Co-Design: Course of Action (COA) Integration Through Common Conceptual Model Building

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Taking more time to plan often results in greater synchronization; however, any delay in execution risks yielding the initiative—with more time to prepare and act—to the enemy.

The Operations Process, FM 5-0, Headquarters Department of the Army, 2010

Agenda

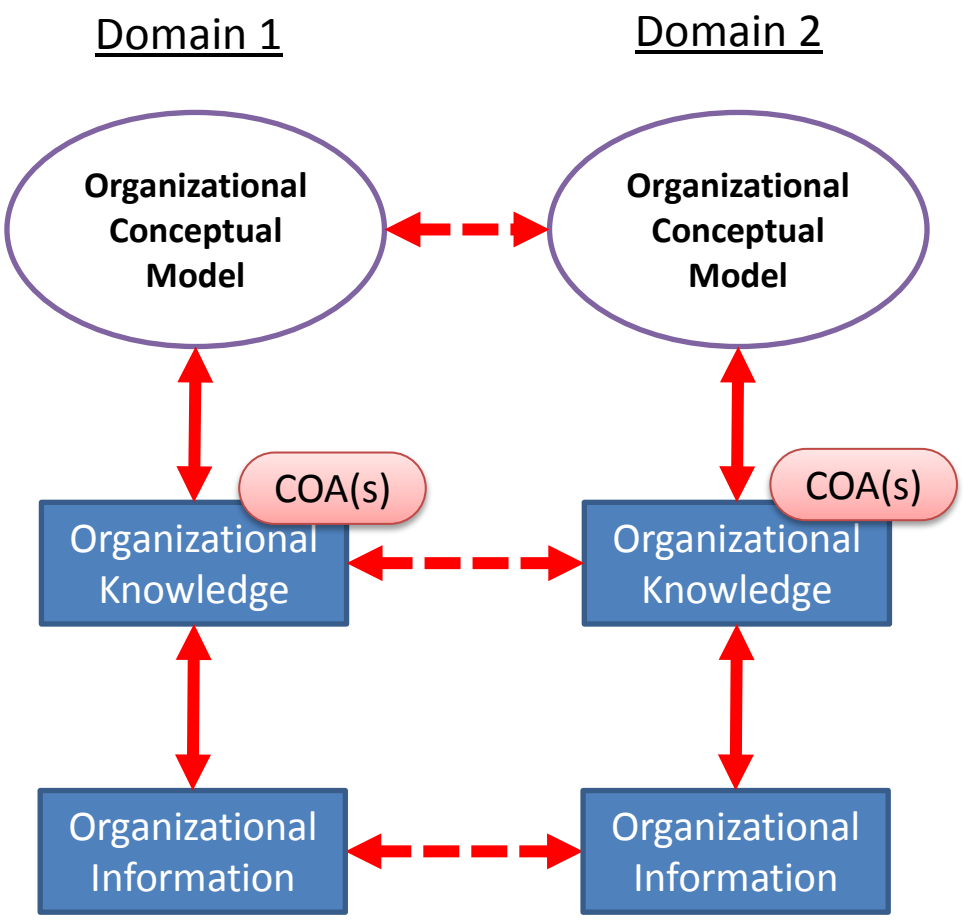
- Introduction
- Organizational Knowledge /Information Sharing
- One Current Approach
- Conceptual Models and Co-Design
- Modeling Approach
- Modeling Results
- Time Compression
- Summary

Introduction

- **Problem Statement: Current Command and Control (C2) enterprise processes cannot produce integrated COAs within the desired timeframes for planning**
  - **Time-constrained crisis action planning results in COAs which are not fully integrated adding more risk to military operations**
  - **Lack of a method to discover and agree upon cross-domain effects makes mutual adjustment between domains very difficult**
  - **Commanders are often required to perform COA integration during decision making as a result of C2 process inadequacies**

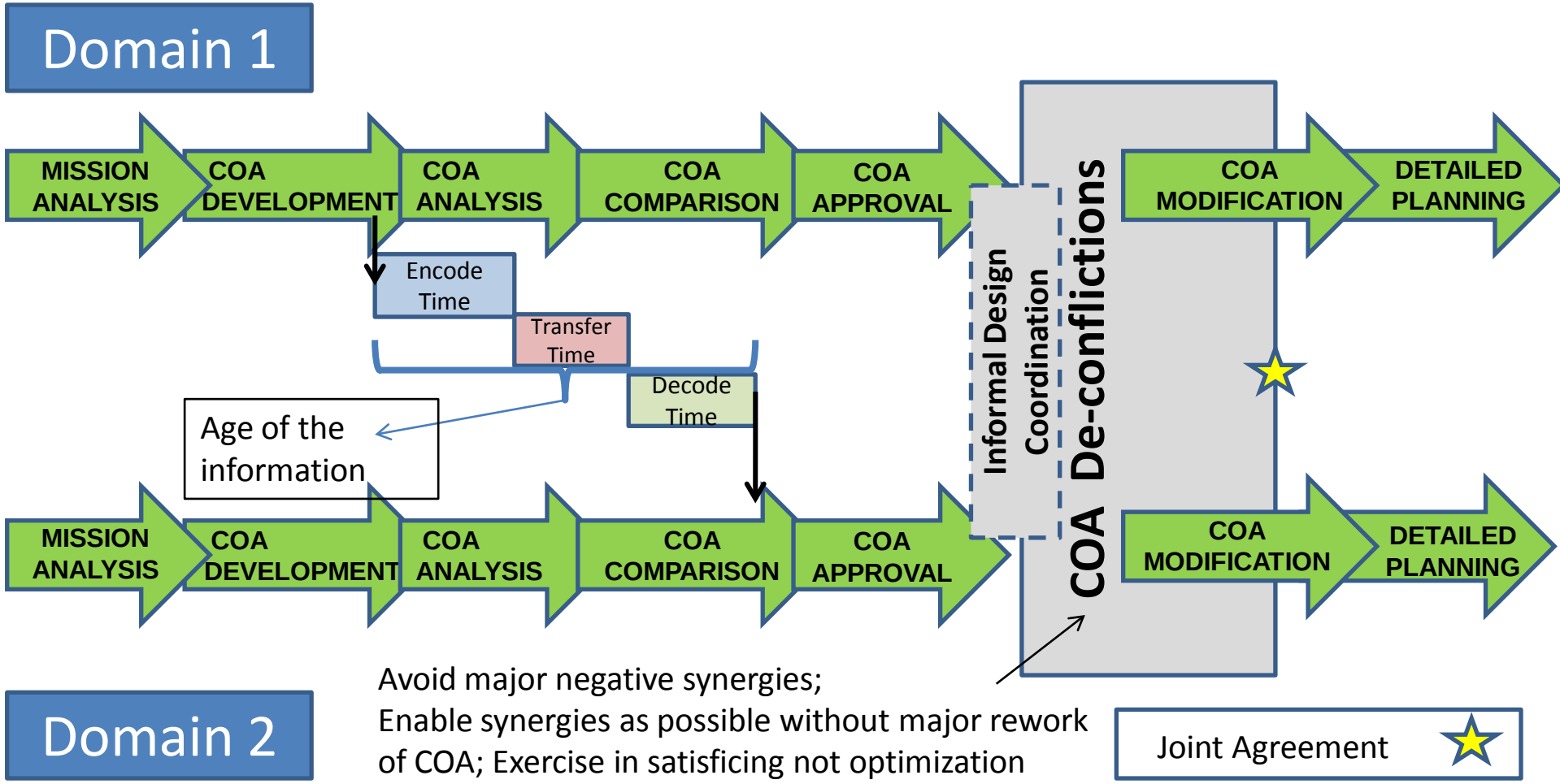
Integrated COA – A COA in which all participating entities act as one organization in pursuit of common goal(s); A COA in which no higher estimation of performance can be obtained by changing the actions taken and action timing in each involved domain

