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The Cost of Organizational Structures and Interfaces

prepared for

Ground System Architectures Workshop

by

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Presentation Contents

- Background, Purpose and Goals
- Rapid Prototype Methodology
- Primary Input Parameter Sensitivity
  - Number of Interfaces
  - Indirect Interfaces
  - Requirements Volatility
  - Organizational Structure Complexity
- Exercise Case Descriptions
- Model Input and Output
- Exercise Results
- Reservations and Recommendations

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Background

- The organizational structure of major programs appears to have an effect on the eventual cost of those programs.

- The hypothesis is that programs that have multiple acquiring organizations, a multitude of interfaces, or complex hierarchy and procurement layers inherently have higher costs due to conflicting requirements, complex management decision mechanisms, complex communications networks, and the protracted schedules that result from those mechanisms.

- This study was a preliminary investigation into the magnitude of cost increases for organizational structures as they move from a simple procurement tree to complex programs with multiple government agencies, multiple agency centers, and multiple contractors.

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Purpose and Goals

- **Purpose**
  - Quantify organizational structure cost driving issues
  - Estimate relative costs of program organizational structures
  - Perform trade studies and highlight major issues

- **Goals**
  - Develop rapid prototype model of organizational cost drivers
  - Model must be simple to understand and operate
    - Training time must be minimal
    - Maximize traceability
  - Ability to incorporate knowledge of multiple personnel
  - Quantify common issues by analogy in lieu of substantial research in the area of organizational structure costs
  - Provide a framework-vehicle for more advanced research
  - Maximize flexibility, credibility and utility
  - For expedience – “estimate costs in the right direction the right magnitude for the right reasons”

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Rapid Prototype Methodology –1

- The methodology chosen is a rapid prototype Excel spreadsheet model of different options for organizational structures that determine the resultant cost effects.
- The cost driving parameters include interface cost driving functions such as wrap factors, design integration activities, integration and test, oversight, multiple requirement originating organizations, and the experience of teams.
- The functions are assembled into a model and provided representative generic organizational structures with appropriate interfaces.
- The model is tested against known program costs and calibrated to those programs when possible.
- The output is cost ratios of all program organizational structures versus the simplest organizational structure in the candidate list. When a candidate program structure is a real program with dollar value, the costs of the program organizational structures may be inferred.

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Rapid Prototype Methodology - 2

- **Create cost functions based upon data and information from government, FFRDC, and industry sources**
    - Published technical articles
    - Commercial cost models
    - Available research
    - Quantified experience of NOAA and Aerospace personnel
- **Model organizational interface activities**
    - Organization ‘blocks’
    - Interfaces between blocks
    - Intensity of traffic in interfaces
    - Experience of personnel at tasks
    - Requirements volatility
    - Block Scope
- **Model calibrated to baseline case costs**
- **Succeeding cases modeled as deltas by changes in organizational structure**

