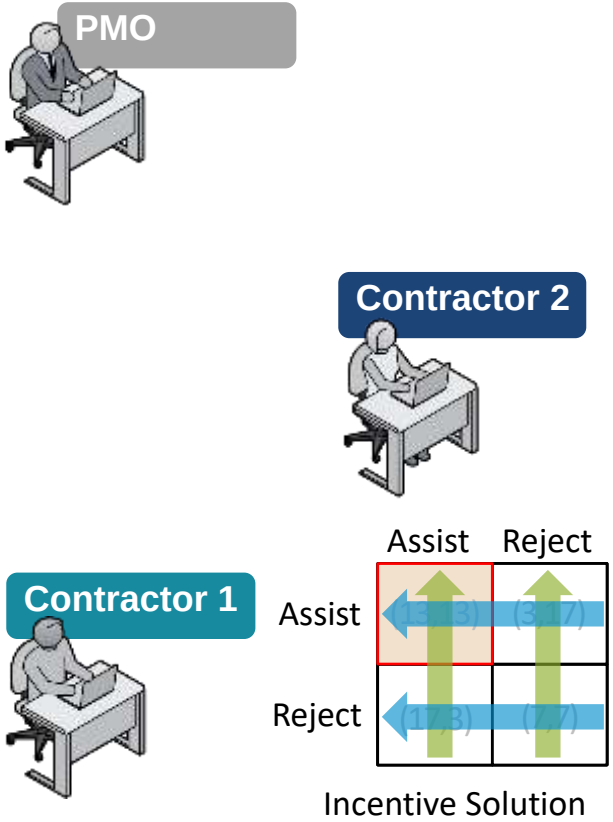
7 Assuming that contractors not cooperating on interfaces will hurt the program, combining the benefits and impacts ("utilities") to both the contractors and the overall program can produce the following payoffs—which form what's called a "coordination" game, where participants tend to end up in one of two solutions (i.e., "Nash equilibria")—but neither one is good for the program.

Research Approach



8 If the contractors' incentives are slightly different due to the program's context (e.g., the level of distrust between them, or the criticality of the IP), the utilities can form another game called the "Prisoner's Dilemma," where participants end up in only one Nash equilibrium where neither cooperates—which is the worst outcome for the program.

