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DOD Mission Engineering and Integration Explorative-Exploitative Architecture for Technology Innovation

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DOD MISSION ENGINEERING AND INTEGRATION EXPLORATIVE-EXPLOITATIVE ARCHITECTURE FOR TECHNOLOGY INNOVATION

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ABSTRACT

DOD MISSION ENGINEERING AND INTEGRATION EXPLORATIVE-EXPLOITATIVE ARCHITECTURE FOR TECHNOLOGY INNOVATION

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The ability of U.S. Department of Defense to achieve timely innovation in support of U.S. National Defense and Military Strategies continues to increase in significance. The growing challenges in U.S. Department of Defense (DoD) technological innovation in a context of global security and rapid pace of global competitiveness continue to reveal many shortcomings in current weapon systems development and acquisition practice. As the pace of technological innovation is accelerating, the DoD faces the challenge that the same disruptive technological advances are also being made available to or developed by its adversaries. Based on literature review, no innovation system theory exists that accounts for organization interaction with the environment given socio-economic objectives and associated missions, including a less closed-system approach to interactions across the private and public sector boundaries.

The Mission Engineering Explorative-Exploitative Architecture for Innovation expands Bennan & Tushman's (2003) and O'Reilly & Tushman (1996) explorative-exploitative theory from a process management, innovation behavior, and private firm's performance within the context of environmental technological change. A System Theory framework based qualitative content analyzes the innovation and Department of Defense dataset and produced a set of initial seed-categories. These seed-categories were interpreted resulting in architectural views and associated propositions. The resulting architecture contributions are propositional definitions for

Mission Engineering and Integration Management functions in the context of military missions and complex situations including constructs for identifying socio-technical misalignments as basis for understanding and identifying technological innovation opportunities and associated partnerships.

DISCLAIMER

In accordance with 5 CFR § 3601.108 - Disclaimer for speeches and writings devoted to agency matters

"The views expressed are those of the author and do not reflect the official policy or position of the U.S. Department of Defense or the U.S. Government."

This dissertation is dedicated to my wife, son and daughter.

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NOMENCLATURE

ASDR&E	Assistant Secretary of Defense for Research and Engineering
DoD	Department of Defense
JCIDS	Joint Capabilities Integration and Development System
IAC	International Armaments Cooperation
NATO	North Atlantic Treaty Organization
DoN	Department of the Navy
S&T	Science and Technology
RDT&E	Research, Development, Test and Evaluation

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CHAPTER 1

INTRODUCTION

1.1. THEORETICAL AND TECHNICAL FORMULATIONS

The U.S. DoD Science and Technology community and the U.S. DoD national security research and development enterprise are structured to respond to military threats and economic opportunities of the last century. From power and energy to intelligence gathering, stealth technologies, precision-guided munitions, integrated command and control, the national security research and development system relied on an inwardly focused strategy. NSTC (2016) recognizes that national security science, technology, and innovation enterprise involves a "*much larger ecosystem of academic and industry stakeholders*." The strategy also calls for modernization of the enterprise to ensure: "*(1)* The ability to access the best talent in the world for the national security mission; (2) Proactive and collaborative investments in specialized facilities necessary for critical national security science and technology needs; (3) Intelligent management of the business of national security science and technology, and associated risks, to achieve the best outcomes as an enterprise; and (4) Adoption of transformative frameworks and innovative practices from the private sector, where it makes sense to do so for the national security mission." (Holdren, 2016, p. ii)

Kadtke and Wells (2014) propose near term changes in foresight, international governance, public-private cooperation, and workforce development changes for maintaining DoD global leadership in technological innovation. The current U.S. DoD Security Cooperation statutory framework from the U.S. Congress directs DoD to consider partnerships with allied partners as an integral element of the DoD mission. In a Congressional Report on Security

Cooperation Issues, Skorupski & Serafino (2016) state that the current statutory framework for security cooperation “has evolved into a cumbersome system,” including inconsistent definitions and practices for interagency coordination. The International Armaments Cooperation is part of the DoD’s Security Cooperation framework for co-development, delivery, and sustainment of technologically superior weapon systems. The Recent DoD guidance for maintaining technological superiority published by the Assistant Secretary of Defense for Research and Engineering (2014) includes allied partner organizations as part of the DoD’s Research Engineering Enterprise. The DoD’s International Science and Technology Engagement Strategy publication promotes an increase of situational awareness across the military services’ through intra-agency coordination and the use of science and technology roadmaps to establish and strengthen international science and technology partnerships. The historical evolution of International Armaments Cooperation started with the premise that the U.S. would be open to allied partner cooperation in return for access to the European market. Yan and Azadegan (2017) investigate characteristics of international joint development programs that result in cost, schedule, and technical program impacts as well as the quality of the final product. Kapstein (1991) argued that national solutions to acquire high-technology defense products dependent on technological and financial assets. He argues that when states have the scientific, industrial base, and financial resources, they will pursue autonomous solutions to weapons acquisition. When countries achieve a certain level of technological capability but lack financial support, they seek to share development risks for collaborative development projects.

Today there is a recognition that the clear technological advantage by U.S. national security science and technology enterprise and industrial base is at risk. The U.S. DoD lacks an effective innovation architecture to support the National Security Strategy. Pollock (1999) addresses international cooperation issues: (1) program selection; (2) poor timing; (3) lack of training; (4) cultural issues. U.S. government personnel view international armaments cooperation view as highly problematic, adding risks to program managers without compensatory advantages.

Rogers (2003) argues that "*getting a new idea adopted, even when it has obvious advantages, is difficult.*" He defines diffusion as *"the process in which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas."* (Rogers, 2003, pp. 35-36)

Benner & Tushman (2003) argue that "process management activities must be buffered from exploratory activities and that ambidextrous organizational forms provide the complex contexts for these inconsistent activities to coexist."(p. 238)

1.2. RESEARCH PURPOSE

The research purpose is to develop a Systems Theory-based Mission Engineering and Integration Explorative-Exploitative Architecture for Technology Innovation and focusing on exploration-exploitation technology innovation for military weapon systems that will provide the means to:

- Perform Mission Engineering functions that will promote the conceptualization of missions by defining and linking activities, resources, and technologies against vulnerabilities and threats

- Perform Interoperability and Integration management functions related to the ability of the mission constituents to interoperate, maintain resilience and levels of redundancy at an aggregate level
- Use Mission Engineering, Interoperability and Integration Management parameters to identify promising technological innovation partnership opportunities
- Identify conditions linked to explorative and exploitative innovation partnerships with allies for technological innovation diffusion of weapons technologies.

1.3. RESEARCH PROBLEM

No unified theoretical basis exists to evaluate the conditions for the development of strategies for allied partnerships in support of mission-driven technological innovation goals.

- Harmonization of mission-driven operational needs
- Context-driven technological innovation opportunity identification
- Understanding the degree of innovativeness of external partners
- Socio-cultural-economic attributes that aid the evaluation of conditions for explorative and exploitative partnerships for technological innovation

1.4. RESEARCH DELIMITATION

This research used publicly available corpora related to military missions with global linkages among missions, tasks, platforms, systems, components, and enabling technologies to support the definition of high-level Mission Engineering and Integration Management functions. The corpora used in the content analysis was be limited to the past 15 years with a specific focus on the following theories and research areas:

- Innovation Diffusion research focusing on definition and evaluation of conditions that help innovation
- Explorative-Exploitative Innovation
- Mission Engineering and Integration
- Inter-Organizational Partnership selection research
- For International Armaments Cooperation corpora used will be post-DoD Authorization Act of 1986. The context of focus is U.S. DoD.

The applicability of the architecture is a topic of future research. Researchers are responsible for making their judgment on widening the scope of research results to their intended research problems. This research did not address the use of architectural elements defined for designing new techniques for estimating the rate of innovation. The focus and delineation of the research are for characterization of the conditions/antecedents and evaluation of condition parameters to estimate innovation opportunities that include international cooperation from a mission-driven perspective.

1.5. RESEARCH SIGNIFICANCE

Theoretical: The seed-categories, architectural views, and propositions from this research expand Benner & Tushman (1996), Rogers (2003) explorative-exploitative innovation as well as innovation diffusion from a profit and market share focused performance within the context of technological cycles and competition to a broader cross-sector model of explorative-exploitative innovation taking into account additional organizational, management, leadership, and resource characteristics within a broader technology cycle, socio-economic objective, and well-being of society context structured from a perspective of U.S. Department of Defense and military task and strategic planning structure. The Mission Engineering and Integration propositional functions build upon Sousa-Poza's (2016) Mission Engineering functions within the Mission Engineering continuum within complex situations.

Methodological: The Mission Engineering and Integration Explorative-Exploitative Architecture for Technological Innovation will provide a starting point for future methodologies in Mission Engineering and Integration, and identification of explorative-explorative partnership opportunities with allied partners for technological innovation and diffusion.

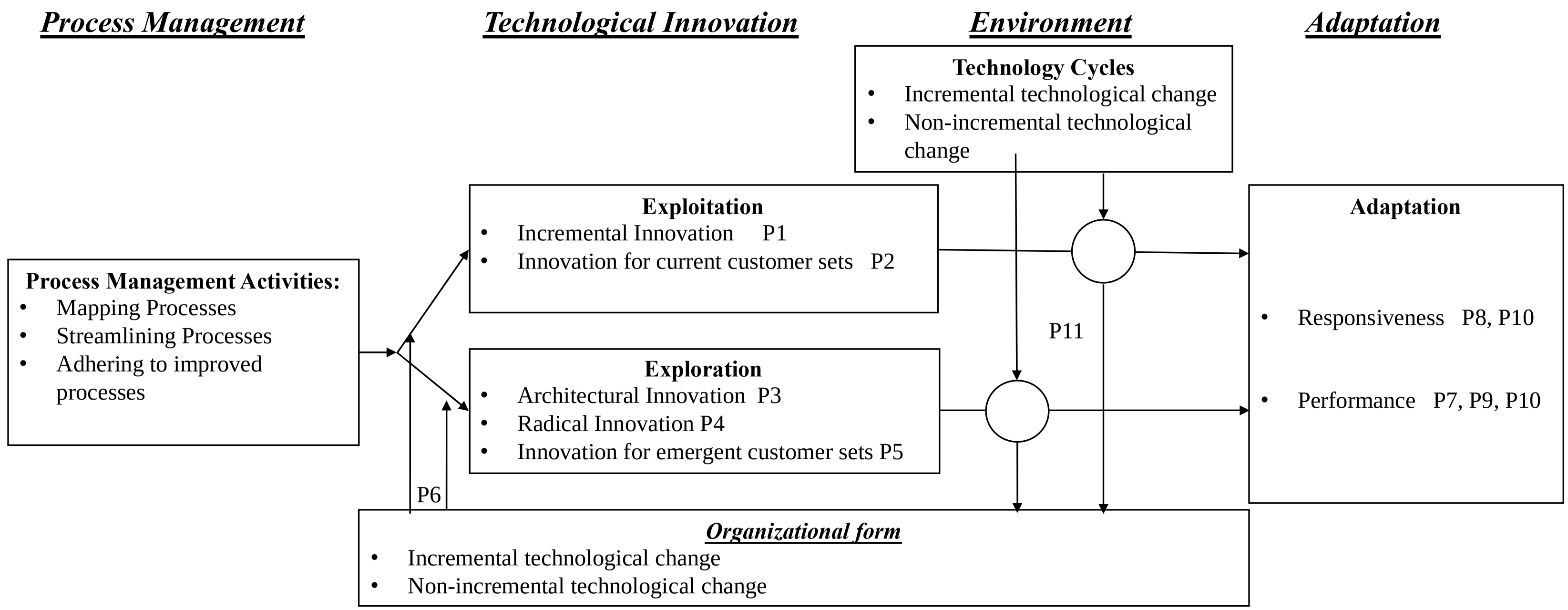
Practical: The architecture will be a starting point for operationalizing its seed-categories and propositions into information systems supporting strategic planning for technological innovations and partnership management. The information systems can serve as a coordination and harmonization instrument over appropriate communication channels to facilitate agile generation of strategic plans related to addressing mission needs with technological innovation. This includes analytical facilities to help decision makers better understand the impacts of policies related to technical innovation across the areas of innovation activities such as research, development, prototyping, and experimentation.

CHAPTER 2

BACKGROUND OF THE STUDY

2.1 EXPLORATIVE AND EXPLOITATIVE INNOVATION

O'Reilly & Tushman (1996) argue that firms must continuously explore and exploit opportunities for innovation to grow and stay viable in the long run amid external environmental influences like technological change, levels of globalization, and intensified competitive landscape. Brenner & Tushman (2003) proposed the initial integration of exploitation, exploration, and process management that culminated in a model shown in Figure 1, including 11 testable propositions about the relationship between a firm's process management and innovation. According to Benner & Tushman (2003) the organizational environment is characterized technological variation cycles, alternating between periods of incremental change and rapid innovation. Exploitative organizational patterns are associated with the organization's incremental adaptation within the context of a stable environment. Explorative organizational patterns are associated with organization's response to a higher degree of environmental uncertainty caused by rapid innovation and change.



Propositions - Increases in Process Management Practices will:

P1 Promote incremental innovation
P2 Promote innovation for existing customer sets
P3 Decrease architectural innovation
P4 Decrease radical innovation
P5 Decrease innovation for new customer sets
P6 Increase exploitative innovation but do not dampen exploratory innovation

P7 Improve performance in eras of incremental technological change
P8 Speed organizational responsiveness during eras of incremental technological change
P9 Decrease performance in eras of technological ferment
P10 Slow organizational responsiveness in eras of technological ferment
P11 Will enhance responsiveness and performance during eras of incremental technological change but will have no effect on responsiveness or performance during eras of technological ferment

Figure 1. Explorative-Exploitative Architecture. Source: (Tushman & O' Reilly, 1996, p.244)

Benner & Tushman (2003) defined propositions on how high-technology commercial firms process management practices affect dynamic organizational capabilities. Additional research investigated exploration and exploitation by testing hypotheses and linking several organizational, leadership, and contextual factors to a firm's success. (Gupta, Smith, & Shalley, 2006; Jansen, 2006; Andriopoulos & Lewis, 2009; Li, Vanhaverbeke, & Schoenmakers, 2008).

The environmental context, socio-technical factors, and associated explorative-exploitative models influence innovation strategies that consider variables reflecting the competitive landscape and its relative position in the market. Benner & Tushman's propositions revolved around the concept of process management with attributes within organizational behavior, nature of innovation (incremental versus radical), sales, management ambidexterity, adaptation against stable and turbulent environments, and the financial performance of the firm.

O'Reilly & Tushman (1996) researched management and organizational ambidexterity, focusing on innovation patterns in technological cycles. They also highlight organization learning behavior, using feedback from the market to continuously refine the organization to accomplish its mission. Mueller et al. (2013) focus on institutional environmental conditions of national culture (collectivism, power distance, uncertainty avoidance) and social welfare (level and distribution) that influence firm performance in exploratory and exploitative innovation.

2.2 STRATEGY AND INNOVATION

In 2015 the United States Defense Business Board published a report to the Secretary of Defense titled "Innovation: Attracting and Retaining the Best of the Private Sector." (Defense Business Board Task Group, 2015) The report included over 40 interviews with leaders in commercial companies. The report recommendations include DoD policy and process changes, improved messaging, program, and industry structure changes. Some highlights are:

- The DoD is considered an “adjacent” market to commercial companies.
- Commercial companies don’t have incentives to change their business models to sell to the U.S. Department of Defense

On the need for both sustaining and disruptive innovation in DoD.

- DoD has (inadvertently) erected barriers against innovation.
- DoD acquisition current acquisition system characterized as a “closed-system” that discourages innovation.
- Consequences of budget reduction actions - “Contracting offices often not able to make “best-value” decisions compatible with mission goals.
- Government efforts to reduce profit impacts industry willingness to invest.
- Defense industry less attractive to compete for capital and talent.
- Barriers from requirements determination – Assessing cost from prescriptive inputs rather than focusing on performance goals and the job that must be performed (by the DoD and military).

The Defense Science Board (2017) highlighted the contributions to innovations and Defense Research Engineering Enterprise value-add to national security, and impact to private sector. Some of their recommendations to improve Defense Research Engineering Enterprise include:

- Embrace open innovation and technology defense.
- government labs need to be more active in the DoD requirements process.

- Labs need to lead DoD through fundamental technology shifts.
- The Task Group recommended that the labs should evolve their missions, focusing on technology leadership, defense, and open innovation.

The GAO (2017) contrasted the management and approaches of science and technology investments of DoD and major commercial sector companies in high technology areas. The report concluded that:

- DoD funding policies and culture limit science and technology approach and management of investments.
- Leadership does not guide assessment to determine the mix of incremental and disruptive innovation.
- Responsibilities for technology versus product development contributes to a culture that discourages collaboration and the ability to prototype.

Sargent, Schwartz, & Gallo (2018) discuss changes in the global R&D landscape and U.S. government policies, and perspectives on maintaining U.S. technological leadership. The report highlights the recognition that potential U.S. military adversaries may have access to the same commercially available technology as the DoD stresses the premium for speed in developing and making new or improved technologies available to the warfighter. The authors of the current U.S. Department of Defense Strategy published in 2018 recognize that success no longer goes to the country that develops a new fighting technology and goes to the country that better integrates it and adapts its way of fighting. Brown (2019) accounts for the strategic challenges related to the DoD's anti-innovation hierarchical culture and calls for renewing the DoD innovation system by disrupting its foundations. The National defense strategy calls for a reorganization of the Department of Defense to achieve innovation. Millett, Murray, & Watman

(1987) state that although a sizeable theoretical literature exists on organizational efficiency, the issue of military effectiveness remains ill-defined.

Military activity has vertical and horizontal dimensions. The vertical dimension involves the political, strategic, operational, and tactical levels. These levels produce a hierarchy of actions and associated required coordination from the political to tactical levels. The horizontal dimension consists of simultaneous and interdependent tasks that organizations need to execute at each level. They include personnel, procurement, planning, training, logistics, intelligence, technical adaptation, and combat. Military effectiveness assessments need to assist in the identification of likely barriers for purposeful change, and opportunities for reform.

Millett, Murray, and Watman (1987) define military effectiveness as the process by which “armed forces convert resources into fighting the power,” and the ability to derive maximum combat power from available physical and political resources. The necessary amount and nature of combat power depend on the ability to destroy the enemy while limiting friendly forces inflict in combat. In the military domain, resources represent the assets necessary to military organizations: (1) human and natural resources; (2) money; (3) technical “prowess”; (4) industrial base; (5) government structure; (6) sociological characteristics; (7) political capital; (8) intellectual qualities of military leaders; (9) and morale. They state that military effectiveness cannot be measured with precision. They establish a thread describing effectiveness as “a means to an end” relationships across all military levels of activity. They pose the question: what kinds of military effectiveness are most relevant under what conditions? There is a strong dynamic conditional element to judging military effectiveness, and non-quantifiable attributes play a role in assessing military effectiveness, such as organizational attitudes, behaviors, and relationships.

Table 1 provides a highlight of their dimensions, characteristics, and general attributes of effectiveness across military activity levels.

Table 1. Levels of military effectiveness from Millett, Murray, & Watman (1987)

Activity Level	**Characteristics**	**Pattern/Characteristic**	**Attributes**
Political	Ability to consistently secure resources required to address National Security and Military Strategy Resources include financial support, sufficient military-industrial base, sufficient quantity and quality of personnel, control over conversion of resources into military capabilities	1. Military leaders assess potential adversaries and calculate the variety and level of the threat posed to national security 2. On the basis of conclusions from 1, present arguments to political leadership for share of resources over time to meet threats to national security Military political effectiveness depends on ability to articulate needs persuasively	Degree in which U.S. Sr. Government Leadership perceives and regards military activity as legitimate and regard to Sr. Military Leaderships
Strategic Effectiveness	Employment of national armed forces to secure national goals and interest defined by U.S. Sr. Government Leaders	Analysis and selection of strategic objectives and linkage to national goals through campaigns or contingency plans	iterative process

Table 1 continued

Operational Effectiveness	analysis, selection and development of institutional concepts or doctrines for employing forces to achieve strategic objectives within a theater of war	analysis, planning, preparation, and conduct of various facets of a specific campaign	disposition of military units, selection of theater objectives, arrangement of logistical support, direction of forces. Shaped by mission, threats, geography, logistics, allied and national force availability, time available for mission accomplishment.
Tactical effectiveness	specific techniques used by units to fight engagements in order to secure operational objectives.	movement of forces against enemy, provision of fire power, arrangements of logistical support directly applicable to engagements	

Davis (2002) developed a monograph discussing how the U.S. Department of Defense could change its system of analysis to support capabilities-based planning. He argues for the need for a new analytical architecture for:

- "Identifying capability needs.
- Assessing capability options for effectiveness in stressful building-block missions (i.e., operations)
- Making choices about requirements and ways to achieve them; doing so in an integrative portfolio framework that addresses future war-fighting capabilities, force management, risk tradeoffs, and related matters in an economic framework". (Davis, 2002, p.xi)

- In his proposed new analytical architecture, the following is the general process:
- Survey of capability needs:
- Appreciation for a range of plausible scenarios
- Moving from scenarios to Capability Requirements
- Taking a Mission-System View
- Develop the alternative concept of operations, identify forces and programs to enable them
- Identify potential potentially critical components of capability
- Relate critical components with Quadrennial Defense Review goals
- Assessing Capability Options in a Mission-System Framework
- Identify mission and metrics of strategic and operational success and a given of capability options
- Conduct exploratory analysis over a range of circumstances
- Integrations and Tradeoffs in an Economic Framework
- Integration and choice in the context of a budget

In his monograph, Davis defines capabilities-based planning as planning under uncertainty to provide capabilities suitable for a wide range of modern-day challenges and circumstances, while working within an economic framework. The context for capabilities-based planning is portfolio management. It contains a conceptual framework, an analytical framework, and a solution framework. Moreland (2009) identifies characteristics and capabilities required to address the range of threats that exist today as we as threats in future environments within the U.S. Naval operations context.

“Credible Vision of the Future: The strategic analysis capability examines potential future world environments, and then assess the capability performance and its acquisition planning implications. The analysis capability includes the development of multiple force designs for multiple alternative futures, selecting key characteristics that contribute to a robust force.

The Challenges: Capabilities must be defined to convey the urgent accomplishments to execute the strategy, continuously evaluate the magnitude and type of demand signal for capabilities and develop a force structure based on the real-time demands. As a change in strategy occurs, immediate response in force capabilities needs to occur. DoD currently suffers from a demand signal disconnect where strategy calls for capabilities that are not provided by the military, and our force generators produce force structures that the strategy may not require any more

Cost Estimating: Approach to reducing or eliminating the redundancy and duplication of acquisition and development while continuing to find ways to minimize costs.

Acquisition Strategy: program managers are not required to develop their programs in a cross-platform enterprise approach. Each development potentially uses a different set of standards. The uncoordinated acquisitions result in compatibility issues affecting system/component value-chains during sustainment.

Social-Organizational Integration: federalism as an effective way to deal with a balance between the paradoxes of power and control. It also addresses interdependence as a principle highlighting the importance of working together based on need without moving toward the familiar model of centralization. The principle of “uniform and standardization way of doing business” emphasizes basic rules of conduct, conventional ways of communicating, and standard metrics. The principle of separation of powers involves separation of management, monitoring, and governance functions.

- Human integration: as an integral part of the systems engineering process. Human Integration includes the active participation of the warfighters and user community as part of the design process
- Technological Integration: dependable systems integration should drive the evaluation of technologies in the System of Systems environments. A knowledge repository could be created to identify technology readiness levels for kill chain options
- Balancing Instruments of National Power: because of the diverse perspectives and objectives of decision-making actors, the approach must consider the cultural environment, societal structure, leveraging unique partnerships established through everyday interactions of the actors.
- Innovative Opportunities in Acquisition, Design, and Development
- Open Architecture and Common Scalable Modular Systems
- Common Equipment Sets
- Integrated Distance Support
- Common controls and displays
- Modular System Design." (pp. 35-50)

Moreland (2009) provides a technical Mission Engineering and Integration framework that addresses rapid, continuous, and long-range force-capability-decisions. The context of the framework is socio-economic and involves stakeholder interaction at the strategic level across institutional sectors. From a social perspective, it establishes a framework to drive individual behavior towards achieving common goals taking into account mission-oriented goals and objectives. From a U.S. DoD perspective, Moreland, (2009); Davis, (2002); Millett, Murray, and Watman, (1987) outline methodologies, perspectives, and organizational, leadership, and mission-based characteristics supporting establishing DoD's strategies for competitiveness based on attributes of mission effectiveness. From a private firm perspective, Srivastava, Sultan, & Chashti (2017) argue that firm competitiveness within the context of innovation still lacks standard definition, determinants, and methods of measurement. Their study reveals a positive relationship between firm competitiveness and innovation competence of the firm. They state that managers and policymakers need to identify the sources and means of nurturing innovation competence. Watts et al. (2012) present a three-category model to serve as a "barometer" of innovation competence. Their model combines the individual, interpersonal, and network as competence domains in innovation. They also highlight the lack of a formal system of identification and innovation competences within the scope of their study. Bhatnagar & Gopalaswamy (2017) identified six distinct dimensions and associated attributes on a firm's service innovation competence. They state that a competence-based perspective suggests that for a firm to exploit its resources in a goal-directed manner, it must possess specific competences. "In this view, service innovation is driven by the firm's capacity to creatively use the benefits of technological advances, new knowledge, and relationship networks.

Wang (2014) outlines a study that combines institutional theory and the resource-based view of the firm in a theoretical framework for analyzing the relationship between innovation efforts and quality management. In this case, it uses measures of competence related to quality management, product innovation, process innovation with other control variables such as firm age, size, and assets. The findings provide insights into the non-linear relationship between firm-specific R&D activities with ISO quality management activities in the high technology industry.

Wang & Dass (2017) define innovation capability as a "firm's ability to generate, accept, and implement new ideas, processes, products, or services, is one of the key resources that drive a firm's success in the marketplace." (Wang & Dass, 2017, p. 128)

Wang & Dass (2017) explore the role of top-level management in a firm's innovation processes, and that managers tend to focus more on exploration strategies than exploitative strategies once committed to innovation. The study's implications provide insights on how managers can contribute to the financial performance of the firm by becoming more involved in innovation.

Innovation Diffusion is defined by Rogers (2003, pp. 35-36) as "the process in which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas. Rogers (2003, pp. 36-37) defines uncertainty as "the degree to which a number of alternatives are perceived with respect to the occurrence of an event and relative probability of these alternatives." Figure 2 illustrates Rogers' (2003) Innovation-Decision Process. The Innovation-Decision process is an information-seeking and information-processing activity in which an individual obtains information to gradually decrease uncertainty about the innovation."

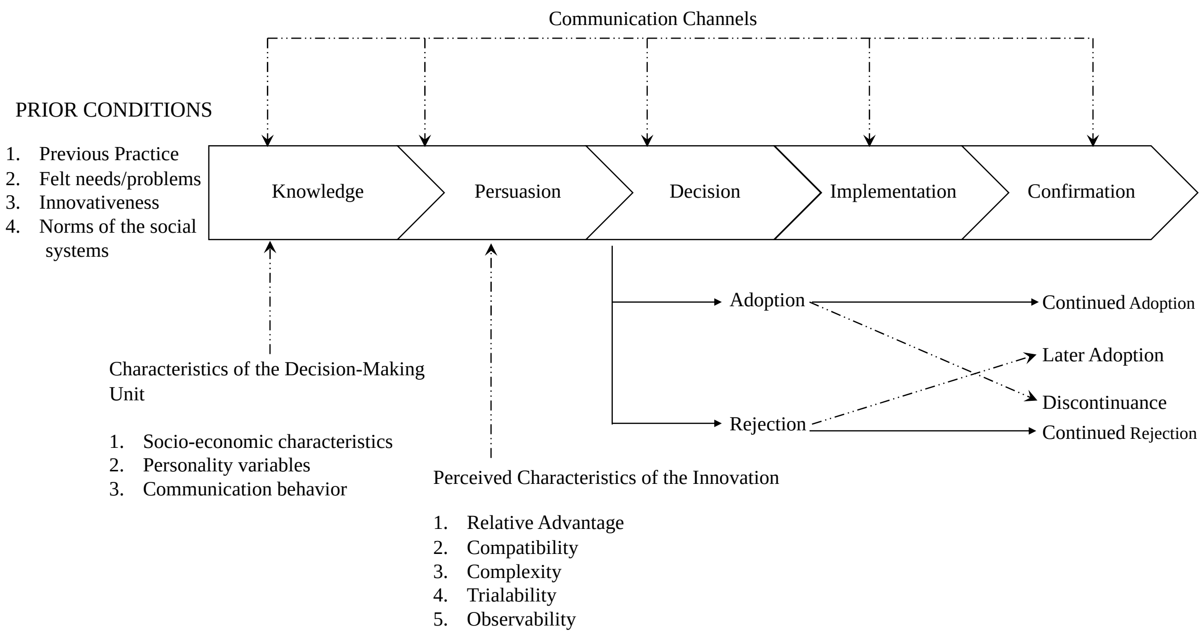


Figure 2. Five Stages in the Innovation-Decision Process. From Rogers (2003)

O'Reilly & Tushman (1996) provide a basis for linking private firm innovation behavior characteristics with process management, and firm performance, and Rogers (2003) outlines a process for innovation-decision that either leads to continued adoption or continued rejection of the innovation. In the knowledge stage, an individual or decision-making unit is made aware of and exposed to the existence of an innovation and gains an understanding of how it functions. Within the knowledge stage, fundamental challenges exist, such as determining if needs or the awareness of innovation should come first. Individuals or decision-making units may actively seek innovation awareness while susceptible to selective exposure and perception. Other questions remain regarding the generation of needs linked to innovation. A need may exist without the awareness of innovation or maybe initiated after awareness of innovation.

Depending on the innovation, its awareness may cause second and third-order implications to the state of affairs and require additional innovations and changes in process related to innovation's application and integration. The new innovation coupled with associated changed process is prototyped and demonstrated so that it can be evaluated and proceed through to the confirmation stage. During the knowledge stage, the initial awareness of innovation causes uncertainty for an individual or decision-making unit and creates the need to acquire knowledge about the innovation.

As described by Rogers (2003) there are three types of knowledge about an innovation:

- knowledge defining the innovation.
- How-to knowledge describing how the innovation works.
- Principles-knowledge describing the underlying principles that explain further how the innovation works and what defines the innovation.

"How-to knowledge consists of information necessary to use an innovation properly. The adopter must understand what quantity of innovation to secure, how to use it correctly, and so on. In the case of innovations that are relatively complex, the amount of how-to knowledge needed for adoption is much greater than in the case of less complex ideas…. Principles-knowledge consists of information dealing with the functioning principles underlying how an innovation works." (pp. 326-327)

Within this model Rogers (2003) summarizes generalizations regarding early knowledge about innovations:

Generalization 5-1: Earlier knowers of an innovation have more education than do later knowers

Generalization 5-2: Earlier knowers of an innovation have higher social status than do late knowers

Generalization 5-3: Earlier knowers of an innovation have more exposure to mass media channels of communication that do later knowers.

Generalization 5-4: Earlier knowers of an innovation have more exposure to interpersonal channels than do later knowers.

Generalization 5-5: Earlier knowers of an innovation have more contact with change agents than do later knowers.

Generalization 5-6: Earlier knowers of an innovation have more social participation than do later knowers.

Generalization 6-7: Earlier knowers of an innovation are more cosmopolite than are later knowers. (pp. 328-329)

Michael Polanyi (1967) argues that "if tacit knowledge is a central part of knowledge in general, then we can both (1) know what to look for, and (2) have some idea about what else we may want to know" (Polanyi, 1967, p. xi). The assertion that we can know more than we can tell also influenced the categories of knowledge being explicit (knowledge that can be transmitted in a formal systematic language) and tacit (difficult to formalize and communicate). Zander and Kogut (1995) follow Roger's (2003) thinking to establish the constructs of knowledge within the context of innovation diffusion as being codifiability, Teachability, Complexity, System Dependence, and Product Observability:

- "Codifiability captures the degree to which knowledge can be encoded, even if the individual operator does not have the facility to understand it…

- Teachability…captures the extent to which workers can be trained in schools or on the job; it reflects the training of individual skills.
- Complexity picks up the inherent variations in combining different kinds of competencies; knowledge no matter the education of the worker, is simply more complex when it draws upon distinct and multiple kinds of competencies
- System Dependence captures the degree to which a capability is dependent on many (groups of) experienced people for its production
- Product Observability, finally, captures the degree to which capable competitors can copy the manufacturing capability, because they are able to manufacture the innovation once they have understood the functions of the product"(Udo & Bruce, 1995, p. 79)

In Roger's (2003) Innovation-Decision Process, the persuasion stage in the innovation-decision process is when the individual or decision-making unit makes a favorable or unfavorable attitude towards the innovation. Rogers defines attitude as "a relatively enduring organization of an individual's beliefs about an object that predisposes his or her actions. Whereas the mental activity at the knowledge stage was mainly cognitive (or knowing), the main type of thinking at the persuasion stage is affective (or feeling)." (p. 330) The persuasion stage ends with a favorable or unfavorable attitude toward the innovation. At this stage, the innovation evaluation information is sought to reduce uncertainty about innovation expected consequences.

The Decision stage in the innovation-decision process is when adoption or rejection occurs. This stage leads to a decision to reject or adopt the innovation. The rejection may be active or passive. The active rejection involves a decision not to adopt, whereas the passive involves never considering using the innovation.

At the Implementation stage, the individual or decision-making unit uses the innovation. When the adopter is an organization, the implementers may be different from the decision-makers. This stage is when innovation (in the organizational setting) becomes institutionalized and used in adopter's operations. During this stage, innovation re-invention may occur. During the Confirmation stage, an individual or decision-making unit may reach dissonance (disequilibrium, uncomfortable state) regarding the innovation. The dissonance may lead to a rejection of an innovation after its adoption. The discontinuance may be because of dissatisfaction with its performance. Another element in the innovation-decision process is the communication channels. Rogers (2003) categorizes communication channels as interpersonal versus mass media and "localite versus cosmopolite." Interpersonal channels involve a two-way exchange of information and persuade an individual to form or change a strongly held attitude. The category of channels is more prevalent and present in certain stages in the innovation-decision process. The Theory of Diffusion of Innovations and its innovation-decision process provide a starting point to model the various phases of innovation, linked to Tushman and O'Reilly's exploitative-explorative research related to process management and impact to firm's performance and organizational form. They also provide an opportunity for linking and identifying potential variables and attributes of innovation adoption rates with responsiveness and performance attributes in the DoD/allied partner inter-organizational setting. Figure 3 depicts Rogers' variables that contribute to innovation's rate of adoption.

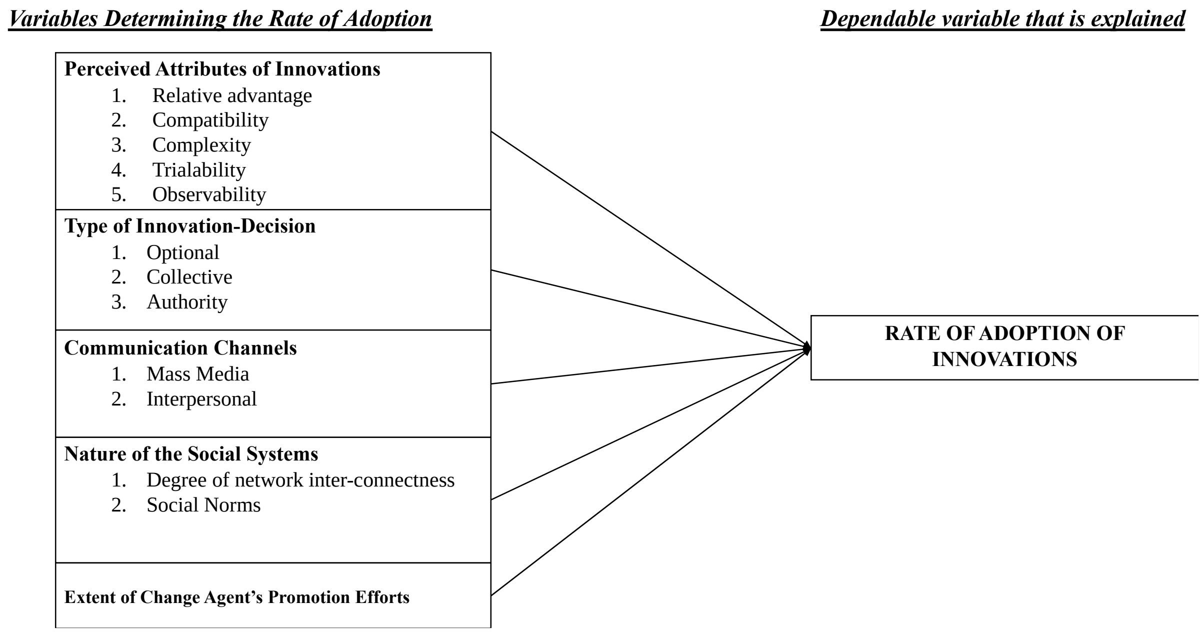


Figure 3. Variables that contribute to innovation's rate of adoption. From Rogers (2003)

The "Organisation for Economic Co-operation and Development" (OECD) has published a series of methodological guidelines for measuring innovation and innovation related activities. The "Measurement of Scientific and Technical Activities" OECD (1994) publication provides a high-level description of Research and Development "statistics" along with definitions related to innovation.

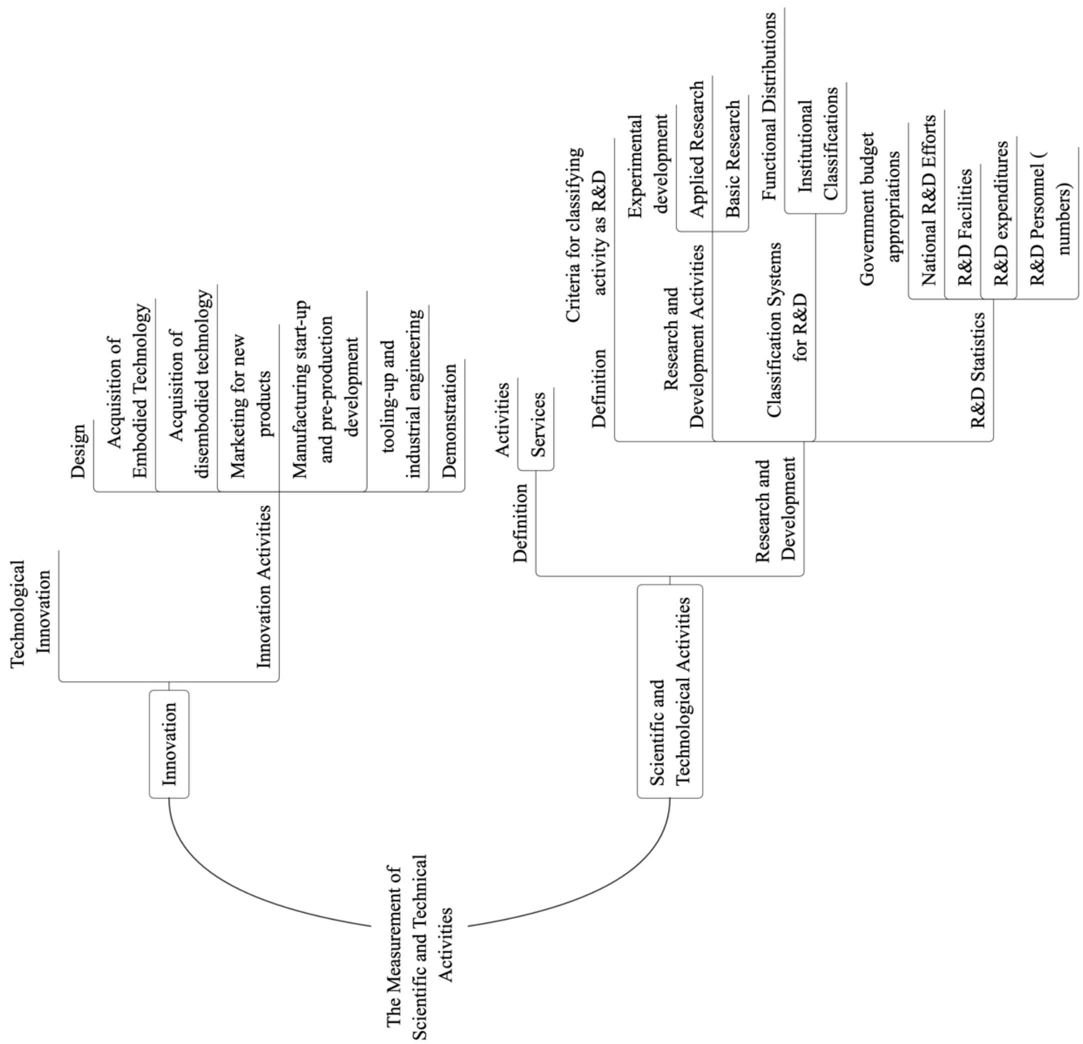


Figure 4. Key concepts and definitions from OECD (1994)

Figure 4 illustrates the key concepts and definitions contained in OECD (1994). In this publication, there is a definition of technological innovation: “Technological innovations comprise new products and processes and significant technological changes in products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovations, therefore, involve a series of scientific, technological, organizational, financial, and commercial activities.” (p. 5)

OECD (1994) also provides definitions of Scientific and Technological Activities, including Research and Development definitions, classifications for R&D “statistics,” and overall R&D classification system types. From a public-sector perspective, OECD also highlights some of the challenges related to establishing norms for categories to national governments related to research investments, indicating that the research funding investments have various policy connotations. From a military perspective, OECD notes that military R&D patterns of international comparisons differ, noting fluctuations in military R&D investments with changing political situations. Another issue related to applying the concepts of basic and applied research and experimental development in defense and aerospace industries is the terminology and categories used by the militaries. OECD (1997) published guidelines for collecting and interpreting technological innovation data. In this publication, the concept of knowledge appears to have an essential role in firm innovation performance as well as its overall performance attributed to profit and market share. Also, it highlights the importance of establishing a conceptual framework that enables the organization of technological innovation data.