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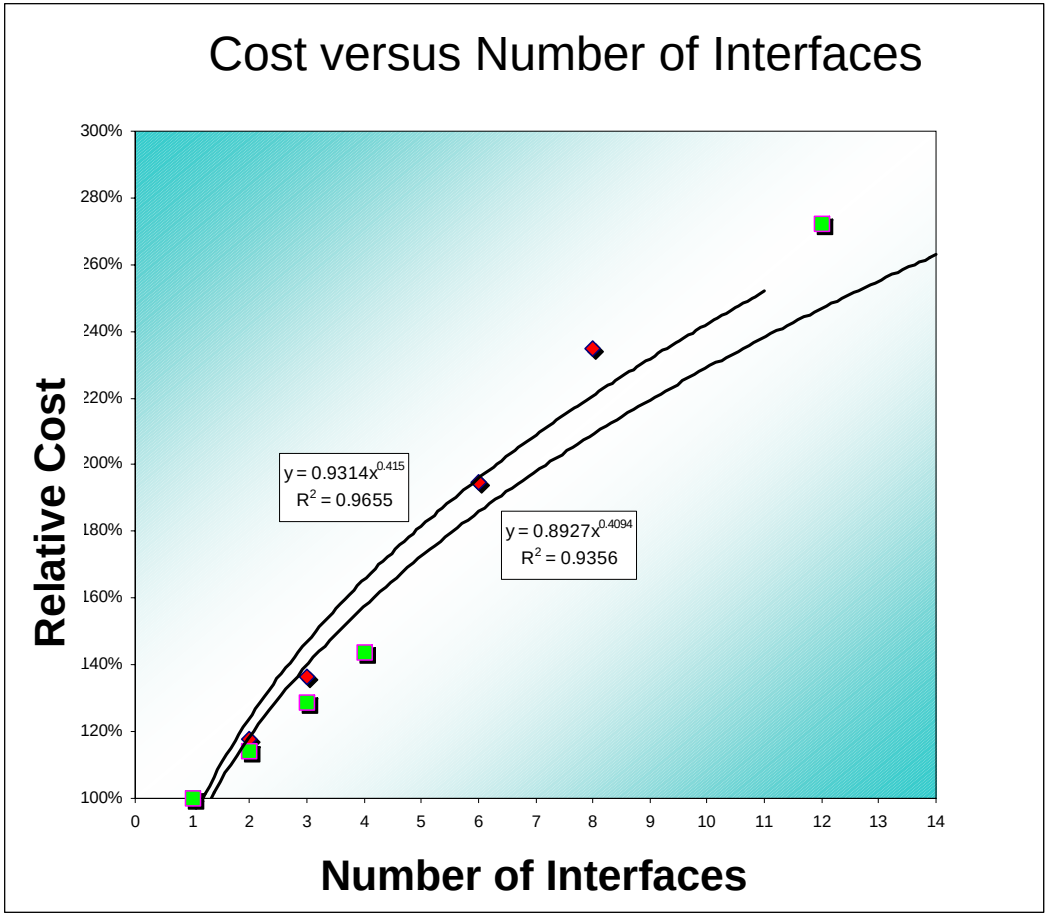
Primary Input Parameter Sensitivity

Number of Interfaces



- As the number of Interfaces increases, cost of coordination, control and management increases
- Represents increased communication and coordination between different organizations

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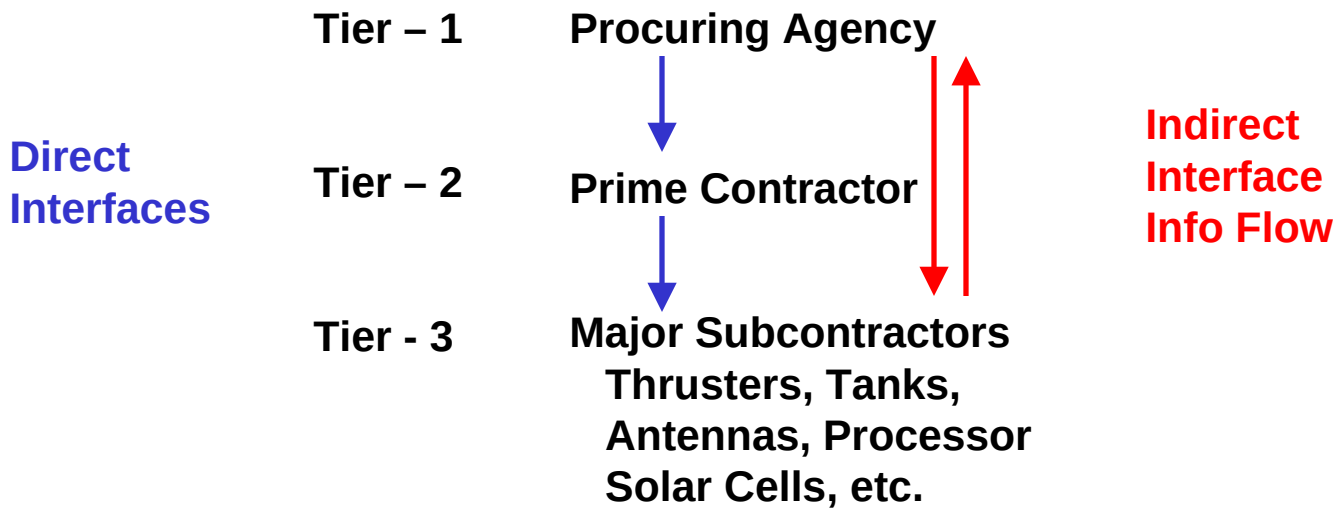
Primary Input Parameter Sensitivity

Indirect Interfaces



- Indirect interfaces in the organizational structure are caused by sub organizations and the information flow that they provide.
- Direction and requests for information flow down through the organization path and at each node in the organization system; ramifications of requests from the next higher level are analyzed and compartmentalized for further flow down.
- The third tier nodes (organizations, suppliers) flow business and technical feedback up the organization tree where it is reviewed before being summarized and continued up the organization tree.

