AGILITY MEASUREMENT FOR LARGE ORGANIZATIONS

DISSERTATION

Jeremy R. Geiger, Lieutenant Colonel, USAF

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AGILITY MEASUREMENT FOR LARGE ORGANIZATIONS

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Abstract

There is an ongoing demand for organizations to become more agile in order to prosper amongst their competitors. Many organizations, including the United States Department of Defense (DoD), have declared a renewed focus towards organizational agility. This research begins by providing a suitable and formal definition of organizational agility (OA) by exploring and analyzing relevant scholarly literature on the subject. Existing methods to measure OA are examined and summarized, and their current limitations are highlighted. Previous studies to find characteristics associated with organizational agility are examined and the Q-sort method was employed to discover, analyze and eliminate redundant items from the data set, ultimately resulting in 64 unique characteristics. Exploratory factor analysis (EFA) was applied to a preliminary study with over 250 respondents representing 13 organizations to establish the structure of a latent construct to measure OA along with the individual characteristics necessary to calculate its factors. A second study, this time representing 40 organizations and with over 1,100 respondents, used confirmatory factor analysis (CFA) to confirm and validate the latent construct, its factors, and the fundamental questions necessary to measure OA. Lastly, the principles of convergent and discriminant validity were applied to test the validity of the OA model. Overall, this research contributes a model to proactively measure OA utilizing a 20-question survey, allowing leaders the insight necessary to improve their organizations and to be prepared to capitalize on innovative opportunities.

Acknowledgments

I would like to express my sincere appreciation to my committee members for their continued patience, guidance, and support; all of which I desperately needed along my journey. I would like to especially thank Dr. Elshaw for steering me to a suitable research methodology and for teaching me throughout the different phases of analysis.

And for Dr. Jacques; your genuine sincerity, care of my well-being and overall progress, re-direction when needed, and weekly status checks are the largest factors that contributed to my success. Thank you.

Jeremy R. Geiger

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AGILITY MEASUREMENT FOR LARGE ORGANIZATIONS

I. Introduction

1.1 Motivation

Over the last decade we have seen smaller, more efficient agile organizations outmaneuver traditionally established institutions. The pace of change has accelerated throughout the information age; an age where information is readily available and transformative technologies can topple legacy designs overnight. Although particularly evident in the business sector, this phenomenon has also gained significant momentum in the defense sector. The President, Department of Defense (DoD) executives, Congress, and our service chiefs have all come to the same conclusion; that a more agile, flexible and technologically advanced fighting force is needed to outmaneuver our adversaries (Modigliani, 2016). Leadership's renewed emphasis on improving agility has been communicated via updated priorities, policy and legislation, including the 2015 Better Buying Power 3.0 initiatives, the FY16-19 National Defense Authorization Acts (NDAAs), and the Secretary of Defense's re-confirmation of DoD priorities in 2019 (Modigliani, 2016; *National Defense Authorization Act for Fiscal Year 2019*, 2019; Shanahan, 2019).

"The relentless pace of change continues to increase complexity and decrease predictability in warfare" (*AF Discusses Game-Changing Technologies During Defense Innovation Hearing*, 2016). Our adversaries have taken note; their efforts to utilize disruptive technologies to create asymmetric opportunities in their favor have been intensified and are capitalizing on the increasing speed of technology change. To re-establish the U.S.'s military lead, the DoD needs to transform into an agile organization

that can rapidly assess the situation, redirect its resources, and provide valuable offensive and defensive solutions with greater speed, efficiency, and effectiveness than our adversaries. To do this, we need to develop an understanding of the characteristics related to, and a method to effectively measure, *organizational agility*.

1.2 Problem Statement

The DoD's pace of fielding technologies is not fast enough to sustain a technological advantage over all possible adversaries. The DoD needs to transform into an agile organization that can rapidly assess the situation, redirect its resources, and provide valuable offensive and defensive solutions with greater speed, efficiency, and effectiveness than our adversaries. To do this, we need to develop an understanding of the characteristics related to, and a method to effectively measure, *organizational agility*.

1.3 Research Objectives

- Identify organizational characteristics that relate to organizational agility.
- Identify any existing methods to measure organizational agility and any limitations they may have.
- Identify and/or develop effective methods to measure each of the organizational characteristics.
- Assess the relationship between each organizational characteristic and organizational agility.
- Develop an effective method to measure organizational agility.
- Work towards validating the organizational agility measurement construct utilizing an existing measurement method.

1.4 Research Questions

Research Question #1: What are the characteristics related to organizational agility?

Research Question #2: What are the current methods, if any, used to measure organizational agility? What are their strengths and weaknesses?

Research Question #3: How can these characteristics be used to estimate organizational agility?

1.5 Assumptions and Limitations

- The agility characteristics provided by Kuruppalil in 2007, Yusuf, Sarhardi & Gunasekaran in 1999 and Lepore and Colombi in 2002 can be combined to create a single, all-encompassing set of agility characteristics.

- Contextual adjustments can be effectively applied to author definitions of key terms when definition components are omitted or vague.

- The initial theoretical construct can be built using reflective indicators.

- Survey respondents are expected to answer each question in regard to the project they are currently (or mostly) assigned to. This will preclude responses to smaller and past projects.

- This research pulled a sample from the population of large U.S. Air Force organizations and its findings may only be directly applicable to that population. Expansion to a larger population is expected to increase measure reliability and domain applicability.

- Existing data of DoD Acquisitions, such as the Selected Acquisition Report (SAR) was sought to validate the developed latent construct. Unfortunately, no existing reports/data containing the schedule, performance, and changes necessary to manually assess organizational agility was found.

- Additional research is required to validate these initial results. Expansion of the sample set, a change to the test population, or a more thorough analysis of a few of the organizations would provide additional evidence to validate the proposed model.

1.6 Document Outline

The remainder of this document is comprised of five additional chapters. Chapter 2 is a detailed literature review of organizational agility and includes a summary of the existing methods used to measure OA and an analysis of characteristics. Chapter 3 represents a paper that was meant to establish and solidify the foundations of OA, which was necessary for the paper that followed. Chapter 4 is a paper that describes the process and methodology used to collect the data, the results of exploratory and confirmatory factor analysis, a latent construct and the seven important, measurable dimensions necessary to develop a measure for OA. Chapter 5 represents a paper where convergent and discriminant validity were explored to provide additional validity for the OA measure. Finally, chapter 6 provides the research conclusion, significance, and recommendations for future work.

II. Literature Review

2.1 Literature Overview

The literature reviewed consists of 94 sources consisting of publications on agility and methods to develop an effective measure. The literature search focused on retrieving relevant publications that were recent and highly relevant to the subject at hand. An online academic database search was initially used to locate and scope the body of relevant work, focusing on terms such as *agility*, *resiliency*, and *flexibility*. Highly cited publications from the core topic area of *agility* were then reviewed for their relevance and to help shape the remaining searches. Using the referenced sources and bibliographies of those publications, the literature search expanded to cover topics closer to the boundaries of the research area. Based on the initial findings, the focus terms were expanded to also include *robustness*, *versatility*, *ambidexterity*, and *adaptability*. Continuous efforts were then made to uncover increasingly more recent publications, trying to follow the academic discovery and advancement in the same chronological manner that it had originally occurred.

From the literature review, it was observed that although increased agility is a stated objective of many organizations, the ability to actually measure *organizational agility* was lacking. Several notable models to measure agility were found, however they were often too narrowly focused for widespread adoption. Further, the research to date has failed to provide a widely accepted definition of *organizational agility*. Resolution of the definition for *agility*, at least to where it can be consistently applied during this research, is a key component of the foundation required to complete this research.

2.2 Defining Relevant Terms

As is the case with many other research fields, it is important to capture and explain the relevant terms, especially terms that do not have a widely accepted definition or where the reader may arrive with preconceived, albeit possibly incorrect, notions. This research dissertation will focus on *organizational agility*, and thus an in-depth review of that term is warranted. In an effort to define related terms that are frequently used in conjunction with, and sometimes errantly in-place-of, *agility*, this document will also explore the related terms of *resiliency*, *flexibility*, *robustness*, *versatility*, *adaptability ambidexterity*, and *rapid* (Ryan et al., 2012). The intent of this section it to provide relevant contextual information on the subject of agility; it is not meant to develop an exhaustive ontological framework.

2.2.1 Organizational Agility

Emerging in the late twentieth century, the term *organizational agility* became a widely discussed and published topic in the fields of business, software development, and manufacturing. By the early twenty-first century, the U.S. Department of Defense also began to direct its attention towards its internal agility (Modigliani, 2016). Although the concept of organizational agility was being developed during the same period and some overlap between industries existed, the concept was largely developed within each specific domain in relative isolation from the other domains. This caused industry unique definitions and confusion amongst individuals when the term is applied.

The construct of *organizational agility* has several distinct definitions across a large number of publications, many offering their own, often tailored, definition. Those that do not directly provide a definition rely on directing the reader to previous publications. This method would be sufficient if there was a shared definition in which the community could

agree upon; unfortunately, a collective definition has remained elusive despite a multitude of attempts by researchers in this field. 24 publications were found that distinctly attempted to define organizational agility. Table 1 provides a snapshot of the leading definitions that have been offered through publications. Through a detailed examination of each offered definition and their respective context, a democratic approach was used to develop a consolidated definition. This approach was also used by Ryan et al. (2012) in their publication on terminology related to flexibility.

Language is the accepted method of human communication that can be understood within a specific community. It is both acceptable and preferred that a democratic approach amongst community members is used to formally define *organizational agility*. If the words being defined were directly linked to physical objects or represented scientific state-of-the-art concepts, then the preferred approach would be to achieve academic consensus by holding a community wide discussion until agreement is reached (Ryan et al., 2012).

We consider unpacking the difference in definitions of organizational agility found in the literature. Many authors blur the line between *capability* and *capacity*, and far too often, mistakenly use them interchangeably. Formally defining *capacity* as an ability that exists at present and *capability* as a higher level that can be achieved in the future, each definition in Table 1 was evaluated to determine their intended context and assessed as to whether they represented a capacity, capability, or both. Of the 24 definitions of organizational agility, 10 were categorized as capacity; 10 as a future capability; and four provided a mix of capacity and capability.

Table 1. Summary of Organizational Agility Definitions

Year	Author(s)	Definition	Capability	Capacity
1995	Goldman, Nagel & Preiss (1995)	Firms ability to cope with rapid, relentless, and uncertain changes and thrive in a competitive environment of continually and unpredictably changing opportunities.	X	X
1995	Gehani (1995)	An agile organization can quickly satisfy customer orders; can introduce new products frequently in a timely manner; and can even get in and out of its strategic alliances speedily.	X	
1996	Cho, Jung, Kim (1996)	Capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and electively to changing markets, driven by customer-designed products and services	X	
1997	Morgan (1997)	Internal operations at a level of fluidity and flexibility that matches the degree of turmoil in external environments.		X
1998	Dyer & Shafer (1998)	Capacity to be infinitely adaptable without having to change…necessary core competence for organizations operating in dynamic external environments…develop a built-in capacity to shift, flex, and adjust either alone or with alliance partners, as circumstances change.	X	X
1998	Kidd (1995)	Unites organizational processes and people with advanced technology to meet customer demands for customized high quality products and services in a relatively short timeframe.		X
1998	Feng and Zhang (1998)	An agile enterprise could swiftly reconfigure operations, processes, and business relationships, thriving in an environment of continuous and unpredictable change.		X
1999	Sharifi and Zhang (1999)	The ability to cope with unexpected changes, to survive unprecedented threats of business environment, and to take advantage of changes as opportunities.		X
1999	Yusuf, Sarhadi, Gunasekaran (1999)	Agility is the successful exploration of competitive bases through the integration of reconfigurable resources and best practices in a knowledge-rich environment to provide customer-driven products and services in a fast changing market environment.		X
2001	Grewal & Tansuhaj (2001)	Organizational ability to manage economic and political risks by promptly responding in a proactive or reactive manner to market threats and opportunities.	X	
2002	Dove (2002)	Providing the potential for an organization to thrive in a continuously changing, unpredictable business environment.	X	
2003	Alberts & Hayes (2003)	The synergistic combination of robustness, resilience, responsiveness, flexibility, innovation, and adaption.	X	X
2006	Van Oosterhout, et al (2006)	The ability to swiftly and easily change businesses and business processes beyond the normal level of flexibility to effectively manage unpredictable external and internal changes.		X
2008	Erande, Verma (2008)	Ability to respond to unpredictable changes with quick response and profitability.	X	
2008	Doz & Kosonen (2007)	Capacity to continuously adjust and adapt strategic direction in a core business to create value for a company.		X
2009	Worley & Lawler (2009)	Dynamic organization design capability that can sense the need for change from both internal and external sources, carry out those changes routinely, and sustain above average performance.	X	X
2011	Tallon, Pinsonneault (2011)	Agility is the persistent, systemic variations in an organizations' outputs, structures or processes that are identified, planned, and executed as a deliberate strategy to gain competitive advantage.		X
2011	Ryan, Jacques & Colombi (2012)	The measure of how quickly a system's capabilities can be modified in response to external change.	X	
2011	Lu and Ramamurthy (2011)	Firm-wide capability to deal with changes that often arise unexpectedly in business environments via rapid and innovative responses that exploit changes as opportunities to grow and prosper.	X	
2014	Weber & Tarba (2014)	The ability to remain flexible in the face of new developments.	X	
2014	Worley, William, Lawler & O'Toole (2014)	The capability to make timely, effective, sustained organizational change…a repeatable organizational resource.	X	
2015	Lee, Sambumurthy, Lim & Wei (2015)	Firm's ability to simultaneously pursue exploration and exploitation in their management of IT resources and practices		X
2016	Teece, Peteraf & Leih (2016)	Capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant		X
2020	Walter (2020)	Organizational Agility is a learned, permanently-available dynamic capability that can be performed to a necessary degree in a quick and efficient fashion, and whenever needed in order to increase business performance in a volatile market environment.	X	

By analyzing the specific words and meaning within these definitions, a breakdown of the important components can be achieved. As shown in Figure 1, the most repeated components of the definition are "rapid response" and "stimuli is external environment." These are followed closely by "customer driven output," "environment of uncertainty," and "opportunistic outcome."

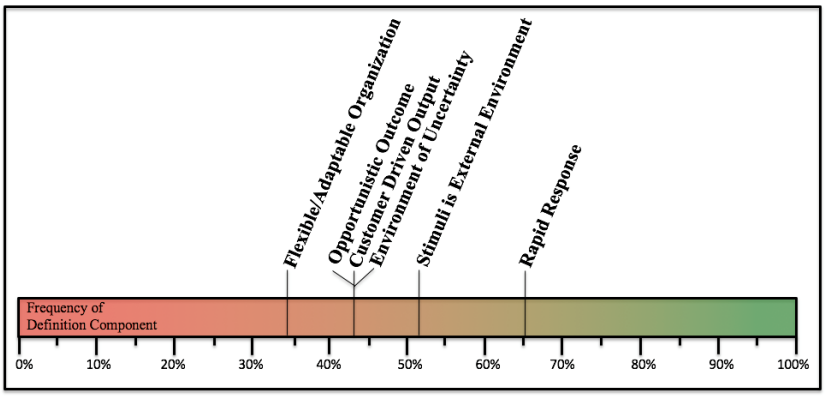


Figure 1. Frequency of Components of Organizational Agility

It is important to note that this method of finding common themes amongst definitions suffers from interpretation errors. Interpretation errors are reduced by evaluating each definition element in the context that it was originally provided and making logical contextual adjustments, when necessary, to apply it to the new context. Omissions by the author are also an important source of interpretation error; each omission may be due to purposeful deletion of that element or due to its lack of importance in that context. For instance, if a few authors describe an item as being externally stimulated and others describe it as internally stimulated, how do you correctly apply a definition that omits that element entirely? Did they purposely omit the element to mean that it is *both* internally and externally stimulated, or did their contextual application not require further delineation, thus meaning *one, the other, or neither*? Despite these inherent errors, the cumulative effect of these two error sources is considered insignificant after making the contextual adjustments (Ryan et al., 2012).

The definition provided by Teece, Peteraf & Leih in their 2016 publication includes each of these key components described in Figure 1. Further, it remains fully applicable when applying organizational agility to research pertaining to the U.S. Department of Defense. Therefore, the following definition will be applied throughout this research.

Organizational Agility: "Capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant" (Teece et al., 2016).

This definition contains a few "loaded" terms, and thus it is prudent to provide additional meaning and explanation for key elements of this definition (Meriam-Webster Dictionary, 2019).

Efficiency: producing desired results with little or no waste (time or materials)

Effectively: producing a decided, decisive, or desired effect.

Value Creating: increase in the worth of goods or services

Value Protecting: maintaining the same worth of goods or services

Higher Yield: increase in production from an investment

Warrant: to serve as or give adequate ground or reason for

2.2.2 Organizational Resiliency

Organizational resiliency is related to organizational agility, and the two terms are often used mistakenly interchangeably for one another. It is also common to see the terms erroneously paired with one another. There are a significant number of publications that discuss personal resiliency, however only eight were found that specifically addressed organizational resiliency**.** Table 2 provides a snapshot of the leading definitions that have been offered through publications.

Table 2. Summary of Organizational Resiliency Definitions

Year	Author(s)	Definition	Recover	Advance
1988	Wildavsky (1988)	The capacity to cope with unanticipated dangers after they have become manifest.	X	
1998	Home III & Orr (1997)	Resilience is a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior.	X	
2002	Bunderson& Sutcliffe (2002)	Capacity to maintain desirable functions and outcomes in the midst of strain.	X	
2003	Riolli&Savicki (2003)	Organizational ability to manage economic and political risks by promptly responding in a proactive or reactive manner to market threats and opportunities.	X	X
2003	Sutccliffe&Vogus (2003)	The ability to absorb, strain, or change with a minimum of disruption.	X	
2006	Gittell, Cameron, Lim & Rivas (2006)	Ability to bounce back from crisis	X	
2007	Vogus& Sutcliffe (2007)	Maintenance of positive adjustment under challenging conditions such that the organization emerges from those conditions strengthened and more resourceful.		X
2011	Lengnick-Hall, Beck &Lengnick-Hall (2011)	Ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organization survival.	X	X

Analyzing the individual definitions into their core pieces, the components of "response to disruption" (vice opportunity), "recovery outcome" (vice advance), and "reactive" (vice proactive) are present in a majority of definitions, as shown in Figure 2.

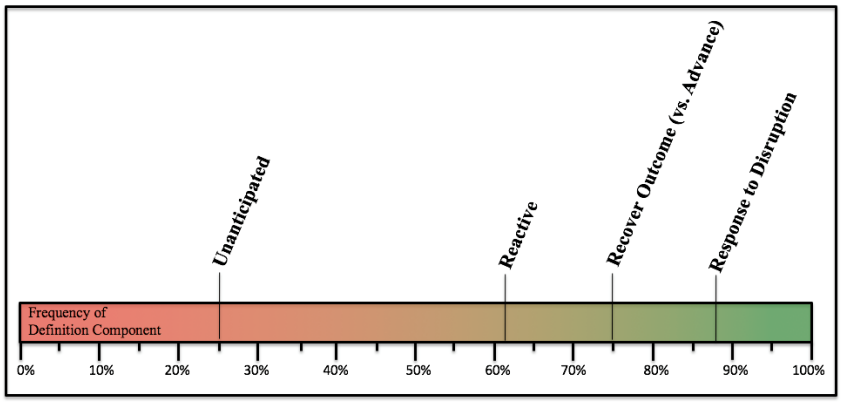


Figure 2. Frequency of Definition Components

The definition provided by Lengnick-Hall, Beck & Lengnick-Hal in their 2011 publication, likely due to its most recent publication and inclusion of the other definitions is the only definition that includes each of these key components. Therefore, the following definition will be applied throughout this research.

> **Organizational Resiliency:** "ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organization survival" (Lengnick-Hall et al., 2011).

2.2.3 Organizational Flexibility

Organizational flexibility is also highly related to organizational agility, as demonstrated in the work by Ryan, et al. in their development of an ontological framework concentrated on flexibility. Although their work specifically focused on system flexibility rather than organizational flexibility, the research is in the same domain (DoD) and is still applicable within this discussion. In their work, the authors reviewed over 200 papers and found 21 relevant definitions for flexibility. Through the breakdown of key elements and application of the democratic method similar to that described in section 2.2.1 of this document, their efforts culminated in an accepted definition. Since these methods are highly aligned with those described in this document, their resultant definition will be applied to this research with a single change. The term *system* used in their definition will be expanded to include the organizations that design, develop, manufacture and operate the specific hardware solution, thus making it applicable to organizations and systems (Ryan et al., 2012).

> **Organizational Flexibility:** the measure of how easily a system's capabilities can be modified in response to external change (Ryan et al., 2012).

2.2.4 Rapid Organization

The definitions of flexibility and agility are quite similar, however the definition of agility includes an element of time, as evident in the *efficiently* component. Time is the obvious choice for further description, however applying it in the proper context is critical. In this context, it becomes apparent that a "short period of time" descriptor is actually required. This is due to the fact that *agility* represents a positive attribute under the conditions of a "short period of time."

This is similar to a specific numeric measurement of temperature. Temperature is "the degree of hotness or coldness measured on a definite scale," yet we consistently only measure *hotness* [22]. Further, *coldness* is simply defined as the opposite, or lack of, *hotness*. Similarly, we will use *rapid* (and/or the lack thereof) to measure time. Further, *rapid* is a common term used in the context of agility and its related descriptors within the DoD.

There is little argument as to how to define *rapid*; all definitions center on meeting a time-based measurement. To calculate the time, there must be well-defined starting and stopping points, however each industry will define these points and the timeframe differently. Industry specific examples are shown in

Table 3.

Table 3. Example Industry Specific Definitions of Rapid

Industry & Application	Starting Point	Ending Point	Defined as Rapid	Normal Timeframe
Auto – New Model Design	Formation of design team	First car manufactured via assemble line	< 24 months	4-5 years
Auto – Fix supporting safety recall	Identification of systemic safety issue	Installation of fix on 90% of affected vehicles	< 12 months	3-4 years
Smart Phone – iOS patch supporting security patch	Identification of security issue	Software fix available for user download	< 24 hours	5-15 days
Aircraft – New Model (non-military)	Approval of customer requirements	Delivery of first aircraft	< 4 years	5-15 years
Aircraft – New Model (military)	Approval of customer requirements	Delivery of aircraft, spares, parts and training to constitute "initial operating capability"	< 2 years	5-15 years

For the use of this research, which is primarily focused on the DoD, *rapid* will be defined using the definition provided by Lepore, et al. in their 2012 report that also focused on the DoD.

> **Rapid:** "delivering a capability as quickly as 2 months and no longer than 24 months" for DoD programs (Lepore et al., 2011). For non-DoD efforts, the time scale may be changed to "less than half the industry standard for similar products/programs."

To use this definition, further description on the measurement period, or start and stop points is required. For this research, we will use the following additional definitions.

Starting Point: approval of customer requirements (for formal acquisition programs) or formal acknowledgement of opportunity/disruption (all other uses)

Stopping Point: declaration of initial operating capability (for formal acquisition programs) or establishment of new product/service/capability (all other uses)

2.2.5 Robustness / Versatility / Adaptability / Ambidexterity

In an effort to provide additional formal definitions for relatable terms, the definitions for robustness, versatility, and changeability are also offered. These terms were selected due to their proximity to agility in the Ryan, et al.., ontology; however, they are deemed as supplemental in nature only (Ryan et al., 2012). Their definition is provided in an attempt to offer clarity in relation to the definition of agility. Their selection as relevant terms should not be misconstrued as the culmination of an exhaustive list of terms, nor should their provided definition be taken as a complete study within their respective fields. Again, relying on the work of Ryan, et al.., the following definitions are provided.

Robustness: the measure of how effectively a system can maintain a given set of capabilities in response to external changes after it has been fielded.

Versatility: the measure of how broadly a system's capability extend in terms of foreseeable and unforeseeable sources of change.

Adaptability: the measure of how effectively a system can modify its own capabilities in response to change after it has been fielded.

During the research, a final, related term was also located. The term organizational ambidexterity was found in several publications, and often used synonymously with OA. To provide additional clarity, the definition provided by Raisch and Birkinshaw (2008) is also used:

> **Ambidexterity**: ability to be aligned and efficient in management of current demands while being adaptive to changes in the environment.

2.2.6 Comparison of Relevant Terms

The formal definitions put forth in the previous sections leave something out; how do the terms relate to one another? *Agility and resiliency* are both organizational characteristics; each describing an organizational response to different stimuli, as visually depicted in Figure 3. Figure 3 also depicts the measure of *response time*, which is the direct measure used to determine whether an organization is *rapid and* is inherently present in the other organizational characteristics.

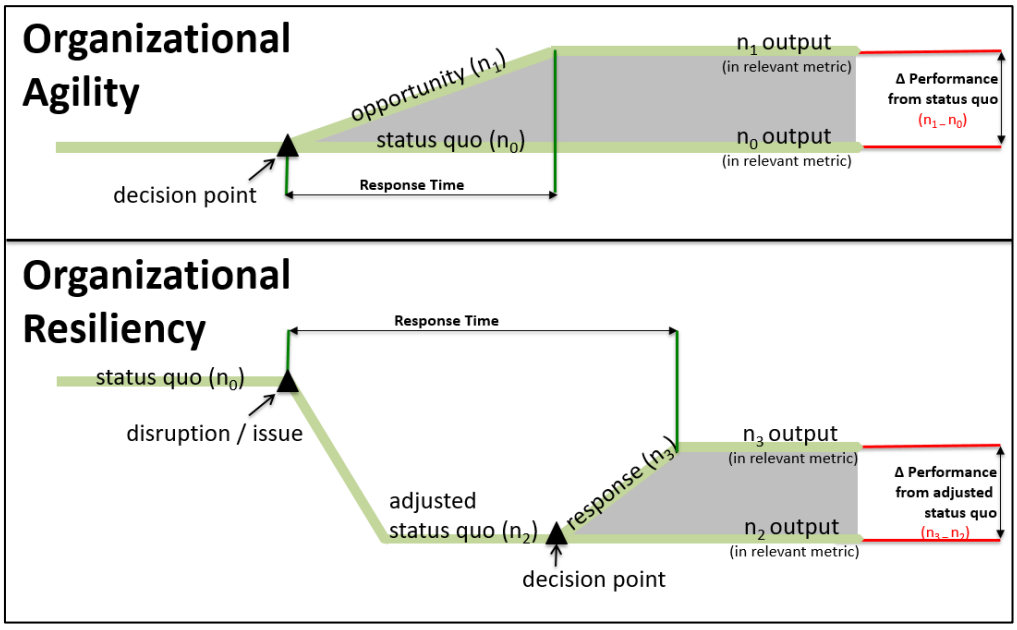


Figure 3. Visualization of Relatable Terms
(adapted from Husdal, 2019)

Agility and resiliency share a majority of the same key components of their definition. They both require responses to stimuli that may be internal or externally produced and result in an increase in output capability, whatever that may be. In manufacturing for instance, that may be the number of units produced, the number of different types of units, the individual unit performance, or even an increase in company profit. In the DoD, this may manifest itself as speed of production, variety of mission scenarios supported, reduction in estimated lives lost, decrease in mission time, increase in trained soldiers, etc. Where the definitions of agility and resiliency differ is the type of stimuli. Resiliency is associated with the occurrence of a risk, which could also be described as a disruption or issue to the status quo, and implies that if the organization does not respond, the output capability will be reduced. Agility is associated with opportunities, where the organization has the opportunity to respond to an event, but failure to do so does not jeopardize the status quo output capability. An organization can possess one, both or neither of these attributes. This is different from individual events, however, as each event will only lead to a single occurrence of agility or resiliency, as determined by the type of event at the decision point, which is either an opportunity or disruption/issue. This is shown in the flowchart in Figure 4.

