

**A NEW METHOD FOR
THE EXAMINATION OF
POLICY SYSTEMS OF SYSTEMS**

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Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Public Administration and Public Affairs

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October 25, 2011

Alexandria, VA

Key Words: Three-Dimensional Policy Design Structure (3DPDS), Space Launch
Policy, Systems of Systems (SoS)

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ABSTRACT

This dissertation examines multi-agency policy environments as a policy system of systems (SoS). The research conducted for this dissertation establishes the need to develop a method of analysis suitable for the analysis of a policy SoS that allows for the examination of individual policy relationships while maintaining a holistic perspective of the entire SoS. The Three-Dimensional Policy Design Structure (3DPDS) is proposed as a method of analysis suitable for examination of a policy SoS. This dissertation focuses on application of the 3DPDS to three specific areas of space launch policy that impact space launch capacity: (1) policies related to space launch vehicles, (2) policies related to space launch facilities, and (3) the potential impacts of the cancellation of the Ares 1 launch vehicle. The first two applications of the 3DPDS provide a retrospective analysis of the policy relationships within the space launch policy SoS. The final application uses the results of the examination of policies related to space launch vehicles to systematically examine a current issue. The results of the first two applications, when compared against data gathered from subject matter experts during the interview process, provided a much more complete and holistic perspective of the policy relationships within the SoS, including identification of policy outliers. The third application enabled a systematic review of a current policy issue that incorporated information from formal policy documents with information provided by subject matter experts during the interview process.

ACKNOWLEDGEMENTS

Just as it takes a village to raise a child, it takes a committee to build a dissertation. As such, I am thankful for the thoughtful critique and timely advice provided by mine. The entire Virginia Tech community has made an incredible impression on me. In addition to my committee and professors, I would like to thank Irene Jung, who kept us all on track.

The fourteen anonymous subject matter experts who participated in this study were generous with their time, thoughts, and expertise. Their participation in the interview process was essential to this dissertation. It was a privilege to have had the opportunity to speak with such an amazing group of professionals.

Trevor Mower and Timothy Thielke accomplished the impossible: taking my vision and initial sketches, and turning them into three-dimensional models. Their illustrations can be seen throughout this dissertation. Their efforts, along with those of Nancy DeFavero, who spent hours editing this document, contributed significantly to the quality of the product I was able to produce.

I would like to thank everyone who offered words of advice, support, and encouragement throughout this entire process. While time and space won't allow listing everyone by name, please know that your efforts were appreciated.

However, in addition to those already mentioned above, I would remiss if I didn't mention a few others. I would like to thank my parents for sharing the value of knowledge and education with me, and letting my brother and I believe that we could accomplish anything if we only put our minds to it.

Finally, I would like to thank my husband for his support, thoughtfulness and kindness throughout this entire process. He was a sounding board, an editor, a technical consultant, a therapist, and a wonderful husband. Thank you.

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LIST OF ABBREVIATIONS

3DPDS	Three-Dimensional Policy Design Structure
CBO	Congressional Budget Office
DoD	Department of Defense
DoT	Department of Transportation
DSM	Design Structure Matrix
Ec	Expected Casualty
EELV	Evolved Expendable Launch Vehicle
ELV	Expendable Launch Vehicle
FAA	Federal Aviation Administration
HSF	Human Space Flight
ITAR	International Traffic and Arms Regulations
JSMB	Joint Space Management Board
NASA	National Aeronautics and Space Administration
NSS	National Security Space
PERT	Program Evaluation and Review Technique
SoS	System of Systems
ULA	United Launch Alliance
USAF	United States Air Force

PART I

Chapter 1: Introduction

In her book, *Behind the Iron Curtain*, Annette Krygiel described the integration of systems of systems. Her book included a case study describing the integration efforts of the Defense Mapping Agency's (now the National Geospatial-Intelligence Agency) Digital Production System, a ten-year multi-billion dollar development program to deliver a digital processing pipeline for the production of mapping, charting, and geodesy products (Krygiel, 1999). While Krygiel took great pains to describe the need for this system, its development, and its final state, only in a footnote does she mention that the capability was delivered later than planned due to the consequences of the Balanced Budget and Emergency Deficit Control Act of 1985. Even though Krygiel refers to the integration of the technological system of systems (SoS) as a success, changes in the policy system in which the agency operated, including a change in mission for the agency (from a posture of producing mapping, charting and geodesy products to one providing geospatial information and services) significantly contributed to a change in customer needs, and although the program reached full operational capability in November of 1992, the technology was never used as envisioned (Krygiel, 1999).

The application of systems of systems concepts has allowed for the successful integration of numerous technological or engineered systems into systems of systems, defined by DeLaurentis and Callaway as a "combination of a set of different systems that forms a larger 'system of systems' that performs a function not performable by a single system alone (2004)." There are a number of studies that address the integration and acquisition of various technological systems of systems, focusing on the technology systems themselves (Dunn and Sussman, 2005; Krygiel, 1999; Maier, 1999;

DeLaurentis, 2005; Shah et al, 2007). However, there are also a number of cases where the development, implementation or acquisition of these technological systems did not go as planned (Krygiel, 1999; Hoos, 1972). In some of these cases, the technological or engineered system that was designed, developed, or acquired was acted upon by some element of policy or impacted by some outside element (Krygiel, 1992; Hoos, 1972). The policy SoS that impacts the funding, development, and implementation of the technological system has yet to be fully examined in the same manner as the technological system; yet it is the policy SoS that could very well set the course of development for the acquisition of the technological system.

The purpose of this dissertation is to determine the necessity for a new method of analysis for policy systems of systems; introduce a new method for the examination of policy systems of systems; and begin to apply, or demonstrate, the new method for the examination of policy systems of systems by applying it to several examples related to space launch policy. The first part of the dissertation focuses on the examination of SoS concepts and methods currently employed in multiple disciplines. It recommends the development of a new method that can be used to examine a policy SoS that impacts the acquisition, development, and integration of technological government systems, while building on SoS concepts already in use. This dissertation will focus specifically on the policy SoS rather than the technological systems or systems of systems impacted by the policy SoS.

This new method uses the Three-Dimensional Policy Design Structure (3DPDS), which is, in effect, a three dimensional depiction of the policy SoS being examined.

This method focuses on specific interactions between agencies, from formal policy documents, and relies on clustering techniques to identify policy outliers.

The second part of this dissertation is devoted to the initial testing of the proposed 3DPDS using several closely related applications. The examples chosen for these applications all impact some aspect of US space launch capacity. The first two examples provide a retrospective examination of launch capacity, specifically policy decisions influencing space launch vehicles and launch facilities. The final example makes use of the first application to address a current problem: understanding the potential impacts of the decision to cancel Ares 1, the proposed replacement for the Space Shuttle.

The results of the first two applications, when compared against data gathered from subject matter experts during the interview process, provided a much more complete, holistic perspective of the policy relationships within the SoS, including identification of policy outliers. The third application allowed for a systematic review of a current policy issue that incorporated information provided in formal policy documents with information provided by subject matter experts during the interview process.

Space launch policy was chosen for the initial applications of the 3DPDS in this dissertation because the topic is timely, and it possesses the two characteristics of a policy SoS as defined in Chapter 2 of this dissertation: (1) there is an element of independence between interrelated policy systems, and (2) emergent properties of the policy SoS appear that are not apparent or predictable from the properties of the constituent policy systems themselves, in this case the resultant policy outcomes. There are a number of independent policies initiated by individual government agencies

that influence US space launch policy and impact the options and policies of other agencies, as the policy systems are closely related. This will become more apparent as this study unfolds. The entire policy SoS creates a set of rules, regulations, laws, and guidance that together create a complex policy environment that no single policy could accomplish and that overarches all of the component systems. These characteristics make space launch policy an excellent candidate for examination in this dissertation.

The Policy System of Systems

One of the goals of this dissertation is to introduce a new method for the examination of policy systems of systems, in which multiple policy systems interact in such a way as to become a SoS. The method of analysis proposed in this dissertation will examine the impacts that a single policy decision can have on a broader policy system of systems (SoS), particularly those organizational elements within the SoS. It is envisioned that, once more fully developed, this method will help decision makers understand the implications of one policy system acting on another policy system within an overarching SoS, and potentially play a role in an effort to anticipate or avoid system-wide challenges in the future.

One of the challenges of describing policy as a SoS lies in the broad usage of the term “system of systems.” There is little consensus as to what constitutes a universally accepted definition of a “SoS,” but an understanding of the term can be gained by examining a number of the existing definitions and characteristics from a variety of disciplines. In order to define a “policy system of systems” it is first necessary to examine the general characteristics of a SoS, and those of the policy system.

By using an organism, a purely scientific example of a system, biologist Ludwig von Bertalanffy described a system in which the organism is influenced by, and influences, its environment (Bertalanffy, 1950). This description can also be applied to the policy system, which is acted on by a number of forces and also influences those forces.

There are many definitions of a system. For the purposes of this paper, the one provided by Ackoff (1971) will be used. In his article "Towards a System of Systems Concepts," Ackoff (1971) describes a system as "a set of interrelated elements." He further explains that a system is an entity which is comprised of at least two elements and a relationship between those elements and at least one other element in a set (Ackoff, 1971).

Ackoff's early attempts to apply systems concepts to management, in a *Management Sciences* article, did not treat policy as a SoS, but rather arranged systems-related terminology into a vocabulary list. While he defined a system as "an entity which is composed of at least two elements and a relation that holds between each of its elements and at least one other element in the set," he did not venture so far as to define a SoS (Ackoff, 1971). Early applications of systems concepts to the social sciences like this did nothing to maintain a common lexicon among engineers, physical scientists, and social scientists concerning the term "SoS" and other systems concepts.

Building on the work of researchers before them (Grumm, 1973; Lewis-Beck, 1977), Richard Hofferbert and Ustun Erguder explored the dynamics of the policy system. They concluded that the most important parts of the policy system are the dynamics of external forces and their interactions as determinants of policy outputs

(Hofferbert and Erguder, 1985). These policy outputs, which are so heavily influenced by external forces, are in turn implemented, evaluated, and eventually modified again, using feedback provided through the system. It stands to reason that the policies within a policy SoS would influence the system as a whole, as well as the individual organizations within the system.

Authors from other disciplines have provided definitions and characteristics of systems of systems. For example, Maier provided a description of several types of technological systems of systems, including some types of networks (1999). He claimed that a system could be considered a SoS when (1) its components fulfill a valid purpose in their own right, and continue to operate to fulfill those purposes when disassembled from the overall system, and (2) the components are managed (at least in part) for their own purposes rather than the purposes of the whole (Maier, 1999).

From the systems engineering perspective, Eisner provided, rather than a straight forward definition of a SoS, a set of observations that would be indicative of a SoS in the engineering field (1991). This list included: independently acquired systems, overarching management or control of the SoS, couplings that are neither totally dependent nor independent, individual systems that are uni-functional, and systems of systems that are multi-functional (Eisner, 1991).

DeLaurentis and Callaway (2004) built on the common definition of a system and described a SoS as “a combination of a set of different systems that forms a larger ‘SoS’ that performs a function not performable by a single system alone.” Along with other characteristics, they determined that emergent behavior was a characteristic of

systems of systems, meaning that, properties appear in the SoS that are not apparent from the constituent systems (DeLaurentis, 2005).

DeLaurentis and Callaway focused on a lexicon that incorporated categories of systems (resources, operations, economics, and policy) and levels of hierarchy. The categories highlight what DeLaurentis and Callaway (2004) perceive to be one of the distinguishing traits of SoS problems: the heterogeneous mix of engineered systems together in one problem setting. The framework proposed by DeLaurentis and Callaway (2004) considered policy as one system of several in a hierarchy, which acted as an external forcing function on the organizations.

DeLaurentis and Callaway examined policy as a system in a larger organizational context along with resources, operations and economics (2004). They did not focus on the examination of the policy SoS itself, but rather, they viewed policy as one system within a larger SoS context. In contrast, this dissertation examines the policy SoS itself, and focuses on the policy interactions that take place between agencies in formal policy documents.

While there are some vast differences in the definitions and descriptions of systems of systems from the various disciplines presented in this summary, there are some common elements. Summarizing the common elements of the various systems of systems descriptions, a SoS would exhibit the following characteristics: (1) there is an element of independence between interrelated systems; and (2) the SoS provides for emergent behavior, where properties appear in the SoS that are not apparent in the constituent systems.

A policy SoS would display characteristics similar to those of other types of SoS. For the purpose of this study, a policy SoS will be said to exist when two conditions are met. First of all, there is an element of *independence* between interrelated policy systems. Each policy system within the SoS functions independently, with its own governance, as well as part of the larger SoS. Second, the emergent properties of the policy SoS appear that are not apparent or predictable from the properties of the constituent policy systems themselves, in the case of the policy SoS, the resultant policy outcomes.

The Research Questions

The purpose of this dissertation is to determine the necessity for a new method of analysis for policy systems of systems; introduce a new method for the examination of policy systems of systems; and begin to apply, or demonstrate, a new method for the examination of policy systems of systems. Two retrospective applications examining elements of space launch capacity have been selected, specifically focusing on the formal policy decisions within the policy SoS that have interagency implications. This is possible because the agencies operate at some level of autonomy, while influencing the overarching policy SoS. The resultant observations will then be applied to a current problem: understanding the impacts of the decision to cancel the Constellation Program, particularly looking at the cancellation of Ares 1, the proposed replacement for the Space Shuttle. While it is understood that no amount of examination of the past will allow for the prediction of the future, it may be possible to examine past policy interactions and apply these interactions to future issues. Because the research concentration of this dissertation is twofold, the research questions have been divided to

better define the two parts of this study. The two parts of this study will examine the following questions:

Part I

1. Is a new method required to examine policy systems of systems; and what methodological approach is most appropriate for the examination of policy systems of systems, and why?

Part II

1. What does the application of the Three-Dimensional Policy Design Structure (3DPDS) illustrate about the policy interactions related to two elements of US space launch capacity: space launch vehicles and space launch facilities?
2. Do the policy interactions identified in this study provide any insight regarding the complexity of the US space policy SoS, or allow the researcher to identify frequent policy interactions in space launch policy?
3. If frequent interactions can be identified, can they be used to examine the influence of policy decisions in the future, specifically with regards to the cancellation of Ares 1?

Relating this Research to the Relevant Published Literature

The systems of systems literature that exists in the social science fields largely builds from the contributions of Jackson and Keys. Jackson and Keys built on Ackoff's use of the terms *machine age* and *systems age* to refer to eras characterized by concern with understanding these types of systems (Ackoff, 1974; Jackson and Keys, 1984; Jackson, 1990; Jackson, 1991).

Jackson and Keys referred to “mechanical” problem contexts as those which contain relatively simple systems and “systemic” problem contexts as those which contain very complex systems (Jackson and Keys, 1984; Jackson, 1991). Jackson and Keys focused on the types of systems analysis used in operations research and the management sciences (Jackson and Keys, 1984; Jackson, 1990; Jackson, 1991). In their early work, Jackson and Keys (1984) developed a “system of system methodologies” as the “interrelationship between different methodologies along with their relative efficiency in solving problems in various real-world problem contexts.” They determined that problem contexts could be divided into four categories: mechanical unitary, systemic-unitary, mechanical-pluralistic, and systemic-pluralist. For each of these categories, they recommended

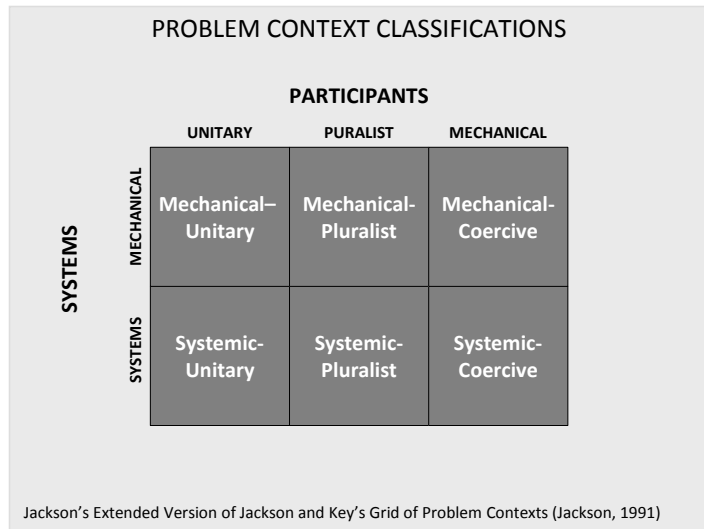


Figure 1.1: Problem Context Classifications (Jackson and Keys, 1984; used with permission)

different types of systems methodologies for analysis; however, even Jackson and Keys did not propose to study policy problems as “systems of systems.” Jackson (1991) eventually added to the four categories he and Keys had introduced: problem contexts could now be unitary, pluralist, or *coercive*, in addition to the mechanical and systematic classifications. These problem contexts are depicted in *Figure 1.1*.

Jackson (1991) describes unitary systems as those in which participants “are in genuine agreement on objectives, share common interests, have compatible values and beliefs, and all participate in decision making.” Pluralist systems have been described by Jackson (1991) as those in which the participants “have divergent values and beliefs, and to some extent, differing interests and objectives, but a genuine accommodation or compromise can be reached upon which all agree,” whereas he uses the term coercive to describe those situations in which “there is little common interest between the participants, there is fundamental conflict, and the only consensus that can be achieved is through the exercise of power and through domination of one or more groups of participants over others.”

Banathy (1987) proposed that the appropriateness of a methodology was dependent on four dimensions of the design inquiry: the system type, the nature of the design inquiry, the characteristics of the design problem disputation, and the functional context of the design situation. He constructed a model that displayed five major

Problem Contexts and Systems Methodologies [Adapted from Jackson and Keys (1984) and Using the Schema, in Paraenthesis, of Banathy (1987)]

Participant's relationship	System Type	
	Mechanical	Systemic
Coercive	Mechanical-coercive Methodologies Yet to emerge	Systemic-Coercive Methodologies Yet to emerge
Pluralist	Mechanical-pluralist (heuristic) Methodologies 1. Dialectic inquiry systems, e.g., SAST 2. Double-loop organizational learning	Systemic-pluralist (purpose seeking) Methodologies 1. Interactive planning 2. Checkland's soft systems methodology
Unitary	Mechanical-unitary (rigidly controlled) (deterministic) Methodologies 1. Classical OR 2. Systems Engineering 3. Systems Analysis 4. (Living system process analysis) 5. (Management cybernetics)	Systemic-Unitary (purposive) Methodologies 1. Organizational Cybernetics 2. Sociotechnical systems thinking 3. General systems theory 4. Modern contingency theory 5. (Living system process analysis) 6. (System design)

From Oliga (1988)

Figure 1.2: Problem Contexts and Systems Methodologies (Oliga, 1998; used with permission)

systems types: rigidly controlled, deterministic, purposive, heuristic, and purpose seeking.

Oliga (1988) made efforts towards merging the work of Banathy and Jackson and Keys, incorporating the various problem contexts proposed by Jackson and Keys, and further developed by Jackson, with the schema proposed by Banathy, and incorporated the various methodologies appropriate for the study of each schema and problem context, as depicted in *Figure 1.2*. There are two problem contexts for which, according to Oliga, methodologies for study have yet to emerge. These two problem contexts are mechanical-coercive and systemic-coercive. While Jackson (1991) devised his own determinations of the types of analysis that would be appropriate for his six proposed problem contexts, Oliga's depiction is more inclusive and far more detailed, making it easier to determine where additional efforts could (and possibly should) be concentrated.

Contribution and Importance of the Research

The first part of this dissertation is devoted to the development of a new method for the analysis of policy systems of systems. This method is meant to be used to support decisions addressing complex policy issues that influence multiple government agencies at a very strategic level. In this dissertation the application of this method is focused on the space launch policy problem set. However, it is envisioned that once the 3DPDS is refined and further tested, it could be used to address a number of complex public policy issues that would be classified as systematic-coercive problem contexts developed by Jackson and Keys. This method of analysis could potentially be used to examine policies influencing maritime domain awareness, homeland security

and border security, as well as other areas in which multiple organizations are influenced through multiple policy systems.

While it is accepted that the method proposed in this study will not be fully validated in this dissertation, initial testing will be performed. Through further testing and refinement beyond this dissertation, the method proposed will provide a means of repeatable “dissection” of complex and interdependent policy systems of systems, which then lends these problem sets to more focused and effective study.

While matrix forms of analysis for systems of systems are not unusual; this method is unique. The primary focus is on the policy language of formal policy documents: the units of analysis are the policy interactions themselves, which are examined as a SoS.

This method will provide decision makers and their staffs who work in complex policy environments, as well as academic researchers studying these policy environments, with a tool that will help them understand the complexity of the policy environment in which they operate. It will give them a tool that allows them to break down, unpack, or dissect complex interrelated policy systems of systems while maintaining a holistic perspective.

The method of analysis proposed in this study is meant to be used to study systemic-coercive systems, addressing one of the two gaps in the literature identified by Oliga (1988). Only after further testing and evaluation will it become clear that the proposed method of analysis would be an acceptable means of addressing the systemic-coercive problem context, or any of the other systems contexts broken out by Oliga. While the proposed method of analysis could help to address gaps in the

academic literature, it is primarily being proposed as a tool that will provide decision makers and researchers with a means for repeatable “dissection” of complex and interdependent policy systems of systems while maintaining a holistic perspective of the policy environment to support well-informed decision making and ultimately reduce the incidences of unintended consequences.

In addition, this research will provide a lexicon for the analysis of systems of systems that incorporates elements of the engineering and public policy literature. This will provide researchers with a method of analysis that can be readily understood by those who wish to examine the acquisition and development of technological systems of systems, as well as the policy systems that direct, and at times hinder, their development.

This dissertation also provides a unique look at US space launch policy by examining it as a system of systems. This examination provides a new perspective of the system and non-system actors that influence, and are influenced by US space launch policy, and the various policy systems that, together, constitute US space launch policy.

Chapter 2: The Literature Review

Government acquisition efforts within one agency can be impacted by policy decisions made by a number of different agencies. Space launch is one area in which the policies of one government organization can significantly impact the actions of another agency. As a result of divergent missions and complex policy relationships, the US is now faced with a very expensive situation: excess launch capacity (CBO, 2006). In order to study this type of problem and fully understand its complexity, one must begin with an appropriate method of analysis for the examination of policy SoS.

This section of the dissertation focuses on determining if a new method is required for the analysis of multi-agency problems such as those described above. In order to achieve this goal, it is necessary to examine the desirable traits of other analytical methods and incorporate them into this new method. This will be done by examining a number of types of analysis that are currently available for the examination of policy, technological systems, and SoS. This chapter will briefly examine the strengths and weaknesses of these methods as they could be applied to the policy SoS. This chapter will explore a variety of methods. Each of these methods focuses on its object of study from a slightly different perspective, such as statistical data, the interrelationships between systems, and the integration of systems into a SoS. These methods will be reviewed to determine if any are suitable for the examination of the policy SoS, or if they possess any characteristics desirable in a new method of analysis.

A review of the ideal problem contexts introduced by Jackson and Keys, discussed in Chapter 1, suggests that in cases of this nature, the method used to examine the problem must be robust enough to examine a systemic-coercive problem context (Jackson and Keys 1984; Jackson, 1990; Jackson, 1991). As described by

Jackson, the systemic-coercive problem context is one in which “there is little common interest between the participants, there is fundamental conflict, and the only consensus that can be achieved is through the exercise of power and through domination of one or more groups of participants over others (1991).” Space launch policy is an example of the systemic-coercive problem context, as the goals of the different organizational elements involved in the SoS are divergent, and as such, there is little common interest between the participants.

Jackson describes a mechanical problem context as one which contains relatively simple systems, and a systemic problem context as one which contains very complex systems (1991). He further describes simple systems as those containing a small number of elements with regular interactions between them and with subsystems which do not pursue their own goals (Jackson, 1991). On the other hand, he describes complex systems as highly interrelated, impacted or influenced by their environment, with purposeful parts (Jackson, 1991). Using these descriptions, the space launch policy SoS can be classified as systemic rather than mechanical, as the organizational elements that comprise the SoS impact and influence each other, have goals and purposes independent of the goals and purposes of other elements of the SoS, and are impacted by environmental factors, described by Jackson (1971) as elements outside of the system.

Jackson (1991) described the coercive problem context as one in which “there is little common interest between the participants, there is fundamental conflict, and the only consensus that can be achieved is through the exercise of power and through domination (overt or more or less concealed) of one or more groups of participants over

others.” The space launch policy SoS can be visualized in this manner as each of the organizational elements involved has its own goals and interests and consensus is usually achieved through the exercise of Presidential power.

As presented in the first chapter of this dissertation, according to Oliga (1988), there is no method of analysis recommended for the examination of the systemic-coercive problem context. It is therefore necessary to examine some of the methods that have been used to study SoS in other contexts. Part I of this dissertation is focused on seeking a method of analysis that allows for the examination of the relationships within the systematic-coercive problem context, allowing for the identification of individual policy relationships while maintaining a holistic perspective of the entire policy SoS. This type of analysis would be appropriate for the examination of complex, interconnected (or interdependent) policies at the strategic level, spanning multiple government agencies, and that impact entities inside and outside of the federal government system.

Extrapolative Techniques and Statistics

Policy analysts have used extrapolative techniques to try and predict program requirements for the future, to forecast projects, or to measure policy impacts (Patton and Sawicki, 1993). The basic assumption behind this type of analysis is that “a simple extension of what has occurred is a good approximation of what will occur (Patton and Sawicki, 1993).” The tools and techniques of quantitative methods for policy analysis have come from a number of disciplines, including game theory, economics, statistical decision theory and operations research (Bankes, 2002). A common example for using extrapolative techniques cited by Patton and Sawicki is population projection. For

instance, by plotting past populations of the US on a simple graph and fitting a straight line through these points, future populations can be extrapolated by extending the line into the future (Patton and Sawicki, 1993)

These techniques have many advantages. First of all, they are simple and easy to use; second, they can be more accurate than more sophisticated models (Patton and Sawicki, 1993; Isserman, 1977). In a study of various extrapolative techniques, Isserman (1977) found that exponential extrapolation was the most accurate for predicting rapidly growing or declining trends, and linear extrapolation was found to be more accurate for moderately growing trends in a given set of data.

However, as Patton and Sawicki (1993) point out, these techniques have two underlying assumptions: that the patterns that existed in the past will continue into the future; and that the patterns are regular and can be measured. While these types of analysis allow trends to be identified, growth or decline, they do not necessarily indicate which policies have impacted the data.

Steven Bankes, of the RAND Corporation, further claims that the tools of probability and statistics do not suffice for all problems for a number of reasons. First of all, he claims that the representations of probability and statistics “often provide a poor ontology for capturing our knowledge about complex and adaptive systems, requiring that different representations be used if we are to use all our knowledge (Bankes, 2002).” A second challenge to the use of the classical methods of statistical uncertainty analysis is “that the assumptions that motivate representational choices of probability and statistics are in conflict with the pragmatics of many policy contexts (Bankes, 2002).” This could be because, rather than having only a single decision maker, with

specific values, and explicitly described knowledge, policy problems “often present communities of stakeholders with values that are incommensurate and group knowledge that is very difficult to elicit and capture in a single probabilistic structure (Bankes, 2002).”

The examination of space launch policy as a SoS could be an example of the type of problem referenced by Bankes. The policy SoS involves a number of different organizations, each with its own mission, goals, and objectives and its own budget and leadership.

This dissertation examines space launch policy and its impact on two elements of space launch capacity: space launch vehicles and space launch facilities. Unlike the example of population projection, there is little evidence that the number of past launches can be used to accurately predict the number of future launches. Additionally, while this type of analysis is useful in examining specific statistics, such as the number of rockets launched each year, it doesn't help provide explanations for changes in the data being measured. While a surge in the number of commercial launches performed in a specific year may be noted, this type of analysis doesn't highlight the environmental factors outside the system, or the policy factors within the system, that caused this variation.

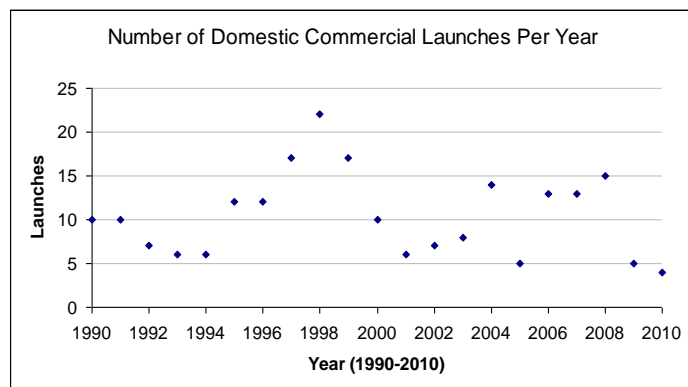


Figure 2.1: Number of Domestic Commercial Launches per Year
(From FAA Historical Launch Data, 2011)

For the problem of excess space launch capacity, it is important to

note that sending satellites into orbit has only taken place since the launch of Sputnik on October 4, 1957. The United States didn't launch its first satellite, Explorer 1, into orbit until January 31, 1958. Since 1958, the annual number of US government and commercial satellite launches has varied. For example, the number of FAA-licensed launches each year has varied significantly, as depicted in *Figure 2.1*. There were only four launches in 1989 and five launches in 2005 and 2009, while there were twenty-two launches in 1998, and fifteen launches in 2008 (FAA Historical Launch Data, 2011). These wide variations over a short time frame hardly lead to the predictable patterns on which extrapolative techniques and traditional statistics rely. There is neither consistent growth nor decline in the market, and the variables that impact the market are often beyond control of the industry itself. A straight forward, numerical measure of how many launches have taken place each year, or a prediction of how many launches may take place in the future, is not sufficient to demonstrate the interrelated nature of the commercial, civil and national security segments of the space field, nor the impacts that policy decisions have on the number of launches per year, and the vehicles and facilities required to support not only the commercial industry, but the government agencies as well.

Backcasting

The challenge of dealing with any of the elements of space launch capacity is not just a supply and demand issue; as both supply and demand for launch services are largely influenced by policy decisions issued by a number of government entities. In order to find a suitable method by which to examine US space launch policy, and its impacts on space launch capacity, it may be desirable to examine how other industries in which

supply and demand are significantly impacted by policy address these issues. Backcasting, for example, is a technique that has been used in resource management, particularly energy management and water management (Brandes and Brooks, 2007; Robinson, 1982; Anderson, 2001).

Simply put, whereas traditional planning would start from the present and look forward, “soft path” approaches using “backcasting” do the opposite. First, a sustainable and desirable state for the future is defined, and then planners work backward to identify policies and programs that will connect the future to the present (Brandes and Brooks, 2007). The process of developing scenarios by working back from the future allows for the potential impacts of future events, such as climate change, to be incorporated into the current planning process for managing supply and demand (Brandes and Brooks, 2007).

Backcasting was recommended by Brandes and Brooks as part of a “soft path” method by which to examine approaches to water management (2007). In a 2007 publication, they described three approaches to water management: supply management, demand management, and a “soft path” for management. They described supply management as an approach in which planners would extrapolate from current consumption to determine future requirements, and then focus on locating the resources to meet the demand (Brandes and Brooks, 2007). They also examined demand management, in which efficiency and information programs and pricing would be used to maximize the use of the existing infrastructure (Brandes and Brooks, 2007). They also offered a “soft path” approach that would allow planners to model a sustainable future state for water use with attention to long-term economic and social

prosperity; after this was accomplished, “backcasting” was used to devise a feasible path to reach that state (Brandes and Brooks, 2007). Recommendations included policy changes at the federal, state, and municipal levels of government to ensure that the desired end state could be accomplished (Brandes and Brooks, 2007).

As explained by Robinson, there are major differences between backcasting and forecasting, primarily that “backcasts are not intended to indicate what the future will likely be, but to indicate the relative implications of different policy goals” (Robinson, 1982). Relating backcasting to the energy industry, Robinson (1982) explains that, “Whereas good forecasts would presumably converge upon the most likely future and make some attempt to estimate its degree of likelihood, good backcasts can be expected to diverge, to reveal the relative policy implications of alternative energy futures.” This type of analysis focuses explicitly upon policy implications and is therefore more orientated to the policy process than traditional forecasting (Robinson, 1982).

According to Robinson (1982), one of the advantages of this type of analysis is that it “renders impossible a common reversal of cause and effect whereby the future (as revealed in forecasts) is treated as the case of present events (i.e., policy decisions). Such a reversal obscures the real relationship between policy making and future supply and demand, and allows the decision making process to operate under a spurious cloak of objectivity.” Admittedly, backcasting techniques are not meant to replace forecasting techniques in their entirety, but rather are meant to offer supplemental information relating to the examination of the social, environmental, and political implications of various decisions (Robinson, 1982).

Building on the work of Robinson (1982), Lovins (1976) and others, Anderson proposed that backcasting be used as an alternative strategic structure for reconciling a reliable and affordable energy industry with the broad tenets of sustainable development (Anderson, 2001). Anderson suggests that 'market' and 'forecasting' approaches have caused the energy debate to be viewed solely in terms of energy generation and supply. However, referencing Lovins, he points out that, rather than attempting to examine the complexities of uncertain supply and demand patterns, it would be beneficial to describe a desirable future and assess how it could be achieved (Anderson, 2001; Lovins, 1976). The central tenet of this approach is that future demand is primarily a function of current policy decisions (Anderson, 2001; Lovins, 1976).

Resource management, to include water management and energy management, is an industry in which supply and demand are influenced by policy decisions (Robinson, 1982; Brandes and Brooks, 2007), much like space launch capacity. A method of analysis that incorporates some of the same techniques used to examine resource management and policy issues may be appropriate for the study of space launch issues. While this particular method doesn't address the divergent goals of the multiple entities, the focus of these methods on discovering the underlying influencing factors on supply and demand could be a useful characteristic in a method of analysis used to examine space launch policy or other policy SoS (Robinson, 1982; Brandes and Brooks, 2007).

Program Evaluation and Review Technique

Gebala and Eppinger reviewed a number of design process models that have been used to study various systems and systems of systems. One of the techniques they reviewed is the Program Evaluation and Review Technique (PERT). PERT is widely used in systems engineering, and is shown in *Figure 2.2*. This technique was developed to measure and control the development progress of the Polaris Fleet Ballistic Missile program as the government and defense contractors sought a meaningful system to relate time, function and cost (Malcolm, et al., 1959; Roman, 1962).

