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Acquisition Risks in a World of Joint Capabilities

17 August 2011

Dr. Mary Maureen Brown, Professor

The University of North Carolina at Charlotte

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Abstract

The move to joint capabilities has proven to be an important paradigm shift in defense. The reasons for the shift are grounded in the need to allow the agility that shared resources provide. This research sought to identify whether the need for joint capabilities influenced acquisition success. This study examined five years worth of data and looked at a number of interdependencies for their influence on acquisition success. Two specific objectives were pursued: (1) to test the influence of funding and data interdependencies on acquisition performance, and (2) to test the interdependent programs for the presence of cascading effects. The results proved particularly pivotal. With additional research, the study of interdependencies may offer promise for improving early assessment of program development resources, establishing more realistic program thresholds, and highlighting areas of risk that may have escaped management attention.

Keywords: Interdependency, Complexity, Acquisition Performance, Joint Capabilities

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Under the auspices of Defense Secretary Donald Rumsfeld, Department of Defense (DoD) transformation became a compelling objective in the aftermath of September 11, 2001 (Rumsfeld, 2003). During the Cold War era military strategy was predicated on the belief that deterrence was best achieved through arms superiority. Quantitative and qualitative superiority was achieved by heavy reliance on scientific management principles as an organizing paradigm (Hughes, 1998). Economies of scale were achieved in arms production through a capital-intensive industrial base that stressed the principles of scientific management: hierarchy, division of work, functional specialization, and the separation of planning from operations. These strategies gave rise to a plethora of individual subcultures with distinct missions, goals, and vocabularies.

The demise of the Soviet Union, and the resulting proliferation of multiple non-state-affiliated threats, coupled with emergent, limited interventions around the globe, called into question the arms superiority philosophy as a deterrent. In this multilateral, asymmetric threat world, the deterrent value of massive armed forces eroded and the normative framework that defined the Cold War, and the DoD, imploded. Instead, the operational advantage shifted from a focus on mass and firepower to one of agility and precision (Chairman of the Joint Chiefs of Staff, 2000). Quite suddenly, agile, tightly integrated Joint Status operations, in which functional specialists are brought together to provide a specific capability suited to a particular operational context was needed.

The need to adopt a "Joint Status" perspective was first echoed in 1996 in a publication by the Office of the Joint Status Chiefs of Staff entitled *Joint Status Vision 2010*. Termed "Joint Status Capabilities," the concept was later formalized in the *2001 Quadrennial Defense Review.* Because it was believed that the future operating environment would be characterized by uncertainty, complexity, rapid change, and persistent conflict, DoD leadership initiated the capability to act jointly. The fact that irregular warfare threats exceed the capabilities of any single agency of government is no longer disputed. It has become clear that future forces will find themselves operating as one military element in an integrated national task force or, at a minimum, in close conjunction with other agencies of government.

The transformation to joint capabilities attempts to provide military forces with the capability to adapt quickly to new challenges and unexpected circumstances by leveraging a wider range of assets. Central to the transformation was the desire for enhanced coordination among agencies and across all levels of government (coalition, federal, state, and local). In addressing the need for interagency cooperation, then Vice Chairman of the Joint Chiefs of Staff Admiral Giambastiani (2003) claimed that the integrated force had to become interdependent. That is, it must be capabilities-based, collaborative, and network centric. Giambastiani argued that military efforts required high-level, or large-scale, vertical and horizontal collaboration—up and down the chain of command and across all capabilities and forces.

At its core, the transformation is about instilling processes and practices that promote knowledge and agility. In short, joint capabilities is viewed as a mechanism to expand both the breadth and depth of current understandings, and to facilitate the agility needed to spontaneously leverage a wide range of inter-service, inter-governmental, and inter-national resources. According to Admiral Mullen to be successful the DoD needs new joint doctrine, tactics, techniques, and procedures (Garamone, 2009). Apparently, new methods for integrating activities both internally and with partners are needed. Jointness requires that the DoD select, educate, train, equip, and manage differently. Moreover, new technologies are needed to adapt to existing technologies to achieve new joint missions.

Despite the recognized need for jointness, the literature on its influence on acquisition is largely lacking. Research is especially crucial because jointness cannot be successful without the implementation of requisite material solutions. Successful joint initiatives require more than human collaboration. They require material solutions that operate together in a systematic fashion. The ability to develop material solutions that can undergird joint demands is ultimately an issue of acquisition because joint acquisition efforts are typically needed to recognize joint military operations. A recent Government Accountability Office (2011) report argued that sharing domain information, policy and processes, technology, legal restrictions, and cultural barriers all impede the ability to benefit from joint capabilities. These same factors are also likely to stymie acquisition. Thus, the study of the risks associated with joint acquisition is an important, albeit understudied, topic. This research seeks to address this gap and looks at jointness in the acquisition arena from a number of different dimensions.

The report begins with a short introduction of the salient components of the networks that form interdependent activities. Some of the risks are also discussed. The research questions are then provided. The research methods follow. The report closes with a discussion of the findings and the implications for DoD acquisition.

The Organizational Networks of Interdependent Activities

The study of jointness is fundamentally a study of interdependence. Joint actions rely on an exchange of resources. Exchange theorists argue that organizations develop interdependent relationships with other organizational entities to either obtain critical resources or to provide critical capabilities. Typical resources that are often exchanged include labor, materials, data, and financial capital. Interdependencies occur when a given organization relies on the exchange to maintain fitness. The exchanges give rise to a network of actors that exchange resources to achieve goals that otherwise could not be obtained. In this way, the study of organizational interdependencies is simultaneously a study of organizational networks.

As discussed further in this report, program networks serve as the basis from which the interdependence is defined and the wider array of resources become available. Hence, they are a critical underpinning to the realization of joint capabilities. Program networks exhibit five salient components. The examination of each of the components provides important insight into the nature of the network. As elaborated on, it can provide important information on issues pertaining to performance, risk, cost, and schedule. Program networks can be defined according to their nodes, assets, configurations, channels, and zones.

Program Network Nodes

In general, in any network a node is a connection point that acts as a redistribution point, or an end point, for a transmission of some sort of asset. In program networks nodes include systems, organizations, individuals, and computers. In fact, unlike computer networks, which define only processing units as nodes, a program network will often include a mixture of systems, organizations, and computers. However, the primary node tends to be the organization with its associated systems and computers. The organizations that act as nodes in the network often differ in a variety of ways. They can be government entities or private sector entities. They can be similar in discipline and function or they can vary widely. Regardless, they all tend to share one important trait—they tend to exhibit a high degree of autonomy over the scope and nature of their involvement in the network. The autonomy derives from the fact that each member comes from a different organization and it is relatively impossible to superimpose a hierarchical command structure. By definition, program networks differ from hierarchical forms of organization by the sheer fact that it is virtually impossible to establish a single centralized authority structure that is capable of enforcing unilateral compliance. The boundaries of most networks are defined according to the type of interdependencies that exist among the nodes. Many network initiatives seek to minimize the number of nodes to reduce complexity. Hence, most nodes will bring critical assets to the network that cannot be easily obtained elsewhere.

In the economics arena, there is an assumption that organizations will only engage in a network to the extent to which benefits are realized. Once the cost outweighs the benefits, the resources will be obtained in a different manner. Hence, networks provide a net benefit. In the government sector, this assumption rarely rings true. Policy legislation often mandates that networks achieve given goals and, as discussed further below, these mandated relationships can accrue transaction costs. As a result, networks are likely to influence both the cost and risk of acquisition.

Program Network Assets

Program networks exist for the sole purpose of sharing, exchanging, or transferring resources or assets. In most program networks, the assets are in the form of capital, data (to include information, knowledge, or expertise), materiel, or labor. In many of the DoD initiatives, program networks are established to facilitate the transfer of data. However, others exist to share capital. For example, JSTARS was a joint Air

Force-Army initiative that was predicated on sharing financial capital. The U.S. Congress refused to authorize the initiative unless both Services pooled their financial resources and developed the capability jointly. Still others will share or trade critical materiels, labor, or expertise. Under some situations, a given program network will actually involve the trading, sharing, and transferring of all of these assets (capital, data, materiel, and labor). An important dimension of the program network, as will be discussed further later in this report, is the issue of “balance” or symmetry. When each of the nodes benefits equally from involvement, the network is seen as balanced. However, when some nodes or organizations benefit to the detriment of others, the network is unbalanced and is at risk for problems (this topic is discussed further in the “risk” section).