Organizational Knowledge/Information Sharing



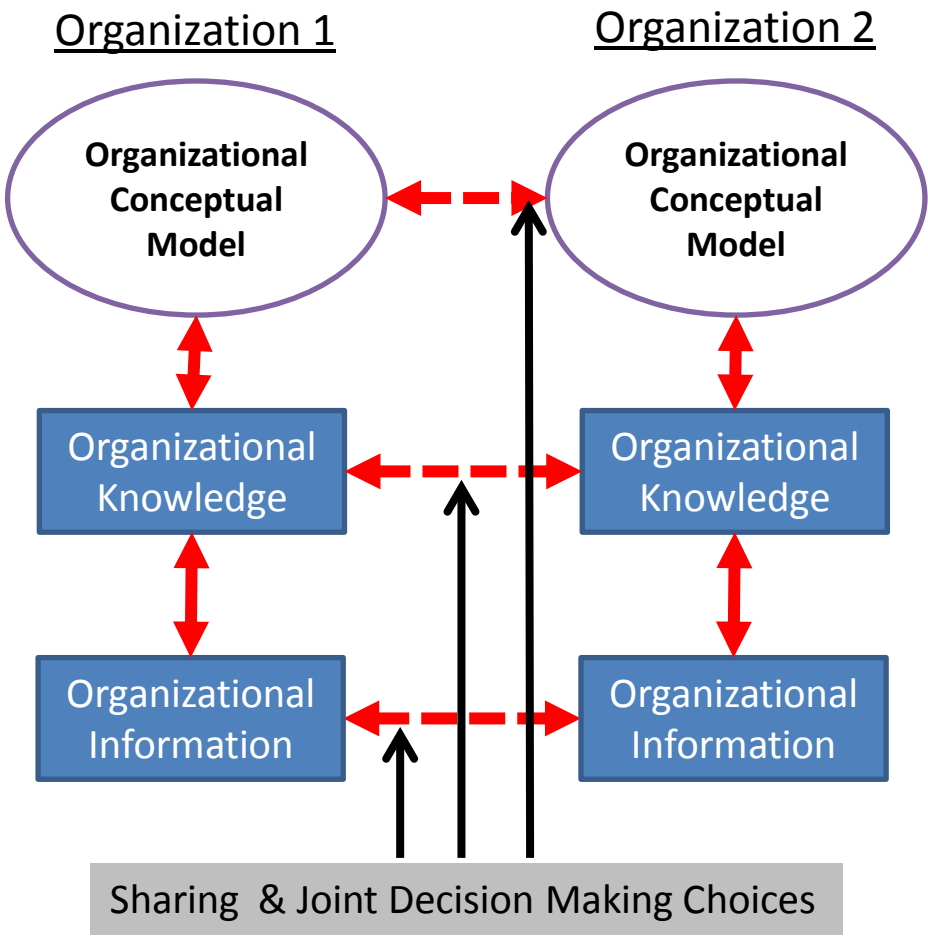
Kinetic	Cyber
"Power facilities in city 1 do not affect network infrastructure In city 2"	"Power facilities in city 1 do affect network infrastructure In city 2"
"Conducting general strikes on power facilities in city 1 with effects Z"	"Conducting cyber disinformation campaign using nodes C, D, and E"
"Hit target location X and time Y"	"Conduct exploit A and time B"