Those who developed this technique felt that the most important requirement of project evaluation was an estimate of time constraints on future activities (Malcolm, et al., 1959). This technique,

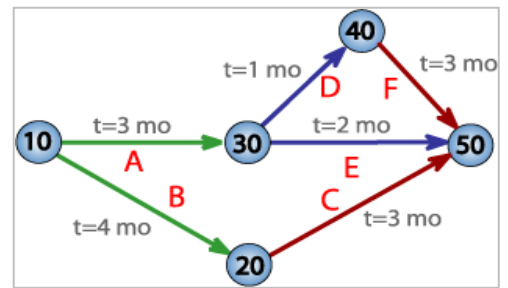


Figure 2.2: PERT Chart
(public domain)

in its simplest form, depicts the nodes of a diagraph arranged along a time line (Gebala and Eppinger, 1991). A fundamental tool used in this approach is the flow plan, as the analysis tool focuses management attention on the importance of planning and control and coordination of functions; PERT draws direct links between events and includes the time and responsibility for accomplishing an event (Roman, 1962). This analytical tool shows the interrelationship between all of a program's vital functions in terms of which tasks need to be accomplished to complete the integration of a technological SoS.

Though it is frequently used to depict milestones in the acquisition process, this model is still inadequate for representing the vast majority of design procedures where iteration is involved. This evaluation technique has other limitations: it requires that humans estimate completion times for events based on their own personal evaluation,

which generally is overly optimistic or overly pessimistic for those elements in the critical path, and can lead to skewing the timeline of the entire program (Roman, 1962). Additionally, the program is dependent on the active involvement of decision makers, which is challenging in a multi-agency environment; and, with schedule as the sole criteria for status determination, other factors may be overlooked (Roman, 1962).

Process models can fail to represent the full range of interactions among activities because of the complexity that this adds (Browning, 2002). Indeed, for the policy SoS that will be examined in the second part of this dissertation that may very well be the case. This model works for the program management of a single program, but when independent programs with limited interdependencies are involved, this technique would become more cumbersome. Additionally, this technique is focused on timelines and task completion. While it may be a helpful tool in managing a technological program, or integrating programs, it doesn't hold much promise for the examination of a policy SoS in which the organizational elements involved have separate, and at times conflicting, goals.

Graphical Mapping

Other models often used to examine technological systems and networks in multiple disciplines use graphical mapping or network analysis. In this type of analysis, shown in *Figure 2.3*, an entire activity is represented as a system of interconnected nodes. Traditional network analysis focuses on the structure of the network and the communications between nodes in the network (Wellman, 1983; Rowley, 1997; Galaskiewicz and Wasserman, 1994). Graphical mapping and graph theory were used and popularized by scholars like Frank Harary (1960), who attribute the origins of graph

theory to eighteenth century mathematician Euler. Euler solved the now infamous Königsberg bridge problem.

The Königsberg bridge problem was one in which two islands existed in a river with bridges to the banks of the river linked together by a bridge, as in *Figure 2.4*.

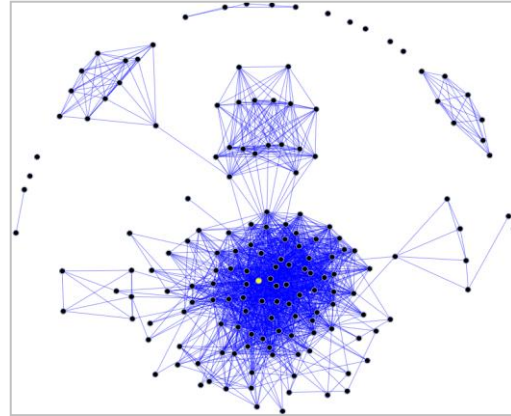


Figure 2.3: A Social Network Diagram
(public domain)

As Harary (1960) describes, “the problem was to start at any one of the four land areas and without swimming or flying or traveling around the world to traverse each bridge exactly once and return to the starting point.” Euler proved that the problem

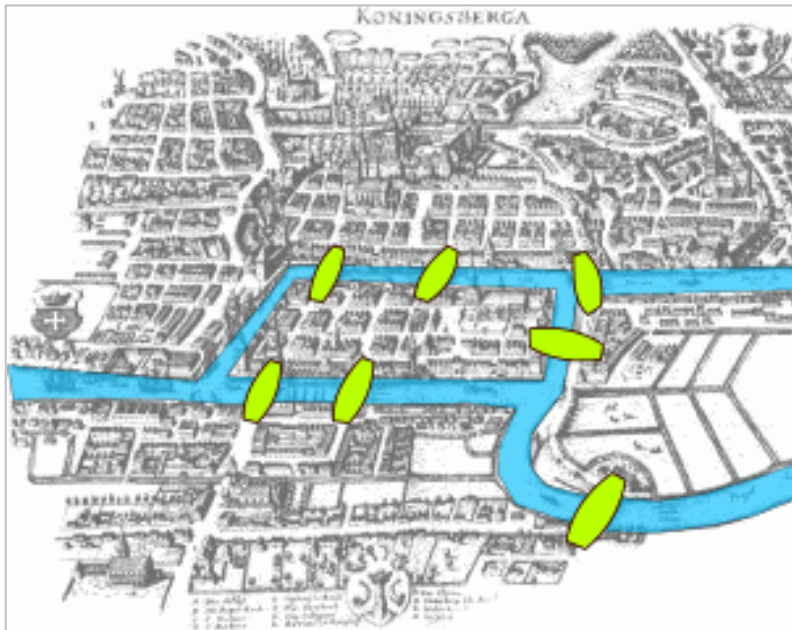


Figure 2.4: The Problem of the Seven Bridges of Königsberg
(public domain)

couldn't be solved. If one were to replace each land area with a point or node and replace each bridge with a line, there would be an odd number of lines coming from each point, so each point would be considered odd. The result of this is *Euler's*

Theorem, which states that “a

connected graph can be traversed by a complete closed line sequence if and only if every point is even (Harary, 1960).” Because all of the points in this problem are odd, the problem is unsolvable.

Temel, Janssen, and Karimov (2001) also used graphical mapping techniques in their study of agricultural innovation systems. They found that these techniques could be used to assess alternative pathways, identify effective pathways and identify the constraints facing a particular organization (Temel, Janssen and Karimov, 2001).

These conclusions may be optimistic when it comes to applying graphical mapping techniques to a variety of problems, as many graphical mapping techniques and models become cluttered when there are too many nodes, or when the flow of information is too complex (Gebala and Eppinger, 1991). Models like this are useful when the number of nodes is small enough not to clutter the model and when the flow of information is not very complex (Gebala and Eppinger, 1991). Euler's problem, the Königsberg bridge problem, consisted of only seven nodes or points. While this method of analysis provides the benefit of a visual representation of the system, the visual depiction can become cluttered.

In the example of the US space launch policy, it is necessary to examine not only the interactions between a number of government and non-government agencies and organizations, but also necessary to examine these interactions in a number of policy systems. While this type of analysis would be beneficial in examining the interactions between organizations, simultaneously depicting the interactions among the various organizations and the multiple policy systems within the US space launch policy SoS would be challenging, as there is no mechanism to incorporate unlike elements into the graphical map.

The Design Structure Matrix

After examining a number of methodologies used for the analysis of various types of systems and systems and systems, it was determined that the Design Structure Matrix (DSM), introduced by Stewart as an analysis tool for complex systems (Dunn and Sussman, 2005; Stewart, 1984), held the most promise as a building block for this type of analysis. The design structure matrix has proven itself to be a useful analysis tool in a myriad of environments. It has been used for system integration, program planning, program execution, and many other applications (Browning, 2002; Dunn and Sussman, 2005; Stewart, 1984; Gebala and Eppinger, 1991). It derives its value from the relationships and interactions among its elements or activities, and is useful in examining complex engineering problems and the inter-dependencies among activities that are common to engineering problems (Browning, 2002). By using this type of method in systems engineering, tasks are classified as dependent tasks, independent tasks, and interrelated tasks (Eppinger, 1991), and can be manually arranged to depict the sequencing and interrelationships of interactions. An example of this, from the work of Dunn and Sussman, is depicted in

Figure 2.5.

In this case, a team-based DSM for a restaurant is used. Identically labeled rows and columns indicate teams at the restaurant, and an 'x' indicates a transfer of information from a column element to a row element. Because an element's

	Bar Staff	Cleaning Staff	Cooks	Hosts	Managers	Owners	Valet Staff	Wait Staff
Bar Staff					x			x
Cleaning Staff				x	x			
Cooks	x				x			x
Hosts		x			x		x	x
Managers	x	x	x	x		x	x	x
Owners					x			
Valet Staff	x				x			
Wait Staff	x		x	x	x			

Figure 2.5: DSM Example 1
(Dunn and Sussman, 2005; used with permission)

relationship with itself offers no meaningful information, the main diagonal of the matrix is blocked out (Dunn and Sussman, 2005; Yassine, 2004). Additionally, elements with no exchange of information are left blank. Dunn and Sussman explain that, “In the first column, bar staff send information to cooks when bar customers place food orders, to managers for special customer attention or work-related requests, to valet staff for alerting them of unruly patrons, and to wait staff when tabs and customers are transferred from the bar to the dining area. They do not, however, communicate with cleaning staff, hosts, or owners.” This type of matrix indicates that the relationships between elements are intertwined; it is possible for element ‘a’ to influence element ‘b’ and element ‘b’ to also influence element ‘a’ (Yassine 2004).

With furtherer examination of this example presented by Dunn and Sussman, it is possible to observe how clustering is used to manipulate the data (2005). The elements of the matrix on each axis may be re-arranged in an order that allows for the identification of particularly dense relationships among several elements, which are ‘clustered’ as boxes along the diagonal. Dunn and Sussman claim that, by recognizing the set of relationships among teams, the teams can more readily anticipate and participate in information exchange and communication (2005). Dunn and Sussman re-arranged the restaurant DSM to demonstrate clusters of teams with high degrees of intra-cluster information flow and very little extra-cluster information flow, as in *Figure 2.6*. Ideally, the DSM would allow researchers to attempt to find a sequence of interaction between elements that would allow for the matrix to be arranged in such a manner that each interaction is completed only after all requisite prior interactions are completed. However, this rarely happens (Eppinger, 1991).

Researchers tout the versatility of the design structure matrix, sometimes referred to as the design structure system. According to Donald Steward, “the design structure system can be applied to organize the design of a system, to develop an effective engineering plan, to show where estimates are required, and to analyze the flow of information that occurs during the design work. This information flow can be used to determine the consequences

Figure 2.6: DSM Example 2
(Dunn and Sussman, 2005; used with permission)

	Bar Staff	Wait Staff	Cooks	Cleaning Staff	Hosts	Valet Staff	Owners	Managers
Bar Staff		x						x
Wait Staff	x		x		x			x
Cooks	x	x						x
Cleaning Staff					x			x
Hosts		x		x		x		x
Valet Staff	x							x
Owners								x
Managers	x	x	x	x	x	x	x	

of a change in any variable on the rest of the variables in the system, and thus to determine which engineers must be informed and which documents must be changed (1984).” By applying this structure to public policy, it is possible for

researchers to identify organizations between which policy interactions take place and to determine the relative frequency of those interactions. Like the engineering problem, looking at the interactions between organizations would allow policy makers to determine which other policy systems could be impacted by a particular policy system, and coordinate accordingly. As previously mentioned, the DSM is a flexible approach to analysis. There are several recognized types of DSMs, which focus on different approaches to the analysis at hand and allow for different types of analysis. Researchers in mechanical engineering, systems engineering, and management have modified and manipulated the DSM, which allows researchers and managers to more easily identify opportunities to improve efficiencies in interactions between organizations

(Dunn and Sussman, 2005). For the purpose of the method being developed in this paper, the primary focus will remain on the team-based DSM and clustering techniques.

Summary and Conclusions

As evidenced by the examination of a number of different methods currently used to examine systems and SoS in this chapter, it is clear that a an alternative method is needed to examine the policy SoS at a level that allows for a holistic view of the policy SoS as well as a focused view of individual policy relationships. A number of analytical methods currently used to analyze systems and SoS in a number of disciplines have characteristics that could be incorporated into a new method.

As previously discussed, traditional quantitative analysis and statistical methods are insufficient for this type of analysis. There are few good examples of quantitative policy analysis tools being successfully used for a complete policy analysis of problems where complexity is central to the policy issue (Bankes, 2004). Indeed, Bankes claims that there are a sufficient number of examples of misleading analyses resulting from the naïve application of these approaches to complex systems, which would make these methods of analysis inappropriate for the analysis of SoS, which are complex in nature.

Extrapolative techniques, commonly used in nearly all fields and disciplines, despite having the advantage of being relatively easy and inexpensive to use, assume that patterns exist (and will continue to exist) in the object of study, and that these patterns are regular and can be measured (Patton and Sawicki, 1993). Policy SoS and the consequences of policy interactions within the SoS may not always be predictable. While these techniques have their uses, they do not focus on the interrelationships and

interdependencies of the policy SoS. Rather, they focus on measurable outputs from a system, which may not always be available in a policy SoS.

Backcasting holds promise as a method of analysis used to examine policy systems in a dynamic environment, as it has been used to examine resource management policies in the energy and water conservation fields, industries which are highly susceptible to public policy (Brandes and Brooks, 2007; Anderson, 2001). One favorable characteristic of backcasting is that this method focuses on the relative implications of different policy goals (Robinson, 1982). However, this technique tends to focus on policy systems with similar goals, not on a policy system of systems that includes a variety of policy systems with separate, and sometimes divergent, goals. Backcasting techniques offer supplemental information relating to the examination of the social, environmental, and political implications of various decisions, but don't necessarily offer a structure that permits the examination of the policy environment when the organizations involved have conflicting goals and objectives.

Traditional forms of graphical mapping, often used in network analysis, provide a graphical representation of various nodes within a system, but don't provide a means by which to incorporate non-like objects, for instance, policies and organization, in one graphical depiction. While graphical mapping techniques can provide a visual representation of the relationship between elements of a system or SoS, it is important that the method of analysis proposed for this study be arranged in such a fashion as to allow for the examination of a large number of potential interactions in a very organized manner.

The Program Evaluation and Review Technique (PERT) and other process models focus too much on timelines for the integration of the technological SoS to be appropriate for the analysis proposed in this dissertation. These techniques focus on an ordered, or sequenced, approach to system integration whereas the policy systems within a larger policy SoS act, and are often implemented, independently of one another.

For the type of analysis which will be performed in this dissertation, the analysis of a policy SoS, the analytical methods described in this section are insufficient, as they fail to address not only the relationships of the organizational elements involved in the policy SoS, but because they fail to include the policies themselves as part of the analysis. The DSM comes closest to the type of analysis that is desired. However, although it relates various activities to one another or various organizations to one another, it doesn't provide a graphical depiction of the various organizations involved along with the various policy systems in which these interactions take place. The two-dimensional approach provided by the DSM allows only for the examination of relationships between organizational elements. The type of analysis desired for a policy of SoS needs a way to examine the interactions that influence multiple organizational elements in multiple policy systems. It is necessary to view multiple policy systems as part of the policy environment they collectively create, the policy SoS.

The type of meta-policy analysis desired in this dissertation must confront the complexity of the policy SoS. According to Bührs and Bartlett (1993), the type of analysis that is needed to provide an overarching understanding of complex policy systems, or SoS, should provide a meta-policy perspective, which "does not assume

that outcomes can be measured, that causality can be attributed, that knowledge is reliable, or that policy should always be instrumentally rational.” A meta-policy perspective should provide, not the answer, but, rather, a level of understanding and appreciation that is more than the sum of separate, diverse analysis (Majore, 1989; Bührs and Bartlett, 1993).

To accomplish a more complete analysis of the complex issues within a policy SoS, it is necessary to examine the interactions between organizations within their policy environments, to develop a meta-policy approach for analysis of not only the relationships among organizations in policy systems, but also the multiple policy systems in which the relationships exist. While aspects of the various methods of analysis discussed in this chapter can, and should, contribute to and influence a method of the type of meta-policy analysis desired in this dissertation, to accomplish this task, a different method is required.

Chapter 3: The Method of Analysis

As evidenced by the examination of a number of different methods currently used to examine systems and SoS in the previous chapter, it is clear that an alternative method is needed to examine policy SoS. This chapter introduces the Three-Dimensional Policy Design Structure (3DPDS) as a method for the examination of policy SoS, and discusses how the 3DPDS will be evaluated. The primary goal of this dissertation is to introduce a new method for the examination of policy systems of systems that provides an objective, reliable, repeatable means by which to dissect the interrelationships and interdependencies of policy systems of systems while maintaining a holistic perspective of the policy environment.

Examination of the policy SoS as a “design problem” could allow for visualization of the interrelationships and interdependencies of the multiple policy systems and organizations involved. If this were possible, policies could be “designed” in such a manner as to consider the other organizations and policy relationships they are likely to impact. As described by DeLaurentis and Callaway (2004), “The objective of the system of systems perspective is not prediction (which remains notoriously difficult to do over the long run), but instead is an understanding that the essence of the problem, the hard-to-grasp insight, likely appears only at this elevated perspective.”

The Three Dimensional Policy Design Structure

This chapter proposes a new method for the examination of policy SoS: the Three-Dimensional Policy Design Structure (3DPDS), which is in its earliest stages of development. The 3DPDS is largely based on the DSM and incorporates a third dimension to allow for the examination of various policy systems in addition to the

relationships between organizational elements. It would be considered a “meta-policy” approach, as described by Bührs and Bartlett (1993). As such, it provides for the analysis of a system in the framework in which it is created, in this case, the policy SoS in its organizational framework (Bührs and Bartlett, 1993; Dror, 1983).

Approaches like these allow for a degree of overarching understanding that remains hidden in other forms of policy analysis (Bührs and Bartlett, 1993). That overarching understanding is precisely what an advanced method of analysis applied to the study of any policy SoS should try to provide. The goal of this new method of analysis, once tested and refined, is to provide an objective, reliable, repeatable means by which to dissect the interrelationships and interdependencies of a policy SoS while maintaining a holistic perspective of the policy environment. Specifically, this dissertation will seek to provide a method for visualization of the complex policy relationships between multiple organizations that influence space launch policy in a variety of policy systems by examining them as a policy SoS.

The 3DPDS will examine the policy SoS at the strategic level, looking beyond traditional process models to consider the internal and external forces acting on the policy SoS. It provides decision makers with a systematic method to examine multi-agency policy problems from a strategic perspective by focusing on the interactions that policy systems have with one another. This is expected to allow for a deeper, more analytic retrospective understanding of complex policy decisions, as well as for the “design” of prospective complex policy decisions.

The 3DPDS, in *Figure 3.1*, allows for a simplified, yet well structured, view of a very complex environment in which many policy systems and organizational elements

are present. Utilization of the 3DPDS requires a content analysis of formal policy documents to identify policy interactions, as the units of analysis using this method are the policy interactions identified in these documents. In order to collect this data, policy documents are searched using key words. The passages containing the key words are further examined to determine if they contain a policy interaction, defined for the purposes of this study as a specific direction from one organizational element to another in a formal policy document.

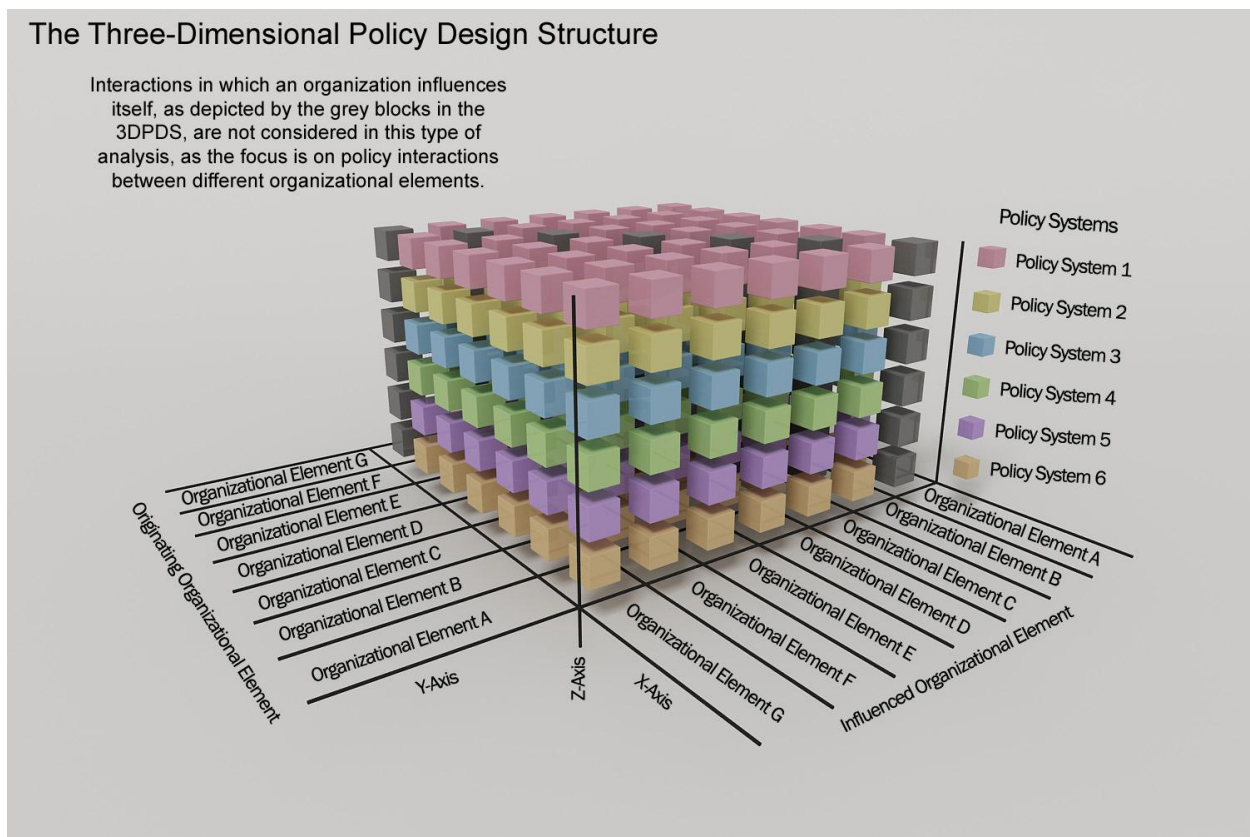


Figure 3.1: The Three-Dimensional Policy Design Structure
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

Each policy interaction is described by the originating organizational element; the impacted, or influenced, organizational element; and the policy system in which the interaction took place. Amplifying or clarifying sentences and/or paragraphs do not

count as separate interactions unless a specific, different direction or instruction is contained. It is possible for one document to have many different passages containing policy interactions, and also possible for one passage to have several interactions between a number of organizational elements.

Defining the specific interactions has been made more difficult by the formatting adopted in the most recent national level policy documents. Whereas the older documents followed an outline format where specific actions between organizations could be broken out in paragraphs, or some small, identified element thereof, the newer documents follow less of an outline format and read like a narrative. Therefore, in addition to having to sort through related text that only serves to amplify specific points, it is necessary to break up paragraphs in some documents for the sake of identifying individual passages that contain policy interactions.

Each passage that contains a relevant policy interaction is placed into a database. The originating organizational element is noted, as is the policy system to which the source document belongs, for instance, trade policy or transportation policy. The organizational elements, including the system and non-system actors, influenced by each particular policy passage are also noted. This allows the researcher to search, count, and order the policy interactions based on frequency, policy type, agency influenced, or any number of other variables.

The 3DPDS is then used to visually depict the policy interactions in the SoS. In *Figure 3.1*, the X-axis is comprised of the originating organizational elements and the Y-axis is comprised of the organizational elements influenced by the policy interactions. The policy systems are depicted along the Z-axis. Each policy system is shown in a

different color to allow for easy identification of concentrations of interactions within the same policy system.

Interactions within a particular organizational element are not part of this study, which focuses on the policy interactions between different organizational elements. Therefore, in *Figure 3.1*, the blocks in the 3DPDS which would depict an agency influencing itself through policy are shaded in grey, as they will not be considered in this analysis.

To analyze a complex policy problem, one must identify which organization is acting upon which other organization, and via which mechanism, or policy system. This allows the interactions to be mapped in a three-dimensional environment. In the generic example provided in *Figure 3.2*, a policy from organizational element B influenced organizational element C in policy system 3. Another policy interaction happened between organizational elements B and A in policy system 1.

Once the data points representing all of the policy interactions identified in the formal policy documents have been plotted, those organizational element and policy system combinations in which no policy interactions took place can be removed from the 3DPDS, and the blocks in which policy interactions took place can be redrawn. The blocks will be re-drawn in their original position, but will vary in size based on the number of policy interactions that were plotted in each box. Those organizational element and policy system combinations which occurred most frequently will be represented by the largest blocks in the 3DPDS. Smaller numbers of interactions will be represented by smaller blocks, and combinations in which no policy interactions took place will not be plotted at all. This allows for a simple visual representation of the

organizational element and policy system combinations in which policy interactions took place within a particular policy SoS.

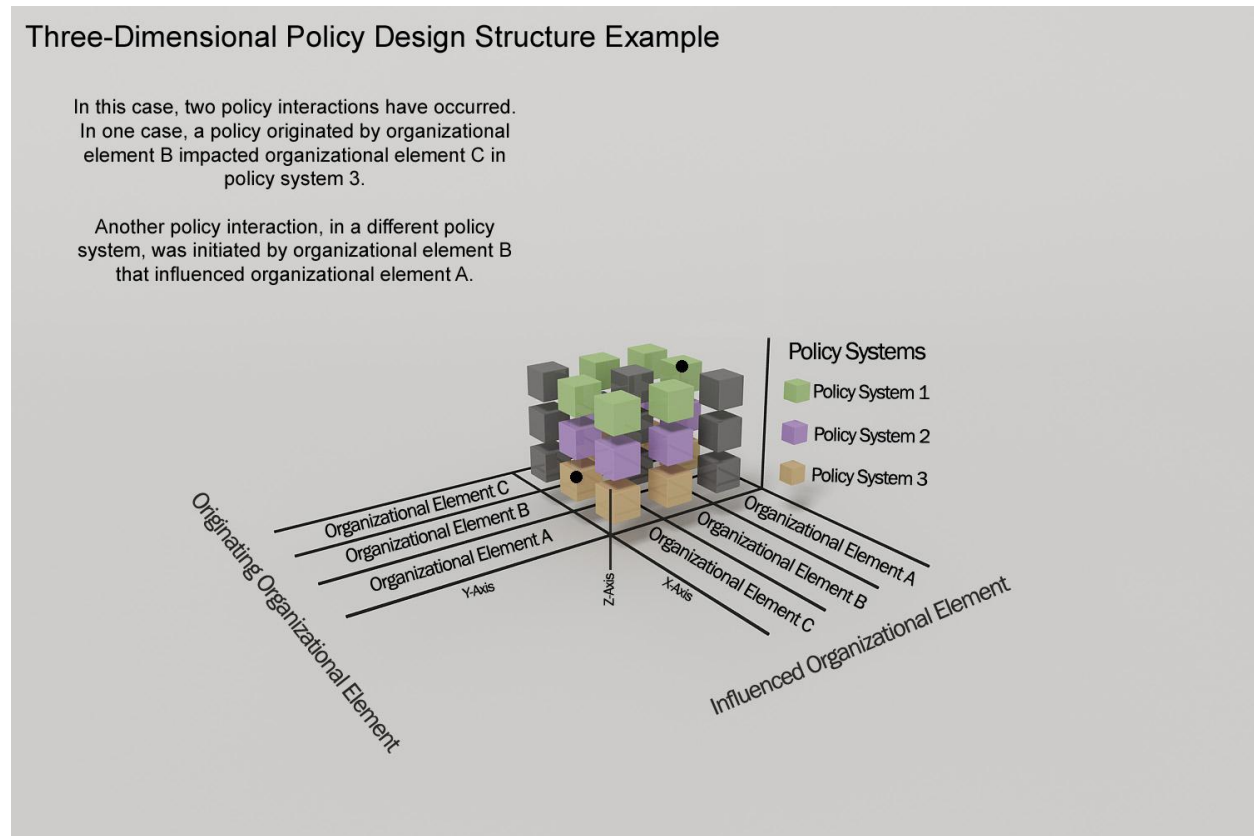


Figure 3.2: Three-Dimensional Policy Design Structure Example
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

Use of the 3DPDS in this manner allows for identification of the relevant organizational relationships within the policy SoS. While the 3DPDS allows for the identification of areas of high concentrations of policy interactions, it may also be used to identify policy outliers: areas with very few policy interactions. Using the 3DPDS, as much attention is given to the policy outliers as those combinations in which many policy interactions take place, as these outliers could have potentially significant influence on the policy SoS and should be identified and further examined.

With this method, the policy interactions are not weighted, as the relative “importance” of policy interactions would be highly subjective. This analysis does not attempt to place any relative significance or importance to the policy interactions themselves; rather, it counts the frequency and concentration of policy interactions between the various organization elements in the different policy systems within the 3DPDS.

The significance of frequency as a statistic in this study is its use in further arranging and presenting the data in the 3DPDS. There is no effort in this study to correlate the frequency of policy interactions with the importance of the policy interactions being examined. Instead, use of the frequency statistic in this manner allows for easier identification of policy outliers, which may otherwise go unconsidered by policy makers, and allows visualization of high concentrations of policy interactions.

Careful use of frequency as a statistic is supported by Plomp, who studied the statistical relativity of citation frequency as an indicator of the scientific impact of research carried out by various authors (Plomp, 1989). He noted that the use of frequency may be misleading, as some articles are cited frequently the first year or two after they are published, while others are cited with the same or greater frequency, but over a larger span of time (Plomp, 1989). As offered by Plomp, one must exercise caution and not reach unjustified conclusions using the measure of frequency as a statistic, but there is still value in the measure (Plomp, 1989).

The value of the 3DPDS is its ability to provide a holistic view of the relationships within the policy SoS. To accomplish this, the frequency statistic will be used with clustering techniques to further arrange the data in the 3DPDS. Clustering, frequently

used by researchers and analysts in a variety of fields, is used to group similar data points together (Berson, Smith, and Thearling, 2000). Clustering offers a higher level perspective of what is happening in a data set, and can be used to more easily identify outliers, or data points that stand out from the others in a data set (Berson, Smith and Thearling, 2000). In the policy SoS, interaction combinations that take place most infrequently will be considered “policy outliers” or simply “outliers.”

Particular attention in this study is paid to the units of analysis. For this particular study, the units of analysis are the policy interactions themselves. Each position on the initial 3DPDS allows for the “mapping” or “accounting” of multiple policy interactions. The organizational structure of the overarching organization is not considered, nor is the formal relationship among the various organizations, their positions in an organizational hierarchy, or other characteristics, like size or budget. The analysis looks only at the policy interactions themselves. Once all of the policy interactions have been accounted for, the clustering can begin.

In the clustering process, data fields on each axis will be arranged based on the number of interactions in that particular data set. The data fields on each axis will be rearranged, from lower numbers of interactions to higher numbers of interactions, as in *Figure 3.3*. This will provide a visual representation of the organizational element and policy system combinations in which policy interactions occur most frequently in the policy SoS.

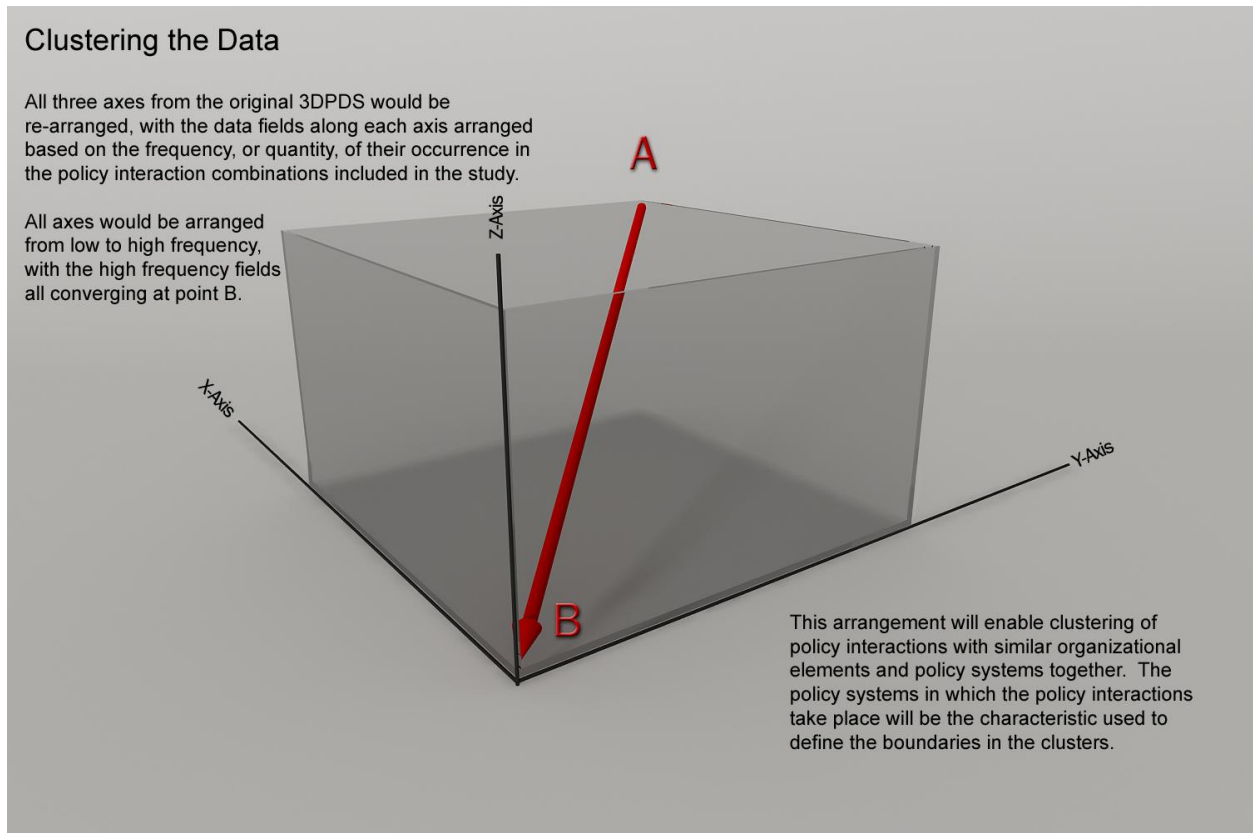


Figure 3.3: Clustering the Data

(Illustration by Trevor Mower and Timothy Thielke; used with permission)

This will allow methods of analysis using the 3DPDS to accurately identify which organizational elements are involved in the policy SoS, including those with a very limited involvement in the SoS. Although the test cases in this dissertation will not “weight” or prioritize the specific interactions, but rather focus on their frequency, the 3DPDS could allow for the possibility of weighting interactions in the future, if, based on the test cases, such a change is deemed necessary to further refine and improve the method.