Program Network Configurations

Thompson’s (1967) work on organizations in action defined three types of network configurations: pooled, sequential, and reciprocal. Since the time of his research, the nature of the configurations has grown increasingly more complex—in short, as discussed further later in this report, they have grown beyond the simple tripartite definition. But as a starting point, his definition provides the basic structural elements that underpin program networks. The structural configuration defines how the assets flow among the nodes. It is, in short, the architecture of the transactions that occur in the network.

According to Thompson (1967), in pooled configurations the various parties contribute to, and draw on, resources from a shared pool. A typical example might be to share a common core of hardware and software. In fact, the DoD’s move to service-oriented architectures or cloud computing can be thought of as a pooled configuration. The various branches will post data and services on the network, and subscribers will have the luxury to draw down from the pool of resources. Another example might be the economies of scale that two or more nodes achieve by procuring from the same source. In this case, the withdrawal of one of the nodes may end up increasing the costs for the remaining nodes. The important characteristic of pooled configurations is that each of the contributors and beneficiaries act independently. They may rely on the pool for needed resources, but their actions are not intricately linked. This type of interdependency is only indirect in nature because each node can provide its contribution to the system independently, but for the success of the system, both will have to succeed in their contributions. For this reason pooled configurations are seen as “loosely coupled.”

Gaining in complexity, the second configuration is termed “sequential” (Thompson, 1967). In sequential configurations, the exchange of resources flow in one direction only, from one party to the next, and then the next. Typical examples are supply chain systems. Figure 1 provides an illustration of a sequential configuration.   It is important to recognize that with sequential configurations, the output of one party becomes the input of another. Because one party is dependent on another for its output, the structure is more “tightly linked” than in the pooled configuration.

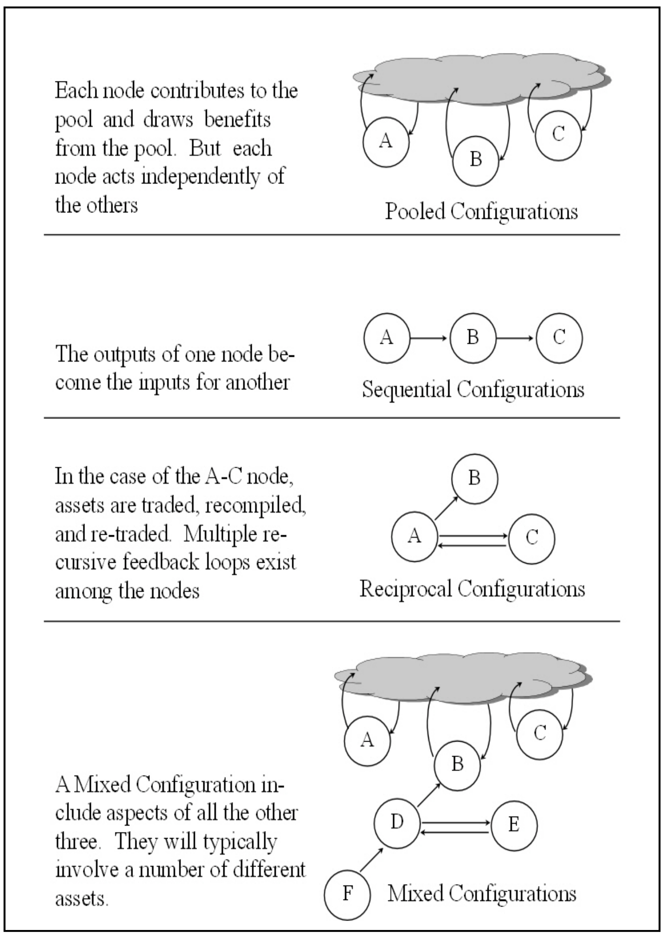


Figure 1. Program Network Configurations

Another defining characteristic of sequential configurations is that they can be decomposed into dyads, or pairs of nodes. The general thinking is that each party will work to ensure that their source of input is stable, reliable, and meets quality thresholds. Hence, bilateral agreements are not uncommon in this situation. So, the sequential configuration tends to be made up of a number of bilateral pair-wise agreements. In this way, the chain is maintained. To date, a significant amount of study has focused on pair-wise sequential approaches to product and service acquisition and delivery. Because they are easily decomposable, much has been learned about behaviors, costs, and risks.

The third configuration form is termed “reciprocal” (Thompson, 1967). In reciprocal arrangements resources are frequently traded, recompiled, and re-traded (see Figure 1). These configurations tend to include multiple recursive feedback loops among the parties involved. Of the three configurations, reciprocal configurations are the most difficult to design, implement, and maintain yet they also tend to yield the greatest benefits. They also tend to be the source of the greatest agility, primarily because they adapt well to new encounters and can adapt to meet immediate needs. These relationships are also known to demonstrate synergistic gains. Nonetheless, they tend to be high risk (more on this topic later in this report).

Whereas the three configurations provide a starting point for understanding interdependent activities, the reality of today’s activities are far more complex. In short, it is not unusual for the acquisition or production of a service to incorporate multiple configurations with resources flowing in and out across organizations of public and private entities. As such, the most common configuration is the “mixed” pattern incorporating all three of the configurations and a wide array of nodes, assets, channels, and zones. Hence, the value chain of the joint capability is laden with junctions and bifurcations where delay, defection, or shirking can occur. Furthermore, as is evident in Figure 1, the value chain is laden with both direct and indirect interdependencies.

Program Network Channels

Channels are the links or ties that span the nodes. They are the mechanisms that act to transport an asset from one node to another. Hence they are critical to the functioning of the network. Typical mechanisms for the transfer of assets include postal services, telephones, and face-to-face channels. Face-to-face approaches are often needed to both initiate and sustain efforts. More recently, products and services are either routed or transferred via computer networks, satellites, and sensors. Regardless of the channel, issues of bandwidth, congestion, and noise all remain salient. As expected, it is not uncommon to employ multiple channels and redundancy is often used when the resource is particularly critical. The choice of a given channel, and its specifications, typically needs to be coordinated between the sender and the receiver to ensure that the resource is received accurately, in a timely manner, and at the proper specification level.

Channels can be formal or informal, permanent or ad hoc. They can be governed by simple handshakes or they can involve detailed contracts and agreements. Moreover, depending on the assets and the terms of the transfer, the channel can be asynchronous or synchronous. Channels are often defined in light of the direction of the flow of the resource, and the reliability, integrity, and performance of the channel is often contingent on the value of the asset being transported.

Program Network Zones

As illustrated in the mixed model in Figure 1, the notion of zones refers to the boundaries of a given network. In general, a zone is an area of administration. The program network zone is the area inside the boundaries that must be administered and monitored for proper functioning.

The zone makes up the entire landscape of the program network and includes all of the relevant nodes, assets, configurations, and channels that must be administered. In reality, program networks will exhibit multiple zones simultaneously. For example, one zone of nodes and channels may relate to financial assets, but a second zone drawn around data assets may show a different set of nodes and channels (see Figure 2). As such, it is often a relative term. Program network zones are contiguous to the point of final termination. Hence, the boundaries can be difficult to isolate. It is not uncommon for the zones to change over time.