OECD (1997) published the "Innovation Policy Terrain" conceptual framework can assist in organizing and understanding technological innovation data. Within this framework, there are four categories of factors relating to innovation:

- business enterprises ("firms").
- science and technology institutions.
- issues of transfer and absorption of technology, knowledge, and skills.
- surrounding environment of institutions, legal arrangements, macroeconomic settings, and other conditions that exist regardless of any consideration for innovation.

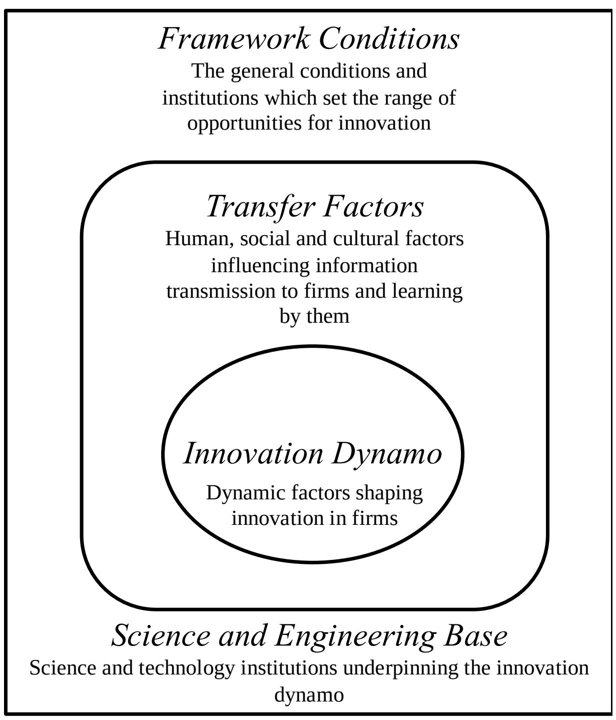


Figure 5. Innovation Policy Terrain Conceptual Framework. From (OECD, 1997, p. 19)

Figure 5 depicts the "Innovation Policy Terrain" conceptual framework for organizing and understanding innovation data.

- The broader framework conditions of national institutional and structural factors (e.g., legal, economic, financial, and educational) setting the rules and range of opportunities for innovation.
- The science and engineering base – the accumulated knowledge and the science and technology institutions that underpin business innovation by providing technical training and scientific knowledge, for example.
- Transfer factors strongly influence the effectiveness of the linkages, flows of information and skills, and absorption of learning. These factors are essential to business innovation.
- The innovation dynamo is the domain most central to business innovation – it covers dynamic elements within or immediately external to the firm and very directly impinging on its innovativeness." (OECD, 1997, pp.19-20)

Figure 6 outlines the "Innovation Policy Terrain" conceptual "Framework Conditions elements.

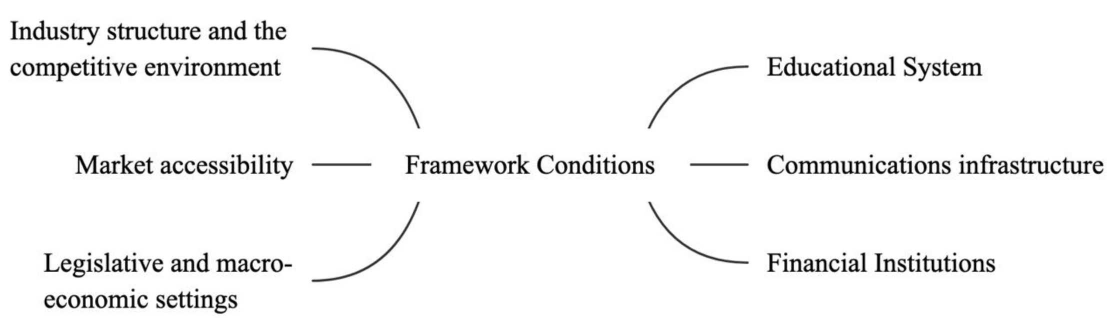


Figure 6. Innovation Policy Terrain Framework Conditions. From OECD (1997, p. 20)

Below are Innovation Policy Terrain Framework definitions OECD (1997) :

- the basic educational system for the general population, which determines minimum educational standards in the workforce and the domestic consumer market.
- the communications infrastructure, including roads, telephones, and electronic communication; • financial institutions determining, for example, the ease of access to venture capital.
- legislative and macro-economic settings such as patent law, taxation, corporate governance rules – and policies relating to interest and exchange rates, tariffs and competition.
- market accessibility, including possibilities for the establishment of close relations with customers as well as matters such as size and ease of access.
- industry structure and the competitive environment, including the existence of supplier firms in complementary industry sectors.*"*(OECD, 1997, p. 20)

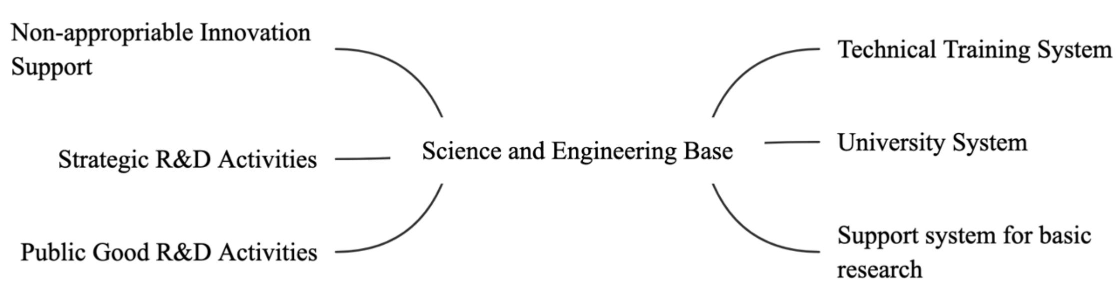


Figure 7. Policy Terrain Science and Engineering Base. From OECD (1997, p.20)

Figure 7 illustrates the elements of the Science and Engineering Base within the OECD (1997) Innovation Policy Terrain Science and Engineering framework. Below are the element definitions:

- The specialized technical training system.
- The university system.
- The support system for basic research (radical breakthroughs and long-term benefits aside, basic scientific research is sometimes perceived as providing little direct benefit to business innovation. However, its indirect benefits can be very substantial. Scientific investigation often requires the development of highly sophisticated and ultra-sensitive equipment. Thus, many areas of basic research provide fertile ground for the training of skilled technology-oriented scientists – whose experience can often help solve industrial problems.).
- Public good R&D activities – funding programs and institutions generally directed towards areas such as health, the environment, and defence.
- Strategic R&D activities – funding programmes and institutions directed towards “pre-competitive R&D” or generic technologies.
- Non-appropriable innovation support – funding programmes and institutions directed towards research in areas where it is difficult for individual enterprises to appropriate sufficient benefit from their own in-house research.”(OECD, 1997, p. 21)

Figure 9 outlines the elements of the human, social, and cultural factors supporting the operation of innovation at the firm level. According to the OECD (1997) these factors are mostly based around the concept of learning and relate to: (1) ease of communication within organizations; (2) informal interactions; (3) co-operation and channels of information and skills transmission between and within organizations; (4) social and cultural factors impacting operation of channels of information and co-operation.

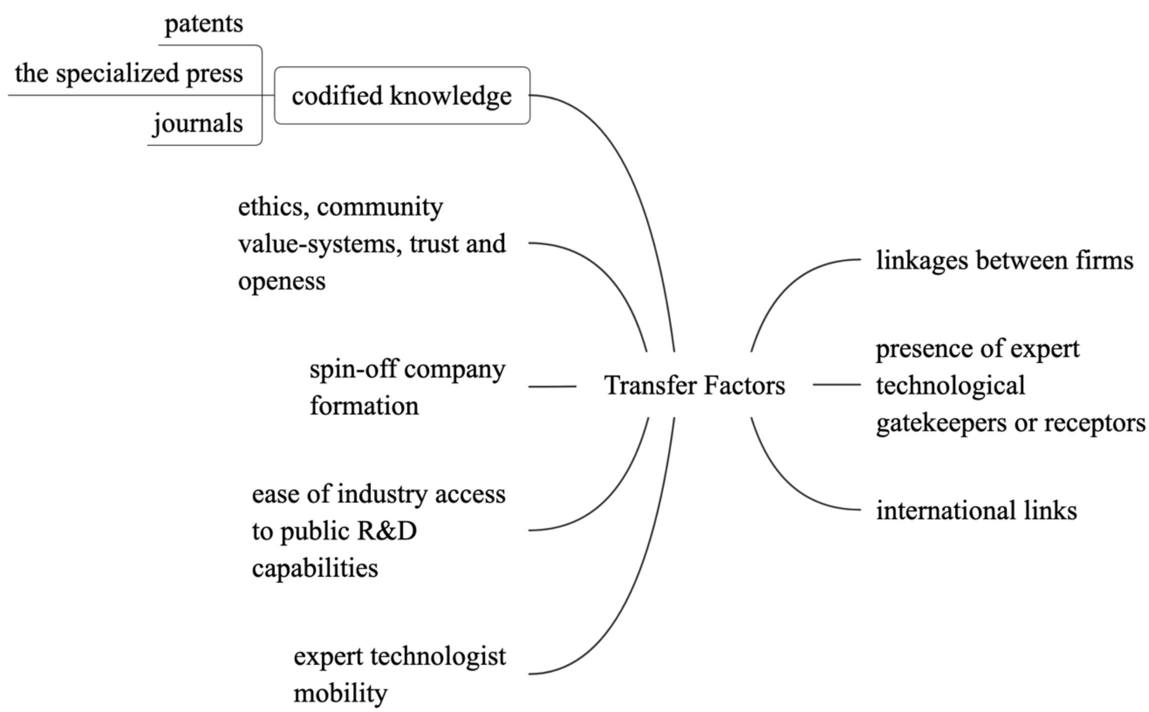


Figure 8. Transfer factors within Innovation Policy Terrain. From OECD (1997, p. 21)

The “Innovation Dynamo” described by the OECD (1997) illustrated in Figure 9, represents a system of factors shaping innovation at the firm level. It describes the innovation capability of the firm relative to its ability to combine factors towards realizing technological innovation faster than the competition and outlines some high-level characteristics for the firm based on a learning perspective.

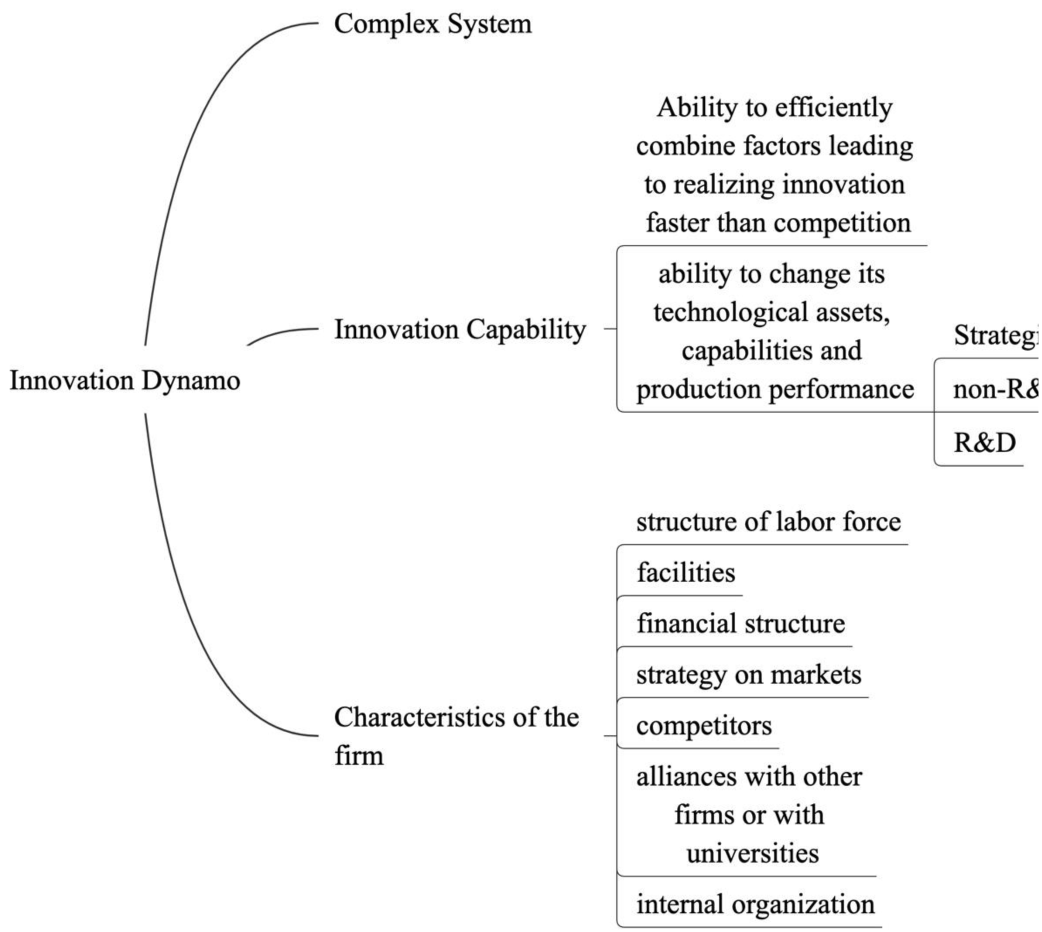


Figure 9. Innovation Policy Terrain. From OECD (1997, p. 21)

The nature of the concepts within the Innovation Dynamo have some characteristics of organizational behavior, organizational structure, and its positioning within the external context. Within the Innovation Capability element, Figure 11 provides a more detailed breakdown extracted from OECD (1997) relative to a firm's ability to innovate and the types of activities characterized as strategic, R&D, and non-R&D.

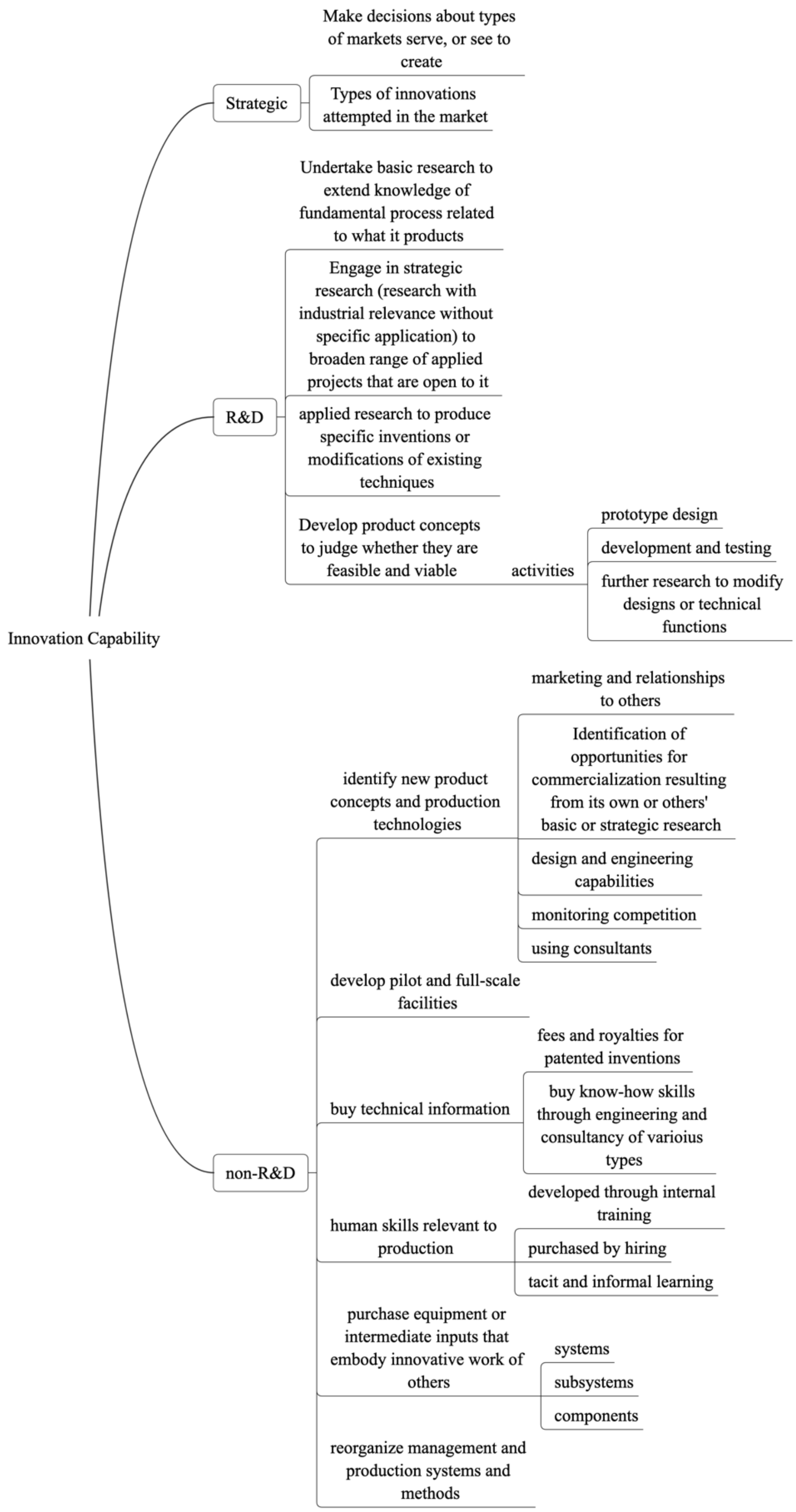


Figure 10. Innovation Capability within Innovation Policy Terrain. From OECD (1997)

Figure 11 provides OECD (1997) inputs, constraints, and minimal description of outputs of innovation within the perspective of stakeholders having the ability to measure and understand innovation. OECD (1997) highlights the importance of innovation in the "knowledge-based economy":

"Today, knowledge in all its forms plays a crucial role in economic process. Nations which develop and manage effectively their knowledge assets perform better. Firms with more knowledge systematically outperform those with less. Individuals with more knowledge get better paid jobs. This strategic role of knowledge underlies increasing investments in research and development, education and training, and other intangible investments, which have grown more rapidly than physical investment in most countries and for most of the last decades. The policy framework should thus put central emphasis on the innovative and knowledge-creating and using capacity of OECD economics. Technological change results from innovative activities, including immaterial investments such as R&D, and creates opportunities for further investment in productive capacity. Therefore, in the long term, it creates jobs and more income. A main task for the government is to create conditions that include firms to engage in the investments and innovative activities required for enhancing technical change." (p.15)

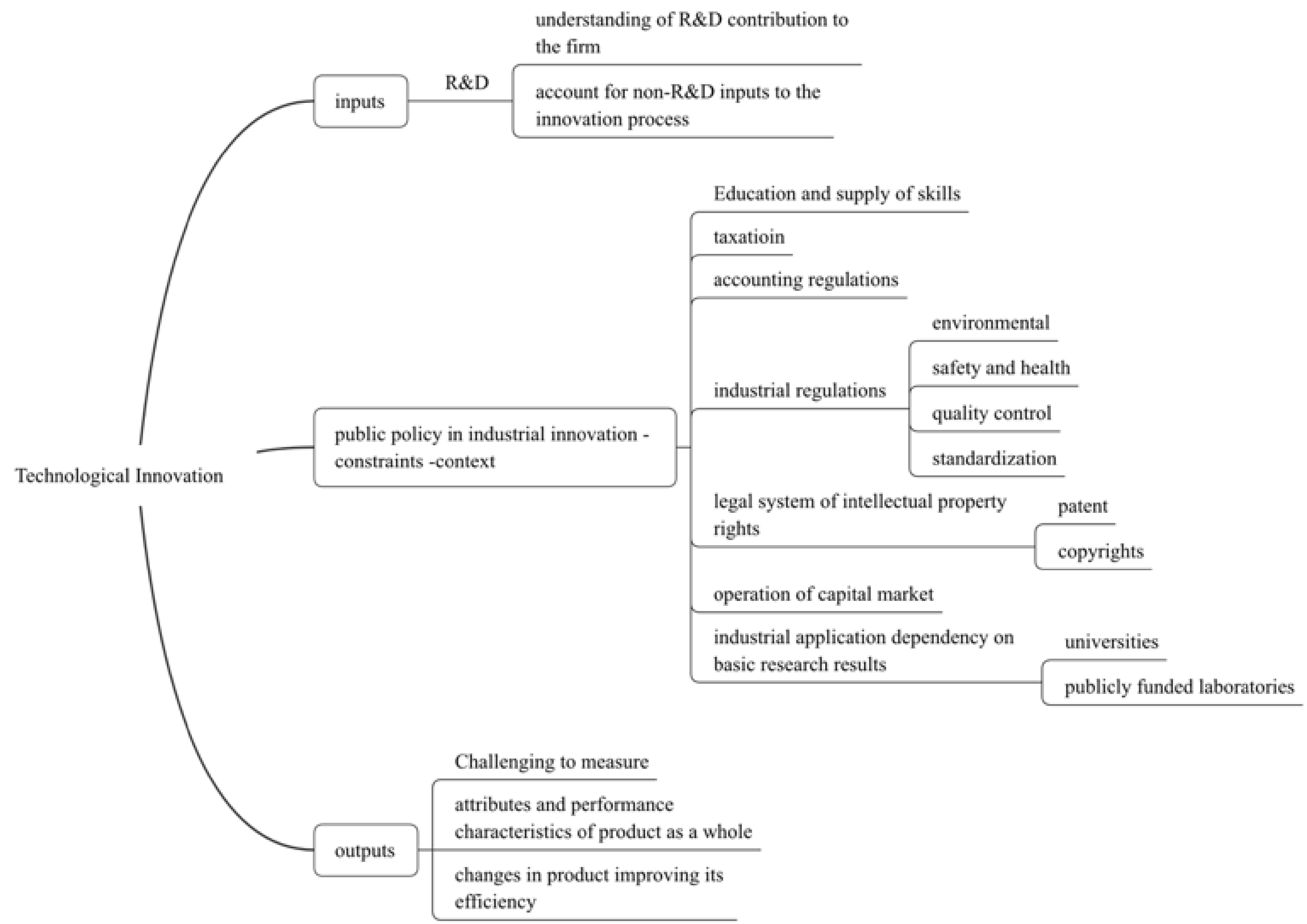


Figure 11. Technological Innovation inputs, constraints, and outputs. From OECD (1997)

OECD (1997) presents definitions and provides an account of innovation policy in industrial product and process innovation as follows:

> **Technological product and process (TPP) innovations**: *"*implemented technologically new products and processes and significant technological improvements in products and processes. A TOO innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organizational, financial, and commercial activities. The TPP innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period under review*"* (OECD, 1997, p. 31)
>
> **Technologically improved product**: an existing product whose performance has been significantly enhanced or upgraded. A "simple product may be improved (in terms of better performance or lower cost) through use of higher performance components or materials, or a complex product which consists of a number of integrated technical sub-systems may be improved by partial changes to one of the sub-systems" (OECD, 1997, p. 32)
>
> **Technological process innovation**: "adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment, or production organization, or a combination of these changes, and may be derived from the use of new knowledge. The methods may be intended to produce or deliver technologically new or improved products, which cannot be produced or delivered using conventional production methods or essentially to increase the production or delivery efficiency of existing products". (OECD, 1997, p. 32)

Worldwide TPP innovation *"*occurs the very first time a new or improved product or process is implemented*."* (OECD, 1997, p. 32)

Firm-only TPP innovation "occurs when a firm implements a new or improved product or process which is technologically novel for the unit concerned but is already implemented in other firms and industries. (OECD, 1997, p. 32)

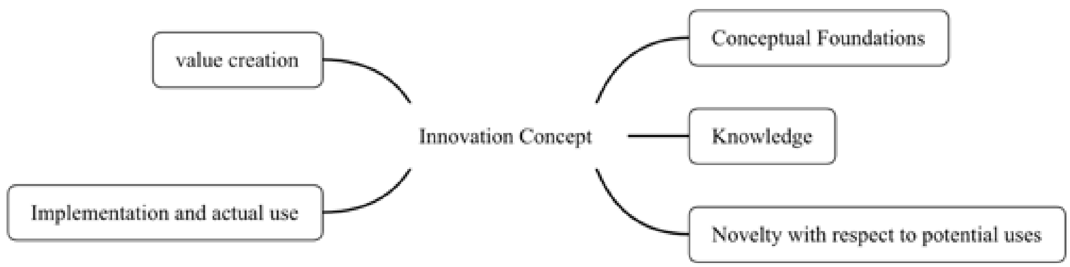


Figure 12. OECD/Eurostat (2018) Innovation Concept

In 2010 OECD published a book titled "Measuring Innovation: A New Perspective." In the book, the following were some proposed actions for stakeholders involved in innovations:

Action 1: Improve the measurement of broader innovation and its link to macroeconomic performance. The improvement in measuring innovation includes going beyond targets and aggregates towards understanding why and how innovation happens in firms

Action 2: Invest in high quality and comprehensive data infrastructure to measure the determinants and impacts of innovation, including going beyond the traditional actors and better addressing the role of government in innovation

Action 3: Recognize the role of innovation in the public sector and promote its measurement, including examination of the extent to which concepts and metrics used in the context of business innovation can be used and adapted.

Action 4: Promote the design of new statistical methods and interdisciplinary approaches to data collection, including improvement of the measurement of innovative activity in complex business structures, organizations, and networks. It also includes the measurement of the skills required in innovative workplaces; and promoting joint measurement of emerging and enabling technologies. Finally, it involves going beyond economic goals and measuring innovation for social goals and the social impacts of innovation**.**

The latest OECD/Eurostat (2018) "Oslo Manual," among other novelties, broadens the conceptual framework and general definitions applicable to businesses, government, non-profit institutions serving households, and Households.

Figure 12 outlines the OECD/Eurostat (2018) innovation concept, consisting of:
The conceptual foundations primarily derived from management and economics disciplines, theories related to the innovation concept, and the emerging systems perspectives.
The four dimensions of innovation, including knowledge, novelty, implementation, and value creation. Figure 14 outlines the OECD/Eurostat (2018) concept of innovation, consisting of:
The conceptual foundations primarily derived from management and economics disciplines, theories related to the innovation concept, and the emerging systems perspectives.
Knowledge, novelty, implementation, and value creation as innovation dimensions, in more detail, Figure 16, the conceptual foundations are further linked to theories and the systems

perspective. These are conceptual foundations used in the development of the innovation concept in OECD/Eurostat (2018).

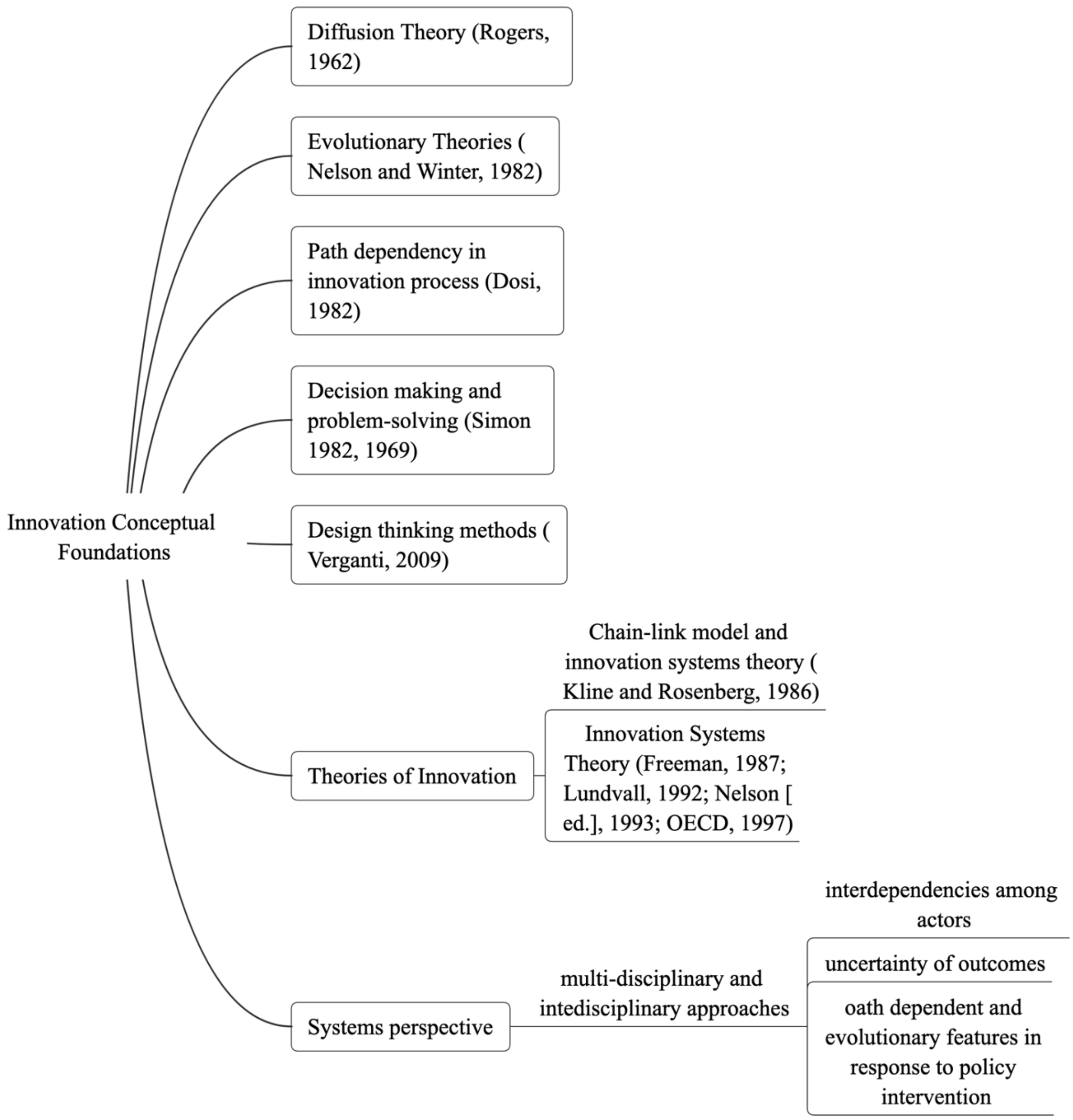


Figure 13. Innovation Conceptual Foundations from OECD/Eurostat (2018)

Figure 13 depicts the conceptual foundations outlined in OECD/Eurostat (2018), mainly derived from management and economics disciplines. The OECD/Eurostat (2018) also outlines the elements of an innovation measurement framework illustrated in Figure 14. The elements in linkages to the general statistical frameworks in OECD/Eurostat (2018) Innovation Measurement framework contain concepts mainly derived within the context of the business sector, from a perspective of economic growth.

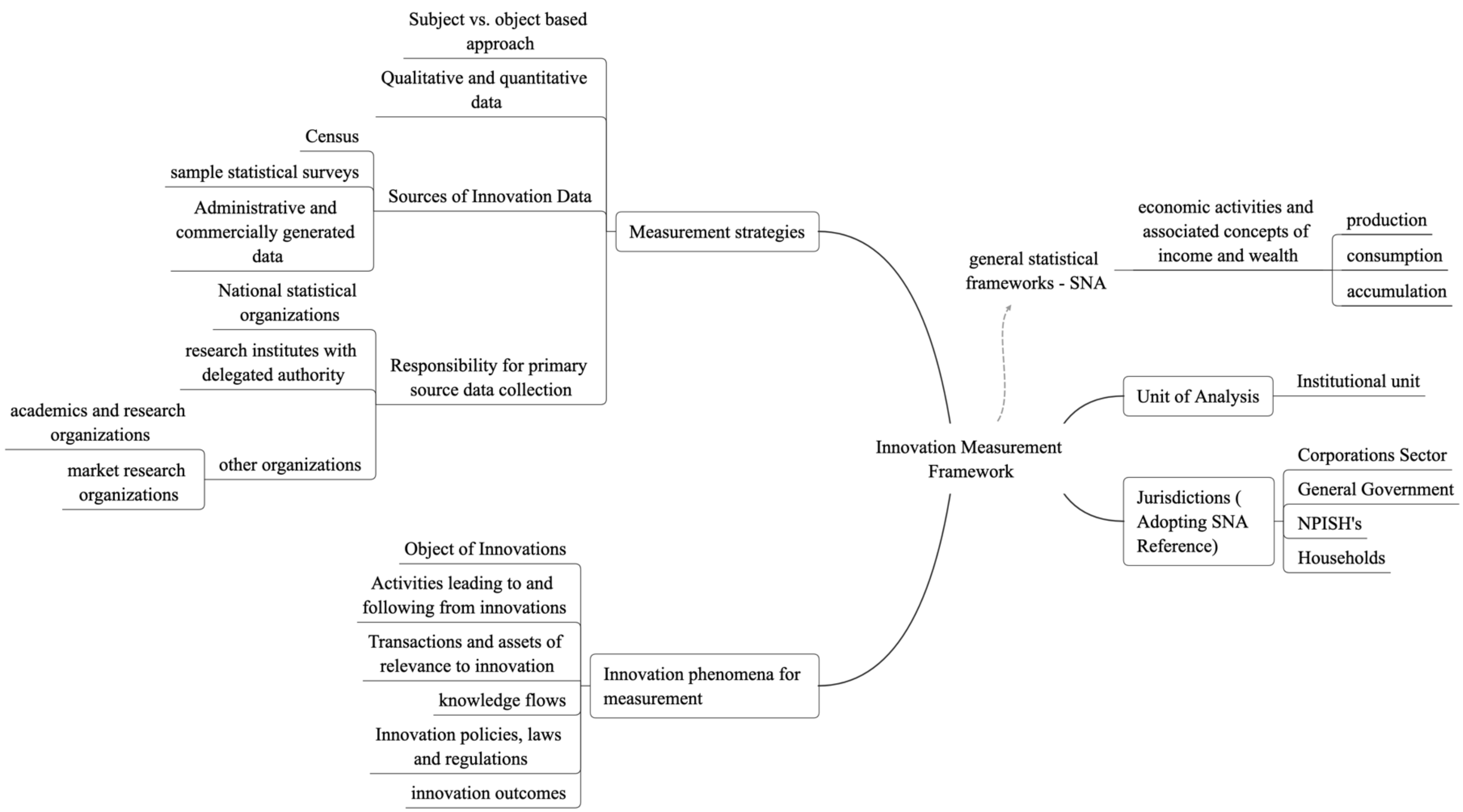


Figure 14. OECD/Eurostat (2018) Innovation Measurement Framework

While new concepts emerge and mature for adoption into the overall innovation measurement framework, OECD/Eurosat (2018) made some revisions to the definition of innovation:

- An innovation is a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) and brought into use by the unit (process)." (OECD/Eurostat 2018, p. 60) The OECD/Eurostat (2018) also makes a distinction between Innovation in the General government sector versus the business sector.
- Government units are established by political processes with legislative, judicial or executive authority and occur at the national, regional, and local administrative levels.
- The range of goods and services provided by the government, and the prices charged, are based on political and social considerations rather than on profit-maximization or related business objectives... influences the types of product innovations developed by institutional units within the Government sector and made available to households, non-profits or business enterprises.
- The absence of a market alters both the incentives for innovation and the methods for measuring innovation outcomes compared to the business sector….High-quality outcome measures are generally only available for specific innovations. Examples include the cost and benefits of new treatments or protocols in hospitals or new educational methods in schools.
- The study of innovation within government and the public sector more broadly has attracted a growing body of empirical research, motivated in part by the increasing demand for benchmarking the efficiency and quality of public services as well as

identifying the factors that contribute to desirable innovation outputs and outcomes. (OECD/Eurostat 2018, p. 60)

The OECD (2015) establishes the guidelines for collecting and reporting data on research and experimental development. It is also known as the "Frascati Manual." The OECD (2015) describes it as "not only a standard for R&D data collection in OECD member countries. As a result of initiatives by the OECD, UNSECO, the European Union, and various regional organizations, it has become a standard for R&D measurement worldwide." (OECD, 2015, p-4)

The Frascati Manual provides concepts and definitions for identifying research and development (R&D), classification and definition of institutional sectors for R&D statistics, guidance for measurement of (1) R&D expenditures; (2) R&D personnel; (3) Measuring R&D methodologies and procedures. It also includes sector-specific guidance, including an entire part dedicated to measuring government support for R&D.

The OECD (2015) lists NABS categories for socioeconomic objectives (SEO) for R&D. They include: (1) exploration and exploitation of the earth; (2) Environment; (3) Exploration and Exploitation of space; (4) transport, telecommunication and other infrastructures; (5) Energy; (6) Industrial production and technology; (7) Health; (8) Agriculture; (9) Education; (10) Culture, recreation, religion and mass media; (11) political and social systems, structures and processes; (12) General advancement of knowledge: R&D financed from general university funds; (13) General advancement of knowledge: R&D financed from other sources than GUF; and lastly (14) Defense.

The OECD (2015) states that the Defense SEO covers research and development for military purposes and may include primary research and space research when financed by ministries of defense.

2.3 INTER-ORGANIZATIONAL RESEARCH

Lundvall (2016) characterizes a system of innovation as constituted by elements and relationships that "interact in the production, diffusion, and use of new and economically useful knowledge and that a national system encompasses elements and relationships, either located or rooted inside the borders of a nation-state (p.86)." Lundvall describes the national system of innovation as a dynamic social system where the central activity is social and involves interaction between people. Lundvall's primary purpose in national systems of innovation was to contribute to a theoretical understanding of learning (interactive) and innovation. The national systems aspect could be useful to inspire public policies at the national and international levels. The national system of innovation's most relevant performance indicators includes efficiency and effectiveness in producing, diffusing, and exploiting economically useful knowledge. Some of the output measures include patents, the proportion of new products in sales, and the proportion of products in foreign trade, noting that diffusion of process technology needs consideration. Table 2 summarizes the characteristics of Lundvall's (2016) National Innovation Systems theory.