One Current Planning Process



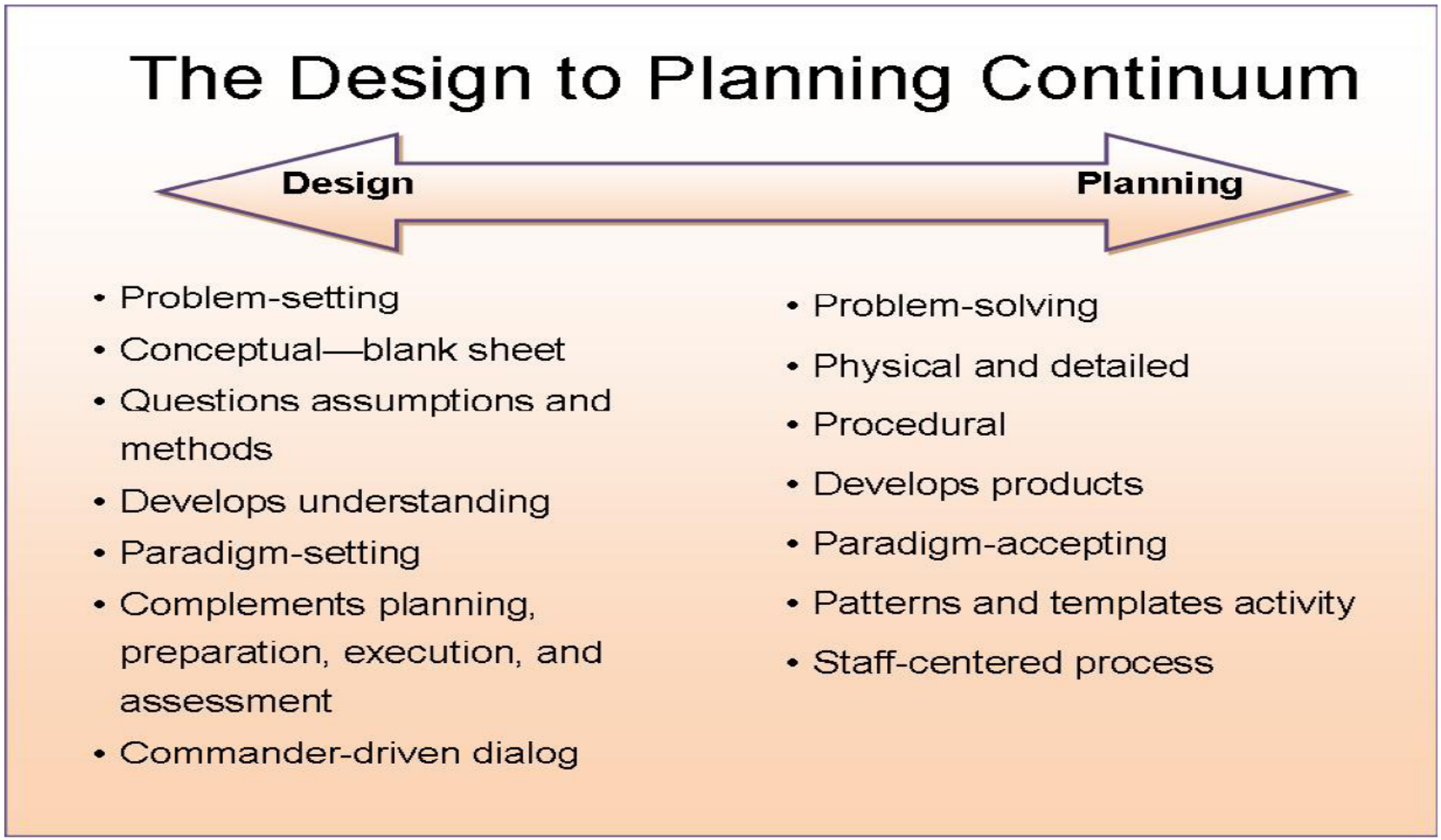
Conceptual Models

- Why conceptual models?
  - A broad concept that captures an organization's emergent understanding of the operational environment
  - Can encapsulate the complementary concepts of planning and design
  - Conceptual model agreement is a key concept in related non-military fields
  - Common conceptual models allow Joint Option Awareness[1]



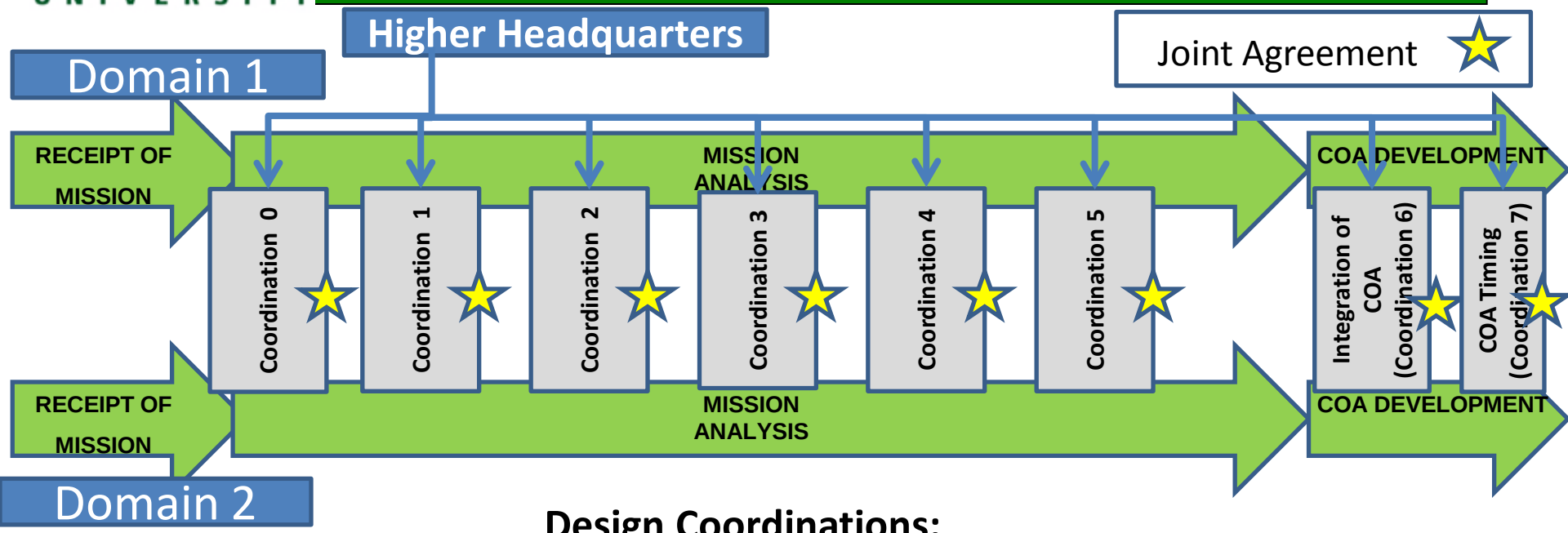
[1] G. L. Klein, J. L. Drury, M. Pfaff, and L. More, "COA Action: Enabling Collaborative Option Awareness."

Planning and Design



Graphic From: United States Army War College, 2008. Campaign Planning Handbook Final Working Draft., Department of Military Strategy, Planning, and Operations U.S. Army War College

Co-design Approach to Planning Integration



Design Coordinations:

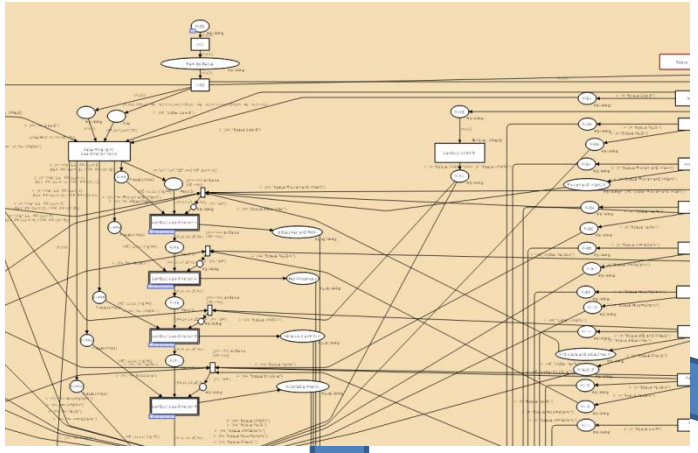
0. Coordination Approach
1. Objective(s) and metric(s)
2. Key Influencers of objective(s)
3. Adversary and environment potential actions
4. Organizations' (Domains') potential actions
5. System structure (interactions, constraints, synergies)
6. Integrated COA
7. Integrated COA Timing

General Modeling Approach

- Models must relate the planning approach to the performance of COAs produced in planning
- A two part approach is used:
  - A discrete event model is used to model the timed execution of domain planning and integration processes
  - An influence net model is used to model the domain planners' estimation of COA performance

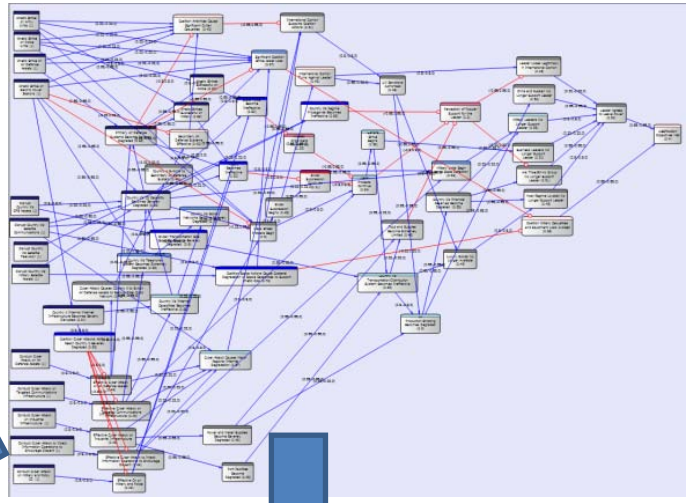
Relating Planning Process to Planning Results