Research Approach



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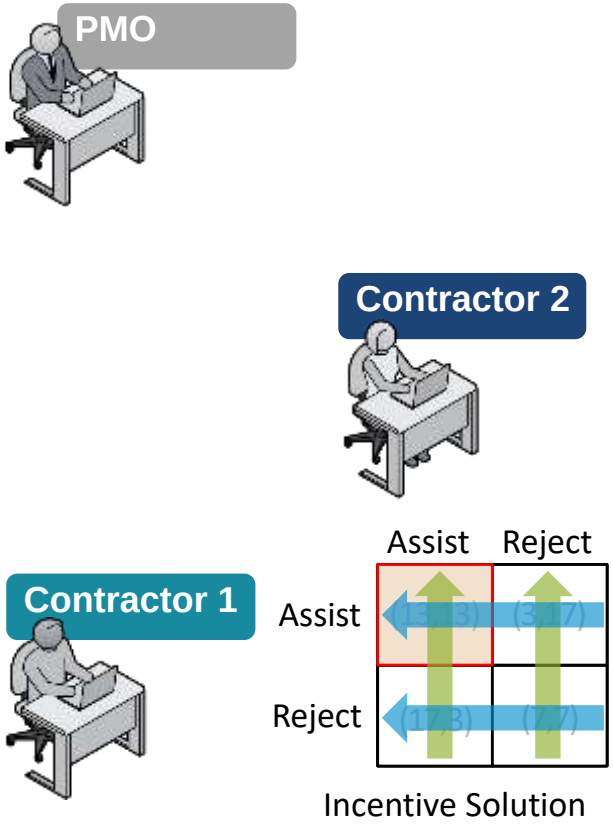
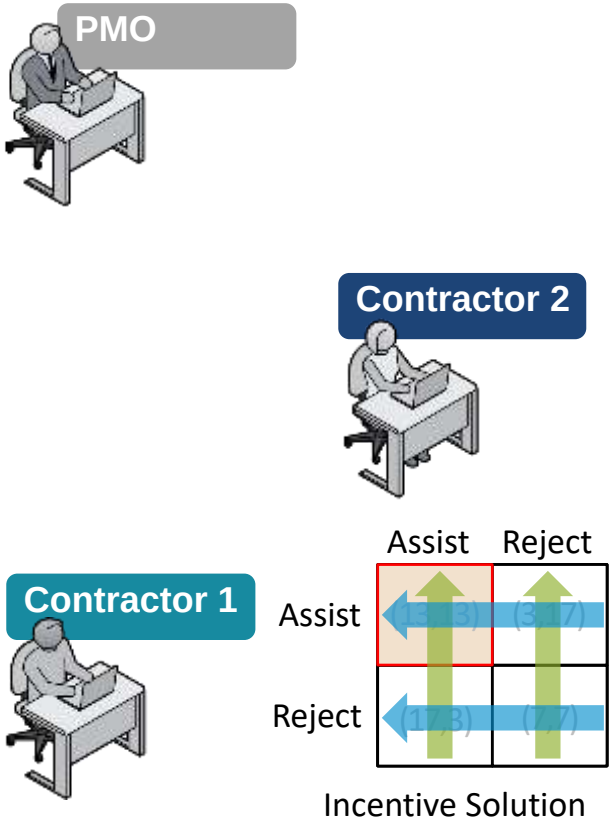
To prevent these undesirable outcomes, the PMO can incentivize the contractors to cooperate, using award fee incentives that change the game to one in which the only Nash equilibrium serves the interests of the program.

Research Approach



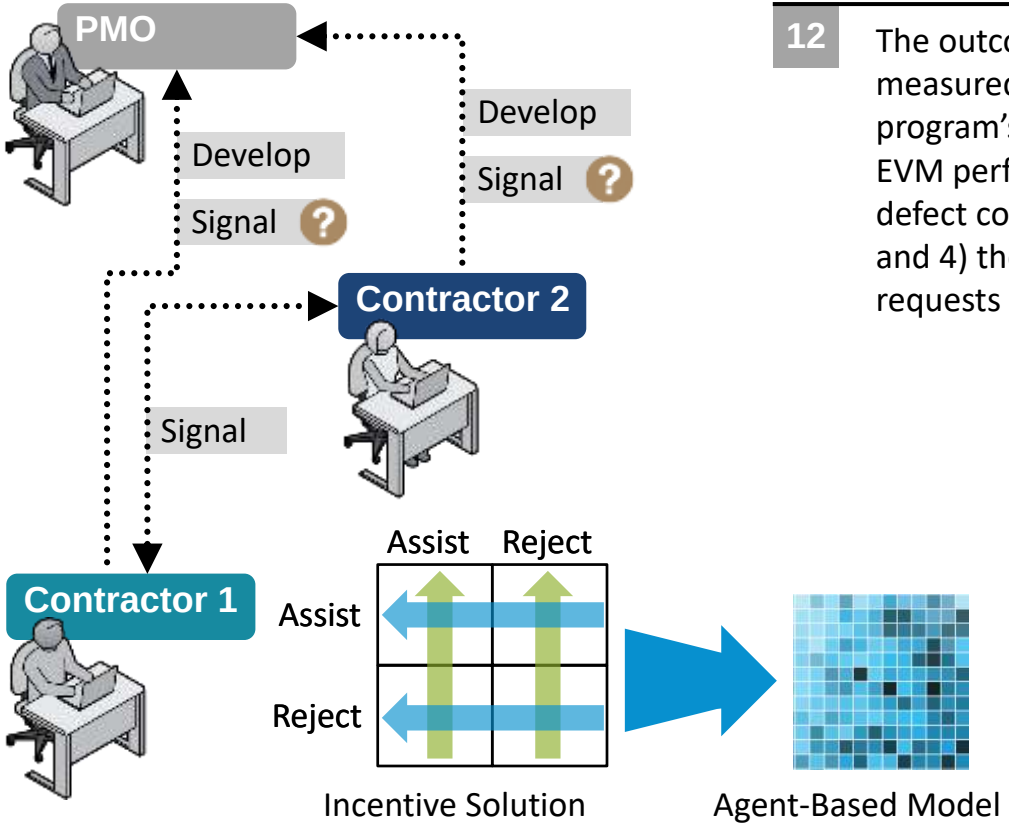
10 Some specific solution "mechanisms" for contractor cooperation issues include "Shared Destiny" (all players win or lose based on the outcome), "Assigned Fault" (some win and some lose based on a fault determination), or a "Risk Pool" (a reserve fund used to mitigate issues that arise).