In these first two applications, clusters will be bound in each policy system, as the focus of the study is the policy SoS. Organizational element combinations within the same policy system that are within two “blocks” of each other along the X- or Y- axis will

be clustered together. The exception to this rule will be interactions that include “Other Agencies & Organizations,” which will be considered as outliers because of the uniqueness of the entities included in this organizational element.

The result of the analysis will be a visual depiction of the relative frequencies of policy interactions, broken out by policy system (trade, defense, etc.) The value that the 3DPDS provides is an understanding of where to focus future analytical efforts, as it can be used to identify the organizational relationships in specific policy systems, highlighting not only the most frequent interactions, but also the outliers.

This method is flexible enough to bring attention to a wide variety of policy interactions that can then be unpacked in an orderly manner and studied when the time and resources are available or priorities dictate. This method can help analysts decide where to focus their efforts when examining the impacts of policy decisions, or the quality or effectiveness of policies, within the SoS.

Anticipated Strengths and Weaknesses of the 3DPDS

Bührs and Bartlett discuss the strengths of meta-policy approaches, such as the 3DPDS, in broad terms. They claim that the weaknesses of this type of approach to policy analysis are also its strengths (Bührs and Bartlett, 1993). It confronts the complexity of institutional and conceptual frameworks without attempting to master them; it does not assume that outcomes can be measured or that causality can be established; it is limited in the explanations it can offer; and finally, it provides not an answer, but rather an overarching understanding and appreciation that other forms of analysis do not provide (Bührs and Bartlett, 1993; Majone, 1989).

One of the advantages of the 3DPDS is its structured simplicity, which allows for structure in a complex SoS which does not lend itself to rigorous quantitative analysis. Additionally, elements of this design may be added or subtracted to allow for more a concentrated or expanded study of specific interactions. This method can help analysts determine which policy interactions to consider when performing retrospective or contemporaneous analysis and developing new policies. This can be particularly beneficial when focusing on policy “outliers” and trying to identify policy interactions that may lead to unintended consequences.

This method is flexible enough to bring attention to a wide variety of policy interactions that can then be unpacked in an orderly manner and studied when the time and resources are available or priorities dictate. This method can help analysts decide where to focus their efforts when examining the impacts of policy decisions, or the quality or effectiveness of policies, within the SoS. The same framework can be used for a quick, cursory view of the policy interactions within a SoS, or an in-depth analysis of a specific issue, based on the time and resources available for further analysis.

The 3DPDS provides researchers and decision makers with a repeatable means of dissecting the policy SoS, allowing for a visual representation of the organizational elements involved in policy interactions in the SoS, and of the specific policy systems in which these interactions occur.

Use of the 3DPDS can lead researchers to relevant and significant interactions within a policy SoS, including policy outliers, which could provide researchers with a starting point when trying to identify, anticipate, or minimize unnecessary or inefficient decisions and actions or unintended consequences.

The 3DPDS will allow analysts and policy makers to determine on which interactions and relationships to focus for deeper review, assessment and analysis either prior to or subsequent to policy decisions. This method does not seek to prioritize these relationships. By using this method to provide a retrospective analysis of policy decisions that have already been made, one may be able to identify which elements played a part in the policy ramifications, or outcomes. This could be an important part of determining what, if any, policy elements need to be adjusted for current environmental conditions. Additionally, the 3DPDS, once applied to past decisions, can be used to study the future impacts of policy decisions by using the organizational element and policy system combinations identified during the previous applications to systematically examine the potential impacts within each of these combinations within the larger policy SoS.

Admittedly, the 3DPDS does have its shortcomings. Like other types of systemic analysis, the 3DPDS will not provide decision makers with a policy solution (for example, what should be done about illegal immigration), or tell a researcher if a specific policy interaction is good or bad. Deeper analysis of the organizational relationships and policy interactions identified using the 3DPDS will be required.

While three-dimensional modeling tools assist with depicting the interactions and “clustering” of the data, the data collection and the analysis process can still be time consuming. Also, like any other type of method used for policy analysis, the results of the analysis are limited by the quantity and quality of information going into the 3DPDS and the specific topic being studied, or question being examined.

Initial Testing and Evaluation of the 3DPDS

As mentioned, the 3DPDS is in its earliest stages of development. While it is understood that it would be impossible to completely test and validate this method of analysis based only on the work in this dissertation, this dissertation will provide the beginning steps in that direction.

Testing and evaluating a method are important steps in eventually reaching a point where it is considered validated and can be more broadly accepted and applied, or is considered to accurately represent the agreement between the behavior of the data and the real world system being analyzed (Gass, 1983; Fishman and Kiviat, 1967). The basic steps in this process include testing the method, validation based on studies of real world situations or scenarios, and public debate and evaluation by others (Clark and Cole, 1975; Gass, 1983). The second part of this dissertation will begin to test the proposed method, focusing on the application of the 3DPDS to a specific policy SoS.

Yin (1994) promotes the use of a single case study when that single case study can represent a critical case in testing a well-formulated theory, or represent an extreme or unique case. However, as this dissertation will begin to examine and test the feasibility of a new method by which to examine policy systems of systems, it is imperative that the 3DPDS be applied to more than one application, and that refinement of the method be included as part of the process.

From preliminary examination, the 3DPDS has demonstrated that it may provide a quick method by which to discern the organizational elements and policy systems involved in a specific complex policy issue. Further application and evaluation of this method will help define the parameters of future studies, and help determine how the 3DPDS might be used, for instance, as a filtering mechanism.

The 3DPDS will be applied to several examples to begin testing its validity. In the evaluation process, the data derived from the interview process will be compared with the 3DPDS output for each application. The first application will examine policy interactions that impacted space launch vehicles. The second will examine policy interactions that impacted space launch facilities. The third application will employ the results of the first application to identify the policy relationships relevant to space launch vehicles. An ordered examination of these relationships will then be done, focusing on the policy decisions relevant to the cancellation of the Ares 1 launch vehicle and the actual and anticipated impacts of that decision, as identified by the relevant policy documents and data collected through expert interviews.

The interviews were used in the first two applications to provide a “real-world” perspective of the policy SoS. The interview data represents the perspective of a representative sample of experts from the major sectors of the US space launch policy SoS. The interview database catalogues the organizational element and policy system combinations that correspond to the policy decisions the subject matter experts perceive to have most influenced their respective organizations. For the first two applications of the 3DPDS, the results will be evaluated against data gathered through expert interviews.

As mentioned, the 3DPDS will initially be tested on two very closely related applications. The applications conducted in this dissertation will examine policies related to two elements of space launch capacity: space launch vehicles and space launch facilities. The applications are closely related, but future applications should cover a wide range of data sets to reduce the risk of developing a method of analysis

that is so specific that it has little applicability outside the SoS examined in these applications.

In order to evaluate the 3DPDS, it is important to be able to define what constitutes success. For the first two studies, which examine two related elements of launch capacity, success will be evaluated using the following criteria:

1. Did the method of analysis, using the 3DPDS, offer any insight regarding the policy relationships that have the most frequent influence on space launch capacity?
2. Did organizational element and policy area combinations depicted in the 3DPDS as those that occur most frequently correspond with policy interactions most frequently contained in the policy passages referenced by experts during the interview process?
3. Were policy outliers identified through use of the 3DPDS, and were these outliers identified during the expert interviews?
4. Did use of the 3DPDS assist in identifying any additional system or non-system actors that could be considered as part of the policy SoS?

It is expected that the 3DPDS data will roughly correspond with the data collected during the interview process. The most frequent policy interactions would correspond to the policy decisions most often described by the interview participants. Likewise, it is expected that few of the policy outliers will have been discussed by the industry experts during the interview process.

It is also expected that the initial applications of the 3DPDS, and methods of analysis using this tool, will identify ways in which the tool and the method can be improved for future applications.

For the third application, the examination of the decision to cancel the Ares 1 launch vehicle, the previous application specific to space launch vehicles will be considered to determine which relationships are likely to be involved in this decision and its ramifications. Success, again, is subjective, but will be evaluated using the following criteria:

1. Did the method of analysis, using 3DPDS output from previous applications, allow for the ordered examination of a current policy issue?
2. Was the use of the 3DPDS for space launch vehicles appropriate for the examination of a sub-element of “space launch vehicles?”
3. Did the 3DPDS offer any insights into the policy relationships within the SoS that were not highlighted during the expert interviews?

It is expected that a method of analysis, using output from a previous application of the 3DPDS, will allow for a more efficient, targeted examination of current policy issues by guiding the systematic examination of the policy system. It is further expected that policy interactions other than those discussed by the industry experts will be highlighted in the block by block examination.

This method of analysis is intended to be used by decision makers and their staffs, and those in academia, to identify the organizational element and policy system combinations in which policy interactions take place within a policy SoS. It is not a crystal ball: it will not tell decision makers what decisions to make. Rather, it will show

them which policy relationships may be influenced by their decisions, thus focusing further analytical efforts, and providing a means by which to graphically depict these policy relationships, and systematically consider them when considering policy changes.

The Research Design

This type of study will allow for policy analysis at a strategic level, providing a high-level, overarching view of the policy relationships that influence policy systems of systems. This study will begin to evaluate the 3DPDS by applying the method to two examples and providing recommendations for adjustment to the 3DPDS. To begin this evaluation, the 3DPDS will be used to analyze space launch policy, specifically those policy decisions that influenced space launch vehicles and space launch facilities. The unit of analysis for this study will be the specific policy interactions, applied across the organizational and policy framework represented in the 3DPDS.

In this case, the organizational elements included in the analysis will include the following system actors from within the federal government: National Security Space (which consists of the Department of Defense and the Intelligence Community), Civil Space (predominately the National Aeronautics and Space Administration), Congress, the President, and other government agencies (such as the Department of State; the Department of Transportation, to include the Federal Aviation Administration; the Department of Commerce; and the Department of Energy) and two non-system actors: foreign entities and the commercial space industry. The Commercial Space Industry will consist of commercial providers and suppliers such as United Launch Alliance, Space Exploration Technologies (SpaceX), Orbital Sciences Corporation, and others (regardless of their NSS or Civil Space customer base), as well as those involved in the

commercial launch business for non-government payloads. The policy systems that will be examined include: national security, defense, transportation, trade, foreign policies and others. Congressional legislation will be included with the policy system it influences.

As discussed, this study will include a number of policy systems that comprise the policy SoS that influence space launch decisions, identifying the policy interactions in existing documents which will then be mapped in three dimensions. The policies included in this study will include national-level security, defense, and intelligence policies and documents, International Traffic in Arms Regulations (ITAR), National Aeronautics and Space Administration (NASA) and Federal Aviation Administration (FAA) policies, and other policy documents and related Congressional legislation.

The US Space Launch Policy SoS will be bounded by the policies of those agencies and organizations that are part of the overarching Federal government system. Policies examined will be limited to national and agency-level documents that influence space launch policy. Those documents that are completely internal to any one of the organizational elements that are included in this study will not be included in this analysis, as the focus of this study is the policy interaction among the different organizational elements within the overarching US space launch policy SoS. The non-system actors, for this study, will be limited to foreign entities and the industrial base. The organizational elements, including the system and non-system actors, and the policy systems that will be included in this study are illustrated in the depiction of the 3DPDS that will be used for this study, in *Figure 3.4*.

Additionally, in order to accurately portray the policies put in place to affect commercial Space flight by the FAA, it is necessary to include a number of pieces of legislation, as the FAA is subject to the Administrative Procedures Act, and therefore its policies go through standard rule making procedures.

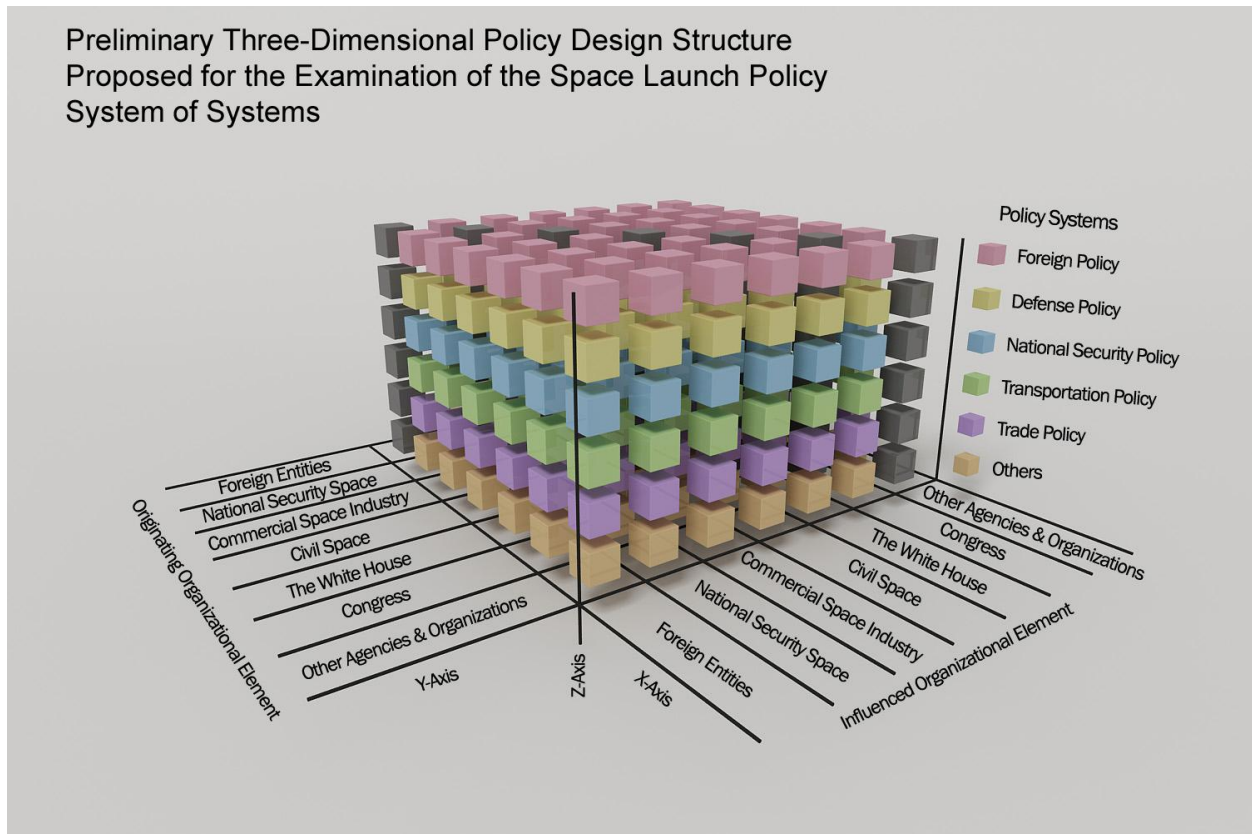


Figure 3.4: Preliminary Three-Dimensional Policy Design Structure Proposed for the Examination of the Space Launch Policy System of Systems
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

The data analyzed for this study came from multiple sources. The data sources consisted of those policies that currently address and/or influence the topics of this study at the national and agency level. All of the documents used in this study are readily and publically available. Defense policies, presidential directives, and trade policies were included in the study. Lower level internal documents were not used in this study. In this study, the policy interactions were viewed as the independent variable.

The method, in its current state, makes use of readily available basic database software. The databases for this dissertation were constructed in Microsoft Excel. Additionally, AutoCAD was used to construct the three-dimensional graphics and depict the output of the 3DPDS.

As previously mentioned, the analysis of interactions will be completed using three-dimensional graphing and clustering techniques. Part II of the dissertation will focus on the data collection and analysis of the policy decisions influencing space launch vehicles and space launch facilities using the 3DPDS.

PART II

Chapter 4: The Space Launch Policy System of Systems

The first part of this dissertation focused on addressing the following questions: Is a new method required to examine policy SoS; what methodological approach is most appropriate for the examination of policy SoS; and why? Chapter 2 discussed desirable properties in a method for the examination of policy SoS, and Chapter 3 introduced the Three-Dimensional Policy Design Structure (3DPDS) as a tool for the analysis of policy SoS.

Part II of this dissertation focuses on testing the 3DPDS by applying it to policy decisions that influence space launch vehicles and policy decisions that influence space launch facilities. After applying the 3DPDS to the first two examples, the 3DPDS will then be applied to a third example. While the first two applications examine how policy has influenced specific elements of space launch capacity in the past, the third application focuses on how policy may influence elements of space launch capacity in the future. Specifically, the third application examines the impact of the Presidential decision to cancel the Ares 1 launch vehicle, the proposed replacement for the Space Shuttle. This chapter will describe the space launch environment and the space launch policy system of systems. The following chapters will focus on data collection and testing the 3DPDS. The final chapter will focus on conclusions that can be drawn from the applications in this dissertation, the potential for the application of the 3DPDS to other problem sets, and relating the research conducted in this dissertation to the existing literature.

A Historical Look at the Space Launch Environment

The entire space launch policy SoS creates a set of rules, regulations, laws, and guidance that together create a complex environment that no one policy system could accomplish on its own. The resultant policy SoS encompasses all of the component systems. From the beginning of the US space program, there were a number of independent policies initiated by individual government agencies that impacted the options and policies of other agencies, as the policy systems that comprise the space launch policy SoS are closely related. In order to more fully understand the complex space policy environment, it is necessary to understand how the US space launch industry evolved.

The US space launch industry, even in its infancy, was an industry that experienced deep divides. Because the space program largely grew out of the military ballistic missile industry, the struggle between the Army and the Air Force in 1949 over intermediate-range ballistic missiles grew to include space launch policy in the late 1950s, and eventually included the Navy, whose submarine force also carried ballistic missiles (Neufeld, 2005).

In 1957, the Soviet Union used a modified intercontinental ballistic missile to place the world's first artificial satellite, Sputnik, into orbit, beginning the space race between the US and the USSR. Shortly after the Navy's failed launch attempt of the Vanguard satellite, the US Army succeeded in launching the first US military satellite, Explorer 1, in January of 1958. According to Neufeld (2005), the Sputnik program allowed for the creation of "a US Army space program on top of its missile program."

Shortly after successful launches by the Navy and the Army, NASA was created by the National Aeronautics and Space Act of 1958. In this act, Congress directed that

aeronautical and space activities, with the exception of those particular to or primarily associated with the development of weapons systems, military operations, or the defense of the United States be directed by a civilian agency (PL #85-568, 72 Stat. 426). The Navy's Vanguard group became the core of the new agency's spaceflight activities (Calderwood, 1998). Later that year, NASA publicly announced its manned space flight program (Space News, 2007). The following year, the heart of the Army's space capability, Dr. Wernher von Braun's division of the Army Ballistic Missile Agency, was reluctantly transferred to NASA in a move that "fulfilled the long-held desire of the US Air Force to gut the Army's capability in long range missiles, yet ... denied to the US Air Force von Braun's fabled rocket-engineering group (Neufeld, 2005)."

In 1960, recognizing the potential of satellites for communications, AT&T surprised a number of government agencies by filing a request with the Federal Communications Commission for permission to launch an experimental communications satellite; as no policies were in place at that time to respond to such a request (Whalen, 2007). However, by the end of 1961, NASA had awarded contracts for two satellites, and entered an agreement with AT&T to launch one of its satellites on a cost-reimbursable basis (Whalen, 2007). In 1963, the Department of Defense (DoD) and NASA signed an agreement in which the DoD would continue to be responsible for launch range operations, an agreement that is still in effect today (McNamara and Webb, 1963).

Early Bird, touted as the world's first commercial communications satellite, built by Boeing for the Communications Satellite Corporation (COMSAT), was launched by NASA in April of 1965 on a Thrust Augmented Delta (TAD), a three stage rocket built by

Douglas Aircraft Company (Boeing: Early Bird, 1995; Whalen, 2007). Following this precedent, NASA continued to launch commercial satellites on a cost-reimbursable basis (Boeing: Westar, 1995).

The success of the manned space program paralleled the success of the unmanned program. In 1961, Alan Shepard became the first American in space, and in 1962, John Glenn orbited the Earth aboard Mercury 6 (Space News, 2007). Following the Mercury program, the Gemini spacecraft, launched on Titan rockets, began carrying astronauts into space, including Ed White, the first American to walk in space (Space News, 2007). Most notably, in 1969, the crew of Apollo 11 landed on the moon. Thanks to commercial communications satellites, which had completed a global network for television signals just days earlier, the event was broadcast to millions of viewers worldwide (Whalen, 2007).

In 1972, President Nixon approved NASA's plan for the space shuttle, anticipating that it would become the primary launch vehicle for all NASA and DoD launches (Smith, 2003). While this decision made NASA and the DoD dependent on a single launch vehicle, the higher launch rate was expected to reduce launch costs (Smith, 2003). Instrumental in implementing this arrangement was Dr. Hans Mark, who was the director of the NASA Ames Research Center prior to becoming the Undersecretary of the Air Force and the Director of the National Reconnaissance Office (1977-1979), and then the Secretary of the Air Force (1979-1981). Dr. Mark ensured that Pentagon payloads flew on the shuttle (Day, 2006). The shuttle was declared operational in 1982 and the phase-out of the other launch programs began (Smith, 2003).

In November of 1982, two commercial satellites were deployed from the space shuttle Columbia, and the shuttle appeared to be capable of accommodating national security, civil and commercial launches (Space News, 2007). However, to ensure continued access to space for national security missions, the Air Force successfully argued the need for another launch vehicle, an expendable launch vehicle (ELV) called the Titan IV, as a backup launch vehicle for the shuttle (Smith, 2003). In 1986, the Challenger accident brought shuttle flights to a halt for more than two years (Space News, 2007). Additionally, a Titan III exploded in April of 1986, and a Delta failed in May of that same year (Smith, 2003). The danger of relying on a single launch system was realized, and, in response a mixed fleet of expendable launch vehicles and shuttle launch vehicles was funded by Congress. As a result, the Reagan administration revised US launch policy from primary dependence on the space shuttle to the “mixed fleet” approach (Longsdon, 1986; Smith, 2003).

In the meantime, as other countries achieved space flight, additional launch options became available for commercial satellite companies. By the end of 1980, seven countries were capable of conducting launches into space (Space News, 2007). In 1984, Arianespace, a European multi-national private stock company, launched the US commercial satellite, Spacenet 1 (Space News, 2007). In 1998, PanAmSat launched its first satellite on a French Ariane rocket, and in 1990 China launched Asiasat-1, a commercial communications satellite (Heydon, 1996; Space News, 2007). In 1993, DirecTV launched its first satellite aboard an Ariane 4 rocket (Space News, 2007). Launch services, once the exclusive domain of the US and Soviet governments, became a global industry (Smith, 2003).

However, two launch failures would eventually change the US launch policies that pertained to the international launch market place. Two Chinese Long March rockets were being used to launch the Hughes-built Apstar-1 and an Intelsat satellite (Behrens, 2006). Allegedly, during the insurance investigations following these failures in 1995 and 1996 technology transfers took place that improved the reliability of Chinese nuclear missiles (Behrens, 2006).

These allegations ultimately resulted in the US government barring launches of US-built satellites on Chinese rockets (Lee, 2008). As a result of these events, since 1999, the International Traffic in Arms Regulations (ITAR) have included not only weapons, but commercial satellites and most detailed information about them (Lee, 2008; Dinerman, 2008). Additionally, regulatory power for defense trade controls was passed from the Department of Commerce to the Department of State (Dinerman, 2008).

Subsequent to the ITAR changes between 1999 and 2006, no Chinese satellite operator chose to purchase a satellite that was subject to US export regulations; European and Israeli suppliers were selected for more than half a dozen satellite orders during that timeframe (Zelino, 2006).

Other sectors of the space community were evolving as well. The DoD began its Evolved Expendable Launch Vehicle (EELV) program in Fiscal Year 1995, eventually awarding contracts for The Boeing Company's Delta IV and Lockheed Martin Corporation's Atlas V. Both companies were awarded \$500 million for development, and additional funds for launches (Smith, 2003). However, a sharp decrease in the commercial market led both companies to approach the government for more funding

(Smith, 2003). Sustaining both providers “has become known as ‘assured access to space’ in the sense of assuring that both companies remain in the EELV business so DoD has redundancy in capability should one of the launch vehicles experience difficulties (Smith 2003).”

When The Boeing Company was found to have obtained proprietary information about the Lockheed Martin Corporation program, the DoD suspended three Boeing Company business units from eligibility for new contracts, and shifted seven existing launch contracts from The Boeing Company to Lockheed Martin Corporation (Smith, 2003). The government further disqualified The Boeing Company from bidding for three new launch contracts, which were subsequently awarded to Lockheed Martin Corporation (Smith, 2003). In 2005, The Boeing Company and Lockheed Martin Corporation announced their intention to form a joint venture called the United Launch Alliance, which would provide Delta and Atlas rockets for US government and commercial launches (ULA, 2011).

The government’s manned flight program fell into further uncertainty in 2003, when Columbia disintegrated as it returned from orbit due to damage to its left wing from a piece of foam insulation that had detached from the external tank during launch (Behrens, 2006).

In December of 2004, the George W. Bush Administration authorized a new US space transportation policy, which directed NASA to implement the President’s 2004 Vision for Space Exploration (Behrens, 2006). This plan included retiring the space shuttle after completion of the International Space Station, returning to the moon, and developing a new crew exploration vehicle to reach low earth orbit and beyond.

A Look at the Current Space Launch Environment

Whereas launching satellites into orbit was once the exclusive domain of the US and Soviet governments, it is now a global industry in which a number of countries compete (Smith, 2003). Similarly, the manned space industry has become more commercial. The world has seen its first space tourist, and NASA, the agency once responsible for US manned spaceflight, faces cancellation of its replacement for the Space Shuttle, and will rely on commercial and foreign providers for transportation to the International Space Station and for other scientific and civil missions.

Recently, the Washington Post ran a headline that read “NASA’s \$9.4 Billion Mission to Nowhere” (Achenback, 2010). Beneath this headline was a photograph of a \$500 million mobile launch tower that was intended for use with NASA’s Constellation program. However, in April of 2010, the Obama administration publicized a plan to scrap parts of the Constellation program, including the Ares 1 rocket for which the 355-foot launch tower was built (Achenback, 2010). President Obama publicized his plan at a news conference held at Kennedy Space Center on April 15th, 2010. In these remarks, the President explained the administration’s plans to cancel significant portions of the Constellation program, including Ares 1, while increasing NASA’s budget by \$6 billion over the next five years and promoting programs that include robotic exploration of the solar system, scouting new missions to Mars, and contracting with private companies to provide transportation to the International Space Station (Obama, 2010).

The existence of a \$500 million launcher for a rocket that does not exist, and likely never will, is not the result of poor systems engineering or integration efforts in the traditional sense, or even of a failed acquisition strategy. Rather, this is the result of a

policy decision, in a fiscally constrained environment, coupled with shifts in priorities between Presidential administrations. The results of the policy decision to terminate the program will be far reaching, and will, undoubtedly, have unintended consequences.

President Obama, in his address, made clear a number of his specific objectives for NASA, including plans to utilize commercial space launch services to provide transportation for humans and cargo to the International Space Station (Obama, 2010). However, as civil space launch capacity is transitioned to the commercial market, what will the impact be on NASA and other government agencies, such as the DoD and the Intelligence Community, who rely on space assets to perform critical functions ensuring national security?

According to *Seeking a Human Space Flight Program Worthy of a Great Nation*, a report produced by the Review of Human Space Flight Plans Committee (HSF Committee), led by Norman Augustine, the Ares 1 would have had limited use. An analysis of the Constellation Program conducted for the report concluded that the Ares 1 would likely not be ready to reach the International Space Station prior to the space station's planned termination in 2015 (HSF Committee, 2009).

While Augustine's report discussed the limited use of the Ares 1 rocket for manned spaceflight as a concern (HSF Committee, 2009), the Congressional Budget Office (CBO) raised concerns regarding excess capacity for unmanned launches (CBO, 2006). A CBO publication reports that, with the exception of the timeframe spanning from 1997 to 2001, when a number of communications satellites from companies such as Iridium and Global Star were launched, both past and future worldwide demand for space launches has been, and will be, dominated by government launches of

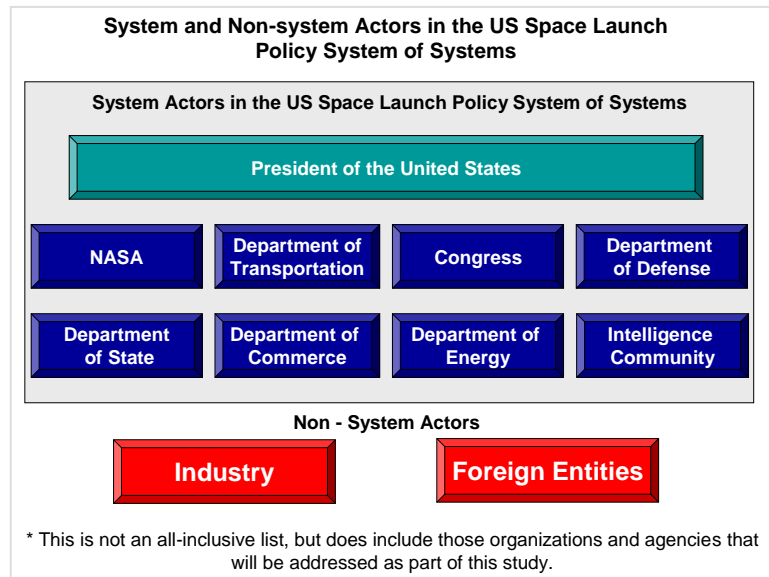
environmental-sensing satellites, remote-sensing satellites, and other military satellites (CBO, 2006). Along with a steady, if not decreasing demand for commercial launch capabilities, some government agencies, like the United States Air Force (USAF), generally meet just over 70 percent of their forecasted launches due to delays in development and manufacture of the satellites scheduled for launch (CBO, 2006). In 2006, projections indicated that maximum worldwide launch capacity for payloads of less than 25 metric tons would exceed demand by up to 100 percent for the foreseeable future; and CBO claims that these projections may actually be underestimated (CBO, 2006).

However, despite the apparent excess supply of launch capacity for unmanned programs and the perceived limited use of the Ares 1 rocket, the cancellation of the Ares 1 rocket could have unintended consequences for other government agencies. In order to better understand the impacts of the cancellation of the Ares 1 across the national security and civil sectors, it is necessary to view the impact that this policy decision will have not only across one sector of government, but also across the many interrelated sectors of government that are influenced by the space launch policy SoS.

The US Space Launch Policy System of Systems

As demonstrated, the domestic space industry has many sectors and divides, with a number of goals and missions put in place by numerous organizations. As such, US space launch policy is a practical example of the policy SoS. For the purpose of this study, the overarching SoS will be contained within the Federal government and the policies of the agencies and organizations. The system and non-system actors included in this study have been depicted in *Figure 4.1*. In this study, these will be defined as the

system actors in the overarching space launch policy SoS. The *National Space Policy* provides overarching guidance for the government’s interests in space (White House, 2010). However, each organization also maintains and is responsible for its own independent policy system. When the elements of their policies related to space launch are combined, the US space launch policy SoS emerges. Two primary non-system actors will also be considered in this study: the commercial space industry and foreign entities. Although not part of the formal government policy structure, these two non-system actors are influenced by the space launch policy SoS. This study will allow us to see more clearly the extent of these interactions.



This space launch policy SoS exhibits the characteristics

Figure 4.1: System and Non-System Actors in the US Space Launch Policy System of Systems

of a policy SoS, as described in Chapter 1. First of all, there is an element of *independence* between interrelated policy systems, meaning that each policy system within the SoS functions independently, with its own governance, generally as part of a separate organization. Each organization within the SoS has its own independent mission and goals, and these goals are supported through a number of policy systems. These independent policy systems are part of the overarching policy SoS in which the component systems may have divergent goals. In this case, there is overarching

guidance in the form of the *National Space Policy*, but each organization has rules, regulations, or policies that influence or are influenced by the *National Space Policy* (White House, 2010). The organizations are also *interrelated*, as supporting elements of the overarching *National Space Policy* (White House, 2010).

Secondly, the policy SoS exhibits emergent properties, or policy outcomes. These appear in the SoS, but are not apparent in the constituent systems. For instance, the Federal Aviation Administration licenses commercial launches within the United States. However, the regulations that govern which foreign entities may use US launch facilities, and how much technical assistance they can receive from their launch service provider, are part of the Internal Traffic in Arms Regulations (ITAR), which are primarily administered by the Department of State (US Code Title 22, Subchapter M, Part 120.1). The result of this peculiar arrangement may be the granting of a license to a US company to launch a foreign satellite from a US facility by the Federal Aviation Administration in which the US companies providing the launch services are unable to provide the integration support needed to successfully launch the foreign satellite from the US facility, per the ITAR administered by the Department of State.

This situation may seem far-fetched, but as recently as 2009, a vibration problem that delayed the SpaceX launch of Malaysia's RazakSat satellite could have been fixed with a minor adjustment to the satellite. However, ITAR regulations prohibited the company from assisting the satellite owner, and resulted in SpaceX providing a shock-absorbing interface to accommodate the payload (CSA, 2009).

There are a number of independent policies initiated by individual government agencies that influence US launch policy and impact the options and policies of other

agencies, as the policy systems are closely related. This will become more apparent as this study unfolds. The entire policy SoS creates a set of rules, regulations, laws, and guidance that together create a complex environment that no one policy could accomplish on its own and that encompasses all of the component systems. These characteristics make space launch policy an excellent candidate for examination as part of this dissertation.

Chapter 5: Data Collection

The first part of this study was the data collection phase. During this phase, national and agency level documents relating to space policy were collected. These documents came from a variety of sources. No documents were included that were not readily available in the public domain. Documents were found using internet searches, references in policy documents, and bibliographies of other documents. Additionally, interviews with recognized subject matter experts were conducted to determine which policies were identified as significant by those who worked and held leadership positions in the principal space sectors.

Documents were searched with the assistance of tools available in Microsoft Word and Adobe Acrobat Reader, in order to find passages specific to space launch vehicles and space launch facilities. Key words used to initially find relevant passages in these documents included: space, launch, vehicle, Shuttle, Ares, Constellation, expendable launch vehicle, facilities, ranges, and infrastructure. These may seem like rather broad key words, but not all of the documents included in this study would be obvious sources of space launch policy. In addition to legislation specific to the DoD and NASA, the search included a number of documents related to national security and transportation policy.

Policy documents reviewed included the Federal Register; various sections of US Code; Authorizations and Appropriations acts for the DoD and NASA; and national level policy documents from the DoD, the Department of Transportation, and others. Legislative documents were included in this study because many of the documents that impact US space launch policy are not incorporated in Agency level documents, but rather in actual legislation or in final Agency rules posted in the Federal Register.