Table 2. Characteristics of National Innovation Systems from Lundvall (2016)

Theory element	**Characteristics**
Innovation as Cumulative Process	Innovation as a cumulative and ongoing process. Most important forms of learning regarded as interactive process. Learning with economic structure establishes the framework for the processes of interactive learning sometimes resulting in innovations.
Learning and production structure	Innovation rooted in the prevailing economic structure. Areas of technical advance take place where firm or national economy is already engaged in routine activities.
Learning and industrial setup	Institutions provide agents and collectives with guideposts for action. Institutions make guide everyday actions in production, distribution, and consumption and can be guideposts for change. One fundamental characteristic is institution stability over time.
Product Innovation and user-producer interaction	rate and direction of innovation affected by structure of production and institutional setup. Indicator is level of interaction between producers and users. 1. micro level - structure of production defines sets of user-producer relationships that condition scope and direction of process of innovation 2. Institutional form characterizes the relationships reflects the characteristics of the innovation process 3. The institutional setup will affect the rate and direction of innovation 4. User-producer relationships can be shown to be distance in cultural and geographical space.
Learning, searching, and exploring	exploring - searching for alternatives in product, processes, markets. Less goal-oriented than profit-oriented searching.
Incremental versus radical innovations	The characteristics of the innovation (incremental versus radical) have either technical or economic dimensions. Incremental technical innovations may have crucial impact on economy (evolutionary technical with tremendous impact on productivity). In the other hand, possible for breakthrough technical innovation to result in limited to no impact in economy. Innovation process is neither totally accidental nor totally predetermined by economic structure and institutional set-up.

Nelson (1993) and the contributors and steering committee for the National Innovation Project illuminated the institutions and mechanisms supporting technical innovation in several studies over 15 countries. Within the U.S. National Innovation System, Nelson provides an account of the commercial firm's impact on military Research and Development spending. The National innovation system characterization does not allow for calculating innovation spending based on R&D and acquisition of tangible items and services.

During post World War II, investments from Defense procurement contributed to lowering the market-based barriers of entry for private firms such as General Radio, Texas Instrument, and Transitron. Nelson also discusses the military-civilian spillover phenomena. The economic spillover effect from defense research appears to fluctuate over time within a specific technology. One crucial factor is the generic similarity of civilian and military requirements within a technology. OECD/Eurostat (2015) defines innovation as "a new or improved product, or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)." (OECD/Eurostat, 2015, p. 20)

Fagerberg, Mowery, & Nelson (2013) provide an account of the innovation phenomena and its many traditions and perspectives from many disciplines, including the systemic nature of innovation. The systemic nature of innovation is characterized by the approach to delineate systems on technological, sectorial, industrial characteristics and include, but not limited to, institutional, political process, public research infrastructure, financial factors. In the DoD/allied partner, inter-organizational relationships setting the knowledge of allied partner common needs and associated technological innovations may be achieved, by an individual, decision-making unit, or individuals across decision-making units organized either in a tightly or coarsely coupled organizational form. One important element of an innovation-decision process within the U.S. DoD with allied partners is the communication channels and associated attributes of trust across organizations, including alignment of change agents, adopters, decision-makers, implementers, and decision-making units.   The literature review of the inter-organization research is concentrated on inter-organizational knowledge acquisition, partner selection, planning, and collaborative innovation strategies across organizations. The work of Chiang and Hung (2010) argues that accessing knowledge from a broad range of external channels can enhance the firm's radical innovation performance, providing differing results more oriented towards open search depth being positively related to incremental innovation performance. The work of Conteh (2013) argues that "public management can be understood intrinsically consisting of funding and sustaining a good fit between agency's mission and the strategies and the forces in its external environment that create both opportunities and threats". Conteh also argues that "emphasis on strategic partnerships which facilitate inter-jurisdictional and inter-organizational co-operation by which governments can facilitate the solution of social problems or the commissioning of innovation aimed at productivity and economic development." (p. 518)

Gattringer, Wiener, and Strehl (2017) make the distinction between corporate and collaborative foresight and present some benefits to collaborative foresight activities and discuss several criteria for partnership selection and optimal partner arrangements. They claim that geographic proximity was helpful in the exchange of tacit knowledge and bringing organizations together.   Gulati (1998) defines strategic alliances as "voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services".(p. 293). Gulati provides a social network perspective to study strategic alliances and five key issues: (1) The formation of alliances; (2) The choice of governance structure; (3) The dynamic evolution of alliances; (4) The performance of alliances; (5) The performance consequences for firms entering alliances" (p. 293)

Knoben (2006) provides a multidimensional construct covering the concept of inter-organizational proximity. Figure 15 depicts the different types of proximity and associated levels of analysis and overlaps.

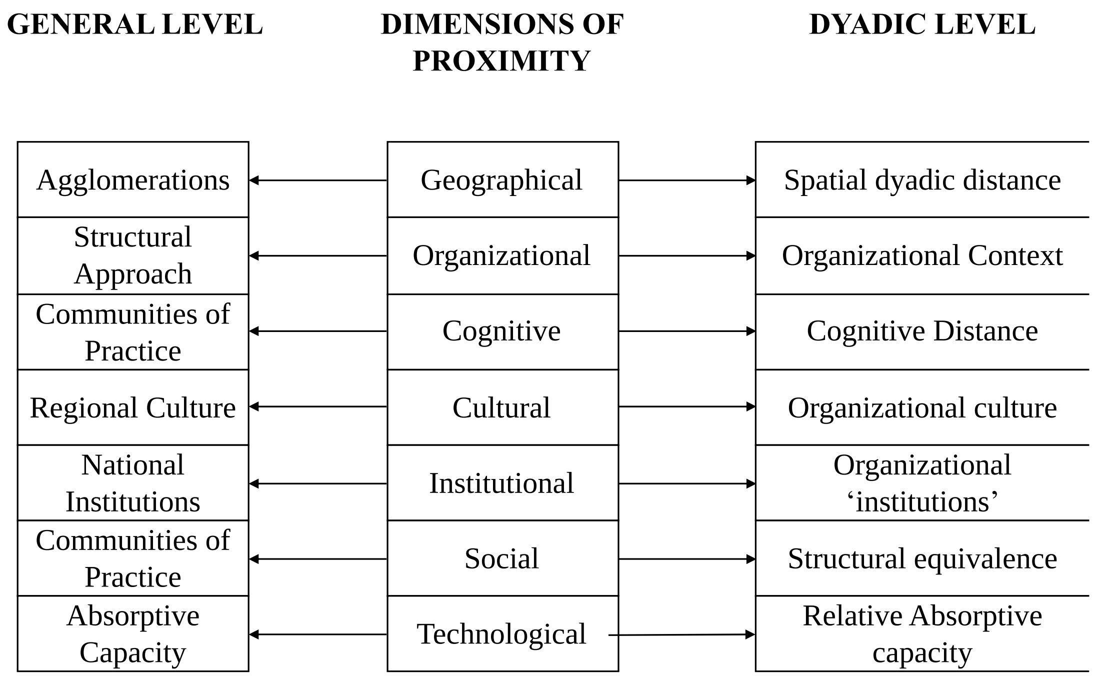


Figure 15. Dimensions of Proximity. From Knoben (2006, p. 79)

The main dimensions of proximity, according to Knoben’s research at the dyadic level are organizational, technological, and geographical proximity. The research of Loebbecke, van Fenema P., and Powel (2016) explore the importance of knowledge exchange management across organizations, and outlines the explicit and tacit knowledge distinctions. Other works (Piltan & Sowlati, 2016; Sivadas & Dwyer, 2000; Yan & Azadegan, 2017) compare new product development strategies related to partnering choices, examine success factors of internal and alliance-based processes, and decision support models for evaluating the performance of partnerships.

2.4 DOD ALLIED PARTNER SECURITY COOPERATION

According to Skorupski & Serafino (2016), DoD Security Cooperation consists of more than 80 authorities U.S. Congress has provided to assist and engage with foreign governments, militaries, security forces, and populations. Security Cooperation has policies and guidelines promulgated within the U.S. Department of Defense ((AT&L), 2007, 2015; DAU, 2017; Defense, 2014; I/C, 2012; Policy, 2016). The security cooperation and authorities have been growing as a statutory framework for U.S. DoD and have become a cumbersome system.

A summarized description from Skorupski & Serafino (2016) outlines each category. Contingency Operations and Related Coalition Operational Support is a security cooperation category that provides DoD several authorities to support U.S. military operations or other military efforts in conflict zones.

- Counter narcotics, Counter-Transnational Organized Crime, and Counterproliferation provide authorities to conduct counter-narcotics, counter-transnational organized crime, assistance, including defense articles and services to certain countries.
- Defense Institution Building and Support executes military-to-military informational engagements to promote reform of foreign defense institutions.
- Education and Exchange Programs – support the participation of U.S. and foreign military personnel in education and personnel exchange activities.
- Exercises – U.S. support for the participation of foreign forces in "combined exercises involving the U.S. and foreign forces."

- Global and Regional, Non-Contingency Train and Equip, and Other Assistance – authorities to provide training, equipment, and other support to build partner capacity.
- Humanitarian Assistance and Disaster Relief – support U.S. DoD responses to foreign disasters and humanitarian crises for rapid deployment
- International Armaments Cooperation – permits information sharing and cooperative research and development with other countries and organizations related to weapon systems.

Based on the literature review, the security cooperation category associated with partnerships for gaining knowledge and co-development of innovative technologies is the International Armaments Cooperation. Most of the challenges have a component of policy, knowledge, strategic planning and management, coordination, requirements generation and harmonization, and human cultural factors related to the inter-organizational setting.

2.5 INTERNATIONAL ARMAMENTS COOPERATION

The U.S. Congress provided two authorities for DoD in the U.S. code of law that permit information sharing and cooperative research with other countries and organizations, related to weapon systems. According to International Armaments Cooperation (IAC) is a "cooperative research, development, test, and evaluation of defense technologies, systems, or equipment; joint production and follow-on support of defense articles or equipment; and procurement of foreign technology, equipment, systems or logistics support." (I/C, 2012, p. 2)

Some of the key objectives of International Armaments Cooperation are:

- "Deployment and support of common and interoperable equipment with U.S. friends and allies.

- leverage resources through cost-sharing and economies of scale by conducting coordinated research, development, production, and logistics support programs.
- Exploitation of the best technologies, military or civilian, available for equipping the U.S., its allies, and other friendly nations.
- supply the best available defense material to the U.S., its allies, and other friendly nations in the most cost-effective manner.
- Maintenance of strong industrial base for the U.S., its allies, and other friendly nations.
- Promote the integration of environmental, safety and occupational health considerations into U.S., allied, and other friendly nations' defense planning.
- Enhance national security strategies of modernizing and strengthening existing alliances and friendships while reaching beyond traditional allies and friends, but increasing transparency in armaments and improving understanding" (Hartman, 1997, p. 7)

In broader terms, according to (I/C, 2012), the core objectives of international [armaments] cooperation are:

- Operational – increase military effectiveness through interoperability and partnership with allies and coalition partners.
- Economic – reduce weapons acquisition cost and achieve Better Buying Power (BBP) by sharing costs and economies of scale, avoiding duplication of development efforts; and achieving the cooperative production or sales of more weapons systems to our allies and friends.

- Technical – to access the best defense technology worldwide and help minimize the capabilities gap with allies and coalition partners.
- Political – strengthen alliances and relationships with other friendly countries; (5) Industrial – bolster domestic and allied defense industrial bases”. (I/C, 2012, p. 3)

Ross (2017) defines International Armaments Cooperation as acquisition programs that involve technical and defense industrial base cooperation. Some work related to formulating strategies for International Armaments Cooperation by Roe (2000) discusses the integration of processes, technology, management alternatives, and contracting vehicles. Interviews conducted with people involved in international cooperation by Pollock (1999) provides some insights on mainly budgetary and defense industrial considerations as reasons for cooperation and highlights issues related to International Armaments Cooperation attributed to organizational challenges, and success factors attributed to policy, requirements, integration of acquisition systems, and leadership incentives. The U.S. Defense Acquisition Guide by Defense Acquisition University (2017) provides a high-level set of guidance on how a program should address the integration of international aspects in acquisition and technology development strategy. In the case of the DoD, development of strategies that involve varying levels and modes of cooperation with allied partners involve stakeholders that view such partnerships differently from many perspectives, including political, military, economic, social, information, and technological. International Armaments Cooperation provides a way to share costs and risks, support broader political objectives, address coalition interoperability issues, access and co-develop technologies (knowledge, products) that are both superior and innovative. From an industry base perspective, International Armaments Cooperation is considered as an opportunity to exchange technology for market access. According to Kapstein (1991), U.S. industry views International Armaments

Cooperation as a trade-off between high-market access in exchange for development and production work as well as technology, with the fear of long-term implications such as increased competition. Most of the research in International Armaments cooperation was conducted in the 1970s through the 1990s addressing international political economy aspects (Kapstein, 1991), standardization (Activity, 1990), contracting terminology (Brown, 1994). The research of Constant (1991) addresses evaluation factors for the selection of cooperative arrangements and concluded the identification of "six basic factors: technology, industrial base, political, economic, program stage, and requestor's motives." (p. viii)

Hartman (1997) concluded that economic factors caused U.S. and allies to develop and explore models for arms cooperation programs and recommended using two programs (MEADS and JSF) as baseline models for international armaments cooperation. The research of Wilkerson (2010) highlights the challenge of maintaining common capabilities with maintaining partner expectations based on program performance and partnership structure data. While commonality is essential for JSF's program cost control, the diversity of partners and their unique requirements becomes a challenge for maintaining the cost, schedule, and performance of the program. Wilkerson's research highlights the importance of National Disclosure Policies (e.g., regulatory policies for sharing data from the U.S. to allied partners) for the common configuration of the Joint Strike Fighter system design. Other research and publications attempt to address the definition of International Armaments Cooperation (Kwatnoski, 1991), and institutional Fora for International Armaments Cooperation appraisal (Nauta, 1989).

2.6 GAPS IN THE LITERATURE

The explorative-exploitative literature reviewed (Benner & Tushman, 2003; Gupta et al., 2006; Jansen, 2006; Lewis, 2009; Ying Li et al., 2008; Yi Li et al., 2010; Michael & Charles A. O'Reilly, 1996; Mueller et al., 2013) focused on:

- innovation performance in intra-organizational setting,
- success patterns,
- ambidexterity,
- issues of lack of a formal definition of explorative-exploitative innovation.

Based on literature research, explorative-exploitative innovation is viewed from the business enterprise sector. Within that viewpoint, the research focus is on evolutionary and disruptive cycles of technological innovation. The firm’s main purpose id profit and market share maximization with ability to adapt during stable environments and rapidly change during periods of disruption. No research has been conducted in helping define explorative-exploitative innovation strategies from a broader multi-sectoral perspective.

Rogers' (2003) innovation diffusion theory and the explorative-exploitative concept (O'Reilly & Tushman's, 2003; Bennan & Tushman's, 1996) can be unified towards a more comprehensive model for innovation. Research discussing the expansion of the explorative-exploitative model for innovation was not found in the literature review.

From a U.S. DoD innovation and partnerships perspective there is a lack of shared understanding of how International Armaments Cooperation can be better integrated as a strategic partnership instrument for explorative-exploitative technological innovation linked to U.S. national security, military, and defense strategies and military mission needs.

CHAPTER 3

METHODOLOGY

The purpose of this chapter is to describe the research theoretical framework, associated methodologies, and methods. The chapter also outlines a detailed overview of the research phases.

3.1 RESEARCH THEORETICAL FRAMEWORK

Systems Theory guides the researcher's general frame of inquiry. Systems Theory provides a "trans-disciplinary framework for a simultaneously critical and normative exploration of the relationship between our perceptions and conceptions and the world they purport to represent" (Jordan, 1998, pp. 47). Bertalanffy (1973) introduced General Systems Theory as a general science of "wholeness," interdisciplinary, centered in the General Systems Theory, unifying, and integrative. Concerning normative considerations, "a systemic orientation is needed to maintain a holistic, critically self-reflective attitude that seeks to integrate individual satisfaction (including the physical, mental, emotional, and spiritual needs of human beings) with their societal and natural environments in consideration of dynamic developmental laws and processes." (Jordan, 1998, p. 50).

Table 3 outlines key characteristics of Systems Theory as a conceptual field of inquiry for the research. As outlined by Jordan, J.S. a systems theory field of inquiry is concerned with the holistic and integrative exploration of phenomena and events and pertain to both epistemological and ontological situations.

Table 3. Key System Theory Characteristics guiding research

Characteristic	**Description**	**Source**
Reduction to Dynamics	Almost every real-world system contains large number of components and is expose to large number of external forces and events	Jordan (1998)
Emergent Properties	Emergent property is marked by appearance of characteristics exhibited on the level of whole ensemble. When component is removed from the whole, it loses its emergent properties	Jordan (1998)
Systems Approach	Focuses attention on the whole and complex inter-relationships among its parts	Jordan (1998)
Systems Approach Methodology	Qualitative heuristic function: identify specific entities capable of being modeled as systems, and wider areas of their relevant environment. Systems thinker’s perception always incorporates an element of human intuition	Jordan (1998);

Table 3 continued

Method	model complex entities created by multiple interaction of components. Abstract certain levels of detail of structure and component. Concentrate on dynamics that define characteristic functions, properties, and relationships internal and external to the system	Jordan (1998)
Process of Inquiry	1. Deconstruction of what which is to be explained 2. Formulation of explanations that account for the behavior or properties of the components taken separately 3. Synthesis of the explanations into an aggregate understanding of the whole	Jordan (1998)

As outlined in Table 3 the system theory method of inquiry is to model complex entities, to abstract certain levels of detail of structure and component, and concentrate on dynamics characterizing functions, properties and system relationships. The Systems Approach Methodology incorporates a gnosiological philosophy of incorporating human intuition in system thinker's perception.

The nature of the research problem requires some theoretical framing from a management philosophical perspective. The research purpose is to depict a theoretical construct represented as an architecture reflecting a real-world system reflecting individual, interpersonal, organizational, and inter-organizational that have primary purposes and goals operating under many constraints. Goldratt (1990) has developed the Theory of Constraints. A key first step in Goldratt's theory is the recognition that systems were built for a purpose. The system's purpose implies that before considering improvements in any part of the system, the systems global goals and associated measurements on the system must help judge impact of subsystems and any local decision to the global goal. The second step is to use the terminology of the system we are trying to improve and use terminology of the improvement process itself. In his theory, a constraint is anything that limits a system from achieving higher performance against its goal. Theory of Constraints identifies the approach below for identifying and managing system constraints (using the terminology of the system we seek to improve)

1. Identify the system's constraints
2. Decide how to exploit the system's constraints
3. Subordinate everything else to the above decision
4. Elevate the system's constraints
5. If in the previous step a constraint is broken, go back to step 1, but do not allow inertia to cause a system constraint. (pp. 76-77)

Goldratt (1990) also states that for a process of ongoing improvement to be effective we must know:

1. What to Change – ability to pinpoint core problems. Problems that once corrected will have major impact
2. What to change to – provide ability for managers and leaders to construct simple and practical solutions

3. How to cause the change – mostly a psychological question.

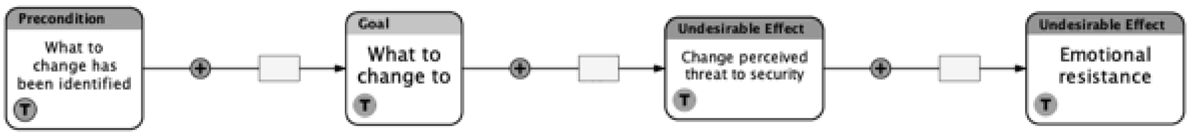


Figure 16. Undesirable effects of organizational change process

Figure 16 outlines Goldratt's (1990) model for undesirable effects that occur once "what has to change" has been identified and what to change to goal has been established. The undesirable effect makes the "how to cause the change" very challenging, even when the how to change approach presents itself as technically acceptable. In this research the Theory of Constraints drivers for development of the architecture are:

- The idea that systems are conceptualized and built for a purpose. A system's global goal needs to be defined along with the measurements that will enable judging impact of any subsystem and local decision.
- Use the terminology of the system we are trying to improve and using terminology of process improvement itself.
- System constraints as system variables tied to the global system objectives.

The Theory of Constraints will drive the capture of the logical inferences conducted during the qualitative content analysis leading to the development of the architecture. Whenever possible, the inferences will be illustrated using evidence-based analysis, conflict resolution, effects-based planning, or pre-requisite trees.

The nature of the research problem and purpose requires methods that support the systems theory and Theory of Constraints approaches relying on text as the sole source of data in the research. The various facets of the phenomena being investigated are manifested and recorded in various types of literature, from government sponsored articles and government publications to peer reviewed journals. The combined methods designed in this research are based on Krippendorff (2004) conceptual framework for content analysis. An extraction of the key components of the framework are outlined in Table 4. His framework is intended to guide the conceptualization and design of content analysis research, guide the analytical purpose facilitated by the critical examination and comparison of content analysis, and methodologically point to performance criteria and precautions researchers can apply in evaluating content analyses. The framework contains the following conceptual components:

- A body of text, the data that a content analyst has available to begin an analytical effort
- A research question that the analyst seeks to answer by examining the body of text
- A context of the analyst's choice within which to make sense of the body of text
- An analytical construct that operationalizes what the analyst knows about the context
- Inferences that are intended to answer the research question, which constitute the basic accomplishment of the content analysis
- Validating evidence, which is the ultimate justification of the content analysis. (pp. 29-30)

Kippendorff (2004) notes that most content analyses start with data not intended to analyze specific research questions. In the case of this research the original inquiry started with a real-world problem, which is documented by government reports and policy documents. The exploratory review of that problem through researcher's experience and available text data led to researcher's pursuit of better understanding the problematic and fundamental problems surrounding the originally perceived problem. This pursuit led the researcher to further investigate other broader aspects of the problem, which led to seeking a broader set of texts that led to a formulation of the research question.

Table 4 - Content Analysis Framework. From Krippendorf (2004, pp. 29-40)

Conceptual Component	**Description**
A body of text, the data analyst has available to begin analytical effort	Readers may decompose what they read into meaningful units, recognize compelling structures, rearticulate their understandings sequentially or holistically, and act on them sensibly
A research question that analyst seeks to answer by examining body of text	Research questions/objectives are targets of analyst inferences from available texts. Research questions of content analysis must be answered through inferences drawn from the text. Research Questions have the following characteristics: • They are believed to be answerable (abductively inferable) by examinations of body of texts
A research question that analyst seeks to answer by examining body of text	• They delineate a set of possible (hypothetical answers among which analysts select) • The concern currently inaccessible phenomena They allow for acknowledging another way to observe or substantiate the occurrence of the inferred phenomena

Table 4 continued

A context of the analyst's choice within which to make sense of the body of text	Context specifies the world in which texts can be related to the analyst's research questions. Knowledge of the context for content analysis separated as two kinds: • Network of Stable Correlations – connect available texts to the possible answers to given research questions, whether these correlations are established empirically from applicable theory, or merely assumed for the purposes of an analysis • Contributing Conditions, which consist of all the factors that are known to affect that network of stable correlations in foreseeable ways
Analytical construct that operationalizes what analyst knows about the context	Procedurally, analytical constructs contain rules of inferences that guide the analyst. Purpose of analytical constructs is to ensure that texts are processed in reference to what is known about their use.

Table 4 continued

Inferences that are intended to answer the research question, which constitute the basic accomplishment of content analysis	Deductive inference: implied on their premises. For Example: "if all humans speak a language, then John, being human, must speak one as well". Deductive inferences are logically conclusive. They proceed from generalization to particulars Inductive References: generalization to similar kinds. Example: inferring from the fact that all neighbors speak English that all humans do. Inference is not logically conclusive but has certain probability of being correct. Abductive Inferences: proceed across logically distinct domains, from particulars to one kind of particulars to other kind. One can make such inferences only with a certain probability.
Validating Evidence, which is the ultimate justification of the content analysis	Framework demands merely that a content analysis be validatable in principle. This prevents analysis from pursuing research questions that allow no empirical validation of that yield results with no backing except for the authority of the researcher.

Krippendorff (2004) categorizes content analyzes focusing on how researchers use content analytic techniques and how researchers justify drawn in the analysis. A summarized account of the categories is shown on Table 5. The author also adds that content analyses are most successful when focusing on facts that are constituted in language, summarized in Figure 17.

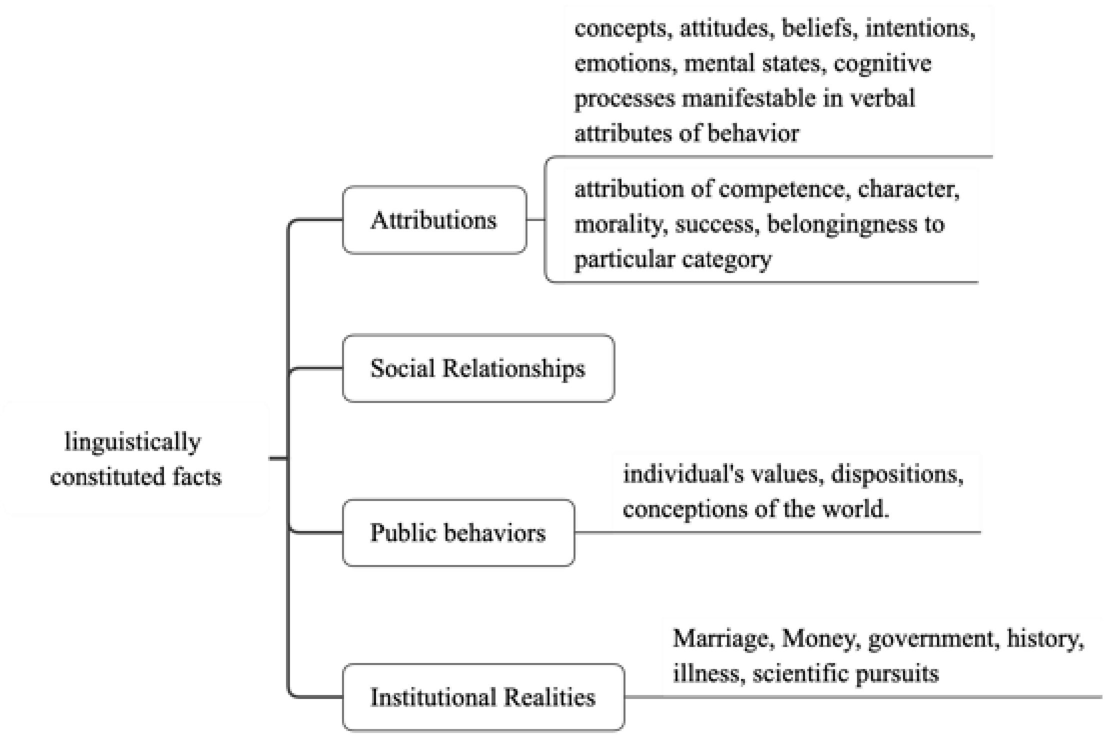


Figure 17. Content analysis and focus of linguistically constituted facts

Table 5. Categorization of Content Analysis from Krippendorff (2014)

Type of Inference in the content analysis	Description	Analyical Appplications
Extrapolation	Inferences of unobserved instances in the intervals between or beyond observations (data points). Kinds of extrapolations are: interpolations, predictions, extensions, derivations of theorems from other theorems, and systems.	System Approaches: -extrapolation of trends -differentiation from comparisons among the variable components of a system may be extrapolated ti differences among similary components elsewhere
Standards	in content analysis standards are often implicit and facilitate inferences of a certain kind.	Identifications: concerns what something is, what it is to be called, or what class it belongs to. Something either is or not of a certain kind on the basis of a standard. Evaluations: based on a standard criteria of evaluations. Subjective to analyst biases. judgements: are based on standards with additional provision that they are prescribed or legitimated by institutions
Indices and symptoms	An index is a variable whose significance rests on its correlation with other phenomena. An Index must be causally connected to the event it signifies. An underlying mechanism such that relation between an index and what it represents is a necessity. indices are conceived in medicine as symptoms.	indices used in mass communication research: - presence or absence of a reference or concept taken to indicate the source's awareness or knowledge of the object referred to or conceptualized - The frequency with which a symbol, idea, reference, or topic occurs in a stream of messages is taken to indicate the importance or, attention to, or emphasis on that symbol, idea, reference, or topic in the message - Numbers of favorable or unfavorable characteristics attribute to a symbol, idea, or reference are taken to indicate the attitudes held by the writers, the readers, or their common culture toward the object named or indicated. - The kinds of qualifications - adjectives or hedges - used in statements about a symbol, idea, or reference are taken to indicate the intensity, strenth, or uncertainty associated with the beliefs, convistions, and motivations that the symbol, idea, or reference signifies. - the frequency of co-occurence of two concepts (excluding those that have grammatical or collocational explanations) is taken to indicate the strength of associations between those concepts in the minds of the mengers of a population of authors, readers, or audiences.
linguistic re-presentations	analyze the conceptual structure that a text invokes in particular readers. Re-presentations provide conceivable worlds, spaces in which people can conceptualize reality, themselves, and others.	analysis of text as re-resentations has to acknowledge connectedness of larger textual units
Conversations	analysts aim to understand the structure of naturally occurring speech, which includes two or more participants.	analysis of exchanges between leaders of organizations, understand pathologies of communication, understanding of organizational and leadership characteristics based on human interaction
Institutional Processes	institutions tend to remain hidden behind habitual practices until flaws emerge and certainties break down. The properties of the medium of communication in which an institution is constituted have profound effects on the development of that institution.	content analysis of institutions often focus on communications at moments of breakdown: - legal explanations - economic explanations - political explanations - technical-structural explanations

The research used Elo et al. (2014) trustworthiness checklist as part of the research evaluation. Trustworthiness refers to ‘credibility,’ ‘dependability,’ ‘confirmability,’ ‘transferability,’ and ‘authenticity.’ Elo et al. (2014) captured a trustworthiness checklist for each phase of the research outlined in Figure 18.

Krippendorff (2004) outlines the typical parts of content analysis research:

- *A statement of the general epistemic or methodological issue* that the proposed analysis will address what that issue is and why and to whom it is significant.
- *A review of available literature on the context* in which this issue resides, showing the kinds of questions that have been asked and answered, the kinds of research methods previously applied, and what has worked and what has not, including the analysts' own research experiences, if relevant.
- *A formulation of the specific research questions* to be answered by the proposed research, which should be embedded in an account of the framework adopted, and the *workd of the analysis* that makes sense of these questions and points to a *body of text* by which the analysts expect these questions….
- *... a description of the procedure to be followed*, including accounts of any preparatory research already undertaken or to be carried out…. (pp. 359-360)

Preparation Phase

- Data Collection Method
  - How do I collect the most suitable data for my content analysis?
  - Is this method the best available to answer the target research question?
  - Should I use either descriptive or semi-structured questions?
  - Self-awareness: what are my skills as a researcher?
  - How do I pre-test my data collection method?
- Sampling Strategy
  - What is the best sampling method for my study?
  - Who are the best informants for my study?
  - What criteria should be used to select the participants?
  - Is my sample appropriate?
  - Is my data well saturated?
- Selecting the unit of analysis
  - What is the unit of analysis?
  - Is the unit of analysis too narrow or too broad?

Organization Phase

- Categorization and abstraction
  - How should the concepts or categories be created?
  - Is there still too many concepts?
  - Is there any overlap between categories?
- Interpretation
  - What is the degree of interpretation in the analysis?
  - How do I ensure that data accurately represent the information that the participants provided?
- Representativeness
  - How do I check the trustworthiness of the analysis process?
  - How do I check the representativeness of the data as a whole?

Reporting Phase

- Reporting results
  - Are the results reported systematically and logically?
  - How are connections between the data and results reported?
  - Is the content and structure of concepts presented in a clear and understandable way?
  - Can the reader evaluate the transferability of the results (are the data, sampling method, and participants described in a detailed manner)?
  - Are quotations used systematically?
  - How well do the categories cover the data?
  - Are there similarities within and differences between categories?
  - Is scientific language used to convey the results?
- Reporting Analysis process
  - IS there a full description of the analysis process?
  - Is the trustworthiness of the content analysis discussed based on some criteria?

Figure 18. Trustworthiness checklist for research. From Elo et al. (2014)

3.2 MULTI-PHASE RESEARCH DESIGN

This section outlines the overall phases and stages of the research design. Figure 19 illustrates the overall organization of the research design. A key aspect of this research is that it started when researcher, in his professional setting, perceived a complex real-world interaction among various systems exposed to a large number of external and internal forces and events. This led to conducting literature review that resulted in identifying a potential unifying context and an organization of a broader system with better defined components addressing additional perspectives surrounding both the broader context and the initial problem. Based on the literature review and formulation of the research problem and purpose, the research design for architecture development considered the following drivers:

- Data language ambiguity. During the literature review researcher noticed a potential high degree of ambiguity in key concept definitions either within a certain domain and/or across domains (e.g. private versus U.S. DoD public sector). An example is the use of the words *firm*, *business*, *private firm*, *business enterprise*, *industry partner*, *contractor*. Other example is the use of the word “exploitative and explorative”. These are words used to defined concepts, and they don’t seem to have a widely accepted definition.
- The ability to provide better definitions and clarity of the main concepts and to organize these elements in a [system] architecture.

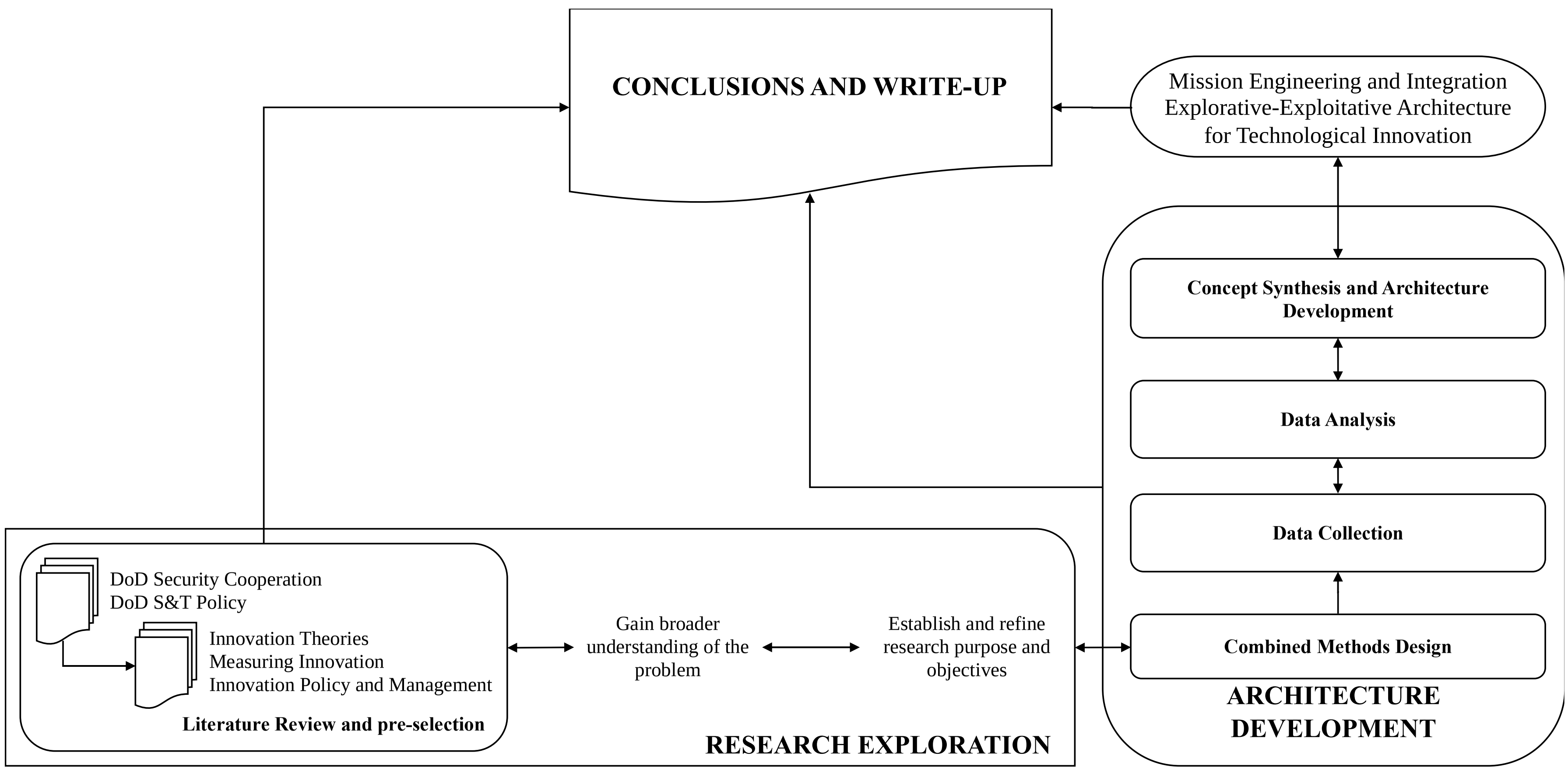


Figure 19. Multi-Phase Research

3.3 RESEARCH EXPLORATION PHASE

The entry point in the research exploration and literature review was the researcher's interest in the ability of the U.S. Department of Defense to evaluate and establish partnerships with allied partners for research and development. The literature review led to broader innovation and partnership challenges in DoD and the U.S. Security Cooperation system of policies and incentives for partnerships with allied partners supporting U.S. National Security objectives. As the researcher gained a broader understanding of the problem, the literature review helped further refine and serve as the basis for the undertaken research purpose and objectives.

The exploration phase consisted of a hermeneutical review of the literature associated with the first security cooperation and partnerships problem. The exploratory phase literature review led to the researcher's linking through literature review the security cooperation partnership problem to a broader issue related to the Department of Defense's ability to innovate in the context of rapid global change. The discovery, by literature review, of these broader issues led the researcher to investigate prominent theories related to the innovation phenomena and the gaps in the literature. With the gaps identified, the researcher developed the research problem and research purpose. The candidacy examination and feedback from the dissertation committee provided additional guidance and shape to the research purpose and research problem.

3.4 ARCHITECTURE DEVELOPMENT PHASE

The starting point of the architecture development phase was the design of the combined methods based on the research purpose and problem statements agreed upon by the researcher and committee. The design of the combined methods in the research took into account Jordan, J.S. (1998) systems approach methodology supported by a content analysis supporting the development of the theoretical architecture.

3.4.1 Combined Method

Research planning started generating guiding questions based on the research problem. These questions helped aid in research planning and des. Figure 20 outlines questions that helped shape the research planning and design phase, including data collection approaches. Some of the questions, keeping in mind that scope and limitations of the research were used as guides only, and the intent is not to try to answer them as conclusively answering them would be much beyond the scope of this research.