Research Approach



11 The effectiveness of the solution approaches can be tested by simulating a model of each mechanism in the context of the program with its specific incentive values, playing out all combinations of moves and counter-moves into the projected future and evaluating the outcome. The most promising mechanisms can be piloted with the collaborating program.

Research Approach Future Work



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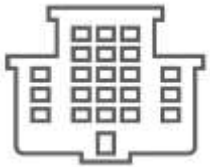
The outcomes of the piloted efforts can be measured in terms of: 1) compliance with program's "Giver/Receiver" list schedule, 2) EVM performance and schedule variance, 3) defect counts from testing of that interface, and 4) the number of waivers/deviation requests submitted for interface issues.

Incentive Mechanisms in Combination

Distinct types of incentives affect contractors differently—and the combined impact can be more effective in influencing a range of contractors sufficiently to change their behavior.



Business: Future Business Incentives (*appeal to High-Level Management*)

- ***Example*: Reputation Tracking**: Reputational impacts affect future business opportunities in the absence of award or incentive fee.

Money: Direct Financial Incentives (*appeal to Project Management*)

- ***Example*: Truth-Revealing Incentive Mechanism (TRIM)**: A sliding CPIF fee based on schedule (e.g., sooner completion, larger fee incentivizes early delivery.
- ***Example*: Shared Destiny**: All teams only receive as much award fee as the worst team gets, so all are incentivized to help the poorest performing team.

Social: Team Networking Incentives (*appeal to Project Teams*)

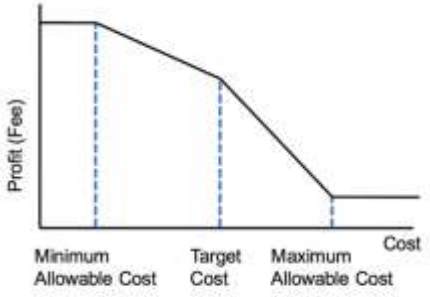
- ***Example*: Co-Location**: Teams with greatest potential for poor cooperation are co-located (and kept badge-less) to foster communication and trust.

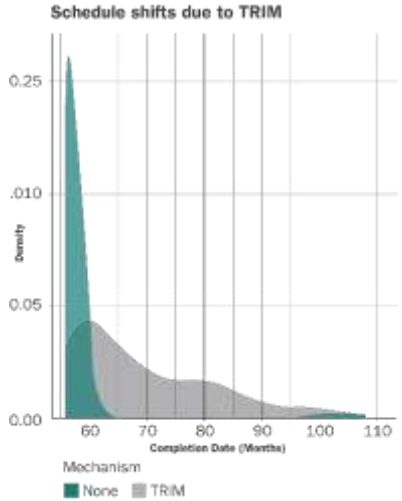
Takeaway **Combine multiple incentives to align the contractor organization with the PMO, maximizing improvement**

Truth-Revealing Incentive Mechanism (TRIM)

Example: PMO wants to keep contractors working on the program, and not diverting resources toward other profitable activities

The TRIM[1] mechanism has a sliding incentive fee for CPIF[2] contracts based on completion date (e.g., sooner completion, larger fee, with rapidly diminishing (non-linear) returns—incentivizing early delivery.