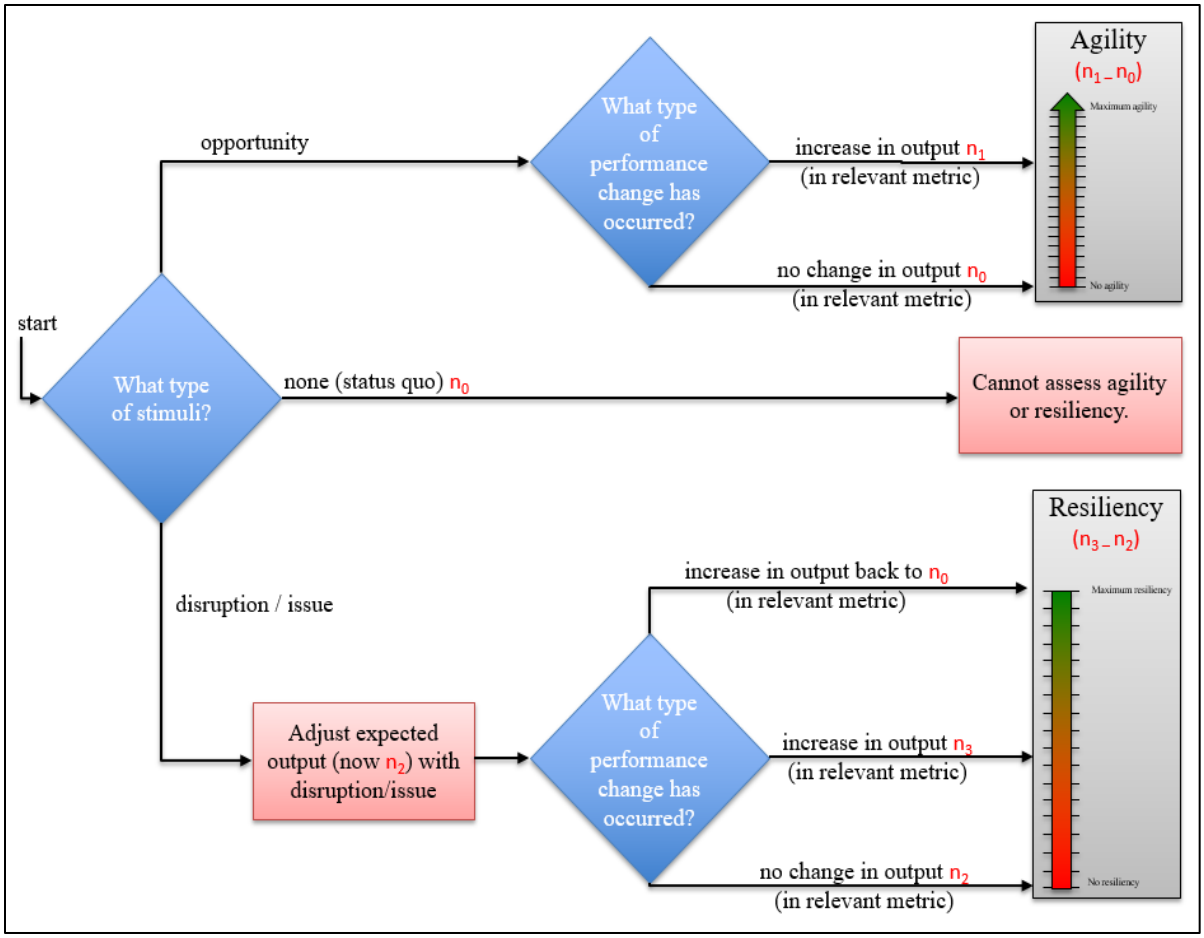


Figure 4. Flowchart of Scenario to Organizational Characteristic

Evaluation of *flexibility* also shows significant definition overlap with *agility* and *resiliency*. Flexibility encompasses the nature of a system (organization) to adapt to change, which is found in both agility and resiliency. Where flexibility differs, however, is that it is determined by the response without a time element. This means that only a single dimension (capability, time or cost) is required to understand flexibility, while *agility* and *resiliency* both require two dimensions (capability & time). Thus, *agility* or *resiliency* are hierarchical in nature to *flexibility*, as shown in Figure 5. Any time an organization displays a*gility* or *resiliency*, it also displays *flexibility*.

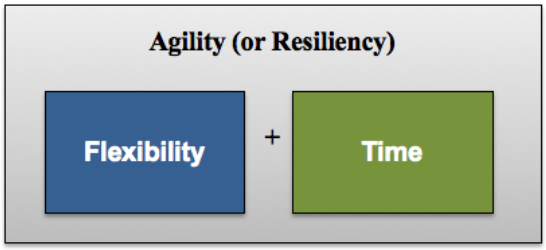


Figure 5. Hierarchical Model of Agility

Application of these terms can be further explained through the series of examples shown in Table 4.

Table 4. Application of Key Terms to Various Examples

	Scenerio	Agility	Resiliency	Flexibility	Rapid	Explanation
1.	An automobile manufacturing company produces 3.0M vehicles on an average year, averaging $5K profit per vehicle ($15B total profit on sales).					
a.	A new plastic is developed that has the equivalent strength of steel, but is lighter, cheaper, and does not oxidize. The company designs new tooling to form the material and new painting techniques and uses the material as a direct replacement of steel body panels. The new plastic will be introduced to the public with the next model line in 4 years.	X		X		This is an example of the company's *Flexibility* and *Agility*. Since the external stimuli was opportunistic in nature, meaning that the company was not forced into making a decision and the company improved their product's capabilities and attributes while improving their profit margin on a given time scale, it was *agile*.
b.	The same tariffs that hit the steel industry have hit the semi-conductor industry. The chips used in the automobiles entertainment system can no longer be sourced. There is no equivalent chip at that price point made locally. The company decides to purchase the next, more powerful chipset. To offset the cost increase of the chip and the R&D required to re-code the software, several additional features were added to the entertainment system. This allowed the company to charge the customer a higher price for the additional features to offset the increase in cost. Customers received the upgraded system starting 12 months after the original chip vendor went bankrupt.		X	X	X	This example highlights the company's *resiliency*. The stimuli was an externally caused disturbance, which caused the company to re-evaluate their offering. They then provided a more capable system to their customer while reserving their profit margin. Since the transition was completed in a short timeframe, it was also done *rapidly*.
2.	Now in its 27th year of development, the F-35 Joint Program Office is 75% complete with its developmental testing, 35% complete with its operational testing, and has just executed its 5th lot buy, adding another 100 aircraft in production to the current flying fleet of 355.					
a.	During developmental testing, it is found that a newly installed ground air traffic control radar interferes with the navigational system of the aircraft. The new control radar was FAA and FCC approved, and is being installed at all major airports over the next 5 years. The F-35 program office swaps the existing navigation antennae with a multi-band antennae with almost the same performance. It will take 24 months of development and testing before the antennae can be installed on any aircraft.		X	X	X	This example highlights the JPO's *resiliency*. The stimuli was an externally caused disturbance, however the JPO was able to develop a solution which provided the nearly the same capability as originally offered. Since the transition was completed in a short timeframe, it was also done *rapidly*.
b.	Using the same scenario as 2.a., but this time the multi-band antennae chosen can also provide a backup communications antennae if the primary one fails. It will take 48 months of development and testing before the antennae can be installed on any aircraft.		X	X		This example highlights the JPO's *resiliency* up to the point that the original capability was regained. Further credit cannot be taken for the additional capability under the title of *resiliency*, rather it was a missed opportunity that was present before under *agility*. Since the transition was completed in a short timeframe, it was also done *rapidly*.
c.	A report by a tire company shows that a new rubber compound has been found that increases the wear time of tires without any measurable decrease in operational performance. The JPO determines that the new tires could provide reduced F-35 maintenance cost and increase its Mean-Time-Between-Failures (MTBF), and key metric it has been struggling with. The tires will be produced within 6 months, and will be phased into the maintenance supply chain as the current tire supply is used.	X		X	X	This example highlights the JPO's *agility*. The stimuli was an externally created opportunity that when exploited, increased the capability of F-35 through a reduction in maintenance down time. Although the tires may not be fitted to the aircraft for several years due to the existing, usable tire stockpile, this is an example of *rapid* since the tires became available to the user in a short timeframe.

2.3 Organizational Agility Framework

Now that we have a working top-level definition of organizational agility, further analysis and breakdown can be accomplished. According to Teece, Peteraf and Leih in their 2016 paper, the framework to organizational agility is through a three-step process consisting of *sensing*, *seizing* and *transforming*, as shown in Figure 6 (Weber & Tarba, 2014; Teece et al. 2007).

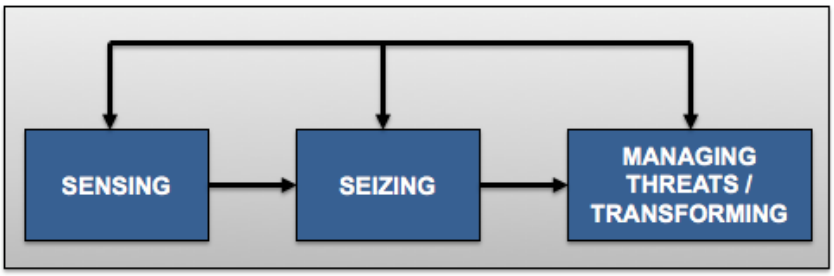


Figure 6. Foundations of Agile Organizations (Teece et al., 2007)

2.3.1 Sensing

Sensing is the identification of technological opportunities and is critical if an organization is to ever attempt to capitalize on them. "Generative-sensing capabilities involve undertaking actions to proactively create hypotheses about the future implications of observed events and trends and testing these hypotheses to grease the pathways for new products, services, and business models" (Teece et al., 2016). Scenario planning and what-if analysis (aka development planning within the DoD) are typical sensing techniques. Sensing is more than predicting future customer desires; it also includes the synthesis of different ideas, processes and technologies to form new products that provide value to the consumer. Existing organizations tend to focus on existing ideas and processes, whereas new entrants are often more poised to develop new combinations and technological innovation (Cohen & Levinthal, 1990; Henderson & Clark, 1990). Within each of those organizations, middle-level management is the most acute at splicing together different

ideas and technologies and executive level management is better poised to understand the changing customer desires (Kendall, 2017).

2.3.2 Seizing

Seizing is the implementation of new systems, processes or services. It is the first step that requires the sizable expenditure of resources, as investments in development are often required (Teece, 2007). The total amount of uncertainty has been reduced, with a portion being converted into quantifiable risk. An organization must be poised to seize opportunity, as "addressing opportunities involves maintaining and improving technological competences and complementary assets and then, when the opportunity is ripe, investing heavily in the particular technologies and designs most likely to…acceptance" (Teece, 2007). In the business world, this often involves having a stockpile of cash reserves, equipment and/or expertise, while this manifests in the DoD as trained personnel, stockpile of equipment, allies, the budgeting processes, and a decision process that evaluates and welcomes opportunities.

2.3.3 Transforming (aka Pivoting)

Transforming is the restructuring of an organization to capitalize on a new technology. The newest methodology to do this is through a practice known as "build-measure-learn" where a minimum viable product is produced, allowing the company to release it, learn from their successes and mistakes, and quickly improve the product (Teece, et al., 2016). Similarly, the DoD has recently created an acquisitions model with similar characteristics known as *rapid prototyping*. This, when paired with creating small "startup" units within the organization to manage the new technology, allow an organization a reduction in risk when developing a new technology while remaining poised

to capitalize on those that succeed. Each transformation has a cost that must be overcome each time an organization attempts to take advantage of an opportunity. This transformation cost represents the non-value added effort required for the organization to transition from one to state to another. For organizations with a high transformation cost, this can be seen as an agility inhibitor.

2.4 Existing Methods to Measure Agility

Despite the need for organizations to become agile, the simple act of measuring agility has remained elusive. The difficulty arises when trying to create a measure that is both general enough to apply to multiple industries, yet specific enough to capture the important essence of each particular industry (Erande & Verma, 2008). To address this, most measures of agility to date are domain specific. Further, *agility* joins other important metrics such as morale, happiness, satisfaction, justice, and quality, in that it is not directly measurable. A latent construct, which is where a variable is inferred through a model from other variables that are more readily observed, is required.

To date, there have been several attempts at measuring agility. A summary of these methods follows.

2.4.1 The Two-Dimensional Dichotomy

Within the research that attempts to measure agility, a significant majority rely on some form of a two-dimensional construct. This frequently manifests itself in the form of *magnitude of variety/change* and the *response time/rate* (Singh et al., 2018). These variables exist with a degree of dichotomy; the actions required by an organization to increase the *magnitude of variety* of services or products is often contradictory to a firm's ability to increase efficiency and reduce their *response time* (March, 1991).

The *magnitude of variety/change* attempts to capture an organizations current capability of interest, and to quantify their change in that domain. For instance, for a smart phone manufacturer, it may be increased production, greater features on a device, a greater variety of devices produced, or a new method to reduce the cost to produce each item (March, 1991). *The response time/rate* variable is meant to capture the temporality of the change in a suitable unit of time, such as days, months, per year or per cycle. Both dimensions are applicable across multiple industries, however they must be calibrated for their respective industry, such as those described in

Table 3. Despite general consensus on the use of this theoretical construct, the literature indicated a variety of techniques to further relate agility to these two dimensions.

In an attempt to arrive at a single measure for agility, and under the assumption that *magnitude of variety* and *response time* are unrelated, Grewal & Tansuhaj (2001) combined both terms through simple addition. Although this method is easy to apply, it lacks acceptance due to its reliance on an unsupported assumption.

Using *magnitude of variety* and *response rate*, multiple authors developed first-order models to calculate agility (Adler et al., 2008; Bahrami, 2012). This alleviated the unsupported assumptions required in the Grewal & Tansuhaj model, however the first order models lacked support and applicability across different industries (domains).

In their paper, Singh et al. (2018), present a representative graph of both variables and introduce "agility curves," as shown in Figure 7. The agility curves, such as the one labeled M2, have significant meaning; two points on the graph can result in the same agility rating, and that there is an inherent tradeoff between the *magnitude of variety change* and *rate of variety change*. Both of these notions are aligned with the argument of dichotomy between the dimensions. As represented in the graph by the line labeled M3, each successive agility curve away from the origin represent a higher degree of agility. The

lines marked as M1 represent an increase in agility based on increasing either variable while holding the other one constant (Singh et al., 2018).

This model is supported within the academic community, however it lacks a simple, repeatable method to measure the *magnitude of variety* and *response rate* and the scale can be difficult to determine, and is thus limited in its actual implementation.

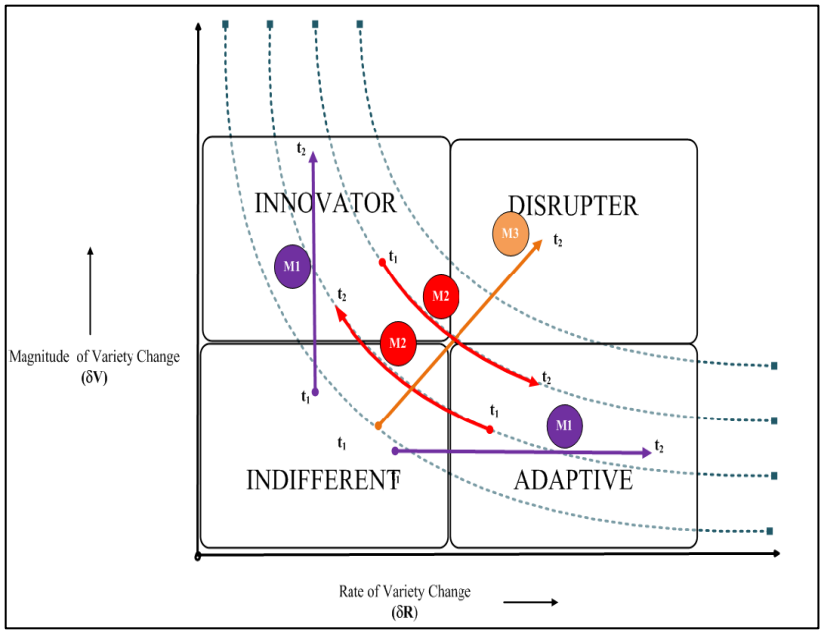


Figure 7. Two-dimensional Framework for Organizational Agility (Singh et al., 2018)

2.4.2 The Comprehensive Agility Measurement Tool (CAMT)

Developed at Old Dominion University by Erande and Verma (2008), the Comprehensive Agility Measurement Tool (CAMT) proved industry agnostic. The tool relies on ten "agility enablers" to measure agility on a scale of 1 to 5 and an analytical hierarchy process (AHP) to ensure that it can be effectively applied to a multitude of industries. Starting from the set of 41 agility enablers found by Kuruppalil (1998), the survey administrator selects the ten most relevant factors for the given domain and assesses

them utilizing a 5-point Likert scale. After applying a weighted average to each of the ten areas, a weighted agility measure is obtained (Erande & Verma, 2008; Kuruppalil, 1998).

Although CAMT uses a mathematical model, it is highly subjective due to administrator's selection of the ten relevant factors, and the weights applied to each agility enabler. The subjectivity required within CAMT has inhibited its overall support and application.

2.4.3 Key Agility Index

Lomas et al. (2006) propose a method to measure design process agility by assessing the product development process and making the case that each product process provided a narrow glimpse of the overall organization's agility. They developed the Key Agility Index, which is the ratio of "Time taken to complete Change Related Tasks and Time taken to complete the whole project." This method has high internal validity within a domain, but the authors warn against comparison between different market sectors. Further, this model fails to take into account other factors, such as an effective systems engineering plan. For instance, a product with a poor quality systems engineering plan will likely require a greater number of changes and greater overall variability in the time required to complete change related tasks" (Lomas et al., 2006).

2.4.4 Other Models

There are several additional models to measure agility, but they don't warrant full descriptions in this review due to their limited applicability to the DoD.

- Arteta and Giachetti offer that organizations should be assessed based solely on their complexity. They contend that agility is inversely proportional to complexity (Arteta & Giachetti, 2004).
- Yauch proposed a survey based framework that utilizes the measures of success and turbulence to calculate agility (Yauch, 2005).

- Ramasesh, et al. developed a quantitative method to assess the value of a firms' agility based on common financial terms. In particular, they used the firm's Net Present Value (NPV) as the direct calculation on their agility (Ramasesh et al., 2001).

- Tsourveloudis, et al. incorporated fuzzy logic to determine an organization's overall agility by first assessing sub scores of the production, market, people and information infrastructures (Tsourveloudis et al., 1999).

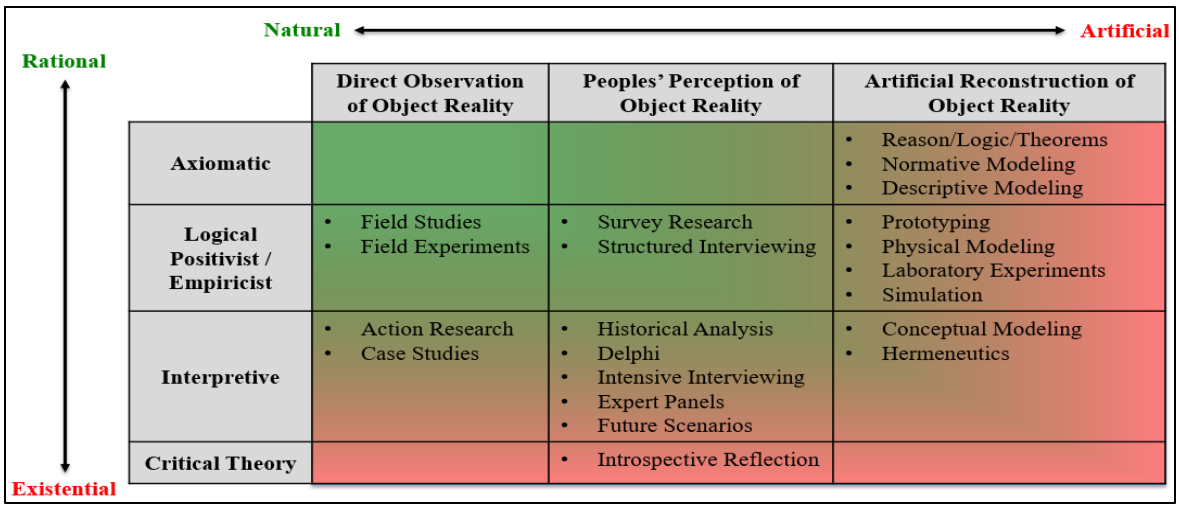
2.5 Research Methods to Develop Measures

Measures of success are present in nearly all aspects of life. Their contribution to individual and organization performance is undeniable and their mere existence often causes changes in behavior. More specifically, measures of success provide a means to quantify performance and in turn contribute to the development of effective incentive structures. When accurately and effectively measured, they can be used to steer performance to achieve higher level objectives, ultimately changing behaviors. Unfortunately, most fields outside of the financial sector struggle to obtain suitable measures that are valid and reliable (Skyrme, 1998). Latent constructs are developed when a variable of interest cannot be observed or measured directly, and thus measurement is achieved via a theoretical relationship between that variable of interest and other, more directly, measurable indicators, known as *factors*. Development of the theoretical relationship underlying *organizational agility* is the focus of this research.

In their work on research methods, Meredith et al. (1989), provided a framework for a variety of research methods, as shown in Figure 8. This framework relates each research method through two continuums; rational/existential (R/E) and natural/artificial (N/A).

The N/A continuum reflects the source of information by assessing the human influence on a scale ranging from objective (natural) to subjective (artificial). The R/E continuum is a relative measure of the amount of deductive (rational) and/or inductive

(existential) skillset that is used by the researcher (Dunn et al., 1994). Although each of the research methods found in Figure 8 are valid and acceptable, researchers tend to strive towards the Rational and Natural ends of their respective continuums, which is where the scientific process is rooted, whenever possible.



	Direct Observation of Object Reality	Peoples' Perception of Object Reality	Artificial Reconstruction of Object Reality
Axiomatic			• Reason/Logic/Theorems • Normative Modeling • Descriptive Modeling
Logical Positivist / Empiricist	• Field Studies • Field Experiments	• Survey Research • Structured Interviewing	• Prototyping • Physical Modeling • Laboratory Experiments • Simulation
Interpretive	• Action Research • Case Studies	• Historical Analysis • Delphi • Intensive Interviewing • Expert Panels • Future Scenarios	• Conceptual Modeling • Hermeneutics
Critical Theory		• Introspective Reflection	

Figure 8. Framework for Research Methods (Meredith et al., 1989)

2.5.1 Case Study

Case study research is designed to "focus on understanding the dynamics present within single settings," and is often used when focusing on a single phenomenon or particular aspect (Eisenhardt, 1989). It is particularly useful when trying to discover fundamental characteristics and their respective relationships, or when shaping of an initial hypothesis is necessary. Case studies are often utilized in the early phases of a specific region of research and are qualitative in nature.

Through their work and respective publications, Glaser and Strauss (1967), Strauss (1987), Yin (1984) and Eisenhardt (1989) have developed a robust approach to conduct case study research. Their work has been cited tens-of-thousands of times and is used by researchers throughout academia with great success. In regard to developing new

measures, their methods are well suited to uncover the complete set of factors and their relationships at the onset of initial system characterization, as case studies do not require any preconceived notions, hypothesis, or theories.

A common method to collect case study data is through the interview process. An interview is a qualitative research method that utilizes a series of questions during a conversation to collect data. Due to the personal nature of interviews, most interview research relies on a small number of respondents for data collection. Structured interviews were used by Lepore et al. (2012), in their study of *rapid* within 31 different organizations, and through their use of grounded theory, a complete set of factors relating to rapid (within the DoD) was developed. Given the state of knowledge in the area of *rapid* at the onset of their study, interviewing was the most appropriate research method.

2.5.2 Survey Research

Survey research consists of a predefined series of questions that is given to a subset of the population under study. Through the examination of internal and external validity, the survey sample is expected to reflect the greater population from which is was conducted. It is widely accepted throughout the business, psychology, and logistic communities, and is often desirable for researchers due to its ease of use, larger sample size, and (often) quantitative outcomes.

Researchers have consistently applied survey research in developing measures of latent constructs. In his work, Colquitt (2001) first published a method to utilize survey research to develop a latent construct, and then successfully applied it to develop a latent construct for *organizational justice*. Ko and Stewart (2002) and Bernstein et al. (2003) applied similar methods to develop constructs to measure *resident attitudes* and *childhood trauma*, respectively. In each of these cases, the researchers utilized pre-existing research

to focus and develop the surveys, and then used survey data and subsequent factor analysis to refine the measure.

2.5.3 Selecting a Research Method for Agility Measurement

While trying to determine an appropriate method to develop a measure for agility, each of the methods shown in Figure 8 were evaluated against the backdrop of the current state of the related literature. The Delphi study completed by Kuruppalil (1998), detailed literature review completed by Yusuf et al. (1999), and the structured interviews conducted by Lepore et al. (2012) resulted in three sets of factors related to agility. Utilizing these findings and comparing their results, it is expected that a single set of factors can be created. Further research can then be completed using the single set of factors, allowing advancement towards a more deductive method create a measure. Given the state of research on *agility*, survey research is the next logical step.