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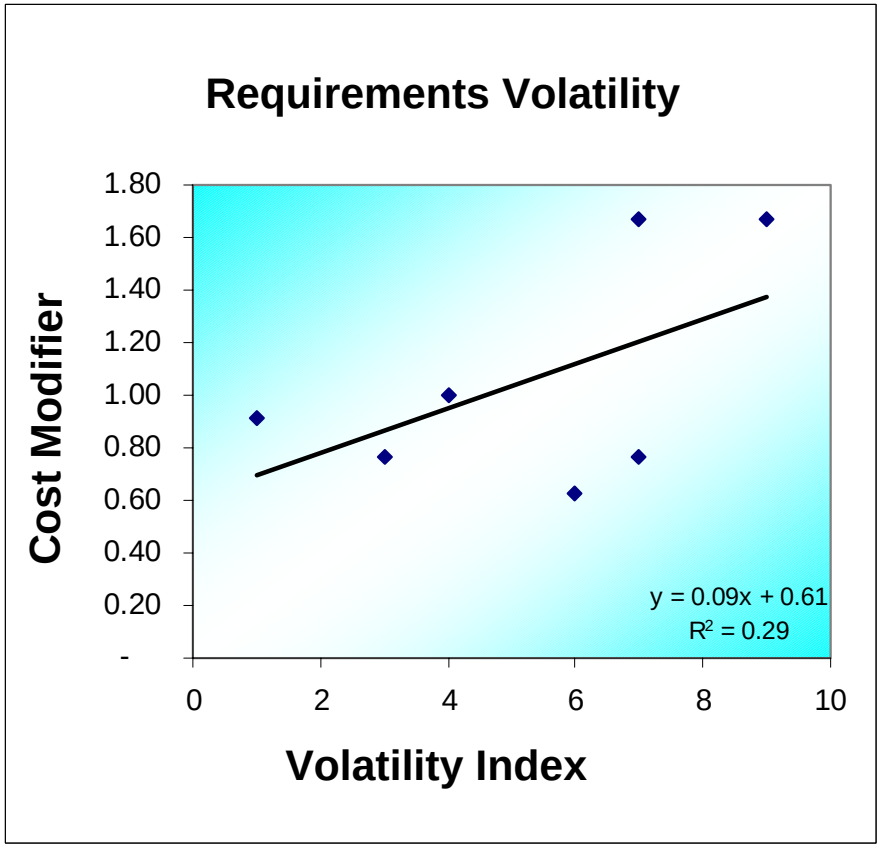
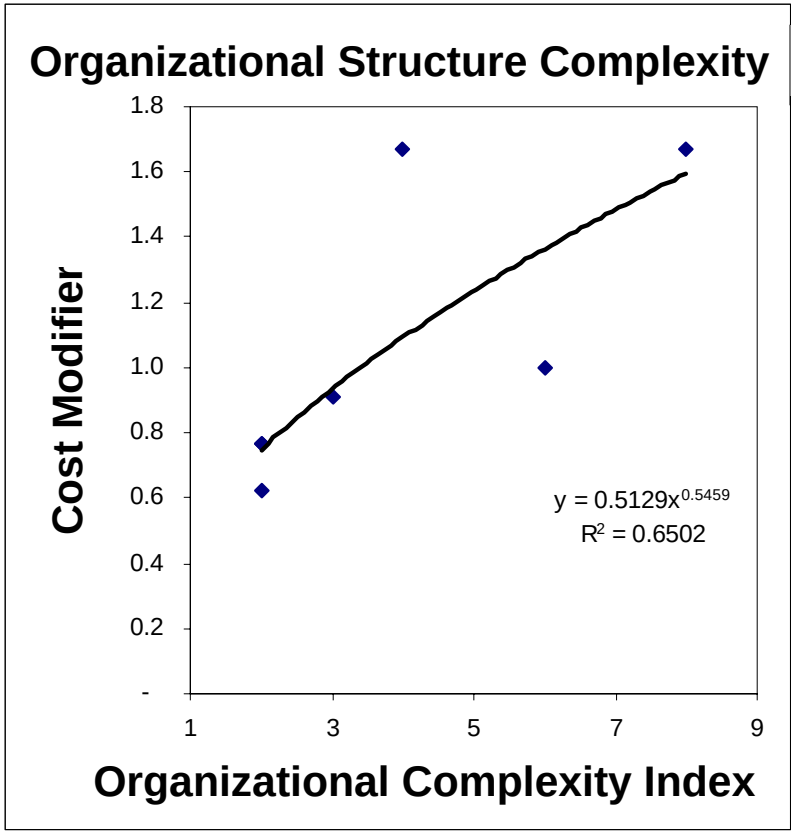
Primary Input Parameter Sensitivity