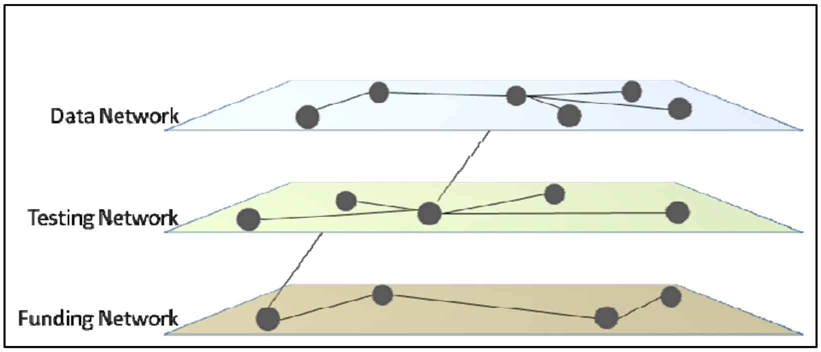
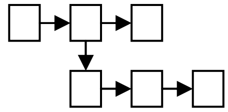
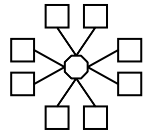
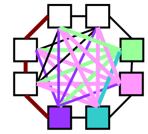


Figure 2. Network Layers With Interlocks

In most cases the boundaries will be drawn, and the zone thus identified, based on the assets that are transferred or exchanged to provide a given capability. But zones can also be isolated from the context of a single node. In this way the flows in and out of a node can be examined in much the same way as supply chains or pooled configurations. The notion of zones becomes especially important in light of the network's stability and the need to maintain equilibrium. In a joint capability arena, warfighters should be able to move across program zones with ease, tapping the resources that are needed anywhere anytime. To the warfighter, the various program zones should be invisible and seamless. Table 1 provides an overview of the three configuration types along a number of dimensions.

Table 1. Operational Configurations

Configuration / Dimensions	Sequential 	Pooled 	Reciprocal 
Interdependency Level	Low	Medium	High
Design Focus	Pair-wise Space	Combined Space	Collective Space
Ability to Structure	High	Medium	Low
Conflict Potential	Low	Medium	High
Benefit Gain	Additive	Additive	Synergistic
ROI	Low	Medium	High
Risk	Low	Medium	High
Analytical Design Demands	Low	Low to Medium	High
Transaction Costs	Low	Low to Medium	High
Military Example	Procurement	Logistics	Situational Awareness

As discussed previously, program networks can be examined in light of their nodes, assets, configurations, channels, and zones. Each of these dimensions provide critical insight into the fitness of the network and its potential for success. An important determinant of a network's cost, schedule, and performance is grounded in the ability to adapt to changes relatively easily without encountering too much turbulence.

Despite the difficulty that reciprocal configurations pose, they hold tremendous potential for returns on investment and benefit gain. The gains that tend to arise from reciprocal configurations are often synergistic in nature rather than additive. Because they are data rich, they allow data to be extracted, fused, and recompiled to provide additional value that is not normally achievable at an individual level. Reciprocal configurations tend to have high analytical demands on the design process because the collective space from which synergistic benefits derive must be constructed. Unlike the other two configuration types, there is no existing knowledge base from which to base a design. Instead, the solution space must be crafted. The design process is time and attention intensive because solutions must be crafted to meet a vast array of divergent needs. As a consequence, the transaction costs can be very high—and they are often hidden and under predicted.

According to researchers, network success is contingent on intentionally adapting, coordinating, and safeguarding the exchanges that occur within the network (Jones, Hesterly, & Borgatti, 1997). But, how one successfully coordinates and safeguards the exchanges remains the subject of tremendous debate. Provan and Milward (2001) argued that, due to the open and permeable boundaries and the lack of centralized command structures, management challenges are immense. They claimed that managers must continuously deal with problems requiring negotiating, coordinating, monitoring, holding third parties accountable, and writing and enforcing contracts all in an inter-organizational setting in which information asymmetries and moral hazards abound.

According to Agranoff and McGuire (2001), networks demand transparency and detailed knowledge of their member affiliates. Isett and Provan (2005) argued that success is dependent on the development of formal agreements to limit opportunistic behavior. This may be especially true because program managers tend to be very skilled at hedging. Concerned about risk, program managers often keep options open so that they can pursue one strategy over another in the event of unacceptable risk. Hence, defection can be a problem. Yet, Radin and Romzek (1996) disagreed and suggested that networks are likely to be more effective under low-control accountability relationships rather than under high-control relationships that employ legal or hierarchical authority.

Conversely, Mandell (2001) argued that there is no evidence that any "best practice" or favored institutional form has had any positive effect on network outcomes. Despite the lack of congruence in the findings thus far, few would dispute the notion that open and permeable boundaries typify network structures. It is precisely these "open boundaries" that render it difficult to coordinate and safeguard exchanges because of the uncertainty and unpredictability that accompanies environmental flux. In exchange theory, the uncertainty is often attributed to the interdependencies that exist among the organizations. The source of this uncertainty can come from suppliers, customers, competitors, regulatory agencies, unions, or financial markets (Miles & Snow, 1978). Shirking or defection of a network member can have dire consequences on the survival and performance of the network in total and the network participants in general. Because of the nature and influence of the ties that bind organizations, Levinthal's (1997) research indicates that increasing the density of the interdependencies that connect the organizations affects the complexity of the "landscape" in which the organization operates. Levinthal (1997) found that these interconnections, or flows, yield nonlinear consequences that often involve multiplier effects based on the nature of the interdependencies in the system.

While DoD agencies are expected to embrace joint capabilities, literature findings regarding the risks and best practice mechanisms of joint interdependent activities lag far behind. Whereas early research did provide some insights, the research activities have stalled and progress is lacking. For example, back in 1937 Coase found that interdependencies are based on mutual exchanges that can be examined at the transaction level. He argued that these transactions accrued costs that could be attributed to establishing the rules of engagement, enforcing agreements, and monitoring compliance. Unfortunately, specific cost functions were never isolated.

Despite the scholarly activities, 10 years ago Agranoff and McGuire (2001) wrote that "there are many more questions than answers in network management," and the assertion continues to ring true. Apparently, the field is rich in anecdotal findings but poor in empirical evidence (Alexander, 1995). Oliver and Ebers (1998) likened the state of the field to a messy situation marked by a cacophony of heterogeneous concepts, theories, and research results. Whereas the growth of networks and interdependencies is clearly on the rise, DoD acquisition is moving forward with little insights into the risks and threats of joint efforts. Without a deep understanding of the risks and threats that interdependent efforts encounter, governance mechanisms that can help to insure acquisition success are beyond reach. Given the pace at which joint efforts are pursued, early indicators of acquisition risk are needed to help isolate the critical governance mechanisms that will mitigate performance shortfalls.

This research examines the ties that bind acquisition initiatives in light of two different types of transactions: data ties and funding ties. And it begs the question: what influence do data and funding interdependencies exhibit on acquisition success? Additionally, the research begs the question: do these interdependencies create cascading effects on neighbor programs?

Research Methods

The study relied on data derived from the Defense Acquisition Management Information Retrieval (DAMIR) system. The results are based on a longitudinal analysis of all active Major Defense Acquisition Programs (MDAPs) over the 2004–2009 time period. CY 2004 was chosen as the beginning point because, as illustrated below, prior to 2004 few networks were in place.

To test the influence of interdependencies on acquisition success, several interdependency measures were collected and or constructed. The first major interdependency metric related to program funding. Two measures were developed. The first measure considered the sheer number of program elements (PEs) that funded the MDAP research, development, test, and evaluation (RDT&E) efforts. Procurement program elements were not considered because the belief was that the RDT&E interdependencies were the most critical to program performance. Because program elements fund multiple MDAPs, “funding nearest neighbors” could be isolated. Thus, two proxy measures for funding were obtained:

1. the sheer number of program elements that fund a given MDAP, and
2. the number of neighboring MDAPs.

A second set of measures involves data interdependencies among MDAPs. The data sharing linkages among the MDAPs were obtained from Defense Acquisition Executive Summary (DAES) reports. Thus, the data interdependency measure is the number of data linkages of a given MDAP. It should be noted that the data interdependencies were collected by the Office of the Secretary of Defense (OSD) over a relatively short time frame (FY 2006–2007). As a result, changes in the data interdependencies could not be isolated. Moreover, because of the desire to test cascades, the data set was purged for any connections with ACAT 2 programs.

A dummy variable was also constructed on whether the MDAP had an official joint status (0 = nonjoint, 1 = joint). For those that were officially joint, the number of signatories on the requirements document was also collected. To rule out countervailing influences, several control variables were also employed: development cost estimate, program manager turnover rates, and a dummy variable for time.

Because the research was interested in acquisition success, six dependent variables were isolated annually:

1. Total Percent Acquisition Unit Cost growth from the original baseline,
2. Annual Percent RDT&E PAUC growth (note that since programs started earlier than 2004, the annual and total growth variables are not synonymous),
3. the number of APB performance breaches,
4. percent of schedule cost variance,
5. percent of estimation cost variance, and
6. percent of engineering cost variance.