2.5.4 Reflective vs Formative Indicators

There are two perspectives that are used when developing a theoretical latent construct; *reflective* and *formative*. The vast majority of latent constructs rely on a *reflective* indicator perspective, which is defined as "indicators are seen as functions of the latent variable, whereby changes in the latent variable are reflected in changes in the observable indicators." Indicators are *formative* when changes to the value of a latent variable are determined by changes to the indicators (casual). Although researchers are expected to choose the most suitable perspective to develop the initial theoretical construct, the effect of selecting the incorrect perspective is minimal during the initial pool selection (characteristic refinement) phase. The minimal effect nature of proper selection does not apply during the data analysis phases, however. Each of the perspectives rely on different

data reduction and correlation techniques and will result in different outcomes. Fortunately, most data sets can be collected in a manner that will lend itself to both sets of data analysis techniques, allowing for a shift in research mid-way if necessary (Diamantopoulos & Siguaw, 2006). For the purposes of this research on agility, the theoretical construct will rely on an initial assumption of a reflective indicators.

2.6 Characteristics Related to Agility

Many researchers have attempted to capture the important characteristics of organizational agility. By reviewing and collecting these "sets" of characteristics, one can create a more complete, single set, of characteristics. The goal would be to err on the side of first collecting all prospective characteristics that could be used to measure agility, and then to systematically remove duplicates and non-relevant items. Since agility is highly related to the terms such as flexibility, rapid, resiliency, and robustness, any characteristic used in their descriptions were also collected.

Utilizing a 3-round Delphi study designed to develop the framework for a survey questionnaire on leanness and agility, Kuruppalil (1998) identified the top 45 agility indicators for job shops from 14 different domains. Yusuf et al. (2002), studied manufacturing agility, and found 32 key attributes comprised within 10 different domains, which was later reduced to seven a few years later. Research conducted by Lepore et al. (2012) that focused on military rapid development projects found 43 unique attributes by utilizing in-person interviews. Table 5 provides a summary of agility characteristics offered by these publications.

Table 5. Initial List of Characteristics Related to Agility

	Kuruppalil (1998)	
Manufacturing	Adaptive evaluation and reward metric	Knowledge management
	Capability to quickly adjust bus. & man. strategies	Knowledge of competitors
	Capability to quickly adjust orgl characteristics/design	Mass customization
	Concurrent engineering	Multi skilled people
	Concurrent technology	Organization flexibility
	Continuous improvement	Proactive customer relationships
	Customer and supplier integration	Proactively exploration of new opportunities
	Decentralized organization	Product model flexibility capability
	Developing unique capabilities & characteristics	Product volume flexibility capability
	Development of effective responses to new challenges	Pull production
	Effective sensing of changes in the business environment	Quality over product life
	Electronic commerce	Quick response to changing regulation/legislation
	Employee satisfaction	Rapid adjustment of people capabilities (skills & knowledge)
	Empowering workforce with knowledge	Rapid adoption of new methods, techniques, tech & processes
	Encouraging innovation	Rapid delivery
	Enhancing skill and knowledge by training	Rapid partnership
	External integration of information	Rapid prototyping
	Fast product development cycle	Reconfigurable production/process technology
	Faster manufacturing times	Reconfigurable supply chain and business partnership
	Flexible production technology	Responsiveness to market change
	Internal integration of information	Team based leadership
	Investing in innovation	Virtual enterprising
	Investment in appropriate technology	

	Yusuf, Sarhardi, Gunasekaran (1999)	
Manufacturing Job Shops	Concurrent execution of activities	Short development cycle times
	Enterprise integration	Continuous improvement
	Information accessible to employees	Culture of change
	Multi-venturing capabilities	Rapid partnership formation
	Developed business practice difficult to copy	Strategic relationship with customers
	Empowered individuals working in teams	Close relationship with suppliers
	Cross functional teams	Trust-based relationship with customers/suppliers
	Teams across company borders	New product introduction
	Decentralised decision making	Customer-driven innovations
	Technology awareness	Customer satisfaction
	Leadership in the use of current technology	Response to changing market requirements
	Skill and knowledge enhancing technologies	Learning organization
	Flexible production technology	Multi-skilled and #exible people
	Quality over product life	Workforce skill upgrade
	Products with substantial value-addition	Continuous training and development
	First-time right design	Employee satisfaction

	Lepore & Colombi (2012)	
DoD "Rapid" Acquisitions	Build and Maintain Trust	Right-size the Program - Eliminate Major Program Oversight
	Designing out All Risk Takes Forever…Accept Some Risk	Strive for a Defined Set of Stable Rqmts Focused on Warfighter
	Incremental Deployment is Part of the Product Plan	The Government Team Leads the Way
	Keep an Eye on "Normalization"	Use Mature Technology – Focus on the State of the Possible
	Maintain High Levels of Motivation and Expectations	Work to Exploit Maximum Flexibility Allowed
	Populate Your Team with Specific Skills and Experience	

2.6 Summary

During the literature review, it was evident that a consistent, well accepted definition for organizational agility was missing. A detailed review of publications that offered definitions was completed and a suitable definition was found and supported. Additionally, characteristics related to organizational agility were discovered and aggregated from multiple publications, allowing for the eventual development of a focused survey. To further establish these findings, and ultimately build a foundation that be used to advance this field of study, a paper was drafted detailing these result. The following chapter is a re-creation of that paper.

III. Establishing the Foundations to Measure Organizational Agility Across the DoD

3.1 Chapter Overview

During the literature review of this research, it became evident that a consistent set of terminology in this area was missing. In particular, there were over a dozen definitions and several different terms being used interchangeably. To establish a solid foundation to support this research, a detailed paper was drafted to describe the background of organizational agility, provide a defendable definition, and to define related terms. This paper was extended to describe the process of collecting related characteristics and reducing redundant items. Some tables and figures that have already been presented in this dissertation will be repeated and renumbered; this is to ensure that the paper remains intact and could stand as a single product. The full text of this manuscript (excluding bibliography) begins on the following page. The paper has been submitted for publication in the Defense Acquisition Review Journal.

3.2 Abstract

There is an ongoing demand for organizations to become more agile in order to prosper amongst their competitors. Many organizations, including the United States Department of Defense (DoD), have declared a renewed focus towards organizational agility. This article begins by providing a suitable and formal definition of organizational agility by exploring and analyzing relevant scholarly literature on the subject. Related terms, such as organizational resiliency, flexibility, robustness, versatility, and adaptability are also explored to examine their definition boundaries and any overlapping areas. Existing methods to measure organizational agility are examined and summarized, and the current limitations to their application are highlighted. Previous studies to find characteristics associated with organizational agility were also examined, and an initial set of 88 organizational agility characteristics was built. Since these included possible redundant or overlapping characteristics, the Q-sort method was employed to discover, analyze and eliminate redundant items from the data set, ultimately resulting in 64 unique characteristics. The result is a suitable definition for Organization Agility and a list of potential associated characteristics grounded that summarize related research to date. This groundwork establishes the foundation to conduct a 50 organization study across the DoD to further refine the characteristic list and ultimately develop a method to measure organizational agility.

Keywords: flexibility, measure development, Q-sort, metrics

3.3 Introduction

Over the last decade we have seen smaller, more efficient agile organizations outmaneuver traditionally established institutions. The pace of change has accelerated throughout the information age; an age where information is readily available and transformative technologies can topple legacy designs overnight. Although particularly evident in the business sector, this phenomenon has also gained significant momentum in the defense sector. The President, Department of Defense (DoD) executives, Congress, and our service chiefs have all come to the same conclusion; that a more agile, flexible and technologically advanced fighting force is needed to outmaneuver our adversaries (Modigliani, 2016). Leadership's renewed emphasis on improving agility has been communicated via updated priorities, policy and legislation; including, the 2015 Better Buying Power 3.0 initiatives, the FY16-19 National Defense Authorization Acts (NDAAs), and the Secretary of Defense's re-confirmation of DoD priorities in 2019 (Modigliani, 2016; *National Defense Authorization Act for Fiscal Year 2019*, 2019; Shanahan, 2019).

Nation-state militaries spend a significant amount of financial resources and are expected to succeed against their opponent, yet often times they do not directly engage with their opponents for decades at a time. What happens in a sector where innovation and agility are both vitally important, but a timely and consistent feedback mechanism to measure one's progress is virtually non-existent? Although the true test of a military is during a turbulent period of engagement with an opponent, interim methods must be developed to measure each critical organizational trait.

The goal of this manuscript is to isolate the variables needed to measure Organizational Agility (OA) in large organizations, allowing for the future development of a suitable method to measure OA without the need to interact with outside organizations. It is broken into three sections: defining related terms, summarizing existing agility measurement methods, and the development of a set of factors to create a latent construct.

3.4 Defining Related Terms

3.4.1 Literature Review Summary

A literature review, consisting of publications on agility and measurement development, was completed to determine if a common definition exists. An online academic database search was initially used to locate and scope the body of relevant work, focusing on terms such as *agility*, *resiliency*, and *flexibility*. Highly cited publications from the core topic area of *agility* were then reviewed for their relevance and to help shape the remaining searches. Using the referenced sources and bibliographies of those publications, the literature search expanded to cover topics closer to the boundaries of the research area. Based on the initial findings, the focus terms were expanded to also include *robustness*, *versatility*, *ambidexterity*, and *adaptability*. Continuous efforts were then made to uncover increasingly more recent publications, trying to follow the academic discovery and advancement in the same chronological manner that it had originally occurred.

It is important to capture and explain the relevant terms, especially terms that do not have a widely accepted definition or where the reader may arrive with preconceived, albeit possibly incorrect, notions. This paper focuses on *organizational agility*, and thus an in-depth review of that term is warranted. This document will also explore several related

terms that were uncovered during the review (*resiliency*, *flexibility*, *robustness*, *versatility*, *adaptability* & *rapidness)* in an effort to define related terms that are frequently used in conjunction with, and sometimes errantly in-place-of, *agility* (Ryan et al.., 2012). The focus of this section is to provide relevant contextual information on the subject of agility; it is not meant to be an exhaustive ontological framework or to fully define the related terms.

3.4.2 Defining Organizational Agility

The term *organizational agility* became a widely discussed and published topic in the fields of business, software development, and manufacturing starting in the late twentieth century. Although the concept of organizational agility was being developed during the same period and some overlap between industries exist, the concept was largely developed within each specific domain in relative isolation from the other domains. This caused industry unique definitions and confusion amongst individuals when the term was applied.

The construct of *organizational agility* has several distinct definitions across a large number of publications, many offering their own, often tailored, definition. Of those reviewed, 24 publications were found that distinctly attempted to define organizational agility. Table 6 provides a snapshot of the leading definitions that have been published. The goal was to promote or create a definition that encompassed the necessary aspects of the versions already published. This method mirrored the approach previously used by Ryan et al. (2012) in their publication on terminology related to *flexibility*. This method is appropriate because it follows the true meaning of what language is; the *majority* accepted method of communication.

Table 6. Summary of Organizational Agility Definitions

Year	Author(s)	Definition	Capability	Capacity
1995	Goldman, Nagel & Preiss (1995)	Firms ability to cope with rapid, relentless, and uncertain changes and thrive in a competitive environment of continually and unpredictably changing opportunities.	X	X
1995	Gehani (1995)	An agile organization can quickly satisfy customer orders; can introduce new products frequently in a timely manner; and can even get in and out of its strategic alliances speedily.	X	
1996	Cho, Jung, Kim (1996)	Capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and electively to changing markets, driven by customer-designed products and services	X	
1997	Morgan (1997)	Internal operations at a level of fluidity and flexibility that matches the degree of turmoil in external environments.		X
1998	Dyer & Shafer (1998)	Capacity to be infinitely adaptable without having to change…necessary core competence for organizations operating in dynamic external environments…develop a built-in capacity to shift, flex, and adjust either alone or with alliance partners, as circumstances change.	X	X
1998	Kidd (1995)	Unites organizational processes and people with advanced technology to meet customer demands for customized high quality products and services in a relatively short timeframe.		X
1998	Feng and Zhang (1998)	An agile enterprise could swiftly reconfigure operations, processes, and business relationships, thriving in an environment of continuous and unpredictable change.		X
1999	Sharifi and Zhang (1999)	The ability to cope with unexpected changes, to survive unprecedented threats of business environment, and to take advantage of changes as opportunities.		X
1999	Yusuf, Sarhadi, Gunasekaran (1999)	Agility is the successful exploration of competitive bases through the integration of reconfigurable resources and best practices in a knowledge-rich environment to provide customer-driven products and services in a fast changing market environment.		X
2001	Grewal & Tansuhaj (2001)	Organizational ability to manage economic and political risks by promptly responding in a proactive or reactive manner to market threats and opportunities.	X	
2002	Dove (2002)	Providing the potential for an organization to thrive in a continuously changing, unpredictable business environment.	X	
2003	Alberts & Hayes (2003)	The synergistic combination of robustness, resilience, responsiveness, flexibility, innovation, and adaption.	X	X
2006	Van Oosterhout, et al (2006)	The ability to swiftly and easily change businesses and business processes beyond the normal level of flexibility to effectively manage unpredictable external and internal changes.		X
2008	Erande, Verma (2008)	Ability to respond to unpredictable changes with quick response and profitability.	X	
2008	Doz & Kosonen (2007)	Capacity to continuously adjust and adapt strategic direction in a core business to create value for a company.		X
2009	Worley & Lawler (2009)	Dynamic organization design capability that can sense the need for change from both internal and external sources, carry out those changes routinely, and sustain above average performance.	X	X
2011	Tallon, Pinsonneault (2011)	Agility is the persistent, systemic variations in an organizations' outputs, structures or processes that are identified, planned, and executed as a deliberate strategy to gain competitive advantage.		X
2011	Ryan, Jacques & Colombi (2012)	The measure of how quickly a system's capabilities can be modified in response to external change.	X	
2011	Lu and Ramamurthy (2011)	Firm-wide capability to deal with changes that often arise unexpectedly in business environments via rapid and innovative responses that exploit changes as opportunities to grow and prosper.	X	
2014	Weber & Tarba (2014)	The ability to remain flexible in the face of new developments.	X	
2014	Worley, William, Lawler & O'Toole (2014)	The capability to make timely, effective, sustained organizational change…a repeatable organizational resource.	X	
2015	Lee, Sambumurthy, Lim & Wei (2015)	Firm's ability to simultaneously pursue exploration and exploitation in their management of IT resources and practices		X
2016	Teece, Peteraf & Leih (2016)	Capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant		X
2020	Walter (2020)	Organizational Agility is a learned, permanently-available dynamic capability that can be performed to a necessary degree in a quick and efficient fashion, and whenever needed in order to increase business performance in a volatile market environment.	X	

It was found that many authors blur the line between *capability* and *capacity*, and far too often, mistakenly use them interchangeably. *Capacity* is an ability that exists at present and *capability* represents a higher level ability that can be achieved in the future. Each definition in Table 6 was evaluated to determine the intended context and assessed whether it represented a capacity, capability, or both. Of the 24 definitions of

organizational agility, 10 were categorized as capacity; 10 as a future capability; and four provided a mix of capacity and capability. A breakdown of the important components was achieved by analyzing the specific words and meaning within these definitions. As shown in Figure 9, the most repeated components of the definition are "rapid response" and "stimuli is external environment." These are followed closely by "customer driven output," "environment of uncertainty," and "opportunistic outcome."

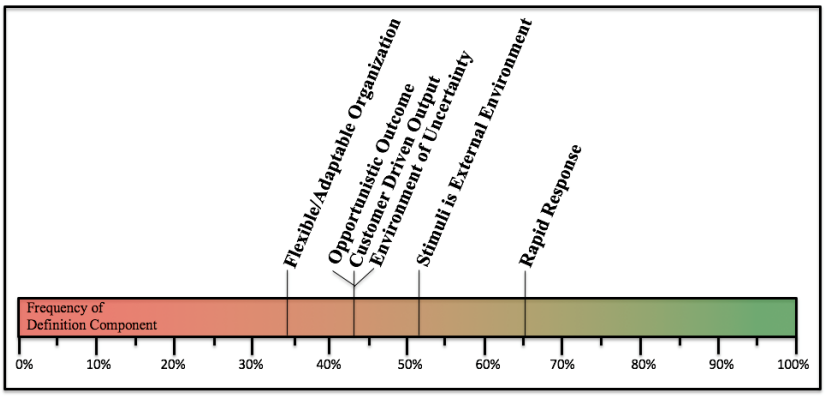


Figure 9. Frequency of Definition Components of Organizational Agility

It is important to note that this method of finding common themes amongst definitions suffers from interpretation errors. Interpretation errors are reduced by evaluating each definition element in the context that it was originally provided and making logical contextual adjustments, when necessary, to apply it to the new context. Omissions by the author are also an important source of interpretation error; each omission may be due to purposeful deletion of that element due to its lack of importance in that context. For instance, if an author describes an item as being externally stimulated and others describe it as internally stimulated, further contextual analysis is required for any version that omits internal/external completely. It may be found that an author purposely omitted the element

to mean that it is *both* internally and externally stimulated or that their contextual application does not require further delineation, thus meaning *one, the other, or neither*. Despite these inherent errors, the cumulative effect of these two error sources is considered insignificant after making the contextual adjustments (Ryan et al., 2012).

The definition provided by Teece et al. (2016) includes each of the key components described in Figure 9. Therefore, the following definition will be applied throughout this paper.

> **Organizational Agility:** "Capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant" (Teece et al., 2016).

This definition contains a few "loaded" terms, and thus, it is prudent to provide additional meaning and explanation for key elements of this definition (Meriam-Webster Dict., n.d).

> ***Efficiently:*** in a manner that produces desired results with little or no waste
>
> ***Effectively:*** producing a decided, decisive, or desired effect.
>
> ***Value Creating:*** increase in the worth of goods or services
>
> ***Value Protecting***: maintaining the same worth of goods or services
>
> ***Higher Yield***: increase in production from an investment
>
> ***Warrant:*** to serve as or give adequate ground or reason for

3.4.3 Related Terms

When examining organizational agility, several related terms consistently appear. It is important to determine the degree of commonality, overlap, and uniqueness of these terms. *Organizational resiliency* is related to organizational agility, and the two terms are often used interchangeably for one another. There are a significant number of publications that address personal resiliency, however only eight were found that specifically addressed organizational resiliency. Table 7 provides a snapshot of the leading definitions that have been cited in the literature.

Table 7. Summary of Organizational Resiliency Definitions

Year	Author(s)	Definition	Recover	Advance
1988	Wildavsky (1988)	The capacity to cope with unanticipated dangers after they have become manifest.	X	
1998	Home III & Orr (1997)	Resilience is a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior.	X	
2002	Bunderson& Sutcliffe (2002)	Capacity to maintain desirable functions and outcomes in the midst of strain.	X	
2003	Riolli&Savicki (2003)	Organizational ability to manage economic and political risks by promptly responding in a proactive or reactive manner to market threats and opportunities.	X	X
2003	Sutccliffe&Vogus (2003)	The ability to absorb, strain, or change with a minimum of disruption.	X	
2006	Gittell, Cameron, Lim & Rivas (2006)	Ability to bounce back from crisis	X	
2007	Vogus& Sutcliffe (2007)	Maintenance of positive adjustment under challenging conditions such that the organization emerges from those conditions strengthened and more resourceful.		X
2011	Lengnick-Hall, Beck &Lengnick-Hall (2011)	Ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organization survival.	X	X

Using the same method as previously described, the key components of *organizational resiliency* were "response to disruption" (vice opportunity), "recovery outcome" (vice advance), and "reactive" (versus proactive). The definition provided by Lengnick-Hall et al. (2011) is the only definition that includes each of these key components. Therefore, the following definition will be applied throughout this research.

> **Organizational Resiliency:** "ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to

capitalize on disruptive surprises that potentially threaten organization survival" (Lengnick-Hall et al., 2011).

Organizational flexibility, robustness, versatility, and adaptability are constructs that also highly relate to organizational agility (Ryan et al., 2012). Although their work specifically focused on system flexibility rather than organizational flexibility, the research is in the same domain (DoD) and is still applicable to this discussion. In their work, the authors reviewed over 200 papers and found 21 relevant definitions for flexibility. Their efforts culminated in an accepted definition through the breakdown of key elements and application of a similar democratic method. Their resultant definition will be applied to this research with a single change. The term *system* used in their definition was expanded to include the organizations that design, develop, manufacture and operate the specific hardware solution, and then replaced with the word "organization" to make it applicable to organizations (Ryan et al., 2012).

Organizational Flexibility: "the measure of how easily [an organization's] capabilities can be modified in response to external change."

Organizational Robustness: "the measure of how effectively [an organization] can maintain a given set of capabilities in response to external changes after it has been fielded."

Organizational Versatility: "the measure of how broadly [an organization's] capability extend in terms of foreseeable and unforeseeable sources of change."

Organizational Adaptability: "the measure of how effectively [an organization] can modify its own capabilities in response to change after it has been fielded."

3.4.4 Relationship of Terms

The formal definitions put forth in the previous sections leave out their relationship to one another. *Agility and resiliency* are both organizational characteristics; each describing an organizational response to different stimuli. *Agility and resiliency* share many of the same key components of their definition. They both require responses to stimuli that may be internal or externally produced and result in an increase (or restoration) in output capability. In manufacturing for instance, that may be the number of units produced, the number of different types of units, the individual unit performance, or even an increase in company profit. In the DoD, this may manifest itself as speed of production, number of missions supported, decrease in mission time, increase in trained soldiers, etc. Where the definitions of agility and resiliency differ is the type of stimuli. *Resiliency* is associated with the occurrence of a disruption/issue, which could also be described as a disruption or issue to the status quo, and implies that if the organization does not respond, the output capability will be reduced. *Agility* is associated with opportunities, where the organization has the opportunity to respond to an event, but failure to do so does not jeopardize the status quo output capability. An organization can possess one, both or neither of these attributes.

Evaluation of *flexibility* also shows significant definition overlap with *agility* and *resiliency*. Flexibility encompasses the nature of a system (organization) to adapt to change, which is also found in both agility and resiliency. Flexibility differs in that it is determined by the response without a time element. This means that only a single dimension (capability, time or cost) is required to understand flexibility, while *agility* and

resiliency both require two dimensions (capability & time) to be measured. Any time an organization displays a*gility* or *resiliency*, it also displays *flexibility*.

3.5 Existing Agility Measurement Methods

Despite the desire for organizations to become agile, the ability to measure agility has remained elusive. The difficulty arises when trying to create a measure that is both general enough to apply to multiple industries, yet specific enough to capture the important essence of each particular industry (Erande & Verma, 2008). To address this, most measures of agility to date are domain specific. Further, *agility* joins other important metrics such as morale, happiness, satisfaction, justice, and quality, in that it is not directly measurable. A latent construct, which is where a variable is inferred through a model from other variables that are more readily observed, is required (Everitt, 1984). To date, there have been several attempts at measuring agility. A summary of these methods follows.

1. The *two-dimensional dichotomy* is the most common method used to measure organizational agility. It frequently manifests itself in the form of *magnitude of variety/change* and the *response time/rate* (Singh et al.., 2018). These variables exist with a degree of dichotomy; the actions required by an organization to increase the *magnitude of variety* of services or products is often contradictory to a firm's ability to increase efficiency and reduce their *response time* (March, 1991). The *magnitude of variety/change* attempts to capture an organizations current capability of interest, and to quantify their change in that domain. For instance, for a smart phone manufacturer, it may be increased production, greater features on a device,

a greater variety of devices produced, or a new method to reduce the cost to produce each item (March 1991) . *The response time/rate* variable is meant to capture the temporality of the change in a suitable unit of time, such as days, months, per year or per cycle (March 1991). Both dimensions are applicable across multiple industries, however they must be calibrated for their respective industry.

2. *First-order models* that calculate agility by relying on the magnitude of variety and response rate have been developed by multiple authors (Adler et al.., 2008; Bahrami, 2012). These first order models often lack support and applicability across different industries (domains). More specifically, no models have been developed to apply to the defense sector.

3. *Agility curves* were developed and presented by (Singh et al.., 2018). The agility curves have significant meaning; two points on the graph can result in the same agility rating, and there is an inherent tradeoff between the *magnitude of variety change* and *rate of variety change*. Both of these notions are aligned with the argument of dichotomy between the dimensions. This model is supported within the academic community; however, it lacks a simple, repeatable method to measure the *magnitude of variety* and *response rate* and the scale can be difficult to determine and is thus limited in its actual implementation.

4. *Comprehensive Agility Measurement Tool* (CAMT), developed at Old Dominion University (Erande & Verma, 2008), has proven industry agnostic. The tool relies on ten “agility enablers” to measure agility on a scale of 1 to 5 and an analytical hierarchy process (AHP) to ensure that it can be effectively applied to a multitude

of industries. Starting from the set of 41 agility enablers found by (Kuruppalil, 1998), the survey administrator selects the ten most relevant factors for the given domain and assesses them utilizing a 5-point Likert scale. After applying a weighted average to each of the ten areas, a weighted agility measure is calculated. Although CAMT uses a mathematical model, it is highly subjective due to the administrator's selection of the ten relevant factors, and the weights applied to each agility enabler. The subjectivity required within CAMT has inhibited its overall support and application.

5. *Key Agility Index* (KAI) is a method developed by Lomas, et al., to measure design process agility by assessing the product development process and making the case that each product process provided a narrow glimpse of the overall organization's agility. They developed the Key Agility Index, which is the ratio of "time taken to complete change related tasks and time taken to complete the whole project (Lomas et al.., 2006). This method has high internal validity within a domain, but the authors warn against comparison between different market sectors. Further, this model fails to take into account other factors, such as an effective systems engineering plan. For instance, a product with a poor quality systems engineering plan will likely require a greater number of changes and greater overall variability in the time required to complete change related tasks (Lomas et al., 2006).

Each of these methods provides a different approach to measure organizational agility, but currently lack application within the Department of Defense (DoD). Further, there are no measurement methods that tie directly to the definition of OA provided by Teece that

we have adopted. Thus, the stage has been set by utilizing this definition of OA, a new measurement method can be developed that to support the DoD.

3.6 Development of a Set of Factors

3.6.1 Developing a New Organizational Agility Measure

Measures of performance are present in nearly all aspects of life. Their contribution to individual and organization performance is undeniable and their mere existence often causes changes in behavior. More specifically, measures of performance provide a means to quantify success and in turn contribute to the development of effective incentive structures. When accurately and effectively measured, they can be used to steer performance to achieve higher level objectives, ultimately changing behaviors. Unfortunately, most fields outside of the financial sector struggle to obtain suitable measures that are valid and reliable (Skyrme, 1998). Latent constructs are developed when a variable of interest cannot be observed or measured directly, and thus measurement is achieved via a theoretical relationship between that variable of interest and other, more directly, measurable indicators, known as *factors*.