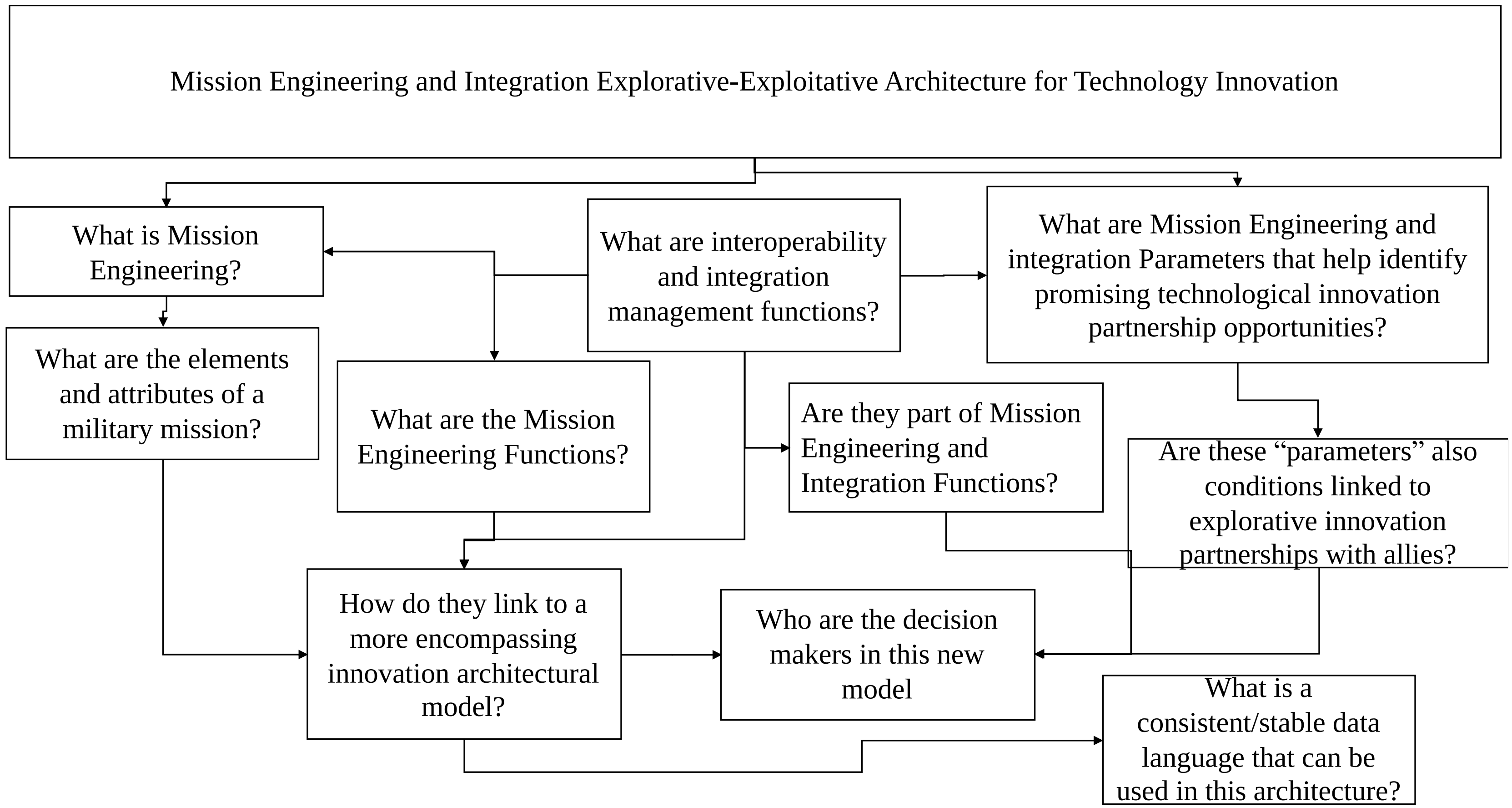


Figure 20. Researcher questions used in research planning

The questions derived from the research purpose and problem statements helped the researcher formulate methods of analysis data collection approach.

The “What is Mission Engineering” question led to the stratified and purposive sampling of peer-reviewed published journal articles that led to a definition of Mission Engineering. The only peer-reviewed published journal found was Sousa-Poza (2015). The initial review of the journal led the researcher to conduct purposive searches in the military domain for publications that were related to measuring military effectiveness. The “What are Interoperability and Integration Management” functions led to the purposive sampling of journals and publicly available publications within the U.S. DoD domain related to interoperability and integration management of military systems. These two questions led to the purposive search for journals and publications related to Mission Engineering parameters that help [decision makers] identify technological innovation partnership opportunities. The purposive search led to a discovery of journals and publications related to DoD’s strategies and challenges related to Science and Technology, Research and Development, ability to innovate rapidly with a more efficient approach, and issues related to its ability to establish partnerships not only internationally, but also domestically with industry and academia.

During the purposive search guided by the questions, the researcher intuitively had the idea of creating a more encompassing explorative-exploitative innovation architecture. The more encompassing architecture integrates the technological innovation and Mission Engineering concepts and ideas, and the ordering of perspectives among purpose, strategy, partnership, and actions. Also, the idea of an architecture that better accounts for complex situations as the context for explorative-exploitative technological innovations. Figure 21 illustrates the combined methods designed to address the research purpose.

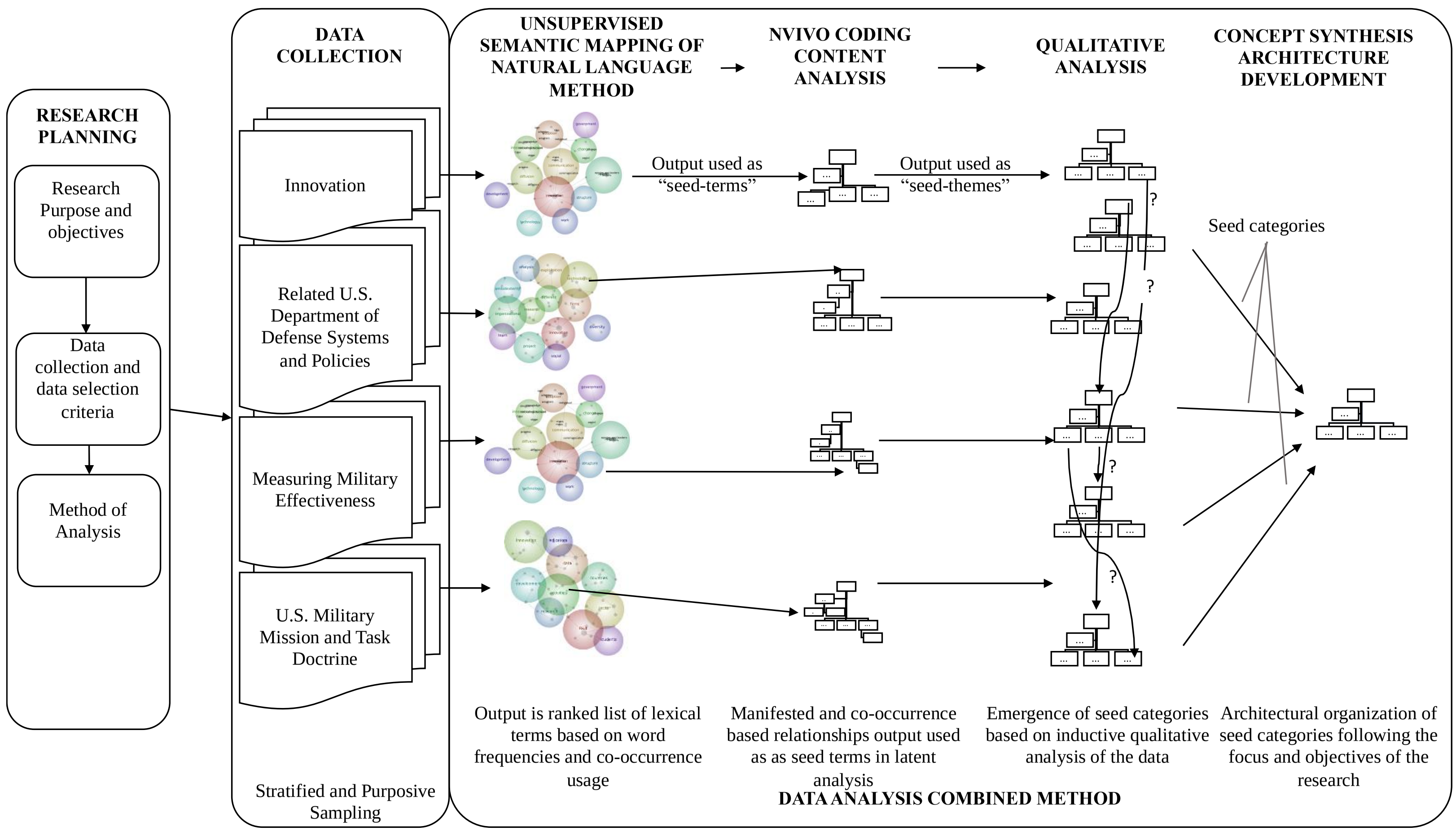


Figure 21. Combined Methods Design

3.4.1.1 Data Collection

The data was collected conducting online searches using Old Dominion University's online library search capability, including the U.S. Library of Congress, Google Scholar, SAGE Encyclopedia, Web of Science, various international open-access peer-reviewed journals, and publicly available government policy web sites. Table 6 specifies the criteria used for the inclusion of text data for analysis.

Table 6. Criteria for Data Collection

Criteria for Data Collection	
Include	Peer-reviewed literature
	published journals
	textbooks
	seminal published works
	publicly available government documents
	government issued reports and manuals
	online articles by non-governamental agencies sponsored by U.S. government
Exclude	Non-peer reviewed literature
	unpublished works (reports, papers, journals)

Figure 22 and Figure 23 provide a more detailed accounting of the data collected to be analyzed.

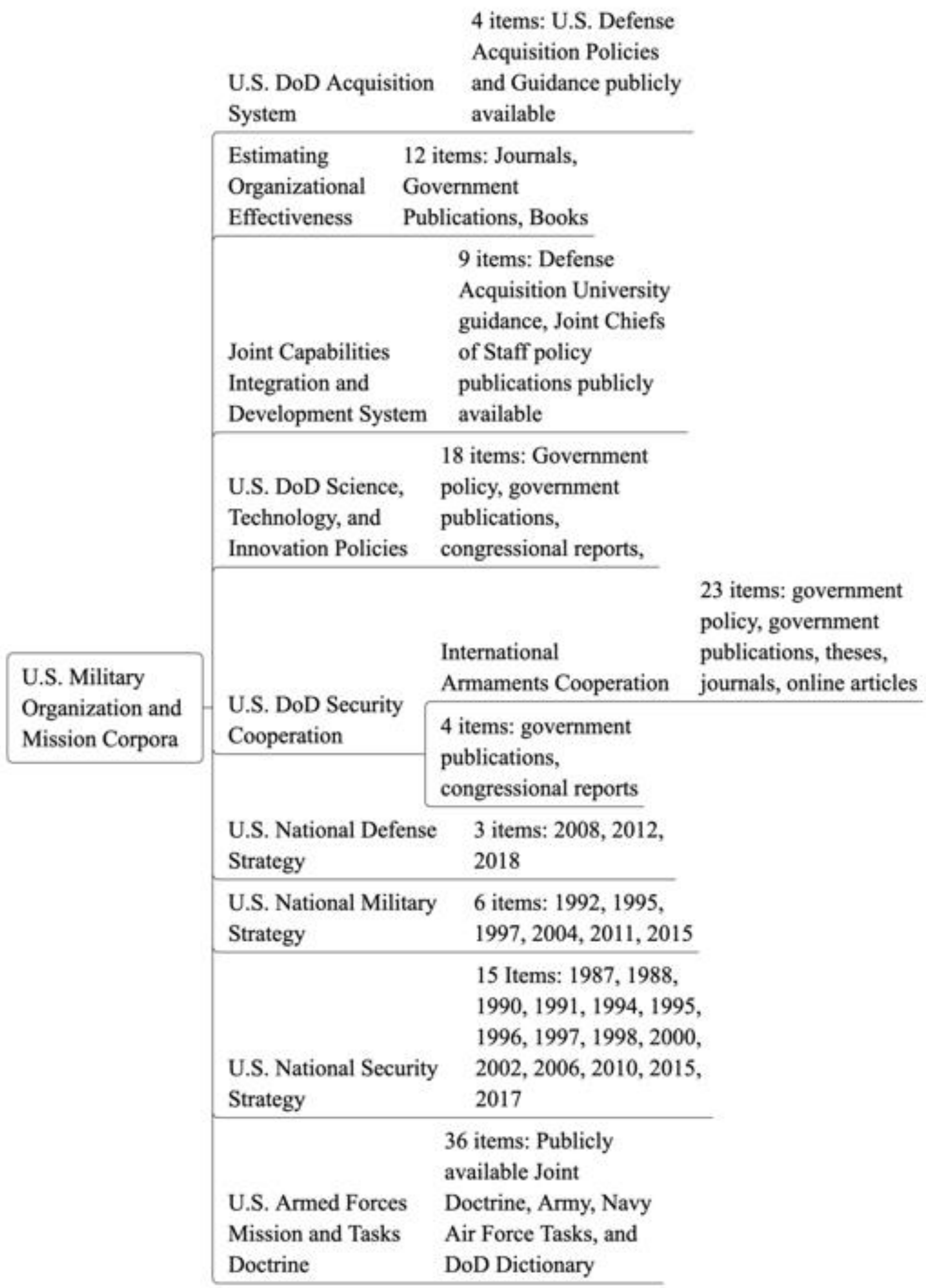


Figure 22. U.S. Military Organization and Mission Corpora

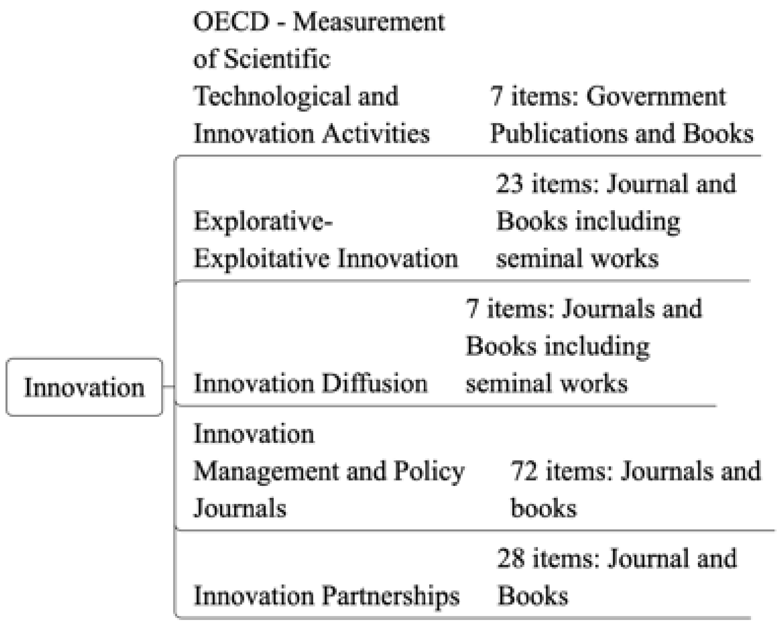


Figure 23. Innovation Corpora

Krippendorff (2004) lists three main definitions of the content analysis research method:

1. Definitions that take content to be *inherent* in a text.
2. Definitions that take content to be *a property of the source* of a text.
3. Definitions that take content to *emerge in a process of researcher analyzing a text* relative to a particular context. (p. 19)

Krippendorff (2004) also lists six features of texts within his definition of content analysis:

1. *Texts have no objective* – that is, no reader-independent qualities…
2. *Texts do not have single meanings* that could be "found", "identified", and "described for what they are…
3. *The meanings invoked by texts need not be shared…*
4. *Meanings (contents) speak to something other than the given texts…*
5. *Texts have meanings relative to particular contexts, discourses, or purposes…*

6. *The nature of text demands that content analysts draw specific inferences from a body of texts to their chosen context.* (pp. 24-25)

According to Krippendorff (2004) "*extrapolations are inferences of unobserved instances in the intervals between or beyond the observations (data points).*" One central characteristic in systems approaches is to have the ability to differentiate.

The content analysis approach in this research is the following:

1) Understand how stable the system elements are:
   a) By frequency and associations: "how often are they mentioned in the dataset, what other elements are they associated with?"
   b) What are they? Activities, actors, behaviors, variables…taking into account the context in which they are being used in dataset
   c) Capture reasoning behind their associations and definitions from the content
   d) Capture variability in their definitions
2) Adopt or propose new definitions and harmonize difference in definitions using extrapolation and inferencing.
3) Organize the elements architecturally along with the reasoning behind their definitions and connections.

To achieve this, the rest of this outlines the detailed architecture development's data analysis combined method illustrated in Figure 21.

3.4.1.2 Unsupervised Semantic Mapping of Natural Language Method

Unsupervised semantic mapping of natural language method was used to output a ranked list of manifested and lexical seed-terms based on word frequencies and co-occurrence usage. As described in Smith & Humphreys (2006), the words seed a thesaurus builder that learns a set of classifiers by iteratively extending the seed word definitions. The resulting term classifiers are then referred to as concepts in the software. With the concepts, classification of the text occurs. The output is a concept index for the corpora and a concept co-occurrence matrix. The asymmetric co-occurrence matrix results from calculating the relative co-occurrence frequencies of the concepts. The co-occurrence matrix is used to generate two-dimensional concept maps using an "emergent clustering algorithm." The “connectedness” of each concept in the resulting semantic network is employed to generate a third hierarchical dimension, allowing for displaying more general parent concepts at higher levels. Figure 24 provides a detailed outline of the semantic and relational extraction process used in Leximancer.

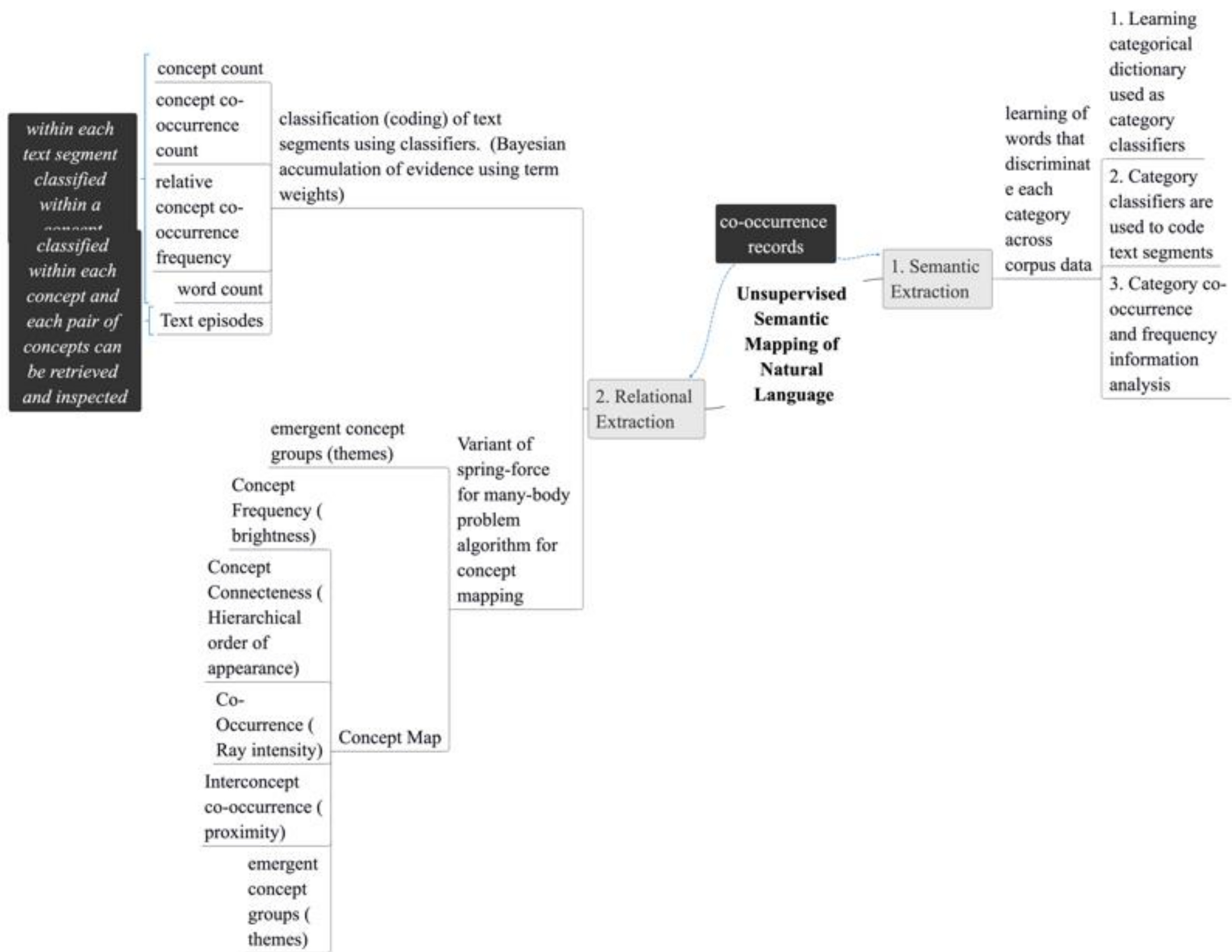


Figure 24. Semantic Mapping of Natural Language. From Smith & Humphreys (2006)

The semantic and relational extraction is achieved using the Leximancer Portal user interface. A screenshot of the user interface and projects used in the research is shown in Figure 25.

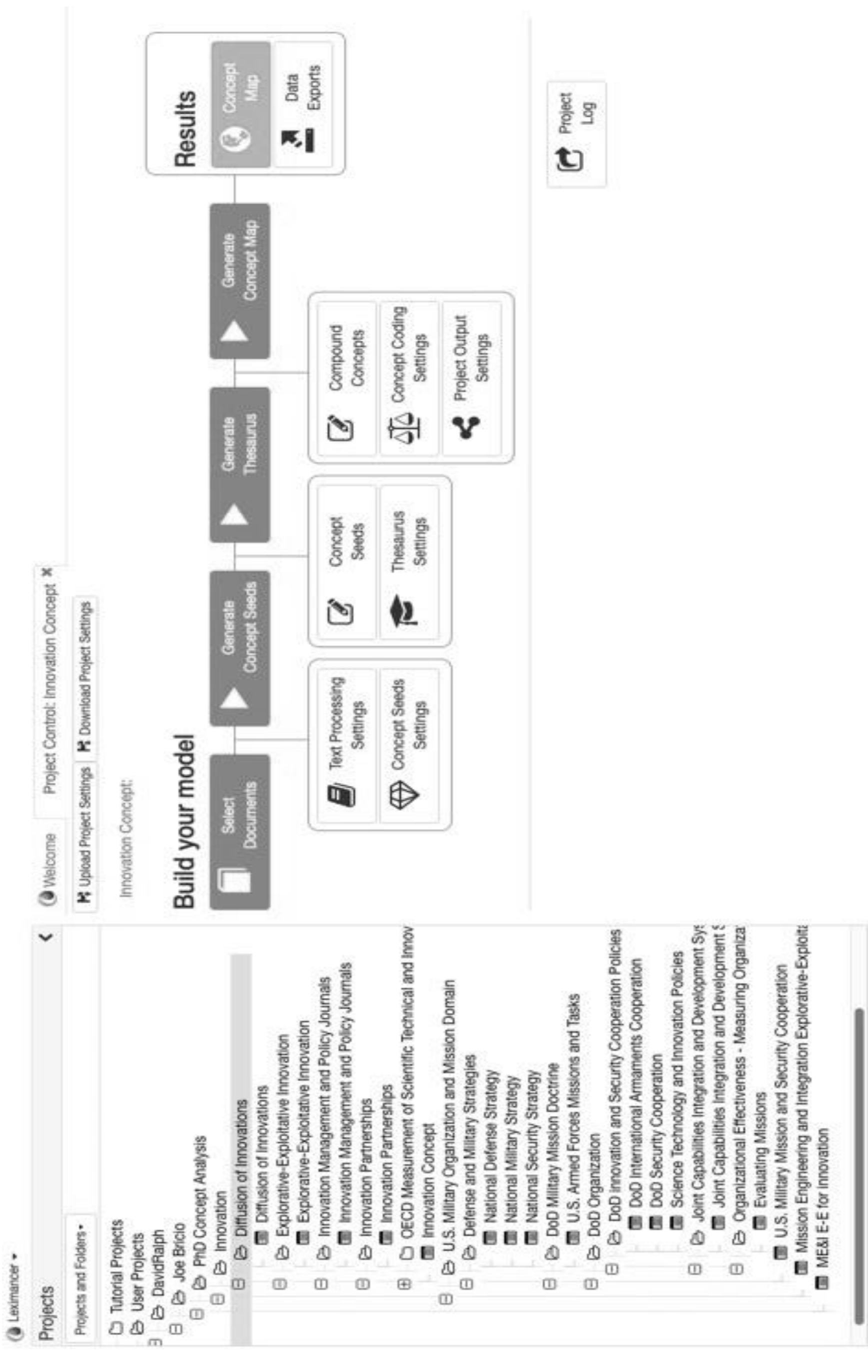


Figure 25. Leximancer Portal User Interface

The workflow used in the portal for the research is as follows:

- Establish the projects in the Portal.
- Following the overall data collection approach in the research, each set of data (corpus) was organized on their own project.
- For each project, the data was uploaded to the portal using the “select documents” button on the main interface of the portal project.
- For each project, the text processing settings were kept with default configuration and concept seed settings configured as shown in Figure 26 and Figure 27.

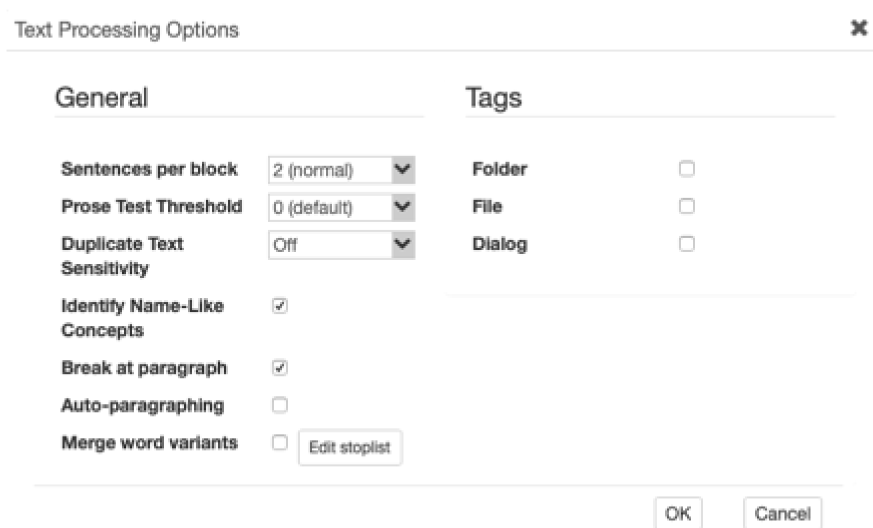


Figure 26. Text Processing Settings

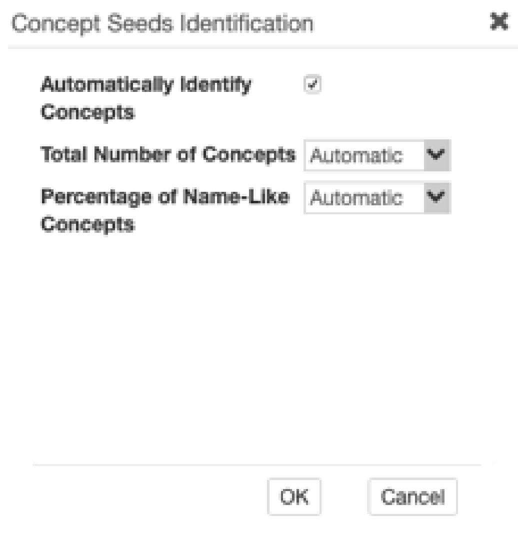


Figure 27. Leximancer Concept Seeds Settings

- Once the concept seeds are generated using the text processing and concept seeds settings configuration, the next step was to edit, delete, merge the concept seeds. This was an opportunity to conduct basic lemmatization and stemming of some of the words.
- With the set of word seeds the thesaurus settings were configured as shown in Figure 28.

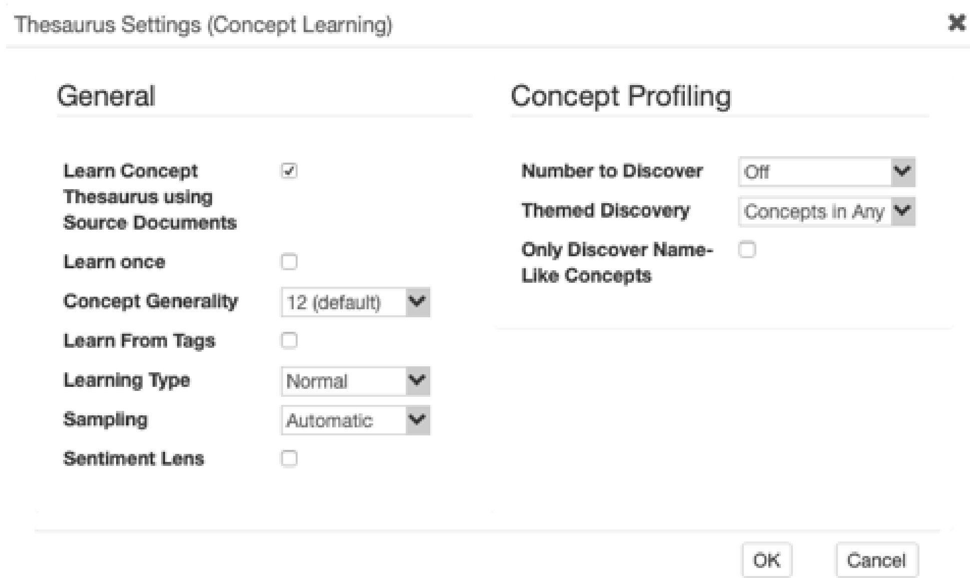


Figure 28. Leximancer Portal Project Thesaurus Settings

- The next step was to configure the type, theme size, and map size of the concept map.

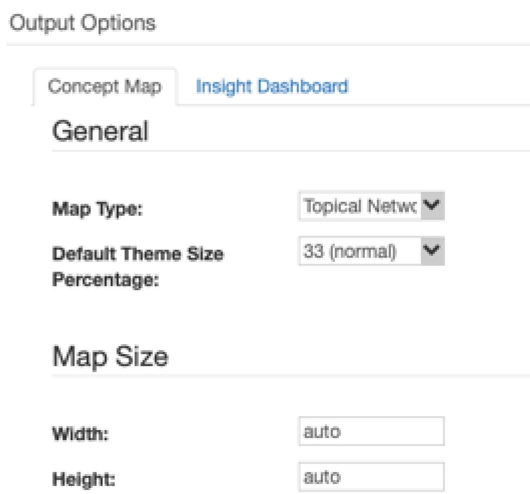


Figure 30. Project Output Options

- The final step was to record all the seed-terms and seed-term relationship visualizations and data from each Leximancer project. The resulting seed-terms were organized and recorded in APPENDICES A through L along with the seed-themes and seed development material. In the combined method used in this research, the output from each Leximancer project resulted in a set of "seed-terms" that were used as inputs to the NVIVO coding.

3.4.1.3 Software Assisted Content Analysis using NVivo.

Kaefer, Rober, & Sinha (2015) illustrate the use of qualitative data analysis software (QDAS) as a research tool in conducting qualitative analysis and provide a more detailed process of using software to facilitate qualitative content analysis. In the combined method used in this research, the qualitative data analysis software NVivo was used to support content analysis. Figure 29 contains a screen capture of the NVivo user interface used in the NVivo coding.

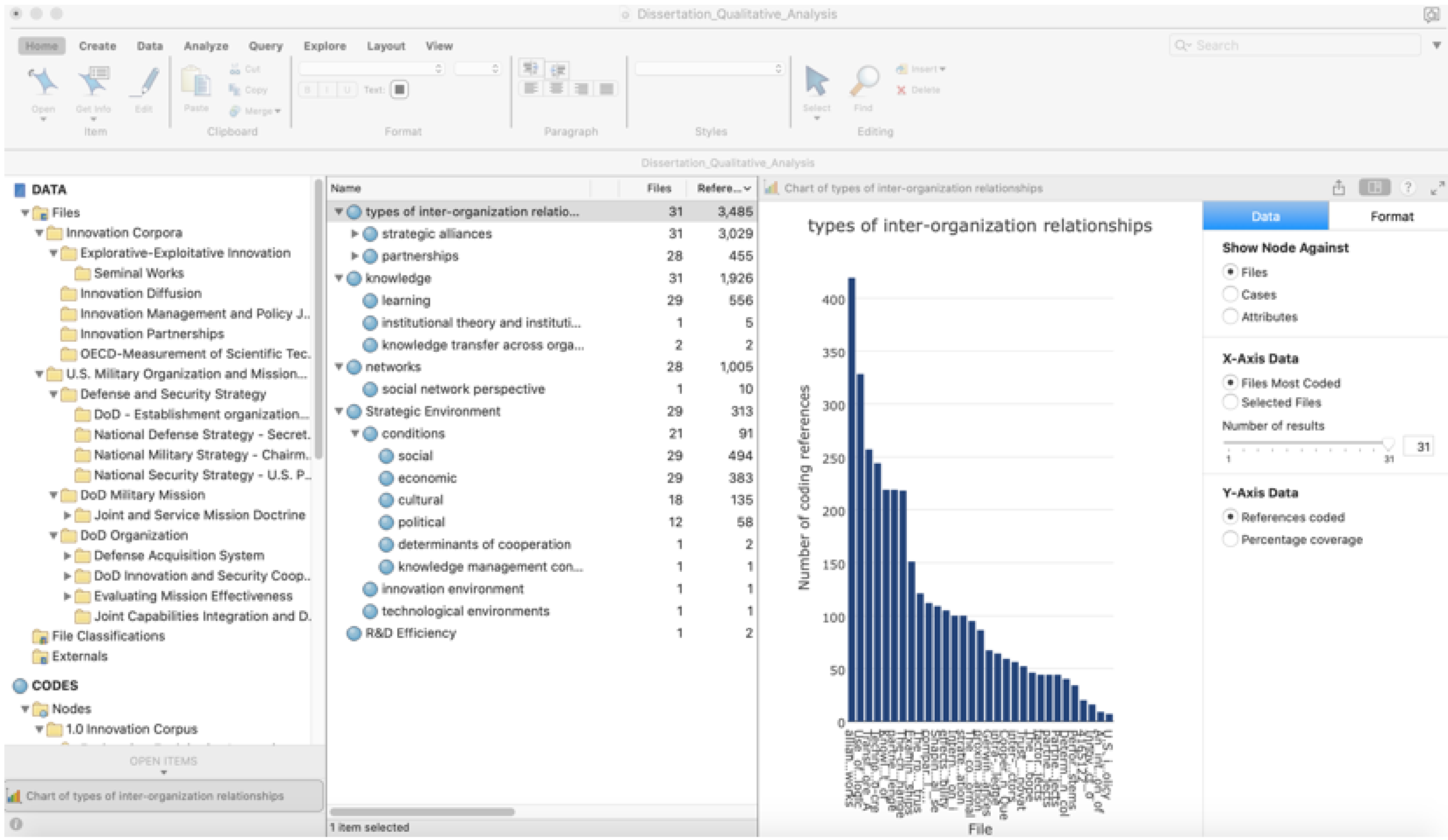


Figure 29. NVivo project user interface

The NVivo coding steps used in the research were:

- The dataset reflecting each of the Leximancer projects was set up as internal files in NVivo. Figure 29 provides an overview of the folder structure created, representing the breakdown of the dataset.
- For each subset of the dataset reflecting each of the Leximancer projects, each seed word (outputs of Leximancer) were used as text queries in NVivo. The queries were applied only to the corresponding Leximancer dataset (the corpus of literature) and generated the same amount of references in the data as Leximancer. In this process, the "dross" was removed from the coding references such as word occurrence in titles, references or any other portion of the literature that was not part of the main body.
- The coding nodes were organized in a folder structure replicating the datasets
- During the coding process, notes were captured as annotations, and additional graphical connections among seed-words and seed-themes were captured using a software package called Flying Logic.
- For generating the seed categories, a separate folder structure was generated in NVivo for the nodes. The synthesis of the seed-categories was supported by merging of the NVivo nodes, recording the inferences made wherever applicable in Flying Logic software, and building an excel spreadsheet containing the final seed category codebook.

3.4.1.4 Generation of Architectural Views

The final activity in the research was the generation of architectural views that organize the results of the research.

- The Mission Engineering Explorative-Exploitative Architecture for Technological Innovation. This view consists of the main seed-concepts and their relationships.
- Mission Engineering and interoperability and integration management functions.
- A strategic decision model for evaluation of explorative and exploitative partnerships.

CHAPTER 4

RESULTS

This chapter outlines the results obtained during the research. Figure 30 illustrates the organization and flow of this chapter.

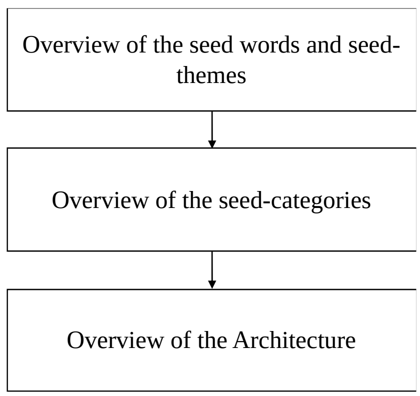


Figure 30 - Organization of this Chapter

1. Key codes from seed-words into seed-categories related to mission engineering explorative-exploitative architecture for technological innovation are presented.
2. Followed by the presentation of a schema elaborating the interconnections among the seed-categories (elements of the architecture) developed from interpretative content analysis.
3. Elaboration on how the seed-categories were refined and synthesized based on shared characteristics.

4.1 SEED-THEMES

This section provides an overview of the seed-theme results obtained and researcher interpretations and considerations. The details and descriptions of the seed-themes, including the evolution from seed-terms to seed themes, are outlined in Appendices A through K.

4.1.1 Measuring Innovation

The seed-themes that resulted from the research from the Measuring Innovation dataset are outlined in Appendix A. The Measuring Innovation dataset contained the manuals and guidance publications related to measuring scientific, technological activities from the OECD library:

- Oslo Manuals (OECD/Eurostat, 2018, 2005)
- Frascati Manual (OECD, 2002, 2015)
- Proposed Guidelines for Collecting and interpreting Technological Innovation Data (OECD, 1997)
- The Measurement of Scientific and Technical Activities (OECD 1994)

The OECD/Eurostat (2018) provides a general and 2 operationalized definitions for innovation:

*An **innovation** is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).*

***Innovation activities** include all developmental, financial, and commercial activities undertaken by a firm that are intended to result in an innovation for the firm…*

*…A **business innovation** is a new or improved product or business processes (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.* (p. 20)

Based on Innovation Diffusion Theory of Rogers (2003), O'Reilly and Tushman's (1996) exploitative and explorative innovation perspectives:

- "Differs significantly" implies a radical difference, which based on O'Reilly and Tushman (1996) as well as Bennan and Tushman (2003) concepts of exploration and exploitation, is associated with exploration innovation behavior.
- Also, defining innovation as a product or process categorically leaves out Roger's (2003) perspective of innovation as a social system innovation-decision process that has a connection with how knowledge about an innovation and the main features of its information to facilitate innovation adoption criteria are determinants in innovation adoption.
- Considering the OECD body of work, Innovation Management and Policy, and Innovation Management and Policy datasets, innovation activities and business innovation exclude the possible combinations of cross-sector partnerships and the chance that the government sector itself may conduct innovation activities. Although dated, according to statistics reported by Jaffe and Lerner (2001) between 1941 and 2000 U.S. government is the largest performer and funder of research and development in the world at $2.7 trillion expenditure with an average of patents issued to national R&D laboratories of approximately 1,300 per year.

With the public sector reform seed-theme the overall perspective implied in the discussions and definitions give yield an impression that these views come from the private-sector looking at the government sector, and not a holistic view. The seed-themes reflect some highlighted elements that resulted from the content analysis that could be recontextualized into a more encompassing model for innovation with a value system more aligned with outcomes of common interest across the public-private sectors such as well-being, prosperity, and security of society within the context of a healthier international competitive system.

4.1.2 Innovation Diffusion

The seed-themes that resulted from the research from the Innovation Diffusion dataset are outlined in Appendix B. Rogers (2003) elaborations leading to explaining innovation diffusion process as a purely social system when taking into account the context of technological innovation (hardware and software) may leave room for reconsiderations:

- When adopters are made aware of technological innovation, uncertainty about the innovation drives adopters to learn more about the innovation in a search space instrumented by inter-personal, and mass media communication channels.
- The contents of the technology information that determine its complexity, try-ability, and observability are mostly technical, resulting from innovation activities outlined in OECD/Eurostat (2018). These activities, except for marketing, are mainly technical.
- Rogers (2003) states that "Diffusion occurs within a social system." (p. 71)
- Roger's innovation-decision process starts when "… an individual (or another decision-making unit) passes from gaining initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision." (p. 316)

- The innovation-decision process does not clearly define the issues and needs phase that leads to the opportunity for technological innovation.
- From a knowledge perspective, depending on a more concise definition of diffusion innovation process membership, a more integrated “principles, know-how, awareness” knowledge evolution model can be established.
- According to Rogers (2003) “*Uncertainty* is the degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probabilities of these alternatives. Uncertainty motivates people to seek information”. (p. 30) Also, according to Rogers (2003), “*technology* is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving the desired outcome” (p. 54). These two definitions encapsulate technology as a means to reduce uncertainty with a situational context (e.g., technology reducing uncertainty in real-world situations), and create a potential ambiguity relative to the dimensions of uncertainty.
- The reduction of uncertainty that technology causes within a purpose-mission-task in a real-world situation.
- The reduction of uncertainty relative to the knowledge about a technological innovation based on its observability, try-ability, and complexity with the objective of adoption in the innovation-decision-process.