Table 2 identifies the variables employed in the research along with the mean, range, and standard deviation, and Table 3 provides an overview of all the variables in the dataset. In terms of the objectives of the research, the first step was to identify and characterize the nature of MDAP interdependencies and to examine how the interdependencies changed over time. Figure 3 provides network renditions of the funding interdependencies among the MDAPs over the 2004–2009 time frame. As demonstrated in the network depictions, the complexity of the funding interdependencies has grown significantly over the past five years. The number of links grew from 39 to 291 and the density (proportion of all possible links to actual number of links) grew from 4% to 23%. The percent of MDAPs that share a funding source grew from 30% to 70% over the four-year period (see Figure 4). The growth in the number of MDAPs sharing a program element may prove illustrative of added complexity and added risk. Hence, the number of programs that a given MDAP share a program element with is included in the models below.

Table 2. Key Variables

	Range	Mean	Standard Deviation
Dependent Variables			
Annual RDT&E PAUC Growth	6,278.03	98.86	505.55
Percent Cost Growth From Baseline	380.95	30.22	59.76
Percent Schedule Cost Variance	42.92	0.54	3.32
Percent Engineering Cost Variance	1,433.47	4.66	71.35
Percent Estimating Cost Variance	324.72	3.02	17.77
Number of APB Performance Breaches	2.00	0.08	0.27
Independent Variables			
Number of RDT&E Program Elements Funding MDAP	47.00	3.50	4.04
Number of Data Links	13.00	1.48	2.12
Number of Signatories on Requirements Document	8.00	1.24	1.10
Both Data and Funding Interdependencies			
Number of Neighboring Funding Links	22.00	1.53	2.60
Official Joint Status		25%	
Control Variables			
Development Estimate	32,300.00	2,190.31	5,009.12
Program Manager Turnover (per year)		18%	
Stage - Procurement		49%	

Table 3. Variables Collected

Program Number
Total number of Data links
Lead service
Year of Data
Annual PAUC percent growth -- difference from previous year
PAUC percent growth from baseline
Development estimate at Base Year
Stage (0=development 1 = production)
Program's base year
Percent of RDTE funding coming from non-lead component
Whether PM turned over during a given year taken from Change in PM's name in SAR 0=no 1=yes
Number of program elements funding a given PNO
Number of PE nearest neighbors derived from network renderings

Number of nearest data neighbors derived from network renderings of Finley diagrams
Economic Cost Variance
Percent economic variance
Schedule Cost Variance
Percent schedule variance
Engineering Cost Variance
Percent engineering variance
Estimating Cost Variance
Percent estimating variance
Other Cost Variance
Percent other variance
Percent quantity variance
Support Cost Variance
Percent support variance
Total percent variance
Number of schedule breaches by a PNO
Number of performance breaches by a PNO
Number of RDTE breaches by a PNO
Number of procurement breaches by a PNO
Number of PAUC breaches by a PNO
Number of APUC breaches by a PNO
Total number of breaches by a PNO
Number of current Nunn McCurdy PAUC breaches
Number of current Nunn McCurdy APUC breaches
Number of services involved taken from SAR
Whether a PNO has been designated as joint
Lead component (Service)
Air Force signatures Authority
Navy signatures Authority
Army signatures Authority
Number of International Signatures for Change Orders taken from Contracts
Majority funder's percent contribution
Service that provides the majority funding
Number of Signatures on Change Orders taken from MOUs
Army provides labor
Air Force provides labor
Navy provides labor
Whether the program is collocated
Total number of signatures on MOA
Whether the program has a joint program office 0= no 1=yes
Number of foreign military sales
Program's age - years from MSB
Popular Name