The work completed by Colquitt in summarizing a method to utilize survey research to create a latent construct, and his subsequent application to develop an *organizational justice* measure, can be similarly applied to develop a measure for *organizational agility*. Utilizing the assumption that there is a set of factors that can be used to measure organizational agility, the next step is to identify any relevant factors.

3.6.2 Factors Related to Organizational Agility

Many researchers have attempted to capture the important characteristics of organizational agility. By collecting the *sets* of characteristics developed by other researchers, a more complete single set of characteristics was created. The process was to collect all prospective characteristics that could be used to measure agility, and then to systematically remove duplicates and non-relevant items. Since agility is highly related to constructs such as flexibility, rapidness, resiliency, and robustness, any characteristic used in their descriptions were also collected.

Utilizing a 3-round Delphi study designed to develop the framework for a survey questionnaire on leanness and agility, Kuruppalil (1998) identified the top 45 agility indicators for job shops from 14 different domains. Yusuf, et al. (1999), studied manufacturing agility, and found 32 key attributes comprised within 10 different domains, which was later reduced to seven a few years later (Gunasekaran & Yusuf, 2002; Yusuf et al., 1999). Research conducted by Lepore et al. (2012), that focused on military rapid development projects found 11 unique attributes by utilizing in-person interviews. Table 8 provides a summary of agility characteristics offered by these publications.

Table 8. Initial (Expanded) Set of Organizational Agility Characteristics

Manufacturing

Kuruppalil (1998)	
Adaptive evaluation and reward metric	Knowledge management
Capability to quickly adjust bus. & man. strategies	Knowledge of competitors
Capability to quickly adjust orgl characteristics/design	Mass customization
Concurrent engineering	Multi skilled people
Concurrent technology	Organization flexibility
Continuous improvement	Proactive customer relationships
Customer and supplier integration	Proactively exploration of new opportunities
Decentralized organization	Product model flexibility capability
Developing unique capabilities & characteristics	Product volume flexibility capability
Development of effective responses to new challenges	Pull production
Effective sensing of changes in the business environment	Quality over product life
Electronic commerce	Quick response to changing regulation/legislation
Employee satisfaction	Rapid adjustment of people capabilities (skills & knowledge)
Empowering workforce with knowledge	Rapid adoption of new methods, techniques, tech & processes
Encouraging innovation	Rapid delivery
Enhancing skill and knowledge by training	Rapid partnership
External integration of information	Rapid prototyping
Fast product development cycle	Reconfigurable production/process technology
Faster manufacturing times	Reconfigurable supply chain and business partnership
Flexible production technology	Responsiveness to market change
Internal integration of information	Team based leadership
Investing in innovation	Virtual enterprising
Investment in appropriate technology	

Manufacturing Job Shops

Yusuf, Sarhardi, Gunasekaran (1999)	
Concurrent execution of activities	Short development cycle times
Enterprise integration	Continuous improvement
Information accessible to employees	Culture of change
Multi-venturing capabilities	Rapid partnership formation
Developed business practice difficult to copy	Strategic relationship with customers
Empowered individuals working in teams	Close relationship with suppliers
Cross functional teams	Trust-based relationship with customers/suppliers
Teams across company borders	New product introduction
Decentralised decision making	Customer-driven innovations
Technology awareness	Customer satisfaction
Leadership in the use of current technology	Response to changing market requirements
Skill and knowledge enhancing technologies	Learning organization
Flexible production technology	Multi-skilled and #exible people
Quality over product life	Workforce skill upgrade
Products with substantial value-addition	Continuous training and development
First-time right design	Employee satisfaction

DoD "Rapid" Acquisitions

Lepore & Colombi (2012)	
Build and Maintain Trust	Right-size the Program - Eliminate Major Program Oversight
Designing out All Risk Takes Forever…Accept Some Risk	Strive for a Defined Set of Stable Rqmts Focused on Warfighter
Incremental Deployment is Part of the Product Plan	The Government Team Leads the Way
Keep an Eye on "Normalization"	Use Mature Technology – Focus on the State of the Possible
Maintain High Levels of Motivation and Expectations	Work to Exploit Maximum Flexibility Allowed
Populate Your Team with Specific Skills and Experience	

Each of these characteristic sets were created to fully encompass organizational agility, meaning that each of these sets are believed to be comprehensive and complete, albeit in their respective domains. With the sets provided by Kuruppalil (1998) and Yusuf, et al. (1999) both originating in the manufacturing domain, one would expect there to be significant overlap in sets. Further, the characteristic set provided by Lepore et al. (2012),

provides a well needed bridge into the DoD domain. By combining the three sets into a single set it is reasonable to believe that 1) the new set will be larger than each of the individual sets, 2) the new set will have a greater chance of encompassing the factors necessary to develop a latent construct, and 3) there will be redundancies within the new set. In most cases when combining data sets, redundancy is relatively easy to identify and eliminate. In this case, however, redundancies are difficult to recognize due to the varied wording used to describe each characteristic. The Q-sort method was used to compare, combine, and reduce redundancies in these sets.

3.6.3 The Q-sort Method

Q-sort is "a method of assessing reliability and construct validity of questionnaire items being prepared for survey research " (Nahm et al., 2016). First developed and published by Catell (1946), the Q-sort method was one of the six correlation methods (P, Q, R, O, S, & T). The Q-sort method was further refined by Stephenson (1953) and J. Block (1961) into the incarnation that is used today. It is an iterative process where the level of agreement between judges is measured and used to determine overall construct validity (Block, 1961, Nahm et al., 2016, Ozer, 2004, Stephensen, 1953).

The procedure to conduct a Q-sort is as follows:

1. Collect items to be sorted. These items are expected to be a sample from the entire population of items that could be used.

2. Select number and capacity of judges. One of the most useful features of the Q-sort method is the limited experience and training that is required of the judges to conduct the sorting. Judges should be knowledgeable in the domain specific to the items, but do not need any formal experience in the Q-sort method itself. The minimum number of judges is two, however the benefit of having additional judges beyond two is often quickly outweighed by the level of disruption it causes when calculating Cohen's Kappa and the level of agreement. For these reasons, two judges are most often preferred.

3. Apply a suitable construct in which the judges can sort the items. This construct may be developed in advance or by the judges themselves. It is recommended that the construct include an "other" category for items that are difficult to fit into a single category.

4. Judges sort the items independently. Methods to ensure independence include keeping each judge out of view of the other, sort via a computer database, or having the items to be sorted in a different, random order for each judge.

5. Calculate Cohen's Kappa and the Agreement Ratio. To calculate the agreement ratio, a table that utilizes the number of items for each category is constructed. Figure 10 provides a generic setup for judges (most common); a similar 3-dimensional model can be created if three judges were used.

		Judge 1				
		Cat 1	Cat 2	Cat 3	Cat 4	Totals
Judge 2	Cat 1	X_{11}	X_{12}	X_{13}	X_{14}	X_{1+}
	Cat 2	X_{21}	X_{22}	X_{23}	X_{24}	X_{2+}
	Cat 3	X_{31}	X_{32}	X_{33}	X_{34}	X_{3+}
	Cat 4	X_{41}	X_{42}	X_{43}	X_{44}	X_{4+}
	Totals	X_{+1}	X_{+2}	X_{+3}	X_{+4}	N

Figure 10. Two Judge Agreement During Q-Sort

Converting Figure 10 into percentages can be done by dividing each table cell by *N*, resulting in Figure 11.

		Judge 1				
		Cat 1	Cat 2	Cat 3	Cat 4	Totals
Judge 2	Cat 1	P_{11}	P_{12}	P_{13}	P_{14}	P_{1+}
	Cat 2	P_{21}	P_{22}	P_{23}	P_{24}	P_{2+}
	Cat 3	P_{31}	P_{32}	P_{33}	P_{34}	P_{3+}
	Cat 4	P_{41}	P_{32}	P_{33}	P_{44}	P_{4+}
	Totals	P_{+1}	P_{+2}	P_{+3}	P_{+4}	100

Figure 11. Normalized Two Judge Agreement During Q-Sort

The agreement ratio is then calculated as:

$$Agreement\ Ratio\ = \frac{\boldsymbol{Number\ of\ Agreements\ (\sum diagonal\ elements)}}{\boldsymbol{Number\ of\ Items\ Placed\ (N)}} \qquad (1)$$

Cohen's Kappa is calculated by first determining the chance of agreement and then removing it from the total number of actual agreements. Chance agreements are calculated by multiplying the cross row-column totals, as:

$$Total\ Chance\ Agreement_i = \sum_i P_{i+}|P_{+i} \qquad (2)$$

From there, the total number of actual agreements is also calculated, as:

$$Number\ of\ Actual\ Agreement = \sum_i P_{ii} \quad (3)$$

The difference between the Number of Actual Agreements and Total Chance of Agreement, standardized for the maximum possible value, which is known as Cohen's Kappa, can then be calculated as:

$$Cohen's\ Kappa = \frac{\sum_i P_{ii} - \sum_i P_{i+}|P_{+i}}{1-(\sum_i P_{ii} - \sum_i P_{i+}|P_{+i})} \quad (4)$$

There is no agreement on a minimum acceptable Cohen Kappa. Landis and Koch published a detailed guideline in their 1977 work, where they provided the following recommendation (Landis, 1977):

Perfect Agreement: Kappa > 0.81

Substantial Agreement: 0.61 ≤ Kappa ≤ 0.80

Moderate Agreement: 0.41 ≤ Kappa ≤ 0.60

Fair Agreement: 0.21 ≤ Kappa ≤ 0.40

No to Slight Agreement: Kappa ≤ 0.20

Using the guidelines from Landis and Koch, a minimum Kappa of 0.61, representing "substantial agreement," was used.

3.6.4 Applying the Q-sort Method to Organizational Agility

The Q-sort method was applied to the agility characteristics already described. The ultimate goal was to determine which, if any, characteristics were redundant in the set. In accordance with the recommendations by Ozer, two judges were used. Both judges had backgrounds representative of the expected survey respondents' that would be used later in this research but possessed minimal knowledge on the Q-sort method. The procedure required a two-round Q-sort method, each round further delineating and categorizing each characteristic (Ozer, 2004).

Round 1. Both judges were given the complete set of items from Table 8 (N=88) and were asked to categorize each item. Previous research on the OA Framework by Teece et al. (2016) resulted in three categories for OA characteristics, including *sensing, seizing* and *transforming*. These three categories, along with their descriptions provided by Teece et al. (2016), were used to form the bins for the first round. A brief description of these categories was given to each judge to better align their meaning against that of the original authors, and to reduce any pre-conceived notions. Each of the items were written on a 3x5 index card, and subsequently shuffled (randomized) for each judge to ensure independence. Once the judges were both complete, the cards were sorted and the agreement ratio calculated, as shown in Figure 12. The data set was then normalized (divide by *N*) and Cohen's Kappa was calculated to be 0.74, as shown in Figure 13. This met our set criteria of 0.61, ("substantial agreement"), and the process was advanced to round 2.

		Judge 1				
		Sensing	Seizing	Transforming	Other	Totals
Judge 2	Sensing	21	1	3	1	26
	Seizing	3	31	2	-	36
	Transforming	1	4	21	-	26
	Other	-	-	-	-	0
	Totals	25	36	26	1	88

Number of Items Placed:	88
Number of Agreements:	73
Agreement Ratio:	82.95%

Figure 12. Round 1 Q-Sort Results - Agreement Ratio

		Judge 1				
		Sensing	Seizing	Transforming	Other	Totals
Judge 2	Sensing	0.2386	0.0114	0.0341	0.0114	0.2955
	Seizing	0.0341	0.3523	0.0227	-	0.4091
	Transforming	0.0114	0.0455	0.2386	-	0.2955
	Other	-	-	-	-	-
	Totals	0.2841	0.4091	0.2955	0.0114	1

Number of Agreements:	0.82955
Chance Agreements:	0.3386
Cohen's Kappa:	0.7423

Figure 13. Round 1 Q-Sort Results - Cohen's Kappa

Round 2. The categories used in round 1 (seizing, sensing, transforming) were each broken down into subcategories. The judges were allowed to select the subcategories via a discussion and consensus process amongst themselves. Although the judges were allowed to select from 2-5 subcategories, each of the subcategory selections resulted in exactly three subcategories. From there, the same process as described in the

previous round was repeated. The hierarchical structure and results of round 2 are shown in Figure 14. It is important to note that the first time through in the category of *transforming*, the judges resulted in a Cohen's Kappa of 0.498. This was significantly lower than the goal of 0.61 (or higher), so a mediation round occurred. During this mediation round, each judge was given 60 seconds to discuss the disparate items. Following the time limited discussion, each judge then re-scored the item in secret. After the second attempt within the "transforming" category, the Cohen's Kappa was increased to 0.914. The mediation process had been pre-determined and agreed upon by the judges before the start of the sorting, however extreme caution should be taken when employing such a technique as it may invalidate the assumption of independence. In this case, it was determined the breach of independence was preferred over proceeding with a Cohen's Kappa of 0.498.

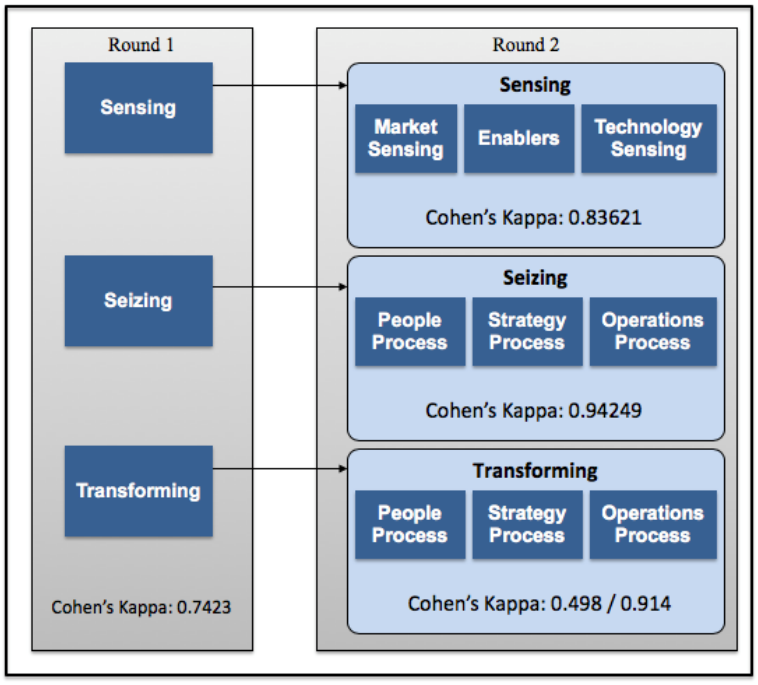


Figure 14. Hierarchical Layout & Results of Q-Sort

At this point, the Q-sort method was complete in its entirety. A final round of discussions was completed to determine which, if any, items were redundant in nature. The judges were given the items, one subcategory at a time (of the 9 total subcategories), and they searched for redundancies. Open discussion and deliberation was encouraged, and it took both judges to agree before a redundancy was declared. In most cases, redundancy were between two items, however a few occurrences of 3-item redundancy did occur. In total, 24 redundant items were removed from the list, resulting in the final characteristic list as shown in Table 9.

Table 9. Final (Reduced) Set of Organizational Agility Characteristics

Adaptive evaluation and reward metric	Investment in appropriate technology
Build and Maintain Trust	Knowledge management
Capability to quickly adjust busikness & manufacturing strategies	Knowledge of competitors
Close relationship with suppliers	Leadership in the use of current technology
Concurrent execution of activities	Learning organization
Continuous improvement	Maintain High Levels of Motivation and Expectations
Continuous training and development	Multi-venturing capabilities
Cross functional teams (including intra & inter company borders)	New product introduction
Culture of change	Partnership
Customer and supplier integration	Populate Your Team with Specific Skills and Experience
Decentralized decision making	Proactive customer relationships
Decentralized organization	Proactively exploration of new opportunities
Designing out All Risk Takes Forever…Accept Some Risk	Product Flexibility
Developed business practice difficult to copy	Products with substantial value-addition
Developing unique capabilities & characteristics difficult to copy	Quality over product life
Development of effective responses to new challenges from competitors	Rapid adjustment of people capabilities (skills & knowledge)
Effective sensing of changes in the business environment	Rapid adoption of new methods, techniques, tech & processes
Electronic commerce	Rapid delivery
Employee satisfaction	Rapid partnership formation
Empowered individuals working in teams	Rapid prototyping
Empowering workforce with knowledge	Responsiveness to market change
Encouraging innovation	Right-size the Program - Eliminate Major Program Oversight
Enhancing skill and knowledge by training	Short development cycle times
Enterprise integration	Skill and knowledge enhancing technologies
External integration of information	Strive for a Defined Set of Stable Rqmts Focused on Warfighter
Fast product development cycle	Team based leadership
Faster manufacturing times	Teams across company borders
First-time right design	Technology awareness
Flexible production technology	Trust-based relationship with customers/suppliers
Incremental Deployment is Part of the Product Plan	Use Mature Technology – Focus on the State of the Possible
Information accessible to employees	Virtual enterprising
Internal integration of information	Work to Exploit Maximum Flexibility Allowed

3.7 Significance

In the ongoing effort to identify the characteristics of an agile organization, this research accomplished three important objectives. First, through the analysis of the available OA definitions, an acceptable, commonly applicable definition was found that can be utilized to develop a method to measure OA. Second, utilizing three highly researched and distinct sets of OA characteristics, each representing a different domain or industry focus, a larger, more encompassing set was created. The aggregation of characteristic sets, by its very nature, greatly decreased the likelihood that a particular important characteristic was missing, as it would have to have been missing in all three of the original researcher's lists. Third, characteristics from the aggregated set that had similar meaning or were redundant were removed. This reduced the characteristic set by 27% and reduced the number of data points that will require dedicated analysis in future research in this field. Alternatively said, there is an increased likelihood that the important characteristics were captured while still achieving the minimum characteristic set to allow efficient follow-on research. Together, these three objectives help in establishing a common understanding of OA that can be used by acquisition professionals across the Department of Defense. Further, they form the necessary foundation to establish a method to measure, and ultimately improve, OA.

3.8 Summary

There is a continuous need for organizations to become agile in order to survive and succeed amongst their peers. A method to accurately measure organizational agility within the DoD has yet to be fully developed. Through literature review, a suitable and

formal definition for organizational agility was found and support confirmed. An initial set of related characteristics, which can be used to develop a latent construct, was discovered and analyzed. Utilizing the Q-sort method, redundant characteristics were eliminated resulting in 64 remaining characteristics that will be used to develop the necessary survey questions to continue this research.

IV. Development of a Latent Construct to Measure Organizational Agility

4.1 Chapter Overview

A survey was developed using the established OA characteristics. Hosted on SurveyMonkey.com, the survey was reviewed and approved by the Air Force Research Laboratories (AFRL) Institutional Review Board (IRB) to ensure the safety of the human subjects. The survey was also approved by the Air Force Safety Office, which specifically allocated the necessary government employee time resources towards this effort.

Surveys were sent to individuals by targeting the members of specific organizations. The Air Force Global Access List (GAL) was used to form the distribution lists. The detailed method is shown in Appendix I.

Two rounds of surveys were used, providing the required data to complete Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The paper entitles "Develop of a Latent Construct to Measure Organizational Agility" describes the survey, the analysis, and the resultant latent construct to measure OA. The full text of this manuscript (excluding bibliography) begins on the following page. The paper has been submitted for publication in the Journal of Product Innovation Management as part of their special issue to address "the Human Side of Innovation Management."

4.2 Abstract

Organizations seeking to increase market share must be prepared to seize opportunities when and where they arise. Organizational Agility (OA) is the "capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting higher-yield activities as internal and external circumstances warrant" (Teece et al.., 2016).

This article begins by providing a theoretical framework to measure OA through a latent construct. Previous studies to find important characteristics related to OA are examined, and an initial set of 88 organizational agility characteristics is assembled. The Q-sort method is used to identify and eliminate redundant characteristics and results in 64 unique characteristics. The characteristics are transposed into Likert scale survey questions.

Exploratory factor analysis (EFA) was applied to a preliminary study with over 250 respondents representing 13 organizations to establish the structure of a latent construct to measure OA along with the individual characteristics necessary to calculate its factors. A second study, this time representing 40 organizations and with over 1,100 respondents, used confirmatory factor analysis (CFA) to confirm and validate the latent construct, its factors, and the fundamental questions necessary to measure OA.

This research culminates in a latent construct to measure OA. From this construct, managers will be able to assess their organizations' ability to capitalize on innovative opportunities through the application of a 20-question survey. Further, managers can identify weaknesses within their OA, allowing them to take proactive steps

to re-adjust their resources and capabilities to remain poised to capitalize on the next innovation within their market.

Keywords

organizational agility, agility, latent variable, latent construct, measure development

4.3 Introduction

The most successful organizations around the world combine people, resources, and ideas to create a product or service of value. Extensive research, combined with centuries of trial and error, has culminated in an environment where the majority of value-creating products and services are now *serviced* by organizations that have spent decades focusing on the efficiency of product manufacturing and distribution. Established organizations seeking to maintain or increase their market share can no longer rely on increased efficiency; they need to focus on innovation. Innovation is widely recognized as being the most critical factor in a company's growth and overall competitiveness (Damanpour & Schneider, 2009; Tellis et al., 2009).

"Innovation can be conceptualized as encompassing two different activities; the development of novel, useful ideas and their implementation" (Baer, 2012). By overlaying the innovation activities onto Boyd's "OODA Loop" as shown in Figure 15, the distinction between idea generation and implementation becomes clearer. More importantly, the notion of a quick, repeatable cycle becomes evident (Boyd, 1976).

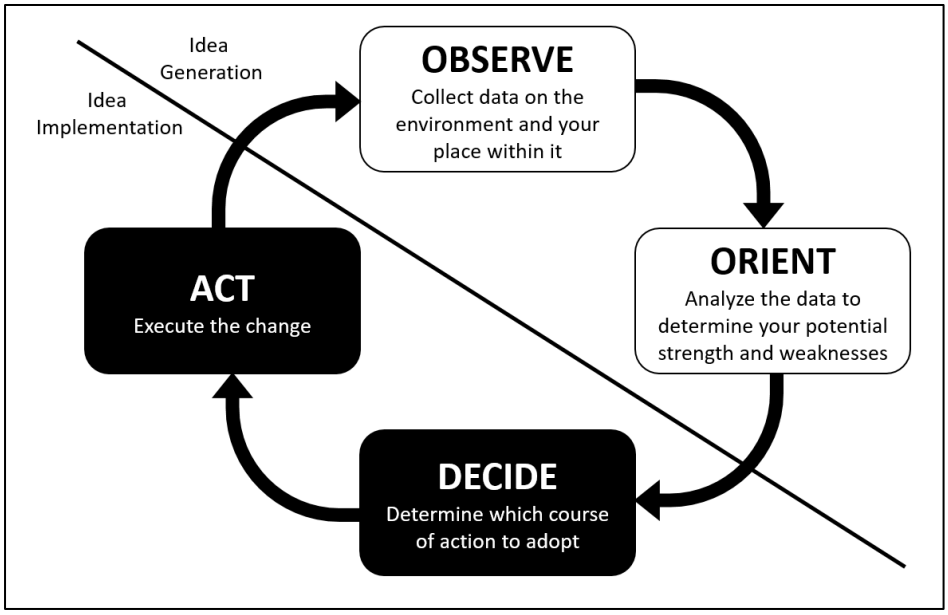


Figure 15. The OODA Loop of Innovation

Organizations with the capacity to quickly innovate and create value-added solutions are often the most prosperous, and possess a key aspect required for innovation. *Organizational agility* is the "capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant" (Teece et al.., 2016). While several studies have been conducted to capture the organizational characteristics necessary to be agile, they do not provide an objective method to measure and track long-term organizational agility. This leaves organizations with an inability to fully assess their innovation readiness and their position amongst their competitors.

A list of potential characteristics related to organizational agility is generated utilizing the results of multiple studies, including publication review, a Delphi study, and interviews. Each characteristic forms a survey question and independent judges evaluate

and remove duplicate and overlapping questions (Geiger et al.., 2020). The resulting list from that effort is used as a starting point for the work described herein.

Exploratory factor analysis (EFA) is applied to a preliminary study with over 250 respondents representing 13 organizations to establish the structure of a latent construct to measure Organizational Agility (OA) along with the individual characteristics necessary to calculate its factors. A second study, this time representing 40 organizations and with over 1,100 respondents, uses confirmatory factor analysis (CFA) to confirm and validate the latent construct, its factors, and the fundamental questions necessary to measure OA.

This research culminates in a latent construct to measure OA. From this latent construct, managers are able to assess their organizations' ability to capitalize on innovative opportunities. Further, managers can identify any weaknesses in their organizational agility, allowing them to proactively adjust their resources and capabilities and remain poised to capitalize on the next innovation within their market.

4.4 Theoretical Framework

4.4.1 Literature Review

Organizational agility (OA) is both highly complex and necessary. Researchers from around the globe created numerous publications to define, characterize, and measure OA. A detailed literature review was completed to determine the most suitable definition of OA. A thorough examination of the definitions provided within 24 publications was completed by analyzing their meaning, key components, the author's intent, and the

applicable domain. This results in what the authors consider the most appropriate definition of OA (Geiger et al.., 2020):

> *Organizational agility* is the "capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant" (Teece et al.., 2016).

A literature review is conducted on existing and proposed methods to measure OA. The results indicate a universal, well excepted measure was still out of reach. The most prevalent methods, along with their limitations, can be found in Table 10 .

Table 10. Summary of Existing Methods to Measure Organizational Agility

Type	Authors Include	Description	Limitations
Two-Dimensional Dichotomy	• Singh, Sharma, Hill & Schnackenberg (2018) • March (1991)	Most common method to measure OA. Most often presented as a form of "magnitude of variety/change" and the "response time/rate" required to make the change.	• Dimensions must be calibrated for each domain. • Cross-domain comparisons are invalid.
First-Order Models	• Adler, Goldoftas & Levine (2008) • Bahrami (2012)	First order mathematical models that rely on a form of the two-dimensional dichotomy model to calculate a value for OA.	• Applicability across different domains is unsupported. • Models created for specific sectors.
Agility Curves	• Singh, Sharma, Hill & Schnackenberg (2018)	A graphical representation that relies on a from of the two-dimensional dichotomy model. Allows for a tradeoff between magnitude of variety of change with rate of variety of change to achieve the same OA value.	• Lacks a simple, repeatable method to measure each of the factors.
Comprehensive Agility Measurement Tool (CAMT)	• Erande & Verma (2008)	Tool to measure agility on a scale of 1 to 5 utilizing ten "agility enablers" via an analytical hierarchy process (AHP). Utilizes a 5-point Likert scale to measure each of ten "agility enablers", which were chosen from a set of 41 possible characteristics.	• Highly subjective results based on the facilitators initial selection of "agility enablers"
Key Agility Index (KAI)	• Lomas, Wilkinson, Maropoulos, & Matthews (2006)	Utilizes small design changes in relation to the overall system development process to estimate an organizations agility. Specifically, it measures the "time taken to complete [a] change related tasks and time taken to complete the whole project", which is then extrapolated to represent overall OA.	• Cross-domain comparisons are invalid. • Poor initial product planning results in artificially higher OA.