Volatility and Organizational Structures





Source: The Impact of Volatility and the Structure of Organizations on Software Development Costs by Jairus M. Hihn of NASA JPL. Journal of Parametrics, Oct 1990, pg. 65

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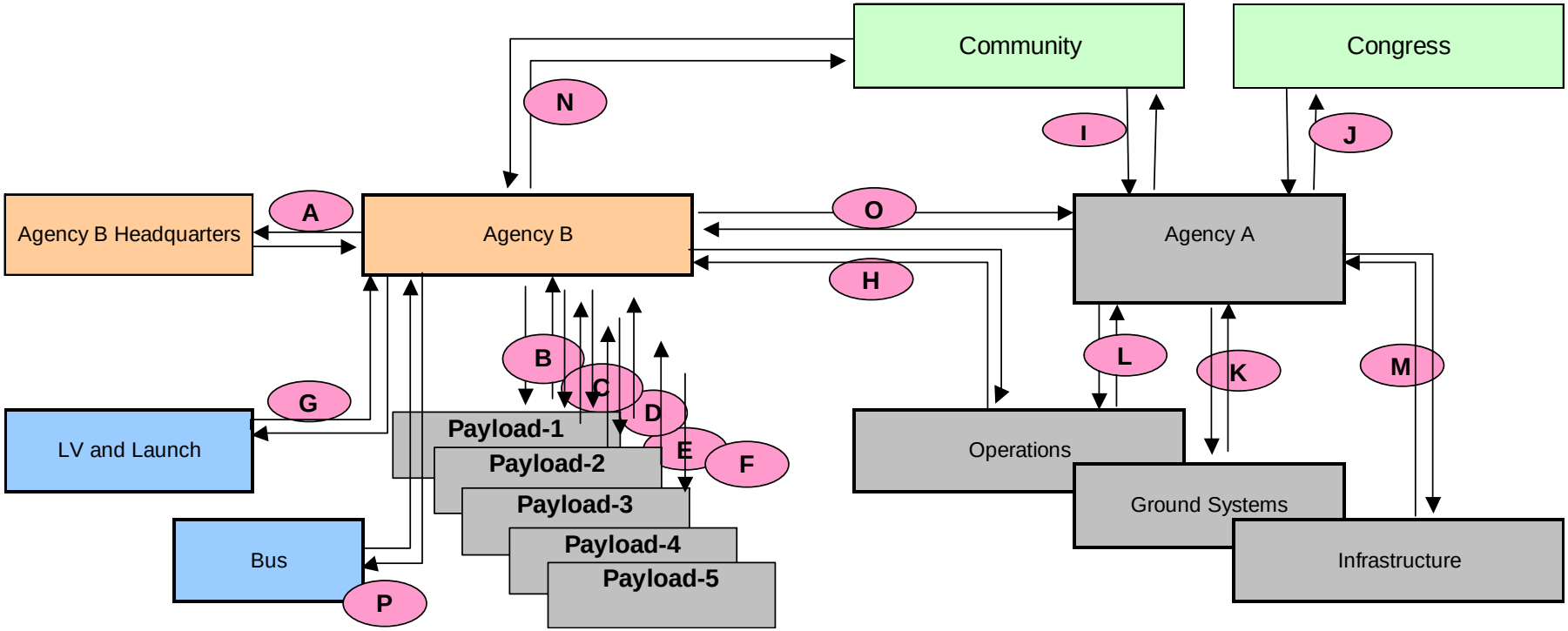
Exercise Case Descriptions