Rogers’s (2003) describes heterophily and homophily as communication principles describing similarity among individuals. “Hererophilous communication between dissimilar individuals may cause cognitive dissonance because an individual is exposed to messages that are inconsistent with existing beliefs, an uncomfortable psychological state.” (p. 598)

4.1.3 Explorative-Exploitative Innovation

The Explorative-Exploitative Innovation seed themes are outlined in Appendix C. From an organization's perspective, O'Reilly and Tushman (1996) describe the context of an organization as the competitive market and its ability to respond to the shifts in technology cycles within that competitive market context. The process is enabled by organizational management and learning. "Successful companies learn what works well and incorporate this into their operations. Organizational learning uses feedback from the market to continually adjust and improve its ability to accomplish the mission. A lack of congruence (or internal consistency in strategy, structure, culture, and people) is usually associated with a firm's current performance problems." (p.18) Andriopoulos and Lewis (2009) bring to light organizational paradoxes and approaches to manage inconsistencies related to strategic intent, customer orientation, and organization internal personal drivers in a cycle of ambidexterity highlighting key attributes related to exploitation and exploration".

Atuahene-Gima & Murray (2007) associate organizational structure and cognitive dimensions to exploratory and exploitative organizational learning. The research takes place in the context of a competitive market for new product performance. The fundamental organization, leadership, management, and innovation behavior paradigm in the explorative-exploitative innovation has the goal of performance based on financial performance and competitive positioning in the context of a competitive market. That paradigm drives the nature of organizational learning, process management, differentiation, and integration strategies to manage innovation behavior tensions. The leadership element is mainly addressed as attributes related to the tendency of leaders to make strategic choices associated with their leadership traits in executing explorative-exploitative strategies for technology innovation in the context of a competitive private firm in high technology markets.

4.1.4 Innovation Management and Policy

The seed-themes developed in the research are outlined in Appendix D. In this dataset, innovation is mainly discussed within the context of environmental, technological, market changes, and uncertainties. Within that environment, the government is perceived as the element that generates policies that either promote or hinder private-innovation performance in a market or national scope. The discussions on activities related to externally searching for knowledge, partnerships, and related information in explorative-exploitative innovation have a policy implication component.

Woiceshyn & Eriksson (2013) discuss how the Finnish government used "broad policy measures to transform the economy: liberalization of markets, joining the EU, and public funding of R&D." (p.22) Accounting for Alberta, the public innovation system was consolidated into consolidated units with a primary focus on facilitating innovation with a separate private-sector innovation system. Within the context of "actions by public organizations influencing innovation processes, they outline the following implications:

- Become an enabler instead of attempting to control innovation
- "Adopt and implement an integrated innovation policy with clear goal." (p.25)

Woiceshyn & Eriksson, (2013) account Alberta's and Finland's policy impacts from the perspective of public policy to facilitate innovation resulting in increases in overall country's financial performance and international trade.

Potts & Kastelle (2010) discuss differences between public and private sector innovation within an organizational domain. "The incentive structure of motivation and accountability, the innovation context distinguishes the public sector from the market sector. From a privately held competitive organization, the incentive structure of accountability is straightforward: accountability is to the owners of the business; by they a boss in a small company or shareholders in a larger 'public' company. Usually, only a few layers of separate innovation initiatives and governance institutions. " (p.124). "The public sector everywhere steers toward socio-politically defined task descriptions of what goods and services need to be delivered" (p.124). "The *public sector* refers to the coordination, production, and delivery of goods and services by publicly owned and accountable organizations. These activities define the economic output, including education, health, social welfare, and the provision of goods that are neither the household nor private sector" (p. 124). In very limited literature in the dataset, technological innovation is addressed in the context of government.

4.1.5 Innovation Partnerships

The resulting seed-themes from the Innovation Partnerships dataset are presented in Appendix E.

The main seed-themes resulted from the content analysis in the innovation partnerships dataset reflect investigations and propositions of determinants, conditions, and factors for success in establishing partnerships for technological innovation in the context of socio-economic complexities and uncertainties. Most of the coded elements leading to the seed themes consider the external environment to a private organization as elements to meet the organization's performance goals. Inter-Organizational partnerships are presented from the following perspectives:

- The ability of organizations to develop partnership strategies with the goals of sharing risks and costs.
- Motivation, determinants for partner selection.
- Factors influencing partnership success.
- The social network nature of partnerships based on open systems perspectives.

The evaluation of conditions for partnerships in the context of technological innovation supporting strategic objectives is mainly discussed within the context of motivation descriptions and success factors for partnerships. Trust, alignment of organizational values, and knowledge exchange are the main drivers for partner selection and partnership success.

Gattringer, Wiener, & Strehl (2017) present their action research related to the joint creation of future "out-of-the-box-thinking" collaborations and associated "special requirements regarding technological and organizational proximity, trust and commitment." (p. 1). Yan & Azadegan (2017) in a use case research conclude that "within the context of inter-organizational product innovation, …results show highly innovative products can provide high financial returns, despite higher risks associated with them, which encourages firms to invest in product breakthroughs by engaging the right external partner the right way." (p. 33)

Although limited in scope to the Dutch biotechnology sector, Aalbers, (2010) explores the value of trust in the context of R&D alliances over time. Within the context of environmental uncertainty and industry technological dynamics, their conceptual model shows that trust reduces uncertainty between partners and strong contractual arrangements lower degree of trust when contractual arrangements are not necessary due to the existence of high trust among partners. Al-Tabbaa, Leach, & Khan (2019) developed an integrative model of the dynamics of collaboration capabilities and actions in cross-sectorial partnerships.

Their definition of cross-sectorial partnerships was limited to non-profit organizations. The interpretation of the seed-themes from the innovation partnerships dataset,
provided insights on conditions, factors, and determinants for innovation partnerships within the context of technological innovation concentrating on organizational trust, knowledge transfer, and innovation performance. No evidence was found of conditions for inter-governmental partnerships in support of technological innovations in the government sector.

4.1.6 Military Effectiveness

The seed-themes generated from the Mission Engineering dataset are outlined in Appendix F. Beam (2015) recommends the use of "specific systems engineering processes supported by measures of effectiveness, performance, and suitability as foundational elements from which to build mission engineering processes." (p. xiv).
According to Beam (2015), the main functions are: (1) to architect; (2) to design; (3) to conceptualize, with a focus on life cycle as opposed to system engineering focus of system design and development to meet specific requirements.

Hernandez, Karimova, & Nelson (2017) describe a U.S. military deliberate planning process linkage to the systems engineering process involving (1) acquisition, (2) integration; and (3) Operations as the main processes for Mission Engineering and Integration. In this cyclical process model, scenario-based analyses and wargaming are used as part of the methods. Moreland (2009) addresses strategic challenges related to the U.S. Department of Defense decision-making approach. The current process-driven "stove-piped" and process-oriented decision-making approach in DoD causes a disconnect between strategic objectives and force capability, competence, and readiness. Moreland (2009) calls for a more agile and improved approach.

"Capabilities must be defined to convey the urgent accomplishments to execute the strategy, continuously evaluate the magnitude and type of demand signal for these capabilities and develop a force structure balance/mix based on the real-time demands. Allowing for these key elements will create a strong linkage between strategy and force structure with a built-in ability to be agile. As a change in strategy occurs, immediate response in force capabilities needs to occur to stay relevant and effective." (p. 38)

Sousa-Poza (2015) accounts for key distinctions in the Mission Engineering approaches from the National Aeronautics and Space Administration (NASA) and the U.S. Department of Defense. The NASA approach as being one that is design-governed to maximize mission assurance, with the ability to design mission parameters and refinement of requirements. In the DoD approach, the nature of missions, objectives, and varying conditions generate integration challenges. These integration challenges are also related to having to integrate different systems and components within a mission context to accomplish objectives that were not originally part of their design requirements. Sousa-Poza (2015) outlines the imperative to form "a complete set of perspectives in complex non-monotonic conditions even though the formation of such a set of perspectives may have a negative effect on the understanding of the overall problem." (p. 168) Sousa-Poza (2015) lays out Mission Engineering functions:

- Interpretation of intent or mission
- Multi-layer conceptual and rational architecture
- High-level process models
- Tool agnostic meta-structures
- Understanding of the operational environment, and the consequence of implemental actions
- Multi-layer empiricist architectures
- Sociotechnical system perspective integrating human and system interfaces
- Evaluation and characterization of legacy operations with respect to the mission (mission readiness)
- Advanced analysis and representation capabilities such as graph theory, or stochastic modeling, to increase the level of understanding of the operation environment
- Experimentation and test evaluation methods and environment
- Understanding of technological possibilities, alternatives, and limitations
- Readiness level for different degrees of granularity of the problem (component, system, network, etc.)
- Advance analysis and modeling techniques to solve higher-order problems
- Model-based systems engineering and analysis. (pp. 180-181)

4.1.7 U.S. Security Strategy

The security strategies seed-themes are outlined in Appendix G. Some key observations captured in the coding process are discussed below:

- International System – In the U.S. National Security Strategies, the strategic objectives are related to U.S. strategic interests of maintaining its position within the international system, which is defined as the member nations in the globe. The National Security objectives are not only of a military nature. They highlight importance of promoting a set of values and standards, and socio-economic stability as a means to address global security challenges
- Military Strategy – although not consistently, the military strategies also layout principles such as collective security, decisive force, agility, integration, force building foundations such as (quality people and force readiness)

4.1.8 Defense Acquisition

The seed-themes from the content analysis of the Defense Acquisition dataset are outlined in Appendix H. During the theme development researcher observed a more technical treatment of interoperability and integration issues related to the acquisition processes. Program success criteria are measured against the technical performance of a weapon system delivered within planned cost and schedule estimates. The programs are not defined or measured by the capabilities and technologies needed to accomplish mission goals. The management of these programs is laden with a complex web of policy statutes that contribute to inflexibility, lack of openness, and a risk-averse culture. (Graham, 1990; DoD, 2017; AT&L, 2012; Wilkerson, 2010)

4.1.9 Joint Capabilities Integration and Development System

The Joint Capabilities Integration and Development System seed-themes are captured in Appendix I. Some key observations below captured during the coding process:

- The Joint Capabilities Integration and Development System's purpose is to translate operational needs into capability requirements. These capability requirements are then used to derive weapon system-level requirements.
- The use of the word technology is to mainly evaluate its maturity in the context of prototyping, test, and evaluation activities based on the weapon system's fitness to support the capability requirements. Technology is used interchangeably with weapon systems.

4.1.10 DoD Innovation and Security Cooperation Policy

The seed-theme results from coding the DoD Innovation and Security Cooperation Policy dataset are outlined in Appendix K. Key observations capturing during the coding process are outlined below:

- Although limited to European nations and covering a range from 1996 to 2006, Thiem (2011) lays out a set intergovernmental armaments cooperation specific conditions for cooperation. These conditions (as formulated) provided the basis for additional coding and further development of the seed-themes.
- Mainly the characteristics of international cooperation appear similar to inter-organizational partnerships with one noticeably contrasting feature related to trust and the sharing of knowledge. The U.S. military organization, for security purposes, has a very robust set of rules related to establishing the necessary approvals for knowledge

sharing. The DoD 5111.21, issued by Undersecretary of Defense Policy titled "Arms Transfer and Technology Release Senior Steering Group and Technology Security and Foreign Disclosure Office" states: "It is DoD policy to make timely decisions that advance U.S. political-military objectives by building the capacities of allies and partners while maintaining U.S. operational and technological advantages and protecting critical technology from diversion to potential adversaries" (p.1) The knowledge spillover phenomenon within international armaments cooperation adds new interpretations to the non-rival nature from a monotonic to a non-monotonic view of knowledge-spill over. Knowledge spillovers in international armaments cooperation are considered very poor management of information and have potentially serious legal consequences for those involved in spillovers.

4.2 MISSION ENGINEERING EXPLORATIVE-EXPLOITATIVE TECHNOLOGY INNOVATION SEED CATEGORIES

In this section the Mission Engineering Explorative-Exploitative Technology Innovation seed categories are described. A concept map containing the seed categories is shown in Figure 31 and described in 7.

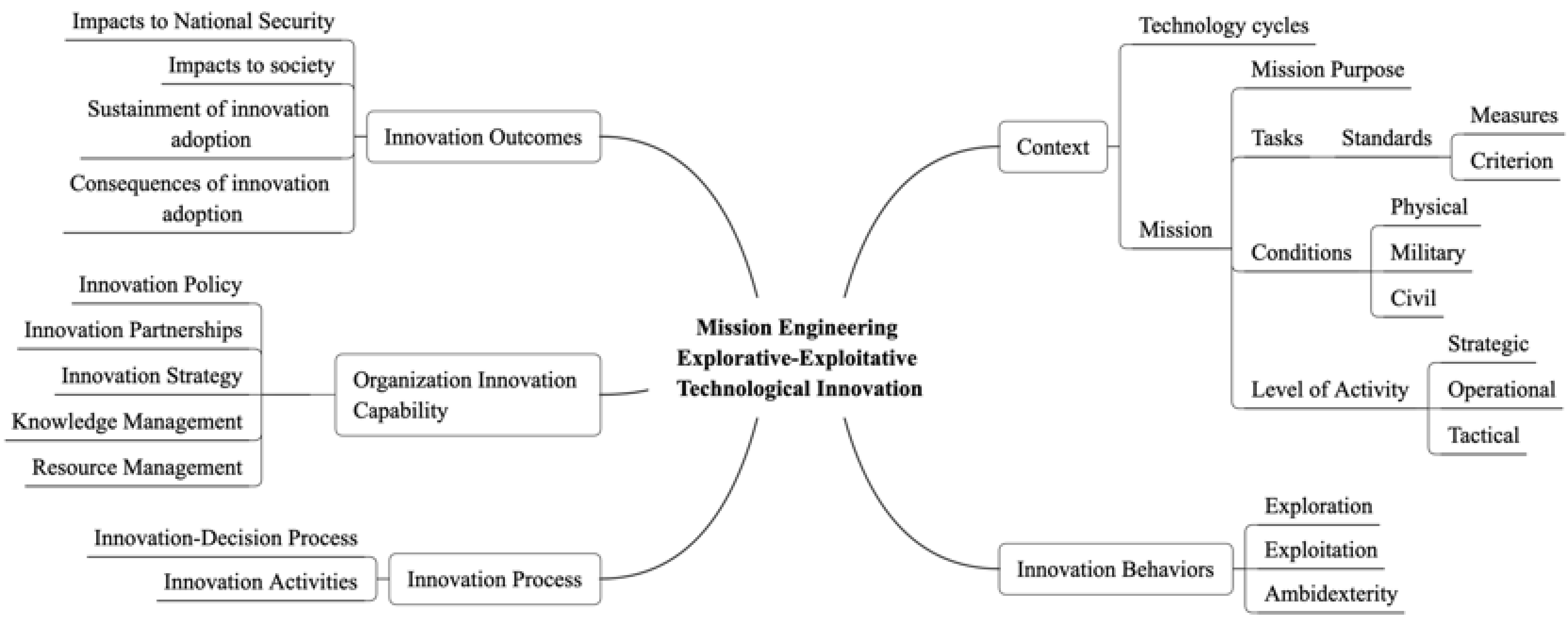


Figure 31. Mission Engineering Explorative-Exploitative Innovation Seed-Categories

Table 7 - Seed-Categories

Seed Categories		**Description**	**# references**	**# Sources**
Context		In the innovation dataset context is characterized as the competitive market and external technology cycles external to private organizations. The environment and technology cycles are mostly characterized as uncertain with market specific periods of disruption. In the DoD dataset the context is mainly described within the international systems geo-political, socio-economic levels. One key characteristic of the context in military dataset is that, by definition, the environment part of the mission definition related to the ability of individuals, units, and organizations to evaluate physical, socio-cultural, and economic conditions as part of the mission.	2635	137
	Technology Cycles	Technology, as software and hardware technologies used within the context of their rate of change over periods of time.	308	19
Organization Innovation Capability		Organization innovation capability seed-category captures, from the dataset, organization's ability to develop strategies, manage resources, establish partnerships, implement policies congruent with strategic objectives and desired innovation behaviors.	3126	71

Table 7 continued

	Innovation Partnerships	Captures the ability of organizations to search, identify, evaluate, and manage external partnerships to enable strategic goals and mission objectives. It includes ability to evaluate conditions for establishing partnerships and evaluating success factors at the strategic level taking into account social, cultural, individual, technical, and other contextual considerations.	4493	32
	Innovation Policy	Innovation Policy reflects organization's ability to establish innovation policies that are aligned with organization's behavior, culture, and partnership strategies	2582	68
	Innovation Strategy	Innovation Strategy reflects organization's ability to rapidly evaluate the environmental conditions using innovation management instruments, identifying necessary changes in innovation behavior, and incentivize internal and external innovation system members.	4306	38
	Knowledge Management	Knowledge management reflects the need to align knowledge management activities with innovation strategies taking into account the characteristics of explorative-exploitative innovation conditions. Knowledge management involves capturing and formulating plans for workforce knowledge that can be used in human resources management for searching, acquiring, and evolving workforce knowledge in support of technology innovation strategic objectives	5479	100

Table 7 continued

	Resource Management	Resource management reflects management of tangible and intangible resources in support of organization innovation behavior and capability. Explorative innovation strategies typically involve higher tangible and intangible resource expenditures than exploitative innovation strategies	143	23
Innovation Behaviors		The innovation behaviors seed category captures exploration and exploitation as distinct behaviors. Ambidexterity is the ability of an organization to maintain both behaviors in support of technology innovation strategies	3510	22
	Explorative	Within the mission context, explorative innovation behavior pursues radical innovation to improve existing or new mission success and has specific characteristics related to its behavior in relation to organization's leadership, management, and partnerships	1348	22
	Exploitative	Within the mission context, exploitative innovation behavior pursues incremental innovation to improve existing mission success and has specific characteristics related to its behavior in relation to organization's leadership, management, and partnerships.	1921	22

Table 7 continued

Innovation Process		Innovation process captures the social diffusion of innovations in the individual and organizational levels. Innovation-decision process established by Rogers (2003) reflects the innovation decision activities associated with adopting innovation. In a broader sense, innovation process involves the technological innovation activities described by OECD/Eurostat (2018) and the Innovation-decision process.	5699	46
	Innovation-Decision Process	Captures the individual and organizational level diffusion processes related to technology innovation adoption.	3815	7
	Innovation Activities	Captures that innovation activities such as research and development, marketing, experimentation and prototyping, testing of technology, technological innovation transfer, delivery, deployment, and commercialization	730	39
Innovation Outcomes		Captures technological innovation impacts to the mission, national security, and society. It also captures consideration for estimating consequences of adopted innovations as well as their sustainment.	23	10
	Consequences of Innovation Adoption	Involves the ability to estimate positive or negative consequences of technological innovation adoption	10	8
	Impacts to National Security	Captures the need to estimate how the technology impacts mission success and its level of contribution to national security	45	12
	Impacts to Society	captures the need to estimate technology innovation impacts to societal quality of life	66	8

4.2.1 Context

Fundamentally the U.S. military structure of missions, from individual task level to the strategic levels, provides a structured approach for interacting the environment. Figure 32 provides a view that captures U.S. Armed Forces task structure, extracted from OPNAVINST 3500.38B – Universal Task List (UNTL).

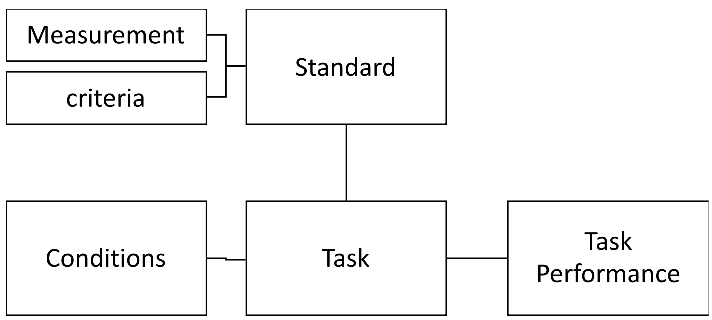


Figure 32 - U.S. Military Task Structure

The conditions reflect how individuals and units perceive the environment. The conditions impact an individual or unit within tactical or national strategic levels of war. They are associated with a task through a task design process, choosing conditions that most affect a specific task at the appropriate level of activity (i.e., tactical, operational, strategic theater, strategic national). Figure 33 provides a graphical depiction of all types of conditions classified in U.S. military. Each condition type has associated specific conditions and associated calculations.

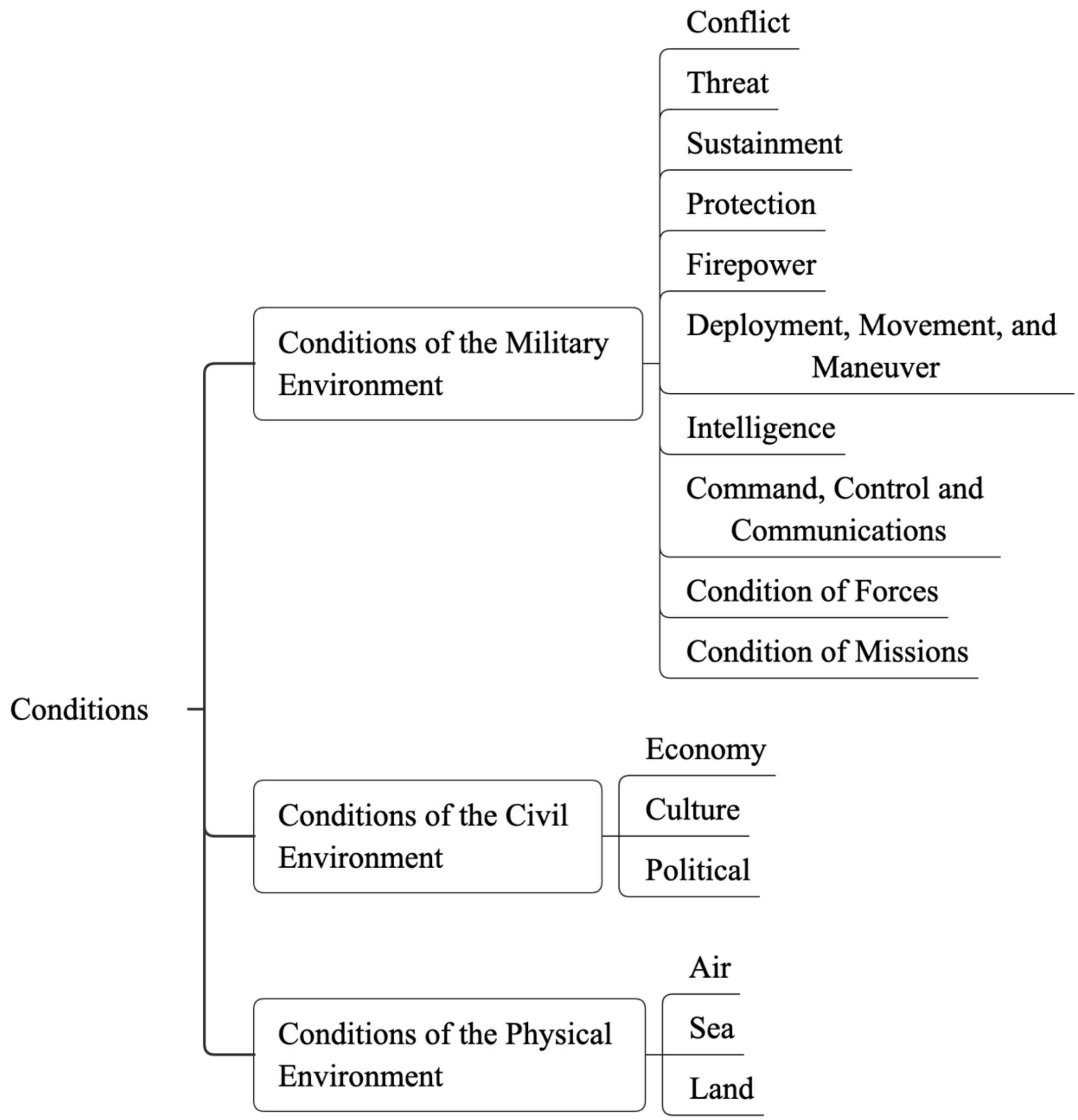


Figure 33 - Conditions in U.S. Military

The task structure of the U.S. military provides the ability for an individual or organization to measure its performance by the task standards defined by measures and criteria, under varying specified conditions that determine a task performance. In the context of technological innovation, a technological product (e.g., weapon system) instruments the individual and larger organizations in its task functions supporting task performance under specified organization leader's standards.

The mission-task-standard-performance model provides a fundamental mechanism for evaluating the utility of technologies and associated contributions to detecting conditions faster, instrumenting individuals and groups in the performance of their tasks, evaluating the conditions, and evaluating the performance as well. Technological innovations can not only affect the utility of the tasks but also how tasks are measured. From the perspective of characterizing context for technological innovation:

- In the innovation datasets and associated themes, the context is characterized by the behavior of competitive firms, and firm's relative positioning in a market space. The geo-political, social, cultural characteristics feed into uncertainty and as elements in the competitive positioning estimations of the private organization.
- In the military datasets, the context is characterized by the international system geo-political, social, economic contexts. The ability to interact with the broader environment, from individual through national strategic levels is intrinsic in the doctrinal task structure of the U.S. military.

From a mission-task oriented perspective, the degree of innovation can be estimated by how technological innovation can help an individual and organization meet the standards of the task performance, change the structure of the task altogether, or elevate the standards in which the tasks are performed. Based on the content analysis, the following are propositional characteristics that may influence the determination of classes of problems that may yield technological opportunities.

- In the military setting, a complex situation is characterized and managed by having the ability to train and equip individuals and organizations based on measures and task standards with their ability to achieve goals and objectives under varying mission conditions. (U.S. Air Force, 1998; Joint Chiefs of Staff, 2005; U.S. Navy, 1996)
- In the private sector setting, the context is characterized by the environment external to the organization. The main object of that environment is the measure of technological changes in their market segments and competitive landscape. (Rogers, 2003, O'Reilly & Tushman 1996, Bennan & Tushman, 2003; Andriopoulos & Lewis, 2009)

4.2.2 Innovation Behaviors

In addition to the seed-category descriptions outlined in 7, Figure 34 outlines innovation behavior attributes synthesized from the datasets and qualitative analysis of the seed-themes and seed-categories. All characteristics, based on the review of the datasets, positively affect exploration and exploitation behaviors, whereas the difference is the focus of the characteristic attributes. From an innovation exploitation perspective, the characteristic of **organizational compatibility** is expressed in terms of compatibility being understood and well managed among organizations. In exploitative innovation, the technical infrastructure is well established, processes in place for the management of the technical activities, and the knowledge strategy is for extending existing knowledge and skills of the members of the organization. The organizational compatibility in exploitative innovation is essential for the collaboration of personnel within the partnership. Within the technical dimension, the organizational compatibility also addresses standards adopted by each organization and how the divergence of standards would cause issues in technical efficiency and product quality. In the case of explorative innovation, the organizational compatibility among partners is developed as the partnership evolves. As the focus is on the generation of radical innovation with a substantial degree of novelty, the impact of standards is diminished, and the compatibility dimension is more related to interpersonal trust attributes and the sharing of common values and knowledge principles.

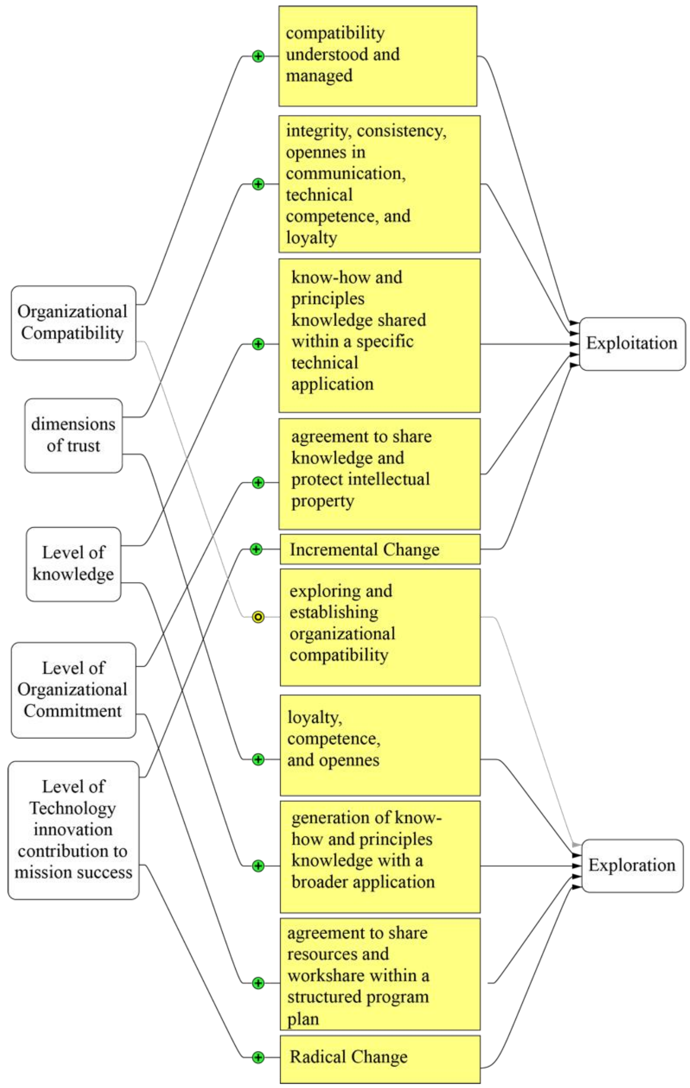


Figure 34. Innovation Behaviors and Attributes modeled in Flying Logic Software

4.2.3 Organization Innovation Capability

Although the technical capabilities of organizations are listed as an organizational capability in OECD/Eurostat 2018, the main focus in the datasets is on the organizational capabilities related to partnerships, policy, strategies, knowledge management, and resource management. From an **innovation partnership** perspective, Figure 46 captured motivation descriptors, success factors in a partnership model as part of seed-theme development. Within the context of intergovernmental international armaments cooperation, Thiem (2011) elaborates conditions for partnership selection for intergovernmental international armaments cooperation in the European setting. From an **innovation policy** perspective, the private firm innovation policy context is the government policies that affect competitiveness and market share resulting from innovation activities. From a U.S. DoD perspective, the policy context is based on its inherently governmental functions and duties of fairness and competitiveness, although it is perceived from the private technological innovation sector as an adjacent market (GAO, 2017).

The innovation policy seed-category represents an organization's ability to establish policies that are aligned with strategically decided explorative, exploitative (or a combination) innovation behaviors. It also addresses the ability to establish policies related to incentives external and internal to the organization affecting their ability to establish innovation partnerships and incentivize workforce innovation competencies and knowledge creation in support of the organization's innovation strategies and goals. The **knowledge management** seed-category reflects the ability of an organization to establish a technical infrastructure supported by communication channels that facilitate appropriate knowledge transfer among the internal and external members of the organization. Knowledge management also takes into account industry-specific spill-over policies that are reflected in the ability to manage partnerships in the form of information/knowledge exchange agreements. Depending on the nature of innovation and innovation behavior, the characteristics of knowledge management can be different. From a **resource management** perspective, the organization innovation capability is reflected as the organization's ability to manage tangible and intangible resources in support of innovation activities, including external knowledge via contracting mechanisms, access to social networks, and sustainment of robust communication infrastructure and channels for knowledge exchanges supporting organization's innovation goals and continuous search activities.

4.2.4 Innovation Process

The innovation-decision process, as captured in Appendix B occurs in a social construct. The DoD dataset defines, by policy, the processes to be followed with an underlying set of principles based on competitiveness, fairness, minimization of risks. The social construct that surrounds these activities and defines the nature of U.S. DoD personnel is not apparent. The **innovation activities** yield information that could be used in the innovation-decision-process supporting trialability, observability, and principles in a more efficient way.

4.2.5 Innovation Outcomes

The seed category **innovation outcomes** reflect the **consequences of innovation adoption, impacts on national security, and impacts on society**. They reflect the need for organizations to have the ability to estimate, under high degrees of uncertainty about future conditions, the impacts that technological innovations may have on national security, society as well as ability to consider their potential consequences. In the entire dataset, this is the seed category with the least amount of references. The innovation outcomes are mostly linked to private firm financial performance and market share.

4.3 EXPLORATIVE-EXPLOITATIVE ARCHITECTURE FOR TECHNOLOGY INNOVATION

During the synthesis of the seed-categories, the Rogers (2003) concepts of homophily and heterophily, and Sousa-Poza's (2015) overview of Situation Theory and the multiple perspectives in complex problem-solving in Mission Engineering and Integration led to the conceptual model illustration shown in Figure 35.

In a military context, the "ability to achieve effects is central for being militarily effective, and any attempt to address military effectiveness has to deal with collective attributes and not aggregate results" (Jobbagy, 2009, p. 506). Jobbagy (2009) also discusses the reason why we attempt to measure military effectiveness. "Western thinking, in general, is inherently linear and obsessed with effects. This is manifest in its preoccupation with numbers, which are often regarded as the only reality instead of as the means to look at reality. Numbers allow for management and something that is seen in Western culture as most important: *control*….Military effectiveness emerges as a result of qualities and behaviours that are choices made by people" (p. 510)

In the mission context, Figure 32 illustrates the U.S. military mission task structure, in which measures and criteria (defined by unit leaders and policy) form the standards that are used to measure task performance under task-specific conditions. The task criteria are established to evaluate performance under the specified task conditions, taking into account several individual competence factors, systems supporting the task, and scenario-specific conditions used to evaluate the task. Figure 35 depicts individual, operational, and strategic level perceptions and understanding connections (left to right) of the irregular hexagons. Each hexagon represents the process of perception, followed by understanding, decision, and action in a given situation. The upper half of the hexagon represents the human individual and collective process for perception, understanding, and action, while the lower halves represent representations, functions, and systems that support the actions at the equivalent levels. According to OPNAVINST 3500.38B, environmental conditions are represented from the mainly physical environment at the individual level of a task through to subjective and interpretative conditions at the civil environment condition level. The military environmental conditions required both physical and more subjective interpretations in the process. Above the individual level, individual level criteria and standards may drive the perception and understanding of the environmental and military conditions and guide the individual actions supported by individual-level functions supported by technologies. Fiske & Macrae (2013) discuss the cognitive differences between characterizing people and objectives in social situations. According to Fiske & Macrae, "social categories serve a identify function, shaping the perceiver's sense of belonging and connection to – or alienation from – others" (p. 454). The standards, which are used in the training and education of individuals, drive behavioral conduct while executing the tasks. At the operational and strategic levels, strategic and operational criteria and standards may guide the individual and collective perception, understanding, and action activities taking place. "Expected values of outcomes play a central role in the specific goals that people set and the extent to which they are motivated to attain them. However, people's goals do not only depend on the expected values. Goals are also structured by the (learned) context in which people bring potential goals and outcomes to mind. Such context frames the reference value or standard in guiding cognition and behavior of a goal, thus explaining why two persons with the same goal respond differently" (p. 133). At the highest level (national strategic level) principles and value-systems manifested as social norms, cultures, beliefs, theories (also including technical subjects), with the understanding that according to Fiske & Macrae, (2013) “differences in individual’s psychological needs and their relative exposure to and frequency of activation of specific ideologies produce variability in the chronic accessibility of specific ideological resources” (p. 708). They also influence the operational criteria and standards at the lower level strategic, operational, and individual levels. The vertical oval lenses depicted in the model represent an individual or collective perceptions, understanding, purpose, values, and beliefs between/among individuals, organizations, institutions, and states in the international system. Their misalignments, which can be carried out and manifested at the lowest technical, functional level, can help identify more fundamental compatibility and interoperability issues related to their mission tasks, strategies, purposes. Fiske & Macrae (2013) outline the various aspects of cognitive and social characteristics in individuals as the basis to differentiate how individuals perceive, understand, and behave in complex social situations. The understanding of these fundamental misalignments and categories of individuals, organizations, and institutions can be the starting point for Mission Engineers to identify more holistic and comprehensive approaches to interoperability and integration issues between/among individuals, organizations, and technologies in complex situations. These misalignments may cause conflicts, socio-economic problems, or not choosing a specific partner for technological innovations. They may also be addressed not only by performance enhancement technological solutions but also by smarter approaches to promote improved alignment of perceptions, interpretations of complex situations, understanding, purpose, and values.

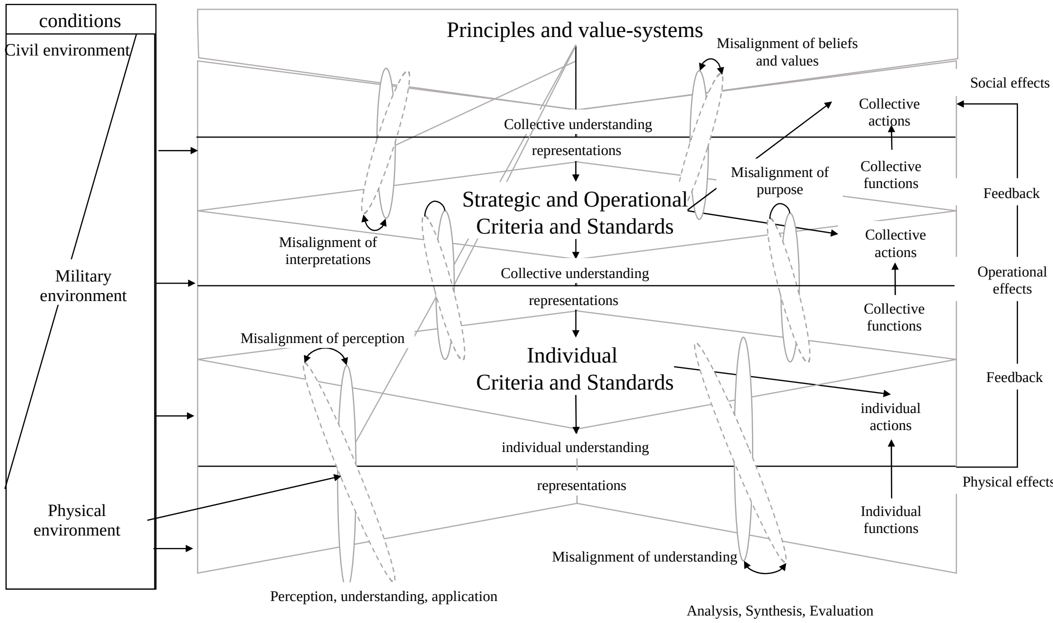


Figure 35. Misalignment of perspectives in a Mission context

By taking into account Sousa-Poza's (2015) complex situations, and Mission Engineering functions and considering the misalignment of perspectives model in a mission context, the following are propositional high-level functions proposed for Mission Engineering and Integration Management:

- Act as a trusted multi-disciplinary leader to facilitate defensible approaches to help organizations understand the nature of the potential problems in a complex situation that may originate from a deep-rooted misalignment of beliefs, values, and standards of socio-cultural-technical nature.
- Enable capturing of the mission essential elements that enable multi-disciplinary teams, users of the technology and task performers, decision-makers policy makers to address either performance issues caused by identified misalignments, technological issues, integration issues, or changes in condition.