Discrete Event Process Model (CPN Tools)



Process Approach Determines Conceptual Model Integration and COA Selection

Timed Influence Net Model (Pythia)



Measures of Performance

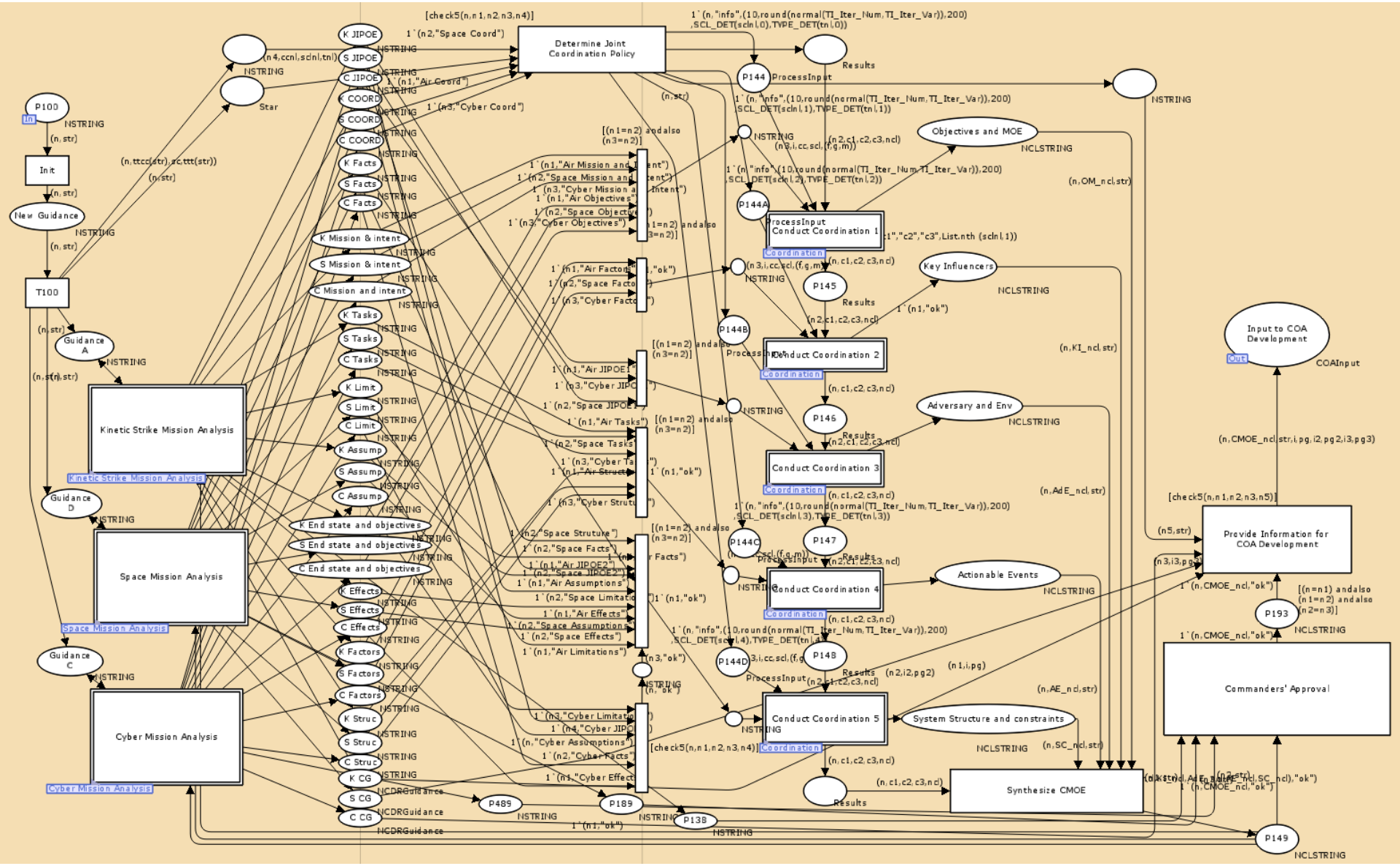
Total Planning Time

Likelihood of Mission Accomplishment

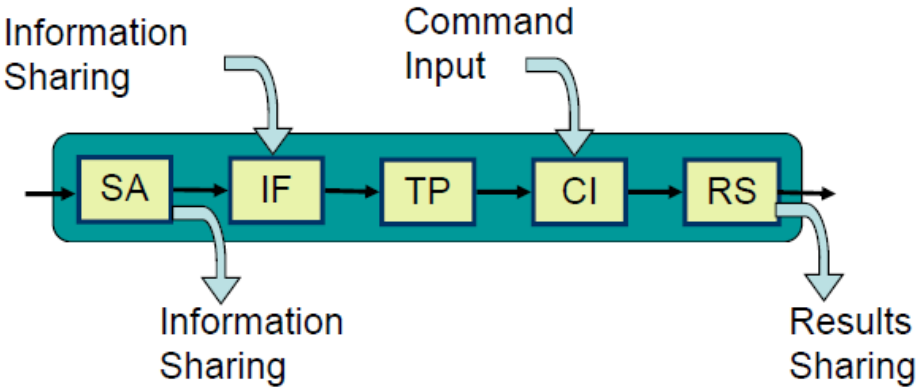
Scenario Model

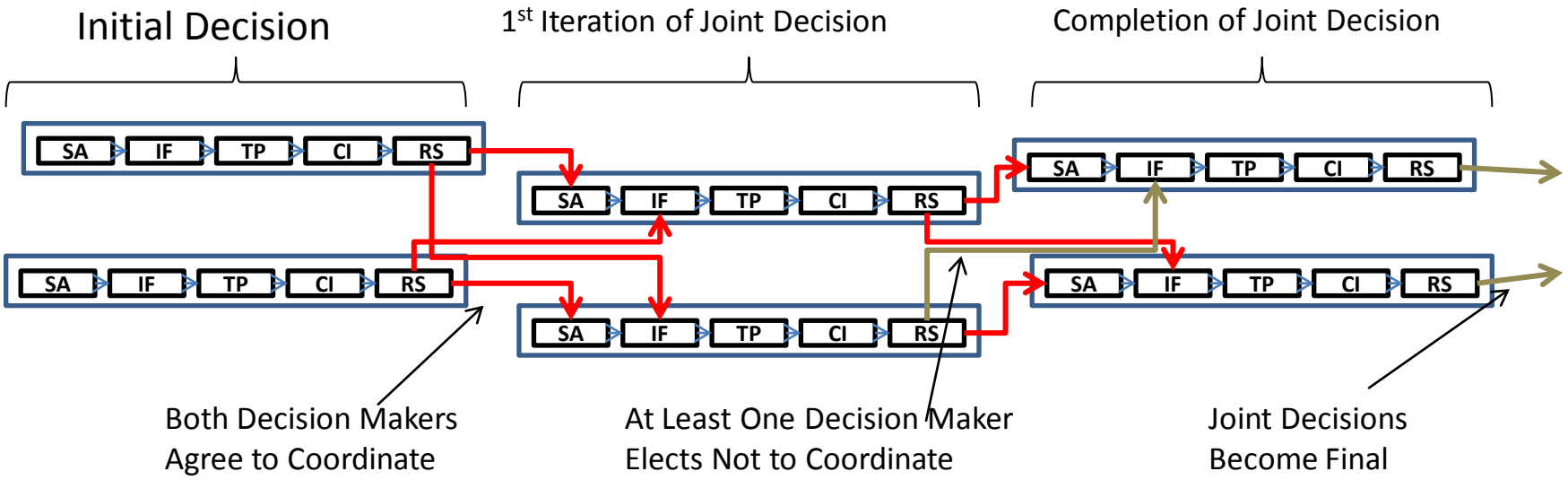
- Loosely based on a Libyan type scenario of potential coalition military intervention to remove a brutal dictator
- Commander of the allied coalition gives subordinate commanders (kinetic, cyber, and space domains) the objective and 48 hours to develop an integrated COA
- An integrated conceptual model represents complete knowledge of the operational environment and the goal of integration
- Each domain has a conceptual model of the operational environment which is a subset of the integrated model