Case 1 (Baseline)

Number of direct interfaces = 7
Number of indirect interfaces = 9
Total Interfaces = 16
Interface Complexity = 100%



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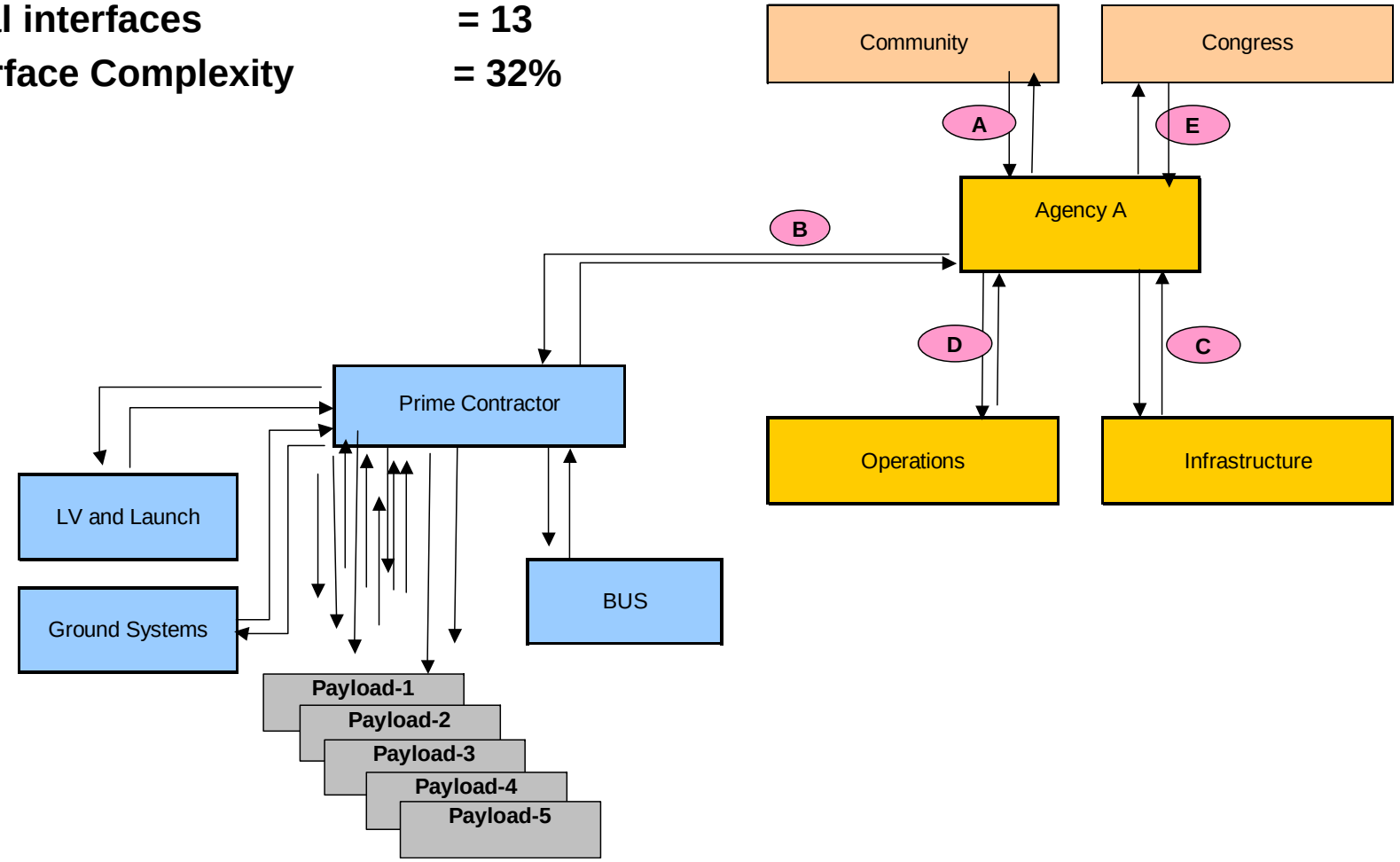
Exercise Case Descriptions
Case 2