- Advise and influence mission planning and technological investment decision makers in achieving a balanced explorative-exploitative approach to technological innovation and its integration in future weapon systems.
- Through more effective analyses influence new approaches that promote the use of a more consistent mission representation that allows multi-disciplinary stakeholders to effectively identify technological innovation opportunities triggered by rapid shifts in mission environmental conditions while maintaining levels of redundancy and resiliency in the technology innovation strategies and missions. The redundancy of investments has to do with the organizational characteristic of "organizational slack" outlined by Rogers (2003). In the case of U.S. Department of Defense, an exploitative approach to incremental innovation already in place by programs to address mission improvements or sustainment can be complemented and, from a long-range perspective transitioned into a more radical long range technological innovation objective that will result in substantial increase of probability of mission success.
- The understanding of the more fundamental misalignments can also help better inform and guide interoperability and integration efforts at the system of systems level. Without a higher level of alignment at many levels, the constant attempts to establish and maintain interoperability at the technical level continue to achieve diminishing results from experimentation, prototyping and interoperability certification of systems in a system of systems context
- Within the characterization of the system of systems architecture that functionally supports the complex situation, have the ability to identify legacy system interfaces

and interdependences in communication. The greater number of interfaces and interdependencies increases the design complexities associated in developing a radically new technological innovation to replace legacy systems

- Mission Engineering may promote the establishment of more effective communication within the organization with improved assessment and analysis constructs and an underlying technical infrastructure that enables more effective and agile problem-solving approaches. The ability to connect these multi-disciplinary perspectives by having an appreciation at a "meta-methodological level" an understanding of what each discipline has to offer in quickly addressing complex mission level problems.

The model construct for misalignment of perspectives within a mission context, and the shared characteristics within each seed-category led to composition of the architecture illustrated in Figure 36.

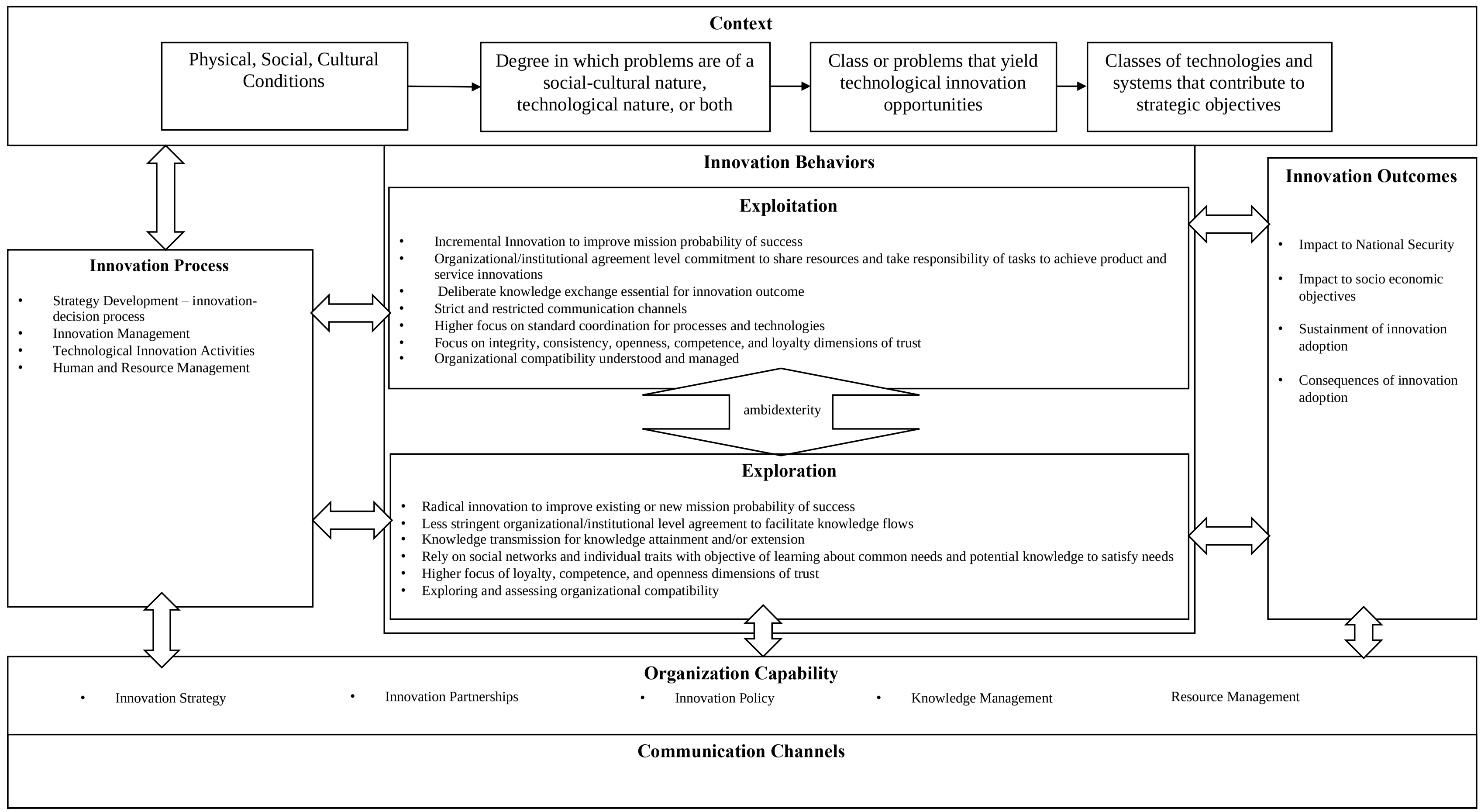


Figure 36. Architectural View

CHAPTER 5

DISCUSSION

5.1 OVERVIEW OF FINDINGS

The research purpose was to develop a Mission Engineering and integration Explorative-Exploitative Architecture for Technology Innovation using a systems theoretical framework using qualitative content analysis with the following focus:

- Perform Mission Engineering functions that will promote the conceptualization of missions by defining and linking activities, resources, and technologies over time against vulnerability and threats.
- Perform Interoperability and Integration management functions related to the ability of the mission constituents to interoperate, maintain resilience and levels of redundancies at an aggregate level.
- Use Mission Engineering, Interoperability and Integration Management parameters to identify promising technological innovation partnership opportunities.
- Identify conditions linked to explorative-exploitative innovation partnerships with allies for technological innovation diffusion of weapons technologies.

5.1.1 Conditions Linked to Explorative-Exploitative Innovation Partnerships

The following are propositional conditions linked to Explorative-Exploitative Innovation based on the combined methodology and interpretation of the seed-categories:

- Exploitation.

- Organizational commitment - Organizational/institutional agreement level commitment to share resources and take responsibility for tasks to achieve product and service innovation.
- Knowledge Management – more protective and deliberate knowledge management impacts innovation outcomes. This has to do with the ability to manage the knowledge that is produced, exchanged against strict policies. The knowledge exchanges are tracked, and knowledge artifacts are protected based on levels of assurance defined in agreements.

Communication Channels – strict and restricted communication channels. Strict in a way that only individuals and organizations with an access need to follow very strict policies for accessing networks.

- Restrictive in a sense that the security policies need to trace knowledge artifacts against their knowledge sharing policies.
- Technical focus – a higher focus on technical and process standard coordination.
- Homogeneity – social, and interpersonal characteristics. Focused on integrity, consistency, the openness of communication within the constraints of the knowledge management and exchange policies, competencies. Loyalty is the predominant dimension of trust.
- Homogeneity and compatibility – the compatibility of organizations in exploitative innovation are understood and managed. They address the compatibility of socio-cultural values and strategies, technical processes, and standards related to quality and efficiency.

- Exploration

- Less stringent agreements are required as the commitment is based on the sharing of new knowledge and achieving radical innovations. Barriers of knowledge flow and management related to restrictive communications are considered a barrier of explorative innovation performance.
- The knowledge exchanges are focused on knowledge attainment and/or extension without the specificity of a legacy knowledge base.
- Rely on social networks and individual traits with the objective of learning about common needs and potential knowledge to satisfy needs. The openness is the main characteristic the defines explorative innovation behavior as opposed to the exploitative restrictive behavior.
- Higher focus of loyalty, competence, and openness dimensions of trust. In explorative exploration, the main focus is the protection of intellectual property that may be exchanged or co-created in explorative collaborative innovation activities.
- The organizational compatibility is being explored, assessed, and formulated during the evolution of the explorative innovation collaboration.

5.1.2 Mission Engineering Parameters for Innovation Partnerships

Building upon the Mission Engineering function high level descriptions in previous chapter the following are parameters that Mission Engineering brings for consideration in helping establish innovation partnerships:

- Context includes an understanding of potential misalignments in a complex situation originated by socio-cultural-technical factors and associated conditions. From each unique complex situation, have the ability to apply multi-disciplinary approaches to identify classes of technologies and systems that can be applied to solve the misalignments.
- Strategy: With the understanding of potential classes of problems associated with technologies and systems, the mission engineering parameters can be used to establish explorative-exploitative and innovation partnerships in the context of the mission and conditions. That linkage provides a much richer set of knowledge and information for innovators to explore technological innovation options to solve the problem, as well as technological application opportunities in adjacent domains.
- Innovation outcomes: the mission engineering parameters can also be used, with modeling and analysis techniques, potential impacts of the innovation against societal, security, socio-economic, and sustainment criteria. This estimation can be achieved in support of the development of courses of action at the strategic level and help decision-makers make credible decisions regarding technological investment areas in support of National Security strategic objectives.

5.1.3 Integration and Interoperability Management

From the research and architectural constructs developed in the research mission engineering functions have an inherent need to estimate misalignments of individuals and organizations supported by technology (systems, a system of systems) functions. The ability to determine the necessary communication flows and paths in architecture is as important as identifying the centrality certain systems have and architectural dependencies with other systems at the system-of-system level. This estimation can be used strategically to decide whether explorative or exploitative innovation approaches are feasible. The degree of architectural dependencies in a system of systems may dictate that a disruptive technological innovation approach may be too risky, and a more evolved approach is necessary for near-term, and a longer-term explorative approach may be pursued taking into account the combined system-of-system lifecycles for a better intervention opportunity.

5.1.4 Mission Technological Innovation Analytical Infrastructure

Based on the research results, the "hard-wiring" of mission activity models to measures of success criteria may be applicable and valuable when all the assumptions related to most important conditions relevant to the problem need to be examined. No single general methodological construct can address all the possible combinations of analytic procedures applicable to fundamental problems perceived in a complex situation.

5.2 RESEARCH IMPLICATIONS

The research resulted in a Mission Engineering and Integration Explorative-Exploitative Architecture for Technological Innovations. The military context for technological innovations, from a situational approach, coupled with the ability to identify cognitive, social, economic, cultural and value-system misalignments presents a fundamental function for a Mission Engineer within a socio-technical paradigm. That fundamental function helps U.S. DoD understand fundamental problems that may be of a non-technical nature, and better identify what problems and opportunities can be applied by technological innovation.

This research contributed in propositional considerations for broad Mission Engineering Functions extending Sousa-Poza (2013), Moreland (2009) descriptions and strategic considerations for a Mission Engineer. From an international partnership and innovation performance perspective, the conditions for innovation partnership yielded propositional conditions that decision makers can use to evaluate international partnership from both government and private firm sector in support of private, governmental, and cross-sector partnerships for technological innovation.

The resulting architecture view expanded O'Reilly and Tushman (2003) explorative-exploitative theoretical constructs:

- Expanded the definitions of context to include the environmental, social, cultural conditions surrounding a complex situation, with mission engineering propositional functions to identify misalignments within the complex situation hierarchy.
- Use the expanded view of the context and the mission strategic level objectives to identify potential promising opportunities for technological innovation that will impact mission success.
- These contributions can be further expanded and defined towards a unified theory for Mission Engineering that reconciles some paradoxical perspectives between government and private sector concerning policies, support, inclusion and incentives for technological innovation weapon systems supporting U.S. strategic security objectives.

The research established initial linkages among technological innovation, mission engineering, and partnerships within a context of a complex situation addressed within the lens of a military mission. The U.S. military strategic and universal task structure related to measures, standards, and performance under a broad range of conditions across individual, tactical, operational, strategic, and political levels may be generalized into a broader structure that can be applied in also non-military complex situations.

The results of this research can be used by decision makers in U.S. Department of Defense to better recognize and articulate more comprehensive partnership strategies and appropriate innovation behaviors. Mission engineering key functions may be associated with the ability of mission engineers to recognize misalignment of perspectives at many levels (e.g., individual, tactical, operational, strategic, and political). The ability to recognize the nature of these alignments in a multi-disciplinary approach, taking into account socio-technical aspects of a complex situation, could provide a powerful tool to better understand what situations lend themselves for technological innovation opportunities versus situations that can be addressed by other means of addressing misalignments of perspectives.

5.3 RESEARCH LIMITATIONS

The development of the initial concept model and high-level architecture used a qualitative methodology and associated combined method that generated seed-terms, seed-themes, and seed-categories, leading to a less structured inference mechanism using mainly extrapolations. The dataset came from very diverse research fields and had a combination of case studies limited to specific technology areas, geographical regions, and situations.

The propositional seed-categories, their inferences, and resulting architectures are not validated against use cases to confirm any cause-effect relationships. This research resulted in a model that can be further refined with additional research and validated using appropriate research methods for validation and cause-effect confirmation in future studies.

During the process of familiarization and corpus selection, it is essential to note that the researcher has an engineering background and has extensive professional experience as a DoD Sr. Science and Technology Manager in the areas of mission integration-related competencies, integration of modeling and simulation tools and techniques for mission analysis, forming and leading multi-disciplinary teams in new programs and initiatives, and establishing International Armaments Cooperation projects in research and development for mission analyses in the past 11 years. Within the potential constraints and limitations related to researcher biases, there is also a limitation of time and resources for capturing the selected corpus for the research.

CHAPTER 6

CONCLUSIONS

6.1 PRIMARY CONTRIBUTIONS OF THIS STUDY

Theoretical: This research produced an initial theoretical Mission Engineering Explorative-Exploitative Architecture for Technological Innovation using a general systems theory framework using qualitative content analysis. The results contribute to the expansion of O'Reilly & Tushman (2003) and Bennen and Tushman (1996) explorative-exploitative theories for innovation performance, expansion of propositional Mission Engineering functions based on Sousa-Poza (2013) and Moreland (2009) concepts.

Methodological: The methodological contributions for the research's resulting architecture is the operationalization of the architectural views and concepts in support of a more comprehensive OECD/Eurostat (2018) approach for measuring innovation in a mission-driven complex situation perspective that places technological innovation performance as its ability to influence positively security, societal and economical objectives.

Practical: The practical contribution of the architecture is that it can be further refined and operationalized into information systems for decision-support applications in the innovation processes, including strategic planning for technological innovations.

6.2 WIDENING THE SCOPE

This research established an initial architecture to unify a very diverse set of views, perspectives, knowledge, and theories surrounding Mission Engineering and Integration, Technology, Innovation, Management, Political Sciences, Social Sciences, Economy, military strategy theories, system theories, and methodologies. Suggestions for future research include: Continue refinement of the Mission Engineering and Integration Architecture, including further definition of Mission Engineering and Integration Management categories, definitions, and methodologies

Further refinement of the parameters used in the research, leading to the generation of dynamic system models that help us understand how the change in variables may affect which innovation strategy to pursue (explorative, exploitative) against pre-determined decision-criteria Further, refine the concepts of resilience and redundancies in estimating desired technological innovation approaches. A long-term view, balanced with near-term constraints based on interoperability and integration dependency characteristics, balanced with strategic objectives, maybe a more balanced approach to manage technology investment portfolios. Further, elaborate and define a set of conditions that can be defined to evaluate partnerships in technological innovation. During the seed-theme development from the innovation partnerships and security cooperation and international armaments cooperation datasets, a limited set of conditions for evaluating partnerships were collected and shown in Table 8.

Table 8. Initial set of Conditions for Innovation Partnerships collected

Partnership Condition	Description	Source(s)	Limitations	Inference
Constitutional Culture	Country's willingness to engage in projects as a function of its tradition to embrace federalist structures. Federalism is unique to American governmental structure related to horizontal and vertical division of powers	Thiem (2011)	scope of study was European Union	Extrapolation. Applying difference in federalist structure of allied partner with U.S. is bi-directional within the same set of potential criteria
Homogeneity and Trust	functional and preferential homogeneity levels moderate cooperative armaments membership	Thiem (2011); Rogers (2003)	scope of study was European Union	Extrapolation. Homogeneity seems to be connected with social construct described by Rogers (2003); related to homophily and heterophily in a technology innovation adoption social network
Power Differential	strategic behavior of using power balancing in alliance	Thiem (2011)	scope of study was European Union	Extrapolation. If a country does not have enough capability to contribute in the imbalance of power, it does not have conditions to partner. If the power differential is low, the allied partner has resources to share in partnerships.

Table 8 continued

Economic Trade	Economic trade and security interdependence have a moderating effect in cooperative armaments membership	Thiem (2011)	scope of study was European Union	Extrapolation. The U.S. security strategy promotes economic prosperity to its partners, so there is an inherent strategic interdependency in economic performance and security based on U.S. security interests and strategies.
Policy Responsiveness	The opinion of voters has a moderating effect on international armaments cooperation	Thiem (2011)	scope of study was European Union	Extrapolation. U.S. Congress has the ability to influence armaments cooperation and foreign military sales on behalf of its constituents.
Technological and industry-base competitiveness	The higher the country's industry and technological base, the higher associated country membership is in international armaments cooperation	Thiem (2011); AT&L (2012)	European Union and U.S. Policy	Extrapolation. U.S. strategic interest is to maintain and foster a capable industrial and technological base
Partnership Success Antecedents	partnership success factors over past cooperation such as structural embeddness, management of expectations, trust, regular information exchanges, constructive management of conflict, ability to safeguard information, flexibility in management	Innovation Partnerships Dataset	no repository of partnership success exists in DoD	Extrapolation. The partnerships antecedents based on partnership history are discussed throughout the innovation partnership dataset. At a bi-lateral level, understanding partner's performance history in similar projects is desirable.

Table 8 continued

Organizational Factors	Organizational structure, social embeddedness, absorptive capacity for assimilating external knowledge, ability to manage partnerships and knowledge flows	Innovation Partnerships Datasets		Extrapolation. The organizational factors applicable in private sector seem applicable to the DoD government sector with one exception: due to U.S. government policies related to knowledge management flows, and with the objective of protecting U.S. security interests, knowledge spill overs only have negative consequences in the military technology innovation domain.

6.3 SUGGESTIONS FOR FUTURE RESEARCH

The initial theoretical model and architecture generated from this research is a starting point towards defining a formal theory of Mission Driven Innovation. The following are key suggestions for future research:

1. Further refinement of the Mission Engineering and Integration Explorative-Exploitative Architecture for Innovation to take into consideration the balance of perspectives from government's mission focus and private-sector profit economic model.
2. Continue to refine the relationships in explorative-exploitative innovation for evaluation of cross-sector partnership opportunities.
3. Implementation of architecture in information systems to aid decision makers in developing strategies for innovation.

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APPENDIX A - MEASURING INNOVATION SEED THEMES

The OECD dataset consisted of literature used as standard manuals for private and public organizations to measure their innovation related activities. The nature of the literature provides an organized hierarchical structure of innovation elements and for defining various aspects of innovation.

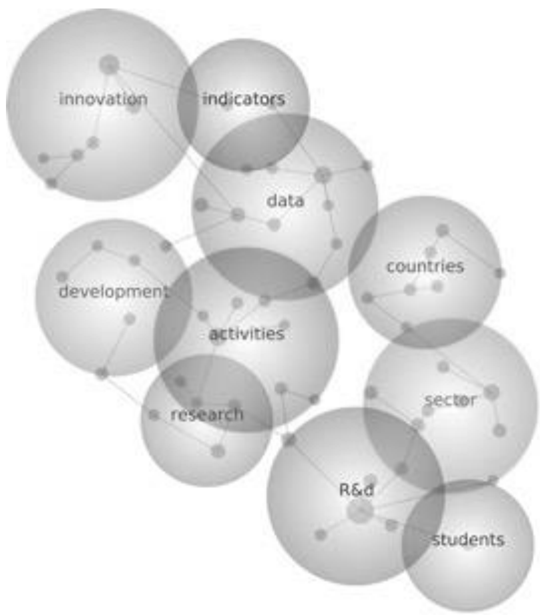

Figure 37. The OECD Dataset Initial Seed Terms and Associated Relationships

Figure 37 illustrates the most prominent seed-terms in the dataset. The coded dataset primary purpose is to provide a standard set of innovation definitions and use definitions and conceptual framework for innovation to better measure innovation and scientific and technological activities. The most prominent seed terms like innovation, indicators, data, activities, and sector highlight a data-indicators centric nature of the dataset, including more detailed approaches for measuring innovation activities. Table 9 outlines the resulting related seed-terms obtained as Leximancer outputs.

Table 9. OECD dataset seed-terms and relationships from Leximancer

Leximancer Project	**Seed Term**	**Related Seed Terms**
OECD Measuring Scientific Technological and Innovation Activities	data	data, business, use, used, information, policy, number, based, time, analysis
	innovation	innovation, firms, product, process, products, edition
	sector	sector, units, government, education, statistical, institutions, tax
	activities	activities, activity, economic, example, basis, science, large
	R&D	R&D, include, expenditure, unit, personnel, costs
	countries	countries, national, international, level, public, country, public sector
	research	research, services, related, work, social
	development	development, knowledge, production, market, technology, technological
	indicators	indicators, respondents
	students	students

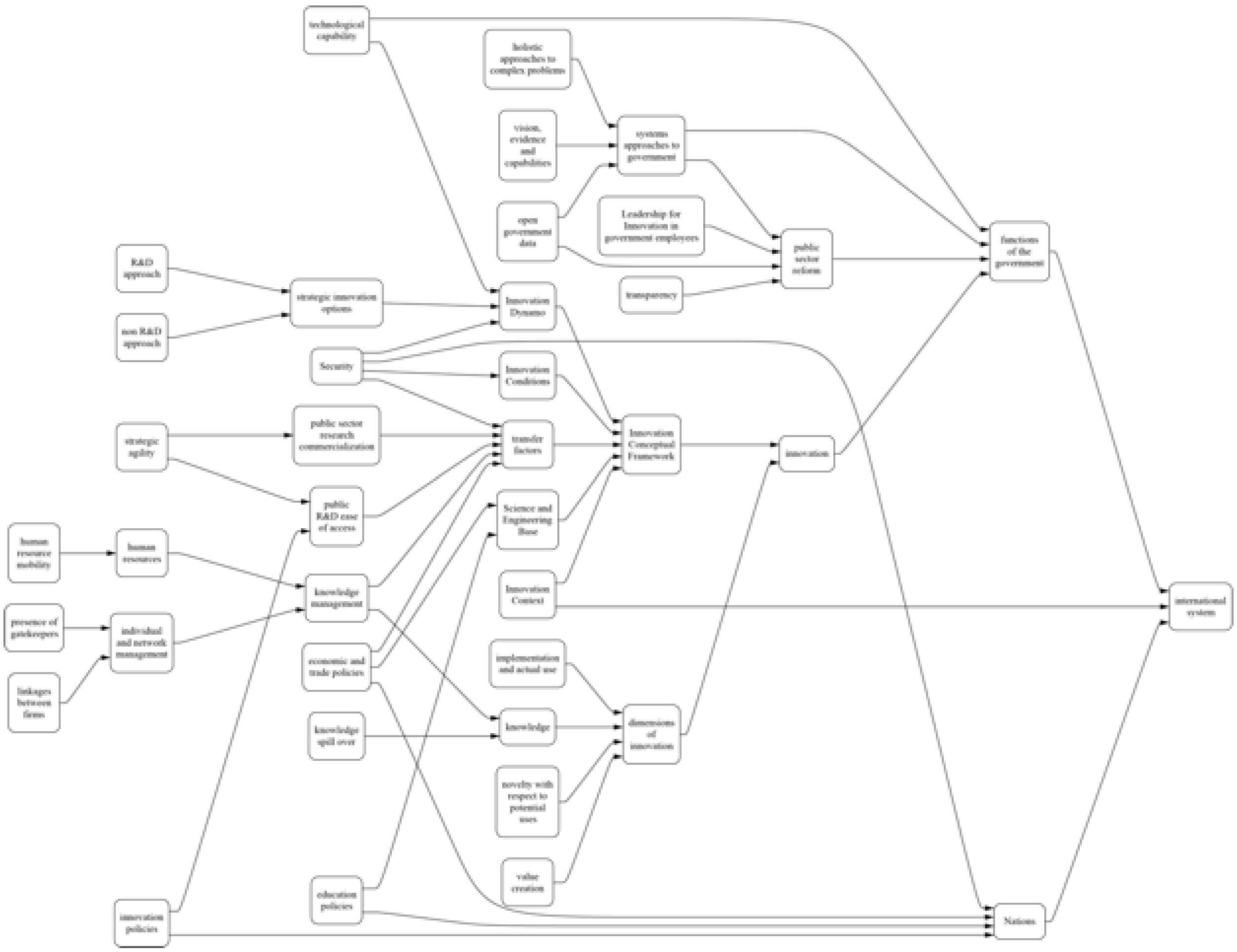

Figure 38. Measuring Innovation seed-theme development. Flying Logic Pro software output

Table 10. Seed Themes for Measuring Innovation

seed-theme		**Description**	**# References**	**# Sources**
Innovation		Innovation within the context of definition innovation from a perspective of its dimensions, conceptual frameworks. Use of conceptual framework as basis for innovation measurement at the organizational, institutional, and national levels	563	8
	data	generating and using data for measuring technological innovation	481	6
	Innovation Conceptual Foundations	Innovation conceptual foundations define dimensions of innovation and the theories related to innovation that led to the generation of the innovation conceptual framework	50	3
	Public Sector Reform	Public sector reform in the context of improving innovation policies, establishing a systems approach to public sector reform addressing workforce, government transparency, and establishment of open data approaches. Within the policy and partnerships context, better methods for measuring cross-sector innovation partnerships are needed and better integrating public sector perspectives in innovation framework is also challenging.	59	5

The **Data** seed theme reflected the guidance literature provided mainly for private firms to provide aggregate measures and reporting on their innovation activities. This includes the types of activities, related expenditures, and approaches for aggregating the data, including standard guidance for developing surveys for collecting innovation activity related data. For the purpose of maintaining focus on the research objectives, these are not further developed and articulated in this research, although the data collection guidance provided can be used in future implementations of the theoretical architecture being developed.

The **Dimensions of Innovation** capture some key seed themes based on the coding. **Knowledge**: " Innovations derive from knowledge-based activities that involve the practical application of existing or newly developed information and knowledge. Information consists of organized data and can be reproduced and transferred across organizations at low cost. **Knowledge** refers to an understanding of information and the ability to use information for different purposes. Knowledge is obtained through cognitive effort and consequently new knowledge is difficult to transfer because it requires learning on the part of the recipient. Both information and knowledge can be sourced or created within or outside a relevant organization" (OECD/Eurostat, 2018, p. 46)

Knowledge is discussed in the literature and referenced throughout the literature as the fundamental intangible resource, that "can be used to develop new ideas, models, methods, or prototypes that can form the basis of innovations" (OECD/Eurostat, 2018, p. 47). Another theme is the "**novelty with respect to potential uses**" and the challenges related to the subjective nature of measuring innovation. In innovation there are some objectively measurable characteristics such as efficiency, performance, physical characteristics, and subjective characteristics such as end user satisfaction, usability, responsiveness to changing conditions"

The **Innovation Conceptual Foundations** captured the various theories and concepts that contribute to OECD's "**Innovation Conceptual Framework"**. They include:

- **Chain-Link Model** - "which conceptualizes innovation in terms of interaction between market opportunities and the firm's knowledge base and capabilities….A key element in determining the success (or failure) of an innovation project is the extent to which firms manage to maintain effective links between phases of the innovation process: the model emphasizes, for instance, the central importance of continuous interaction between marketing and the invention/design stages" (OECD/Eurostat, 1997, p. 24)
- **Diffusion-Theory.** Diffusion theory as "process by which innovations are communicated and adopted over time among the participants in a social system" (OECD/Eurostat, 2018, p. 45)
- **Evolutionary Theories.**
- **Management Perspectives.**

The **Innovation Conceptual Framework** emerged from the baseline conceptual framework presented as the "innovation policy terrain" in OECD/Eurostat (1997). The **Measuring Innovation Activities** seed theme contained the categorization and guidelines rules for inclusion and exclusion criteria for innovation activities. Seed-themes that emerged under the **Measuring Innovation Activities** were:

- **Business Capabilities for Innovation. "**Business capabilities include the knowledge, competencies and resources that a firm accumulates over time and draw upon in the pursuit of its objectives. Business capabilities of relevance to innovation include management capabilities, workforce skills, and technological capabilities.

The discussion of technological capabilities covers technical expertise, design capabilities, and digital competencies" (OECD/Eurostat, 2018 p.103)

- **Business Management Capabilities.** They include:
- **Business strategy** related to ability to formulate goals and identification of policies to reach the goals.
- **Organizational and Managerial Capabilities:** include firm internal abilities, capacities, and competences that can be used to mobilize, command, and exploit resources in order to meet firm's strategic goals. "These capabilities typically relate to managing people; intangible, physical and financial capital; and knowledge. Capabilities concern both internal processes and external relations" (OECD/Eurostat 2018, p. 108)

The **Public Sector Reform** seed theme captured the challenges related to better integrating the public sector perspectives in the guidelines for measuring innovation, including the cross-sector relationships. The **Public Sector Reform** seed theme covers accountability and control of government, transparency of government, strategic agility challenges, systems approach to government policy problems, and government-private sector challenges related to understanding cooperative research and development activities. (OECD, 2017; OECD/Eurostat 2018)

The observations collected during the coding process are as follows:

- Although there is a strong emphasis of capturing innovation activities that occur within private sector firms, the is still lack of a unified conceptual framework that captures both sectors against a higher-level set of socio-economic objectives. This observation is shared and further discussed in Gault (2018)

- Lack of consistency in definitions across the literature: stakeholders, actors, individuals, organizations, businesses, firms, private-firms, institutions, people.
- No formal consistent categorization consisting of members of the “innovation system”. Business leaders, decision makers, engineers, designers, marketing personnel, academics.
- In the literature there are references to datasets and stable categorizations related to levels of education, skills, socio-economic objectives
- In the coding of the “business capabilities” concepts related to competence, capabilities and capacities were interchanged related to strategic management, ability to manage tangible and intangible assets and resources.

APPENDIX B - INNOVATION DIFFUSION SEED THEMES

The Innovation Diffusion dataset was small but concentrated on Rogers (2003) book, which provided perspectives and definitions on his Diffusion Theory. The structure of the literature allowed to capture most of Diffusion Theory key definitions, including its social systems context and associated definitions. Figure 39 illustrates the results of the unsupervised semantic mapping of the explorative-exploitative dataset.

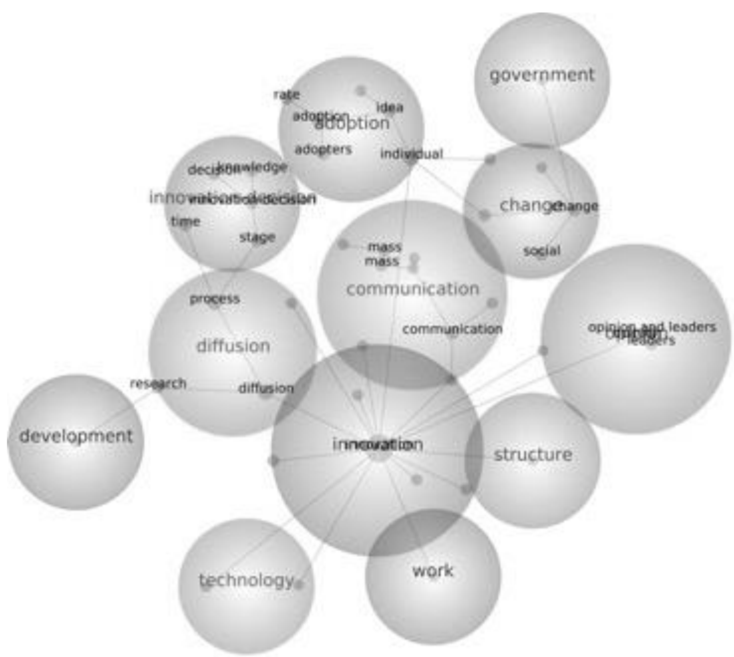

Figure 39. Innovation Diffusion Theory seed-terms from Leximancer

Table 11 provides tabular results of the most prominent seed terms and the most associated seed terms. The highest ranked term based on word frequency is the top seed term innovation, and the associated co-occurrence words are listed on the associated related seed term cell on the same row.

Table 11. Innovation Diffusion Theory seed-terms and relationships from Leximancer

Leximancer Project	**Theme**	**Related Concepts**
Diffusion of Innovation	innovation	innovation, different, model, role, effects
	adoption	adoption, individual, adopters, idea, rate, perceived
	Diffusion	diffusion, process, research, early
	Change	change, social, members, behavior, means
	Innovation-Decision	innovation-decision, stage, decision, time, knowledge
	Communication	communication, mass, information, media, influence, critical mass,
	Opinion	opinion, people, leaders
	Technology	technology, market
	Structure	structure
	Technology	technology
	Development	development
	work	work
	government	government

The Innovation Diffusion Nvivo coding that started from the Leximancer was straightforward in a sense that the dataset mainly used was Rogers (2003) book titled “Diffusion of Innovations”. The book structure was mainly categorical and provided the various definitions of innovation diffusions with sample use cases. The coding process did not require much interpretation or synthesis and the emerging seed themes were a hierarchical organization of the seed terms and further refinement upon review of the context and clarification of the seed terms.

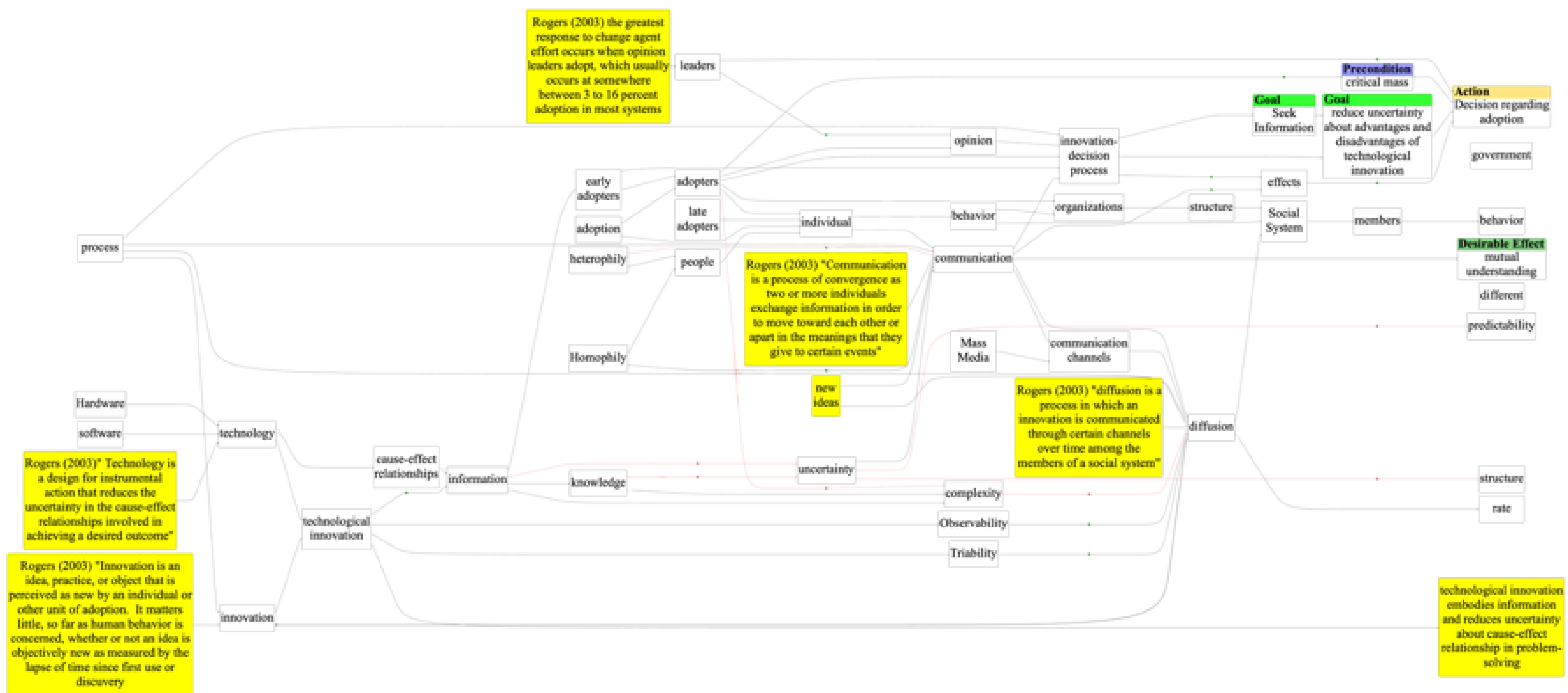

Figure 40. Innovation Diffusion Seed-Theme generation. Flying Logic Pro Software output

Table 12. Innovation Diffusion Seed-Themes

seed-theme			**Description**	**# References**	**# Sources**
Innovation			Innovation used in the innovation diffusion process, and to describe products and processes that are adopted by individuals or organizations based on their perceived level of novelty. Innovation as a process that starts from knowledge of technological innovation by adopters. Through a social system of adoption and a process, technology is diffused	1497	6
	Uncertainty		uncertainty used in the context of innovation adopters seeking more information in the innovation diffusion process	52	4
		knowledge	Knowledge used in the context of innovation-decision process. Knowledge as the element that reduces uncertainty and includes awareness, know-how, and principle knowledge.	155	4
	Technological Innovation		Technological innovation contains attributes of complexity, trialability, observability. These attributes influence their adoption in a diffusion network.	534	4
		Technology	Technology used in the context to reduce uncertainty in cause-effect relationship under uncertain situations. Technology as products (software and hardware).	350	4
		Information	information used in the context of attributes of technology innovation used in the innovation diffusion process	183	4

Table 12 continued

process			Process used as the innovation diffusion, innovation-decision, and the organizational processes from knowledge awareness of innovation through their adoption and diffusion.	3815	4
	diffusion		Diffusion used in the context of indicating when a technological innovation is no longer discussed. Diffusion as the innovation diffusion process, which is described as the innovation-decision process leading to technological innovation diffusion.	1741	4
		adoption	adoption used in the context of the act of adopting technological innovations as the result of the innovation-decision processes and individual and organizational levels.	489	4
		Social System	social system used in the context of a diffusion system that adopters use inter-personal and mass-media communication channels to share information about technological innovation leading to the adoption of the innovation. The attributes that contribute to the adoption are based on social system member (adopters) social attributes, and their associated perception of technology innovation information.	756	4
		rate	rate used in the context of the time it takes for technological innovation to go through the innovation-decision process and diffuse.	202	4

Table 12 continued

	Communication		communication used in the context of helping define diffusion, and the exchange of information shared among members of a social system in the innovation-decision process. Used as a process in a social-system for 2 or more individuals to reach common understanding	258	4
		Communication Channels	communication channels are used to define the inter-personal means of communication as well as the mass media communication channels. Each communication channel type has its characteristics and influence in the innovation-decision process for individuals and organizations	124	4
		effects	• effects of communication • effects of an innovation • effects of communication of new ideas in terms of knowledge gain, attitude formation, and change. • overt behavior change • hierarchy of effects – hierarchy of communication effects • Mass media communication channel effectiveness • Interpersonal communication channels have persuasive effects • Effects of incentives on the rate of adoptions for technological innovations	121	4

Table 13 - Innovation-Decision Process Stages. From Rogers (2003)

Stages in the Innovation Decision Process	Porchaska's Stages-of-Change
1. Knowledge Stage	
1.1 Recall of information	
1.2 Comprehension of messages	1. Pre-Contemplation
1.3 Knowledge of skill for effective adoption of the innovation	
2. Persuastion Stage	
2.1 Linking the innovation	
2.2 Discussion of the new behavior with others	
2.3 Acceptance of the message about the innovation	2. Contemplation
2.4 Formation of a positive image of the message and the innovation	
2.5 Support of the innovative behavior from the system	
3. Decision Stage	
3.1 Intention to seek additional information about the innovation	3. Preparation
3.2 Intention to try the innovation	
4. Implementation Stage	
4.1 Acquisition of additional information about the innovation	
4.2 Use of the innovation on a regular basis	4. Action
4.3 Continued use of the innovation	
5. Confirmation Stage	
5.1 Recognition of the benefits of using the innovation	
5.2 Integration of the information into one's ongoing routine	5. Maintenance
5.3 promotion of the innovation to others.	