Fifty-three documents were initially collected as part of this study. However, this study dealt with only those passages that directly related to space launch vehicles and space launch facilities, so those that did not specifically mention these elements were not included in the study. Additionally, those documents containing policy decisions implemented outside of the timeframe identified for this study were also removed. As a result of these criteria, 33 documents were included in the database for the applications examined in this dissertation. These documents will be considered the source documents for the policy document database used in this dissertation.

The remaining documents were reviewed again, this time looking for specific passages that mentioned the elements of capacity with which these applications were concerned: launch vehicles and launch facilities. These passages were placed into a database. Specific policy interactions were identified in these formal documents using the following criteria, in order:

1. The policy interaction took place in a formal policy document;
2. The interaction was between two or more identifiable government agencies; and
3. The interactions identified are specifically related to space launch vehicles or space launch facilities.

For example, passages such as, “United States access to space depends in the first instance on launch capabilities” were not included because they did not demonstrate an interaction between two different organizations (The White House, 2010). However, passages such as, “The Secretary of Energy shall...assist the Secretary of Transportation in the licensing of space transportation activities involving spacecraft with nuclear power systems” were included (The White House, 2010). This

particular passage was part of the most recent national space policy. As such, it was initiated by the White House, and influenced both the Secretary of Transportation and the Secretary of Energy, who would have to work together to approve licensing space transportation activities involving nuclear power systems (The White House, 2010).

Similarly, the statement that “United States government payloads shall be launched on vehicles manufactured in the United States,” also appears in the 2010 national space policy (The White House, 2010). This interaction, directed by the White House, influences the Secretary of Defense, as launch agent for National Security Space, and the Administrator of NASA, as the launch agent for Civil space applications in the United States. It also influences those who manufacture launch vehicles in the United States, and those directed to provide exemptions to the policy. This example demonstrates that one passage may involve multiple policy interactions, across many different organizational elements of the space launch policy SoS.

Specific passages that pertained to space launch vehicles or space launch facilities were catalogued in the database. Source documents were classified as policies pertaining to foreign policy, defense policy, national security policy, civil space and transportation policy, trade policy, or other miscellaneous types of policy. The originating organizational element of the policy document was noted, as were those elements or organizations influenced by the passage. Passages were indicated as relating to space launch vehicles or space launch facilities. Some passages influenced both launch vehicles and launch facilities. Additionally, those that influenced future launch systems, specifically, the Ares 1, or related elements of the Constellation program were also annotated.

In addition to analyzing the content of policy documents, interviews were used to gain practical perspective from all the commercial, civil, and national security sectors of the space launch policy SoS. These interviews allowed for the determination of which policies were perceived by interviewees to have the greatest impact on their organizations. In order to test the 3DPDS, it is necessary to compare the results achieved using the method with those achieved during the interview process. In the analysis portion of this dissertation, the policies and related impacts referenced during the interviews will be compared and contrasted with those identified in the policy documents identified in this chapter.

Policy Document Review

The timeframe selected for this study, beginning in 1995, includes a number of shifts in space policy. First of all, the mid-1990s marked a critical time in the organization of national security space, as the Secretary of Defense and the Director of Central Intelligence agreed to establish the Joint Space Management Board (JSMB). Chartered in December of 1995, this office was tasked with ensuring that defense and intelligence needs for space systems were satisfied, using integrated architectures (Charter for JSMB, 1995). This created a common board of directors for defense and intelligence space programs, and, in effect, created the entity referred to as “national security space,” which includes defense and intelligence community space programs.

This was a storied time in civil space history as well, as in June of 1995, the Space Shuttle Atlantis made its first rendezvous with the Russian Space Station Mir. Later in the nineties, Space Shuttle Endeavor made its first assembly trip to space for the International Space Station. Additionally, the 1996 National Space Strategy was the

first to encompass any of the recommendations made by the so-called “Augustine Panel,” which published its recommendations pertaining to civil space programs in the *Report to the Advisory Committee on the Future of the US Space Program* (HSF Committee, 2009).

The following paragraphs describe some of the significant policy interactions from passages in national and agency level documents that were included in this study. The descriptions of these documents are arranged chronologically, to provide a narrative of the policy changes as they occurred during the fifteen-year time frame encompassed in during this study. A table showing the policy interactions contained in each of the documents summarized in this section can be found in the appendix.

Source 1: National Defense Authorization Act for Fiscal Year 1996, Public Law 104–106, 104th Congress, 10 February 1996

This congressional legislation provided for the allocation of funds to the DoD for reusable rocket technology programs to the extent that NASA provided at least an equal amount for its Reusable Space Launch Program. Additionally, this defense authorization required the President to submit a report on the effect of the export control policy of the US on the national security interests of the United States. Specifically, the report was to address the relationship between United States policy on the export of space launch vehicle technology and the Missile Technology Control Regime, and a discussion of the history of the space launch vehicle programs of other countries.

Source 2: US National Space Policy, Fact Sheet, The White House, 19 September 1996

In this presidential directive, NASA was directed to work with the private sector to develop flight demonstrators that would support a decision regarding the development of a next generation reusable launch system. Additionally, the DoD was tasked with maintaining the capability to evolve and support space transportation system infrastructure to meet national security requirements. The DoD was also identified as the lead agency for improvement and evolution of the current expendable launch vehicle fleet.

Government agencies were also directed to consider the needs of the commercial space transportation industry when making plans for the future, and factor commercial needs into decisions regarding improvements to launch vehicles and launch facilities. The Department of Transportation was assigned as the lead agency within the Federal government for regulatory guidance pertaining to commercial space transportation activities (as per 49 USC Section 701 and Executive Order 12465).

This presidential directive reiterated current nonproliferation policies, noting that the US government would not support the development or acquisition of space launch vehicles in Non-Missile Technology Control Regime states, nor would the US encourage new space launch vehicle programs from either a proliferation or an economic standpoint.

Finally, this national space policy sought to minimize the creation of space debris and tasked NASA, the DoD and the Intelligence Communities to work with the private sector to develop design guidelines for future spacecraft and launch vehicles to minimize or reduce the accumulation of space debris.

Source 3: National Defense Authorization Act for Fiscal Year 1997, Public Law 104–201, 104th Congress, 23 September 1996

This legislation authorizes funds for space launch modernization efforts, including the Evolved Expendable Launch Vehicle (EELV) program and a competitive reusable launch vehicle program. The funds made available for the reusable launch vehicle program could not exceed the total amount allocated in the fiscal year 1997 current operating plan of NASA for the Reusable Space Launch program. Furthermore, of the funds made available for the EELV program, the total amount obligated for such purposes were limited to \$20 million until the Secretary of Defense certified that funds available for the reusable launch vehicle program had been obligated.

The Secretary of Defense and the Administrator of NASA were tasked with providing to Congress a joint plan for eliminating unnecessary duplication in the operations and planned improvements of rocket engine and rocket engine component test facilities managed by the Department of the Air Force and NASA.

Source 4: National Defense Authorization Act for Fiscal Year 1998, Public Law 105-85, 105th Congress, 18 November 1997

In this act, Congress provided for the storage of material that is not owned by the DoD if the Secretary of the military department concerned determined that the material was required or generated in connection with the use of a space launch facility.

Source 5: National Defense Authorization Act for Fiscal Year 1999, Public Law 105–261, 105th Congress, 17 October 1998.

This Act directs that the United States should pursue policies that protect and enhance the United States space launch industry. It prohibits the export of missile equipment or

technology that would improve missile or space launch capabilities to the People's Republic of China. Included in this direction is the specification that the United States should not issue any blanket waiver of the suspensions contained in section 902 of the Foreign Relations Authorization Act, Fiscal Years 1990 and 1991 (Public Law 101–246), regarding the export of satellites of United States origin intended for launch from a launch vehicle owned by the People's Republic of China. This act also requires the Secretary of Defense to monitor all aspects of foreign launches to ensure that no unauthorized transfer of technology occurs. This monitoring extends to foreign launch vehicles and foreign launch facilities.

Source 6: National Security Strategy for a New Century, The White House, October 1998

This document states that the US government will invest in a world class infrastructure for the twenty-first century, including the national information and space infrastructure essential for our knowledge-based economy. This passage identified space infrastructure, which includes launch ranges and facilities, as a national priority.

Source 7: Commercial Space Act of 1998, Public Law 105-202, 105th Congress, 28 October 1998.

This act decrees that the Secretary of Transportation may establish safety procedures for launch vehicles and reentry vehicles that may be used in conducting licensed commercial space launch or reentry activities. The term "launch activities" is revised to include activities "involved in the preparation of a launch vehicle or payload for launch when those activities take place at a launch site in the United States." The Secretary of Transportation was directed to provide: guidelines for industry and state governments to

obtain sufficient insurance coverage for potential damages to third parties; procedures for requesting and obtaining licenses to launch a commercial launch vehicle; procedures for requesting and obtaining operator licenses for launch; procedures for requesting and obtaining launch site operator licenses; and procedures for the application of government indemnification.

Additionally, the Administrator of NASA is directed to transition from federally operated or federally managed contract operation of space transportation systems to the purchase of commercial space transportation services for all non-emergency space transportation requirements, including human, cargo, and mixed payloads. The Administrator is directed to examine the feasibility of privatization of the Space Shuttle, and to examine, with the DoD, the ability to support commercial launch on-demand activities, taking into account Federal requirements at launch sites or ranges within the United States. This legislation also prohibits any government agencies from converting certain missiles to a space transportation vehicle configuration.

Source 8: Amendments to the International Traffic in Arms Regulations (ITAR); Control of Commercial Satellites on the United States Munitions List, Final Rule, 64 Federal Register 13679, Department of State, 22 March 1999.

The Department of State published a final rule amending the ITAR by reasserting export control jurisdiction with respect to commercial communications satellites under the US Munitions List. This rule change provided for US Munitions List coverage for all spacecraft, including satellites, all spacecraft technical data, components, accessories, related technical assistance, and all launch support activities. The final rule also requires technical assistance agreements for the launch of satellites and components of

US origin from or by nations or countries other than North Atlantic Treaty Organization (NATO) or major non-NATO allies.

Source 9: Commercial Space Transportation Licensing Regulations, Final Rule, 14 CFR Parts 401, 411, 413, 415 and 417, Department of Transportation, Federal Aviation Administration, 21 June 1999.

In this update to commercial space transportation licensing regulations, the Federal Aviation Administration changes its interpretation of the term “launch” to begin with the arrival of a launch vehicle at a federal launch range or other US launch site. Launch ends when the launch vehicle leaves the ground for purposes of ground operations, and after the licensee’s last exercise of control over the vehicle for purposes of flight. By this rulemaking update, the Federal Aviation Administration will license, as launch, those preparatory activities that may be considered part of a launch. The rulemaking further specifies that a launch vehicle must be present for preparatory activities to constitute part of launch.

This rulemaking also formalizes the Federal Aviation Administration’s practice of issuing two different types of launch licenses: a launch operator license in which a licensee may conduct any launches that fall within the broad parameters described in the license, and a launch-specific license, which allows a licensee to conduct only those launches enumerated in the license. The launch operator is required to obtain a license for the launch of a launch vehicle.

Finally, the Federal Aviation Administration has determined that, for launches that take place from DoD or NASA launch ranges, the agency will make use of information provided by the applicant to the federal launch range and of federal launch range analysis and approvals, meaning that the Federal Aviation Administration will rely

on the processes of the federal launch ranges and not duplicate those safety analyses conducted by a federal launch range.

Source 10: Department of Defense Directive 3100.10 Space Policy, Department of Defense, 9 July 1999.

In this document, the DoD takes responsibility to provide stable and predictable US private sector access to appropriate DoD space-related hardware, facilities and data, consistent with national security requirements. Additionally, the DoD makes clear that the US Government's right to use such hardware, facilities and data on a priority basis shall be preserved in order to meet national security requirements.

Source 11: National Defense Authorization Act for Fiscal Year 2000, Public Law 106-65, 106th Congress, 5 October 1999

A significant portion of this legislation relates to security requirements for foreign launches. This Act requires that, as a condition of the export license for any satellite to be launched in a country subject to section 1514 of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999, the Secretary of State shall require the following: that the technology transfer control plan required be prepared by the DoD and the licensee, and that the plan set forth enhanced security arrangements for the launch of the satellite, both before and during launch operations; that the number of persons providing security for the launch of the satellite shall be sufficient to maintain 24-hour security of the satellite and related launch vehicle and other sensitive technology; and that the licensee agree to reimburse the DoD for all costs associated with the provision of security for the launch of the satellite.

Furthermore, this Act directs that the Secretary of Defense prescribe guidelines providing space launch monitors of the DoD with the responsibility and the ability to report serious security violations, problems, or other issues at an overseas launch site directly to the Headquarters of the responsible DoD component. The Secretary of Defense is also required to ensure that persons assigned as space launch campaign monitors are provided sufficient training and have significant experience with the ITAR, satellite technology, launch vehicle technology, and launch operations technology. The Director of Central Intelligence was tasked with establishing an advisory group on the national security implications of granting licenses involving the overseas launch of commercial satellites of US origin. The Secretary of Defense and the Director of Central Intelligence were further instructed to report on current and potential vulnerabilities of US national security and commercial space assets, including an assessment of how these vulnerabilities could influence US space launch policy and spacecraft design.

This act also requires that the Secretary of Defense report on the factors involved in the three failures of the Titan IV space launch vehicle and the systemic and management reforms that the Secretary implemented to minimize future failures of that vehicle and future launch systems. The Secretary of Defense was also instructed to: initiate a study to assess anticipated military, civil, and commercial space launch requirements and to examine technical shortcomings at the space launch ranges. Finally, the Secretary was tasked with estimating future funding requirements for space launch ranges capable of meeting both national security space launch needs and civil and commercial space launch needs.

Source 12: National Aeronautics and Space Administration Authorization Act of 2000, PL 106-391, 106th Congress, 30 October 2000

In this document, the Administrator of NASA was directed to study the priority of all Space Shuttle upgrades currently under consideration. Additionally, this legislation prohibited the launch of a payload containing material to be used for purposes of obtrusive space advertising.

This document also placed limitations on foreign cooperation, specifically requiring certification in advance of any cooperative agreement with the People's Republic of China for spacecraft, launch systems, or technical information. It required that any such agreement not be detrimental to the US space launch industry and not improve missile or space launch capabilities in the People's Republic of China.

Source 13: National Defense Authorization Act for Fiscal Year 2001, Public Law 106-39, 106th Congress, 30 October 2000

The National Defense Authorization Act for Fiscal Year 2001 established a commission on the future of the United States aerospace industry. This commission was chartered to study the issues associated with the future of the United States aerospace industry in the global economy, particularly in relationship to national security; and assess the future importance of the domestic aerospace industry for the economic and national security of the United States. In particular, the commission was tasked with examining programs for the maintenance of the national space launch infrastructure.

Source 14: Commercial Space Transportation Competitiveness Act of 2000, PL 106-405, 106th Congress, 1 November 2000

This Act directs the Secretary of Transportation to report on the liability risk-sharing regime in the United States for commercial space transportation. Specifically, this report should examine the appropriateness of changing the commercial space transportation liability regime to resemble the approach of the airline liability regime as commercial reusable launch vehicles enter service and demonstrate improved safety and reliability.

Source 15: Memorandum of Agreement Between the Department of Commerce (DoC), the Federal Aviation Administration (FAA), and the Department of the Air Force (USAF) on a Spacelift Range Commercial Requirements Process, USAF, DoC, FAA, 2 February 2002

This agreement establishes a process for the Department of Commerce and the Federal Aviation Administration to collect commercial needs for Air Force spacelift range improvements and modernizations and submit these recommendations to the Air Force. This process will take place annually, allowing for Federal Aviation Administration and the Department of Commerce to make a joint presentation of the commercial requirements to the Air Force each January.

Source 16: Amendments to the United States Munitions List, Final Rule, Foreign Relations, 67 Federal Register 59733, Department of State, 23 September 2002

The National Defense Authorization Act for Fiscal Year 1999 mandated the transfer of satellites and “related items” from the Department of Commerce, Commerce Control List to the Department of State, US Munitions List. This final rule clarifies the licensing authority for certain “space qualified” items, which include items designed,

manufactured and tested to meet the requirements needed for use in the launch or deployment of satellites. In this entry in the Federal Register, the Department of State revised Category XV—Spacecraft Systems and Associated Equipment—of the US Munitions List. This regulation clarifies that certain “space qualified” items are covered by the US Munitions List within the ITAR.

Source 17: National Defense Authorization Act for FY 2004, Public Law 108-136, 108th Congress, 24 November 2003

This Act updates Title 10, United States Code, by adding language regarding US policy and assured access to space for US national security payloads. According to the new language, “It is the policy of the United States for the President to undertake actions appropriate to ensure, to the maximum extent practicable, that the United States has the capabilities necessary to launch and insert United States national security payloads into space whenever such payloads are needed in space.” This includes providing resources and policy guidance for the availability of at least two space launch vehicles (or families of space launch vehicles) capable of delivering into space any payload designated by the Secretary of Defense or the Director of Central Intelligence as a national security payload and a robust space launch infrastructure and industrial base. The Act further instructs the Secretary of Defense to pursue the attainment of the capabilities required in coordination with the Administrator of NASA to the maximum extent practicable.

Source 18: US Space Exploration Policy, National Security Presidential Directive (NSPD)-31, The White House, 14 January 2004

This White House policy directs the Administrator of NASA to return the Space Shuttle to flight as soon as practical following the Columbia Accident Investigation Board. The policy further focuses the use of the Space Shuttle to complete assembly of the International Space Station, and for the Space Shuttle to be retired upon completion of the International Space Station.

Additionally, the policy directs the development of a new Crew Exploration Vehicle to provide human transportation beyond low earth orbit, and to separate the transportation of crew and cargo to the International Space Station, to the maximum extent practical. This policy directs NASA to pursue commercial opportunities for providing transportation to the International Space Station and beyond.

Source 19: A Renewed Spirit of Discovery, The White House, January 2004

This document, promulgated by the George H. W. Bush administration, directed NASA to develop a new Crew Exploration Vehicle to provide crew transportation beyond low Earth orbit. The goal of this vision was to “advance US scientific, security, and economic interests through a robust space exploration program.” The goals and objectives of this document were further defined and implemented by the US Space Exploration Policy.

These goals and objectives included implementing a sustained and affordable human and robotic program to explore the solar system and beyond; extending human presence across the solar system and returning a human to the Moon by the year 2020.

Source 20: National Defense Authorization Act for FY 2005, Public Law 108–375, 108th Congress, 28 October 2004

This Act directed the Secretary of Defense to enter into a contract with a federally funded research and development center to establish a panel on future national-security space-launch requirements for the United States and the means for meeting those requirements. In particular, the panel was directed to review launch technologies, to include reusable and expendable launch vehicles and launch infrastructure, to include ranges and facilities.

Source 21: An Act to Extend the Liability Indemnification Regime for the Commercial Space Transportation Industry, Public Law 108–428, 108th Congress, 30 November 2004

This legislation extends the liability indemnification regime for the commercial space transportation industry from December 31, 2004 to December 31, 2009 and directs the Secretary of Transportation to enter into an arrangement with a nonprofit entity to conduct an independent comprehensive study of the liability risk sharing regime in the United States for commercial space transportation and evaluate the direct and indirect influence that ending this regime would have on the competitiveness of the United States commercial space launch industry and assured access to space. This study should include an examination of the liability risk sharing regimes in other nations with commercial launch capability.

Source 22: Commercial Space Launch Amendments Act of 2004, Public Law 108-492, 108th Congress, 23 December 2004

In this document, the Secretary of Transportation is provided the authority to promulgate regulations to encourage, facilitate, and promote the continuous improvement of the

safety of launch vehicles designed to carry humans. This act provides for additional license requirements for a launch vehicle carrying a human, for compensation or for hire, to protect the health and safety of crew or space flight participants. This act also requires crew training and requires that launch participants be informed that the US Government has not certified the launch vehicle as safe for carrying crew or space flight participants. Space flight participants are required to be informed of the risks of the launch and reentry, including the safety record of the launch or reentry vehicle type.

Per this legislation, the Secretary of Transportation is allowed to issue regulations governing the design or operation of a launch vehicle to protect the health and safety of crew and space flight participants. This Act also allows for the application of experimental permits and requirements specific to suborbital rockets.

The Secretary of Transportation, in consultation with the Administrator of NASA, is directed to enter into an arrangement with a nonprofit entity for a report analyzing safety issues related to launching humans into space including: the standards of safety and concepts of operation that should guide the regulation of human space flight and whether the standard of safety should vary by class or type of vehicle, whether expendable and reusable launch and reentry vehicles should be regulated differently from each other, and whether either of those vehicles should be regulated differently when carrying humans.

Source 23: US Space Transportation Policy, NSPD-40, Fact Sheet, The White House, 6 January 2005

In this document, the Secretary of Defense and the Administrator of NASA were assigned responsibility for assuring access to space. The document assigned the

Secretary of Defense responsibility to maintain the capability to develop, evolve, operate and purchase services for those space transportation systems, infrastructure, and support activities necessary to meet national security requirements, and assigned the Administrator of NASA to conduct these activities to meet civil requirements, including the capacity to conduct human and robotic space flight. However, NASA was directed to engage in development activities for these requirements only if the requirements could not be met by capabilities being used by the national security or commercial sectors.

This document directs that the capabilities developed under the EELV program be the foundation for access to space for intermediate and larger payloads for national security, homeland security and civil purposes. This policy further directs that new US commercial space transportation capabilities that demonstrate the ability to reliably launch intermediate or larger payloads be allowed to compete for US government missions. Additionally, the Secretary of Defense is directed to fund two EELV programs until it can be shown that one capability reliably provides assured access to space. It also directs an evaluation recommending a shift in funding responsibility to reflect any change to the balance between national security missions and civil missions using the EELV. Derivatives of the EELV will be examined to meet exploration requirements, and a heavy-lift launch vehicle based on Shuttle-derived systems will also be considered.

The Secretary of Defense, in coordination with the Director of Central Intelligence, is tasked with the development of requirements and concepts of operations for launch vehicles, infrastructure and spacecraft to provide operationally responsive

access to space and support national security requirements. The Secretary of Defense, along with the Director of Central Intelligence, is further responsible for identifying the key modifications to space launch or ground operations that will be required to implement an operationally responsive space launch capability.

The Secretary of Defense and the Administrator of NASA are tasked with operation of the federal launch bases and ranges in a manner so as to accommodate users from all sectors. The Department of Transportation shall license and provide safety oversight responsibility for commercial launch and re-entry operations. US government agencies are tasked with providing a regulatory environment for licensing commercial space launch and reentry activities, and are responsible for providing stable and predictable access to the Federal space launch bases and ranges.

Source 24: National Aeronautics and Space Administration Authorization Act of 2005, Public Law 109-155, 109th Congress, 30 December 2005

This 2005 Authorization Act requires that NASA work closely with the private sector to encourage the work of entrepreneurs who are seeking to develop new means to launch satellites, crew, or cargo and to contract with the private sector for crew and cargo services, including to the International Space Station. Additionally, the Act directs the Agency to use commercially available products and services to support all agency activities. Additionally, NASA is tasked to encourage the commercial use and development of space to the greatest extent practicable and to involve other nations to the extent appropriate.

Despite the desire to involve other nations, NASA is directed not to launch a payload on a foreign launch vehicle except in accordance with the Space Transportation

Policy announced by the President on December 21, 2004. However, the policy does not apply to any payload for which development has begun prior to the date of enactment of this Act.

According to the Act, “It is the policy of the United States to possess the capability for human access to space on a continuous basis.” This legislation directs the Administrator of NASA to report to the Committee on Science of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate on the progress being made toward developing the Crew Exploration Vehicle and the Crew Launch Vehicle and the estimated time before they will demonstrate crewed, orbital spaceflight. The Administrator is further directed to use the personnel, capabilities, assets, and infrastructure of the Space Shuttle program in developing the Crew Exploration Vehicle, Crew Launch Vehicle, and a heavy-lift launch vehicle.

Source 25: National Defense Authorization Act for FY 2006, Public Law 109–163, 109th Congress, 6 January 2006

This Act required a report on cooperation between the DoD and NASA on research, development, test and evaluation activities. Congress recommended that the report include: aeronautics research; facilities, personnel, and support infrastructure; propulsion and power technologies; and space access and operations, including responsive launch and small satellite development.

Source 26: Miscellaneous Changes to Commercial Space Transportation Regulations, 13 Federal Register 51968, Department of Transportation, Federal Aviation Administration, 31 August 2006.

This update to 14 CFR Parts 404, 413 and 420 provides a method for a launch site operator applicant to estimate the expected casualty (Ec) for a representative launch vehicle. As part of the calculation, a casualty area lookup table is used. Recent analysis has shown that expected casualty values generated by the appendix were inaccurate. This update replaced the lookup table with corrected casualty areas, which in turn will produce more reasonable Ec values. According to this document, the new values will be, on average, an order of magnitude lower than their original counterparts.

Source 27: US National Space Policy, NSPD-49, Fact Sheet, The White House, 31 August, 2006

In this presidential directive, the DoD is tasked to provide access to space for national security purposes. This policy directs presidential approval for the launch of nuclear power sources for government and non-government spacecraft, and requires the Secretary of Energy to conduct a safety analysis to evaluate the risks associated with launch and in-space operations of nuclear power sources. For the launch and use of non-government spacecraft using nuclear power sources, the policy directs that the Secretary of Transportation be the licensing authority for US commercial launch activities, and that the Nuclear Regulatory Committee license all activities prior to launch that involve the utilization of facilities and materials not owned by the Department of Energy.

Source 28: National Defense Authorization Act for Fiscal Year 2007, Public Law 109–364, 109th Congress, 17 October 2006

This Act established US policy regarding operationally responsive space and established the Operationally Responsive Space Program Office within the DoD. According to the document, “It is the policy of the United States to demonstrate, acquire, and deploy an effective capability for operationally responsive space to support military users and operations from space.” This consists of: responsive satellite payloads and busses built to common technical standards; low-cost space launch vehicles and supporting range operations that facilitate the timely launch and on-orbit operations of satellites; responsive command and control capabilities; and concepts of operations, tactics, techniques, and procedures that permit the use of responsive space assets for combat and military operations other than war.

Source 29: National Defense Authorization Act for Fiscal Year 2008, Public Law 110–181, 110th Congress, 28 January 2008

This Act requires the Secretary of Defense to submit a report on the status, capability, viability, and capacity of the solid rocket motor industrial base in the United States. This report should include an assessment of the ability to support projected future requirements for vehicles with solid rocket motors to support space launch, missile defense, or any range of ballistic missiles determined to be necessary to meet defense needs or other requirements of the United States Government.

Source 30: National Aeronautics and Space Administration Authorization Act of 2008, Public Law 110-422, 110th Congress, 15 October 2008

In this Act, Congress directs NASA to take all prudent steps necessary to bring the Orion Crew Exploration Vehicle and Ares 1 Crew Launch Vehicle to full operational capability as soon as possible and to ensure the effective development of a United States heavy lift launch capability for missions beyond low Earth orbit. This document directs funds for the Ares 1 Crew Launch Vehicle and other elements of the Constellation Program and to accelerate the initial operating capability of the Orion Crew Exploration Vehicle and the Ares 1 Crew Launch Vehicle.

Additionally, the Administrator of NASA is directed to arrange with the National Academies to conduct a review of suborbital missions, including programs, platforms, and infrastructure as well as planned launch facilities for suborbital missions.

This legislation directs NASA to ensuring that the Nation's future air transportation system can handle up to three times the current travel demand and incorporate new vehicle types with no degradation in safety or adverse environmental influence on local communities.

In order to support operations and utilization of the International Space Station beyond fiscal year 2015, the Administrator is also directed to submit a plan addressing annual up-mass and down-mass requirements and including potential vehicles that will deliver such up-mass and down-mass after the retirement of the Space Shuttle through the year 2020. Additionally, the Administrator is required to provide a report outlining options, impacts, and associated costs of ensuring the safe and effective operation of the Space Shuttle at the minimum rate necessary to support International Space Station operations and re-supply. This report should include cost impacts of options for cost-

sharing with the Constellation program and including the influence of those cost-sharing options on the Constellation Program.

In order to stimulate commercial use of space, help maximize the utility and productivity of the International Space Station, and enable a commercial means of providing crew transfer and crew rescue services for the International Space Station, this legislation further directs the agency to enter into a funded, competitively awarded Space Act Agreement with two or more commercial entities for crewed vehicle demonstration programs. Furthermore, the Agency is required to submit a report on the capacity of the United States industrial base for development and production of engines to meet United States Government and commercial requirements for space launch vehicles.

Source 31: Consolidated Appropriations Act of 2010, Public Law 111-117, 111th Congress, 6 January 2009

This Act authorized appropriations for NASA. The language specified that none of the funds appropriated shall be available for the termination or elimination of any program, project or activity of the architecture for the Constellation program. It also directed that the funds not be available to create or initiate a new program, project or activity, unless such program termination, elimination, creation, or initiation is provided in subsequent appropriations Acts.

Additionally, funds were designated for Space Shuttle operations, production, research, development, and support, and for International Space Station operations, production, research, development, and support.

Source 32: Amendment to the International Traffic in Arms Regulations, Final Rule, 74 Federal Register 38343, Department of State, 3 August 2009

In this Final Rule, the Department of State provides updates to the Arms Export Control Act related to launch services provided by a foreign entity. It states that, “unless an emergency exists which requires the proposed export in the national security interests of the United States, approval may not be granted for any transaction until at least 15 calendar days have elapsed after receipt by the Congress of the certification required by 22 USC 2776(c)(1) involving the North Atlantic Treaty Organization, any member country of the Organization, or Australia, Japan, New Zealand, or South Korea or at least 30 calendar days have elapsed for any other country; in the case of a license for an export of a commercial communications satellite for launch from, and by nationals of, the Russian Federation, Ukraine, or Kazakhstan, until at least 15 calendar days after the Congress receives such certification.”

Source 33: The National Space Policy of the United States of America, The White House, 28 June 2010

This document provides overarching guidance to government agencies that operate in space and is the newest document included in this study. The document states that “United States Government payloads shall be launched on vehicles manufactured in the United States,” and also allows for exemptions to this. This document also directs responsible departments and agencies to invest in the modernization of their space launch infrastructure, and develop launch systems and technologies necessary to assure and sustain access to space, with cooperation from US industry.

This document reiterates orbital debris mitigation standards in the procurement and operation of spacecraft and launch services, provides for Presidential approval for

the launch of spacecraft using nuclear power systems, and directs the Secretary of Energy to assist the Secretary of Transportation in the licensing of spacecraft with nuclear power systems.

Finally, the Administrator of NASA is directed to conduct research and development in support of next-generation launch systems, including new domestic rocket engine technologies; and the Secretary of Defense is directed to provide reliable, affordable and timely space access for national security purposes.

The chart on the following page provides a summary of the policy interactions identified in these documents. Only those interactions specific to space launch vehicles, space launch facilities or the Ares 1 launch vehicle or related elements of the Constellation Program have been included in the data presented in this graphical summary.

Interviews

In addition to examining existing policy documents, interviews with subject matter experts from the major organizational elements represented in this study were conducted. The purpose of these interviews was to understand, from the practitioners' experience and perspective, which policies had the most significant impact on the programs with which they worked. Information derived from the interviews will be plotted in the 3DPDS and compared with the data gathered from the policy documents as part of testing the method.

Study participants were recruited using known points of contact within each of the major sectors of the space launch policy SoS (national security, civil, and commercial), as well as other organizational elements within the SoS. Some of the

initial contacts participated in the interviews; others provided contacts within their organization that they felt would provide more specific policy-related information for the study. Fifteen people were initially contacted for the study; there was one non-response. Fourteen interviews were conducted via telephone, in person, and electronically. All of the data from the interviews was aggregated for use in the next chapter in such a manner that no identifying data could be abstracted, in order to protect study participants.

Interviewees selected for this study were senior level officials within their respective organizations. They were offered complete anonymity for this study. This was necessary to facilitate participation, as interview subjects were sensitive to their relationships with other organizations. As such, no titles, agency names or other information that could be used to identify participants will be used when attributing observations to study participants. Several participants also questioned the funding for this study, and agreed to participate only after they were assured that no funding had been received for this study. Interviews were approximately 30 minutes in length, were uncompensated, and were conducted under conditions of anonymity.

The fourteen study participants represented agencies and organizations active in the national security, civil, and commercial sectors of the US space launch policy SoS. Participants represented the Intelligence Community, the DoD, the DoT, NASA, several commercial entities, and other government entities. The range of experience in study participants was 32 years, with the minimum length of experience at ten years, and the maximum at 42 years in the space industry. The mean (average) length experience in the space industry was 30.5 years and the median length of experience was 33 years.

As shown in *Figure 5.1*, three participants had less than twenty-five years of experience in the space industry; however, two of these participants had at least ten years of additional experience within their agency or organization that was not space specific.

Participants were asked to identify the sector of the industry with which they were most familiar. Five of the fourteen had experience in at least two sectors of the industry.



Figure 5.1: Interview Participants' Years of Experience

During the interviews, participants were asked to identify and describe policy decisions that influenced their organizations. In their narratives, some participants were able to respond with specific documents or references to specific documents; others referred to a specific decision, sometimes accompanied by a year or event, which allowed that policy decision to be attributed to a specific document. These descriptions were correlated with the related passage from the policy documents contained in the policy document data base, and a separate data base was constructed using the policy passages and interactions that correlated with the interviewee responses. During the course of the interviews, none of the participants mentioned a policy document that was not already included in the data base for the timeframe of this study, though several mentioned policy decisions outside of the fifteen year timeframe examined in the applications in this dissertation. Interviewee responses were found to correlate with 20 specific passages from the policy document database containing interactions relevant to space launch vehicles or space launch facilities. These 20 passages came from 12 different policy documents.

The most frequently mentioned policies from those implemented in the past fifteen years dealt with changes in acquisition policies that influenced the EELV. The second most frequently mentioned topic from the past fifteen years was the International Traffic in Arms Regulations (ITAR).

Participants also described the impact that the Ares 1 cancellation could have on their organization. While several participants expected little to no impact on their organization, others expected significant impacts, and claimed that they were already being felt. Some viewed the cancellation optimistically, as it opened the door for further competition for space launch vehicles. Others noted that the cancellation of the program would free up money for other projects.

In the next chapter, the interview data, correlated with passages from the policy document data base, will be used to test the utility of the 3DPDS.

Chapter 6: The Analysis

Chapter 5 described the collection of data related to the three policy areas to which the 3DPDS was applied in this dissertation: space launch vehicles, space launch facilities, and the cancellation of the Ares 1 launch vehicle. This chapter is focused on the application and testing of the 3DPDS.