Full Name
Acquisition Category
DAES Group
FCB type
Commodity type

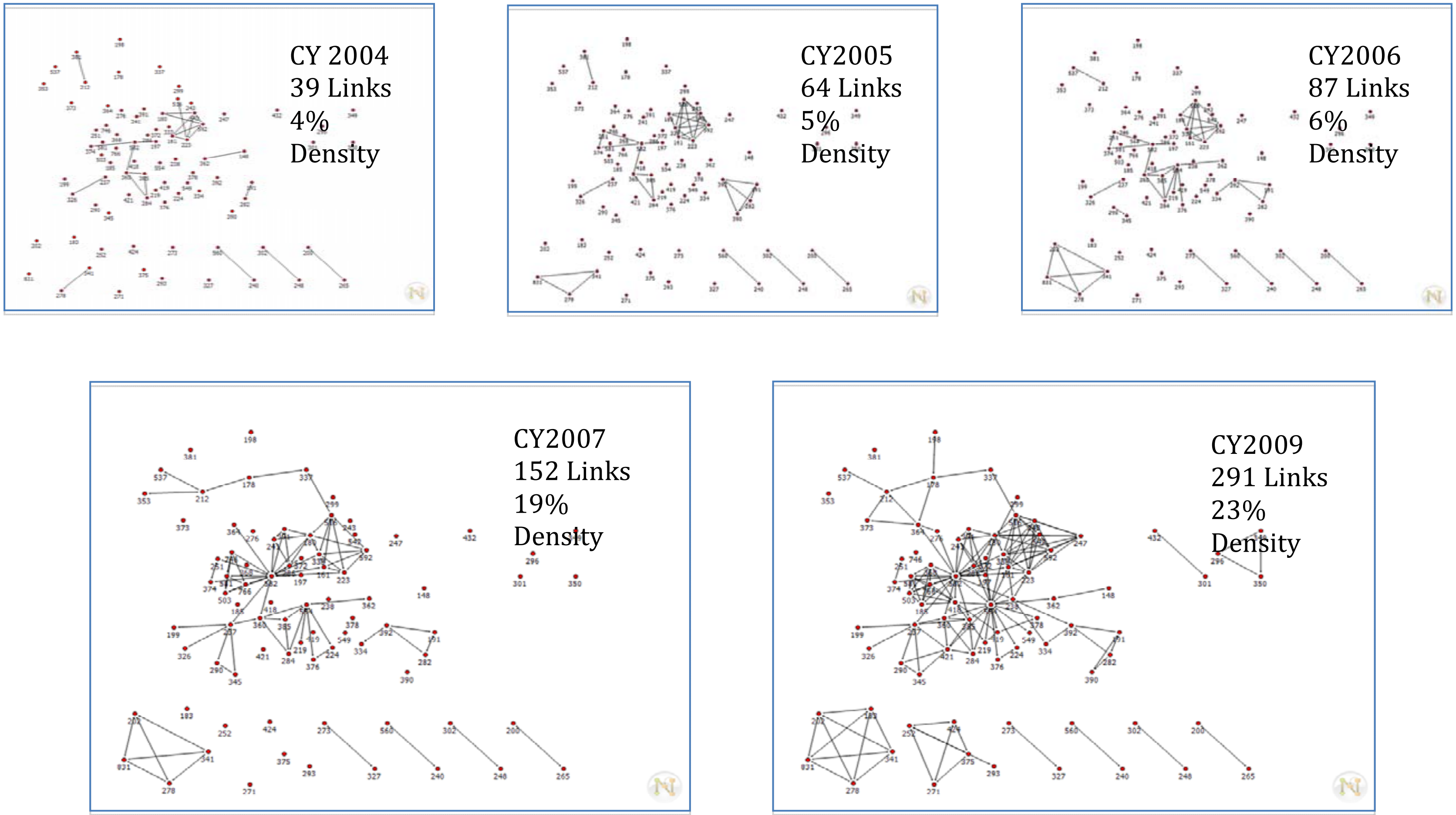


Figure 3. Funding Interdependencies Over Time

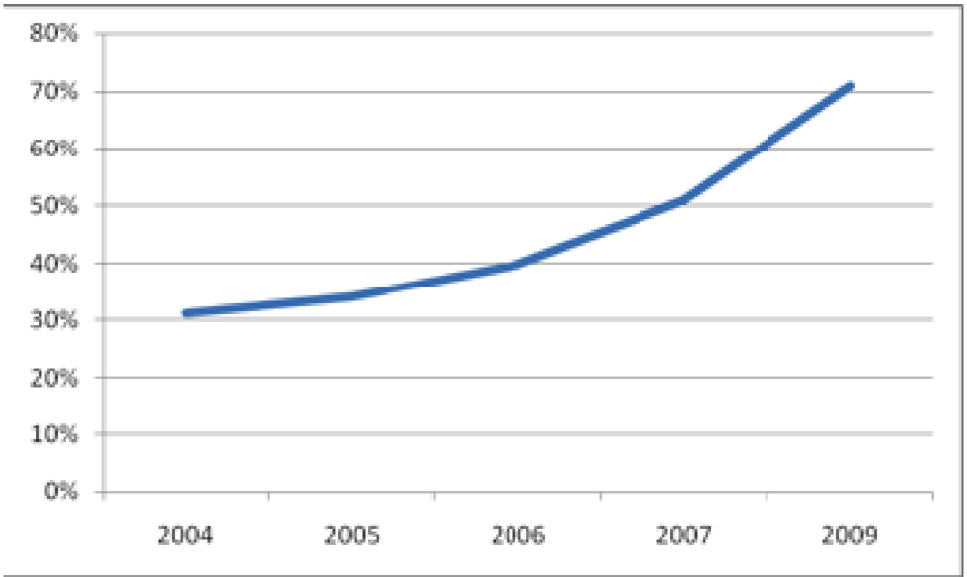


Figure 4. Percent of MDAPs That Share a Program Element

As mentioned, given the data collection procedures, the data interdependencies were static and changes over time could not be isolated.

In total, 97 MDAPs were examined and yielded a total of 353 data links (recall that ACAT 2 programs were not included in the analysis) and a density of 18% (see Figure 5). Given the growth in the funding interdependencies, the percent of programs that share both data and funding sources grew from 10% to 30% over the study time period (see Figure 6). The sharing of both data and funding interdependencies may prove to be an important indicator of risk.

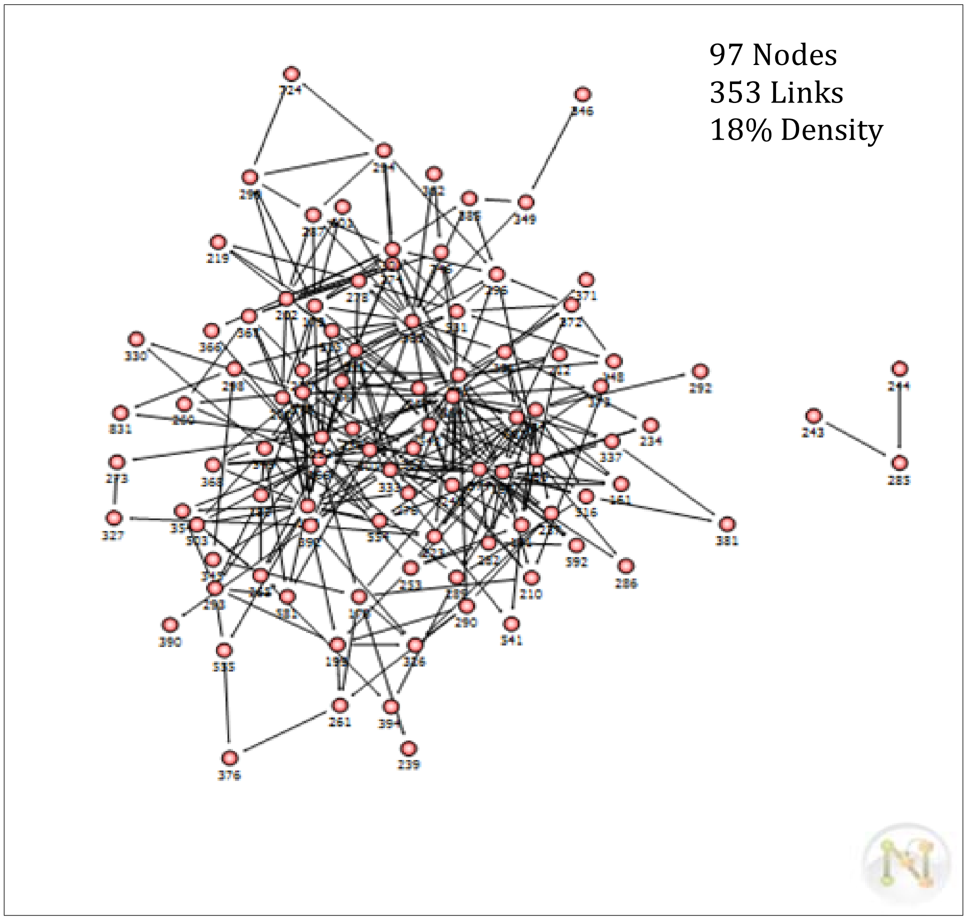


Figure 5. MDAP Data Interdependencies

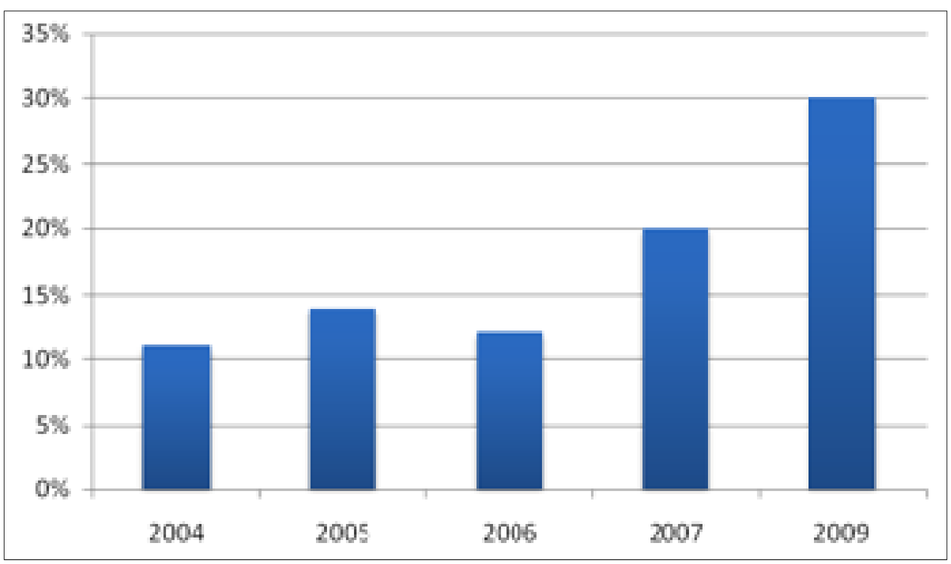


Figure 6. Percent of MDAPs That Share Both Data and Funding Links

Figures 7 and 8 illustrate the scale free nature of both the funding and data networks. Note that the frequency distribution of each of the two networks indicates a power law distribution. The scale free characteristic is important because it may signal that a relatively small number of MDAPs exhibit major influences. The scale free nature is noted but is beyond the scope of this research; it is recommended in the Conclusion section of this research that further follow-up be done on this topic.