There are four prevalent themes found throughout the various methods; 1) a minimum of two-dimensions are necessary to model OA; 2) key characteristics can be used to estimate OA; 3) a Likert-type scale can be used to estimate each characteristic, and: 4) cross-domain comparisons present a challenge. Using these themes, a theoretical framework was developed.

4.4.2 Latent Construct through Factor Analysis

A *latent variable* is a variable that cannot be directly observed or measured, and are common in social, organizational, and behavior sciences. Since OA cannot be directly measured, it is a latent variable and a suitable alternative method is necessary to estimate its value. One particular method is to start with measuring several *related variables* and calculating their subsequent R-matrix (Field, 2013). The R-matrix is a table of correlations between variables, where each cell in the table represents the correlation between the variables represented by that row and column, as shown in the example in Table 11.

Table 11. Example R-Matrix

	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6	Variable 7	Variable 8
Variable 1	**1.00**							
Variable 2	-0.23	**1.00**						
Variable 3	0.24	0.69	**1.00**					
Variable 4	0.08	0.85 Factor 1	0.75	**1.00**				
Variable 5	-0.29	0.30	-0.12	0.12	**1.00**			
Variable 6	0.38	0.27	0.18	0.20	0.81	**1.00**		
Variable 7	0.17	-0.09	0.25	-0.13	0.78	0.68	**1.00**	
Variable 8	0.19	0.15	-0.30	0.21	0.84 Factor 2	0.72	0.91	**1.00**

Each variable is fully correlated with itself, which is represented by the diagonal line in the table. Groupings of highly correlated variables (values near 1.00), when present,

suggest that those variables are measuring aspects of an underlying dimension, known as a *factor*. When one or more factors are identified, they can be used to develop a framework, known as a latent construct, to measure a latent variable (Field, 2013). An outline of the expected latent construct, containing the variables and factors necessary to infer OA is shown in Figure 16.

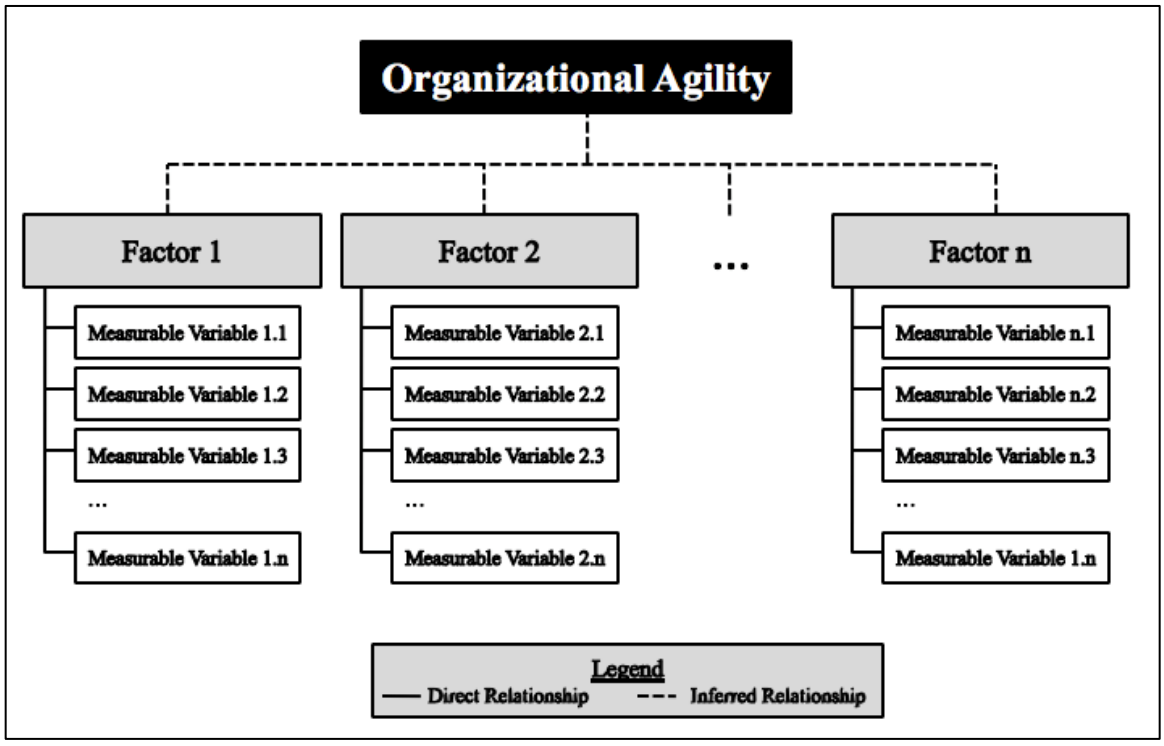


Figure 16. Conceptual Model

Although there are several different methods to discover underlying factors, exploratory factor analysis is the most appropriate when exploring data when a specific hypothesis is unavailable (Tinsley & Tinsley, 1987). Factor analysis is a technique with three main uses: 1) to understand the structure of a set of variables; 2) to construct a questionnaire to measure an underlying variable, and; 3) to reduce a data set to a more

manageable size while retaining as much of the original information as possible. Factor analysis was originally developed to explore data and to generate future hypothesis, rather than test existing hypotheses. As such, it was assumed the technique would be applied to the entire population of interest (Field, 2013). To overcome this deficiency and to apply the results to a larger population than the one observed, two assumptions are made: 1) random selection of participants, and; 2) the variables measured comprise the entire population of variables of interest. Both of these assumptions are met in this study.

4.4.3 Multilevel Analysis

Organizational analysis often suffers from the difficulty of measuring variables at one level while trying to analyze and apply the results at a different level (e.g. individual, department, organization). The inherent multilevel nature of measuring OA necessitates the need for a composition model to specify the functional relationships between individual responses and organizational phenomena. Chan (1998) developed a typology of composition models to explore the applicability of the five different models available. Of those models, the *direct consensus model* is the most appropriate for OA research. The direct consensus model requires within-group consensus of the lower level data to justify its aggregation to represent a higher level. This is an important distinction from the additive model where aggregation does not require within-group consensus. There are two distinct components necessary to use the direct consensus model. First, a conceptual definition must be operationalized for the construct at each level. Second, a pre-determined condition that justifies the aggregation of the measurements must be determined. In this case, we will measure a multitude of OA related variables at the individual level via a survey. The

individual variables will be aggregated (by averaging) to calculate the relevant factors represented at the organizational level. The intra-class correlation coefficient (ICC) will be calculated and the value of 0.75 used to determine the cutoff level of agreement to justify aggregation (Chan, 1998; Cicchetti, 1994).

4.4.4 OA Characteristics to Survey Questions

Several researchers attempted to capture the key characteristics related to OA. Kuruppalil utilized a 3-round Delphi study on manufacturing leanness and agility to identify 45 agility "indicators" across 14 different domains (Kuruppalil, 1998). Further research in the manufacturing domain was conducted by Yusuf, Sarhardi & Gunasekaran, in which they identified 32 key "attributes" (Gunasekaran & Yusuf, 2002; Yusuf et al.., 1999). A third study, this time utilizing in-person interviews focused on rapid development projects, resulted in 11 unique characteristics (Lepore et al.., 2012). A single set of 98 variables was created by combining the results of these three studies, as shown in Table 12. The expanded variable set, when compared to each of its constituent sets, offered a greater chance the entire population of variables was captured--a required item to meet the necessary assumptions when using factor analysis.

Table 12. Initial (Expanded) Set of Organizational Agility Variables

Manufacturing	Kuruppalil (1998)	
	Adaptive evaluation and reward metric	Knowledge management
	Capability to quickly adjust bus. & man. strategies	Knowledge of competitors
	Capability to quickly adjust orgl characteristics/design	Mass customization
	Concurrent engineering	Multi skilled people
	Concurrent technology	Organization flexibility
	Continuous improvement	Proactive customer relationships
	Customer and supplier integration	Proactively exploration of new opportunities
	Decentralized organization	Product model flexibility capability
	Developing unique capabilities & characteristics	Product volume flexibility capability
	Development of effective responses to new challenges	Pull production
	Effective sensing of changes in the business environment	Quality over product life
	Electronic commerce	Quick response to changing regulation/legislation
	Employee satisfaction	Rapid adjustment of people capabilities (skills & knowledge)
	Empowering workforce with knowledge	Rapid adoption of new methods, techniques, tech & processes
	Encouraging innovation	Rapid delivery
	Enhancing skill and knowledge by training	Rapid partnership
	External integration of information	Rapid prototyping
	Fast product development cycle	Reconfigurable production/process technology
	Faster manufacturing times	Reconfigurable supply chain and business partnership
	Flexible production technology	Responsiveness to market change
	Internal integration of information	Team based leadership
	Investing in innovation	Virtual enterprising
	Investment in appropriate technology	

Manufacturing Job Shops	Yusuf, Sarhardi, Gunasekaran (1999)	
	Concurrent execution of activities	Short development cycle times
	Enterprise integration	Continuous improvement
	Information accessible to employees	Culture of change
	Multi-venturing capabilities	Rapid partnership formation
	Developed business practice difficult to copy	Strategic relationship with customers
	Empowered individuals working in teams	Close relationship with suppliers
	Cross functional teams	Trust-based relationship with customers/suppliers
	Teams across company borders	New product introduction
	Decentralised decision making	Customer-driven innovations
	Technology awareness	Customer satisfaction
	Leadership in the use of current technology	Response to changing market requirements
	Skill and knowledge enhancing technologies	Learning organization
	Flexible production technology	Multi-skilled and #exible people
	Quality over product life	Workforce skill upgrade
	Products with substantial value-addition	Continuous training and development
	First-time right design	Employee satisfaction

DoD "Rapid" Acquisitions	Lepore & Colombi (2012)	
	Build and Maintain Trust	Right-size the Program - Eliminate Major Program Oversight
	Designing out All Risk Takes Forever…Accept Some Risk	Strive for a Defined Set of Stable Rqmts Focused on Warfighter
	Incremental Deployment is Part of the Product Plan	The Government Team Leads the Way
	Keep an Eye on "Normalization"	Use Mature Technology – Focus on the State of the Possible
	Maintain High Levels of Motivation and Expectations	Work to Exploit Maximum Flexibility Allowed
	Populate Your Team with Specific Skills and Experience	

The enlarged set of variables is used to create corresponding survey questions on a one-to-one basis. During this process, several terms and concepts were repeated between the original data sets, thus creating a situation where multiple questions are based on similar terms and concepts. It is necessary to distinguish ideas that were truly different from those that used different terms for similar concepts. A technique known as *Q-sort* was utilized

to:1) reduce redundant questions through selective elimination; 2) reduce overlapping questions through elimination and/or rewording; and 3) expand multi-faceted questions. Examples for each are shown in Figure 17 (Geiger et al.., 2020). The resultant list of 68 questions, shown in Table 13, was used for the initial survey.

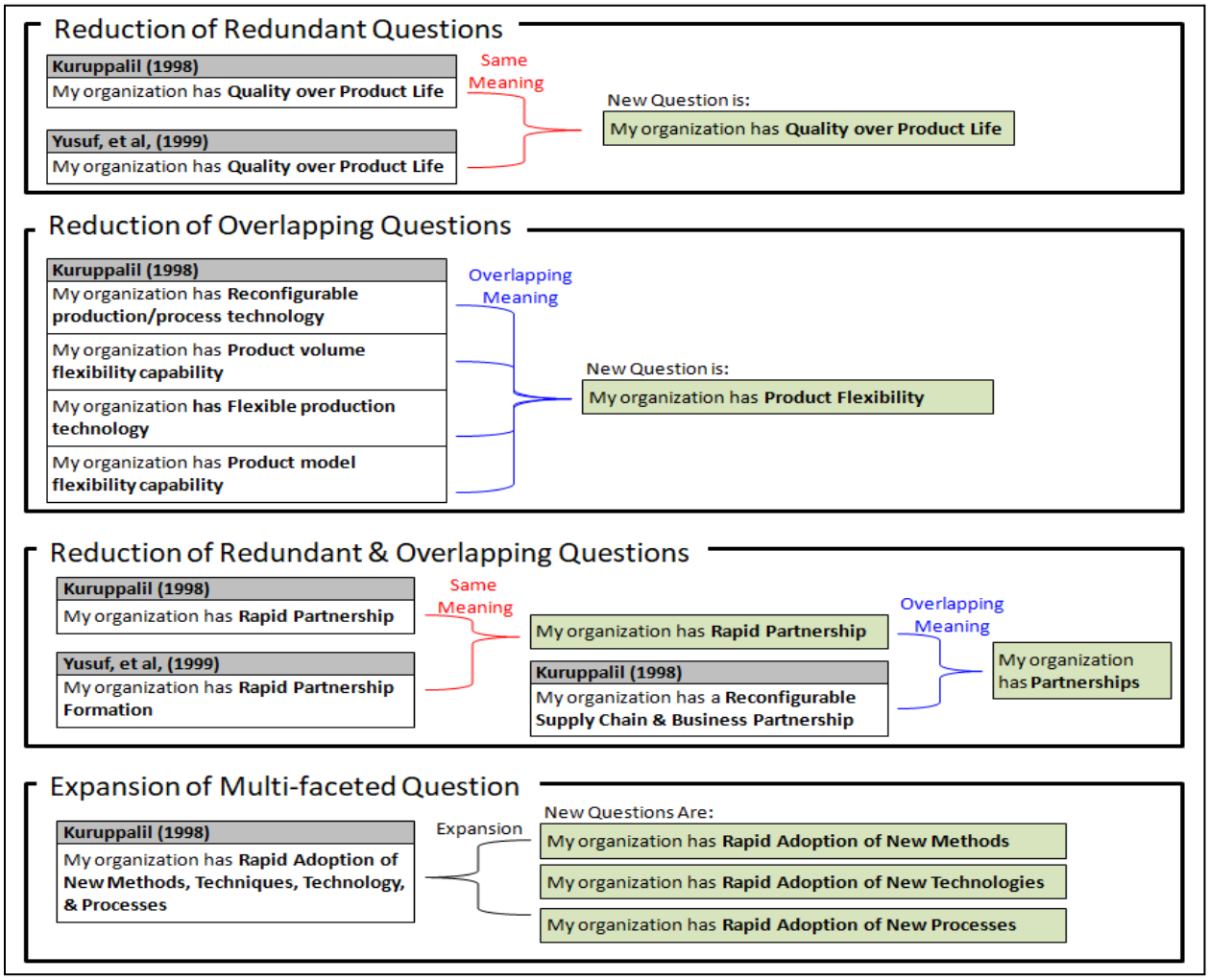


Figure 17. Examples of Question Reduction & Expansion

Table 13. OA Variables & Corresponding Survey Questions

Source of Variable	OA Variables (64)	OA Survey Qeustions (68)
		I believe that my organization has…
Kuruppalil (1998)	Adaptive evaluation and reward metric	an adaptive evaluation and reward metric system
Lepore & Colombi (2012)	Build and Maintain Trust	built and maintains trust
Kuruppalil (1998)	Capability to quickly adjust business & manufacturing strategies	the capability to quickly adjust business strategies
Yusuf, Sarhardi, Gunasekaran (1999)	Close relationship with suppliers	close relationship with suppliers
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Concurrent execution of activities	concurrent execution of activities
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Continuous improvement	continuous improvement
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Continuous training and development	continuous training and development
Kuruppalil (1998)	Cross functional teams (including intra & inter company borders)	cross functional teams
Kuruppalil (1998)	Culture of change	a culture of change
Kuruppalil (1998)	Customer and supplier integration	customer and supplier integration
Kuruppalil (1998)	Decentralized decision making	decentalized decision making
Kuruppalil (1998)	Decentralized organization	a decentralized organization
Lepore & Colombi (2012)	Designing out All Risk Takes Forever…Accept Some Risk	culture that accepts some risk (rather than designing out all risk)
Kuruppalil (1998)	Developed business practice difficult to copy	developed business practices that are difficult to copy
Kuruppalil (1998)	Developing unique capabilities & characteristics difficult to copy	developed unique capabilities & characteristics difficult to copy
Kuruppalil (1998)	Development of effective responses to new challenges	developed effective responses to new challenges
Kuruppalil (1998)	Effective sensing of changes in the business environment	effective sensing of changes in the business environment
Kuruppalil (1998)	Electronic commerce	a majority of supplier/customer interactions electronically
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Employee satisfaction	employees that are satisfied
Kuruppalil (1998)	Empowered individuals working in teams	empowered individuals working on teams
Kuruppalil (1998)	Empowering workforce with knowledge	empowered the workforce with knowledge
Kuruppalil (1998)	Encouraging innovation	a history of encouraging innovation
Kuruppalil (1998)	Enhancing skill and knowledge by training	enahanced workforce knowledge with training enhanced workforce skill with training
Kuruppalil (1998)	Enterprise integration	close relationship with suppliers
Kuruppalil (1998)	External integration of information	the ability to integrate external information
Kuruppalil (1998)	Fast product development cycle	fast product development cycle
Kuruppalil (1998)	Faster manufacturing times	fast manufacturing times
Kuruppalil (1998)	First-time right design	first-time right design (rather than iterative design process)
Kuruppalil (1998)	Flexible production technology	flexible production technology
Lepore & Colombi (2012)	Incremental Deployment is Part of the Product Plan	incremental development as part of original plan
Kuruppalil (1998)	Information accessible to employees	made information accessible to employees
Kuruppalil (1998)	Internal integration of information	internal integration of information
Kuruppalil (1998)	Investment in appropriate technology	invested in appropriate technology
Kuruppalil (1998)	Knowledge management	intentional management of human knowledge
Kuruppalil (1998)	Knowledge of competitors	an accurate and useful knowledge of competitors
Kuruppalil (1998)	Leadership in the use of current technology	leadership in the use of current technology
Kuruppalil (1998)	Learning organization	an environment where learning and improvement are important
Lepore & Colombi (2012)	Maintain High Levels of Motivation and Expectations	the ability to maintain high levels of motivation
Kuruppalil (1998)	Multi-venturing capabilities	a history of developing multiple solutions to same problem
Kuruppalil (1998)	New product introduction	a history of introducing innovative products
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Partnership	partnerships
Lepore & Colombi (2012)	Populate Your Team with Specific Skills and Experience	teams populated with the necessary skills and experience
Lepore & Colombi (2012) Kuruppalil (1998)	Proactive customer relationships	a history of proactively building customer relationships
Kuruppalil (1998)	Proactively exploration of new opportunities	a history of proactively exploring new opportunities
Kuruppalil (1998)	Product Flexibility	product flexibility
Kuruppalil (1998)	Products with substantial value-addition	products with substantial value addition
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Quality over product life	quality throughout the product lifecycle
Kuruppalil (1998)	Rapid adjustment of people capabilities (skills & knowledge)	rapid adjustment of people capabilities
Kuruppalil (1998)	Rapid adoption of new methods, techniques, tech & processes	rapid adoption of new methods rapid adoption of new processes rapid adoption of new technologies
Kuruppalil (1998)	Rapid delivery	rapid delivery of product/service
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Rapid partnership formation	the ability to form rapid partnerships
Kuruppalil (1998)	Rapid prototyping	rapid prototyping
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Responsiveness to market change	responsiveness when requirements change
Lepore & Colombi (2012)	Right-size the Program - Eliminate Major Program Oversight	limited program oversight
	Short development cycle times	short development cycle times
Yusuf, Sarhardi, Gunasekaran (1999) Kuruppalil (1998)	Skill and knowledge enhancing technologies	technologies that enhance human skill & knowledge
Lepore & Colombi (2012)	Strive for a Defined Set of Stable Rqmts Focused on Warfighter	a stable set of customer requirements
Kuruppalil (1998)	Team based leadership	team-based leadership
Kuruppalil (1998)	Teams across company borders	teams across organization borders
Kuruppalil (1998)	Technology awareness	been digitally intergrated/interconnect
Kuruppalil (1998)	Trust-based relationship with customers/suppliers	trust-based relationships with manufacturers trust-based relationships with suppliers
Lepore & Colombi (2012)	Use Mature Technology – Focus on the State of the Possible	a desire to only focus on mature technologies
Kuruppalil (1998)	Virtual enterprising	the ability to to share business resources virtually
Lepore & Colombi (2012)	Work to Exploit Maximum Flexibility Allowed	processes to exploit maximum allowable flexibility

4.5 Study 1 - Methodology

4.5.1 Survey Development

The initial survey was designed to gather enough data to effectively conduct a full factor analysis on the 68 questions related to OA shown in Table 13. Questions pertaining to individual and organizational demographics are added to ensure the results were viewed in the proper context. Nine additional questions that supported the work by Singh et al.., (2018) to measure OA using agility curves are also included. The OA related survey questions relied on a standard 7-point Likert scale. The Likert scale is defined as 1) Very Strongly Disagree; 2) Strongly Disagree; 3) Disagree; 4) Neither Agree nor Disagree; 5) Agree; 6) Strongly Agree; and 7) Very Strongly Agree. The survey method uses a 90 question on-line survey where the respondents were recruited through an email campaign.

4.5.2 Sample

An initial survey consisted of a sample of 13 organizations from the Department of the Air Force. The organizations were not chosen at random; rather they were chosen by first categorizing the population into functional areas (e.g. Space Acquisitions, Fighter Aircraft, Cargo Aircraft, Sustainment, Simulators, etc.) and randomly selecting an organization within each functional area. Only organizations with more than 40 employees were considered to ensure enough individual data is available to calculate an ICC and aggregate at the organizational level. Although these organizations consisted of direct employees (~57%) and contractors (~43%), only direct employees were asked to take the survey to avoid potential conflicts of interest.

4.6 Study 1 – Results & Discussion

4.6.1 Exploratory Factor Analysis (EFA)

Study 1 resulted in 292 completed individual questionnaires. The EFA utilized individual (vice aggregate) data and was analyzed using IBM SPSS version 18. Factor analysis was executed using the *dimension reduction* option in SPSS. The data representing all 68 questions was considered and several decisions were made concerning the methods to conduct the analysis. The following process (or steps) was used for the analysis.

4.6.2 Factor Analysis

The *univariate descriptive* option calculates the mean and standard deviation for each variable, allowing the user to identify any questions that lack consistency amongst the respondents. The rule of thumb presented by Julious (2005) and its further application to Likert-scale questions by Othman et al. (2011) indicate a ratio of 2:1 for the desired maximum to minimum standard deviation, and any ratio exceeding 2:1 would require additional data scaling and normalization. The maximum and minimum standard deviations were 1.587 and 1.060, resulting in a ratio of 1.50:1 indicating internal question consistency.

The *coefficients* option displays the R-matrix. We expected each test question to correlate with the others since they were developed from known OA characteristics to measure the same underlying dimensions. The R-matrix containing the Pearson correlation coefficients was calculated to identify any issues arriving from low cross-correlations (<0.4). Question 68 was the only item that showed potential issues, as it was poorly cross-

loaded in 64 of the 67 interactions. Question 68 was kept since it still met the criteria for three interactions. Multicollinearity, which is represented by a high cross correlation (>0.9) was not evaluated since it does not negatively impact principal component analysis.

The *KMO and Bartlett's test of sphericity* option was selected to test for sampling adequacy. The Kaiser-Meyer-Olkin (KMO) measure results in a value of 0 to 1; Kaiser (1960) recommends using >0.5 as the threshold cutoff, and Hutcheson & Sofroniou (1999) describe the KMO values of 0.5-0.7 as mediocre, 0.7-0.8 as good, 0.8-0.9 as great, and >0.9 as superb. The Bartlett's test of sphericity indicates sample adequacy if the result is significant (<0.05) or highly significant (<0.001). Study 1 met the sampling adequacy requirements with a KMO of 0.887 (suggested min is 0.5) and rating of *highly significant* per Bartlett's test.

The *principal components* method options focuses on discovering the underlying factors from the data set and calculates the contribution of each variable towards those factors. Principal component analysis is a psychometrically sound procedure and is less complex to calculate than factor analysis (not an option in SPSS) (Fields, 2013). Further, Stevens (2002) concluded it was unlikely that principal component analysis and factor analysis would result in different solutions when more than 30 variables are used.

The *correlation matrix* option (default) is left alone, as selecting the *covariance matrix* option should only be done when variables are commensurable, and the statistical analysis requires it. The *scree plot* option results in a graph that provides a visual representation of the individuals Eigenvalues of each variable. This can be used to determine how many underlying factors are present in the data by visually determining the number of components "to the left" of the point of inflexion. The scree plot for study 1 provided

evidence that three underlying factors were present. Although scree plots are fairly reliable when there are >200 participants, factor selection should not be made by scree plot analysis alone (Fields, 2013). The option to extract values *based on eigenvalues greater than 1* results in the retention of all underlying factors with an eigenvalue greater than 1.0, which is supported by Kaiser (1960). When applied to study 1, 11 underlying factors were discovered with eigenvalues >1.0.

The factor rotation method is important, and the decision to select an orthogonal (varimax, quartimax & equamax) or oblique (direct & promax) should be based on the theoretical understanding of the factors. Oblique rotations are used when the factors are believed to be correlated, while orthogonal rotations assume no correlation between factors. Since deliberate efforts were previously made to reduce question overlap and there was no evidence to support factor correlation, an orthogonal rotation was chosen. From amongst the orthogonal options, *varimax* was chosen since it provides a good general approach and simplifies factor interpretation (Fields, 2013).

Principal component analysis can be drastically affected by missing responses to specific values. Study 1 consisted of 292 participants, but value responses were missing throughout the questionnaire, resulting in some questions having as few as 196 participants. *Excluding cases listwise* would have reduced the data set by eliminating any participant that omitted one or more answers, resulting in an insufficient number (only 99) of questionnaires. Replacing missing values with the mean, although valid in many forms of analysis, was not an effective approach in this study since it would have provided a mean value from across all surveyed organizations rather than the mean for that organization.