For the first two applications, the 3DPDS will be used to visually demonstrate the frequency and concentrations of policy interactions among the organizational elements within the US space launch policy SoS and to organize this data in a manner that facilitates decision-makers' and academia's comprehension of this complex policy SoS . For the third application, the 3DPDS will be used to systematically examine the potential impacts of a current policy decision. In order to test, or evaluate, the 3DPDS, the data collected through a content analysis of policy documents will be compared and contrasted with data collected through expert interviews, as described in Chapter 3.

As described in Part I, the US space launch policy SoS was chosen for these applications because it possess the two characteristics of a policy SoS, as defined in Part I of this dissertation: (1) there is an element of independence between the inter-related policy systems, and (2) emergent properties, or resultant outcomes, of the policy SoS appear that are not apparent or predicable from the properties of the constituent policy systems.

For this dissertation, the overarching SoS primarily exists within the Federal government and the national-level policies of those Federal agencies and organizations. Additionally, two groups of non-systems actors, the commercial space industry and foreign entities, were considered in the analysis. As mentioned in Chapter 1, although

these two groups of non-system actors are not part of the formal government policy structure, they are frequently influenced by the US space launch policy SoS.

Fine-Tuning the Analysis

Initially, six policy systems and seven organizational elements were identified as part of

the US space launch policy SoS, as depicted in *Figure 6.1*. The policy systems include: foreign policy, defense policy, national security policy, transportation policy, trade policy systems, and other

policy systems that do not fit into any of these

categories. Documents were identified as part of a specific policy system based on their subject matter. The organizational elements include foreign entities, national security space, the commercial space industry, civil space, the White House, Congress, and other agencies and organizations.

A preliminary plot of the space launch vehicle dataset in the 3DPDS, shown in *Figure 6.2*, was completed using the techniques described in Chapter 3. The accompanying table that follows lists the interactions represented by each block in the figure.

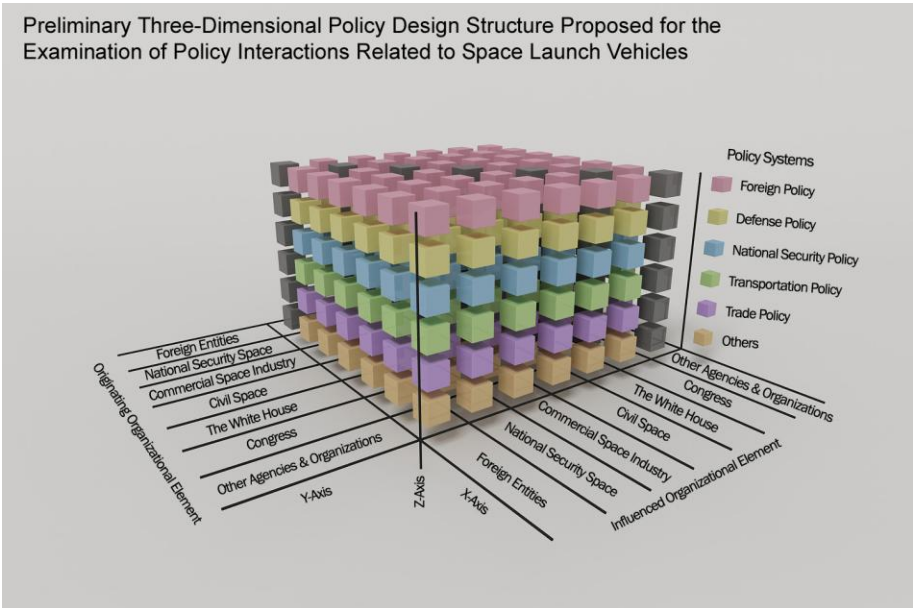
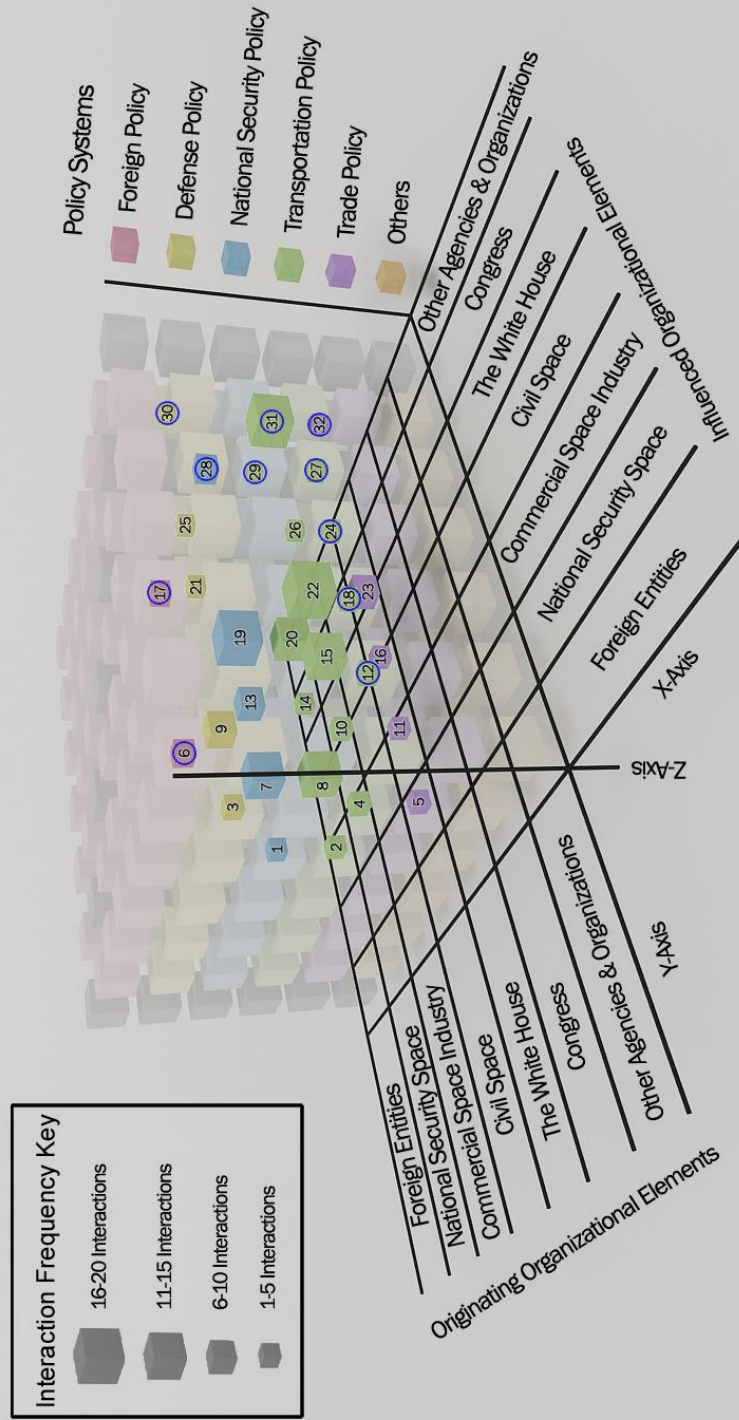


Figure 6.1: Preliminary Three-Dimensional Policy Design Structure Proposed for the Examination of Policy Interactions Related to Space Launch Vehicles
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

Preliminary Analysis of Policy Interactions Related to Space Launch Vehicles Using the Three Dimensional Policy Design Structure



Those blocks circled in blue represent interaction combinations that include the Department of Transportation. Six of the ten policy interactions represented in blocks 6, 12, 17, 18, 24 and 27 were initiated by the Department of Transportation. 28 of the 38 policy interactions represented in blocks 28-32 influenced the Department of Transportation. As a result of the high number of interactions pertaining to "Other Agencies & Organizations" that were relevant to the Department of Transportation, that agency was separated from this grouping, and will be considered as its own organization element.

Figure 6.2: Preliminary Analysis of Policy Interactions Related to Space Launch Vehicles Using the Three-Dimensional Policy Design Structure
 (Illustration by Trevor Mower and Timothy Thielke; used with permission)

Data for Figure 6.2

Block Lable for 3DPDS	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Policy Interactions
1	The White House	Foreign Entities	National Security	3
2	The White House	Foreign Entities	Transportation	3
3	Congress	Foreign Entities	Defense	5
4	Congress	Foreign Entities	Transportation	3
5	Congress	Foreign Entities	Trade	1
6	Other Agencies & Organizations	Foreign Entities	Foreign	2
7	The White House	National Security Space	National Security	12
8	The White House	National Security Space	Transportation	14
9	Congress	National Security Space	Defense	13
10	Congress	National Security Space	Transportation	2
11	Congress	National Security Space	Trade	4
12	Other Agencies & Organizations	National Security Space	Transportation	1
13	The White House	Commercial Space Industry	National Security	8
14	The White House	Commercial Space Industry	Transportation	1
15	Congress	Commercial Space Industry	Transportation	12
16	Congress	Commercial Space Industry	Trade	4
17	Other Agencies & Organizations	Commercial Space Industry	Foreign	2
18	Other Agencies & Organizations	Commercial Space Industry	Transportation	3
19	The White House	Civil Space	National Security	16
20	The White House	Civil Space	Transportation	12
21	Congress	Civil Space	Defense	4
22	Congress	Civil Space	Transportation	17
23	Congress	Civil Space	Trade	6
24	Other Agencies & Organizations	Civil Space	Transportation	1
25	Congress	The White Houes	Defense	2
26	Congress	The White Houes	Transportation	3
27	Other Agencies & Organizations	The White Houes	Transportation	1
28	The White House	Other Agencies & Organizations	National Security	9
29	The White House	Other Agencies & Organizations	Transportation	5
30	Congress	Other Agencies & Organizations	Defense	2
31	Congress	Other Agencies & Organizations	Transportation	17
32	Congress	Other Agencies & Organizations	Trade	5

Given that several interactions were identified that either influenced or were influenced by the organizational element labeled “Other Agencies and Organizations” in the original 3DPDS, that particular organizational element was further scrutinized, and further clustering of the resultant data was not done.

This review showed that 10 of the e11 interactions that were initiated by “Other Agencies and Organizations” were actually initiated by the Department of Transportation; the other one was initiated by the Department of State. Additionally, 22

of the 31 interactions that included “Other Agencies and Organizations” influenced the Department of Transportation, another four influenced the Department of Transportation and at least one other agency or organization, and only five were found not to influence the Department of Transportation. Thus, the decision was made to separate the Department of Transportation from the “Other Agencies and Organizations,” and add the Department of Transportation as its own organizational element in the 3DPDS.

This adjustment was relatively easy to make; another element was added to both the X and Y axes of the 3DPDS to allow for the identification of policy interactions specific to the Department of Transportation. The Z axis remained unchanged, as shown in *Figure 6.3*. This type of adjustment is not necessary, but it can be helpful

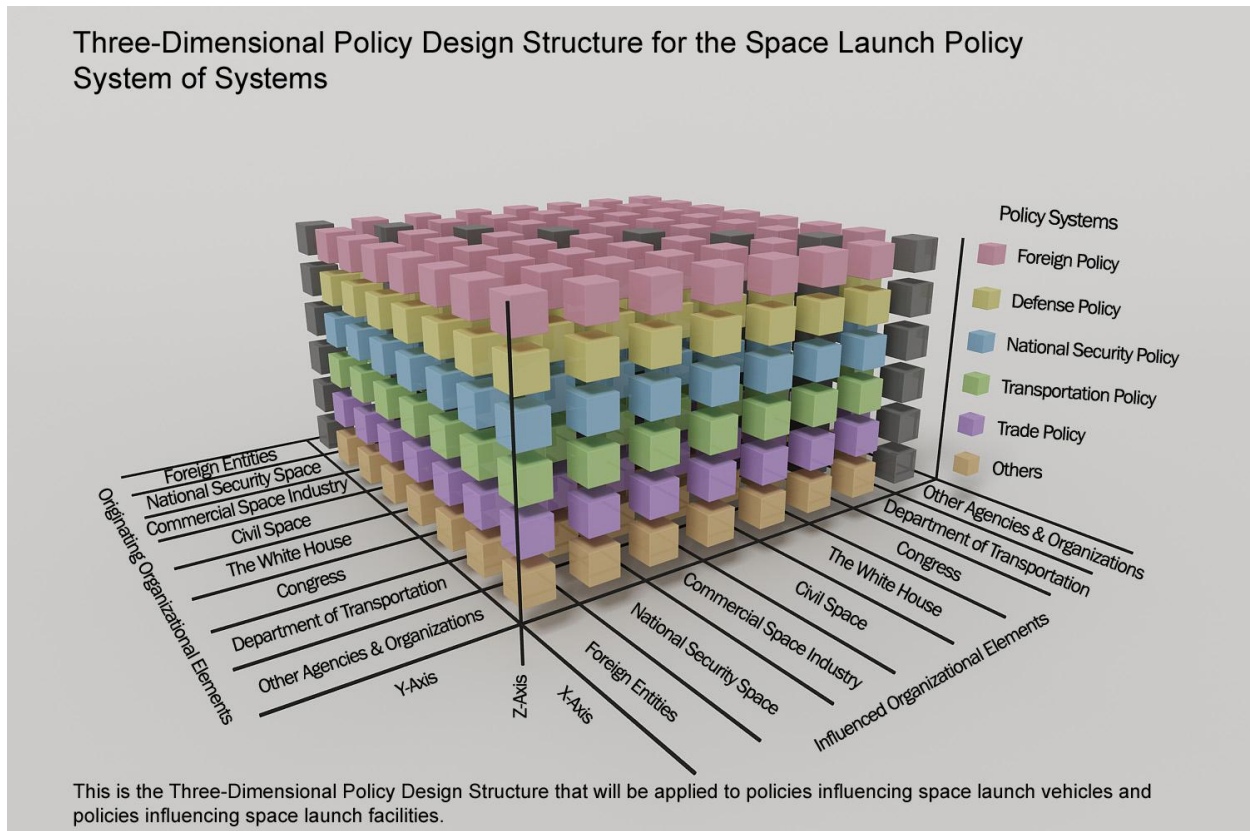


Figure 6.3: Three Dimensional Policy Design Structure for the Space Launch Policy System of Systems

(Illustration by Trevor Mower and Timothy Thielke; used with permission)

when seeking to identify the specific organizational elements within the SoS. In this case, the adjustment was desired, because the Department of Transportation was disproportionately represented among the “Other Agencies and Organizations” in the preliminary plot using the 3DPDS. Identifying the Department of Transportation as its own organizational element in the 3DPDS allowed for a much clearer and more precise view of the holistic policy SoS that influenced space launch vehicles. It is important to note that, although one of the organizational elements was expanded, none were excluded. While this changed the presentation of the data slightly, the data itself was not altered. The analysis was not adjusted to “fit” the data; rather, it was expanded to allow for a more complete analysis.

Fine-tuning the 3DPDS in this manner demonstrates its flexibility. Should the “Other Agencies and Organizations” element again become too cluttered or congested, or require greater specificity, individual organizational elements could be further identified and broken out from this category. Again, while the visual depiction of the original elements may change slightly, the original data did not change, nor was it altered or discarded.

One more adjustment was made across the database prior to the final analysis for all three applications. The policy interaction combinations of organizational elements and policy systems across the entire database were assigned numbers that were used to identify each combination in the entire database. These identification numbers were used to label the corresponding blocks in the 3DPDS. Labeling the blocks made it easier to identify specific combinations of organizational elements and policy systems in the three-dimensional drawings presented in a two-dimensional format. Ensuring that

the combinations contained the same nomenclature in the database made it easier to compare one dataset to another and one application to another.

For example, an interaction initiated by the White House that influenced civil space in the transportation policy system would be represented in a block with the same label (or nomenclature) in each of the three applications included in this dissertation. In some cases, organizational element and policy system combinations contained no interactions in one application, but they did contain at least one interaction in another application. In each application, only those combinations in which one or more interaction took place in the dataset relevant to that application were plotted in the 3DPDS. As a result of this phenomenon, there appear to be “missing numbers” in the 3DPDS depictions, because the blocks are not numbered sequentially. The labels used for each organizational element and policy system combination will be consistent from this point forward.

Application One: Space Launch Vehicles

The first application uses the 3DPDS to examine the interactions that have occurred within the US space launch policy SoS relative to space launch vehicles. To begin to test the 3DPDS and evaluate its utility, the output of the policy document analysis will be compared with the output of data derived from the interviews with experts. Policy interactions that were included in the dataset for this application were identified using the following criteria: the policy interactions took place in a formal policy document; the interactions were between two or more identifiable government agencies; and the identified interactions were related to space launch vehicles.

For each of these interactions, the originating organizational element of the policy document was identified. The organizational elements that influenced other organizational elements in a specific policy interaction were identified, as were those that were influenced by that interaction. The policy system in which the interaction took place was also noted. The dataset for the first application consists of 193 policy interactions that were identified in 113 passages from 33 policy documents.

Each interaction, between a combination of two organizational elements and within a specific policy system, was plotted in the 3DPDS. The number of interactions between each organizational element combination in each policy system was counted, and the 3DPDS was redrawn. The relative frequency of the interaction combinations contained in each block was represented by the size of the block used to represent each combination, as shown in *Figure 6.4*. Each of the blocks in the figure was numbered, and each number referred to a specific organizational element and a policy system combination within the US space launch policy SoS.

Clustering of the Policy Document Data Related to Space Launch Vehicles

Clustering is a method commonly used in a number of fields of study to group together similar data points to produce a high-level perspective of what is happening in a specific dataset (Berson, Smith, and Thearling, 2000). Clustering can also be used to simplify the identification of outliers, or data points that stand out from the other data points (Berson, Smith, and Thearling, 2000). In this application, the clusters of similar data points will be considered, as will the outliers.

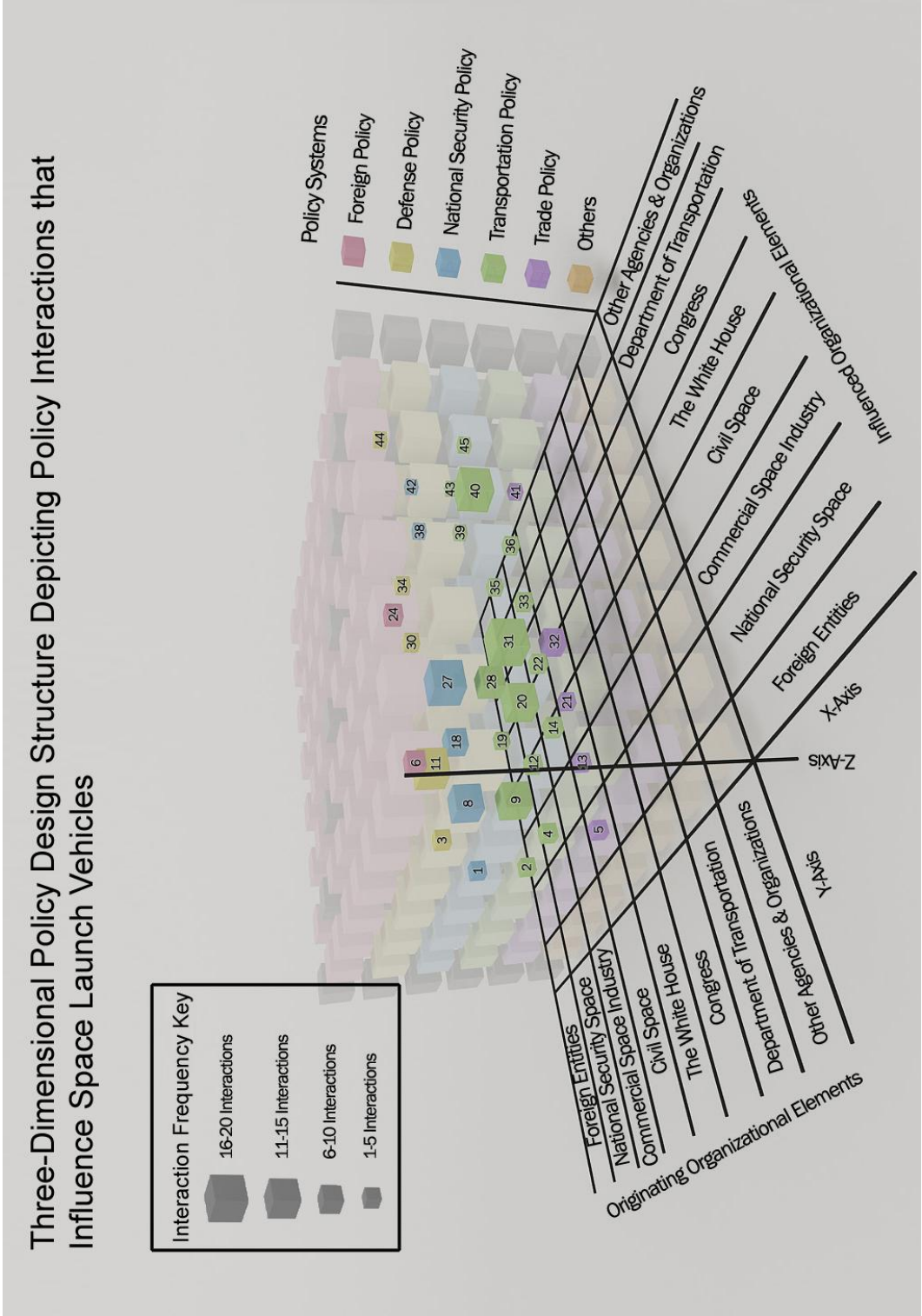


Figure 6.4: Three-Dimensional Policy Design Structure Depicting Policy Interactions that Influence Space Launch Vehicles (Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

Data for Figure 6.4

3DPDS Block Label	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Interactions
1	The White House	Foreign Entities	National Security	3
2	The White House	Foreign Entities	Transportation	3
3	Congress	Foreign Entities	Defense	5
4	Congress	Foreign Entities	Transportation	3
5	Congress	Foreign Entities	Trade	1
6	Other Agencies & Organizations	Foreign Entities	Foreign	2
7	Other Agencies & Organizations	Foreign Entities	Trade	0
8	The White House	National Security Space	National Security	12
9	The White House	National Security Space	Transportation	14
10	The White House	National Security Space	Trade	0
11	Congress	National Security Space	Defense	13
12	Congress	National Security Space	Transportation	2
13	Congress	National Security Space	Trade	4
14	Department of Transportation	National Security Space	Transportation	1
15	Other Agencies & Organizations	National Security Space	Trade	0
16	National Security Space	Commercial Space Industry	Defense	0
17	National Security Space	Commercial Space Industry	Other	0
18	The White House	Commercial Space Industry	National Security	8
19	The White House	Commercial Space Industry	Transportation	1
20	Congress	Commercial Space Industry	Transportation	12
21	Congress	Commercial Space Industry	Trade	4
22	Department of Transportation	Commercial Space Industry	Transportation	3
23	Department of Transportation	Commercial Space Industry	Other	0
24	Other Agencies & Organizations	Commercial Space Industry	Foreign	2
25	Other Agencies & Organizations	Commercial Space Industry	Trade	0
26	Other Agencies & Organizations	Commercial Space Industry	Other	0
27	The White House	Civil Space	National Security	16
28	The White House	Civil Space	Transportation	12
29	The White House	Civil Space	Trade	0
30	Congress	Civil Space	Defense	4
31	Congress	Civil Space	Transportation	17
32	Congress	Civil Space	Trade	6
33	Department of Transportation	Civil Space	Transportation	1
34	Congress	The White House	Defense	2
35	Congress	The White House	Transportation	3
36	Department of Transportation	The White House	Transportation	1
37	Other Agencies & Organizations	Congress	Trade	0
38	The White House	Department of Transportation	National Security	4
39	The White House	Department of Transportation	Transportation	3
40	Congress	Department of Transportation	Transportation	16
41	Congress	Department of Transportation	Trade	5
42	The White House	Other Agencies & Organizations	National Security	5
43	The White House	Other Agencies & Organizations	Transportation	2
44	Congress	Other Agencies & Organizations	Defense	2
45	Congress	Other Agencies & Organizations	Transportation	1

Clustering of the data presented in *Figure 6.4* will allow for a better visual representation of the policy interactions within the US space launch policy SoS that pertain to launch vehicles. This allows the researcher to view the data in another different manner, making it easier to identify areas of high concentrations of policy interactions as well as policy outliers. Clustering, illustrated in *Figure 6.5*, was accomplished through the process described in Chapter 3. The data was rearranged along all three axes. This re-arrangement allows researchers to focus on the specific interactions within each policy SoS, concentrating the most frequent policy interactions in the front, right corner of the 3DPDS.

This depiction shows a number of expected results given the narrative of the various policy decisions discussed in Chapter 5. For instance, this perspective provides a visual representation of the frequent influential actions that Congress and the White House impart on the other organizational elements within the US space launch policy SoS. Transportation policy, as it relates to space launch policy, is influenced by the Department of Transportation, the White House, and Congress. National Security policies related to space launch policy were issued primarily by the White House.

Arrangement of the data in this manner allowed for the easy identification of the policy outliers, shown as blocks 24 and 6 in *Figure 6.5*. In this case, the policy outliers identified using these techniques took place in the foreign policy system. In these blocks, the commercial space industry and foreign entities were influenced by “Other Agencies and Organizations.” These interactions may not be readily apparent and could potentially be missed in other forms of analysis. *Figure 6.6* through *Figure 6.9* depict the interactions in each policy system.

Clustering Technique Applied to Interactions within the Space Launch Policy System of Systems that Influence Space Launch Vehicles

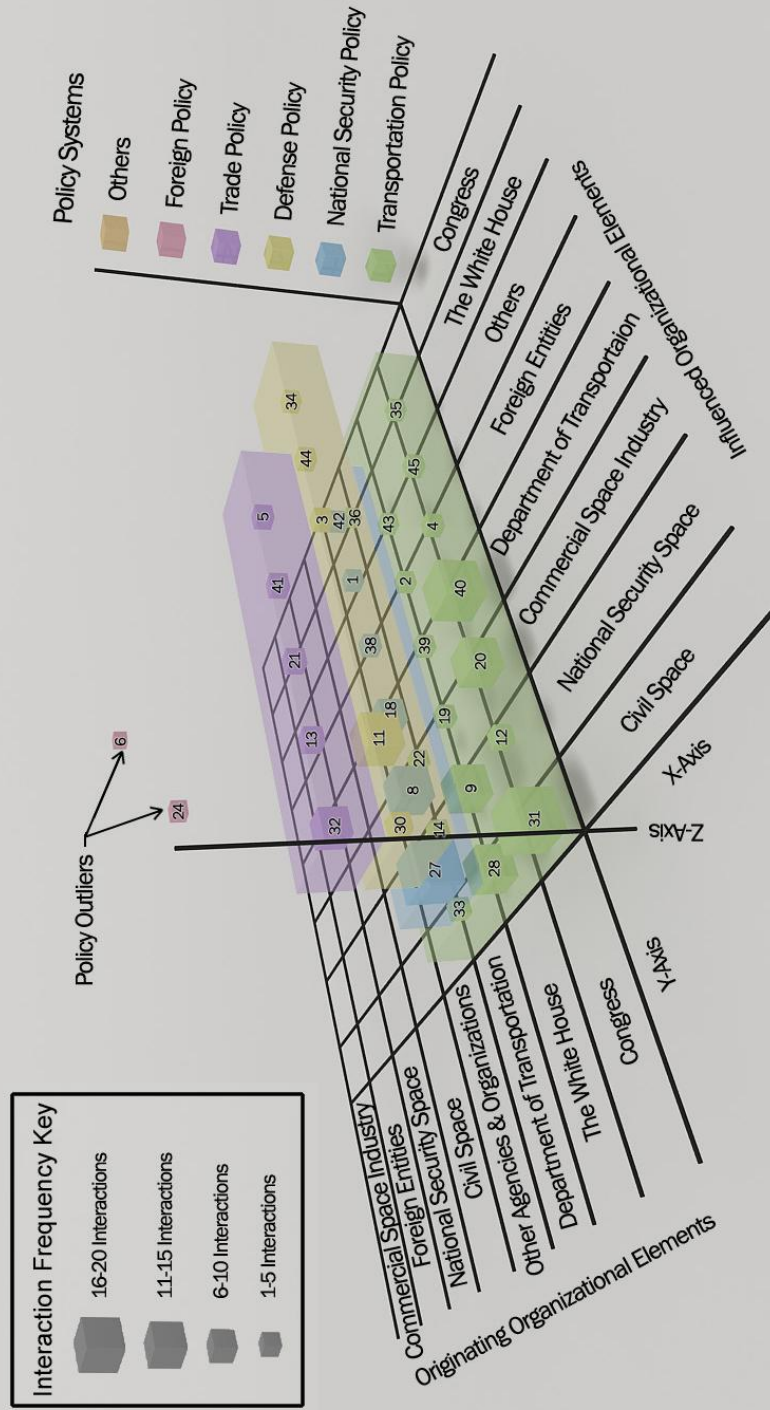


Figure 6.5: Clustering Technique Applied to Interactions within the Space Launch Policy System of Systems that Influence Space Launch Vehicles
 (Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

Data for Figure 6.5

3DPDS Block Label	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Vehicle Interactions
1	The White House	Foreign Entities	National Security	3
2	The White House	Foreign Entities	Transportation	3
3	Congress	Foreign Entities	Defense	5
4	Congress	Foreign Entities	Transportation	3
5	Congress	Foreign Entities	Trade	1
6	Other Agencies & Organizations	Foreign Entities	Foreign	2
7	Other Agencies & Organizations	Foreign Entities	Trade	0
8	The White House	National Security Space	National Security	12
9	The White House	National Security Space	Transportation	14
10	The White House	National Security Space	Trade	0
11	Congress	National Security Space	Defense	13
12	Congress	National Security Space	Transportation	2
13	Congress	National Security Space	Trade	4
14	Department of Transportation	National Security Space	Transportation	1
15	Other Agencies & Organizations	National Security Space	Trade	0
16	National Security Space	Commercial Space Industry	Defense	0
17	National Security Space	Commercial Space Industry	Other	0
18	The White House	Commercial Space Industry	National Security	8
19	The White House	Commercial Space Industry	Transportation	1
20	Congress	Commercial Space Industry	Transportation	12
21	Congress	Commercial Space Industry	Trade	4
22	Department of Transportation	Commercial Space Industry	Transportation	3
23	Department of Transportation	Commercial Space Industry	Other	0
24	Other Agencies & Organizations	Commercial Space Industry	Foreign	2
25	Other Agencies & Organizations	Commercial Space Industry	Trade	0
26	Other Agencies & Organizations	Commercial Space Industry	Other	0
27	The White House	Civil Space	National Security	16
28	The White House	Civil Space	Transportation	12
29	The White House	Civil Space	Trade	0
30	Congress	Civil Space	Defense	4
31	Congress	Civil Space	Transportation	17
32	Congress	Civil Space	Trade	6
33	Department of Transportation	Civil Space	Transportation	1
34	Congress	The White House	Defense	2
35	Congress	The White House	Transportation	3
36	Department of Transportation	The White House	Transportation	1
37	Other Agencies & Organizations	Congress	Trade	0
38	The White House	Department of Transportation	National Security	4
39	The White House	Department of Transportation	Transportation	3
40	Congress	Department of Transportation	Transportation	16
41	Congress	Department of Transportation	Trade	5
42	The White House	Other Agencies & Organizations	National Security	5
43	The White House	Other Agencies & Organizations	Transportation	2
44	Congress	Other Agencies & Organizations	Defense	2
45	Congress	Other Agencies & Organizations	Transportation	1

A New Method for the Examination of Policy Systems of Systems

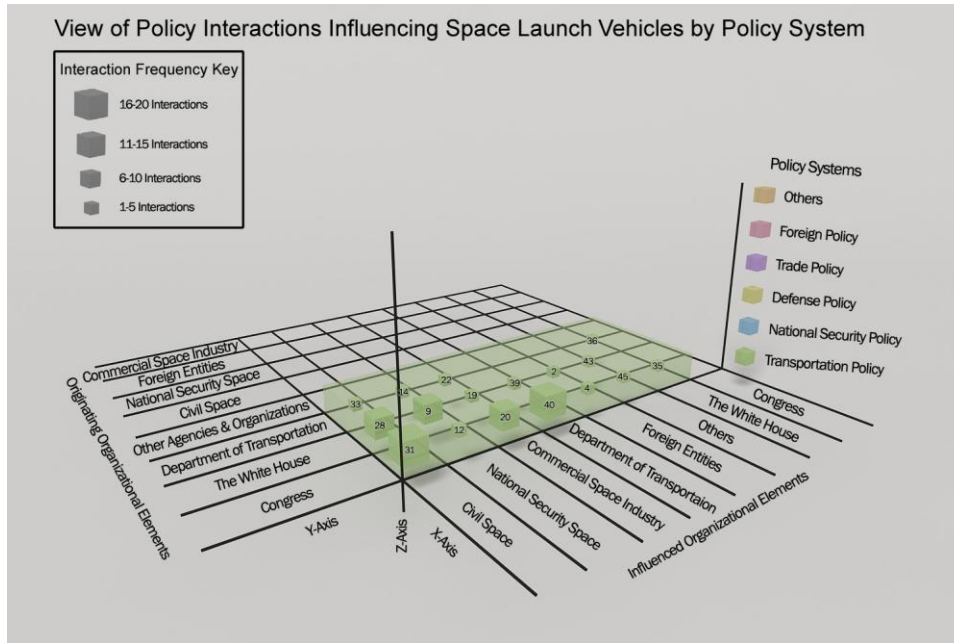


Figure 6.6: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Transportation Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

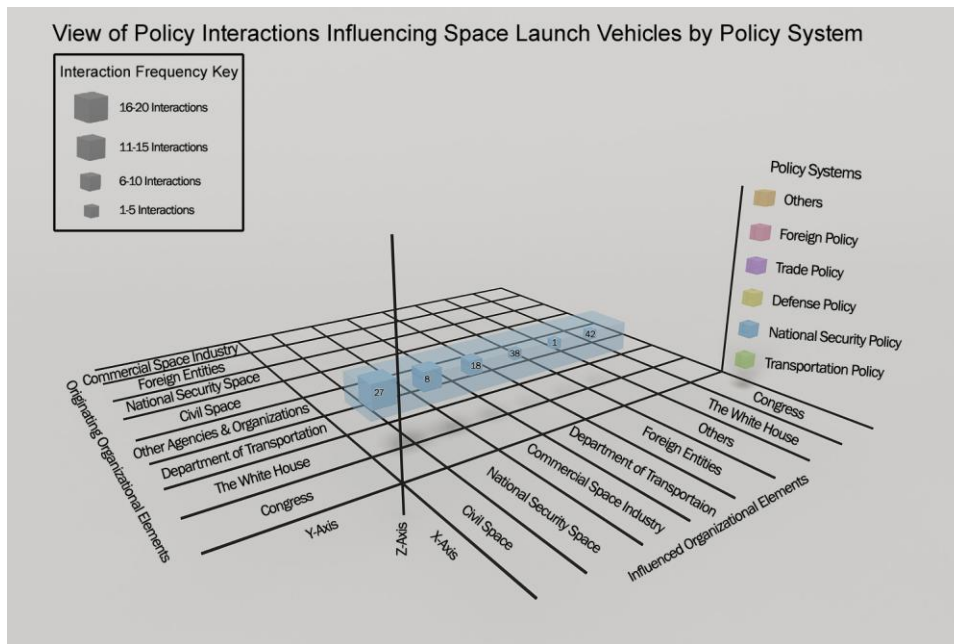


Figure 6.7: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The National Security Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