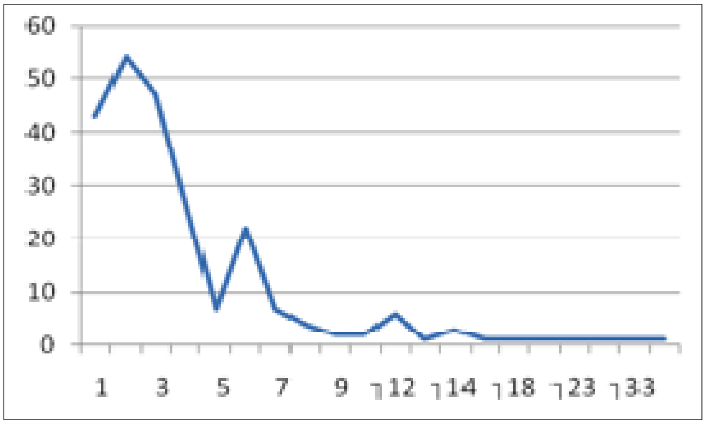


Figure 7. Scale Free Nature of Funding Network

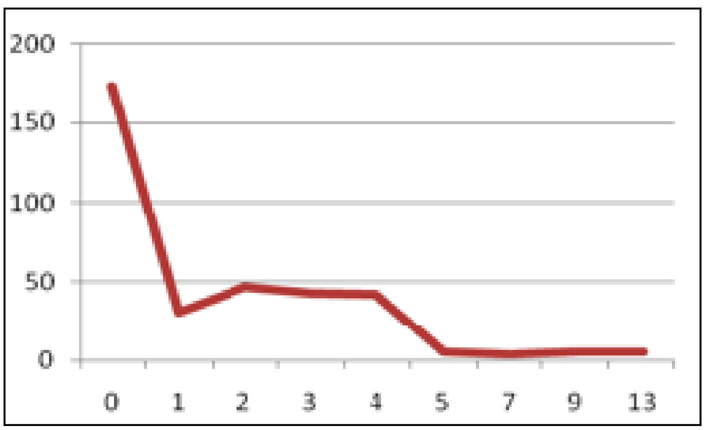


Figure 8. Scale Free Nature of Data Network

The next step was to test to see if performance breaches (specifically, the sum total of the feature changes, cost overrun, and budget shortfall breaches) correlate with any of the interdependency characteristics. Multiple regression was used as the analytical technique. Tables 4 through 9 show the results of the regression models that tested the influence of the interdependencies on the six acquisition success variables. For the most part, the interdependency variables did not offer much in explaining MDAP performance. However, a few relationships are important to point out.

Table 4. Dependent Variable: Percent Growth from Baseline

R Square .13	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	150.83	106.04		1.42	.16
Development Estimate	.00	.01	-.05	-.59	.56
RDT&E Stage	-65.90	78.82	-.06	-.84	.40
PM Turnover	197.36	190.16	.09	1.04	.30
Dummy 2005	148.12	96.69	.12	1.53	.13
Dummy 2006	216.42	95.29	.19	2.27	.02
Number of Program Elements	-24.34	18.58	-.13	-1.31	.19
Total Number of Signatures	-33.20	41.21	-.07	-.81	.42
Number of Data Links	6.82	17.08	.03	.40	.69
Joint Status	351.96	123.45	.27	2.85	.00
Both Data and Funding Links	144.50	120.93	.10	1.19	.23
Number of Neighboring Funding Links	-194.06	96.60	-.18	-2.01	.05

Per Table 4, joint status had a positive influence on percent growth from baseline, indicating that, controlling for the other variables, joint programs appear to experience greater cost growth. However, the number of neighboring funding links was negatively related to percent growth from baseline.

Table 5. Dependent Variable: Percent Annual RDT&E PAUC Growth

R Square. 137	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	48.33	11.46		4.22	.00
Development Estimate	.00	.00	.19	2.87	.00
RDT&E Stage	-10.18	7.74	-.08	-1.31	.19
PM Turnover	8.41	17.71	.03	.47	.64
Dummy 2005	4.62	11.22	.03	.41	.68
Dummy 2006	.60	12.03	.00	.05	.96
Dummy 2007	3.13	11.02	.02	.28	.78
Number of Program Elements	.79	1.94	.03	.41	.68
Total Number of Signatures	-6.04	3.64	-.12	-1.66	.10
Number of Data Links	-1.56	1.69	-.06	-.92	.36
Joint Status	-7.10	11.67	-.05	-.61	.54
Both Data and Funding Links	-36.61	12.16	-.23	-3.01	.00
Number of Neighboring Funding Links	7.43	9.56	.06	.78	.44

In Table 5, those programs that shared both data and funding links demonstrated a negative influence over annual PAUC RDT&E cost growth. The other interdependency variables showed no direct bearing.

Table 6. Dependent Variable: APB Performance Breaches

R .202	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	.07	.06		1.27	.20
Development Estimate	.00	.00	-.09	-1.21	.23
RDT&E Stage	.03	.04	.06	.85	.40
PM Turnover	.01	.09	.01	.08	.93
Dummy 2005	-.05	.06	-.07	-.89	.38
Dummy 2006	-.06	.06	-.09	-1.04	.30
Dummy 2007	-.06	.06	-.10	-1.12	.26
Number of Program Elements	.01	.01	.08	.86	.39
Total Number of Signatures	.01	.02	.03	.41	.68
Number of Data Links	.02	.01	.16	2.40	.02
Joint Status	-.01	.06	-.01	-.09	.93
Both Data and Funding Links	-.02	.06	-.02	-.24	.81
Number of Neighboring Funding Links	-.03	.05	-.05	-.59	.56

The number of data links showed a positive influence over APB performance breaches albeit the slope was marginal (see Table 6).

Table 7. Dependent Variable: Schedule Cost Variance

R Square .102	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	.85	.58		1.47	.14
Development Estimate	.00	.00	.03	.49	.62
RDT&E Stage	.92	.39	.15	2.35	.02
PM Turnover	2.23	.89	.18	2.50	.01
Dummy 2005	-1.05	.57	-.14	-1.85	.07
Dummy 2006	-.83	.61	-.12	-1.37	.17
Dummy 2007	-.86	.56	-.13	-1.54	.12
Number of Program Elements	-.12	.10	-.11	-1.24	.22
Total Number of Signatures	-.40	.18	-.16	-2.19	.03
Number of Data Links	.20	.09	.15	2.37	.02
Joint Status	.74	.59	.10	1.26	.21
Both Data and Funding Links	.17	.61	.02	.27	.79
Number of Neighboring Funding Links	.06	.48	.01	.12	.90

In terms of schedule cost variance the number of signatories yielded a negative relationship whereas the number of data links illustrated a positive relationship (see Table 7).

Table 8. Dependent Variable: Estimation Cost Variance

R Square .032	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	8.60	3.59		2.39	.02
Development Estimate	.00	.00	-.03	-.42	.68
RDT&E Stage	-1.52	2.43	-.04	-.63	.53
PM Turnover	6.15	5.55	.08	1.11	.27
Dummy 2005	-5.50	3.52	-.13	-1.56	.12
Dummy 2006	-5.73	3.77	-.14	-1.52	.13
Dummy 2007	-8.42	3.45	-.21	-2.44	.02
Number of Program Elements	.07	.61	.01	.12	.91
Total Number of Signatures	-.15	1.14	-.01	-.13	.90
Number of Data Links	.24	.53	.03	.45	.65
Joint Status	-2.74	3.66	-.06	-.75	.45
Both Data and Funding Links	1.31	3.81	.03	.34	.73
Number of Neighboring Funding Links	-1.11	3.00	-.03	-.37	.71

None of the interdependency variables proved instrumental in predicting estimation or engineering cost variance (Tables 8 and 9).

Table 9. Dependent Variable: Engineering Cost Variance

R Square .023	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	9.81	16.95		.58	.56
Development Estimate	.00	.00	-.03	-.41	.68
RDT&E Stage	-11.54	11.45	-.07	-1.01	.31
PM Turnover	1.62	26.20	.00	.06	.95
Dummy 2005	-4.33	16.59	-.02	-.26	.79
Dummy 2006	16.95	17.79	.09	.95	.34
Dummy 2007	-2.22	16.30	-.01	-.14	.89
Number of Program Elements	.06	2.87	.00	.02	.98
Total Number of Signatures	2.95	5.38	.04	.55	.58
Number of Data Links	2.12	2.51	.06	.85	.40
Joint Status	-8.87	17.26	-.04	-.51	.61
Both Data and Funding Links	-.44	17.98	.00	-.02	.98
Number of Neighboring Funding Links	-10.86	14.14	-.06	-.77	.44

Whereas some of these relationships are important, the R squares remained fairly low, indicating that important predictors of program performance may have been missing from the models. However, several of the variables were significant at a low enough level to suggest that perhaps their significance would continue in the presence of other predictors.

The next set of tasks was to isolate the extent to which acquisition performance breaches (i.e., per unit cost growth, schedule delays, and feature shortfalls) in an upstream program cascaded to downstream interdependent MDAP programs. A series of t-tests were used to test the relationships.