Number of direct interfaces = 5
Number of indirect interfaces = 8
Total interfaces = 13
Interface Complexity = 32%



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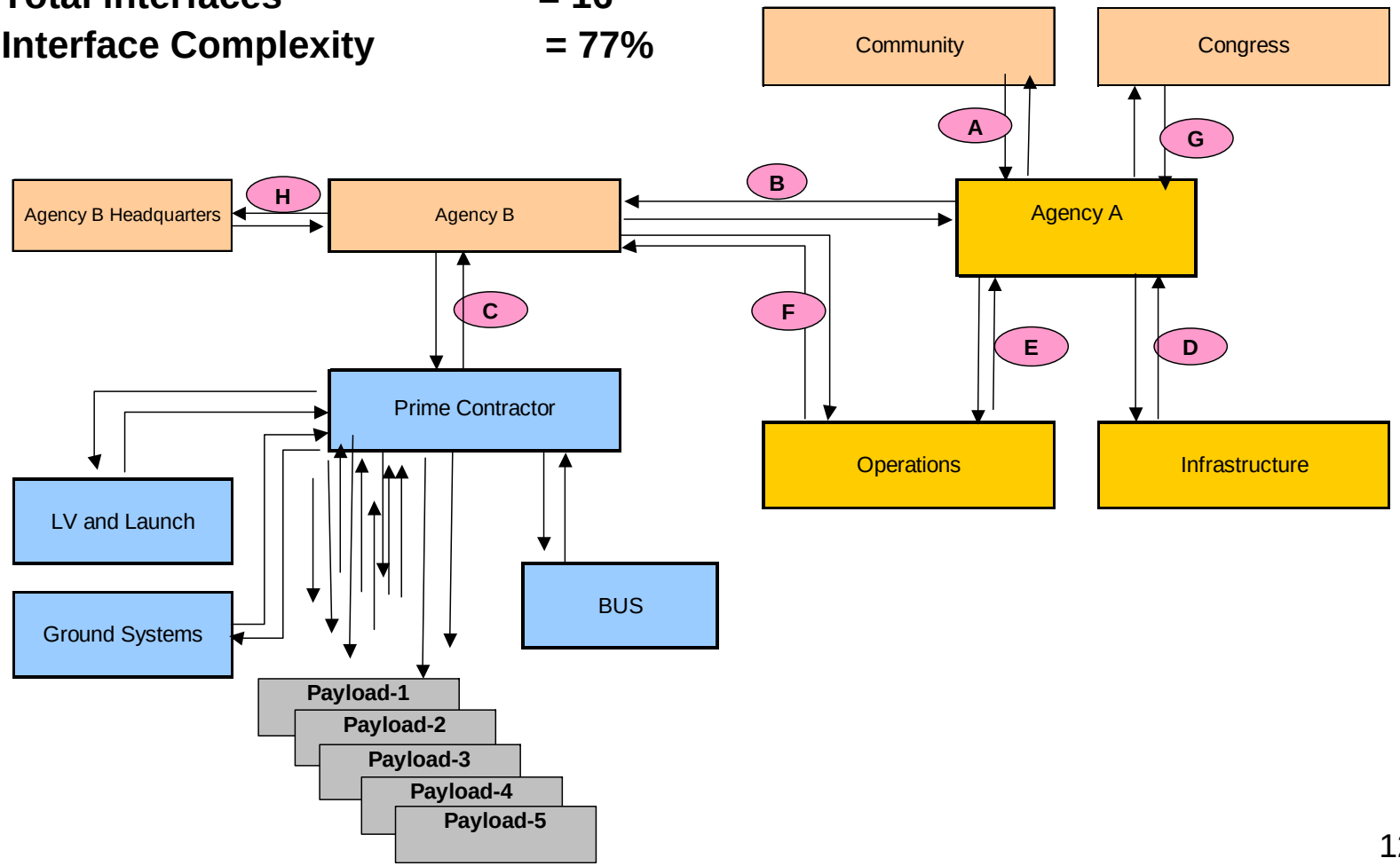
Exercise Case Descriptions
Case 3