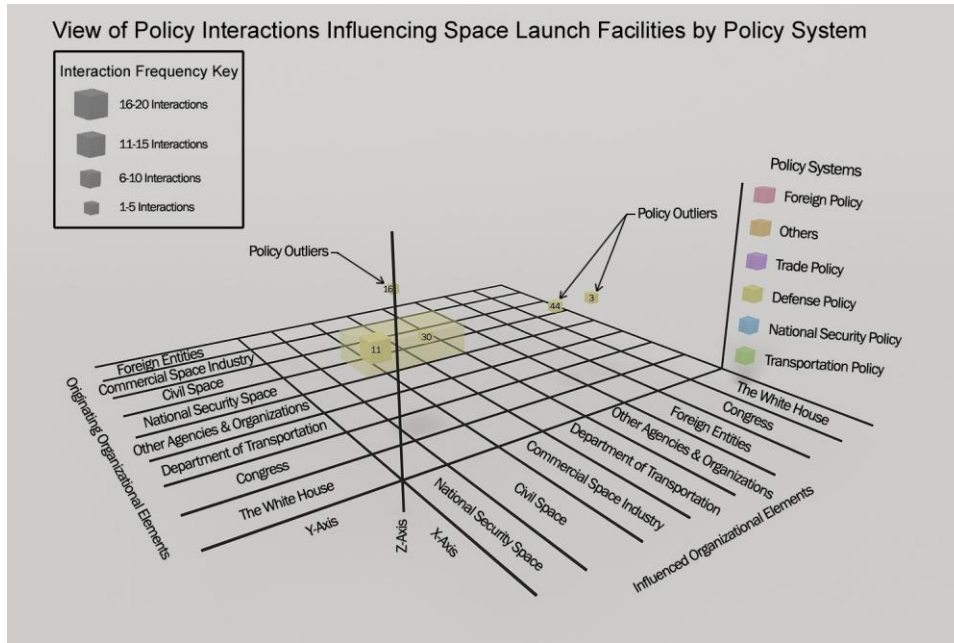


Figure 6.8: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Defense Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

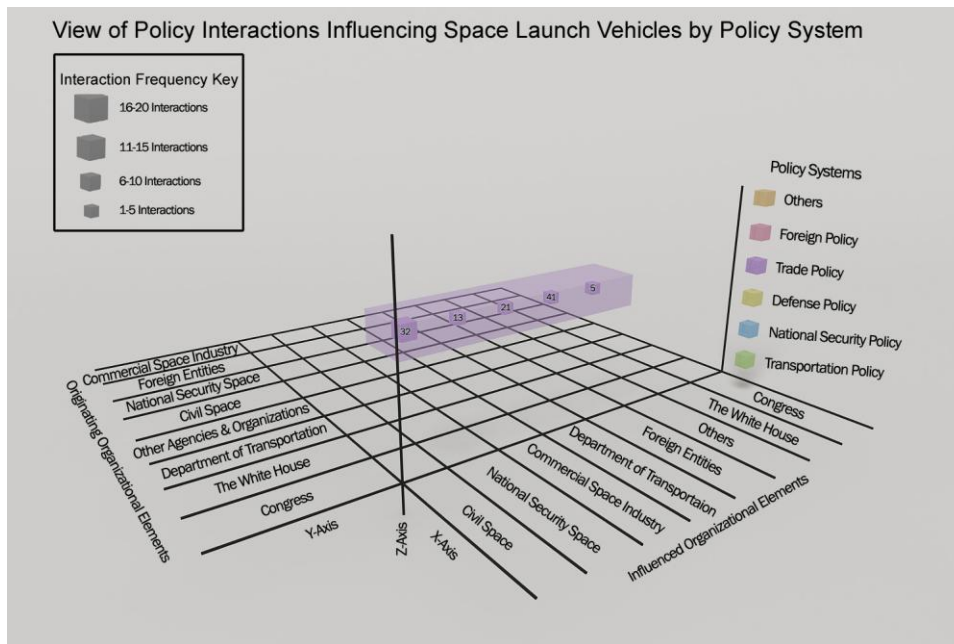


Figure 6.9: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Trade Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

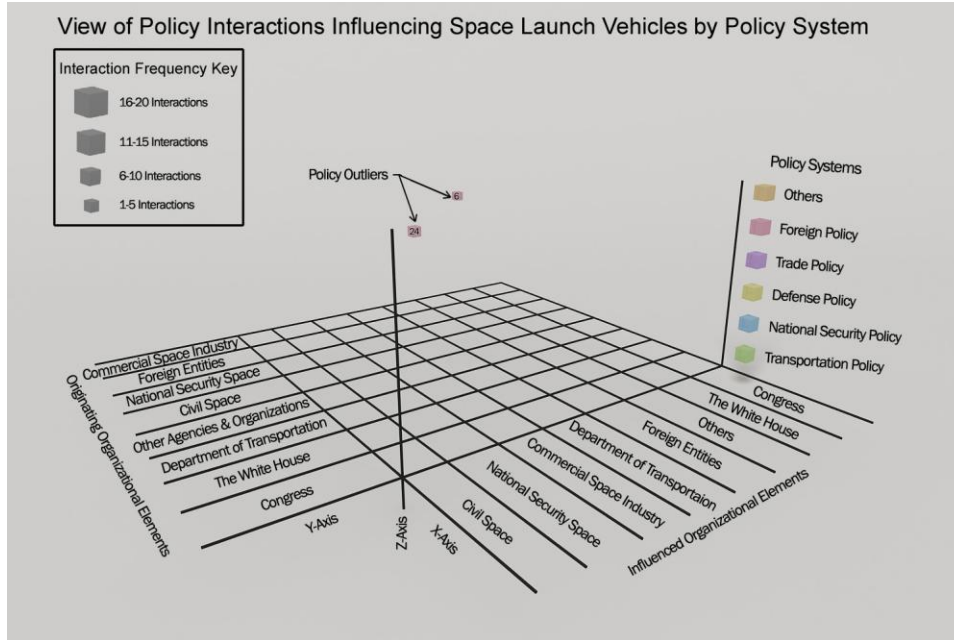


Figure 6.10: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Foreign Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

Relating the Policy Document Data to the Interview Data

As previously discussed, the interviews conducted for this dissertation were intended to “test” the 3DPDS to determine whether it allowed for the identification of policy relationships within the US space launch policy SoS that were identified by industry leaders as being relevant to their work. If no correlation exists between the policy relationships identified by subject matter experts and the policy relationships identified in the policy document examination, the 3DPDS would likely be of little use. If, on the other hand, a significant correlation exists between the interview data and the document data, the 3DPDS will have demonstrated that it is capable of presenting an accurate depiction of the policy relationships within the SoS relative to those referenced by the subject matter experts. There should also be some noticeable differences between the policy document data and the interview data, given that use of the 3DPDS should allow

for more thorough identification of the policy outliers within the US space launch policy SoS.

Interviewees referenced 14 of the 35 organizational element and policy area combinations identified through examination of the formal policy documents. Plotting the combinations identified through the interview process against the previous depiction of the policy SoS allows one to see how these two sets of policy interactions correlate, as in *Figure 6.11*.

One of the outliers represents a policy relationship that was considered by the experts. The experts considered the impact of foreign policy decisions on the commercial space industry, but they did not reference foreign policy decisions that impacted foreign entities, which were represented by the other outlier. Both outliers are easily identifiable in *Figure 6.5* and *Figure 6.11*.

The organizational element and policy system combinations from the policy documents that occurred most often (11 or more times) were all mentioned during the interview process. The interview data indicates that those interactions are readily considered by decision-makers.

This holistic perspective makes it easy to identify the policy relationships that exist within the SoS. *Figure 6.6* illustrates that while the experts readily considered the policy relationships that most frequently impact space launch vehicles and, in this case, even considered one of the two outliers, a number of policy relationships were not readily considered by the experts during the interview process.

Policy Document Data & Interview Data Depicting Policy Interactions that Influenced Space Launch Vehicles

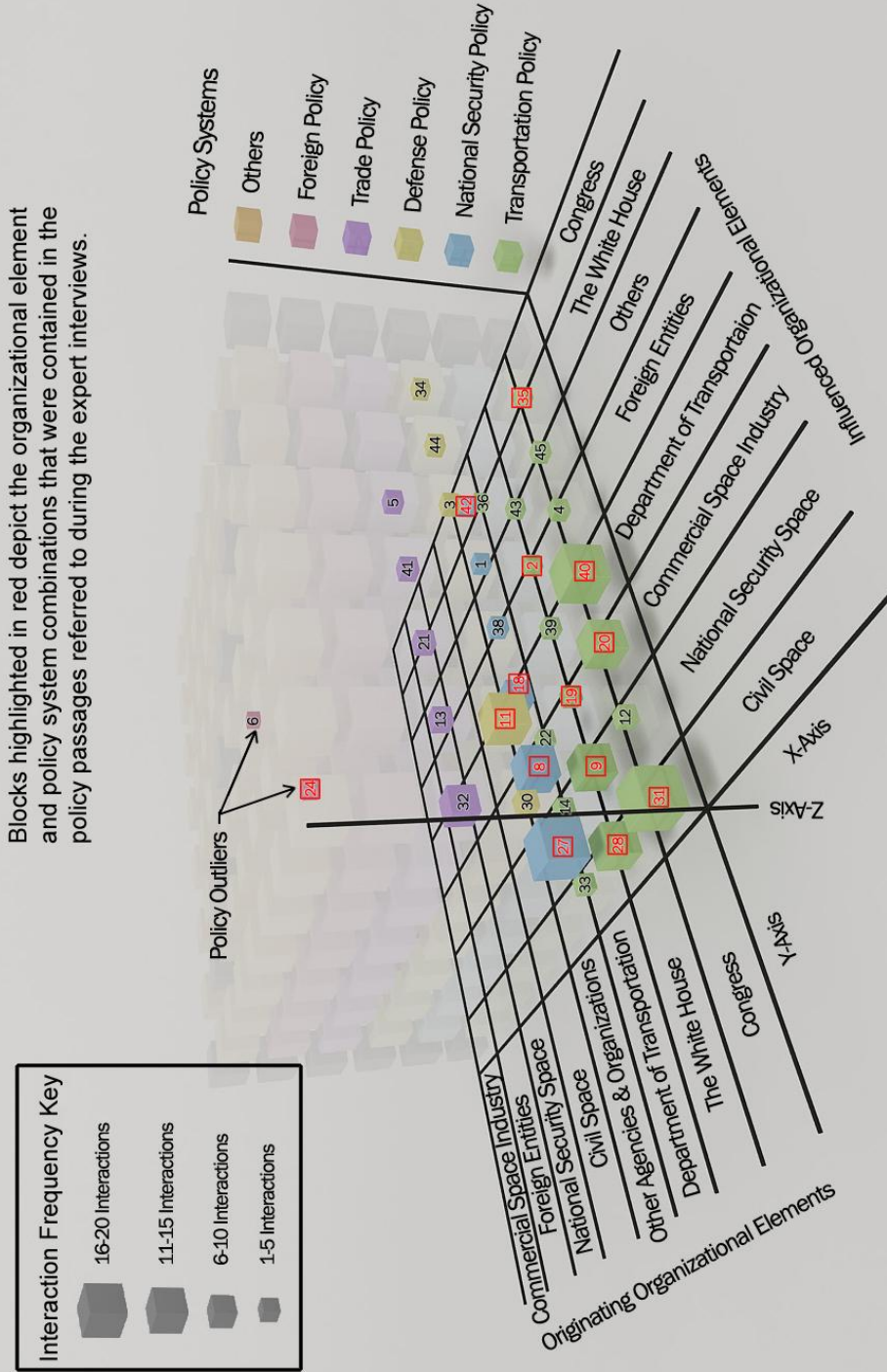


Figure 6.11: Policy Document Data and Interview Data Depicting Policy Interactions that Influenced Space Launch Vehicles (Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

Data for Figure 6.11

3DPDS Label	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Interactions
1	The White House	Foreign Entities	National Security	3
2	The White House	Foreign Entities	Transportation	3
3	Congress	Foreign Entities	Defense	5
4	Congress	Foreign Entities	Transportation	3
5	Congress	Foreign Entities	Trade	1
6	Others	Foreign Entities	Foreign	2
7	Others	Foreign Entities	Trade	0
8	The White House	National Security Space	National Security	12
9	The White House	National Security Space	Transportation	14
10	The White House	National Security Space	Trade	0
11	Congress	National Security Space	Defense	13
12	Congress	National Security Space	Transportation	2
13	Congress	National Security Space	Trade	4
14	Department of Transportation	National Security Space	Transportation	1
15	Others	National Security Space	Trade	0
16	National Security Space	Commercial Space Industry	Defense	0
17	National Security Space	Commercial Space Industry	Other	0
18	The White House	Commercial Space Industry	National Security	8
19	The White House	Commercial Space Industry	Transportation	1
20	Congress	Commercial Space Industry	Transportation	12
21	Congress	Commercial Space Industry	Trade	4
22	Department of Transportation	Commercial Space Industry	Transportation	3
23	Department of Transportation	Commercial Space Industry	Other	0
24	Others	Commercial Space Industry	Foreign	2
25	Others	Commercial Space Industry	Trade	0
26	Others	Commercial Space Industry	Other	0
27	The White House	Civil Space	National Security	16
28	The White House	Civil Space	Transportation	12
29	The White House	Civil Space	Trade	0
30	Congress	Civil Space	Defense	4
31	Congress	Civil Space	Transportation	17
32	Congress	Civil Space	Trade	6
33	Department of Transportation	Civil Space	Transportation	1
34	Congress	The White House	Defense	2
35	Congress	The White House	Transportation	3
36	Department of Transportation	The White House	Transportation	1
37	Others	Congress	Trade	0
38	The White House	Department of Transportation	National Security	4
39	The White House	Department of Transportation	Transportation	3
40	Congress	Department of Transportation	Transportation	16
41	Congress	Department of Transportation	Trade	5
42	The White House	Other Agencies & Organizations	National Security	5
43	The White House	Other Agencies & Organizations	Transportation	2
44	Congress	Other Agencies & Organizations	Defense	2
45	Congress	Other Agencies & Organizations	Transportation	1

Interactions highlighted in red depict the organizational element and policy system combinations that were referenced during the interviews with experts.

Combinations highlighted in grey were not identified in either the policy document data or the interview data for the 3DPDS application relative to space launch vehicles.

Application Two: Space Launch Facilities

The second 3DPDS application examines space launch facilities. Policy interactions that were included in the dataset for this application were identified using the following criteria: the policy interactions took place in a formal policy document; the interactions were between two or more identifiable government agencies; and the interactions identified were related to space launch facilities.

As in the previous application, for each policy interaction, the originating organizational element was identified. Those organizational elements influenced by the policy interaction were also identified, as were the policy systems in which the interactions took place.

In the document database, 60 passages were identified in 30 different policy documents that relate to space launch facilities or a combination of space launch vehicles and space launch facilities. In these passages, 109 policy interactions were identified. As in the previous application, the Department of Transportation was broken out from the “Other Agencies and Organizations.”

The data labels introduced in the previous application were applied across the entire database, so that each organizational element and policy system combination would be represented by the same data label in each of the three applications. The initial 3DPDS analysis depicting interactions specific to space launch facilities is shown in *Figure 6.12*.

Three-Dimensional Policy Design Structure Depicting Interactions that Influence Space Launch Facilities

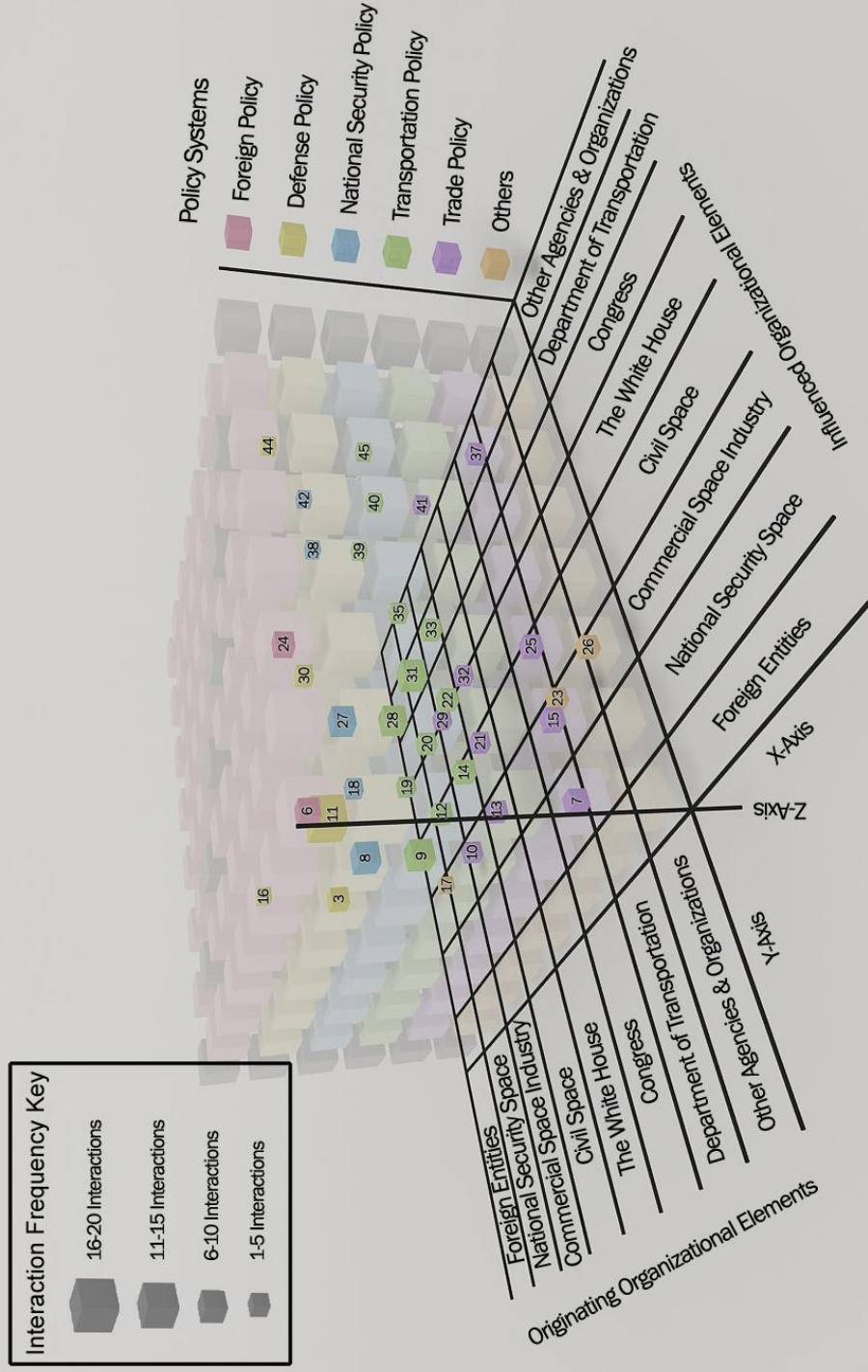


Figure 6.12: Three-Dimensional Policy Design Structure Depicting Interactions that Influence Space Launch Facilities (Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

Data for Figure 6.13

3DPDS Label	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Facility-Specific Policy Interactions
1	The White House	Foreign Entities	National Security	0
2	The White House	Foreign Entities	Transportation	0
3	Congress	Foreign Entities	Defense	2
4	Congress	Foreign Entities	Transportation	0
5	Congress	Foreign Entities	Trade	0
6	Other Agencies and Organizations	Foreign Entities	Foreign	1
7	Other Agencies and Organizations	Foreign Entities	Trade	1
8	The White House	National Security Space	National Security	10
9	The White House	National Security Space	Transportation	10
10	The White House	National Security Space	Trade	1
11	Congress	National Security Space	Defense	11
12	Congress	National Security Space	Transportation	1
13	Congress	National Security Space	Trade	2
14	Department of Transportation	National Security Space	Transportation	2
15	Other Agencies and Organizations	National Security Space	Trade	1
16	National Security Space	Commercial Space Industry	Defense	1
17	National Security Space	Commercial Space Industry	Other	1
18	The White House	Commercial Space Industry	National Security	5
19	The White House	Commercial Space Industry	Transportation	1
20	Congress	Commercial Space Industry	Transportation	3
21	Congress	Commercial Space Industry	Trade	3
22	Department of Transportation	Commercial Space Industry	Transportation	3
23	Department of Transportation	Commercial Space Industry	Other	1
24	Other Agencies and Organizations	Commercial Space Industry	Foreign	1
25	Other Agencies and Organizations	Commercial Space Industry	Trade	1
26	Other Agencies and Organizations	Commercial Space Industry	Other	1
27	The White House	Civil Space	National Security	9
28	The White House	Civil Space	Transportation	7
29	The White House	Civil Space	Trade	1
30	Congress	Civil Space	Defense	5
31	Congress	Civil Space	Transportation	7
32	Congress	Civil Space	Trade	3
33	Department of Transportation	Civil Space	Transportation	2
34	Congress	The White House	Defense	0
35	Congress	The White House	Transportation	1
36	Department of Transportation	The White House	Transportation	0
37	Other Agencies and Organizations	Congress	Trade	1
38	The White House	Department of Transportation	National Security	1
39	The White House	Department of Transportation	Transportation	2
40	Congress	Department of Transportation	Transportation	3
41	Congress	Department of Transportation	Trade	4
42	The White House	Other Agencies & Organizations	National Security	2
43	The White House	Other Agencies & Organizations	Transportation	0
44	Congress	Other Agencies & Organizations	Defense	1
45	Congress	Other Agencies & Organizations	Transportation	2

Clustering of the Policy Document Data Related to Space Launch Facilities

The policy interactions from the formal policy documents that were identified in the database as pertaining to space launch facilities were sorted and clustered using the same method as was used in the previous case. The boundaries of the various clusters were based on those interactions within the same policy system. However, given the physical distance between those interactions represented by Block 13 and the other interaction combinations within the defense policy system, Block 13 was not included in this cluster. Also, all of the interactions identified in “other” policy systems should be treated as outliers, because they do not belong to any of the other policy systems, and because they do not originate from the same organizational element, they should not be clustered together.

Clustering of the policy interactions allows for clearer organization and examination of the data. The data from the facility-specific interactions was clustered as shown in *Figure 6.13*. In the first application, the outliers were few in number and were easily visually identifiable. In this application, identification of the outliers required closer examination. Nevertheless, several policy outliers were identified in a number of policy systems. Nine blocks in the 3DPDS analysis in *Figure 6.13* represent policy outliers in foreign policy, defense policy, transportation policy, and other policy systems. Clustering allowed for the grouping of a number of transportation, defense, and trade policy interactions, which, in turn, allowed for the identification of the outliers in the 3DPDS. *Figure 6.14* through *Figure 6.19* depict the interactions in each policy system.

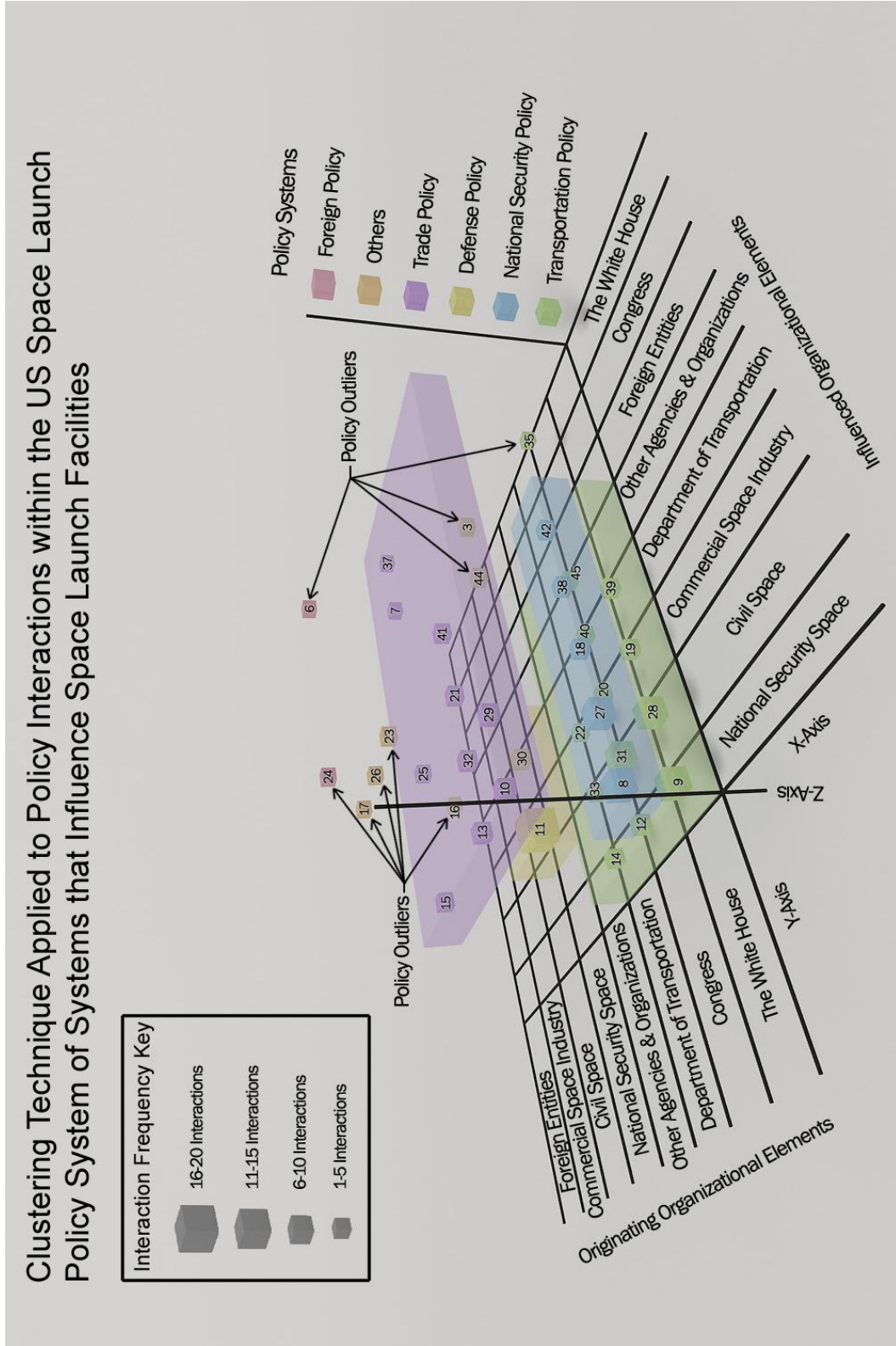


Figure 6.13: Clustering Technique Applied to Policy Interactions within the US Space Launch Policy System of Systems that Influence Space Launch Facilities
 (Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

Data for Figure 6.13

3DPDS Label	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Interactions
1	The White House	Foreign Entities	National Security	0
2	The White House	Foreign Entities	Transportation	0
3	Congress	Foreign Entities	Defense	2
4	Congress	Foreign Entities	Transportation	0
5	Congress	Foreign Entities	Trade	0
6	Other Agencies and Organizations	Foreign Entities	Foreign	1
7	Other Agencies and Organizations	Foreign Entities	Trade	1
8	The White House	National Security Space	National Security	10
9	The White House	National Security Space	Transportation	10
10	The White House	National Security Space	Trade	1
11	Congress	National Security Space	Defense	11
12	Congress	National Security Space	Transportation	1
13	Congress	National Security Space	Trade	2
14	Department of Transportation	National Security Space	Transportation	2
15	Other Agencies and Organizations	National Security Space	Trade	1
16	National Security Space	Commercial Space Industry	Defense	1
17	National Security Space	Commercial Space Industry	Other	1
18	The White House	Commercial Space Industry	National Security	5
19	The White House	Commercial Space Industry	Transportation	1
20	Congress	Commercial Space Industry	Transportation	3
21	Congress	Commercial Space Industry	Trade	3
22	Department of Transportation	Commercial Space Industry	Transportation	3
23	Department of Transportation	Commercial Space Industry	Other	1
24	Other Agencies and Organizations	Commercial Space Industry	Foreign	1
25	Other Agencies and Organizations	Commercial Space Industry	Trade	1
26	Other Agencies and Organizations	Commercial Space Industry	Other	1
27	The White House	Civil Space	National Security	9
28	The White House	Civil Space	Transportation	7
29	The White House	Civil Space	Trade	1
30	Congress	Civil Space	Defense	5
31	Congress	Civil Space	Transportation	7
32	Congress	Civil Space	Trade	3
33	Department of Transportation	Civil Space	Transportation	2
34	Congress	The White House	Defense	0
35	Congress	The White House	Transportation	1
36	Department of Transportation	The White House	Transportation	0
37	Other Agencies and Organizations	Congress	Trade	1
38	The White House	Department of Transportation	National Security	1
39	The White House	Department of Transportation	Transportation	2
40	Congress	Department of Transportation	Transportation	3
41	Congress	Department of Transportation	Trade	4
42	The White House	Other Agencies & Organizations	National Security	2
43	The White House	Other Agencies & Organizations	Transportation	0
44	Congress	Other Agencies & Organizations	Defense	1
45	Congress	Other Agencies & Organizations	Transportation	2

Policy outliers depicted in blue.