Recall that the data collection effort was able to isolate the specific neighboring programs for each MDAP. To obtain the cascades, the upstream MDAP was lagged by one year. This provided the ability to examine how last year's upstream program performance influenced the current year downstream program. Only the data and funding variables were tested because these were the only two variables that provided linkage information. The first test involved examination of the entire dataset for each year (note that CY 2004 is not included because those data become the lag for CY 2005). Where the data allowed, problem MDAP performers (PAUC growth greater than 13 indicating a Nunn-McCurdy Breach) were also tested to see if they might yield greater cascades on their downstream partners. Table 10 provides the results of the t-tests for each of the years. Given the amount of data, only those relationships that demonstrated a significant and positive relationship are discussed below. A significant, positive relationship illustrates that as the upstream experiences problems, so goes the downstream program.

Table 11 illustrates the t-tests for those programs that share a funding interdependency. Note that the only positive relationship was in 2007 and related to annual RDT&E PAUC growth. In terms of the data interdependencies (see Table 11), positive relationships were observed on schedule cost variance (CY 2005), engineering cost variance (CY 2005 and CY 2007), estimating cost variance (CY 2005, CY 2006, and CY 2007), and annual RDT&E PAUC growth (CY 2007).

For those programs that share both data and funding interdependencies, engineering cost variance (CY 2005) and estimating cost variance (CY 2006) demonstrated significant positive relationships. When examining those MDAPs that exhibited cost growth problems, the cascades appeared especially troublesome. For the funding interdependencies positive cascades were identified for estimating cost variance, percent growth from baseline, and annual percent RDT&E PAUC growth. The percent growth from baseline was especially concerning because it was positive for three of the four years (CY 2006, CY 2007, and CY 2008). Moreover, annual RDT&E PAUC growth was positive for CY 2007 and CY 2009.

Similar findings were demonstrated in the data interdependency group. Both the percent growth from baseline and annual RDT&E PAUC growth were positive for the majority of the years. For the data and funding interdependency group, percent growth from baseline was significant for two of the years (CY 2005 and CY 2009), but annual percent RDT&E PAUC growth was only significant in CY 2009 (see Table 12).

Table 10. Funding Interdependencies

year	Variable	Mean	t	df	Sig. (2-tailed)		Growth	Variable	Mean	t	df	Sig. (2-tailed)
Schedule Cost Variane												
2005	Lagged Percent Schedule Variance	2.38	1.47	34	.15							
	Nearest Neighbor Percent Schedule Variance	.00										
2006	Lagged Percent Schedule Variance	.00	-2.33	61	.02							
	Nearest Neighbor Percent Schedule Variance	.31										
2007	Lagged Percent Schedule Variance	.18	-.52	117	.60							
	Nearest Neighbor Percent Schedule Variance	.28										
2009	Lagged Percent Schedule Variance	.76	.46	120	.64							
	Nearest Neighbor Percent Schedule Variance	.62										
Engineering Cost Variance												
2005	Lagged Percent Engineering Variance	3.24	1.40	34	.17							
	Nearest Neighbor Percent Engineering Variance	-.39										

2006	Lagged Percent Engineering Variance	.39	.47	61	.64							
	Nearest Neighbor Percent Engineering Variance	.13										
2007	Lagged Percent Engineering Variance	.63	1.44	117	.15							
	Nearest Neighbor Percent Engineering Variance	.23										
2009	Lagged Percent Engineering Variance	.05	-3.97	120	.00							
	Nearest Neighbor Percent Engineering Variance	.59										
Estimating Cost Variance												
2005	Lagged Percent Estimating Variance	6.54	.79	31	.44		>13	Lagged Percent Estimating Variance	28.01	5.29	7	.001
	Nearest Neighbor Percent Estimating Variance	3.34						Nearest Neighbor Percent Estimating Variance	-1.66			
2006	Lagged Percent Estimating Variance	1.19	.80	57	.43							
	Nearest Neighbor Percent Estimating Variance	.18										
2007	Lagged Percent Estimating Variance	-.03	.26	112	.79							
	Nearest Neighbor Percent Estimating Variance	-.22										
Percent Growth From Baseline												

2005	Lagged Percent Growth From Baseline	29.31	-.36	36	.72	>13	Lagged Percent Growth From Baseline	62.71	.85	17	.41
	Nearest Neighbor Percent Growth from Baseline	32.15					Nearest Neighbor Percent Growth from Baseline	50.64			
2006	Lagged Percent Growth From Baseline	26.35	.84	63	.41	>13	Lagged Percent Growth From Baseline	66.66	2.99	28	.01
	Nearest Neighbor Percent Growth from Baseline	20.43					Nearest Neighbor Percent Growth from Baseline	33.43			
2007	Lagged Percent Growth From Baseline	20.43	.47	118	.64	>13	Lagged Percent Growth From Baseline	72.58	3.40	42	.00
	Nearest Neighbor Percent Growth from Baseline	17.67					Nearest Neighbor Percent Growth from Baseline	32.63			
2009	Lagged Percent Growth From Baseline	13.33	-2.19	241	.03	>13	Lagged Percent Growth From Baseline	70.85	3.69	42	.00
	Nearest Neighbor Percent Growth from Baseline	22.35					Nearest Neighbor Percent Growth from Baseline	34.15			
Annual RDT&E PAUC Growth											
2006	Lagged PAUC Percent Growth	40.79	.01	57	.99	>13	Lagged PAUC Percent Growth	227.07	.99	9	.35
	Nearest Neighbor PAUC Percent Growth	40.46					Nearest Neighbor PAUC Percent Growth	115.61			
2007	Lagged PAUC Percent Growth	196.97	2.74	111	.01	>13	Lagged PAUC Percent Growth	839.11	3.07	25	.01
	Nearest Neighbor PAUC Percent Growth	4.47					Nearest Neighbor PAUC Percent Growth	8.59			
2009	Lagged PAUC Percent Growth	8.46	1.80	127	.07	>13	Lagged PAUC Percent Growth	48.82	4.71	16	.00
	Nearest Neighbor PAUC Percent Growth	4.21					Nearest Neighbor PAUC Percent Growth	8.72			

Table 11. Data Interdependencies

Year	Variable	Mean	t	df	Sig. (2-tailed)			Variable	Mean	t	df	Sig. (2-tailed)
Schedule Cost Variance												
2005	Lagged Percent Schedule Variance	3.77	5.26	287	.00		>13	Lagged Percent Schedule Variance	37.78	24.39	26	.00
	Finley Percent Schedule Variance	.27						Finley Percent Schedule Variance	.15			
2006	Lagged Percent Schedule Variance	.25	-.28	306	.78							
	Finley Percent Schedule Variance	.29										
2007	Lagged Percent Schedule Variance	.27	.17	320	.87							
	Finley Percent Schedule Variance	.26										
2009	Lagged Percent Schedule Variance	.36	.33	214	.74							
	Finley Percent Schedule Variance	.30										
Engineering Cost Variance												
2005	Lagged Percent Engineering Variance	2.16	5.95	287	.00		>13	Lagged Percent Engineering Variance	13.21	.08	1131	.94
	Finley Percent Engineering Variance	-.45						Finley Percent Engineering Variance	12.77			
2006	Lagged Percent Engineering Variance	-.42	-3.31	307	.00		>13	Lagged Percent Engineering Variance	13.21	.08	1131	.94

	Finley Percent Engineering Variance	46.84						Finley Percent Engineering Variance	12.77			
2007	Lagged Percent Engineering Variance	45.04	3.27	320	.00		>13	Lagged Percent Engineering Variance	13.21	.08	1131	.94
	Finley Percent Engineering Variance	.14						Finley Percent Engineering Variance	12.77			
2009	Lagged Percent Engineering Variance	.00	-3.58	214	.00		>13	Lagged Percent Engineering Variance	13.21	.08	1131	.94
	Finley Percent Engineering Variance	.54						Finley Percent Engineering Variance	12.77			
Estimating Cost Variance												
2005	Lagged Percent Estimating Variance	10.13	1.94	287	.05		>13	Lagged Percent Estimating Variance	89.30	5.24	34	.00
	Finley Percent Estimating Variance	4.15						Finley Percent Estimating Variance	-4.16			
2006	Lagged Percent Estimating Variance	3.88	2.00	306	.05		>13	Lagged Percent Estimating Variance	40.20	31.44	38	.00
	Finley Percent Estimating Variance	1.82						Finley Percent Estimating Variance	-1.68			
2007	Lagged Percent Estimating Variance	1.82	5.02	319	.00		>13	Lagged Percent Estimating Variance	32.19	7.75	13	.00
	Finley Percent Estimating Variance	-3.64						Finley Percent Estimating Variance	-48.16			
Percent Growth From Baseline												
2005	Lagged Percent Growth From Baseline	30.43	.68	225	.50		>13	Lagged Percent Growth From Baseline	72.56	5.82	100	.00
	Finley Percent Growth From Baseline	27.06						Finley Percent Growth From Baseline	29.09			