Using a hybrid agent-based/system dynamics model of TRIM, ran 200 simulations of contractor actions with randomized values from input distributions to determine the distribution of key performance measures.

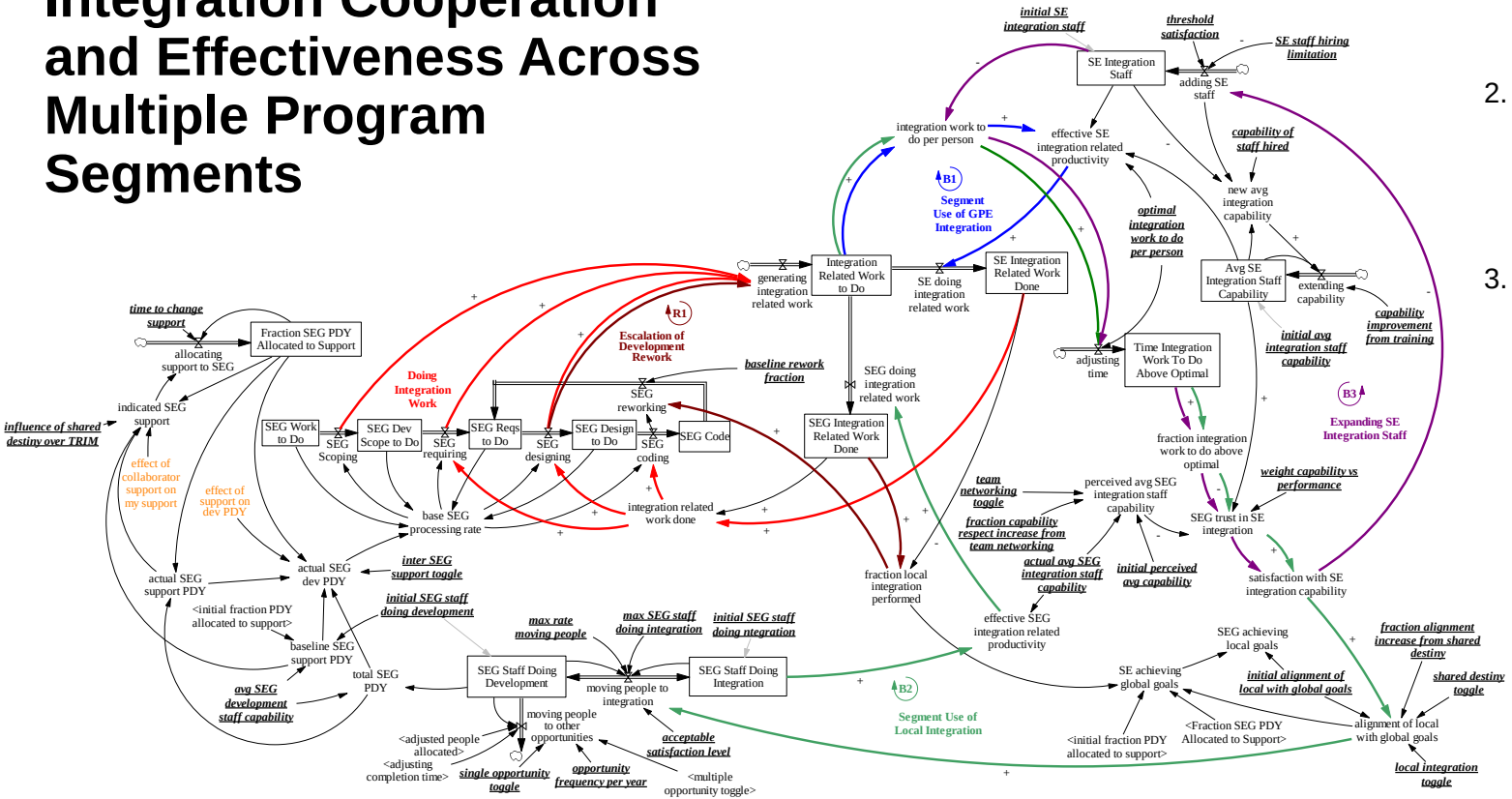
Result: For a simulated 56-month/4.5-year program:

- *With TRIM*: only 6 of 200 runs fall below on-schedule (*97% on schedule*)
- *Without TRIM*: *no* runs are on schedule, and half the runs go *more than a year over*

[1]Truth-Revealing Incentive Mechanism [Coughlan 2010]

[2]Cost-Plus Incentive Fee

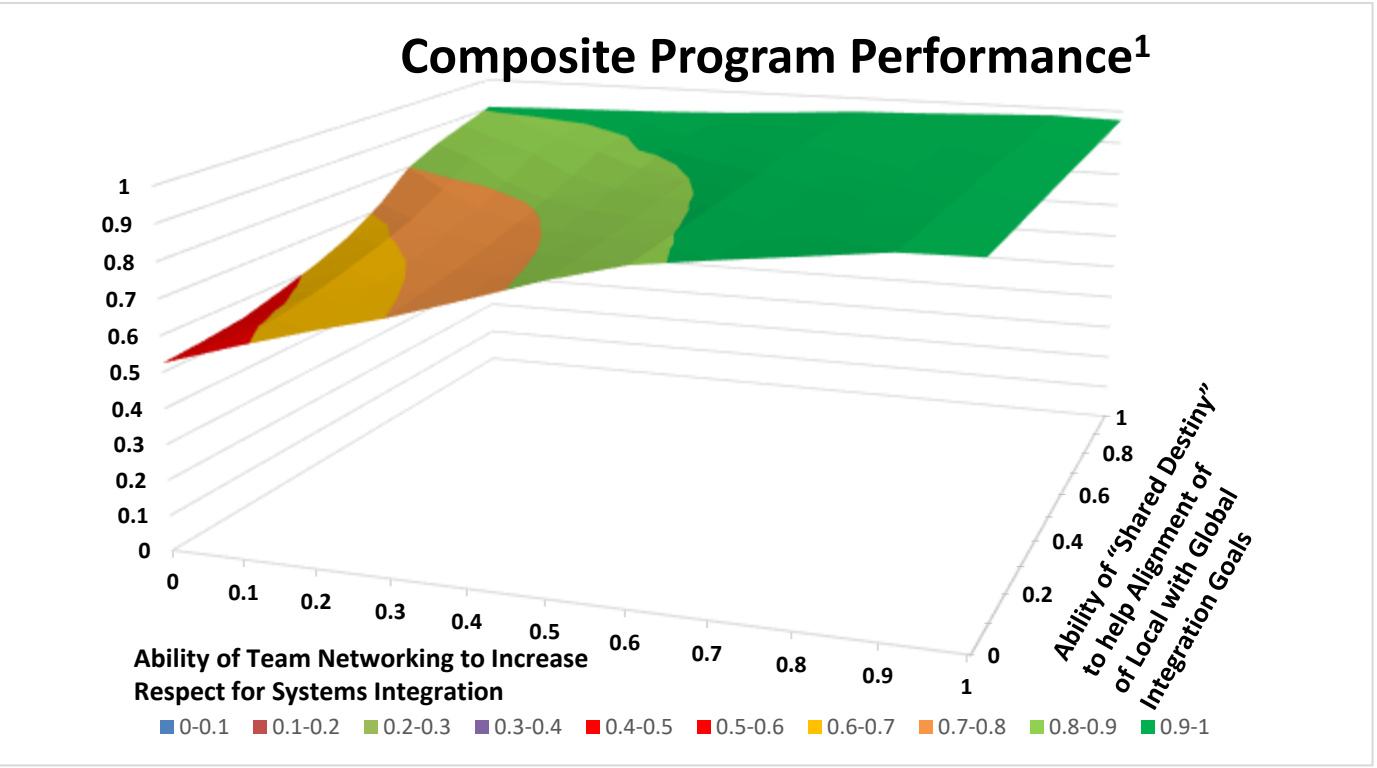
Model of Systems Integration Cooperation and Effectiveness Across Multiple Program Segments