Number of direct interfaces = 6
Number of indirect interfaces = 10
Total interfaces = 16
Interface Complexity = 77%



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Exercise Results

Model Input/Output – Case 3

CASE-3

		A	B	C	D	E	F	G	H
Organization Experience		0.949	1.119	1.119	1.000	0.983	1.068	0.983	1.068
	Unfamiliar								
	Mixed		70%	70%			40%		40%
	Normal	70%	30%	30%	100%	90%	60%	90%	60%
	Extensive	30%				10%		10%	
Interface RelativeComplexity		5.9	8.6	8.1	6.6	6.0	6.7	7.1	4.1
		5.9	8.6	8.1	6.6	6.0	6.7	7.1	4.1
Interface Relative Volume		3.3	4.6	4.1	3.7	3.9	3.7	2.3	1.9
		3.3	4.6	4.1	3.7	3.9	3.7	2.3	1.9
Requirements Volatility Index		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Disenabled	5	5	5	5	5	5	5	5
Organization Str Index		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Disenabled	3	3	3	3	3	3	3	3

Interface Summary

		A	B	C	D	E	F	G	H	
f-3	Organization Experience	0.949	1.119	1.119	1.000	0.983	1.068	0.983	1.068	
f-4	Interface RelativeComplexity	5.900	8.600	8.100	6.600	6.000	6.700	7.100	4.100	
f-5	Interface Relative Volume	3.300	4.600	4.100	3.700	3.900	3.700	2.300	1.900	
f-6	Requirements Volatility Index	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
f-7	Organization Str Index	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
Interface Traffic Figure of Merit		18	44	37	24	23	26	16	8	198

Node Allocations

		A	B	C	D	E	F	G	H		
Agency -1	Agency-1 FOM	18	44		24	23	26	16		153	
	Agency -1 Direct Interfaces =	2.08	2.08		2.08	2.08	2.08	2.08		6	2.08
	Agency -1 Indirect Interfaces =	1.58	1.58		1.58	1.58	1.58	1.58		10	1.58
	Adjusted Agency -1 FOM =	61	146		81	76	88	53		505	
	Interface Cost allocation =	12%	29%		16%	15%	17%	11%		100%	95%
	Interface Cost $m =	27	64		35	33	38	23		219	232
Agency -2	Agency -2 FOM =		44	37			26		8	116	
	Agency -2 Direct Interfaces =		1.77	1.77			1.77		1.77	4	1.77
	Agency -2 Indirect Interfaces =		1.64	1.64			1.64		1.64	12	1.64
	Adjusted Agency -2 FOM =		129	108			77		24	337	
	Interface Cost allocation =		38%	32%			23%		7%	100%	69%
	Interface Cost $m =		90	76			54		17	237	345
Total											
	Total FOM =	61	275	108	81	76	164	53	24	842	77%
	Total Interface Cost $m =	27	154	76	35	33	92	23	17	457	79%
		A	B	C	D	E	F	G	H		

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Exercise Results – Direct Cost Effects

- **Summary of Case Results – Relative Interface Complexity**

	Relative Complexity	Relative Cost Agency A	Relative Cost Agency B	Relative Cost-Total
Case 1 =	**100%**	**100%**	**100%**	**100%**
Case 2 =	**32%**	**104%**	**0%**	**42%**
Case 3 =	**77%**	**95%**	**69%**	**79%**

- Analyst's conclusion is that the rapid prototype developed represents a reasonable analytical emulation of the primary cost parameters of organizational interface complexity
- Relative costs predicted represent the approximate difference expected in real world program organizational structures
- Approach and architecture has the potential for benefits from continued development

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Reservations and Recommendations

- **Initial literature search has provided only limited studies on the cost effects of organizational structures**
- **One article by NASA JPL (1991) researched requirements volatility and organizational complexity**
- **Possible autocorrelation between the input parameter sets**
  - **Interface velocity and complexity**
  - **Organizational complexity and requirements volatility**
- **Calibration of interface traffic volume versus interface complexity and indirect interfaces is recommended during next phase**