A New Method for the Examination of Policy Systems of Systems

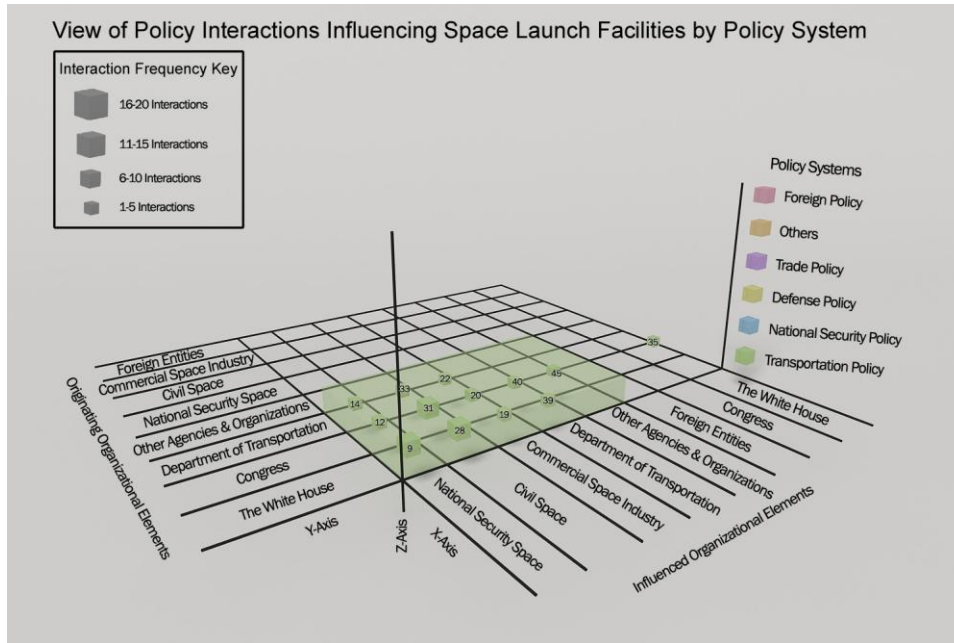


Figure 6.14: View of Policy Interactions Influencing Space Launch Facilities by Policy System: The Transportation Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

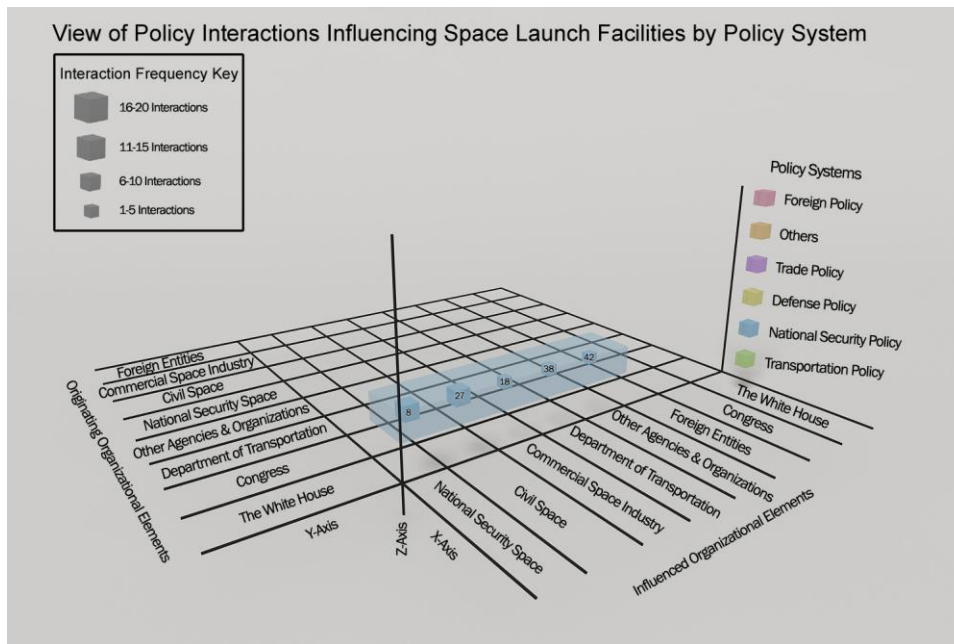


Figure 6.15: View of Policy Interactions Influencing Space Launch Facilities by Policy System: The National Security Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

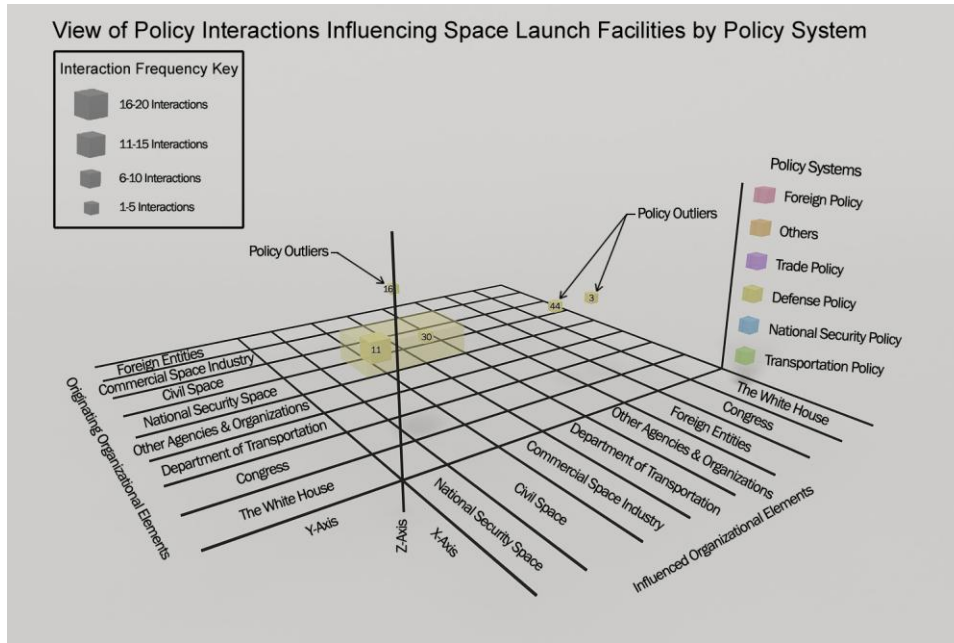


Figure 6.16: View of Policy Interactions Influencing Space Launch Facilities by Policy System: The Defense Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

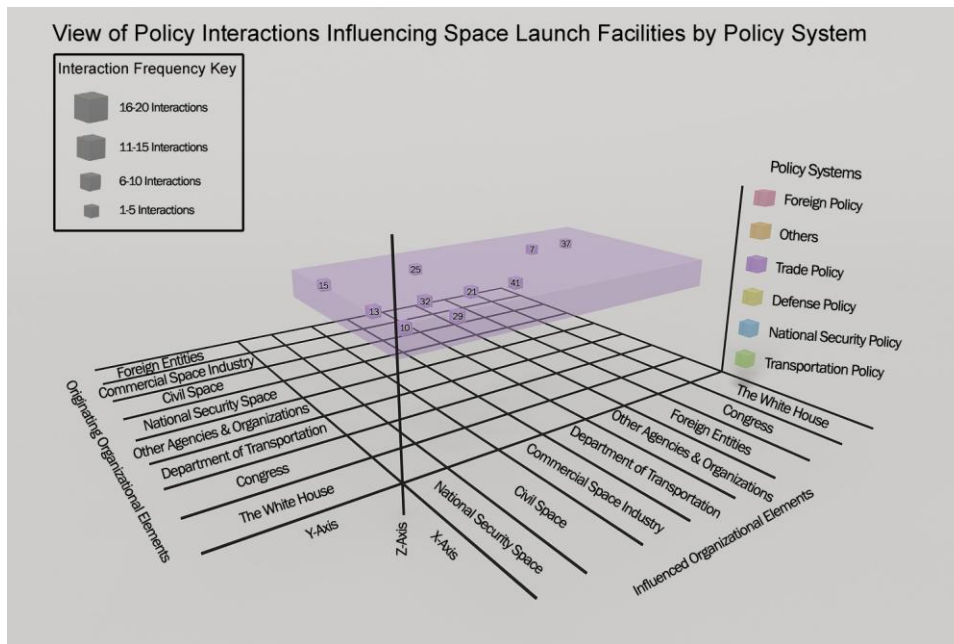


Figure 6.17: View of Policy Interactions Influencing Space Launch Facilities by Policy System: The Trade Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

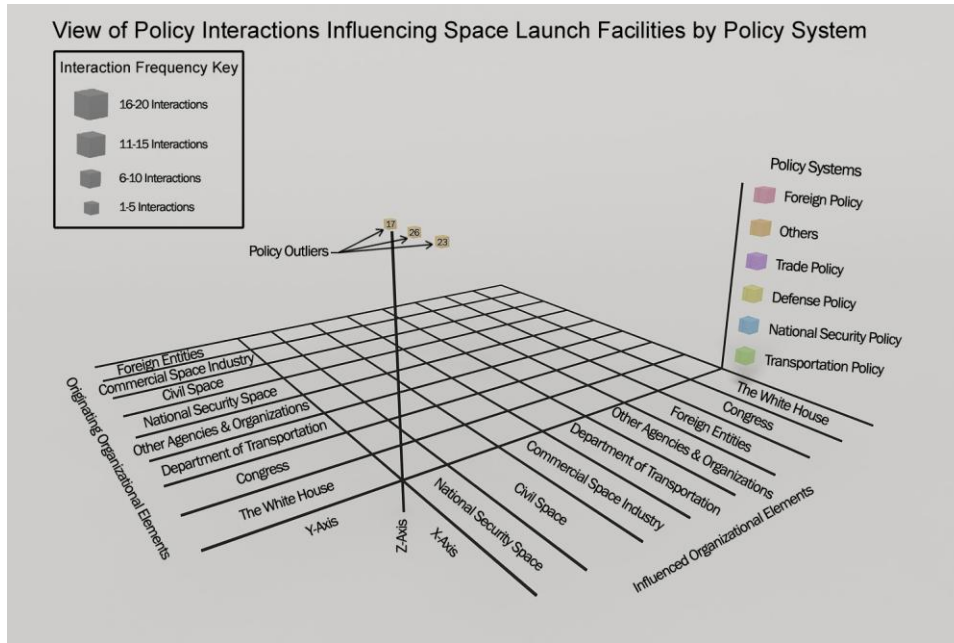


Figure 6.18: View of Policy Interactions Influencing Space Launch Facilities by Policy System: Other Policy Systems
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

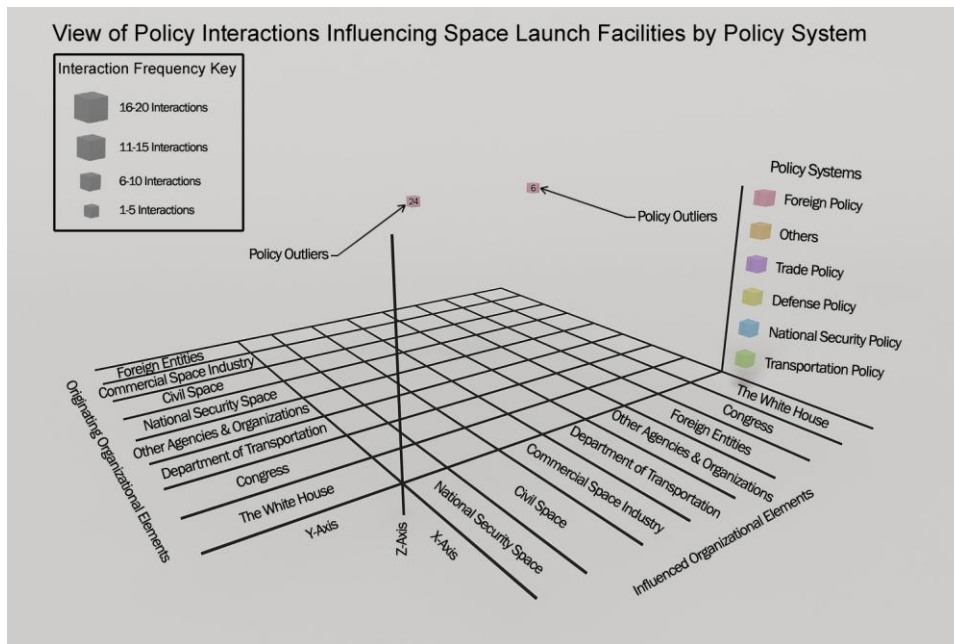


Figure 6.19: View of Policy Interactions Influencing Space Launch Facilities by Policy System: The Foreign Policy System
(Illustration by Trevor Mower and Timothy Thielke; used with permission)

Relating the Policy Document Data to the Interview Data

Interviewees referenced 13 of the passages contained in the space launch facilities data set from 10 different policy documents. Those passages contained 30 interactions from 17 different organizational element and policy system combinations. Plotting the organizational element and policy system combinations cited by the interviewees against the previous depiction of the policy SoS allows one to see how the policy documents and the interview data correlate, as seen in *Figure 6.20*.

As in the previous application, only one of the outliers identified using the clustering technique was mentioned by interview participants. The remaining outliers from the policy document database that were identified using the 3DPDS were not referenced by any of the experts interviewed for this study.

A number of the outliers in this application was either initiated by or influenced by “Other Agencies and Organizations.” A number of these outliers also took place in “Other” policy systems. This suggests that an interaction’s classification as “Other” in any classification category used in the 3DPDS would also classify it as a policy outlier. Frequent references to the same organizational element or policy system within the “Other” category would suggest that the organizational element or policy system should not be included in the “Other” category but, rather, should be separated and considered in its own right, such as the Department of Transportation, which was broken out from that classification.

Policy Document Data & Interview Data Depicting Policy Interactions that Influenced Space Launch Facilities

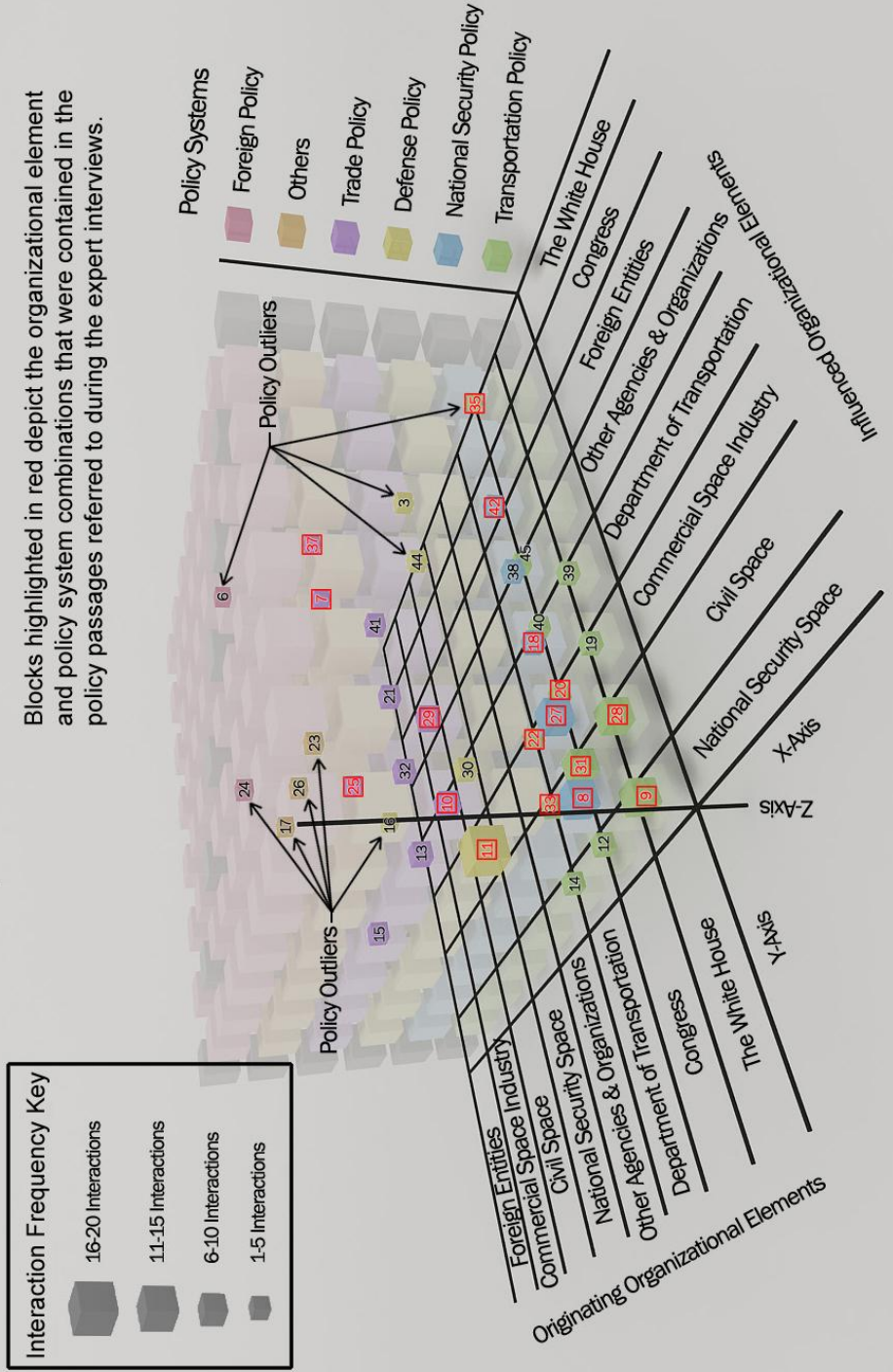


Figure 6.20: Policy Document Data and Interview Data Depicting Policy Interactions that Influenced Space Launch Facilities (Illustration by Trevor Mower and Timothy Thielke; used with permission)

A New Method for the Examination of Policy Systems of Systems

Data for Figure 6.20

3DPDS Label	Originating Organizational Element (X-Axis)	Influenced Organizational Element (Y-Axis)	Policy System (Z-Axis)	Number of Interactions
1	The White House	Foreign Entities	National Security	0
2	The White House	Foreign Entities	Transportation	0
3	Congress	Foreign Entities	Defense	2
4	Congress	Foreign Entities	Transportation	0
5	Congress	Foreign Entities	Trade	0
6	Other Agencies and Organizations	Foreign Entities	Foreign	1
7	Other Agencies and Organizations	Foreign Entities	Trade	1
8	The White House	National Security Space	National Security	10
9	The White House	National Security Space	Transportation	10
10	The White House	National Security Space	Trade	1
11	Congress	National Security Space	Defense	11
12	Congress	National Security Space	Transportation	1
13	Congress	National Security Space	Trade	2
14	Department of Transportation	National Security Space	Transportation	2
15	Other Agencies and Organizations	National Security Space	Trade	1
16	National Security Space	Commercial Space Industry	Defense	1
17	National Security Space	Commercial Space Industry	Other	1
18	The White House	Commercial Space Industry	National Security	5
19	The White House	Commercial Space Industry	Transportation	1
20	Congress	Commercial Space Industry	Transportation	3
21	Congress	Commercial Space Industry	Trade	3
22	Department of Transportation	Commercial Space Industry	Transportation	3
23	Department of Transportation	Commercial Space Industry	Other	1
24	Other Agencies and Organizations	Commercial Space Industry	Foreign	1
25	Other Agencies and Organizations	Commercial Space Industry	Trade	1
26	Other Agencies and Organizations	Commercial Space Industry	Other	1
27	The White House	Civil Space	National Security	9
28	The White House	Civil Space	Transportation	7
29	The White House	Civil Space	Trade	1
30	Congress	Civil Space	Defense	5
31	Congress	Civil Space	Transportation	7
32	Congress	Civil Space	Trade	3
33	Department of Transportation	Civil Space	Transportation	2
34	Congress	The White House	Defense	0
35	Congress	The White House	Transportation	1
36	Department of Transportation	The White House	Transportation	0
37	Other Agencies and Organizations	Congress	Trade	1
38	The White House	Department of Transportation	National Security	1
39	The White House	Department of Transportation	Transportation	2
40	Congress	Department of Transportation	Transportation	3
41	Congress	Department of Transportation	Trade	4
42	The White House	Other Agencies & Organizations	National Security	2
43	The White House	Other Agencies & Organizations	Transportation	0
44	Congress	Other Agencies & Organizations	Defense	1
45	Congress	Other Agencies & Organizations	Transportation	2

Interactions highlighted in red depict the organizational element and policy system combinations that were referenced during the interviews with experts.

Combinations highlighted in grey were not identified in either the policy document data or the interview data for the 3DPDS application relative to space launch facilities.

Conclusions Regarding Space Launch Vehicles and Space Launch Facilities

These two applications were designed to address the following research question: What does the application of the 3DPDS illustrate about the policy interactions related to two elements of launch capacity: launch vehicles and launch facilities?

Comparing the depictions of the space launch vehicle data in *Figure 6.4* with the space launch facilities data in *Figure 6.11* and their corresponding data tables, it is clear that interactions influencing space launch vehicles occurred more frequently in the policy documents examined in this study than interactions influencing space launch facilities. In each case, policy outliers were identified in the policy document data that were not referenced by interview participants. One of the two outliers identified in the space launch vehicle study was discussed by the experts in the interviews, and one of the nine outliers in the space launch vehicle study was referenced during the interview process. While the higher number of policy outliers in the vehicle data was not expected, the fact that the policy outliers were not referenced during the interview process supports their classification as “outliers.”

The clustering also highlights high concentrations of transportation policy interactions, trade policies, defense policies, and national security policies. The correlation between these clusters and the interview data suggests that these policy relationships are currently being considered by experts in the field.

Most noticeably, few formal policy interactions from within the US space launch policy SoS pictured here influence Congress, while Congress frequently influences the other organizational elements of the SoS, including the “system” and “non-system” actors. While organizations attempt to influence Congress through lobbyists and

Congressional liaison offices, those efforts are much more difficult to track than the formal policy interactions considered in this study because they do not take place within the formal policy framework. Congress and the White House are the two organizational elements within the US space launch policy SoS included in this study that most significantly influence the SoS, but they are the two elements that are least influenced by the rest of the SoS through the formal policy documents examined in this study.

Another significant aspect of the SoS that becomes noticeable in both applications through the observation of the clustered data is how frequently trade policy influences nearly all of the organizational elements in the SoS in some manner. The frequency of these interactions suggests that they warrant consideration when considering changes to US space launch policy.

The most frequently observed organizational element and policy system combinations from the formal policy documents were mentioned by interviewees in both applications. However, a number of combinations remained unmentioned during the interview process. This suggests that use of the 3DPDS, as employed in these two applications, can help to identify previously unconsidered policy interactions, including policy outliers, in a complex policy SoS.

In these two applications, the 3DPDS was used to examine two elements of launch capacity: space launch vehicles and space launch facilities. The study examined the policy interactions that led up to a situation of excess space launch capacity. Policy outliers were identified, and frequent policy interactions also were identified.

The primary benefit that these studies bring to practitioners and academics is an elevated awareness of the various policy interactions quantitative information to illustrate which policy interactions occur most frequently. The 3DPDS allows for readily recognizable visualization of these interactions within a very complex SoS. Additionally, this method allows for easy identification of outliers that may influence policy-makers' organizations or other organizational elements.

Application Three: Cancellation of the Ares 1 Launch Vehicle

The third and final application described in this dissertation employs 3DPDS in a different manner to examine the possible impacts of the Presidential decision to cancel the Ares 1 launch vehicle. Employing the 3DPDS in this manner allows for the orderly deconstruction and examination of the policies related to this issue. To conduct a systematic evaluation of the potential impacts of the Ares 1 cancellation, it is necessary to review the potential implications of the existing organizational and policy relationships within the US space launch policy SoS.

Because policy interactions influencing the Ares 1 launch vehicle would be a subset of the dataset influencing space launch vehicle in general, it makes sense to use the results of the first application of the 3DPDS as a starting point. By examining only those organizational element and policy system combinations that were identified in the first application, the number of combinations that should be reviewed concerning current policies and potential future impacts of the Ares 1 cancellation can be significantly reduced. In this manner, related studies can be used to inform subsequent studies. This application will examine the existing, known policy interactions that influence space

launch vehicles within the US space launch policy SoS, as identified in the previous two applications.

Ares 1 Launch Vehicle Background

The Ares 1 and Ares V launch vehicles were part of the Constellation Program, initiated under President Bush, to provide transportation to the International Space Station and to return humans to the moon and beyond (NASA's Ares Projects, 2008). The Ares 1 rocket was designed to carry the Orion exploration vehicle and its crew or small cargo payloads up to 56,200 pounds mass to low earth orbit or to the International Space Station (NASA, 2009; NASA's Ares 1 Upper Stage, 2008). The two launch vehicles were to feature common hardware derived from the Apollo, Saturn, and Space Shuttle programs (NASA's Ares Projects, 2008).

The Ares 1 rocket consists of two separate stages. The first stage contains a number of components including a five-segment solid rocket booster, a parachute recovery system, and an avionics system (NASA, 2009). The five-segment solid rocket booster used by the Ares 1 was derived from the Space Shuttle's four-segment reusable solid rocket boosters used from 1981 to the present (NASA, 2009). The prime contractor for the Ares 1 first stage was ATK Launch Systems of Brigham City, Utah (NASA, 2009).

The Ares 1 upper stage was designed to be powered by the J-2X engine, which would re-enter the Earth's atmosphere and land somewhere in the Indian Ocean (NASA's Ares 1 Upper Stage, 2008). The JX-2 engine is fueled with liquid oxygen and liquid hydrogen and evolved from the J-2 upper stage engine used in the Apollo-era Saturn rockets (NASA's Ares Projects, 2008; PWR, 2007). The prime contractor for the

J-2X engine was Pratt & Whitney Rocketdyne. To pursue other objectives, the Ares 1 was cancelled by the Obama administration (Obama, 2010).

Making Use of the Previous Applications

The US space launch policy SoS, adjusted as the previous two applications were adjusted to separate the Department of Transportation from “Other Agencies and Organizations,” contained a total of 336 possible organization element and policy system combinations, as shown in *Figure 6.3*. From the previous two applications, one can determine the organizational element and policy system combinations that are likely to be most relevant to other scenarios influencing elements of launch capacity. This can be further specified to include only those combinations that have been shown to be relevant to launch vehicles, as in the first application. This reduces the number of organizational element and policy system combinations from 336 possible combinations to 35 combinations that are known to be relevant to space launch vehicles given the first application presented in this dissertation, as depicted in *Figure 6.4*.

After the blocks or organizational element and policy system combinations that warrant further examination have been determined, each block can be examined individually by looking not only at policy interactions specific to the Ares 1 and the Constellation program but also other policy interactions that are represented in these blocks. From this, it is possible to consider the potential implications of the decision to cancel the Ares 1 relative to the organizational element and policy system combinations represented in each of these blocks.

To provide a logical flow of information and reduce redundancy, the organizational element and policy system combinations will be examined as follows:

First, the blocks, or organizational element and policy system combinations, will be arranged by originating organization, then the blocks will be further arranged by the policy system in which the existing policy interactions have taken place and, finally, they will be organized by the influenced organizations. Again, while these blocks could be examined in any particular order, they are arranged here based on the organizational element that initiated the policy interaction to enable a more logical explanation of the contents with minimal redundancy. Those interactions initiated by Congress will be examined first through transportation policy then through trade, defense, national security, foreign policy, and other policy systems, as applicable. The same process will then be used to examine those interactions initiated by The White House, the Department of Transportation, National Security Space, and other agencies and organizations. This could be done in any order, but the decision was made to start with those policies initiated in Congress to follow the results of the 3DPDS after the clustering was completed in the first study, in which Congress was found to have initiated more interactions than any of the other organizational elements.

The blocks are numbered in this application as they were in the previous two studies. This way, one particular block label refers to the same organizational element and policy system combination in this application as it did in the previous two application studies. Because not all of the combinations identified in the previous two applications were found to be specific to space launch vehicles, not all of the 41 organizational element and policy system combinations are used this study. Also, the blocks examined in this application are not presented in numerical order.

While the past policy interactions are easily identifiable, the potential impacts of the Ares 1 cancellation are harder to define and are highly subjective. This dissertation does not seek to make predictions on what may happen but, rather, seeks to demonstrate a method by which researchers could more efficiently and effectively identify the key relationships within the US space launch policy SoS to systematically examine the impacts that industry experts could expect to see with the cancellation of the Ares 1. In this application, the potential impacts will be based on past policy interactions, as identified in the previous 3DPDS application related to space launch vehicles. This method enables one to focus more quickly and effectively on the policy interactions, including policy outliers, that have already been identified. Discussion of the relevant policy document passages related to the Ares 1 cancellation will be augmented by more subjective information gained through the interviews conducted for this dissertation.

The following sections provide a block-by-block examination of the SoS identified in *Figure 6.4*. This examination uses the 3DPDS in a manner that differs from that in the first two applications; here, the 3DPDS is used to systematically examine the policy decisions and information gathered through the interview process as it relates to the potential impacts of the cancellation of the Ares 1. Again, rather than examining all 336 potential organizational element and policy system combinations, only the blocks representing the 35 combinations found to be relevant to space launch vehicles in the earlier application will be examined. The policy documents and interactions described in the following sections were all uncovered as part of the data collection conducted for the previous applications. The data pertinent to space launch vehicles was further

sorted based on whether or not the passages identified were relevant to the Constellation Program, specifically the Ares 1 launch vehicle.

Congress Influences Organizational Elements through Transportation Policy

Block 17: Congress Influences Commercial Space and the Industrial Base through Transportation Policy

In the National Aeronautics and Space Administration (NASA) Authorization Act of 2000 (PL 106-391, 2000), Congress directed NASA to work closely with the private sector and promote the pursuit, by commercial providers, of the development of advanced space transportation technologies, including reusable space vehicles and human flight systems. In 2008, Congress created the Commercial Crew Initiative, which was meant to stimulate commercial use of space and enable a commercial means of providing crew transfer and crew rescue services from the International Space Station (PL 110-422, 2008).

The Ares 1 launch vehicle was being developed at the time Congress legislated the Commercial Crew Initiative. In fact, the NASA Authorization Act of 2008, the same Act in which the Commercial Crew Initiative was mentioned, recognized developing US human space flight capabilities to allow independent US access to the International Space Station as a strategically important national imperative. The Act also stated that “all prudent steps should thus be taken to bring the Orion Crew Exploration Vehicle and Ares 1 Crew Launch Vehicle to full operational capability as soon as possible” (PL 110-422, 2008). The Act further directed that \$1 billion be used to accelerate the initial

operating capability of the Orion Crew Exploration Vehicle and the Ares 1 Crew Launch Vehicle (PL 110-422, 2008).

While Congress was accelerating the Ares 1 Crew Launch Vehicle and investing an additional billion dollars to accelerate the program, it was also encouraging NASA to work with commercial space providers to establish a domestic, commercial means of transporting crew and cargo to the International Space Station (PL 110-422, 2008). As pointed out by several industry experts interviewed for this study, Congress is not providing the commercial space industry with a singular goal that commercial launch providers and the industrial base can use to build a business case to support these competing objectives.

Additionally, Ares 1 was developed in response to a 2004 White House plan, published in *A Renewed Spirit of Discovery*, and the program was already facing cancellation by the Obama Administration in 2010 (The White House, 2004; Obama, 2010). As one interviewee pointed out, the quick cancellation of this program did not reassure the commercial marketplace that the US government is a stable and reliable customer.

In reference to commercial-like launch vehicle acquisitions, several interviewees referenced the Evolved Expendable Launch Vehicle (EELV) program. To provide assured access to space for national security missions, the government directed that two providers be maintained and further directed that commercial-like procurement rules (FAR-12) rather than government-like procurement rules (FAR-15) be used in these acquisitions. The resulting market could not sustain two providers, and the end result was a merger between the two providers and the creation of the United Launch Alliance

(ULA). Commercial carriers for human space transportation are not fully developed, and should more than one carrier successfully achieves the desired technology, there is no guarantee of government business.

With the cancellation of Ares 1 and the retirement of the Space Shuttle, NASA is being forced to move toward commercially acquired launch services. One interviewee noted that, as the US turns towards a more commercial-like launch service arrangement with US providers, the liability-risk-sharing regime will likely have to be reviewed.

Block 28: Congress Influences Civil Space through Transportation Policy

In previous NASA Authorization Acts, NASA was encouraged to promote development of advanced space transportation technologies, including space vehicles and human space systems by commercial providers (PL 106-391, 2000; PL 109-155, 2005). Additionally, the Administrator of NASA was directed to work closely with the private sector, particularly with entrepreneurs seeking to develop new means to launch satellites, crew, and cargo, and to contract with the private sector for crew and cargo services (PL 109-155, 2005).

The cancellation of the Ares 1 launch vehicle left a gap in US human space flight capability. NASA is now dependent on the commercial sector and foreign entities to provide human space transport as the Space Shuttle has completed its final flight. US commercial space transportation technologies are still in development and will not be ready for full operational use for years. NASA will be reliant on foreign transportation to and from the space station until domestic commercial capabilities are available, or until a new government capability is available.

Additionally, the NASA Authorization Act of 2010 directed that Space Shuttle–derived and Ares 1 components and existing US propulsion systems be used (PL 111-167, 2010). This could limit the interest of commercial research and development entities in supporting civil space missions, because it significantly limits the components that can be used, and, in fact, directs the use of components that have already been developed.

Block 10: Congress Influences National Security Space through Transportation Policy

In 2008, Congress requested a report on the US industrial base for launch vehicle engines to ensure that the industrial base could support National Security missions (PL110-422, 2008). Congress continues to fund national security missions and directs the Air Force, as the launch agent for the Department of Defense, to continue to provide assured access to space for national security missions (The White House, 2006; PL 104-314, 2002). The Ares 1 launch vehicle provided some level of commonality among those launch vehicles used for National Security Space missions and those used by NASA, particularly in the form of the RS-68 engines manufactured by Pratt & Whitney Rocketdyne that are currently used in the Delta IV launch vehicles (Cowing, 2005).

The proposed cancellation of the Ares 1 launch vehicle will minimize these commonalities. Whereas the overhead costs could have been distributed over civil and national security launches, they will now be funded nearly entirely by the National Security Space sector, which, according to several interviewees, is already influencing the price per launch for government launches. According to interviewees, other than

the price per launch, the proposed cancellation of the Ares 1 launch vehicle has little immediate impact on National Security Space.

Block 36: Congress Influences the Department of Transportation through Transportation Policy

The language in the Commercial Space Launch Amendments Act of 2004 (PL 108-492, 2004) directs the Department of Transportation to encourage, facilitate, and promote the continuous improvement of the safety of launch vehicles designed to carry humans. Additionally, Congress provided the Department of Transportation with the authority to issue regulations governing the design and operation of launch vehicles to protect the health and safety of the crew and any space flight participants.

Congress has given the authority to regulate commercial launch vehicles to the Department of Transportation. With the cancellation of the Ares 1 and the lack of a NASA launch vehicle for human transport, the Department of Transportation will wield a great deal of influence over the options available and approved for human space transportation regarding the safety of the crew and human passengers.

Block 32: Congress Influences the White House through Transportation Policy

In the NASA Authorization Act of 2005, Congress supported certain provisions of the President's Space Transportation Policy (PL 109-155, 2005; The White House, 2005). Consistent with the President's policy, Congress directed that the Agency not launch a payload on a foreign launch vehicle except in accordance with the Space Transportation Policy (PL 109-155, 2005).

Block 4: Congress Influences Foreign Entities through Transportation Policy

The NASA Authorization Act of 2005 stated that NASA shall not launch a payload on a foreign launch vehicle except in accordance with the Space Transportation Policy announced on December 21, 2004 (PL 109-155, 2005; The White House, 2004). However, this Act allows the President to waive this requirement, allowing for the foreign launch of payloads for which development began prior to the enactment of the Act (PL 109-155, 2005). The exception to this Act already granted for the James Webb Space Telescope opened the door for any payload for which development began prior to November 30, 2004, to pursue foreign launch options (PL 109-155, 2005).

With the retirement of the Space Shuttle and the cancellation of the Ares 1, it is unclear whether agencies such as NASA will seek launch services for scientific payloads from US commercial launch providers, or if more missions will be pursued as international scientific missions to enable the use of foreign launch providers.

The Secretary of Transportation, in 2004, was directed to enter into an arrangement with a non-profit entity to conduct an independent comprehensive study of the liability-risk-sharing regime in the US for commercial space transportation. Congress directed the non-profit entity to determine whether the current system could be eliminated and what other methods might be feasible. According to interviewees, the liability-risk-sharing regime would again have to be studied to ensure the proper coverage for increased use of commercial launches for government activities, particularly those including the transport of people into space.

Congress Influences Organizational Elements through Trade Policy

Block 18: Congress Influences Commercial Space and the Industrial Base through Trade Policy

Congress revised the term “launch” to include activities involved in the preparation of a launch vehicle or payload for launch when those activities take place at a launch site in the US (PL 105-303). This creates a license requirement for activities not actually involved in physically putting a spacecraft into orbit. This could create a larger burden on launch providers if there is an increase in commercial launch activity due to the cancellation of the Ares 1.

Additionally, as part of the NASA Authorization Act of 2008, to stimulate commercial use of space, to help maximize the utility and productivity of the International Space Station, and to enable a commercial means of providing crew transfer and crew rescue services for the International Space Station, the agency was directed to issue a notice of intent to enter into a funded, competitively awarded Space Act Agreement with two or more commercial entities for a Phase 1 Commercial Orbital Transportation Services crewed vehicle demonstration program (PL 110-422). NASA will likely become reliant on commercial or foreign crew transfer and crew rescue services with the cancellation of the Ares 1 and the retirement of the Space Shuttle.

Block 29: Congress Influences Civil Space through Transportation Policy

The Administrator of NASA, in the Commercial Space Act of 1998, was directed to use space transportation services from US commercial providers unless it is inconsistent with international agreements or international cooperative efforts, or unless it is more cost effective to transport a payload in conjunction with the test or demonstration flights of a government-owned space vehicle (PL 105-303, 1998).

Additionally, under this Act, the Agency was directed to prepare for the privatization of the Space Shuttle, which never came to fruition (PL 105-303, 1998).

These decisions preceded the development of the Ares 1 launch vehicle. However, as one interviewee pointed out, as a federal government program, it could have been seen as unnecessarily competing with commercial industry, which is already in the process of developing launch vehicles to reach low earth orbit and the International Space Station. As such, its cancellation was necessary to allow for a more competitive commercial market place for US commercial launch providers. However, Congress has mandated the use of Ares 1 components for future space systems through other policy documents and laws (PL 111-267).

Block 11: Congress Influences National Security Space through Trade Policy

The Commercial Space Act of 1998 allows exemptions for the government acquisition of commercial space transportation services if the Secretary of the Air Force determines that acquisition of commercial launch services is inconsistent with national security objectives (PL 105-303, 1998).

As several interviewees pointed out, the cancellation of Ares 1 launch vehicle will open more doors for competition. However, this will not significantly influence National Security Space, because, after the Challenger accident, National Security Space payloads were not required to use the same launch platform as civil space missions (McCartney et al, 2006).

Block 37: Congress Influences the Department of Transportation through Trade Policy

The Commercial Space Act of 1998 provides for the Secretary of Transportation to establish procedures for requiring and issuing licenses to launch commercial vehicles

and obtaining operator launch licenses for launch (PL 105-303, 1998). This Act also directed the Secretary of Transportation to establish procedures for the application of government indemnification (PL 105-303, 1998).

In 2004, Congress directed the Secretary of Transportation to study the liability-risk-sharing regime and its alternatives (PL 108-428, 2004). Again, as one interviewee pointed out, policies relating to government indemnification will have to be reviewed to further account for government launches on completely commercial vehicles.