Process Modeling

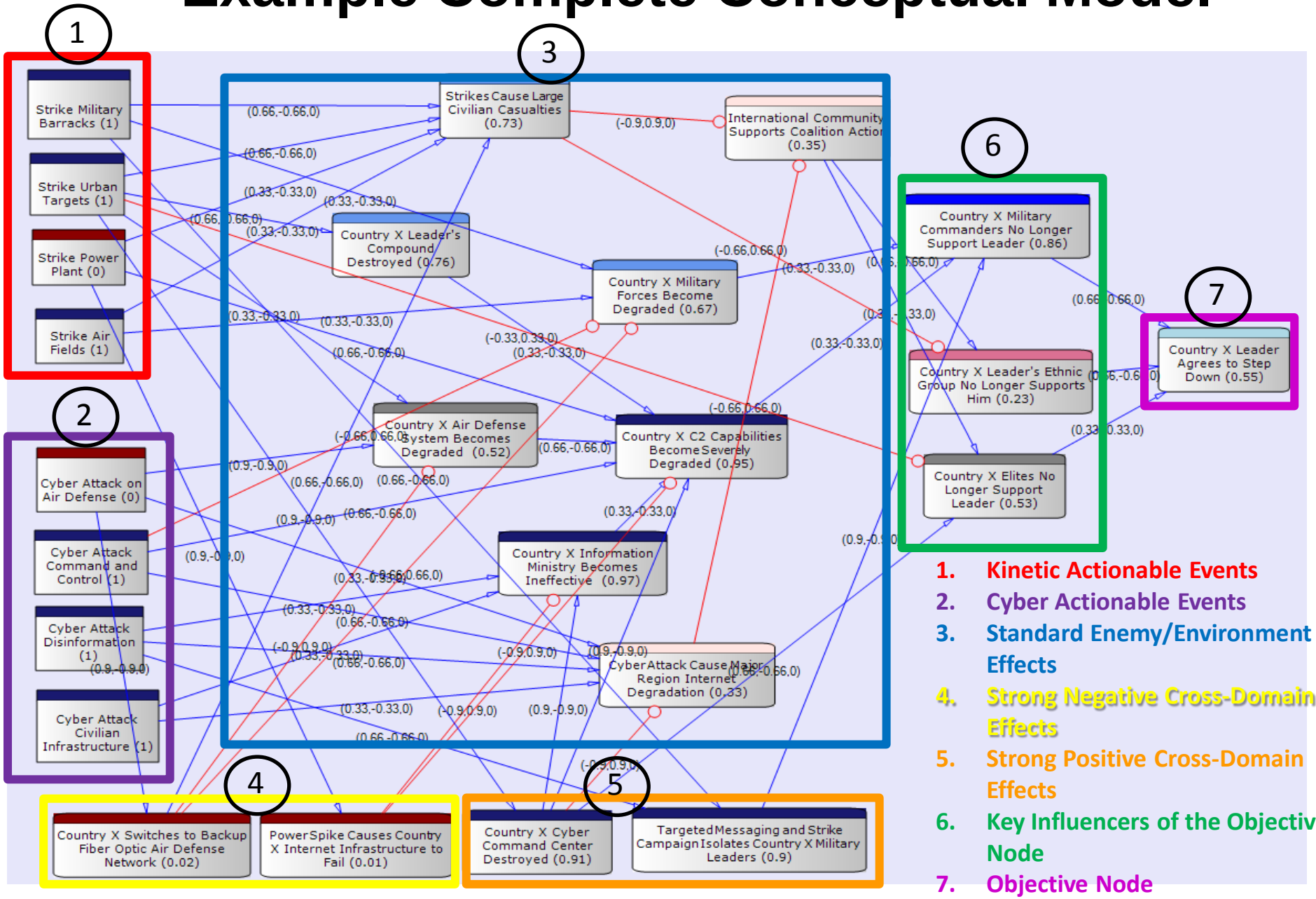


Integrating Process Modeling





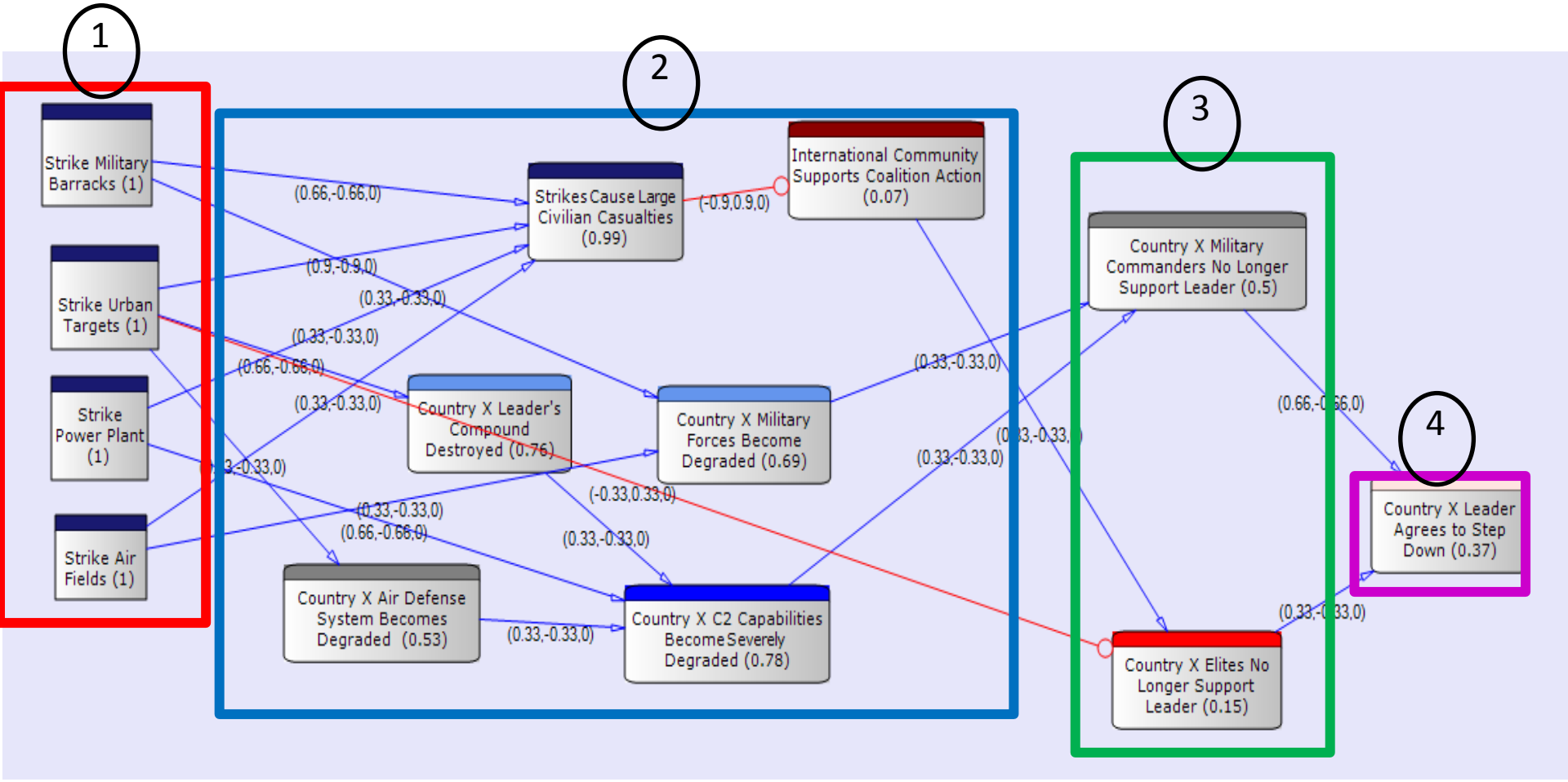
Example Complete Conceptual Model



1. **Kinetic Actionable Events**
2. **Cyber Actionable Events**
3. **Standard Enemy/Environment Effects**