Context:

1. PMO Systems Engineering is resource constrained for doing integration.
2. Segment integration goals aren't consistent with program goals—view it locally, not globally.
3. Segments see PMO Systems Engineering as ineffective—although it isn't.

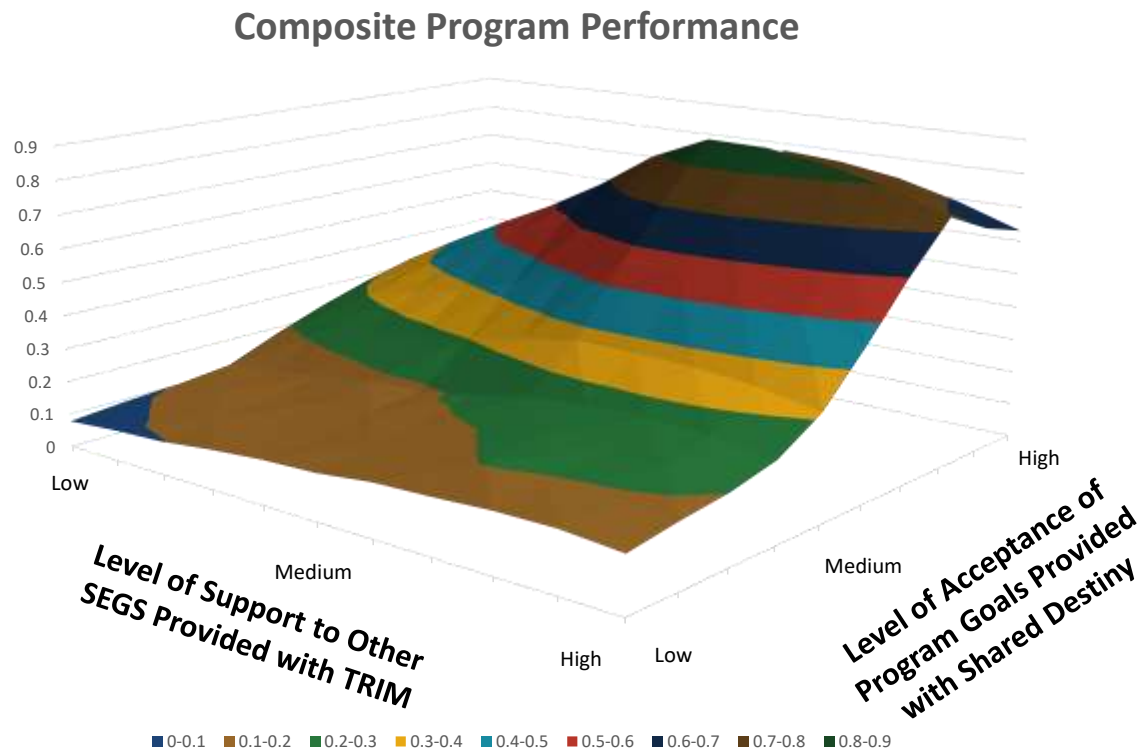
Visualizing the Effects of Cooperation Incentives on Performance [-1]



The effects of combinations of different incentive mechanisms on program performance can be analyzed and predicted