Block 5: Congress Influences Foreign Entities through Trade Policy

A number of the other policies cited in this dissertation address the direction that Federal Government payloads be launched by US launch service providers (The White House, 2006; The White House, 2010). However, the Commercial Space Act of 1998 allows for the Federal Government to not pursue US commercial launch services if it is inconsistent with national security objectives or if it is inconsistent with international agreements for international collaborative efforts relating to science and technology (PL 105-303, 1998).

With the cancellation of the Ares 1 and the retirement of the Space Shuttle, it is unclear whether agencies such as NASA will pursue more international collaborative efforts, as suggested by the US National Space Policy released in June 2010, to facilitate the use of foreign launch services.

Congress Influences Organizational Elements through Defense Policy

Block 27 and Block 9: Congress Influences Civil Space and National Security Space through Defense Policy

In the past, Congress most greatly influenced civil space through designated spending in defense authorization acts. For instance, funds made available to the Department of Defense for reusable rocket technologies were limited by those allocated to NASA for a reusable space launch program (PL 104-106, 1996). With the cancellation of the Ares 1, it is unclear whether both agencies will pursue reusable technologies in the future. Again, any commonalities between defense and civil launch vehicles would be expected to result in some cost savings.

Block 3: Congress Influences Foreign Entities through Defense Policies

Through the National Defense Authorization Acts for Fiscal Years 1999 and 2000, Congress took steps to specifically prohibit satellite launches on Chinese launch vehicles, instituted policies requiring monitoring of satellites using foreign launch providers, and directed the Secretary of State to establish guidelines for personnel assigned as space launch campaign monitors (PL 105-261, 1998; PL 116-65, 1999). The cancellation of the Ares 1 launch vehicle is not likely to influence the organizational element and policy system combinations represented in this block of the SoS.

Block 31: Congress Influences the White House through Defense Policy

Through the National Defense Authorization Acts of 1996 and 1999, Congress requested that the President submit to congressional committees a report on the effect of current export control policy on the national interests of the US, including the export of launch vehicle technology (PL 104-106, 1996; PL 105-261, 1998). Cancellation of the Ares 1 launch vehicle is not likely to be influenced by this combination of organizational elements in this policy system, given that the Ares 1 was not intended for export.

Block 40: Congress Influences Other Agencies and Organizations through Defense Policy

Through the National Defense Authorization Act for 1999, Congress required that the Secretary of State receive a technology transfer control plan for any foreign launches of US satellites (PL105-261, 1998). Additionally, the Secretary of Defense was tasked to prescribe regulations to ensure that persons assigned as space launch campaign monitors were provided with sufficient training, had adequate knowledge of the regulations prescribed by the Secretary of State, known as the International Traffic in Arms Regulations (ITAR), and have sufficient experience (PL 105-261, 1998).

The Ares 1 would have been used to transport humans and cargo to low earth orbit and the International Space Station. The ITAR would apply to the export of commercial launch vehicles and their components. As a government launch vehicle, the Ares 1 launch vehicle likely would not have been used for these types of missions.

The White House Influences Organizational Elements through Transportation Policy

Block 16: The White House Influences the Commercial Space Industry through Transportation Policy

The US Space Transportation Policy made it clear that, for the foreseeable future, the capabilities developed under the EELV program should be the foundation for access to space for intermediate and larger payloads for national security, homeland security, and civil purposes to the maximum extent possible (The White House, 2006). It also made it clear that new US commercial space transportation capabilities that demonstrate the ability to reliably launch intermediate or larger payloads should be able

to compete on a level playing field for US Government missions. As one interviewee pointed out, this particular dichotomy supports the use of the EELV without any guarantee that other platforms may not be used or considered for these types of missions in the future. Again, the fewer commonalities among launch vehicles, the scarcer any economies of scale become.

Block 24: The White House Influences Civil Space through Transportation Policy

US Space Transportation Policy has maintained that NASA be the launch agent for the civil sector and shall maintain the capability to develop, evolve, operate, and purchase services for space transportation systems necessary to meet civil requirements, including the capability to conduct manned space explorations (The White House, 2006).

Now that the Space Shuttle is retired, there will be no government capability to conduct human space exploration, because its replacement, the Ares 1, was cancelled. NASA, in 2008, announced the selection of SpaceX and Orbital Sciences Corporation to re-supply the International Space Station. SpaceX was awarded a \$1.6-billion contract for a minimum of 12 flights (SpaceX, 2010). Orbital Sciences Corporation was awarded a \$171-million contract to demonstrate a new space transportation system for delivering cargo to the International Space Station (Berger, 2008; Orbital, 2008). While these selections address the concerns for transporting cargo to the International Space Station, they do not address the issue of human transport.

Block 7: White House Influences National Security Space through Transportation Policy

As previously mentioned, the White House directed, in the 2006 US Space Transportation Policy, that the capabilities developed under the EELV program would

be the foundation for access to space for intermediate and larger payloads for national security, homeland security, and civil purposes (The White House, 2006). This document also directed that two EELV programs be maintained until it could be proven that assured access could be maintained with only one provider, and further directed that NASA and the Department of Defense examine options for future heavy-lift requirements (The White House, 2006).

As previously stated, the cancellation of the Ares 1 and the retirement of the Space Shuttle left a gap in human exploration of low earth orbit and beyond. Since the Challenger accident, National Security missions have not been dependent on a single launch vehicle and have not been required to use civil space transportation vehicles (McCartney, et al., 2006). Currently, the Delta and Atlas families of launch vehicles provide assured access to space for National Security programs.

As one interviewee noted, the government will maintain adequate launch capability for National Security missions. The interactions represented by this particular combination in the SoS are unlikely to be significantly influenced by the cancellation of the Ares 1 launch vehicle. Should a platform for civil programs be chosen that shares commonalities with those platforms used for National Security missions, it is possible that some level of cost savings will be achieved in both programs, given that overhead costs could potentially be spread across more launches.

Block 35: The White House Influences the Department of Transportation through Transportation Policy

The 2006 US Space Transportation Policy directs the US Government to provide a timely and responsive regulatory environment for licensing commercial space launch

and reentry activities (The White House, 2006). With the cancellation of the Ares 1, the government will be dependent upon commercial launch services. Again, according to interviewees, the regulations involving licensing and liability will both have to be reviewed with the future prospect of government agencies using more commercial launch services.

Block 2: The White House Influences Foreign Entities through Transportation Policy

The US Space Transportation Policy (The White House, 2006) called for US Government payloads to be launched on vehicles manufactured in the United States. Exceptions were allowed by the Director of the Office of Science and Technology Policy, in consultation with the Assistant to the President for National Security Affairs (The White House, 2006). The policy does allow for foreign launch vehicles to be used on a no-exchange-of-funds basis to support international scientific programs and for government-to-government programs (The White House, 2006).

As several interviewees pointed out, the cancellation of the Ares 1 may possibly mean that there will be more launches of civil and scientific payloads for US commercial launch providers; it may also encourage the use of foreign launch vehicles for smaller and secondary payloads, and encourage foreign cooperation to further enable the use of foreign launch providers to support international scientific programs.

Block 39: The White House Influences Other Agencies and Organizations through Transportation Policy

Through the US Space Transportation Policy (2006), the White House directed the Secretary of Commerce to encourage, facilitate, and promote US commercial space transportation activities, including human spaceflight. As previously mentioned, the

cancellation of the Ares 1 launch vehicle will open the doors for commercial spaceflight providers to provide human spaceflight services to NASA. Again, this could mean increased opportunities for companies such as the United Launch Alliance and SpaceX. However, as several interviewees also pointed out, the business case for the commercial launch industry in the US is a tough one to make, regardless of the efforts of the Secretary of Commerce. Referencing the history of the EELV program, several interviewees question whether the existing government demand for launch services could support two commercial launch providers.

The White House Influences Organizational Elements through National Security Policy

Block 34 and Block 38: The White House Influences the Department of Transportation and Other Agencies and Organizations through National Security Policy

Several of the policy interactions represented by these blocks in the SoS deal with space transportation activities involving spacecraft with nuclear power systems and the regulation of these activities (National Space Policy 1996, 2006 and 2010). Because the Ares 1 launch vehicle did not employ nuclear power, its cancellation would be unlikely to influence the organizational elements and policy combinations represented in these two blocks.

Block 23: The White House Influences Civil Space through National Security Policy

Fewer than 15 years ago, NASA was tasked to work with the private sector to develop flight demonstrators that would support a decision on the development of a reusable launch system (The White House, 1996). In *A Renewed Spirit of Discovery*, the Bush administration laid out its priorities for national space programs and directed

the development of a new crew exploration vehicle (The White House, 2004). The development of the Ares 1 launch vehicle and the Constellation program supported the 2004 White House directives.

Only six years later, the Ares 1 launch vehicle and the supporting systems that were developed as a result of policies enacted under President Bush, were cancelled by President Obama (The White House, 2004; Obama, 2010).

The latest presidential directive, found in *The National Space Policy of the United States of America*, called for research and development in support of the next generation of launch systems, including the development of launch systems and technologies necessary to assure and sustain access to space, in cooperation with US industry (The White House, 2010). This document directed the Administrator of NASA to conduct research and development in support of the next-generation launch systems, including new US rocket engine technologies, and directed the development of a new crew exploration vehicle to provide human transportation beyond low earth orbit (The White House, 2010).

As an interviewee noted, businesses cannot afford to change their plans every time there is a change in the administration. Programs of this level of complexity cannot be completed in one presidential term. Interviewees further pointed out that the cancellation risk could discourage some aspects of commercial innovation, given that there is little incentive for businesses to invest research and development dollars in a program that is unlikely to come to fruition. Additionally, NASA will be faced with large termination costs for the Ares 1 launch vehicle and its related infrastructure (Achenbach, 2010).

Block 15: The White House Influences the Commercial Space Industry through National Security Policy

The 2010 National Space Policy of the United States of America directed US Government departments and agencies to develop launch systems and technologies necessary to assure and sustain future reliable and efficient access to space, in cooperation with US industry, when sufficient US commercial capabilities and services do not exist (The White House, 2010).

With the cancellation of the Ares 1 launch vehicle, it is unclear which specific vehicle, if any, future Presidential directives and National Security documents will support. As previously mentioned, after the Challenger accident, National Security Space dependency on civil space launch vehicles was minimized, and the EELV program is now planned to continue until at least 2030 (McCartney, et al., 2006).

As several of the study participants pointed out, with the cancellation of the Ares 1, commonalities across launch vehicles will be minimized, and no efficiencies of scale will likely be realized across the National Security Space and civil space sectors. This is a bad business case for any manufacturer, and prices will likely increase.

Block 6: The White House Influences National Security Space through National Security Policy

This organizational element and policy system combination also encourages the use of launch vehicles manufactured in the United States for US Government launches (The White House, 2010). Additionally, the Secretary of the Air Force, as the launch agent for the Defense and Intelligence sectors, has consistently been tasked with

providing space access for National Security purposes (The White House, 1996; The White House, 2010).

As access to space remains vital to National Security, it is entirely probable that the Department of Defense, on behalf of the Defense and Intelligence sectors, will continue to purchase launch services from US providers. However, as pointed out by several of the study participants, there are a limited number of launches per year and few domestic commercial launches that would offset the cost.

Block 1: The White House Influences Foreign Entities through National Security Policy

The policy interactions represented in this block have dealt with non-proliferation policies and the desire to deny exports of launch vehicles and to not support the development of launch vehicles in non-Missile Technology Control Regime (MTCR) states (The White House, 1996). The cancellation of the Ares 1 launch vehicle will likely have no influence on the organizational elements and policies represented in this block.

The Department of Transportation Influences Organizational Elements through Transportation Policy

Block 12 and Block 30: Department of Transportation Influences National Security Space and Civil Space through Transportation Policy

In 1999, the Department of Transportation provided an updated, unified definition of launch, whether the launch is at federal launch site or other domestic launch site (Final Rule, 1999). Per this rule (1999), the FAA defined launch “to begin with the arrival of a launch vehicle at a federal launch range or other US launch site. Launch ends, for the purposes of ground operations, when the launch vehicle leaves the

ground, and for purposes of flight, after the licensee's last exercise control of their vehicle." As such, the FAA licenses as a launch preparatory activities that may be considered to be part of a launch (Final Rule, 1999).

While, for the most part, this is not an issue for government launches, should the vision of frequent commercial space flight be attained, this licensing requirement could become onerous for commercial providers and may have to be reviewed.

Block 19: Department of Transportation Influences the Commercial Space Industry through Transportation Policy

The Department of Transportation has defined the term "launch" to include a number of preparatory activities (Final Rule, 1999). Additionally, the agency has provided rules and regulations for launch site operators (Final Rule, 1999).

With the cancellation of the Ares 1 launch vehicle and future reliance on the commercial space industry for space transportation, it is possible that the inclusion of all preparatory activities that take place at a launch site under the definition of "launch" would become onerous should the majority of assembly operations take place at a launch site.

Other Agencies and Organizations Influence Organizational Elements through Foreign Policy

Block 21: Other Agencies and Organizations Influence the Commercial Space Industry through Foreign Policy

This specific organizational element and policy combination deals primarily with the Department of State and the ITAR. Because the Ares 1 was a domestic launch

vehicle that was not intended for either export or domestic launch of foreign satellites, it is unlikely that the Ares 1 cancellation will influence the organizational elements and policy system combinations represented in this block.

Conclusions Regarding the Potential Impacts of the Ares 1 Cancellation

While the block-by-block review of the US space launch policy SoS influencing launch vehicles did include some redundant information, it also allowed for an ordered, systematic review of existing policies, recent policy decisions, and recent Congressional actions. The information from the policy documents could be combined with the differing perspectives of the 14 subject matter experts who represented the various sectors of the space launch policy SoS. Using the 3DPDS application from the first study allowed for a more targeted analysis of the organizational elements and policy systems that influenced, and were impacted by, the decision to cancel the Ares 1.

It is impossible to predict the future with complete and total accuracy, but the systematic review conducted for this dissertation suggests that the price per launch for national security space missions will increase, that doors may be opened for the US commercial launch industry, and that Congress and the White House will continue to influence the future of space launch policies and space launch vehicles in the US.

Potential Increase in Price for National Security Space Launches

As previously mentioned, the Ares 1 launch vehicle was designed to use existing Space Shuttle Main Engine (SSME) Block II engines that were used for the Space Shuttle. For heavier cargo, it would use three Pratt & Whitney Rocketdyne RS-68 engines used on the Boeing Delta IV family of launch vehicles (Cowing, 2005). Should National Security Space and civil space programs both use the same engine manufacturer, then National

Security Space would not have to bear the entire financial responsibility for overhead costs for producing these engines, and, theoretically, the price per unit would go down. Interviewees have suggested that the price for rockets using these engines has already increased in reaction to the Ares 1 cancellation as commercial industry leaders reevaluate their business plans. However, the Atlas and Delta families of launch vehicles do provide assured access to space for National Security purposes.

United Launch Alliance, the joint venture formed by Lockheed Martin and The Boeing Company, had its 50th successful launch in May 2011, and it celebrated its fourth anniversary in December 2010. Fifty launches in 53 months is less than one launch per month. As pointed out by several of the subject matter experts, this is a poor business case made worse by the fact that these launches are completed using a variety of launch vehicles; therefore, there is limited commonality and a number of non-recurring engineering costs involved in each launch. In 2010, the United Launch Alliance launched four Atlas V, one Delta II, and three Delta IV rockets (ULA, 2010). Additionally, of the eight launches United Launch Alliance conducted in 2010, only two were for NASA payloads, and only one was a commercial launch (ULA, 2010). That leaves the government, particularly National Security Space, to pick up a large portion of the overhead costs for United Launch Alliance.

Potential for More Competition in Commercial Market Place

The cancellation of the Ares 1 (Obama, 2010) together with the current national space policy (The White House, 2010) suggests that NASA should use commercially available modes of transportation to the International Space Station. SpaceX recently demonstrated its capabilities to launch cargo into outer space by successfully launching

a Falcon 9 rocket and the company's reusable Dragon space capsule. The rocket also carried an Army nano-satellite into orbit.

However, prospects for a truly competitive marketplace are limited. In December 2008, NASA selected SpaceX's Falcon 9 launch vehicle and Dragon Spacecraft to re-supply the International Space Station and selected the Orbital Science Corporation to demonstrate a transportation system for delivering cargo to the International Space Station following the retirement of the Space Shuttle (SpaceX, 1010; Orbital, 2011).

As previously mentioned, the low number of commercial launches conducted by the United Launch Alliance puts a tremendous burden on the government to fund the venture's overhead costs. Should the SpaceX and Orbital vehicles prove to be reliable platforms over time, it is unclear how this will influence the market place.

Presidential Directives Are Limited by Congress

Whereas, in some instances, one may be left to speculate on the actions that Congress may take next to influence the issue at hand, that is not the case in this particular situation, given that the NASA Authorization Act for 2010 was passed after the data collection for this particular study was completed. The Act provided authorizations for NASA projects for Fiscal Year 2011 through Fiscal Year 2013. While this multi-year authorization act will provide some stability and consistency in Congressional direction over the next couple of years, the Act certainly is not an outright authorization in support of current Presidential guidance.

While the President has recommended the development of a new launch vehicle and new technologies, Congress has gone in another direction (The White House, 2010). Regarding the next launch vehicle, termed the "Space Launch System" in

current legislation, Congress has already placed limitations on NASA. For instance, to limit the termination liability for elements of the Constellation program, Congress directed the Administrator of NASA to extend or modify existing development and associated contracts (PL 111-267, 2010). Additionally, Congress instructed the Agency to utilize the existing contracts, investments, industrial base, and capabilities from the Space Shuttle and Ares 1 projects, including Space Shuttle-derived components and Ares 1 components that use existing US propulsion systems (PL 111-267).

The directive to utilize so many of the technologies and sub-systems that were designed to be part of the Space Shuttle-derived Ares 1 launch vehicle significantly limits any new or innovative developments in the commercial sector. There has been nothing done to encourage the growth of the commercial space industry, because this legislation targets those in the industry with existing contracts, which is contrary to the goal of enabling an expanded commercial presence in low earth orbit.

Furthermore, while the Act states that reliance on the use of non-US human space flight capabilities should exist only as a contingency, it is clear that the US will be continue to dependent on foreign spacecraft for crew transportation needs to and from the International Space Station.

Chapter 7: Conclusions

The Three-Dimensional Policy Design Structure and the US Space Launch Policy System of Systems

The necessity for a new method of analysis for the examination of a policy SoS was determined in the first part of this dissertation. The Three-Dimensional Policy Design Structure (3DPDS) was introduced in Chapter 3. The viability of the 3DPDS was demonstrated in three applications examining the US space launch policy SoS in Chapter 6.

The 3DPDS, as used in all three applications described in this dissertation, provided an objective, reliable, and repeatable means by which to dissect the interrelationships and interdependencies of a policy SoS while maintaining a holistic perspective of the policy environment. In the first two applications, the 3DPDS was used to identify the policy interactions within the US space launch policy SoS relevant to space launch vehicles and space launch facilities, and it provided a holistic picture of the policy relationships that influenced these two elements of space launch capacity. In the third application of the method, 3DPDS provided for the systematic evaluation of a current policy decision.

The 3DPDS identified an additional system actor (the Department of Transportation) in the first application, which was carried throughout the remainder of the document. After having been identified as such, the Department of Transportation was included [in the analysis as its own organizational element after a number of interactions attributed to “other agencies and organizations” were identified that originated with the agency or influenced the agency. It is reasonable to assume that other system actors could have been identified by further decomposing the “other

agencies and organizations” until each individual organizational element had been identified, which could make deeper, specific studies more efficient.

Several criteria, as discussed in Chapter 3, were used to evaluate the 3DPDS. With regard to those criteria, the 3DPDS clearly helped to illustrate the policy interactions that most frequently have occurred within the US space launch policy SoS relative to the two elements of launch capacity that were examined: space launch vehicles and space launch facilities. In the first application of the 3DPDS, the subject matter experts who were interviewed cited policy decisions that corresponded to nine of the ten most-frequent organizational element and policy system combinations contained within the policy document dataset and that corresponded to 14 of the 35 total organizational element and policy system combinations captured in the space launch vehicle dataset. Interviewees discussed policy decisions for all five of the specific policy systems identified within the space launch policy SoS and for one of the two identified policy system “outliers.”

In the second application of the 3DPDS, experts referred to policy passages that contain 17 of 38 organizational element and policy system combinations that were identified in the 3DPDS examining the policy decisions related to space launch facilities, and they referred to one of the nine policy outliers identified in the 3DPDS. Several organizational element and policy system combinations were identified through the use of the 3DPDS that were not referenced during the interview process. This demonstrated that the 3DPDS could be helpful in identifying policy interactions, and potentially even system and non-system actors, that may otherwise go unnoticed or not even be considered.

In the second application, the 3DPDS provided for a more comprehensive and holistic perspective of policy interactions within the US space launch policy SoS than was provided by interviews with a high-quality representative sample of experts from all of the major sectors of the US space launch policy SoS. The 3DPDS identified those policy interactions most frequently referenced by industry experts and a number of outliers that could deserve attention. The visual depictions in the 3DPDS very clearly illustrated the organizational element and policy system combinations within which policy interactions frequently occurred.

The 3DPDS provided a much more comprehensive view of the policy interactions involved in the space launch policy SoS pertaining to the two applications than the interview process had provided. A number of policy interactions were identified from the policy documents in each of the 3DPDS applications that would not have been apparent from the interview data alone. The interview process did not reveal any policies, passages, or interactions in either of the first two applications that were not already captured in the 3DPDS. Thus, it may be concluded that the output from the 3DPDS more comprehensively identified the policy interactions within a complex policy SoS such as US space launch policy.

While the overall analytic approach using 3DPDS cannot be used to determine whether any of these policy interactions are any more or less important than any other, it does indicate the frequency and relative concentrations of interactions between specific organizational elements. In many fields of research, frequency and concentration are leveraged to determine whether value and significance exist in the

data collected with respect to the hypotheses being tested or the questions being addressed.

Application of the 3DPDS illustrated a complex policy SoS, in which numerous system and non-system actors are influenced, or impacted, by a several different policy systems. The 3DPDS allowed for the identification of frequent policy interactions in the US space launch policy SoS, high concentrations of policy interactions among the various organizational elements, and policy outliers.

Separate criteria were established in Chapter 3 to evaluate the use of the 3DPDS in the third application. Regarding these criteria, the use of the 3DPDS allowed for the ordered examination of a current policy issue—the decision to cancel the Ares 1—by providing a targeted framework of the organizational relationships and policy systems that should be examined as part of a study involving space launch vehicles.

In this case, the dataset of policy interactions specific to the Ares 1 launch vehicle was a subset of the dataset relevant to space launch vehicles in general. This suggests that using the results of a previous application of the 3DPDS may be appropriate for the deeper analysis of a subset of a particular dataset.

The 3DPDS focused the examination of the policy relationships within the SoS. Various policy interactions identified through the use of the 3DPDS were not referenced during the interview process. This suggests that an analysis using the 3DPDS may be more comprehensive than one that relies solely on the input and experience of subject matter experts. However, the analysis performed in the third application of the 3DPDS would have been lacking were it not for the expert opinions gleaned from the interview process that augmented the formal policy decisions. Use of the 3DPDS allowed for the

systematic incorporation of these opinions with the specific policy decisions to which they pertain, resulting in a more comprehensive understanding of the policy SoS and the potential impacts of these policy decisions.

While additional applications will have to be performed before methods of analysis using the 3DPDS could be considered to be validated, this research has provided an important initial step in this process and has demonstrated two different ways in which the 3DPDS could be employed to examine policy systems of systems.

Re-Addressing the Existing Literature and Looking Forward

While the techniques used to study the space launch policy SoS were drawn largely from the systems engineering literature, the 3DPDS is intended to address perceived gaps in the SoS literature that exist within the social sciences.

Early work within the social science fields included the “SoS methodologies” described by Jackson and Keys. Jackson and Keys (1984) defined various problem context classifications for systems in the social sciences. Oliga merged the various problem contexts proposed by Jackson and Keys with the schema proposed by Banathy (Oliga, 1988; Jackson and Keys, 1984; Banathy, 1987). This merger resulted in a depiction of the various methods of analysis appropriate for the study of each schema and problem context, as discussed in Chapter 1 (Oliga, 1988; Jackson and Keys, 1984; Banathy, 1987).

The problem contexts and systems analytical methods described by Oliga (1988) identified a particular gap in the literature: a lack of analytical methods for the examination of mechanical-coercive and systemic-coercive problem contexts. The 3DPDS proposed in this dissertation could be used to examine the systemic]-coercive

problem context more rigorously and more comprehensively. Other problem contexts might also be suitable for analysis using the 3DPDS, which would make the 3DPDS more widely applicable.

As discussed in Chapter 1, the US space launch policy SoS would be classified as “systemic,” given the problem contexts introduced by Jackson and Keys, because it is a very complex policy SoS with divergent goals, as opposed to being classified as a mechanical system that contains relatively simple systems. The US space launch policy SoS also would be classified as “coercive,” as there is conflict internal to the SoS and overarching policy and guidance often are the result of the exercise of Presidential power.

By applying the 3DPDS to a systemic-coercive problem context, such as the US space launch policy SoS, this dissertation begins to demonstrate that the 3DPDS could be used to better “unpack,” or dissect, the organizational elements and policy systems within a very complex policy SoS for closer examination of those various elements and systems. This suggests that, after the 3DPDS is further tested, refined, and validated, the 3DPDS may provide a method by which other problem contexts could be examined, it could be used to fill one of the methodological gaps identified by Oliga (1988).

A Future Research Agenda

This dissertation provides a method for the analysis of policy SoS that incorporates elements of the engineering and the social science literature. The 3DPDS could provide researchers with a method of analysis that can be readily understood by practitioners in each field.

While the 3DPDS was applied to national-level government policies in this dissertation, with further testing and refinement, the method could be applicable to any policy SoS in which multiple organizational elements interact with each other through a number of policy systems. This type of analysis could help researchers in government and academia to address multi-agency policy issues in which stove-piped, or highly compartmentalized, organizations are involved.

The results of and observations from the applications described in this dissertation are only the first steps toward validating methods of analyses that incorporate the 3DPDS. The three closely related applications of the 3DPDS provided stability for the initial tests of the 3DPDS by limiting the organizational elements and policy areas that constitute the SoS being studied. To establish the versatility of the 3DPDS, it will be necessary to apply it to analyses that address a broader sampling of policy SoS. The 3DPDS could be used to examine a broad range of complex policy constructs, including those related to disaster relief, maritime security, and even education policy. Additional carefully chosen and carefully constructed future studies may help to develop standard guidelines and procedures for employing the 3DPDS. Further study of its application could also define the limits in how and under what circumstances this new analytical technique can be applied. The application of the 3DPDS to a wide variety of policy areas, organizational elements, and specific issues will provide an opportunity to further test and evaluate analytical techniques that may benefit from use of the 3DPDS.

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Appendix A: Policy Document Data

Source Number	Source Document	Policy Type	Originating Organizational Element	Organizational Elements Impacted by Passages Specific to Launch Vehicles, Launch Facilities, or the Constellation Program									Number of Interactions in Document Specific to Vehicles, Facilities or Ares 1			Number Of Passages In Document Specific to Vehicles, Facilities or Ares 1		
				Foreign Entities	NSS	Industry	Civil Space	White House	Congress	DoT	Others	Vehicles	Facilities	Ares 1	Vehicles	Facilities	Ares 1	
1	National Defense Authorization Act for Fiscal Year 1996	Defense	Congress		X		X	X					4	2		2	1	
2	US National Space Policy, PDD/NSC-49/NSTC-8	National Security	The White House	X	X	X	X				X	X	16	9		10	5	
3	National Defense Authorization Act for Fiscal Year 1997	Defense	Congress		X		X						4	2		2	1	
4	National Defense Authorization Act for Fiscal Year 1998	Defense	Congress		X									1		1		
5	National Defense Authorization Act for Fiscal Year 1999	Defense	Congress	X	X								3	2		2	1	
6	National Security Strategy for a New Century (1998)	National Security	The White House		X		X							2		1		
7	Commercial Space Act of 1998	Trade	Congress	X	X	X	X				X		17	9		9	5	
8	Amendments to the International Traffic in Arms Regulations (1999)	Foreign Relations	Other (DoS)	X		X							2	2		1	1	
9	Commercial Space Transportation Licensing Regulations (1999)	Transportation	Department of Transportation		X	X	X						4	6		2	2	
10	Department of Defense Directive 3100.10 (1999)	Defense	National Security Space			X								1		1		
11	National Defense Authorization Act for Fiscal Year 2000	Defense	Congress	X	X				X			X	10	3		5	2	
12	National Aeronautics and Space Administration Authorization Act of 2000	Transportation	Congress	X		X	X	X		X			8	5		4	2	
13	National Defense Authorization Act for Fiscal Year 2001	Defense	Congress								X			1		1		
14	Commercial Space Transportation Competitiveness Act of 2000	Transportation	Congress			X				X			2			1		
15	Memorandum of Agreement between USAF, DoC, and FAA (2002)	Other	NSS (USAF), DoC, DoT (FAA)			X								3		3		
16	Amendments to the United States Munitions List (2002)	Foreign Relations	Other (DoS)	X		X							2			1		
17	National Defense Authorization Act for FY 2004	Defense	Congress		X								1	1		1	1	
18	US Space Exploration Policy, NSPD-31(2004)	National Security	The White House			X	X						6	1		7	2	
19	A Renewed Spirit of Discovery (2004)	Transportation	The White House			X	X						2		1	1		1
20	National Defense Authorization Act for FY 2005	Defense	Congress		X								1	1		1	1	
21	An Act to Extend the Liability Indemnification Regime for the Commercial Space Transportation Industry	Transportation	Congress	X		X				X	X		8	8		2	2	
22	Commercial Space Launch Amendments Act of 2004	Transportation	Congress			X	X			X			19	2		15	1	
23	US Space Transportation Policy, NSPD-40 (2005)	Transportation	The White House	X	X	X	X	X		X	X		34	20		19	11	
24	National Aeronautics and Space Administration Authorization Act of 2005	Transportation	Congress	X			X						8	3	2	4	1	2
25	National Defense Authorization Act for FY 2006	Defense	Congress		X		X							2		1		
26	Miscellaneous Changes to Commercial Space Transportation Regulations (2006)	Transportation	Department of Transportation			X							1	1		1	1	
27	US National Space Policy, NSPD-49 (2006)	National Security	The White House		X	X	X	X		X	X		12	3		6	2	
28	National Defense Authorization Act for Fiscal Year 2007	Defense	Congress		X		X						3	1		2	1	
29	National Defense Authorization Act for Fiscal Year 2008	Defense	Congress		X	X	X						3	3		1	1	
30	National Aeronautics and Space Administration Authorization Act of 2008	Transportation	Congress		X	X	X	X			X		14	5	5	9	3	5
31	Consolidated Appropriations Act of 2010	Transportation	Congress				X						1	1	1	1	1	1
32	Amendment to the International Traffic in Arms Regulations (2006)	Trade	Other (DoS)	X	X	X				X				4		1		
33	The National Space Policy of the United States of America (2010)	National Security	The White House		X	X	X			X	X		12	12	6	6	6	2
Totals													197	116	15	115	63	11

Appendix B: Interview Questions

Substantive Questions:

1. Is your area of expertise in civil, commercial, or national security space?
 - 1a. Could you expand on this?
 - 1b. With which programs are you most familiar?
2. This study specifically studies US Space Launch Policy, particularly those issues that impact launch capacity. Do you recall any policy decisions have impacted launch capacity for your organization?
 - 2a. Was the impact positive or negative?
 - 2b. How was your organization impacted by these decisions?
3. Do you find that your segment of the space industry (commercial, civil, or national security) shares goals with the other segments of the industry?
4. Have policy decisions that were implemented by other segments, or to affect other segments, impacted your organization?
 - 4a. How?
 - 4b. Do you think these impacts could have been predicted?
5. If you are willing to do so, please provide a short narrative of an instance where a policy decision intended for another organization negatively (positively) impacted your organization in terms of launch capacity.
6. Is there any other additional information you would like to share related to US launch policy or launch capacity?

Appendix C: Annotated List of Figures

- Figure 1.1: Problem Context Classifications
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Systems Methodology for the Management Sciences, Jackson, Michael C.
Page 29, Figure 2.2, Copyright 1991 by Plenum Press.
- Figure 1.2: Problem Contexts and Systems Methodologies
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Systemic Practice and Action Research, Methodological
Foundations of Systems Methodologies, Vol. 1, No. 1, 1988, Page
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- Figure 2.1: Number of Domestic Commercial Launches per Year
Figure Created by Tami L Mitchell
Data from FAA Historical Launch Data, 2011
- Figure 2.2: PERT Chart
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- Figure 2.3: A Social Network Diagram
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- Figure 2.4: The Problem of the Seven Bridges of Königsberg
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- Figure 2.5: DSM Example 1
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Dunn and Sussman. Using Design Structure Matrices to Improve
Decentralized Urban Transportation Systems. *Massachusetts Institute of
Technology Engineering Systems Division Working Paper Series*. ESD-
WP-2005-08. August 2005
- Figure 2.6: DSM Example 2
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Decentralized Urban Transportation Systems. *Massachusetts Institute of
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With Kind Permission from Trevor Mower and Timothy Thielke
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- Figure 6.3: Three Dimensional Policy Design Structure for the Space Launch
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- Figure 6.4: Three-Dimensional Policy Design Structure Depicting Policy
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With Kind Permission from Trevor Mower and Timothy Thielke
- Figure 6.5: Clustering Technique Applied to Interactions within the Space
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- Figure 6.6: View of Policy Interactions Influencing Space Launch Vehicles by
Policy System: The Transportation Policy System
With Kind Permission from Trevor Mower and Timothy Thielke

- Figure 6.7: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Transportation Policy System
With Kind Permission from Trevor Mower and Timothy Thielke
- Figure 6.8: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Defense Policy System
With Kind Permission from Trevor Mower and Timothy Thielke
- Figure 6.9: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Trade Policy System
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- Figure 6.10: View of Policy Interactions Influencing Space Launch Vehicles by Policy System: The Foreign Policy System
With Kind Permission from Trevor Mower and Timothy Thielke
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Figure 6.18: View of Policy Interactions Influencing Space Launch Facilities by Policy System: Other Policy Systems
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Figure 6.19: View of Policy Interactions Influencing Space Launch Facilities by Policy System: The Foreign Policy System
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Figure 6.20: Policy Document Data and Interview Data Depicting Policy Interactions that Influenced Space Launch Facilities
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