4. **Strong Negative Cross-Domain Effects**
5. **Strong Positive Cross-Domain Effects**
6. **Key Influencers of the Objective Node**
7. **Objective Node**

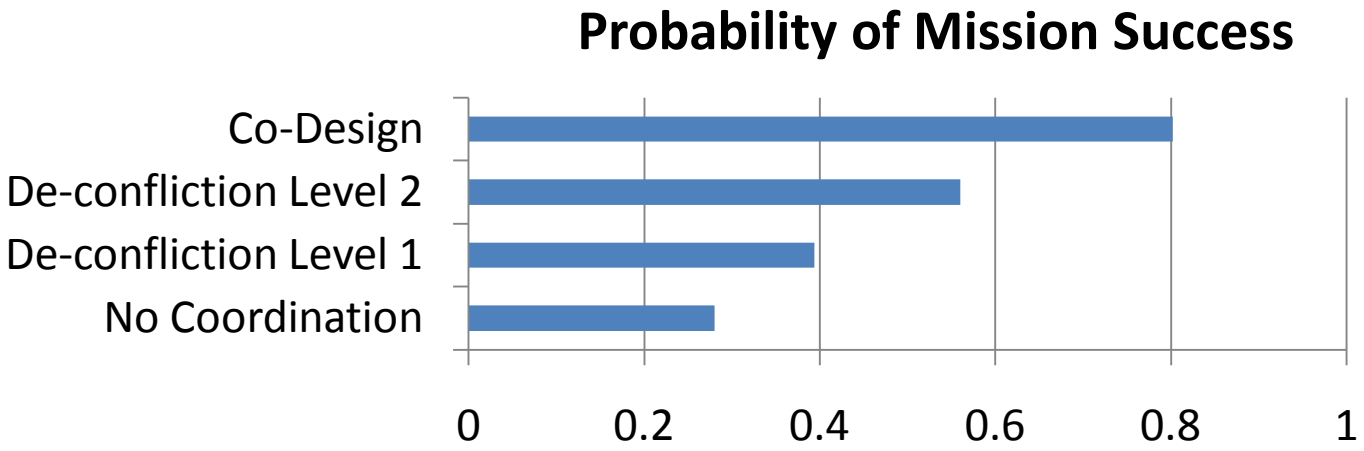
"Strong Cross-domain Effects Cause the Integration Level Performance Difference"