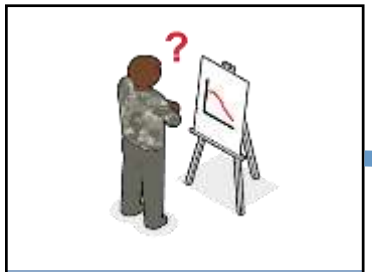
[1]*Composite Program Performance = Segment Schedule Performance Index * Segment Productivity Index * Extent Global Goals are Achieved*

Visualizing the Effects of Cooperation Incentives on Performance -2



Result of combining the “Shared Destiny” and TRIM incentive mechanisms

Acquisition Program Support Engagement Model



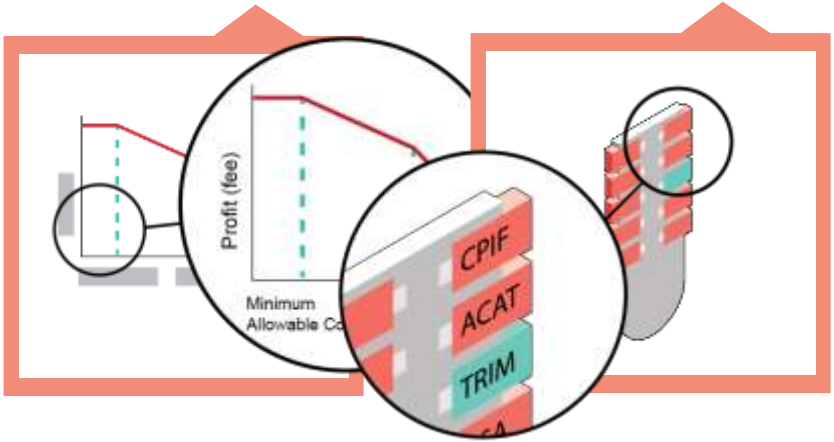
Key Questions to Answer

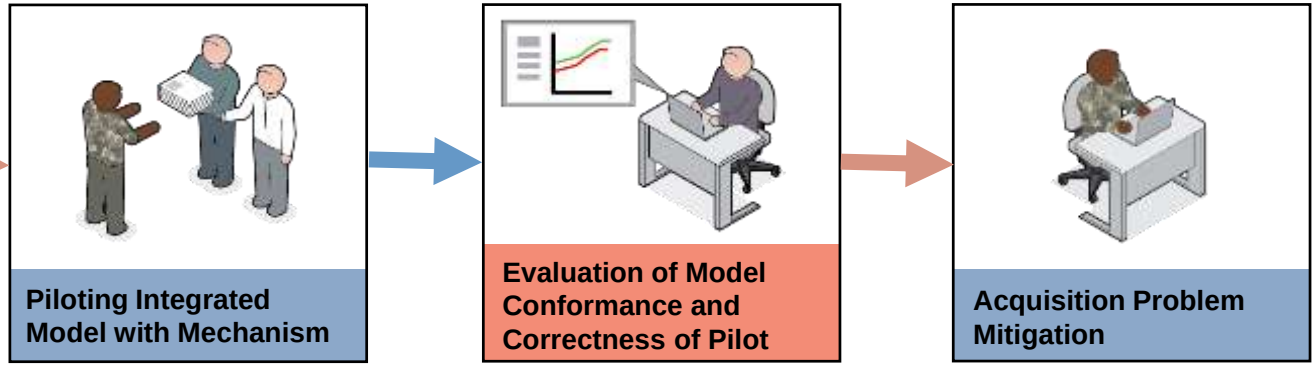
Is poor GATI contractor cooperation hindering the program? And if so, how can I improve it?

Incentive Mechanism Identification

Incentive Mechanism Model Development

Mechanism Integration with Program Model





Continuing Work

- Conduct interviews of acquisition program stakeholders, and collect feedback on game theory-based model and candidate incentive mechanisms

Future Research

- Pilot incentive mechanisms on program to validate effect on contractor cooperation

Vision

- Develop a virtual acquisition modelling laboratory serving DoD acquisition programs to help program managers make evidence-based decisions based on projected performance

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