Excluding cases pairwise, which excludes a participant's data only when from the calculations where it is necessary, was chosen as it fit the data and situation best.

The initial pass through *dimension reduction* was conducted on the 68 OA questions. SPSS first grouped the measurable variables based on their sum-of-squares and cross-product matrices to determine the relationships between them. By default, this created 68 factors (# of factors equal to # of questions) and calculated the subsequent eigenvalue for each, as shown in Table 14.

Utilizing the recommendations from Kaiser (1960), only factors with an eigenvalue greater than 1.0 were retained, and a subsequent rotated component matrix was calculated to show which measurable variables were allocated to each factor, as shown in Table 15. It is important to note only coefficients greater than 0.4 were retained and are shown in Table 15.

Table 14. Initial Eigenvalues from Factor Extraction

Factor	Initial Eigenvalues			Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %		Total	% of Variance	Cumulative %
1	31.979	47.029	47.029	35	0.332	0.488	92.764
2	2.624	3.858	50.887	36	0.325	0.478	93.242
3	2.088	3.070	53.957	37	0.309	0.455	93.697
4	1.933	2.843	56.800	38	0.295	0.434	94.132
5	1.878	2.762	59.562	39	0.276	0.405	94.537
6	1.777	2.613	62.175	40	0.263	0.387	94.924
7	1.604	2.359	64.534	41	0.249	0.366	95.290
8	1.338	1.968	66.502	42	0.238	0.350	95.640
9	1.314	1.932	68.434	43	0.224	0.329	95.969
10	1.224	1.800	70.234	44	0.214	0.315	96.283
11	1.063	1.563	71.797	45	0.211	0.311	96.594
12	0.995	1.463	73.261	46	0.202	0.297	96.891
13	0.969	1.425	74.686	47	0.189	0.278	97.170
14	0.865	1.273	75.958	48	0.180	0.264	97.434
15	0.863	1.270	77.228	49	0.163	0.239	97.673
16	0.800	1.176	78.404	50	0.155	0.228	97.901
17	0.748	1.100	79.504	51	0.147	0.217	98.118
18	0.735	1.081	80.584	52	0.143	0.210	98.328
19	0.697	1.024	81.609	53	0.127	0.187	98.516
20	0.647	0.952	82.560	54	0.125	0.184	98.700
21	0.628	0.923	83.483	55	0.120	0.176	98.876
22	0.611	0.898	84.382	56	0.107	0.157	99.033
23	0.554	0.815	85.197	57	0.096	0.142	99.174
24	0.531	0.780	85.977	58	0.087	0.128	99.302
25	0.513	0.754	86.731	59	0.081	0.120	99.422
26	0.491	0.722	87.454	60	0.075	0.110	99.532
27	0.476	0.701	88.154	61	0.069	0.102	99.634
28	0.440	0.647	88.801	62	0.062	0.091	99.724
29	0.433	0.637	89.438	63	0.054	0.080	99.804
30	0.409	0.602	90.039	64	0.049	0.072	99.876
31	0.397	0.584	90.624	65	0.043	0.063	99.939
32	0.389	0.572	91.196	66	0.026	0.038	99.977
33	0.371	0.545	91.741	67	0.015	0.023	99.999
34	0.364	0.535	92.276	68	0.000	0.001	100.000

Table 15. Initial Factors from Rotated Component Analysis

Measurable Variable (Actual Label Name Masked)	Factor										
	1	2	3	4	5	6	7	8	9	10	11
10		0.50				0.44					
11		0.63									
12		0.54									
13		0.60									
14	0.43	0.67									
15		0.53									
16		0.54									
17		0.61									
18	0.42	0.67									
19		0.56									
20		0.52									
21									0.53		
22			0.43								
23	0.52										
24		0.46									
25		0.52									
26		0.55									
27								0.74			
28								0.53			
29					0.52						
30	0.67										
31	0.66										
32									0.45		
33	0.56										
34								0.44			
35											
36	0.47	0.43									
37											
38	0.58										
39	0.63										
40	0.59										
41	0.73	0.41									
42	0.78										
43	0.70										
44	0.68										
45									0.76		
46	0.50										
47				0.41	0.42						
48								0.52			
49										0.70	
50							0.43				
51			0.51								
52			0.74								
53			0.77								
54	0.43				0.42						
55				0.51							
56				0.61							
57				0.59							
58				0.75							
59				0.51							
60			0.75								
61										0.70	
62					0.63						
63							0.77				
64							0.56				
65			0.57		0.42						
66			0.52		0.56						
67	0.44										
68											0.77
69					0.68						
70							0.67				
71					0.50						
72	0.52						0.40				
73	0.61										
74	0.66										
75						0.66					
76						0.82					
77						0.79					

In cases where a variable is significant (>0.4) for more than one factor, that variable was considered cross-loaded and subsequently removed from further analysis because it did not adequately measure any single factor clearly. In cases were a variable is not significant for any factor, it was also removed. For the first round of dimension reduction, the items meeting these criteria are highlighted in Table 15. After the removal of these measurable variables, dimension reduction is conducted again using the same options and removal criterion. The intent was to repeat the process and remove cross-loaded or unassigned measurable variables until no additional cross loading was present. After four rounds, no additional measurable variables could be removed according to the criteria, concluding the process. During each round of dimension reduction, the number of factors were recalculated utilizing the same criteria for a minimum eigenvalue of 1.0. The number of retained factors dropped from eleven to seven after the four rounds (dropping by four factors over four rounds is merely coincidence). Overall, this analysis resulted in the elimination of 15 questions. It also set the expectation that the final latent construct should consist of approximately seven factors.

4.7 Study 2 – Methodology

4.7.1 Survey Development

The survey used in study 1 was used as the starting point for study 2. The survey was modified by removing the 15 excess questions found during EFA that did not adequately measure a single factor. The reduced survey contained 75 questions. The goal

of study 2 is to collect data from a larger sample for analysis using Confirmatory Factor Analysis (CFA).

4.7.2 Sample

The sample was also created from the same population as study 1, but this time consisted of 40 organizations without any intentional functional area representation. After removing organizations with less than 40 direct employees, the sample organizations were randomly selected from the population, thus satisfying the assumption of random participants. Due to the same limitation encountered during study 1 in regard to contracted personnel, only direct employees were targeted. The sample consisted of 6,064 individuals representing 40 organizations.

4.8 Study 2 – Results & Discussion

4.8.1 Confirmative Factor Analysis (CFA)

Study 2 resulted in 1,138 completed individual questionnaires. Utilizing the knowledge gained during the EFA, confirmatory factor analysis (CFA) was conducted. Factor extraction was conducted against the 53 OA questions using the same settings/options in SPSS. The lone exception was to set the number of factors to seven (confirmatory method) rather than using the eigenvalues (exploratory method) to determine the how many factors were required.

Internal question consistency amongst participants was again calculated, this time resulting in a minimum standard deviation of 1.199 and a maximum of 1.676. The resulting ratio is 1.398:1, which is well within the guidelines presented by Julious (2005).

Survey 2 met all three tests for sample adequacy. The KMO measure of sampling adequacy was calculated at 0.977 (superb per Hutcheson & S0froniou (1999)). With 1,138 participants, the sample exceeded the requirements set by Kass and Tinsley (1979), which was 265 (5 participants x 53 questions). Further, Bartlett's test of sphericity resulted in a highly significant rating for sample adequacy.

Despite setting the number of factors to seven, it is worth noting that a quick evaluation of the eigenvalues showed that either method would have resulted in seven factors. That is, exactly seven factors had an eigenvalue greater than 1.0, as shown in Table 16.

Table 16. Final Eigenvalues from Factor Extraction

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	28.533	53.837	53.837
2	2.337	4.409	58.246
3	1.597	3.013	61.259
4	1.350	2.547	63.806
5	1.263	2.383	66.189
6	1.151	2.172	68.361
7	1.080	2.038	70.399
8	.941	1.775	72.174
9	.836	1.578	73.751
10	.797	1.504	75.256
11	.770	1.453	76.708
12	.690	1.301	78.009

Since the initial CFA matched the EFA in regard to the number of factors, the objective of the cross-loading analysis shifted from trying to eliminate cross-loaded variables to ensuring there were a sufficient number of variables unique to each factor. There was a strong desire that each factor be comprised of the same number of variables (to allow ease of use during future application) and since factors six and seven only contained three measurable variables, it was decided each factor would consist of exactly

three measurable variables. The top three variables representing each factor, as noted by their coefficients shown in Table 17, were evaluated to ensure they were not cross-loaded with other factors. This resulted in the evaluation of the 20 most important measurable variables, which together, comprise the seven factors necessary to build the latent construct for OA.

Table 17. Coefficients from Rotated Component Matrix

Measurable Variable (Actual Label Name Masked)	Factor						
	1	2	3	4	5	6	7
31	0.75						
74	0.78						
73	0.78						
18		0.63					
16		0.64					
17		0.65					
60			0.79				
52			0.84				
53			0.85				
50				0.53			
63				0.69			
70				0.70			
68					0.61		
48					0.62		
27					0.69		
75						0.75	
76						0.75	
77						0.75	
49							0.57
61							0.68

4.8.2 Structural Model for OA

With both EFA and CFA complete, the OA related questions that comprised each factor were applied. The groupings of OA characteristics allowed for the creation of factor names, as noted in the gray boxes in Figure 18.

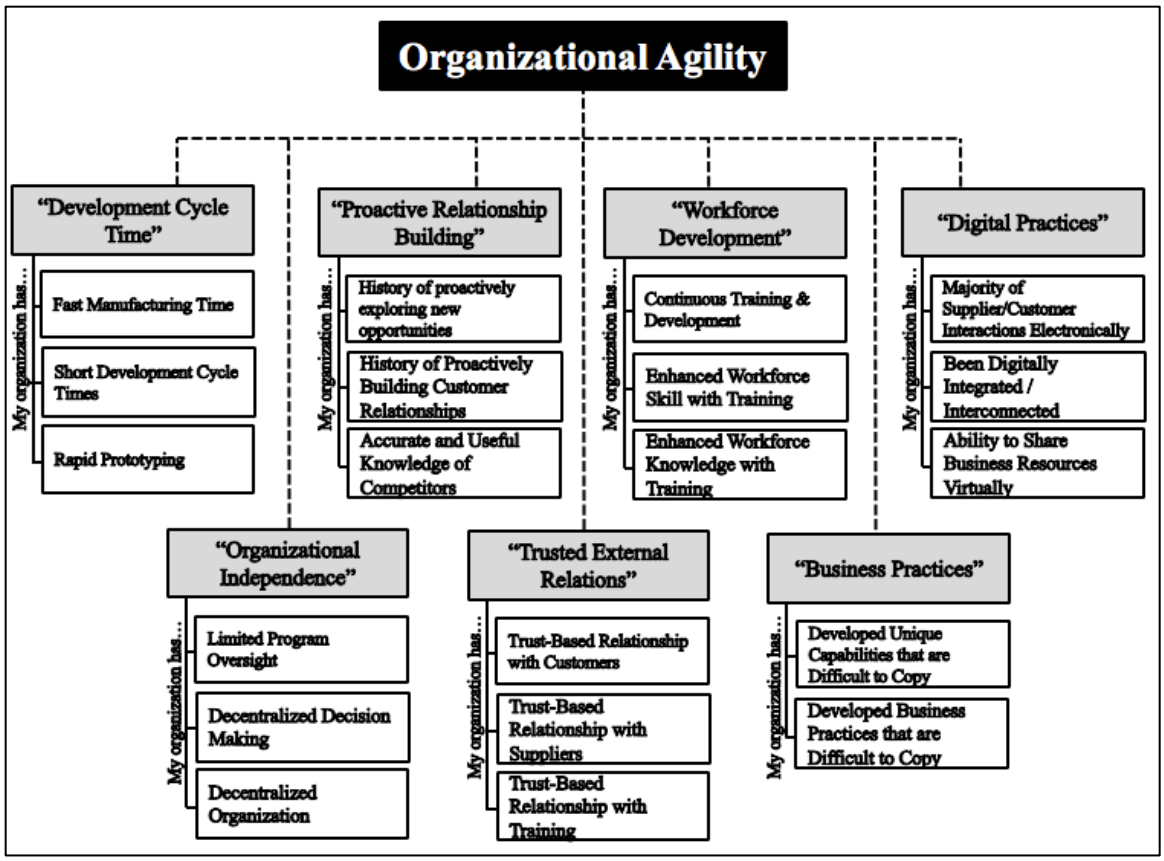


Figure 18. Model of Organizational Agility

4.8.3 Reliability Analysis

To test the reliability of the model, a reliability analysis was conducted using SPSS. Using the Cronbach Alpha model found within the *reliability analysis* menu, the questions for each factor were loaded. The *development cycle time* was the first factor calculated, resulting in a Cronbach Alpha of 0.886. Since any value >0.7 is deemed acceptable, the *development cycle time* factor was found to be reliable. Further Cronbach Alpha calculations, this time in the event that a single question was deleted, were also completed. The objective is to verify that the Cronbach Alpha does not significantly improve if a question is removed. Minor improvements, such as the improvement from 0.886 to 0.900

with the removal of question 31 are considered insignificant. Table 18 shows the Cronbach Alpha for all factors. Although the *business practices* factor had a value of 0.676 and is thus categorized as questionable (0.6≤ Alpha ≤0.7), it was retained.

Table 18. Reliability Analysis

Factor & Questions	Cronbach Alpha	Cronbach Alpha if Item Deleted
Factor 1 - Development Cycle Time	**0.886**	
(31) Fast Manufacturing Time		0.900
(74) Short Development Cycle Times		0.829
(73) Rapid Prototyping		0.782
Factor 2 - Proactive Relationship Building	**0.849**	
(18) History of proactively exploring new opportunities		0.761
(17) History of Proactively Building Customer Relationships		0.752
(16) Accurate and Useful Knowledge of Competitors		0.761
Factor 3 - Workforce Development	**0.950**	
(60) Continuous Training & Development		0.977
(52) Enhanced Workforce Skill with Training		0.904
(53) Enhanced Workforce Knowledge with Training		0.896
Factor 4 - Digital Practices	**0.757**	
(50) Majority of Supplier/Customer Interactions Electronically		0.788
(63) Been Digitally Integrated / Interconnected		0.604
(70) Ability to Share Business Resources Virtually		0.595
Factor 5 - Organizational Independence	**0.706**	
(68) Limited Program Oversight		0.790
(48) Decentralized Decision Making		0.485
(27) Decentralized Organization		0.527
Factor 6 - Trusted External Relations	**0.932**	
(75) Trust-Based Relationship with Customers		0.956
(76) Trust-Based Relationship with Suppliers		0.867
(77) Trust-Based Relationship with Training		0.874
Factor 7 - Business Practices	**0.676**	
(49) Developed Unique Capabilities that are Difficult to Copy		*
(61) Developed Business Practices that are Difficult to Copy		*

* Cannot be computed with less than two variables.

4.8.4 Multi-Level Aggregation

The 1,138 individual suveys represented 40 unique organizations, but up to this point, all analysis was completed at the individual level. Applying the multi-level aggregation critera described earlier, the ICC for each organization was calculated. The

data was first sorted by using a unique organization identifier that was provided to each participant during the survey distribution. It was determined that organizations with less than ten completed surveys were inadequate for aggregation due to an overreliance on each participants' input and the inability to identify outlier responses. Of the 40 organizations, 27 had ten or more respondants and were retained.

The responses to the 20 questions (identified in Table 18) were used to calculate the ICC of each organization. Although SPSS has the capability to calculate ICC, the data was in a format more condusive of the *ICC Calculator* provided by Mangold International (Mangold, 2015). The ICC was calculated using the adjusted method, which removes the mean score difference from the error variance to adjust the score of the most strict and mild raters (outlier reduction). The ICC for 23 organizations met the minimum threshold of 0.75, allowing for the agreggation of data. The individual responses were agreggated at the organizational level by averaging the response to each question. The seven underlying factors were each calculated by averaging the value of their supporting questions. Finally, the estimated OA was calculated by averaging the seven factors for each organization. The ICC, factor values, and OA estimates for each organization is shown in Table 19.

Table 19. Intra-Class Correlation & Organizational Agility

			Factor 1	Factor 2	Factor 3	Factor 3	Factor 5	Factor 6	Factor 7	
Organization ID	Sample Size	ICC	Development Cycle Time	Proactive Relationship Building	Workforce Development	Digital Practices	Empower Decision Making	Trusted External Relationships	Business Practices	Estimated Organizational Agility
6645	15	0.89	4.95	5.52	5.42	5.10	4.93	5.59	4.31	5.12
7315	22	0.75	4.83	5.58	4.73	5.10	4.94	5.46	4.64	5.04
6250	44	0.94	4.72	5.45	5.54	5.09	4.37	5.47	3.96	4.94
9890	16	0.67*	4.28	5.32	5.10	5.23	4.61	4.96	4.80	4.90
7735	16	0.81	3.71	4.97	5.27	4.88	4.34	4.77	4.50	4.63
8110	13	0.83	3.50	5.18	5.38	4.97	4.06	4.80	4.54	4.63
8535	20	0.74	4.08	5.10	4.67	4.53	4.25	5.29	4.06	4.57
8430	40	0.83	4.15	4.98	4.28	5.07	4.35	4.82	4.27	4.56
8220	17	0.84	3.99	5.11	4.98	5.23	4.00	4.83	3.70	4.55
9670	19	0.80	3.88	4.91	5.00	4.54	4.11	4.93	4.26	4.52
5775	32	0.86	4.24	5.12	4.58	4.51	3.94	4.92	4.22	4.50
7945	36	0.90	4.04	5.16	4.66	4.82	3.99	4.99	3.81	4.50
7525	60	0.91	3.84	4.99	4.27	4.85	4.40	4.65	4.34	4.48
8745	103	0.96	3.75	4.99	4.67	4.85	4.15	4.81	4.12	4.48
5110	12	0.59*	4.47	4.80	4.39	4.47	3.81	4.91	4.30	4.45
7210	27	0.89	3.32	4.76	4.98	4.70	3.83	4.95	4.54	4.44
8325	103	0.93	4.04	4.73	4.48	4.54	3.93	4.84	4.26	4.40
7630	22	0.80	3.79	5.12	4.85	4.58	3.64	4.52	4.27	4.39
8955	26	0.83	3.50	4.68	4.65	4.91	4.21	4.75	3.96	4.38
6980	30	0.82	3.77	4.84	4.51	4.62	4.32	4.51	3.70	4.32
8850	78	0.94	3.54	4.80	4.67	4.74	4.00	4.47	4.00	4.32
5350	15	0.63*	3.42	4.58	4.05	4.28	3.63	4.34	4.67	4.14
6865	53	0.94	3.28	4.66	4.31	4.52	3.74	4.76	3.68	4.14
7840	11	0.93	2.37	4.94	5.16	4.19	2.90	4.89	3.94	4.06
5025	24	0.76	3.34	4.20	4.01	4.43	4.05	4.28	3.33	3.95
5275	14	0.69*	3.05	4.05	4.29	3.91	3.74	4.31	4.11	3.92
8640	10	0.80	3.60	4.30	3.76	4.83	2.40	4.12	3.76	3.82

* Denotes a ICC that fails to meet the stablished threshold of ≥0.75.

4.9 Application of OA Assessment

Through the application of the 20 question survey, seven important underlying factors and an estimate for OA can be assessed. By applying this measure to an organization, a self assessment can be made. Let's review an organization to see how this could be done.

Scores could range from 1.0 to 7.0. Organization "8640" scored an overall OA value of 3.85, the lowest of those measured in this study. A breakdown of individual questions is shown in Table 20. Using this scorecard, one can readily identify where to apply additional resources and make improvements to improve their overall OA. The highest factor scores were found in *Digital Practices* (factor 4) and *Proactive Relationship*

Building (factor 2), indicating they have embraced technology to interface electronically and that their relationships with those customers and suppliers has flourished. The lowest score is in the area of *Organizational Independence* (factor 5), indicating that individuals feel they lack decision making independence and empowerment and that it is having a significant negative impact on their OA. Providing additional empowerment and decentralized decision making capability within this organization could increase their overall OA.

Table 20. Organization "8640" OA Scorecard

Factor & Questions	Question Score	Factor Score	Overall OA Estimate
Factor 1 - Development Cycle Time			
(31) Fast Manufacturing Time	3.38		
(74) Short Development Cycle Times	3.43	**3.60**	
(73) Rapid Prototyping	4.00		
Factor 2 - Proactive Relationship Building			
(18) History of proactively exploring new opportunities	4.11		
(17) History of Proactively Building Customer Relationships	4.50	**4.30**	
(16) Accurate and Useful Knowledge of Competitors	4.29		
Factor 3 - Workforce Development			
(60) Continuous Training & Development	3.67		
(52) Enhanced Workforce Skill with Training	3.80	**3.76**	
(53) Enhanced Workforce Knowledge with Training	3.80		
Factor 4 - Digital Practices			
(50) Majority of Supplier/Customer Interactions Electronically	5.00		**3.82**
(63) Been Digitally Integrated / Interconnected	4.80	**4.83**	
(70) Ability to Share Business Resources Virtually	4.70		
Factor 5 - Organizational Independence			
(68) Limited Program Oversight	2.00		
(48) Decentralized Decision Making	2.50	**2.40**	
(27) Decentralized Organization	2.70		
Factor 6 - Trusted External Relations			
(75) Trust-Based Relationship with Customers	4.38		
(76) Trust-Based Relationship with Suppliers	4.14	**4.12**	
(77) Trust-Based Relationship with Training	3.83		
Factor 7 - Business Practices			
(49) Developed Unique Capabilities that are Difficult to Copy	4.11	**3.76**	
(61) Developed Business Practices that are Difficult to Copy	3.40		

4.10 Implications

This research allows for the measurement of Organizational Agility within large organizations through the use of a 20 question survey. We reduced the list of important OA questions from 98 to only 20 by eliminating redundant and overlapping concepts and the application of factor analysis to a real-world sample of 53 organizations containing over 1,400 respondents. With these results, leaders can better understand and measure their OA over time and against similar organizations. Further, it will allow organizations to redirect resources towards any areas related to agility that may be lacking.

4.11 Limitations & Future Work

This research pulled a sample from the population of large U.S. Air Force organizations and its findings may only be directly applicable to that population. Expansion to a larger population is expected to increase measure reliability and domain applicability.

The *business practices* factor only contains two questions. As it currently stands, the 18 questions measuring the other six factors each represent 1/21 (1/7 x 1/3) of the final OA estimate, and the two questions for *business practices* represent 1/14 (1/7 x 1/2). Further question development to include a third question that can also measure the underlying dimension of *business practices* would allow for a more uniform representation of each question in the final estimation of OA.

Additional research is required to validate these initial results. Expansion of the sample set, a change to the test population, or a more thorough analysis of a few of the organizations would provide additional evidence to validate the proposed model.

V. Organizational Agility: An Evaluation of Convergent and Discriminant Validity

5.1 Chapter Overview

This chapter contains the efforts to validate the latent construct to measure Organizational Agility. The paper has been submitted for publication in the Journal of Management in Engineering. The full text of this manuscript (excluding bibliography) begins on the following page.

5.2 Abstract

A recently developed latent construct to measure Organizational Agility (OA) is evaluated by examining 6 different additional traits across 40 organizations that were measured during the original data collection survey. The principles of convergent and discriminant validity are applied to examine the validity of the OA model. Traits are developed and tested for reliability. Correlation coefficients are calculated, discussed and used to assess the OA model validity. Initial expectations are compared to calculated results. Traits that bring the models validity into question are found and discussed. Evidence to support convergent and discriminant validity for the OA model was found. Analysis techniques are discussed and several recommendations to continue this validation effort are offered.

5.3 Introduction

Organizations that can adapt to their changing environment are afforded the opportunity to flourish; those that cannot adapt often perish. Organizations that can modify their operations under the conditions of necessity and opportunity are known as *agile*. Theorizing and measuring *organizational agility* (OA) has remained a challenge spanning three decades (Goldman et al, 1995, Cho et al, 1996, Kidd, 1995, Feng and Zhang, 1998, Sharifi and Zhang, 1999, Yusuf et al, 1999, Grewal and Tansuhaj, 2001, Van Oosterhout, 2006, Teece et al, 2016, Geiger et al, 2020, Walter, 2020). The mere task of creating a unified definition of OA has even proven difficult; a recent systematic literature review identified over 70 relevant OA publications and 24 different definitions (Walter, 2020,

Geiger et al, 2020). The definition drafted by Teece et al (2016) provides a meaningful basis of understanding, has wide applicability across different disciplines, and has garnered significant support across the community.

> **Organizational Agility:** "Capacity of an organization to efficiently and effectively redeploy/redirect its resources to value creating and value protecting (and capturing) higher-yield activities as internal and external circumstances warrant" (Teece et al., 2016, p.17).

Multiple researchers have attempted to measure OA. Efforts to develop first-order models (Adler et al, 2008, Bahrami, 2012), two-dimensional models (Singh et al, 2018), graphical representations (Singh et al 2018), a comprehensive survey tool (Erande & Verma, 2008), and an agility index (Lomas et al, 2006) have shown that measuring OA is quite difficult. Suffering from a high reliance on experts, judge subjectivity, and/or issues with external validity, each of these methods leave room for additional work.

Numerous researchers have assembled lists and categorized the attributes related to OA. The descriptors often used include *characteristics, drivers, enablers, capabilities, factors, indicators* and *dimensions* (Walter, 2020, Geiger et al, 2020). Although acute and valid distinctions can be made between the different categorization schemes offered, those differences become unnecessary when operationalizing the concept of OA. A list containing 88 of these characteristics was assembled by combining the results of a detailed 3-round Delphi study by Kuruppalil (1998), surveys by Yusuf et al (1999), and in-person interviews by Lepore et al (2012). The Q-sort method, first identified by Catell (1946) and

refined by Stephenson (1953) and Block (1961), utilized a set of judges to identify and eliminate duplicate characteristics, resulting in a set of 64 unique items (Geiger et al 2020).

Utilizing the 64 OA characteristics, a survey questionnaire was developed and distributed to individuals representing 11 organizations. Exploratory Factor Analysis (EFA) was conducted on the 259 survey responses, and an initial latent construct was developed. A second survey was sent to individuals representing 40 organizations (unique from the 11 organizations), resulting in 1,138 responses. Applying Principal Component Analysis (PCA) with the data from the second survey, a latent construct to measure OA was developed, as shown in Figure 19(Geiger et al, 2020). OA was subdivided into seven dimensions, each consisting of 2-3 survey questions relating to the characteristics found by Kuruppalil (1998), Yusuf et al (1999), and Lepore et al (2012).