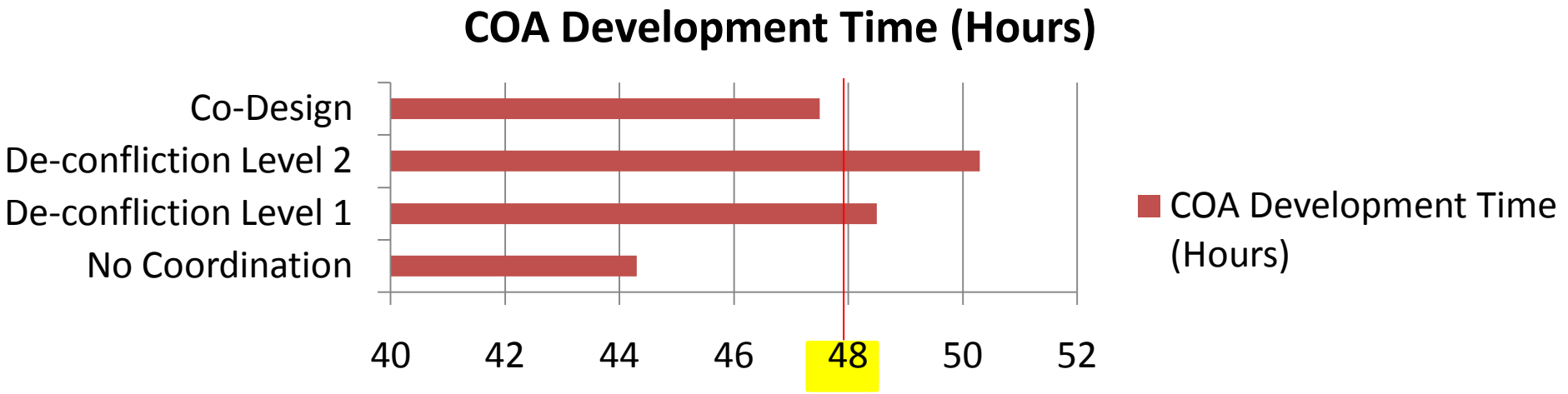
Example Domain Conceptual Model



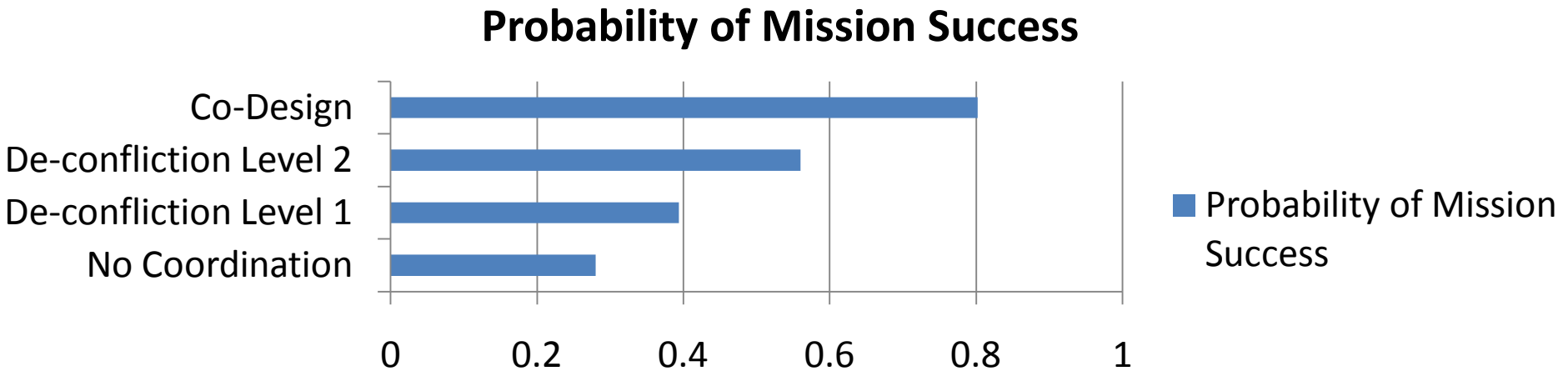
1. Kinetic Actionable Events
2. Standard Enemy/Environment Effects
3. Key Influencers of the Objective Node
4. Objective Node

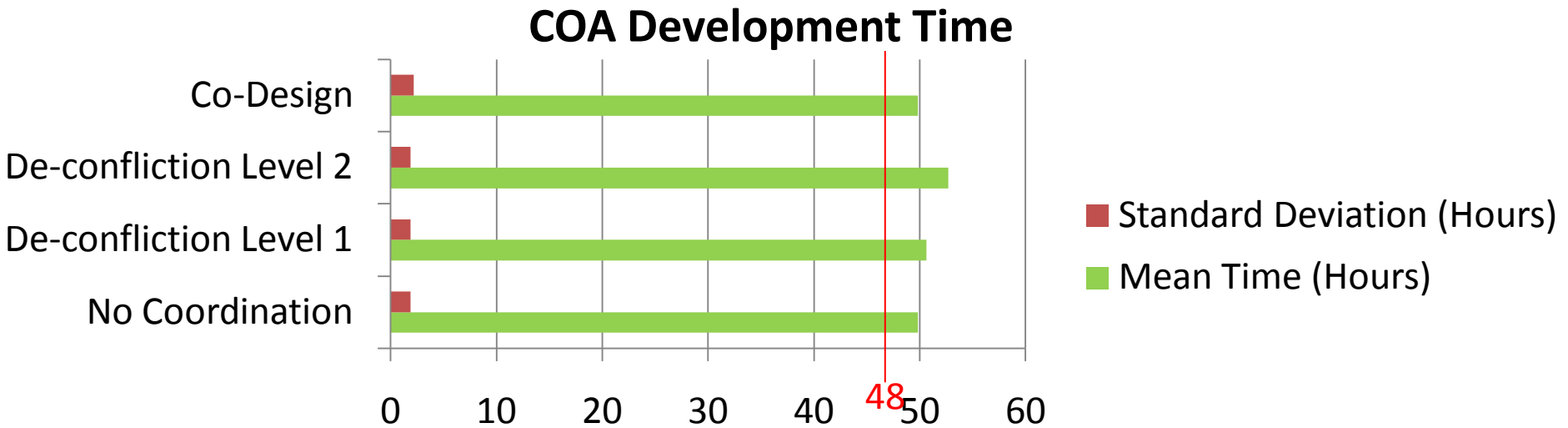
Deterministic Results





Stochastic Results

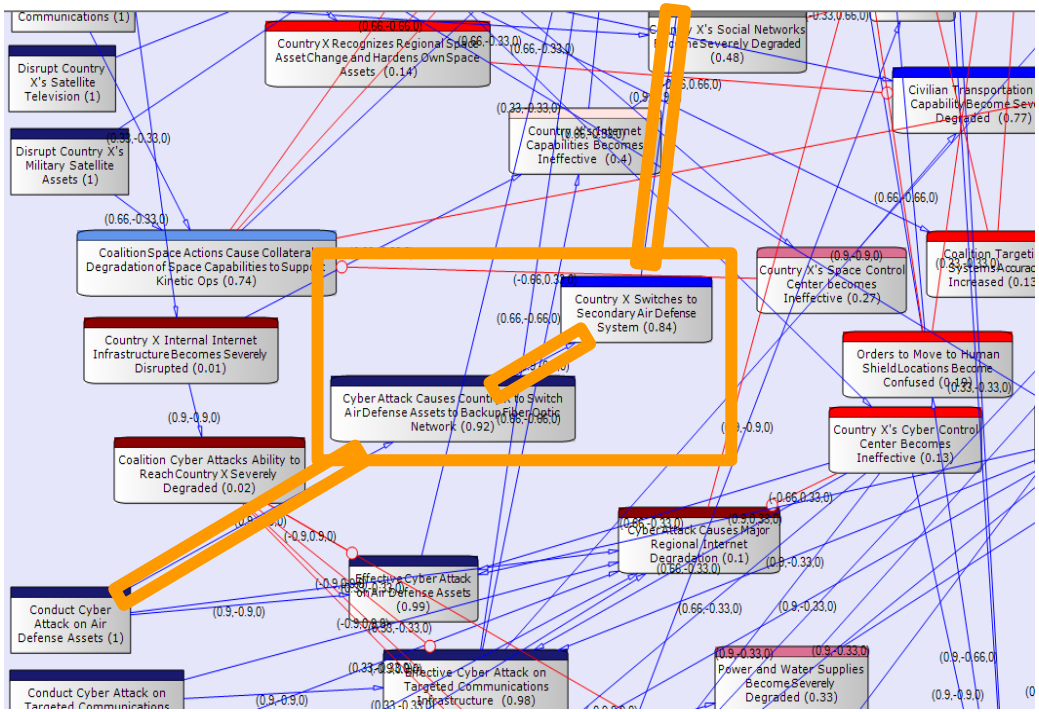




Time Compression

- Adaptation strategy use and results differ greatly by person/group[1]
- Results are highly dependent on situation and task
- Some studies have shown a linear relationship; others contradict this
- Modeling approach limited the amount of information (inference network elements) considered as time was compressed