From the **Innovation-Decision Process** the starting point of the process is knowledge about an innovation (e.g. invention, new approach, new or improved technology) after it has been accomplished. The social network becomes aware of such innovation through the inter-personal and mass media communication channels that support the communication structure of the social system.

The other seed-theme is the **Innovation Development Process**. The "**innovation-development process"** consists of "all the decisions, activities, and their impacts that occur from recognition of a new or a problem, through research, development, and commercialization of an innovation, through diffusion and adoption of the innovation by users, to its consequences" (p. 282). The definitions within the **Innovation Development Process** are extracted from Rogers (2003) and shown on Table 14. According to Rogers (2003) **technology** "is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involving in achieving a desired outcome"(p. 286).

Table 14. Innovation-Development Process. Extracted from Rogers (2003)

Innovation-Development Process	
Step	**Description**
1. Recognizing a Problem or Need	begins with recognition of a problem or need. Problem may be perceived by individuals or may be given priority on a **system's agenda of social problems through an agenda setting process.**
2. Basic and Applied Research	Technological innovation are mostly created by scientific research, although they often result from an interplay between scientific methods and practical problems. The knowledge base for technology usually derives from basic research.
3. Development	process of putting a new idea in a form that is expected to meet the needs of an audience of potential adopters. This includes development of prototypes and commercialization.
4. Commercialization	production, manufacturing, packaging, marketing, and distribution of a product that embodies innovation. Commercialization is the conversion of an idea from research into a product or service for sale in the marketplace.
5. Diffusion and Adoption	Gatekeeping is controlling the flow of messages through a communication channel. Innovation gatekeeping is controlling wheter or not an innovation is diffused to an audience of optential adopters.
6. Consequences	changes that occur to an indivudual or a social system as a result of adoption or rejection of an innovation

Basic research – “Original investigations for the advancement of scientific knowledge and do not have a specific objective of applying this knowledge to practical problems” (p. 287)

Applied research – “scientific investigations that are intended to solve practical problems” (p. 2870

Invention – “Defined as a process by which a new idea is discovered or created. It may be a result from (1) basic research, followed by (2) applied research, leading to (3) development.

Serendipity – accidental discovery of a new idea (p. 288)

One of the questions raised in Rogers (2003) is “can technologies be developed and diffused in a way that leads to greater equality (rather than inequality) in their socioeconomic consequences?” (p. 366).

The “**Innovations in Organizations**” is another seed-theme from the content analysis. Rogers (2003) describes an **organization** as a system in which the innovation-decision occurs. “An *organization* is a stable system of individuals who work together to achieve common goals through a hierarchy of ranks and a division of labor. Organizations are created to handle large scale routine tasks through a pattern of regularized human relationships. Their efficiency as a means of orchestrating human endeavors is in part due to this stability, which stems from the relatively high **degree of structure** that is imposed on communication patterns” (p. 779)

Table 15. Means to achieve organizational structure. Extracted from Rogers (2003)

Means to achieve predictable organizational structure	
Means	**Definition**
1. Predetermined goals	Organizations are formally established for the explicit purpose of achieving certain goals. The objectives of an organization determine, to a large extent, the structure and function of the organization
2. Prescribed Roles	Organizational tasks are distributed among various positions as roles or duties. A role is a set of activities to be performed by an individual occupying a given position. Positions are the "boxes" on an organizational chart. Individuals may come and go in an organization, but the positions continue, as do the behaviors expected of individuals filling these positions
3. Authority structure	In a formal organization, not all positions have equal authority. Instead, positions are organized in a hierarchical authority structure that specifies who is reposible to whom, and who can give orders to whom.
4. Rules and Regulations	A formal, established system of written procedures governs decisions and actions by an organization's members. These rules perscribe procedures for hiring individuals, for promotion, for discharning unsatisfactory eployees, and for coordinating the control of various activities so as to ensure uniform operations.
5. Informal Patterns	Every formal organization is characterized by various kinds of informal practices, norms, and social relationships among its members. These informal practices everge over time and fulfill an important function in any organization. Nevertheless, the intent of bureaucratic organizations is often pepersonalize human relationships as much as possible by standardizing and formalizing them

Table 16 define the types of innovation decisions. Within the organization system, the innovation process is much more complex, involving a larger number of individuals, requiring mutual adaptation and support for organizational change.

Table 16. Types of Innovation Decisions. From Rogers (2003)

Types of Innovation Decisions	
Innovation-Decision Type	**Definition**
Optional innovation-decisions	choices to adopt or reject an innovation that are made by individual independent of decisions by other members of a system.
Collective innovation-decisions	choices to adopt or reject an innovation that are made by consensus among the members of a system.
Authority innovation-decisions	choices to adopt or reject an innovation that are made by a relatively few individuals in a system who possess power, high social status, or technical expertise.
Contingent innovation-decisions	choices to adopt or reject that can be made only after a prior innovation decision. Other sequential conbinations of two or more of the three types of innovation decisions can also constitute a contingent decision.

Rogers (2003) highlights that in past innovation diffusion research studies of organizational innovativeness were oversimplified where the data about the organizational innovativeness were collected by a single individual, risking the reduction of the studies to a single individual. Table 17 outlines the organizational characteristics that, based on a limited set of previous studies, influence organization's innovativeness.

Table 17. Organizational characteristics and innovativeness. From Rogers (2003)

Organizational Innovativeness Characteristics		
Characteristic	**Description**	**Limitations**
Openness	degree to which the members of a system are linked to other individuals who are external to the system	generalizations made based on limited amount of case studies within specific market segments
formalization	degree to which an organization emphasizes following rules and procedures in the role performance of its members	
Size of Organization	size of organization consistently found to positively influence organizational innovativeness. Larger organizations are more innovative	
Structural Characteristics	(1) Individual Leader Characteristics (2) Internal Organizational Structural Characteristics (3) External Characteristics of the Organization	

Figure 41 illustrates a system dynamics model extracted from Rogers (2003) that describe , the independent variables and their relationships to organizational innovativeness (as the dependent variable).

Centralization "is the degree to which power and control in a system are concentrated in the hands of relatively few individuals. Centralization has usually been found to be negatively associated with innovativeness. The more power is concentrated in an organization, the less innovative the organization is. The range of new ideas considered by an organization is restricted when only a few strong leaders dominate the system. In a centralized organization, top leaders are poorly positioned to identify operational level problems or to suggest relevant innovations to meet these needs. Centralization can encourage the implementation of innovations once a decision is made to adopt. (pp. 794-795)

Complexity "is the degree to which an organization's members possess a relatively high level of knowledge and expertise, usually measured by the member's range of occupational specialties and their degree of professionalism (expressed by formal training). Complexity encourages organizational members to grasp the value of innovations, but it may make it difficult to achieve consensus about implementing them" (p. 795).

Formalization is "the degree to which an organization emphasizes its members's following rules and procedures. The degree to which an organization is bureaucratic is measured by its formalization. Such formalization acts to inhibit the consideration of innovations by organization members but encourages the implementation of innovations" (p. 795)

Interconnectedness is the degree to which the units in a social system are linked by interpersonal networks. New ideas can flow more easily among an organization's members if it has a higher degree of network interconnectedness. This variable is positively related to organizational innovativeness" (p. 795)

Organizational slack "is the degree to which uncommitted resources are available to an organization. This variable is positively related to organizational innovativeness, especially for innovations that are higher in cost. Perhaps one reason why organizational size is so highly related to innovativeness is that larger organizations have more slack resources, as mentioned previously" (pp. 795-796)

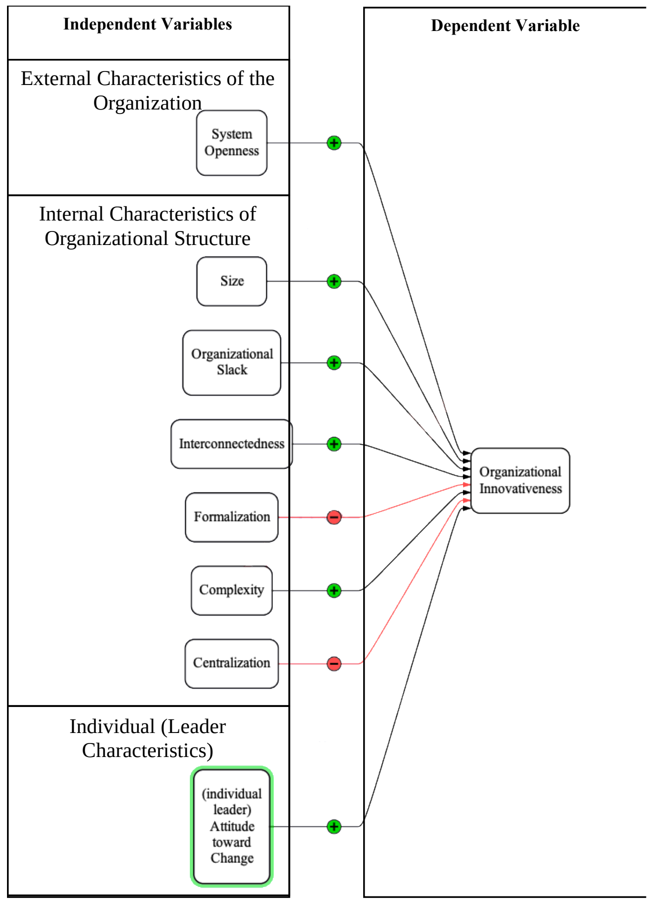

Figure 41. Organizational innovativeness variables. From Rogers (2003)

Table 18 outlines Rogers' (2003) Innovation Diffusion innovation process in an organization.

Table 18. Innovation Process in an Organization. From Rogers (2003)

Innovation Process in an Organization		
Phase	**Stage**	**Description**
Initiation	1. Agenda Setting	general organizational problems that may create a perceived need for innovation
	2. Matching	fitting a problem from the organization's agenda with an innovation
DECISION		
Implementation	3. Redefining/Restructuring	the innovation is modified the re-invented to fit the organization and organizational structures are altered
	4. Clarifying	the relationship between the organization and the innovation is defined more clearly
	5. Routinizing	the innovation becomes an ongoing element in the organization's activities, and loses its identity

Lastly, the coding led to capturing Rogers (2003) dimensions of the consequences of innovation as :

(1) Desirable versus undesirable

(2) direct versus indirect

(3) anticipated versus unanticipated (pp. 789-790)

The following are observations made during the coding process in Innovation Diffusion:

- The independent variable "System Openness" is perceived as an external characteristic to the organization, and not viewed as an internal ability to interact with a broader social system while maintaining its purposeful social system goals and objectives.
- The definition of an organization as a "stable system of individuals". As O'Reilly and Tushman (1996) and Benner and Tushman (2003) argue in their explorative-exploitative behaviors of innovation model, organizations undergo periods of disruptive change. The definition of organization established by Rogers (2003) is challenged in two alternative ways:
    - Organizations are systems that have stable common characteristics, and through resilience and redundancy (e.g. organizational slack) are able to maintain stability by executing a combination of explorative or exploitative innovation behaviors.
    - Organizations pursue stability by continuously adjusting their characteristics and interactions with the external environment
- Based on Rogers (2003) definitions the source of problems that create a perceived need for innovation are originated from within the organization, and the innovation implementation changes the organizational units that implemented the innovations. In the case of U.S. Department of Defense, the innovation process is executed within large sub-units that have sub-unit external boundaries themselves. It is possible that the organization championing the innovation and responsible for its implementation is completely different than the organizational unit that will clarify and routinize the innovation. This observation highlights the need to broaden the organizational characteristics and definitions of the social system to a level that allows for cross-

organization communications through more defined communication networks and channels, with a possible expansion of the definitions for the agents/members in the organization as a social system.

- The final observation was the discussion related to innovation diffusions having a direct or indirect impact on widening socioeconomic gaps in society. The Innovation Diffusion work of Rogers (2003) provides some generalizations and ideas related to the **innovation consequences** within a context of a social system, but lacks an explanatory theoretical model that could help the members contributing to that innovation in the social system to understand the potential socioeconomical consequences related to widening the socioeconomic gap among society members.

APPENDIX C - EXPLORATIVE-EXPLOITATIVE INNOVATION SEED THEMES

Figure 42 illustrates the results of the unsupervised semantic mapping of the explorative-exploitative dataset.

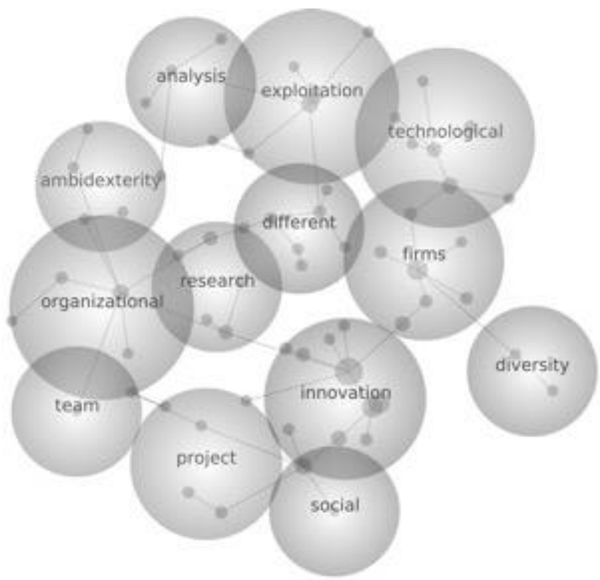

Figure 42. Explorative-Exploitative Innovation Seed Terms and associated relationships

Table 19 provides tabular results of the most prominent seed terms and the most associated seed terms. The highest ranked term based on word frequency is the top seed term innovation, and the associated co-occurrence words are listed on the associated related seed term cell on the same row.

Table 19. Explorative-Exploitative Innovation seed-terms

Leximancer Project	**Seed Term**	**Related Seed Terms**
Explorative-Exploitative Dataset	innovation	innovation, exploratory, exploitative, performance, effect, study, relationship, level, results, resources, likely
	firms	firms, knowledge, product, external, market, learning, existing, number
	organizational	organizational, management, management, strategy, strategic
	research	research, process, studies, empirical, need
	technological	technological, search, value, R&D, information, ties
	exploitation	exploitation, industry, time, case
	different	different, development, incremental, example, large
	project	project, control, business, success, role
	ambidexterity	ambidexterity, change, work,
	analysis	analysis, data, companies, company
	diversity	diversity, network
	social	social
	team	team

Table 20. Explorative-Exploitative Seed-Themes

Seed-Theme			Description	# references	# Sources
Explorative-Exploitative Innovation			Innovation patterns employed by organization to achieve organization's goals	3277	23
	innovation approaches		The innovation approaches are either explorative, exploitative, and may involve a combination of both approaches	3505	23
		exploitation	involves incremental changes and searching for strengthening of existing knowledge base; maintaining and improving existing customer base and market position; seeking efficiencies	1921	22
		exploration	involves seeking new domains, new knowledge, requires greater amount of resources and involves greater risks	1348	22
		ambidexterity	socio-cultural, managerial, structural organizational and leadership instruments to maintain both exploration and exploitation patterns of innovation	241	15
		strategy	leadership attributes related to their choice in implementing exploitative or explorative innovation in support of organization goals and objectives	350	22

Table 20 continued

	Management		• The management approaches to maintain ambidexterity. • The knowledge management approaches for conducting internal and external searches in exploitative and explorative innovation patterns. • The management of relationships external to the organization to support innovation search patterns and alliances supporting explorative-exploitative innovation.	1758	23
		External	the search and relationships activities related to seeking information and knowledge to understand the organization’s competitive environment as well as technology and knowledge in support of explorative-exploitative patterns	303	17
		knowledge management	The management of the activities related to internal strengthening of knowledge, external search activities related to alliances and sources of knowledge and domains that enable organization’s goals and objectives	2088	23

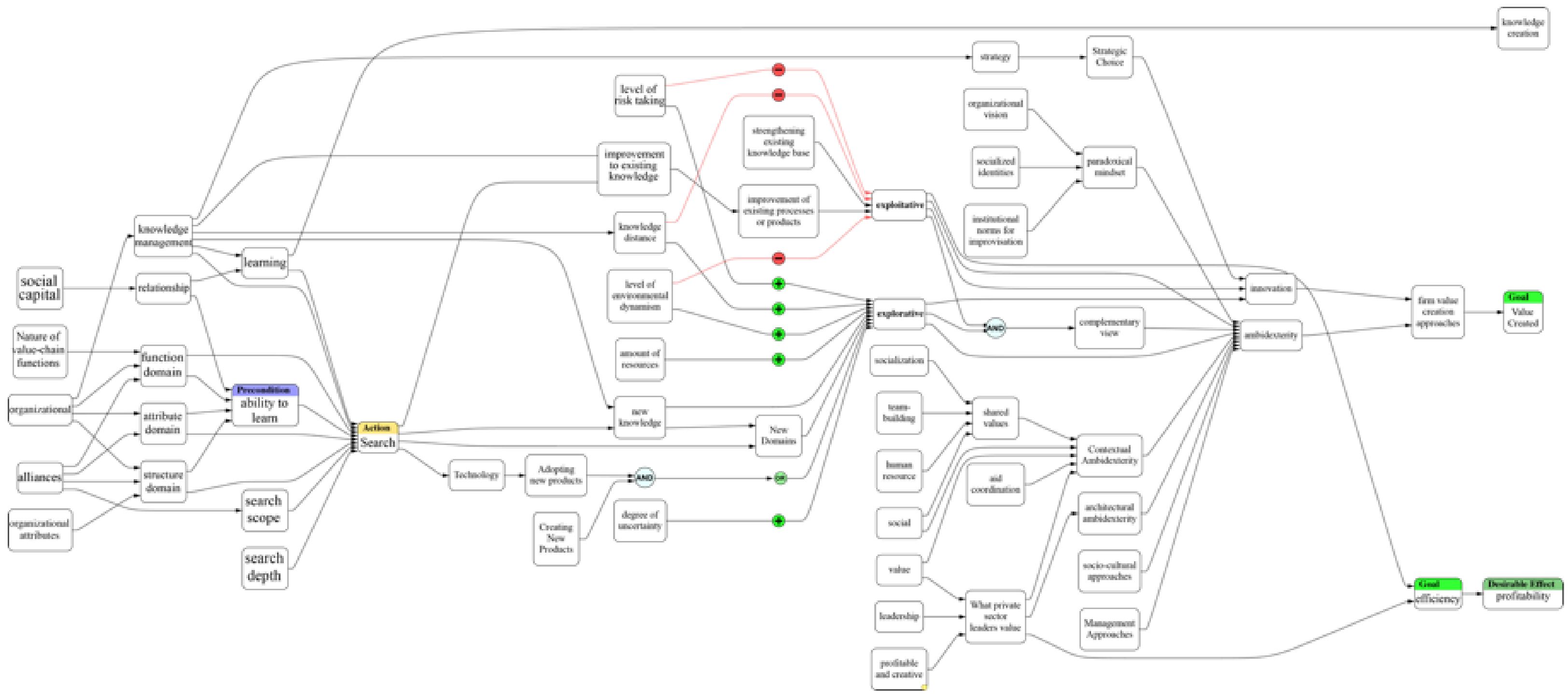

Figure 43. Evolution of Nvivo Coding for Explorative-Exploitative Innovation Dataset

APPENDIX D - INNOVATION MANAGEMENT AND POLICY SEED THEMES

Figure 44. Innovation Management and Policy Seed-Terms

Table 21. Innovation Management and Policy Seed-Terms

Leximancer Project	**Theme**	**Related Concepts**
Innovation Management and Policy	innovation	innovation, sector, public, services
	firms	firms, produce, performance, market, effects, development, business, relationship, success, orientation, quality
	process	process, research, organizational, activities, role, different, approach, literature, managers, government, practices
	technological	technological, innovative, strategy, industry, companies, factors, impact, resources, global
	knowledge	knowledge, information, social, learning, time, change, project, perspective
	management	management, policy
	network	network, analysis, economic, growth, capital, industries, countries
	organizations	organizations, employees, ideas
	behavior	behavior

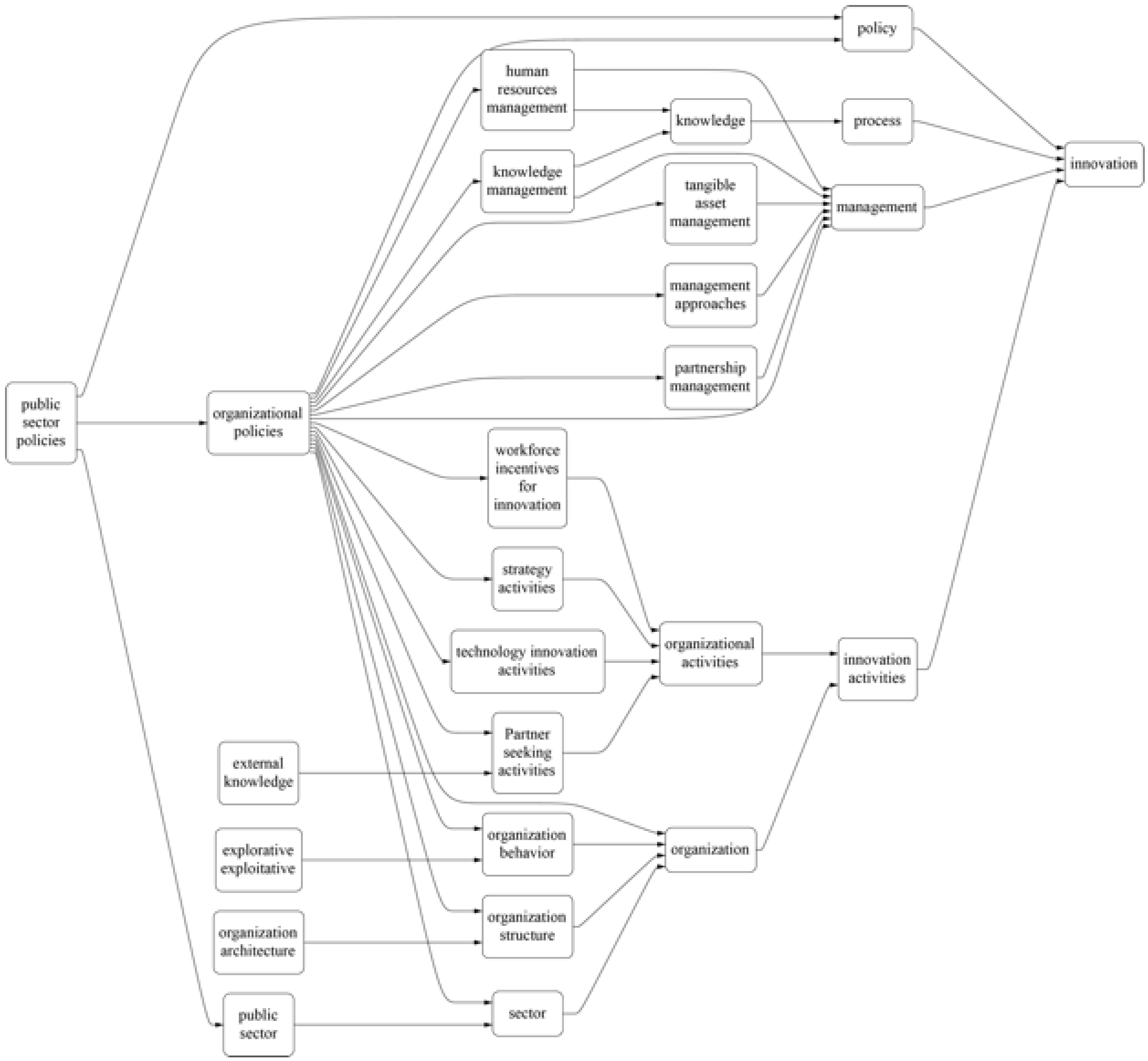

Figure 45. Innovation Policy and Management Seed Theme Development. Flying Logic Pro output

Table 22. Innovation Policy and Management Seed-Themes

Seed-Theme	**Description**	**# references**	**# Sources**
activities	Organizational activities related to promoting individual competencies in support of innovation. Innovation related activities in the organization such as research, development, prototyping, and experimentation.	918	71
behavior	Behavior of agents in the context of a social system (knowledge, agents, institutions, beliefs, goals). Behavior as patterns of innovation behavior supporting pursuits of goals. Behaviors of consumers in context of innovation adoption. Behavior of individuals related to technological innovation. Behavior of partners in the context of technological innovation cooperation activities. Management behaviors for establishing explorative-exploitative ambidexterity in organization innovation activities	430	47
innovation	Innovation in the context of environmental, technological, and market changes and uncertainties. Innovation in the context of policy changes. Innovation in support of organization's strategic goals. Technological innovation activities and their patterns of behavior. Innovation in the context of organizational change and management tensions related to innovation behaviors. Innovation in the context of U.S. government policies for technological innovation. Innovation in the context of establishing organizational conditions for innovation. Innovation in the context of establishing conditions for innovation at the national level	12037	72
knowledge	Knowledge as the creative application of knowledge for innovations. Knowledge in the context or organizational knowledge management supporting explorative-exploitative innovations internally and through communication channels. Knowledge in the context of sharing knowledge within exploitative and explorative organizational and individual behavioral conditions. Knowledge in the context of knowledge spill-over effects. Knowledge in the context of organizational external searches for knowledge in support of innovation cooperation activities. Knowledge as a key element in technological innovation	2028	70

Table 22 continued

policy	Policy in the context of organizational policies related to resource management, investments, incentives, knowledge management to promote and increase performance of technological innovation. Policy as government policies relative to level of incentives and establishing conditions for private-firm technological innovations	2582	68
management	Management in the context of innovation management policies, management of human resources. Management in the context of managerial attributes in support of explorative and exploitative innovation. Management in the context of knowledge management, workforce, management of tangible assets, decision-making. Management in the context of processes related to technological and process innovation in organizations. Management from a perspective of business capabilities related to establishing effective strategies for innovation, management of human, knowledge, tangibly assets (e.g., communication networks), development and management of partnerships, management of human resources. Management approaches for innovation. Process management in exploitative technological innovations. Management of explorative innovation activities.	4535	72
organization	Organization in the context of private versus public sector organizations. Organizational structure, architecture, and culture within the context of explorative and exploitative innovation behaviors. Organization in the context of leadership styles related to explorative and exploitative organizational behavioral patterns.	3126	71
process	Process as in transformation of knowledge leading to technological innovations. Process in the context of improvement of policy development processes for improving innovation performance at organizational, institutional and national levels. Process in the context of characteristics for explorative exploitative innovations. Processes in the context of organizational processes supporting management functions and process improvement.	2018	72
impact	Impact in a context of innovation related variables and case studies. Impacts in the context of policy impacts in private firm innovation performance and competitiveness. Impacts from a perspective of estimating innovation impacts and outcomes	632	63

APPENDIX E - INNOVATION PARTNERSHIPS SEED THEMES

The innovation partnerships dataset consisted of mainly interpretative journals discussing the various aspects of partnerships within mostly private-firm sector. Figure 46 illustrates the results of the unsupervised semantic mapping of the explorative-exploitative dataset.

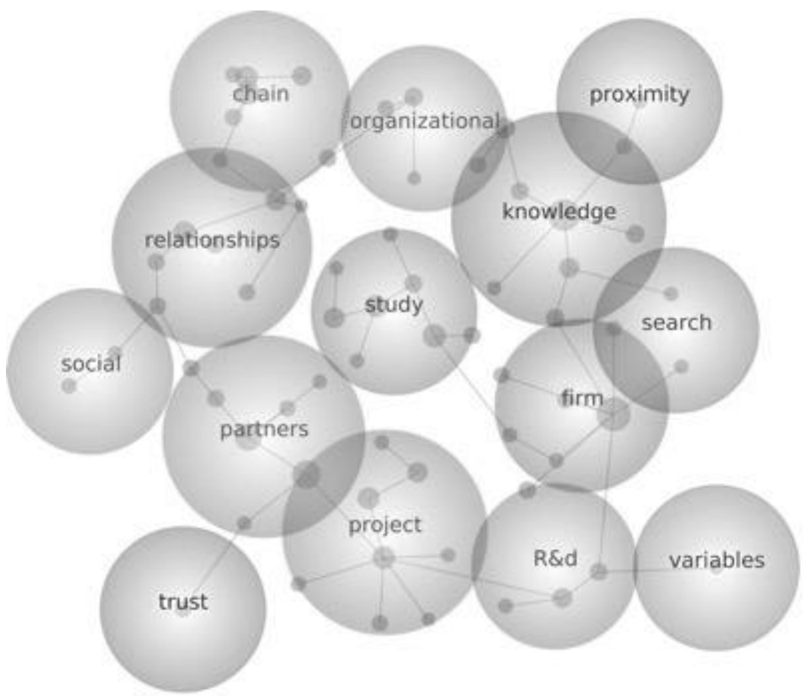

Figure 46. The Innovation Partnerships Initial Seed Terms and Associated Relationships

Table 23. Innovation Partnerships seed-terms and relationships from Leximancer

Leximancer Project	**Theme**	**Related Concepts**
Innovation Partnerships	partners	partners, collaborative, networks, network, role, work, time
	knowledge	knowledge, product, external, technological, different, sources, use, market
	project	project, research, companies, analysis, joint, future, sector, open
	firms	firms, results, level, used, industry, case
	study	study, process, development, literature, important, resources, approach, support
	relationships	relationships, organizations, strategic, business, management, value chain
	chain	chain, supply, performance, capabilities, inter-organizational, IOIS, systems
	organizational	organizational, technology, learning, environment
	R&D	R&D, cooperation, activities, number
	social	social, economic
	trust	trust
	search	using
	proximity	proximity
	variables	variables

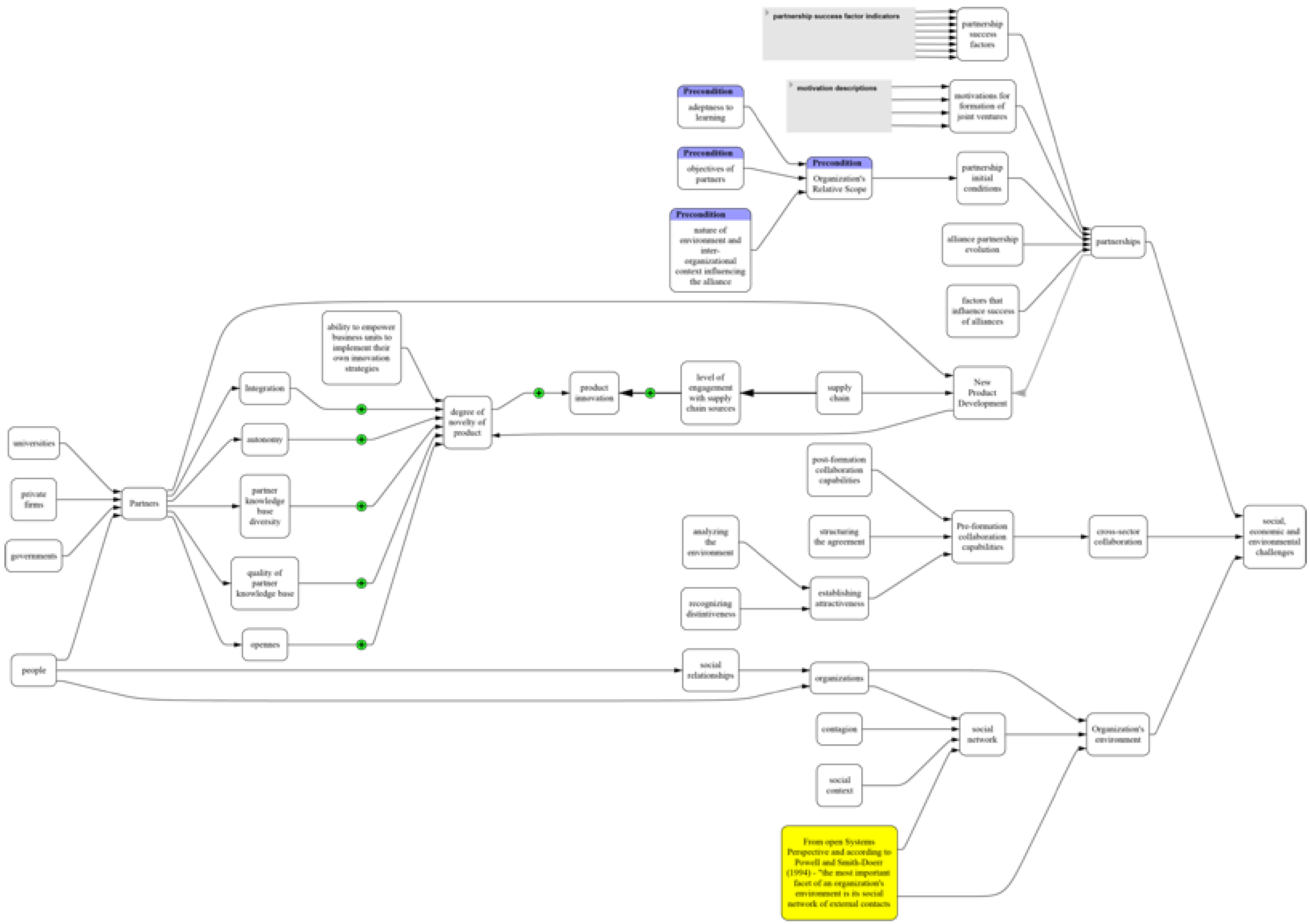

Figure 47. Innovation Partnerships Seed-Theme Development

Table 24 provides a high-level view of the resulting seed-themes from the coding process. The top seed themes were about knowledge, strategic alliances, and the strategic environment within a context of innovation and mostly private firm performance, growth and market share.