2006	Lagged Percent Growth From Baseline	30.10	-.03	253	.98		>13	Lagged Percent Growth From Baseline	73.81	5.72	108	.00
	Finley Percent Growth From Baseline	30.22						Finley Percent Growth From Baseline	31.18			
2007	Lagged Percent Growth From Baseline	30.20	-.34	264	.73		>13	Lagged Percent Growth From Baseline	78.87	6.50	112	.00
	Finley Percent Growth From Baseline	31.96						Finley Percent Growth From Baseline	28.87			
2009	Lagged Percent Growth From Baseline	29.94	-.18	276	.85		>13	Lagged Percent Growth From Baseline	85.71	6.28	97	.00
	Finley Percent Growth From Baseline	30.85						Finley Percent Growth From Baseline	29.00			
Annual RDT&E PAUC Growth												
2006	Lagged PAUC Percent Growth	126.72	-1.22	187	.22		>13	Lagged PAUC Percent Growth	412.36	2.67	56	.01
	Finley PAUC Percent Growth	196.28						Finley PAUC Percent Growth	138.02			
2007	Lagged PAUC Percent Growth	113.79	3.36	205	.00		>13	Lagged PAUC Percent Growth	418.92	3.83	54	.00
	Finley PAUC Percent Growth	9.02						Finley PAUC Percent Growth	9.25			
2009	Lagged PAUC Percent Growth	14.77	1.68	185	.09		>13	Lagged PAUC Percent Growth	48.57	4.38	56	.00
	Finley PAUC Percent Growth	7.76						Finley PAUC Percent Growth	8.10			

Table 12. Both Funding and Data Interdependencies

Year	Variable	Mean	t	df	Sig. (2-tailed)			Variable	Mean	t	df	Sig. (2-tailed)
Schedule Cost Variance												
2005	Lagged Percent Schedule Variance	7.4	1.5	10	.2							
	Coupled Percent Schedule Variance	.0										
2006	Lagged Percent Schedule Variance	.0	-1.0	11	.3							
	Coupled Percent Schedule Variance	.4										
2007	Lagged Percent Schedule Variance	.3	.9	25	.4							
	Coupled Percent Schedule Variance	.1										
2009	Lagged Percent Schedule Variance	.1	-.8	17	.4							
	Coupled Percent Schedule Variance	.6										
Engineering Cost Variance												
2005	Lagged Percent Engineering Variance	7.3	2.3	10	.0		>13	Lagged Percent Engineering Variance	2.4	1.3	66	.2
	Coupled Percent Engineering Variance	-1.0						Coupled Percent Engineering Variance	1.0			
2006	Lagged Percent Engineering Variance	-.3	-2.3	11	.0		>13	Lagged Percent Engineering Variance	2.4	1.3	66	.2

	Coupled Percent Engineering Variance	5.4					Coupled Percent Engineering Variance	1.0			
2007	Lagged Percent Engineering Variance	3.1	1.9	25	.1	>13	Lagged Percent Engineering Variance	2.4	1.3	66	.2
	Coupled Percent Engineering Variance	.3					Coupled Percent Engineering Variance	1.0			
2009	Lagged Percent Engineering Variance	.1	-.9	17	.4	>13	Lagged Percent Engineering Variance	2.4	1.3	66	.2
	Coupled Percent Engineering Variance	.2					Coupled Percent Engineering Variance	1.0			
Estimating Cost Variance											
2005	Lagged Percent Estimating Variance	2.6	-1.8	10	.1						
	Coupled Percent Estimating Variance	22.3									
2006	Lagged Percent Estimating Variance	20.7	3.3	11	.0	>13	Lagged Percent Estimating Variance	42.1	20.1	5	.0
	Coupled Percent Estimating Variance	-.4					Coupled Percent Estimating Variance	.1			
2007	Lagged Percent Estimating Variance	.1	.8	25	.4						
	Coupled Percent Estimating Variance	-1.7									
Percent Growth From Baseline											
2005	Lagged Percent Growth From Baseline	9.2	1.4	12	.2	>13	Lagged Percent Growth From Baseline	52.4	44.2	2	.0

	Coupled Percent Growth From Baseline	-3.4						Coupled Percent Growth From Baseline	.9			
2006	Lagged Percent Growth From Baseline	-3.1	.6	11	.6							
	Coupled Percent Growth From Baseline	-8.3										
2007	Lagged Percent Growth From Baseline	-1.2	-.6	25	.6		>13	Lagged Percent Growth From Baseline	14.7	2.5	4	.1
	Coupled Percent Growth From Baseline	3.2						Coupled Percent Growth From Baseline	3.5			
2009	Lagged Percent Growth From Baseline	9.6	.1	40	.9		>13	Lagged Percent Growth From Baseline	55.4	3.5	6	.0
	Coupled Percent Growth From Baseline	8.5						Coupled Percent Growth From Baseline	-3.4			
Annual RDT&E PAUC Growth												
2006	Lagged PAUC Percent Growth	671.2	1.0	5	.4		>13	Lagged PAUC Percent Growth	2009.8	1.1	1	.5
	Coupled PAUC Percent Growth	152.9						Coupled PAUC Percent Growth	364.8			
2007	Lagged PAUC Percent Growth	54.5	1.3	17	.2		>13	Lagged PAUC Percent Growth	306.9	1.4	2	.3
	Coupled PAUC Percent Growth	1.0						Coupled PAUC Percent Growth	4.3			
2009	Lagged PAUC Percent Growth	6.9	1.3	18	.2		>13	Lagged PAUC Percent Growth	25.9	4.9	4	.0
	Coupled PAUC Percent Growth	-1.0						Coupled PAUC Percent Growth	-.8			

Conclusion

The move to joint capabilities has proven to be an important paradigm shift in defense. The reasons for the shift are grounded in the need to allow the agility that shared resources provide. The ability to immediately tap into partner capabilities to improve response time is an important consideration for future defense needs. This research sought to identify whether the need for joint capabilities influenced acquisition success. The ingoing assumption was that joint capabilities would require joint acquisition solutions and hence would influence the MDAP acquisition risk. This study examined five years worth of data and looked at a number of interdependencies for their influence on acquisition success. Two specific objectives were pursued: (1) to test the influence of funding and data interdependencies on acquisition performance, and (2) to test the interdependent programs for the presence of cascading effects. The results proved particularly pivotal.

First, over the relatively short time span, the MDAPs have experienced tremendous growth in funding interdependencies. Likewise, the percent of programs that share both funding and data links is on the rise. This finding speaks directly to the increasing complexity that MDAPs are encountering. The findings illustrate the influence that joint capabilities is having on the acquisition effort.

Second, the fact that the funding and data networks illustrated a scale free characteristic may prove to offer significant managerial implications. However, additional research is needed to fully understand the dynamic of the scale free nature.

Third, when examining the influence of interdependencies on individual program performance (the multiple regressions) the relationships appeared weak and not particularly useful.

Finally, significant cascades were noted especially for the problem performers. The cascades illustrated that the acquisition performance of downstream programs were often tied to their upstream counterparts.

The extent of the influence suggests further examination of the influence of interdependencies on acquisition success is clearly warranted. According to these results, the field of acquisition may benefit greatly from future research on:

1. the scale free nature of the relationships,
2. metrics to more precisely identify and test interdependencies,
3. greater examination on the program ramifications of the increasing complexity,
4. improved understandings of the cascading effects of the interdependencies, and
5. better insights on managerial strategies that are capable of mitigating the risk of the interdependencies.

With additional research, the study of interdependencies may offer promise for improving early assessment of program development resources, establishing more realistic program thresholds, and highlighting areas of risk that may have escaped management attention.

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