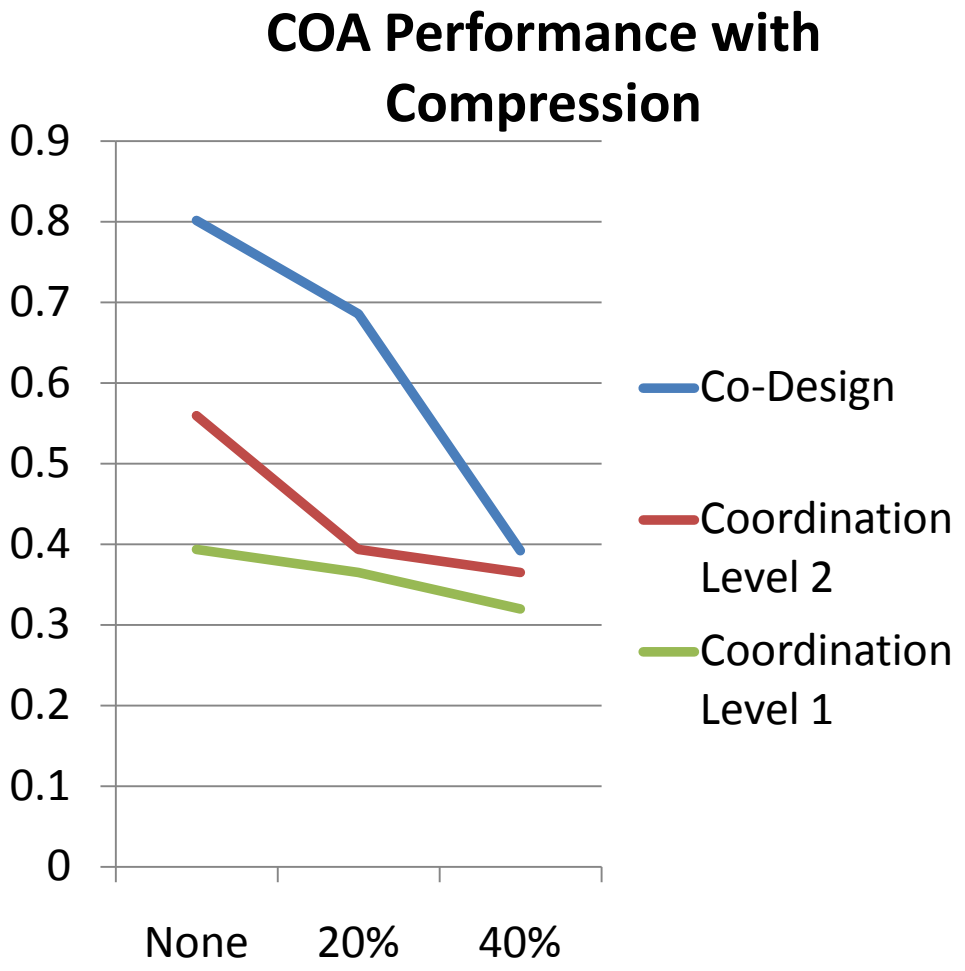
Example Inference Network Element



[1] L. Adelman, S. L. Miller, D. Henderson, and M. Schoelles, "Using Brunswikian theory and a longitudinal design to study how hierarchical teams adapt to increasing levels of time pressure," 2003.

Time Compression Results

Approach and Compression Level	Mean Time (Hrs)	Std DEV (Hrs)
Co-Design	49.8	2.2
20% Time Reduction	48.1	2.1
40% Time Reduction	47.1	1.9
De-conflicted Level 2	52.7	1.9
20% Time Reduction	51.2	2.1
40% Time Reduction	49.9	2.2
De-conflicted Level 1	50.6	1.8
20% Time Reduction	49.9	2.0
40% Time Reduction	48.8	2.2



Results Summary

- Co-design offers the potential for significant performance improvement with minimal increase in process time
- Co-design coordination time has less overall impact on total planning time because the process is largely concurrent with existing activities
- Results were not unusually sensitive to any particular parameter values
- Modeling indicates that the COA performance is sensitive to relatively small amounts of time compression

Approach	Mean Time in Coordination		Standard Deviation in Coordination Time	
	Minutes	Hours	Minutes	Hours
Co-design	694	11.6	68	1.1
Current Level 1	280	4.7	8	0.1
Current Level 2	412	6.9	44	0.7

Potential Areas for Future Research

- C2 laboratory feasibility studies of the Co-design approach
- Conditions for existence and strength of cross-domain effects
  - The importance of integration is based on assumption of their existence
  - What domain capability, operational environment, and objective/goal attributes affect the existence and strength of these effects?
- Alternative domain divisions and vertical integration
- Effects of "supported" or lead domain(s)
  - One integration method currently in use
  - Does selecting a lead domain prior to COA development bias considered COA options?

Questions

Back-up Slides

Deterministic Results

Approach Used	Combined COA Type	Process Times (CPN Model)		COA Performance (Pythia Model)		
		Minutes	Hours	Coalition OBJs Met	Coalition Loss Avoidance	Leader Agrees to Leave Power
New Approach	Integrated COA	2847	47.5	0.802	0.9	0.85
Current Approach Level 2	De-conflicted Level 2	3018	50.3	0.56	0.67	0.59
Current Approach	De-conflicted	2910	48.5	0.394	0.45	0.43
No Coordination	Combined Domain COAs	2660	44.3	0.28	0.32	0.295

Iterative Coordination Process Time Efficiency Assumed

Stochastic Results

Approach Used	Combined COA Type	Process Times (CPN Model)		COA Performance (Pythia Model)		
		Hours (Mean)	Hours (Std Dev)	Coalition OBJs Met	Coalition Loss Avoidance	Leader Agrees to Leave Power
New Approach	Integrated COA	49.8	2.2	0.802	0.9	0.85
Current Approach Level 2	De-conflicted Level 2	52.7	1.9	0.56	0.67	0.59
Current Approach	De-conflicted	50.6	1.9	0.394	0.45	0.43
No Coordination	Combined Domain COAs	46	1.9	0.28	0.32	0.295

Iterative Coordination Process Time Efficiency Assumed

Process Time Compression Results

Integration and Compression Level	Process Time							COA Performance		
	Mean Total Process Time			Standard Deviation		High End of 95% Conf Inv				
	Min	Hrs	% Reduction	Min	Hrs	Min	Hrs	Coalition OBJs Met	Coalition Loss Avoidance	Leader Agrees to Leave Power
Fully Integrated COA	2989	49.8	NA	133	2.2	3015	50.3	0.802	0.903	0.85
20% Process Time Reduct.	2887	48.1	3%	130	2.1	2912	48.5	0.686	0.825	0.694
40% Process Time Reduct.	2827	47.1	5%	120	1.9	2850	47.5	0.392	0.43	0.45
Fully De-conflicted Level 2 COA	3160	52.7	NA	115	1.9	3182	53.0	0.56	0.67	0.59
20% Process Time Reduct.	3075	51.2	3%	130	2.1	3100	51.7	0.394	0.45	0.43
40% Process Time Reduct.	2995	49.9	5%	135	2.2	3021	50.4	0.365	0.45	0.37
60% Process Time Reduct.	2928	48.8	7%	124	2.0	2952	49.2	NA	NA	NA
Fully De-conflicted Level 1 COA	3038	50.6	NA	113	1.8	3060	51.0	0.394	0.45	0.43
20% Process Time Reduct.	2998	49.9	1%	125	2.0	3023	50.4	0.365	0.45	0.37
40% Process Time Reduct.	2932	48.8	4%	133	2.2	2958	49.3	NA	NA	NA
60% Process Time Reduct.	2867	47.8	6%	131	2.1	2893	48.2	NA	NA	NA