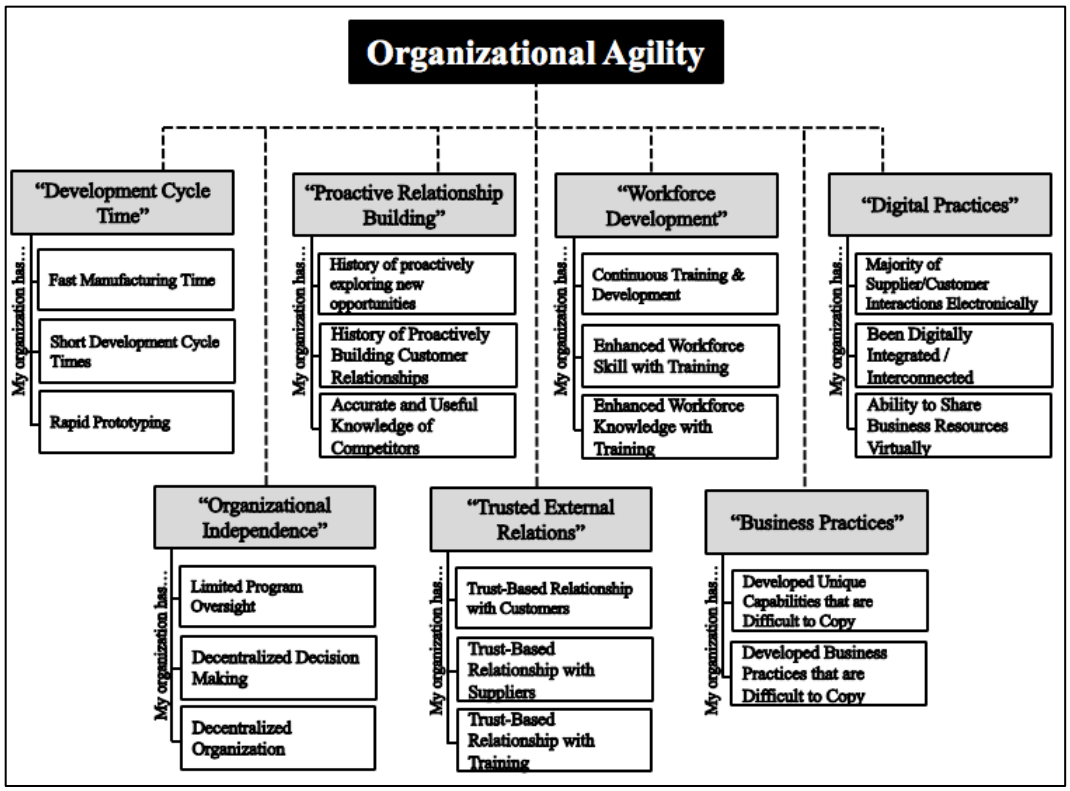


Figure 19. Latent Construct to Measure Organizational Agility

The goal of this paper is to continue the validation efforts of the OA latent construct that was previously provided by Geiger et al (2020B). The data set from Geiger, et al is used to examine the convergent and discriminant validity.

This paper is comprised of four sections, including: theoretical framework, research proposal, methodology, and the results & discussion.

5.4 Theoretical Framework

The framework to examine the validity of a new construct in the field of organizational science involves five key components: content validity, internal consistency, nomological validity, convergent validity and discriminant validity (Venkatraman and Grant, 1986). Content validity is achieved by the review and acceptance

of the construct by additional scholars and experts. Internal consistency is measured by the uni-dimensionality of the underlying factors and reliability measures. Nomological validity is achieved through the confirmation of the model predictions. Convergent validity is "the confirmation by independent measurement procedures" (Campbell and Fiske, 1959, p.81). Divergent validity refers to the "establishment of separation between variables" (Harris, 2004, p.862). A summary of the five validation components is shown in Table 21.

Table 21. Summary of Validation Components

TYPE	MEANING
Content Validity	Review and acceptance of a construct by scholars and experts.
Internal Consistency	Measure of uni-dimensionality of the underlying factors and reliability measures.
Nomological Validity	The degree that a theoretical model makes accurate predictions.
Convergent Validity	Degree to which two or more measures of a construct that are theoretically related are found to actually be related.
Discriminant Validity	Degree that two or more measures of a construct that are theoretically unrelated are found to actaully be unrelated.

This paper will focus on analyzing convergent and discriminant validity. The multitrait-multimethod matrix (MTMM) procedure, first provided by Campbell and Fiske (1959) is the most commonly used test for convergent and discriminant validity. MTMM was designed to analyze multiple data collection methods and multiple traits simultaneously. Although the data set available for this study is sufficiently large (1,138 survey respondents among 40 organizations), only a single data collection method was available. Thus, an adaptation of MTMM was used.

To determine if a variable relates with the proposed construct, the correlation coefficient between additional traits and the construct are calculated. The resultant coefficient is then evaluated to determine if it provides evidence of convergent or discriminant validity. Criteria were necessary to assess the level of correlation between the traits, as direct comparison between correlation values typical in a MTMM was not

possible. The criteria is based on a 2-step process. First, the significance level (using two-tailed method) was evaluated. For items that shows significance at the 0.05 level, the correlation coefficient was evaluated using the guidance provided by Cohen (1992) in his review of effect sizes and their applicability to social sciences. For items that were not found significant, that in itself was sufficient evidence for discriminatory validity. A summary of the validity criterion is shown in Table 22

Table 22. Validity Criterion

Siginificance (2-tailed)	Correlation Coefficient Value	Effect Size	Evidence of Convergent Validity	Evidence of Discriminant Validity
<0.01	0.40	Large	Yes	
<0.01	0.25	Medium	Yes	
<0.01	0.10	Small		
<0.05	0.40	Large	Yes	
<0.05	0.25	Medium	Yes	
<0.05	0.10	Small		
>0.05	-	-		Yes

5.5 Proposal

This study attempts to answer the research question of whether or not the latent construct to measure OA provided by Geiger et al (2020) exhibits convergent and discriminant validity. Through the analysis of 50 additional measured variables, each collected during the survey process and representing the same 40 organizations from the original study, convergent and discriminant validity was assessed. Based on the previous discussion, we will examine the convergent and discriminant validity of OA.

Proposal 1: Evidence to support convergent validity of the OA latent construct will be found.

Proposal 2: Evidence to support discriminant validity of the OA latent construct will be found.

5.6 Methodology

5.6.1 Data

The survey used to create the OA construct included 1,138 responses representing 40 organizations. The scores were gathered using a 7-point Likert scale. The individual responses were then grouped and aggregated to represent the higher, organizational level in accordance with the recommended procedures by Chan (1998). This was done by averaging the value of each question within an organizational grouping. This resulted in 40 organizations (n=40), each consisting of 70 questions.

The 20 questions used to formulate the seven underlying dimensions (see Figure 19) were used to calculate an overall OA score for each organization. The OA score formed the baseline value in which to calculate the correlation coefficients.

5.6.2 Data Analysis

The remaining 50 questions became the focus for this validity analysis. Using principal component analysis, 13 questions were identified and grouped to represent 5 additional underlying dimensions. An additional 9 questions were also used to estimate OA using the two-dimensional Comprehensive agility curves developed by Singh, et al (2018). Together, the agility curve score and the 5 dimensions represent the 6 traits used in the validity analysis. To calculate a single value for each trait, a simple (non-weighted) average of the questions forming each trait was used.

Reliability analysis was conducted and evaluated for each trait. The Chronbach Alpha for each trait was greater than 0.7, and thus all traits were deemed reliable. Table 23 shows the breakdown of the questions that were used to form each trait and their

calculated Chronbach Alpha. Four of the traits (traits 1-4) were expected to support convergent validity and two (traits 6-7) to support divergent validity. The two-tailed significance level and correlation coefficient of each trait was then calculated against the resultant OA score (calculated utilizing the OA construct).

Table 23. Summary of Traits and Reliability Analysis

Traits & Questions	Cronbach Alpha	Cronbach Alpha if Item Deleted
Trait 1 - "Agility Curve"	**0.916**	
My organization has been specifically identified as being "agile" (in your title, mission statement, etc.)		0.910
My organization is agile.		0.892
Others inside my organization would consider our organization to be agile.		0.894
Others outside my organization would consider my organization to be agile.		0.901
My organization meets the required output (product, services, etc.) that the customer desires.		0.904
My organization provides a variety of products, services and/or capabilities.		0.922
My organization has the capability to provide additional products/services/capability if needed.		0.919
My organization exceeds (provides early) the industry standard for similar products or services.		0.902
My organization meets the customer desired timeline.		0.911
Trait 2 - "Employee Satisfaction"	**0.923**	
Employees that are satisfied		0.911
Internal integration of information		0.890
A culture of change		0.923
An adapative evaluation and reward metric system		0.871
Trait 3 - "Rapid Product Development"	**0.873**	
Rapid delivery of product/service		*
Fast product development cycle		*
Trait 4 - "Requirements Stability"	**0.708**	
A stable set of customer requirements		*
A desire to only focus on mature technologies		*
Trait 5 - "Individual Demographics"	**0.857**	
Which best describes your primary function?		0.827
How would you describe your employment type?		0.796
How many years of acquisition experience do you have?		0.784
Trait 6 - "Job Longetivity"	**0.807**	
Years with current employer?		*
Year in current organization?		*

* Cannot be computed with two or less variables.

5.7 Results & Discussion

5.7.1 Convergent Validity

A summary of the correlation coefficients and the support, if any, that they provide is shown in Table 24. Of the 4 traits that were expected to be convergent, all 4 exhibited evidence of convergent validity (effect size of medium or greater). Trait 1, which represented the "agility curve" measurement method by Singh et al (2018) exhibited a high correlation coefficient (0.923). This is the most consequential finding of this analysis; that is, the proposed latent construct to measure OA results in a score that is closely aligned with the existing method proposed by Singh et al (2018). This provides evidence that the agility curves model and the latent construct to measure OA, both of which were developed within their own domains, may be suitable across additional domains. In regards to proposal #1, this study found evidence to support the latent construct to measure OA in the form of convergent validity.

Table 24. Correlation Coefficients of Individuals Traits Against OA Score

Trait	Expected Type of Validity Supported	Correlation Significance (2-tailed)	Correlation Coefficient	Effect Size	Support Provided
Trait 1 - "Agility Curve"	Convergent	0.000	0.923	Large	Convergent
Trait 2 - "Employee Satisfaction"	Convergent	0.000	0.604	Large	Convergent
Trait 3 - "Rapid Product Development"	Convergent	0.000	0.676	Large	Convergent
Trait 4 - "Requirements Stability"	Convergent	0.018	0.371	Medium - Large	Convergent
Trait 5 - "Individual Demographics"	Discrimant	0.221	-	-	Discriminant
Trait 6 - "Job Longevity"	Discrimant	0.129	-	-	Discriminant

5.7.2 Discriminant Validity

Of the 2 traits that were expected to provide discriminant validity, both provided evidence of discriminant validity. Trait 5, which represented the individual respondent's demographic information, had a correlation significance of 0.221. Similarly, trait 6, which

represented the respondent's job longevity, had a correlation significance of 0.129. The means that there is not a significant correlation between traits 5 or 6 and the agility score at either the 0.01 or 0.05 level, resulting in evidence to support discriminant validity. In regards to proposal #2, this study also found evidence to support the latent construct to measure OA in the form of divergent validity.

5.8 Conclusions

The latent construct to measure OA provided by Geiger et al (2020) was examined and the principles for assessing convergent and discriminant validity were applied. The original survey data was used to conduct the analysis, providing data pertaining to 50 additional questions across 40 organizations for examination.

The questions were reduced and grouped to represent six different, additional traits. Of the four traits expected to exhibit convergent properties, all four provided significant evidence of convergent validity. Of the two traits expected to exhibit discriminant properties, both provided significant discriminant validity. Overall, evidence was found to support both convergent and discriminant validity.

The results of this study on the validity of the construct to measure OA show that there is significant work remaining. In regards to the five components of validity, initial steps of both the internal consistency and discriminant validity milestone have been achieved. It is suggested that additional data collection methods are used to investigate the additional traits and to further analyze the convergent/discriminant validity using MTMM.

VI. Conclusions & Recommendations

6.1 Conclusions of Research

There are a number of important conclusions that arose as a result of this research topic. The key conclusions can be summarized as follows:

- Organizational Agility is a highly desired organizational characteristic, yet a consistent and accepted definition was difficult to find. A significant number of alternative definitions were being used. The definition provided by Teece et al (2016) is both suitable and directly applicable to the Department of Defense.

- Division amongst the community exists in regard to the meaning, importance, and application of OA. Research to date has followed these channelized domains, consisting of manufacturing, defense, technology, and software.

- Existing methods to measure OA have each focused on single domains. External validity of each model was questionable when applied in across different domains. No models existed that targeted DoD organizations.

- There are a large number (>90) of organizational characteristics related to OA. A small subset (20) can be used to effectively estimate an organizations overall agility.

- OA can be measured proactively and continuously to ensure that an organization is poised to capitalize on new opportunities. Measuring solely on past events is a reactionary approach and can be less accurate.

6.2 Significance of Research

This research can be applied to achieve significant improvements across the DoD. The six most significant impacts of this research are described as follows.

6.2.1 Defining Organizational Agility

During the course of this research, it was found that although the term *agility* was commonly used, each individual had a different fundamental understanding and belief as

to what it actually meant based upon their experiences to date. Further, unlike uncommon terms where individuals are poised to inquire to their meaning, most people questioned felt that they had a good understanding of agility. Together, these two qualities resulted in a general closed-mindedness to seek a common ground of understanding and an area where miscommunication is commonplace.

Through a detailed review and summarization of existing literature, a common definition was found and supported. This definition is agnostic to the subtle differences between the domains that are found in most other definitions. Further, additional terms were explored and defined to increase the clarity of the ontological structure of related terms. Together, the supported definition and ontology of terms provide much needed clarification to this research area. By offering a single, complete and accepted definition for *organizational agility*, the DoD can now re-establish a baseline understanding of the term.

6.2.2 Establishing the Set of OA Characteristics

An expanded set of OA characteristics was developed. A detailed literature search and background study was completed to locate and identify pertinent characteristics related to OA. Utilizing three highly researched and distinct sets of OA characteristics, each representing a different domain or industry focus, a larger, more encompassing set was created. The aggregation of characteristic sets, by its very nature, greatly decreased the likelihood that a particular important characteristic was missing, as it would have to have been missing in all three of the original researcher's lists. Redundancies were analyzed and eliminated utilizing an established and defensible method with multiple judges,

resulting in a set of 64 OA characteristics applicable across multiple domains. This expanded set of OA characteristics offers several distinct advantages over the previous sets, including: 1) cross-domain applicability; 2) decreased probability that an important characteristic is omitted; 3) greater number of characteristics upon which a latent construct can be developed, and; 4) greater variance in individual term boundaries and overlapping areas allowing for increased precision in construct development.

6.2.3 Latent Construct to Measure OA

The most significant portion of this research is the development of a latent construct to measure OA. A survey was developed and distributed to 53 organizations. Using the combined responses of over 1,350 respondents, a latent construct consisting of 20 questions was developed. This 20-question survey can be used by leaders and managers to quickly and efficiently measure an organization's agility. With these results, leaders can better understand and measure their OA over time and against similar organizations.

6.2.4 Area Identification & Resource Allocation

By employing the survey, a leader can establish their group's OA baseline score. It also provides a score breakdown across the seven most imporant dimensions. The dimensional breakdown provides the necessary insight, data, and tools to re-allocate internal resources to address deficiencies and improve overall agility. The OA score also provides an avenue for individuals within an organization to collectively identify problem areas that may otherwise go unnoticed by at the higher levels.

6.2.5 Continuous Metric

The latent construct can be applied repeatedly by each organization on an established timeline (quarterly, annually, etc.). This will allow the tracking of the OA score over time, providing key insight on an organization's agility score. Evaluating the trendline will also provide the necessary feedback to understand the impacts of the individual changes, allowing leaders to make more informed and impactful future decisions. Simply put, the metric allows for the incorporation of the full OODA loop and thus continuous and targeted OA improvement.

6.2.6 Applying Aggregate OA Scores for Strategic Decision Making

Although scored at the lower unit level, the agility scores will provide significant utility at the agreggate level. A leader at the executive level with access to agility scores across each of their sub-organizations can make more informed, strategic decisions. For example, if the scores of multiple sub-organizations are being lowered by a lack of digital practices (factor 4), the leader would have the information to determine if a significant strategic investment in that area is necessary. An alternative example is that when a new set of work/tasks are taken on by a larger organization, the executive leader can use the OA scores to determine which sub-organization may be best poised to accomplish it.

6.3 Application to Research Questions

This research focused on providing the necessary evidence to adequately answer three research questions. A summary of the research questions and the work completed to answer them follows.

6.3.1 Research Question #1: What are the characteristics of agile organizations that are related to organizational agility?

A thorough review of relevant literature found several publications with characteristics related to organizational agility. Authors vary their categorization methods, using terms such as *drivers, enablers, capabilities, factors, indicators* and *dimensions,* to describe these different characteristics. It was found that three publications encompassed nearly all of the characteristics noted by other researchers. These publications included a Delphi study completed by Kuruppalil (1998), a detailed literature review completed by Yusuf et al. (1999), and a structured interviews conducted by Lepore et al. (2012). These characteristics were combined (Table 8) and redundant items were removed (Table 9).

6.3.2 Research Question #2: What are the current methods, if any, used to measure organizational agility? What are their strengths and weaknesses?

A review of existing method to measure organizational agility was completed as part of the literature review. Seven leading methods were captured and described through five different constructs. The constructs consist of a *two-dimensional dichotomy, first-order models, agility curves, a comprehensive measurement tool (CAMT),* and a *key agility index (KAI)* (Singh et al., 2018; March, 1991; Adler et al., 2008; Bahrami, 2012; Erande & Verma, 2008; Lomas et al., 2006). Each method was explored and analyzed, and

limitations highlighted in the paper titled "Establishing the Foundations to Measure Organizational Agility Across the DoD." A summary of these methods and their limitations is contained in Table 10.

6.3.3 Research Question #3: How can these characteristics be used to estimate organizational agility?

Exploratory factor analysis (EFA) was applied to a preliminary study with over 250 respondents representing 13 organizations to establish the structure of a latent construct to measure OA along with the individual characteristics necessary to calculate its factors. A second study, this time representing 40 organizations and with over 1,100 respondents, used confirmatory factor analysis (CFA) to confirm and validate the latent construct, its factors, and the fundamental questions necessary to measure OA. The 20 measurable variables and their contribution to the overall measurement of OA is shown in Figure 19.

Through the application of an example, the OA construct was applied to organization identified as "8640." The example showed how to apply the 20-question Likert-type survey and to calculate the overall OA score. Further, it used the interim results of each factor score to determine which practices, if any, should be refined to improve agility. This example was highlighted in Table 20.

6.4 Recommendations for Future Research

This research advanced the knowledge and the application of Organizational Agility. It is part of an ongoing effort, and significant future research is needed. Recommendations for the next steps in this research are as follows:

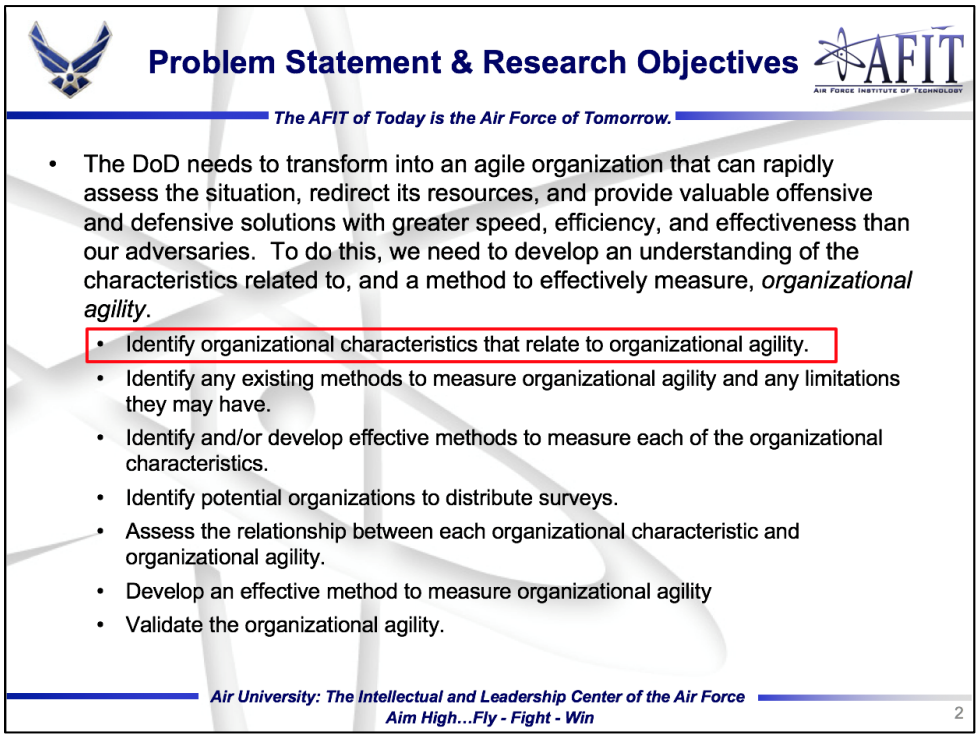
- The *business practices* factor only contains two questions. As it currently stands, the 18 questions measuring the other six factors each represent 1/21 (1/7 x 1/3) of the final OA estimate, and the two questions for *business practices* represent 1/14 (1/7 x 1/2). Further question development to include a third question that can also measure the underlying dimension of *business practices* would allow for a more uniform representation of each question in the final estimation of OA.

- This research pulled a sample from the population of large U.S. Air Force organizations and its findings may only be directly applicable to that population. Expansion to a larger population is expected to increase measure reliability and domain applicability.

- Additional research is required to validate these initial results. Expansion of the sample set, a change to the test population, or a more thorough analysis of a few of the organizations would provide additional evidence to validate the proposed model.

- One or more additional measurement techniques (other than survey) should be used to collect similar data. Combining this with the data already collected would allow the application of Multitrait Multimethod (MTMM) analysis and validation.

Appendix A: Q-Sort Instructions for Judges



Literature Review

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- Hundreds of publications pertaining to agility (and related terms); a few that were source documents for relevant characteristics
  - Yufus, et al (1999) –commercial industry
  - Kuruppalil (2007) – manufacturing
  - Lepore, et al (2012) – rapid DoD acquisitions

Kuruppalil (2007)	Yusuf, et al (1999)	Lepore, et al (2012)
Adaptive evaluation and reward metric	Concurrent execution of activities	Build and Maintain Trust
Capability to quickly adjust business	Enterprise integration	Designing out All Risk Takes Forever…Accept Some Risk
Capability to quickly adjust organizational characteristics/desig	Information accessible to employees	Incremental Deployment (Development) is Part of the Product Plan
Concurrent engineering	Multi-venturing capabilities	Keep an Eye on "Normalization"
Concurrent technology	Developed business practice difficult	Maintain High Levels of Motivation and Expectations
Continuous improvement	Empowered individuals working in teams	Populate Your Team with Specific Skills and Experience
Customer and supplier integration	Cross functional teams	Right-size the Program - Eliminate or Reduce Major Program Oversight
Decentralized organization	Teams across company borders	Strive for a Defined Set of Stable Requirements Focused on Warfighter Needs
Developing unique capabilities and characteristics difficult to copy	Decentralized decision making	The Government Team Leads the
Development of effective responses to new challenges from competitors	Technology awareness	
Effective sensing of changes in the business environment	Leadership in the use of current technology	
Electronic commerce	Skill and knowledge enhancing technologies	
Employee satisfaction	Flexible production technology	
	Quality over product life	
	Products with substantial value-	

Prospectus Progress

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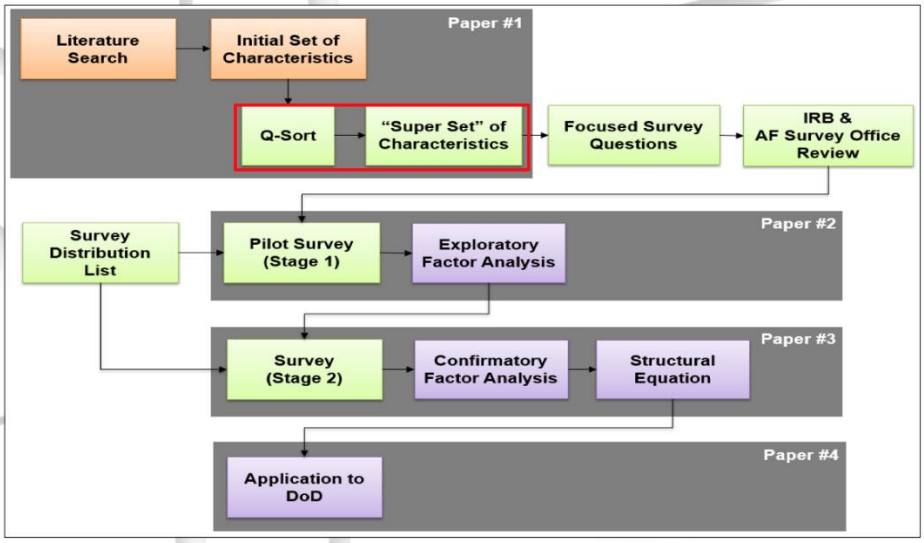

Q-Sort Overview

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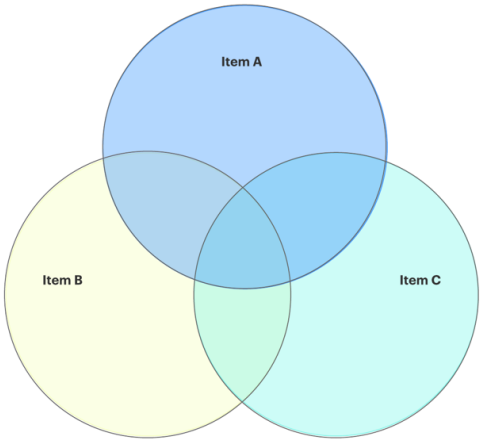

- **Objectives:**
  1. Reduce the characteristics set
  2. Find & eliminate duplicates
- **Trade-Space**
  - Choose Type I errors over Type II…would rather have two characteristics that significantly overlap in meaning than to eliminate a unique characteristic.