Table 24. Innovation Partnership seed-themes

seed-theme		**Description**	**# References**	**# Sources**
Strategic Environment for Partnerships		growing complexities and uncertainties, growing need for innovation collaboration in the context of complex situations and wicked problems facing society. Partnerships in a context of technological innovation under market and competitive uncertainties	30	6
Innovation Collaboration		Innovation collaboration includes the motivation for partnerships in the context of innovation, factors influencing success of alliances, conditions for partnerships, and the social-network perspective to partnership performance	815	29
	Social Network	Building upon open systems perspective, the importance of social networks and organization's ability to be embedded in social networks for successful partnerships enabling technological innovation	799	27
	Partnerships	The nature of partnerships and their attributes within the context of organizational externalities and technological innovation. Partnership attributes include factors that influence success of alliances, cross-sector innovation collaboration, motivations for partnerships, partnership success factors, conditions for partnerships, and partnership factors that enhance technological innovation novelty	810	27

APPENDIX F - MISSION ENGINEERING SEED THEMES

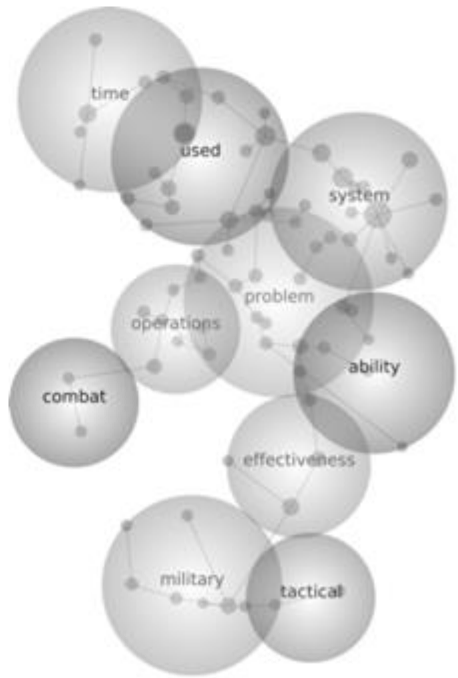

Figure 48. Mission Engineering and Integration Seed-Terms from Leximancer

Table 25. Mission Engineering and Integration Seed-Themes and Relationships

Leximancer Project	Theme	Related Concepts
Mission Engineering	systems	systems, mission, process, engineering, development, design, complex, elements, requirements, SoS, approach, specific, tools, environment, management
	military	military, war, forces, political, force, during, strategy
	used	used, kill, chain, analysis, strike, manned, model, capability, aircraft, based, models, order, required, network, form
	problem	problem, assessment, performance, capabilities, team, information, provide, activities, measures, support, human, important, include, risk
	time	time, simulation, target, number, results, case
	operations	operations, control, factors, command, example, possible, decision, available
	effectiveness	effectiveness, operational, level, means
	tactical	tactical, strategic
	combat	combat, air
	ability	work, security

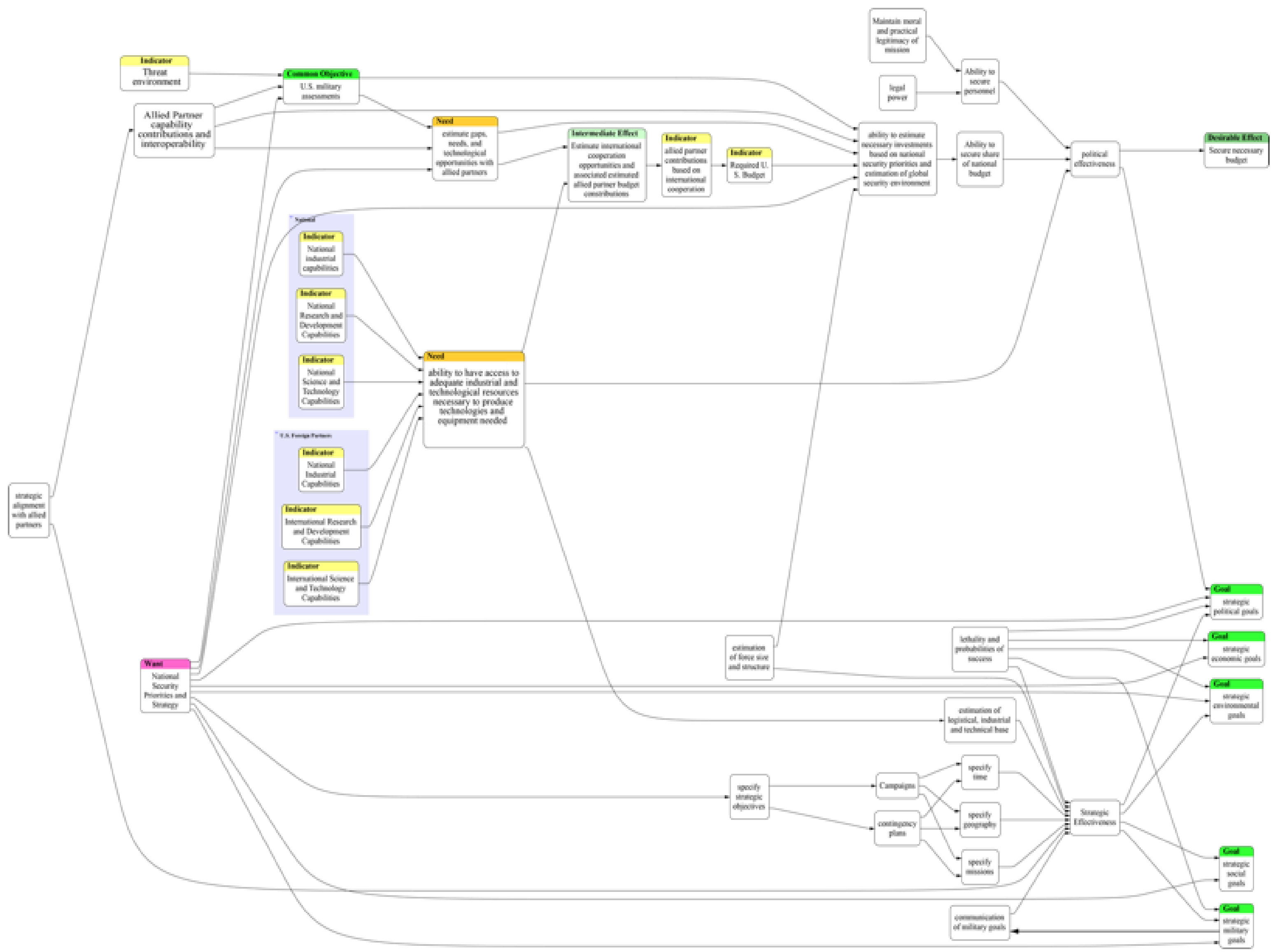

Figure 49. Mission Engineering and Integration Seed-Theme Development

Table 26. Mission Engineering and Integration Seed-themes

seed-theme		**Description**	**# References**	**# Sources**
Mission Engineering		(1) Mission Engineering functions to bridge separation between mission, sytems engineering, and operations. Technical component integral and inseparable from the socio-technical system that generates the mission. Sousa-Poza (2015) (2) Mission Engineering as an approach for linking tactical insights of operational planning to achieve mission wholeness (3) Mission Engineering as a methodology that supports mission analyses with the purpose of optimizing mission success for system-of-systems mainly focusing on technical components.	19	4
Effectiveness of Military Organizations		Military effectiveness as being effective in converting resources into fighting power.	Millett, Murray & Watman (1986)	1
	Strategic Effectiveness	Ability to effectively specify time, geography, mission, and objectives. Includes establishment of strategic objectives to meet national security political, military, economic, social, and environmental goals. Involves conducting analysis in support of strategic objective formulation, campaign planning, and contingency plan development	Millett, Murray & Watman (1986)	1
	Operational Effectiveness	Analysis, selection, and development of institutional concepts or doctrines for employing major forces to achieve strategic objectives within a theater of war within the scope of military operational matters	Millett, Murray & Watman (1986)	1

Table 26 continued

Military Effectiveness Assessment Methodologies		Methodologies used for: (1) assessment of strategic and operational command and control; (2) Assessment of effects-based effectiveness against mission success criteria; (3) analysis of tactical level situations	60	5

APPENDIX G - SECURITY STRATEGIES CONCEPT SEED THEMES

NATIONAL SECURITY STRATEGY

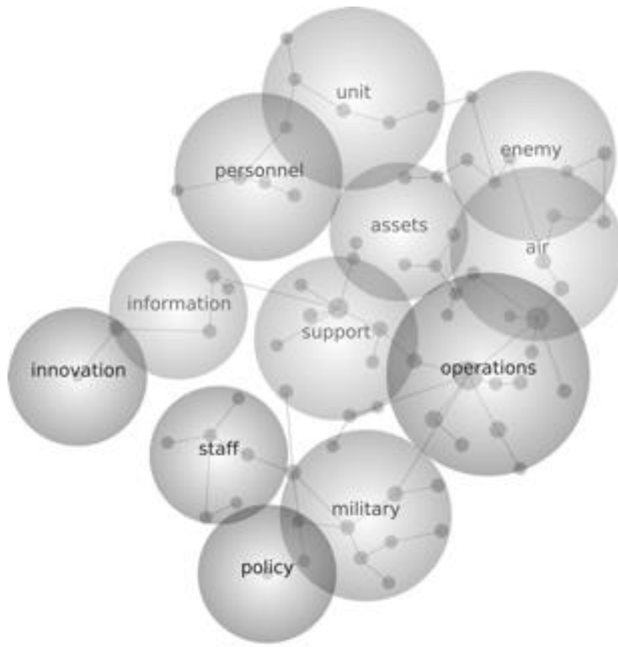

Figure 50. National Security Strategy Seed-Terms from Leximancer

NATIONAL MILITARY STRATEGY

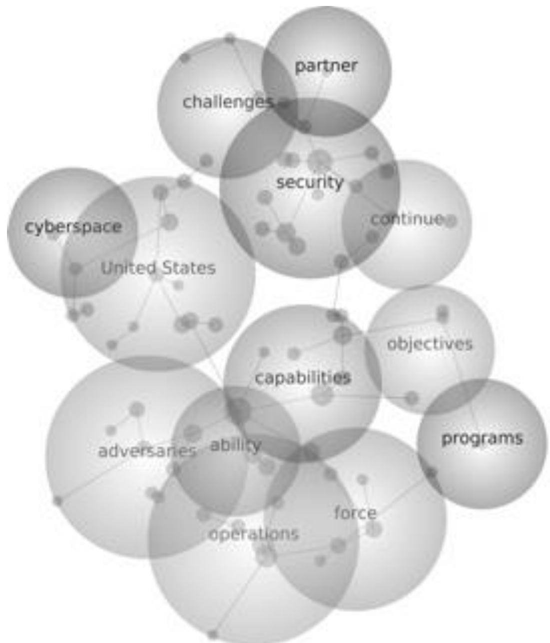

Figure 51. National Military Strategy Seed-Terms from Leximancer

Table 27. National Military Strategy Seed-Terms and relationships

Leximancer Project	**seed-term**	**related seed-terms**
National Military Strategy	capabilities	capabilities, military, support, forces, provide, operational, operational, multinational, mission
	security	security, partners, international, allies, conditions, interests, national, Joint Force, regional, efforts, U.S., strengthen
	United States	United States, strategic, global, access, power, conflict, threats, attack, space, project, technologies, strategies
	Operations	operations, require, range, full, speed
	adversaries	adversaries, Armed Forces, information, systems, innovative, technology
	forces	forces, joint, future, missions, operating, requirements
	ability	ability, requires, require
	continue	continue, stability, defense
	challenges	challenges, nations, partnerships, relationships, system
	objectives	objectives, organizations
	cyberspace	cyberspace, resources
	partner	partner
	programs	programs

NATIONAL DEFENSE STRATEGY

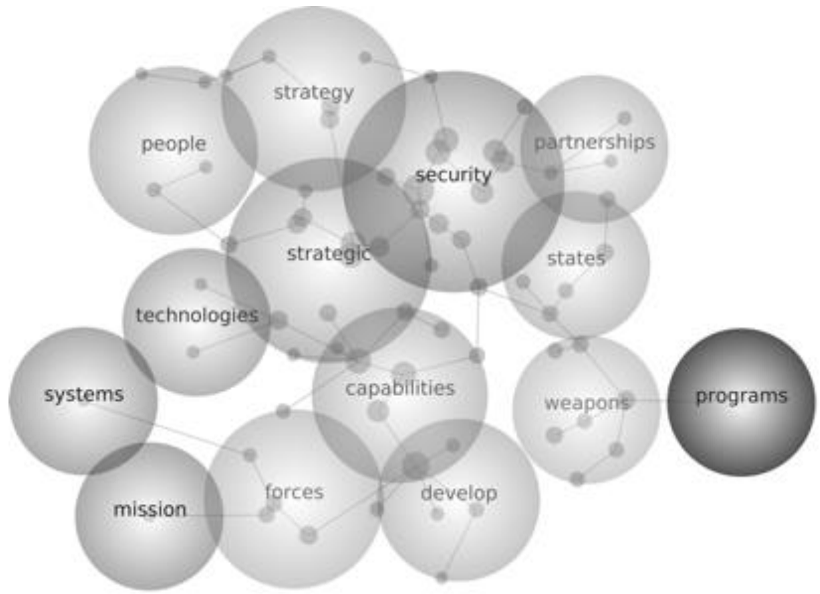

Figure 52. National Defense Strategy Seed-Terms

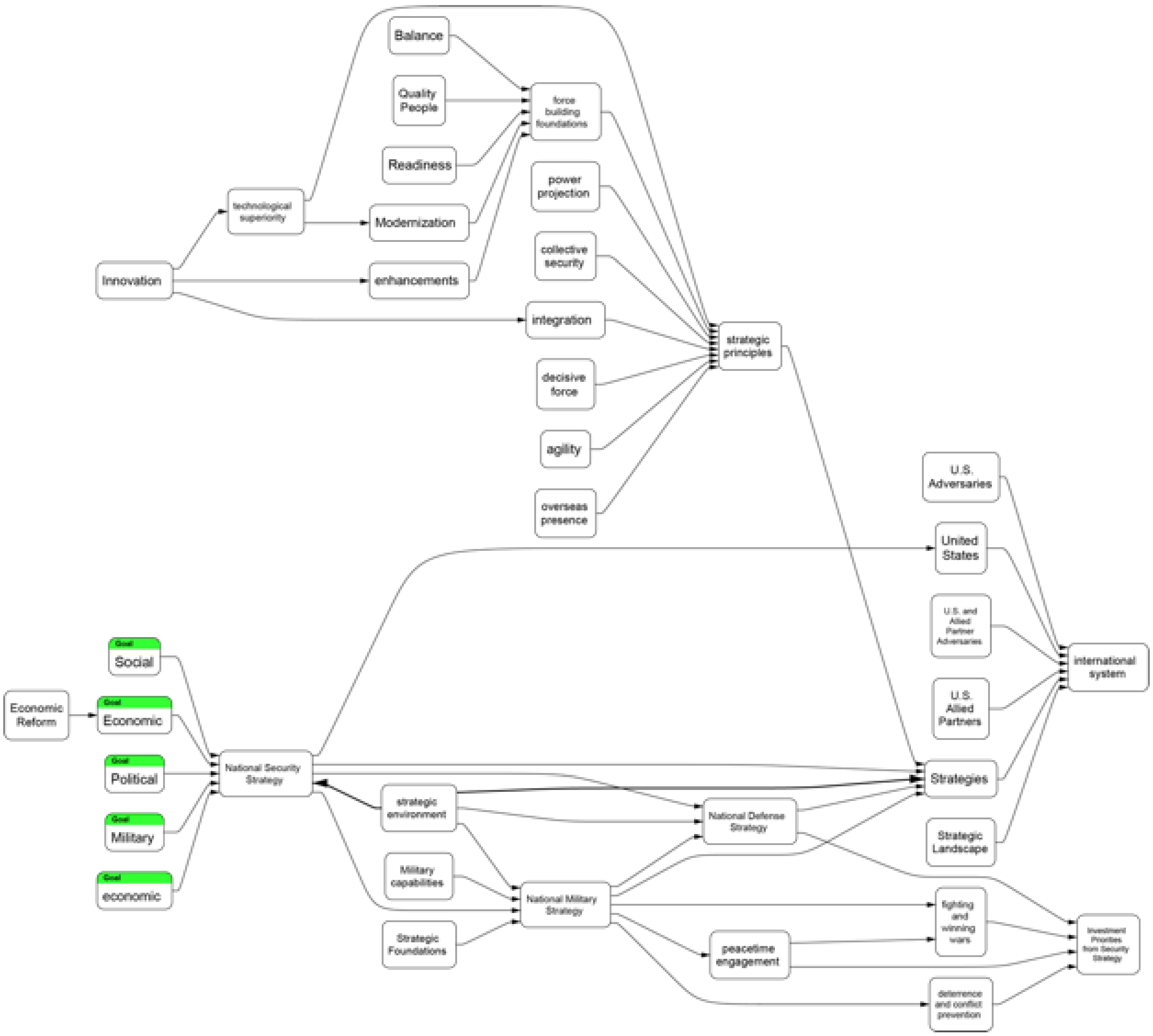

Figure 53. National Security, Military, and Defense Seed-theme Development. Output from Flying Logic Pro Software.

Table 28. National Security, Military, and Defense Strategy Seed Themes

seed-theme	Description	# References	# Sources
International System	International System includes member states in the globe. U.S. national security, military and defense strategies often refer to international system from a perspective of establishing strategic security goals involving political, social, economic, and military strategies. These strategies are supported by U.S. core value principles of justice, freedom, and prosperity.	19	4
Strategic Environment	Commonly referred to as the observations in behavior in the international system related to global economy, environment challenges, adversarial threats and investments in technologies, the disruptive pace of global technological advancement, and the strategic uncertainties associated with the global environment.	35	30
Strategic Principles	The strategic principles for national security are described in the National Military Strategy: collective security, decisive force, agility, arms control, force building foundations (e.g., quality people and force readiness), integration, overseas presence, and technological superiority	27	3
U.S. Strategic Interests	U.S. strategic interests reflect the U.S. value-add and security related interests in the international system. Value-add includes security, international order, enabling prosperity, promoting common values. Promoting U.S. core beliefs and political, social, and cultural values such as democracy, human rights, dignity, and freedom.	27	5
U.S. Security Strategy	The U.S. security strategy takes into account U.S. role in the international system and establishes national security priorities, and approaches to achieve U.S. national security interests and international environmental threats.	46	15
Military Strategy	The military strategy uses National Security Strategy inputs to establish military strategic objectives. The military strategic objectives are expressed in terms of campaign and contingency plans.	50	6
Defense Strategy	Defense Strategy takes National Security Strategy inputs. Coordinates with Military Strategy, and establishes defense wide strategic goals related to capabilities, investments, organizational goals, priorities, and levels of readiness	20	27

APPENDIX H - DEFENSE ACQUISITION SYSTEM SEED THEMES

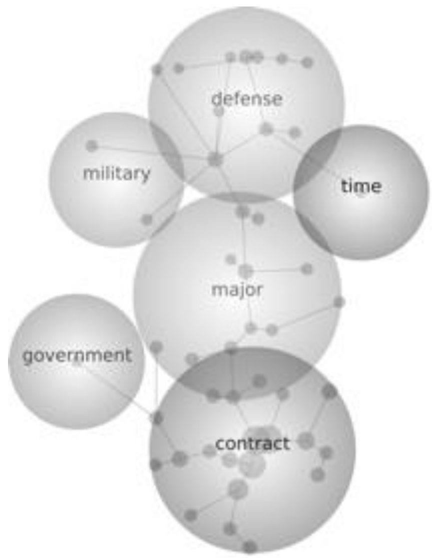

Figure 54. Defense Acquisition System Seed-Terms from Leximancer

Table 29. Defense Acquisition System Seed-Terms and Relationships

Leximancer Project	**Seed-Term**	**Related Seed-Terms**
Defense Acquisition System	contract	contract, obligations, percent, decline, contracts, services, share, cost, contracting, R&D, rate, price, vendors, significant, increase, use, competition, year, billion, million
	major	major, 223ffectively, budget, data, industrial, major program, systems, large, growth, number, interoperability
	defense	defense, acquisition, program, system, research, fundamental, approach, current, international, capability, integration
	military	military, future
	government	government
	time	time

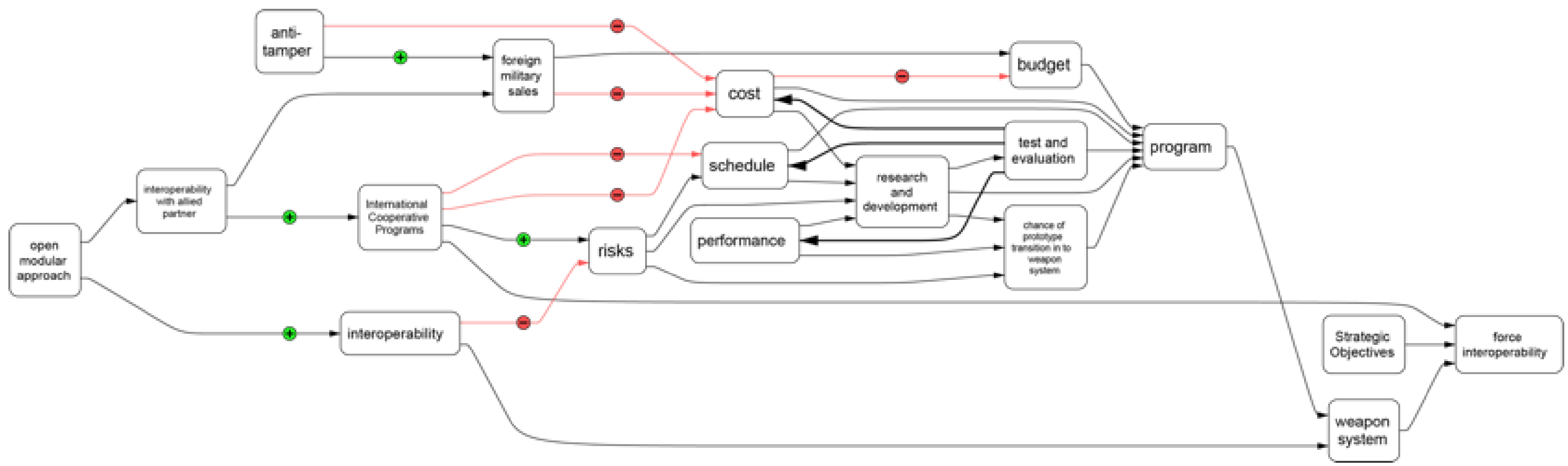

Figure 55. Defense Acquisition System Seed-Theme Development

Table 30. Defense Acquisition system seed-themes

seed-theme	**Description**	**# References**	**# Sources**
program	Programs, in this dataset were used within the context of acquisition of weapon systems. Include research and development programs for weapon systems. Decline in new programs amid decline in budgets. Risk drivers for program are cost, schedule, and performance related risks. International Cooperation Programs and International Acquisition. Challenges in transitioning technologies from research and development programs to acquisition programs for deployment and sustainment. Flexibility in programs related to acquisition policies.	4249	11
System	System in the context of U.S. acquisition, programming, planning, budgeting, and capability development. Systems as weapon systems. Systems used in the context of promoting open modular standards in system requirements for acquisition programs. Systems in the context of improvements of the DoD acquisition system. System in the context of lack of DoD openness caused by defense acquisition system policies.	6333	13
Interoperability	Interoperability in the context of strategic objectives to achieve force interoperability. Interoperability in the context of acquisition policies related to open modular approaches and compatibility to increase interoperability, Interoperability in the context of international armaments cooperation activities to increase interoperability and integration with allied partner nations	169	12
Integration	Minimizing design integration in open modular approaches. Integration of acquisition activities. Integration of developmental and operational test and evaluation activities. Integration of anti-temper approaches to maximize exportability of weapon systems. Integration of open modular approaches to increase interoperability. Integration of set-based design concepts to system requirements.	1008	12

APPENDIX I - JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SEED THEMES

Figure 56. JCIDS Seed-Terms from Leximancer

Table 31. JCIDS seed-terms and relationships

Leximancer Project	**Seed-Term**	**Seed-Term Relationships**
Joint Capabilities Integration and Development System	requirements	requirements, capability, solution, gaps, associated, development, acquisition, activities
	support	support, required, intelligence, changes, information
	authority	authority, review, process
	operational	operational, capabilities
	KPP	KPP, mission
	attributes	attributes, performance
	analysis	analysis, include, additional
	life	life, cost, program
	documents	documents
	joint	force
	architecture	architecture

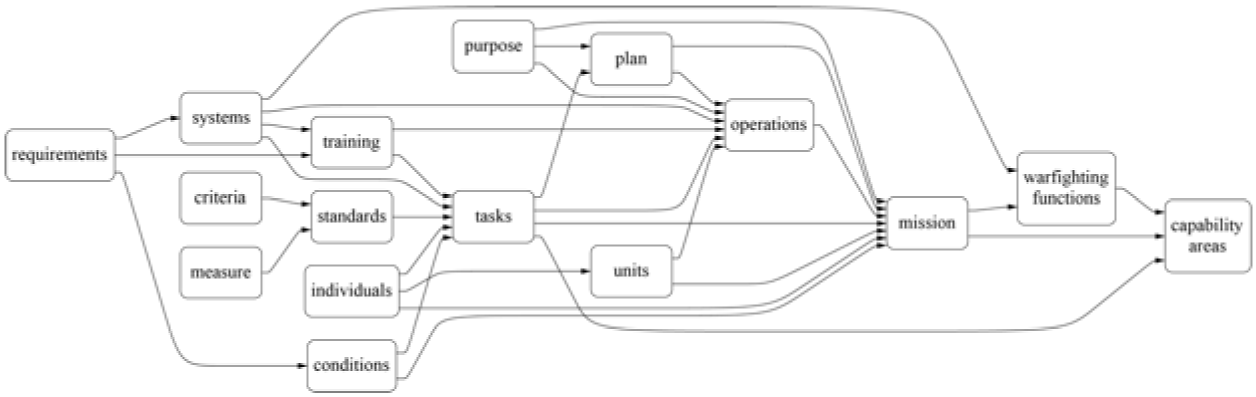

Figure 57. JCIDS seed-theme development

Table 32. JCIDS Seed-Themes

seed-theme	**Description**	**# References**	**# Sources**
Threats	assessment of threats used by military Senior leaders to advise president and secretary of defense on ongoing military operations, allocation and transfer of forces. Used in reviews to advise secretary of defense in overall preparedness of forces to provide assessments on critical deficiencies. Used as part of analyses to evaluate operational gaps and estimate capability requirements	4249	11
technology	used in the context of technology as systems (software and hardware) with respect to their level of maturity in the context of prototyping, test, and evaluation activities. This includes their fitness to support operational requirements	218	4
system	System mentioned as a capability development system used by the U.S. Joint Requirements Oversight Council. Used in the context of open-modular approach policy for weapon systems enabling technical interoperability among systems and providing government with ability to better sustain weapon systems. Systems also discussed in the context of systems analysis. Systems also used in describing weapon systems including command and control, intelligence, targeting, fire control, information management systems.	1193	4
requirements	used in the context of warfighting functional requirements, operational requirements, performance requirements related to tasks, capability requirements portfolios, requirement documents.	2759	4

Table 32 continued

mission	mission in the context of the Joint Requirements Oversight Council, overall mission of the U.S. Joint Forces, broad mission area assessments, and validating mission needs that involve system technology development, maturation, and transfer. Also used in the context of joint mission threads and mission architectures	587	4
Key System Attribute	Key System Attributes associated with capability requirement documents, capturing system performance key attributes	103	3
Key Performance Parameters	Key performance parameters used to determine, document, and evaluate essential performance attributes in a system	894	4
Capability	used in the context of capability requirements and development of capability solutions for military. Used to describe capability gaps and document required capabilities based on military operational needs derived in the Joint Capabilities Development and Integration system. Capability used in the context of forces having the ability to achieve specified objectives in terms of forces, technology, readiness, and ability to sustain	4432	4

Table 32 continued.

interoperability	used in the context of interoperable military capabilities, achieving interoperability through requirements, architectures, standards and assessments. Also used in the context of interoperability of command and control information systems that are connected by a telecommunications networking infrastructure. Used in the context of processes, information, procedures and organizations	267	4
gaps	gaps used in the context of capability, operation, mission, training, force structure, and readiness	366	4
context	context used in defining operational context, global context, capability requirements as context for family of systems to system level requirements. Also used in the context of describing mission context and key performance parameters in the context of warfighting functions	307	4

APPENDIX K - DOD INNOVATION AND SECURITY COOPERATION SEED THEMES

SECURITY COOPERATION

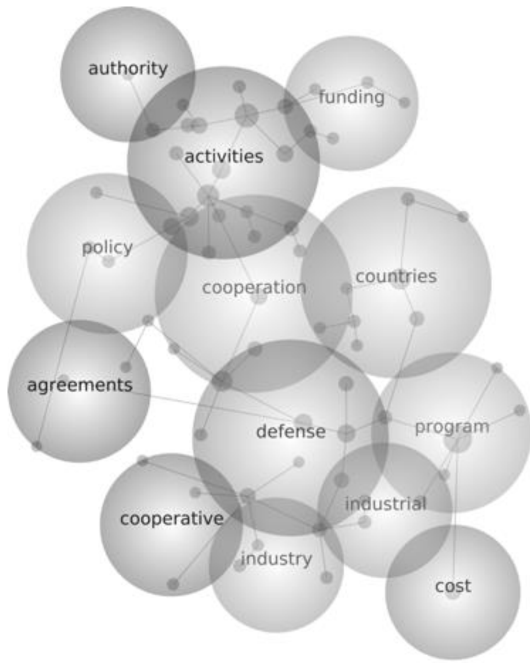

Figure 58. Security Cooperation Seed-Terms from Leximancer

Table 33. Security Cooperation seed-terms and relationships

Leximancer Project	**seed-terms**	**related seed-terms**
DoD Security Cooperation	activities	activities, security, military support, foreign, objectives, forces, planning, capabilities, operations, assistance, training, include, plan, authorities, including, personnel
	defense	defense, partner, requirements, process, management, capability, additional
	program	program, cooperation, partners, national, develop, efforts, approach, current
	countries	countries, partner, requirements, process, management, capability, additional
	cooperation	cooperation, partners, national, develop, efforts, approach, current
	policy	policy, information, services, equipment
	funding	funding, specific, required, available
	industry	industry, production, research
	cost	cost
	industrial	industrial, benefits, economic
	cooperative	cooperative, major, weapons
	agreements	agreements, allies, data
	authority	authority

INTERNATIONAL ARMAMENTS COOPERATION

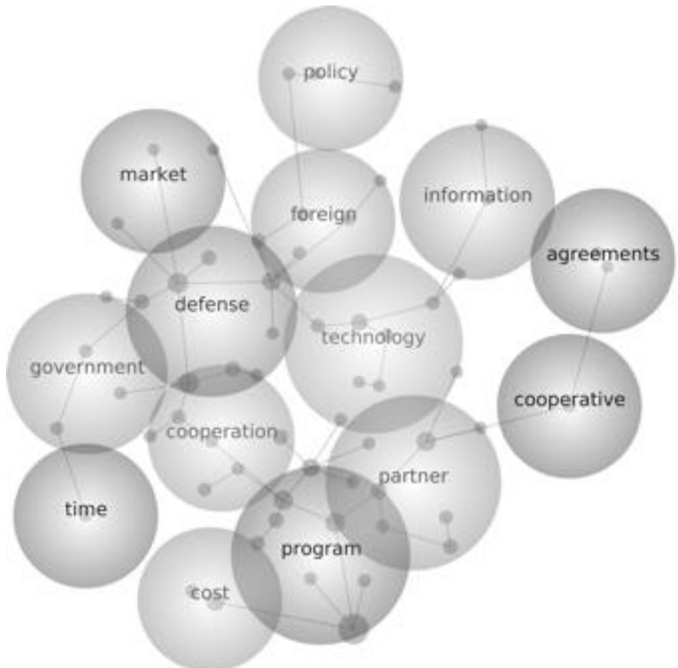

Figure 59. International Armaments Cooperation Seed-Terms

Table 34. DoD Science and Technology Innovation Policy seed-terms and relationships

Leximancer Project	**Theme**	**Related Concepts**
Science and Technology Innovation Policy	capabilities	capabilities, development, systems, acquisition, forces, future, provide, potential, rapidly, important, technical
	technology	technology, research, defense, areas, investment, current
	program	program, system, military, develop, information, cost
	needs	needs, enterprise, mission, open
	process	process, support, intelligence, teams, community
	operational	operational, adaptability, environment, study
	science	science, engineering, engineers, scientists, percent, country
	time	time, performance, skills, space
	training	training, personnel
	advantage	advantage
	leadership	leadership

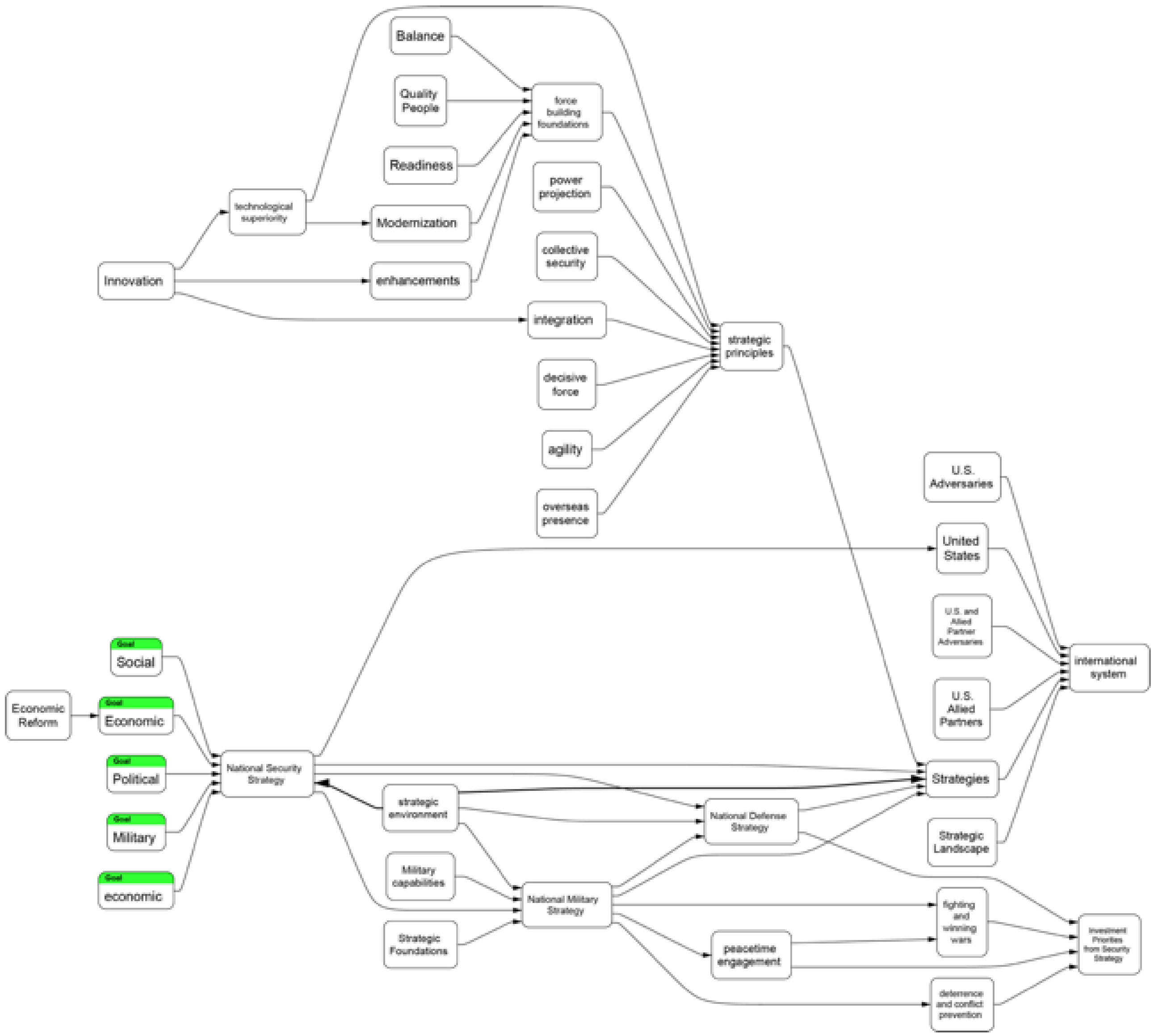

Figure 60. Conditions for International Armaments Cooperation seed theme development

Table 35. DoD Innovation and Security Cooperation Seed Themes

Seed-Theme		**Description**	**# References**	**# Sources**
Conditions for International Armaments Cooperation		Conditions related to the alignment of socio-economic, cultural, technological, and security strategic environment considerations relative to the international cooperation activity	35	4
	markets and competition	the degree of competition and market share of national industrial and technological base influences the nation's membership in international armaments cooperation	12	2
	Policy Responsiveness	the public support for defense cooperation influences nation's membership in international armaments cooperation	2	1
	Security and Dependence	technology and armaments trade dependence influence nation's membership in international armaments cooperation	4	5
	Cultural Conditions	Alignment of cultural values influences nation's memberships in international armaments cooperation	15	5
	Power Differential	Relative power differential among member nations influence memberships in international armaments cooperation	15	5

Table 35 continued

International Armaments Cooperation Characteristics		Characteristics that influence successful international armaments cooperation activities	40	4
	language, culture, and time zone differences	language, culture, and time zone differences influence success of international armaments cooperation activities	3	2
	workshare distribution	workshare distribution conflicts among nations	3	3
	technology novelty trade-off	balancing expectations of degree of technology novelty and complexity accepted and pursued by member nations	3	3
	alignment of operational needs	compatibility and harmonization of nation's security goals and operational needs	10	5
	commitment mechanisms	level of commitment of member nations influences cost, schedule, and performance risks in international armaments cooperation activities	9	3
	nature of needs driving decision making	degree of strategic, political, diplomatic needs influencing the international armaments cooperation activities	9	3

Table 35 continued

	cross sector integration	The degree of national private and public sector integration influence memberships in international armaments cooperation	3	3
	military technology information protection policies	criticality of information and ability of members to sector the information influence knowledge transfer necessary to achieve international armaments cooperation goals	26	3
A Systems Approach to Innovation		conditions that enable or discourage innovation within the U.S. Department of Defense relative to technological innovation and its ability to access industrial and scientific base to accelerate technological innovation under resource constraints	40	5
	government perspectives	cultural and bureaucratic issues that challenge incentivizing technological industrial base for innovation	3	2
	government approach to innovation	concentrating on fairness and competition. Negatively impacts technology innovation performance that ultimately enables warfighter superiority	3	3
	cultural tensions between government and industrial base	lack of government personnel understanding of private sector business	3	3

APPENDIX L - U.S. ARMED FORCES MISSION AND TASK SEED THEMES

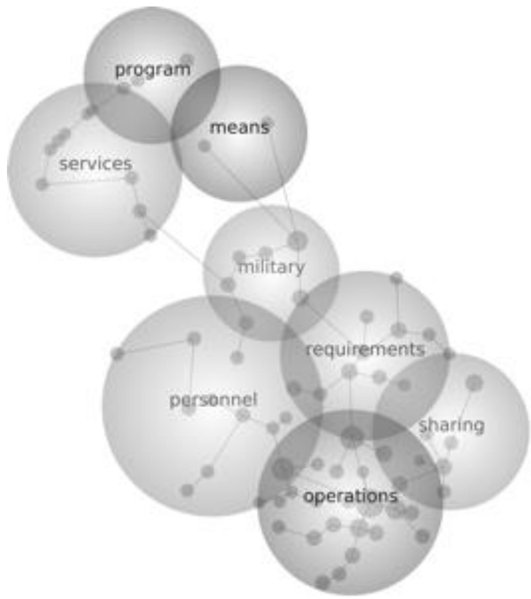

Figure 61. Armed Forces Mission and Tasks Seed-Terms from Leximancer.

Table 36. Seed terms and seed-term relationships from Leximancer

Leximancer Project	**seed-term**	**seed-term relationships**
U.S. Armed Forces Missions and Tasks	operations	operations, support, forces, joint, force, capabilities, operational, JFACC, commander, airspace, mission, area, enemy, coordination, command, friendly, systems, aircraft, conduct, units, combat areas, space, unit
	military	military, congressional, including, during, appropriate, training
	requirements	requirements, activities, security, include, plan, national, system, USG, development, data
	personnel	personnel, time, available, authority, equipment, established, procedures, freedom, facilities
	services	services, health, member, medical, service, retainer, person, chapter
	sharing	sharing, planning, intelligence, directorate, process, NGO’s, OPLANS
	program	program, paragraph, enactment
	means	means, law

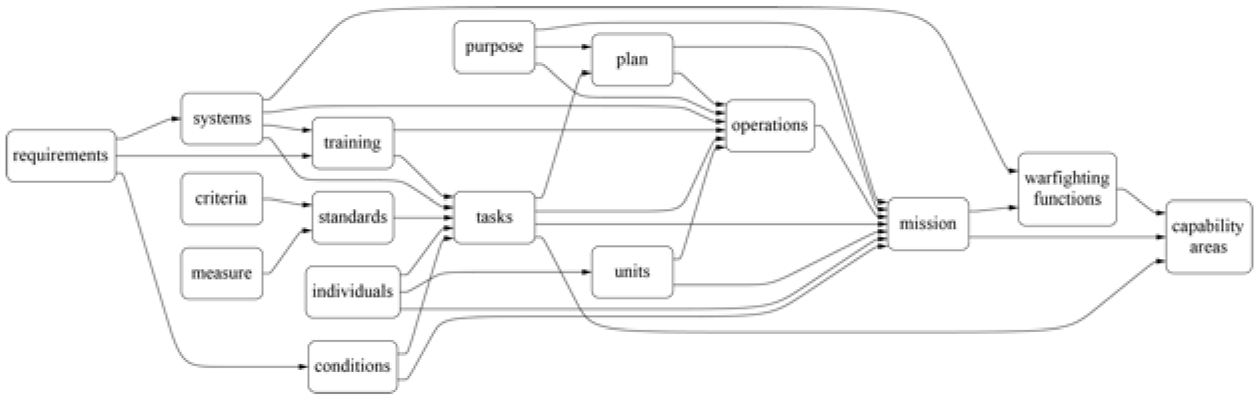

Figure 62. Missions and Tasks seed theme development. Output from Flying Logic Pro Software.

Table 37. Mission and Task seed-themes

Seed-Theme		Description	# References	# Sources
conditions		variables that affect performance of tasks in context of assigned missions. Conditions are categorized as physical (sea state, terrain, weather), military environment (forces, task success, command relationships), and civil environment (political, cultural, and economic factors). Some conditions are used to describe operations such as host nation support, and battlefield. Conditions help frame differences and similarities between assigned missions	1514	34
Operations		activity conducted by armed forces	32648	34
Standard		minimum accepted level of proficiency required in the performance of a particular task under specified set of conditions. Standards are established by a military unit commander.	1394	29
	criteria	defines acceptable levels of task performance	447	31
	measure	term directly connected to a description of a task that describes dimension, capacity, or quantity description	29	1394

Table 37 continued

Plan		U.S. Armed Forces tactical lists are used for military planning purposes. Planning includes training, operations, and capability-based planning. Plan also used as tasks themselves in the context of measurable military planning task with criteria, measures, and conditions.	15954	34
program		a set of activities related to missions, operations, and sustainment of the force with a long-term aim or has an enduring element essential for military readiness and missions	2345	34
training		training based on policy and doctrine to prepare military personnel and interoperable military units. Includes basic, technical, operational, and unit interoperability training. Interoperability training can be either joint combatant commander or initiated by service	2877	31
System		systems as software and hardware military weapon systems: information systems, weapons, training systems. Systems as functional system-of-systems such as theater logistics systems, fire support systems, command and control systems, targeting systems.	5547	34
requirements		requirements as necessary conditions linked to missions, operations, and tasks. Requirements also as in equipment and personnel, training, security, information, and engineering	10468	34
mission		task, together with the purpose, that indicates action to be taken and the reason for taking the action. A mission is also used to describe the duties assigned to military individual or units. It is also used to assign aircrafts to tasks	7621	34

VITA

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Joe Bricio earned his Master of Science in Modeling and Simulation from Old Dominion University in 2009, and Mechanical Engineering bachelor's degree from Old Dominion University in 2002.

Joe Bricio is currently a Naval Surface Warfare Center Dahlgren employee serving as Mission Engineering and Integration Advanced Capabilities Manager in the United States Department of Defense, Office of Undersecretary of Defense for Acquisition and Sustainment. As a NSWC employee Joe served in numerous assignments: Innovation Team Lead; Navy International Programs Office International Cooperative Architecture Manager; Lead Systems Engineer for U.S. Marine Corps Systems Command Systems Engineering, Interoperability, Architectures, and Technology Division; exchange engineer with Australia's Defence Science and Technology Organisation (2 years), and co-chair of the Maritime Theater Missile Defense Forum Modeling and Simulation Working Group.

Joe has made policy contributions to Department of Defense related to international armaments cooperation and contributor in establishing DoD policies for Mission Engineering and Integration. He is also a contributor to a Wiley book titled Engineering Principles for Combat Modeling and Simulation. In 2018 Joe received the NSWC Dahlgren Innovation Award for establishing U.S. Navy's Open Cognitive Computing Framework initiative. In 2020 Joe received a NSWC Dahlgren Honorary Team Award for the development and deployment of U.S. Navy's International Program Opportunity Evaluation tool, which helps U.S. Navy identify cooperative opportunities for technology development with U.S. DoD Allied Partners.