Q-Sort Method: Step 1

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Three Phase Process

1. Two or more judges are requested to sort items into different constructs
   a. Judges assign items to constructs
   b. Review the results each construct.
   c. Determine level of agreement.
   d. Calculate Cohen's Kappa Coefficient.
   e. Move to step 2 if:
      1. Excellent Agreement (0.76 – 1.0)
      2. Fair to Moderate Agreement (0.4 – 0.75) and all judges agree that further discussion is futile.
   f. Review disagreement items between judges to find resolution and re-start on step a.

	Cat 1	Cat 2	Cat 3	Other	
Cat 1	P_{11}	P_{12}	X_{13}	P_{14}	$\mathbf{P_{1+}}$
Cat 2	P_{21}	P_{22}	X_{23}	P_{24}	$\mathbf{P_{2+}}$
Cat 3	P_{31}	P_{32}	P_{33}	X_{34}	$\mathbf{P_{3+}}$
Other	P_{41}	P_{42}	X_{43}	P_{44}	$\mathbf{P_{4+}}$
	P_{+1}	P_{+2}	P_{+3}	P_{+4}	**100**

Q-Sort Method: Step 2

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Three Phase Process

2. Two or more judges are requested to sort items into different constructs
   a. Brainstorm to determine news constructs
   b. Judges assign items to constructs
   c. Review the results each construct.
   d. Determine level of agreement.
   e. Calculate Cohen's Kappa Coefficient.
   f. Move to step 2 if:
      1. Excellent Agreement (0.76 – 1.0)
      2. Fair to Moderate Agreement (0.4 – 0.75) and all judges agree that further discussion is futile.
   g. Review disagreement items between judges to find resolution and re-start on step b.

Q-Sort Method: Step 3

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Three Phase Process

3. Two or more judges review items within a single construct (from step 2) to eliminate redundancy
   a. Choose Type I errors over Type II…would rather have two characteristics that significantly overlap in meaning than to eliminate a unique characteristic.

Appendix B: Organizational Agility Survey

Organizational Performance

Introduction & Disclaimer

Researchers from the Department of Systems Engineering and Management at the Air Force Institute of Technology are examining the relationship between employees and performance variables important to an organization. You have been selected to participate in a voluntary survey about your organization and the program(s) you work on. The survey will take about 15 minutes to complete.

The survey will ask you to provide some general information about yourself, as well as ask you questions related to your organization and the program(s) that you work on. The risk involved by participating in this research project is minimal and is similar to that which is found in everyday life. We want to emphasize that the survey is voluntary and that your participation is greatly appreciated. If you agree to participate, you may withdraw your participation at any time without penalty.

While your survey responses will be kept confidential, summarized responses may be released to the public. Additionally, we cannot provide confidentiality to a participant regarding comments involving criminal activity/behavior, or statements that pose a threat to yourself or others. Do NOT discuss or comment on classified or operationally sensitive information at any point in this survey.

If you have any questions about this research project, please contact Maj Jeremy Geiger (937-255.6565 ext 6128 or Jeremy.Geiger@afit.edu).

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VOLUNTARY PARTICIPATION IN THE SURVEY INDICATES YOUR CONSENT AND THAT YOU HAVE HAD THE OPPORTUNITY TO READ THIS INFORMATION FORM AND ARE PREPARED TO PARTICIPATE IN THIS PROJECT.

Privacy Act Statement
Authority: 10 U.S.C.; 8013, SECAF
Purpose: To provide AFIT with information regarding the relationship between employees and organizational performance variables.
Routine Uses: Feedback will be used to determine the key performance enablers of organizations within the Air Force.

Disclosure: Providing information in this survey is voluntary. Individual responses will not be shared with others unless required by law. The survey results are reported only in a manner that does not identify an individual.

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1. How would you describe your employment type?

- ◯ Government Civilian
- ◯ Civilian (Non-Government)
- ◯ Military (Active or Reserve)
- ◯ Other

2. Which best describes your primary function?

- ◯ Program Management
- ◯ Engineering
- ◯ Finance
- ◯ Contracting
- ◯ Logistics
- ◯ Test
- ◯ Operations
- ◯ Other

3. How many years...

	0-1 years	2-5 years	6-10 years	>10 years	N/A
of acquisition experience do you have?	◯	◯	◯	◯	◯
have you been with your current employer?	◯	◯	◯	◯	◯
have you been in your current organization?	◯	◯	◯	◯	◯

4. Are you a supervisor?

- ◯ Yes
- ◯ No

Organizational Performance

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It is important that we properly define what constitutes your *organization*. For the purposes of this survey, your organization is defined as "the organized body of people established to fulfill a single objective."

- For DoD acquisitions, this will be the smallest unit that you are part of that predominantly works towards a single program of record. That is most often the lowest level of a program that is described by an ACAT level. As an example, if an individual was the Program Manager for an ACAT III landing gear upgrade to the KC-135, their organization would be defined as the body of people assigned to the landing gear upgrade program, not at the KC-135 program level.
- For DoD operations, this will be the smallest unit that you are part of that has a single, identifiable and published mission, and is most often the squadron (or equivalent) level.
- For all others, this will be the smallest organized body of individuals that contains multiple job disciplines but still report to a single individual or office and are similarly focused on a common objective. As an example, in vehicle manufacturing, this would be the group of individuals that work on assembling a single vehicle type, which would include assemblers, painters, quality assurance, supervisors, etc., that all report to a single person (production manager), and share the objective of production output of that product.

For individuals who are assigned to more than one program, reference the program of which you spend a majority of your effort.

The next questions focus on your opinion in regards to your organization's agility. Please use the following definition for informing your answers.

- **Organizational Agility:** "Capacity of an organization to *efficiently* and *effectively* redeploy/redirect its resources to *value creating* and *value protecting* (and capturing) *higher-yield* activities as internal and external circumstances *warrant*"

5. I believe that...

	Very Strongly Agree	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Very Strongly Disagree	N/A or I Don't Know
my organization has been specifically identified as being "agile" (in your title, mission statement, etc.)	○	○	○	○	○	○	○	○
my organization is agile.	○	○	○	○	○	○	○	○
others inside my organization would consider our organization to be agile.	○	○	○	○	○	○	○	○
others outside my organization would consider my organization to be agile.	○	○	○	○	○	○	○	○
my organization meets the required output (product, services, etc.) that the customer desires.	○	○	○	○	○	○	○	○
my organization meets the customer desired timeline.	○	○	○	○	○	○	○	○
my organization exceeds (provides early) the industry standard for similar products or services.	○	○	○	○	○	○	○	○
my organization provides a variety of products, services and/or capabilities.	○	○	○	○	○	○	○	○
my organization has the capability to provide additional products/services/capability if needed.	○	○	○	○	○	○	○	○

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6. I believe that my organization has...

	Very Strongly Agree	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Very Strongly Disagree	N/A or I Don't Know
close relationships with suppliers	○	○	○	○	○	○	○	○
continuous improvement	○	○	○	○	○	○	○	○
cross functional teams	○	○	○	○	○	○	○	○
effective sensing of changes in the business environment	○	○	○	○	○	○	○	○
a history of encouraging innovation	○	○	○	○	○	○	○	○
made information accessible to employees	○	○	○	○	○	○	○	○
an accurate and useful knowledge of competitors	○	○	○	○	○	○	○	○
a history of proactively building customer relationships	○	○	○	○	○	○	○	○
a history of proactively exploring new opportunities	○	○	○	○	○	○	○	○
technologies that enhance human skill & knowledge	○	○	○	○	○	○	○	○
the ability to integrate external information	○	○	○	○	○	○	○	○
a stable set of customer requirements	○	○	○	○	○	○	○	○

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7. I believe that my organization has...

	Very Strongly Agree	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Very Strongly Disagree	N/A or I Don't Know
an adaptive evaluation and reward metric system	○	○	○	○	○	○	○	○
the capability to quickly adjust business strategies	○	○	○	○	○	○	○	○
concurrent execution of activities	○	○	○	○	○	○	○	○
a culture of change	○	○	○	○	○	○	○	○
customer and supplier integration	○	○	○	○	○	○	○	○
a decentralized organization	○	○	○	○	○	○	○	○
culture that accepts some risk (rather than designing out all risk)	○	○	○	○	○	○	○	○
empowered individuals working on teams	○	○	○	○	○	○	○	○
fast product development cycle	○	○	○	○	○	○	○	○
fast manufacturing times	○	○	○	○	○	○	○	○
first-time right design (rather than iterative design process)	○	○	○	○	○	○	○	○
flexible production technology	○	○	○	○	○	○	○	○
incremental development (deployment) as part of original plan	○	○	○	○	○	○	○	○
intentional management of human knowledge	○	○	○	○	○	○	○	○
leadership in the use of current technology	○	○	○	○	○	○	○	○

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8. I believe that my organization has...

	Very Strongly Agree	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Very Strongly Disagree	N/A or I Don't Know
a history of developing multiple solutions to same problem	○	○	○	○	○	○	○	○
a history of introducing innovative products	○	○	○	○	○	○	○	○
product flexibility	○	○	○	○	○	○	○	○
rapid adjustment of people capabilities	○	○	○	○	○	○	○	○
rapid adoption of new methods	○	○	○	○	○	○	○	○
rapid adoption of new technologies	○	○	○	○	○	○	○	○
rapid adoption of new processes	○	○	○	○	○	○	○	○
rapid delivery of product/service	○	○	○	○	○	○	○	○
a desire to only focus on mature technologies	○	○	○	○	○	○	○	○
processes to exploit maximum allowable flexibility	○	○	○	○	○	○	○	○
built and maintains trust	○	○	○	○	○	○	○	○
decentralized decision making	○	○	○	○	○	○	○	○
developed unique capabilities and characteristics that are difficult to copy	○	○	○	○	○	○	○	○
a majority of supplier/customer interactions electronically	○	○	○	○	○	○	○	○
empowered the workforce with knowledge	○	○	○	○	○	○	○	○
enhanced workforce skill with training	○	○	○	○	○	○	○	○
enhanced workforce knowledge with training	○	○	○	○	○	○	○	○
the ability to maintain high levels of motivation	○	○	○	○	○	○	○	○
partnerships	○	○	○	○	○	○	○	○
products with substantial value-addition	○	○	○	○	○	○	○	○
quality throughout the product lifecycle	○	○	○	○	○	○	○	○
teams across organization borders	○	○	○	○	○	○	○	○
responsiveness when requirements change	○	○	○	○	○	○	○	○

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9. I believe that my organization has...

	Very StronglyAgree	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Very Strongly Agree	N/A or I Don't Know
continuous training and development	○	○	○	○	○	○	○	○
developed business practices that are difficult to copy	○	○	○	○	○	○	○	○
employees that are satisfied	○	○	○	○	○	○	○	○
been digitally integrated/interconnected	○	○	○	○	○	○	○	○
internal integration of information	○	○	○	○	○	○	○	○
an environment where learning and improvement are important	○	○	○	○	○	○	○	○
teams populated with the necessary skills and experience	○	○	○	○	○	○	○	○
the ability to form rapid partnerships	○	○	○	○	○	○	○	○
limited program oversight	○	○	○	○	○	○	○	○
team-based leadership	○	○	○	○	○	○	○	○
the ability to share business resources virtually	○	○	○	○	○	○	○	○
developed effective responses to new challenges	○	○	○	○	○	○	○	○
invested in appropriate technology	○	○	○	○	○	○	○	○
rapid prototyping	○	○	○	○	○	○	○	○
short development cycle times	○	○	○	○	○	○	○	○
trust-based relationships with customers	○	○	○	○	○	○	○	○
trust-based relationships with suppliers	○	○	○	○	○	○	○	○
trust-based relationships with manufacturers	○	○	○	○	○	○	○	○

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10. **Do you have any comments that you like to add in regards to this organizational agility?**

(Please note that we cannot provide confidentiality to a participant regarding comments involving criminal activity/behavior, or statements that pose a threat to yourself or others. Do NOT discuss or comment on classified or operationally sensitive information)

11. **Do you have any additional information you would like to add to support or clarify your responses?**

(Please note that we cannot provide confidentiality to a participant regarding comments involving criminal activity/behavior, or statements that pose a threat to yourself or others. Do NOT discuss or comment on classified or operationally sensitive information)

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12. What is your 4 digit organization identifier (found in the email request to take this survey)?

13. Which best describes your organization size?

- ○ 20 or less Assigned Individuals
- ○ 21-50 Assigned Individuals
- ○ 51-100 Assigned Individuals
- ○ 101 or more Assigned Individuals
- ○ I Don't Know

14. Where are members of your organization located?

- ○ 95% or more of Individuals are at the Same Location
- ○ 75%-94% of Individuals are at the Same Location
- ○ 50%-74% of Individuals are at the Same Location
- ○ 49% or less of Individuals are the Same Location
- ○ I Don't Know

15. Which best describes your organizations primary effort?

- ○ Research & Technology Development
- ○ Acquisitions (Space Systems)
- ○ Acquisitions (Cyber Systems)
- ○ Acquisitions (Aircraft Systems)
- ○ Acquisitions (Other)
- ○ Production & Manufacturing
- ○ Test & Evaluation
- ○ Logistics
- ○ Operations
- ○ Intelligence

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16. Which best describes your organization's primary program? See table below.

- ◯ DoD - ACAT I/IA
- ◯ DoD - ACAT II
- ◯ DoD - ACAT III
- ◯ DoD - ACAT IV
- ◯ I Don't Know
- ◯ Other (please specify using terms to describe the size of effort (i.e. budget, sales, production numbers, etc.))

Acquisition Category	Reason for ACAT Designation
ACAT I	Major Defense Acquisition Program (MDAP) (10 U.S.C. 2430 (Reference (h)) • Dollar value for all increments of the program: estimated by the DAE to require an eventual total expenditure for research, development, and test and evaluation (RDT&E) of more than **$480 million** in Fiscal Year (FY) 2014 constant dollars or, for procurement, of more than **$2.79 billion** in FY 2014 constant dollars • MDA designation MDA designation as special interest[1]

ACAT IA[2,3]	MAIS (10 U.S.C. 2445a (Reference(h))): A DoD acquisition program for an Automated Information System[4] (AIS) (either as a product or a service[5]) that is either:
	• Designated by the MDA as a MAIS program; or
	• Estimated to exceed:
	  • **$40 million** in FY 2014 constant dollars for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, and deployment, and incurred in any single fiscal year; or
	  • **$165 million** in FY 2014 constant dollars for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, and deployment, and incurred from the beginning of the Materiel Solution Analysis Phase through deployment at all sites; or
	  • **$520 million** in FY 2014 constant dollars for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, deployment, operations and maintenance, and incurred from the beginning of the Materiel Solution Analysis Phase through sustainment for the estimated useful life of the system.
	MDA designation as special interest[1]

ACAT II	• Does not meet criteria for ACAT I or IA
	• Major system (10 U.S.C. 2302d (Reference (h)))
	  • Dollar value: estimated by the DoD Component Head to require an eventual total expenditure for RDT&E of more than **$185 million** in FY 2014 constant dollars, or for procurement of more than **$835 million** in FY 2014 constant dollars
	  • MDA designation[6] (10 U.S.C. 2302 (Reference (n)))

ACAT III	ACAT III programs are defined as those acquisition programs that do not meet ACAT I or II criteria.
ACAT IV	ACAT programs not otherwise designated as ACAT III are designated ACAT IV. There are two categories of ACAT IV programs: IVT (Test) and IVM (Monitor). ACAT IVT programs require Operational Test and Evaluation (OT&E) while ACAT IVM programs do not. [See "Navy Acquisition Category"]

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17. What is your organization's annual budget?

- ◯ < $1M
- ◯ $1.1M - $5M
- ◯ $5.1M - $10M
- ◯ $10.1M - $25M
- ◯ $25.1M - $100M
- ◯ >$100M
- ◯ N/A or I Don't Know

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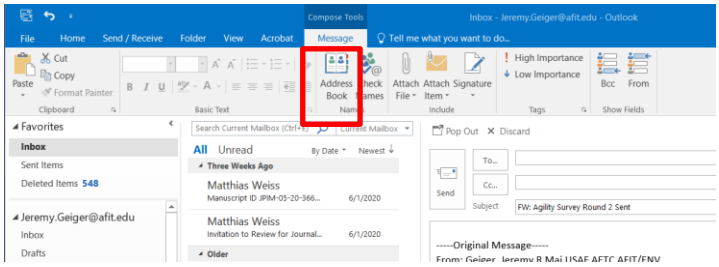
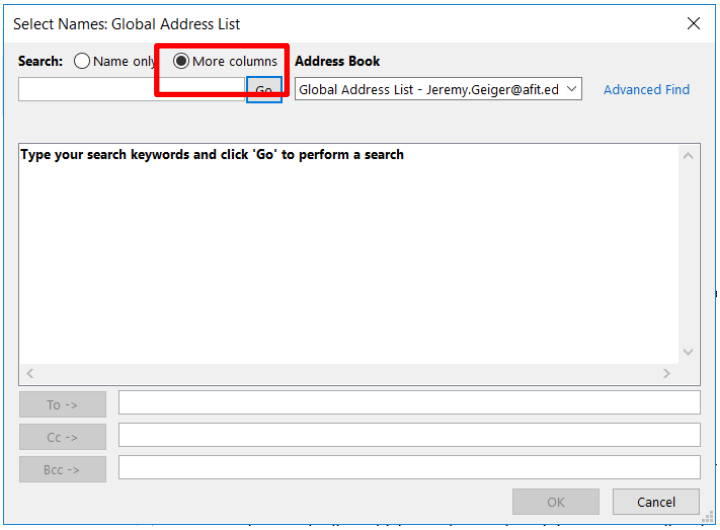
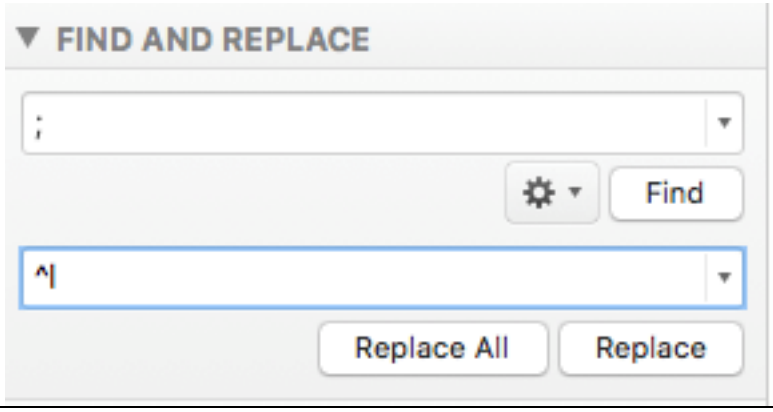
Survey Complete! Thank you for your time and support.

If you have any questions about this research project, please contact Maj Jeremy Geiger at 937-255.6565 ext 6128 or Jeremy.Geiger@afit.edu.

Appendix C: Process to Extrapolate Email Addresses from GAL by Organization

Several iterations were required to develop an efficient and useful method to create targeted survey distribution lists. The following process was developed to create organization specific email distribution lists that also allowed for the removal of contractors (an Air Force Survey Office requirement).

1	**Identify & Pull Addresses using Global Access List (GAL)**
1.a.	From a U.S. Government computer connected to the AFNet, open Outlook.
1.b.	Click ***address book*** 
1.c.	Select ***more columns*** 
1.d.	Type in the 3-letter designator for a unit, such as ***WNS***
1.e.	Select the resulting list using the mouse and shift key. You cannot select more than ~50 at a time.
1.f.	Go to ***File / New Message.*** This will put all of the selected individuals into the "to" block of a new email.

1.g.	Select all of the individuals in the "to" block by using ***CTRL*** and ***A.*** Be careful NOT to send the email.
1.h.	Paste the individuals into a blank Microsoft Word Document.
1.i.	Repeat steps 1.e. through 1.h. as needed until the entire list is in Microsoft Word.
2	**Format the Continuous List into Separated List**
2.a.	Select ***Find and Replace***
2.b.	Enter "***;*** " (semicolon with a space after it) in the ***Find*** box
2.c.	Enter "***Manual Line Break***" from the drop down menu in the ***Replace*** box. Alternatively, enter "^|", which is the Word symbol for a manual line break. 
2.d.	Select ***Replace All***
2.e.	***Select All, Copy.***
3	**Enter into Excel & Parse Email Addresses**
3.a.	Open a new worksheet in Microsoft Excel
3.b.	**Select cell A2**. ***Paste*** the list from Microsoft Word. This should put each person in their own cell in a single column.
3.c.	Type (or copy/paste) the following command **into cell B2.** This will pull the email address out of the string of characters. =CONCATENATE((RIGHT((LEFT(A2,((FIND(">",A2,2))-1))),(FIND(">",A2,2)-FIND("<",A2,2))-1)),";")
3.d.	Type (or copy/paste) the following command **into cell B3**. This will pull the org identifier out of the string of characters. =LEFT((RIGHT(A2,(LEN(A3)-FIND("/",A2,1)))),(FIND(" ",(RIGHT(A2,(LEN(A2)-FIND("/",A2,1)))),1)))
3.e.	Type (or copy/paste) the following command **into cell C3**. This will identify any contractors. =IF(ISNUMBER(SEARCH("CTR",A2)),"CTR","")

3.f.	Using the "plus sign", ***Select/Copy/Paste*** the equations in cell B2/B3/B4 down to the last row of your data. This will copy/paste the equations and apply them to each row.
3.g.	If needed, sort and eliminate any individuals that are contractors.
3.h.	Verify the organization; it should be the same for everyone. Remove any outliers. For instance, if the organization being sought was "RHO," this technique will also pull individuals with the last name "Rhodes". This step identifies and removes those individuals that were accidently pulled but are part of different organizations.
3.i.	***Copy*** the column with the email addresses. ***Paste*** it into another column using the "***paste values***" option in Microsoft Excel.
4.	**Transfer Email Addresses to Outlook for Distribution**
4.a.	***Copy*** the entire column in Microsoft Excel of email addresses that you want to send. You must use the final column in Excel were you "***pasted values***". There is no limit on the number of individuals you select.
4.b.	***Paste*** in the "to" line of a new email in Microsoft Outlook. Hit ***tab*** twice. The email addresses should become bolded and separated by a ";". This means that Outlook has checked the email addressed against the GAL and accepts them.

Appendix D: Summary of Survey Tasking & Response Rate by Unit

Summary of Survey Taskings & Response Rate by Unit

Survey 1 - Exploratory Factor Analysis

Identifier	Directorate	3-LTR	# Sent	# Completed	% Completed
4179	WK - Tanker Directorate	WKD - Legacy Tanker Division	206	20	9.71%
3068	RD - Directed Energy	RDH - High Power Electromagnetics Division	85	3	3.53%
4175	WL - Mobility Directorate	WNY - LAIRCM Program Office	458	36	7.86%
4170	LP - Propulsion Directorate	LPA - Acquisition Division	160	16	10.00%
3150	WL - Mobility Directorate	WVV - Commercial Derivative Aircraft Division	146	15	10.27%
3271	RD - Directed Energy	RDL - Laser	60	6	10.00%
4680	WN - Agile Combat Support	WNS - Simulators	189	53	28.04%
4525	WN - Agile Combat Support	WNU	177	8	4.52%
1025	LP - Propulsion Directorate	LPS - Sustainment Division	304	29	9.54%
2050	WL - Mobility Directorate	WLM - C-17 - Division	206	15	7.28%
3075 & 4010	WW - Fighter & Bomber Directorate	WWU - F-22 Division	241	51	21.16%
5042	RD - Directed Energy	RDS - Space EO	82	7	8.54%
			2314	**259**	**11.19%**

Survey 2 (Used for Confirmatory Factor Analysis)

Identifier	Directorate	3-LTR	# Sent	# Completed	% Completed
6100	LP - Propulsion Directorate	LPZ - Integration Division	35	6	17.14%
6250	AZ - Acquisition Excellence Directorate		188	44	23.40%
6375	RD - Directed Energy	RDF	35	2	5.71%
6405	RD - Directed Energy	RDM	69	9	13.04%
6530	RD - Directed Energy	RDK	28	2	7.14%
6645	AQ		97	15	15.46%
6755	WL - Mobility Directorate	WLI - International Acquisition Program Division	22	4	18.18%
6865	WL - Mobility Directorate	WLN - C-130 Hercules Division	418	53	12.68%
6980	WL - Mobility Directorate	WLS - C-5 Galaxy Division	170	30	17.65%
7105	WL - Mobility Directorate	WVB	42	9	21.43%
7210	EB - Armament Division	EBA	136	27	19.85%
7315	EB - Armament Division	EBD	185	22	11.89%
7420	EB - Armament Division	EBG	65	9	13.85%
7525	EB - Armament Division	EBH	333	60	18.02%
7630	EB - Armament Division	EBJ	142	22	15.49%
7735	EB - Armament Division	EBM	97	16	16.49%
7840	EB - Armament Division	EBS	106	11	10.38%
7945	EB - Armament Division	EBW	144	36	25.00%
8110	EB - Armament Division	EBY	109	13	11.93%
8220	HN - C3I & Networks Division	HNA	121	17	14.05%
8325	HN - C3I & Networks Division	HNC	793	103	12.99%
8430	HN - C3I & Networks Division	HNI	293	40	13.65%
8535	HN - C3I & Networks Division	HNJ	141	20	14.18%
8640	HN - C3I & Networks Division	HNS	62	10	16.13%
8745	WW - Fighter & Bomber Directorate	WWM - F-16 Division	618	103	16.67%
8850	WW - Fighter & Bomber Directorate	WWQ - F-15 Division	401	78	19.45%
8955	WW - Fighter & Bomber Directorate	WWZ - B-2 Division	202	26	12.87%
9140	ACC	601 AOC/ISRD	28	1	3.57%
9245	PACAF	607 AOC/ISRD	77	6	7.79%
9350	AFCENT	609 AOC/ISRD/TARGETS	42	3	7.14%
9455	AFSPC	614 AOC/ISRD/ISR OPS	80	8	10.00%
9560	ACC	624 OC/ISRD/ACF	56	6	10.71%
9670	WN - Agile Combat Support Division	WNA	110	19	17.27%
9780	WN - Agile Combat Support Division	WNK	84	9	10.71%
9890	WN - Agile Combat Support Division	WNM	87	16	18.39%
5025	WN - Agile Combat Support Division	WNZ	124	24	19.35%
5110	RV - Space Vehicles	RVO - Integration & Operations	41	12	29.27%
5275	HPW - 711 Human Performance Wing	RHM	46	14	30.43%
5350	HPW - 711 Human Performance Wing	RHD	90	15	16.67%
5775	HPW - 711 Human Performance Wing	RHC	147	32	21.77%
Other (Org not coded)			0	186	-
			6064	**1138**	**18.77%**

Appendix E: Overall OA Estimate by Unit

Overall OA Estimate by Unit

Identifier	Directorate	3-LTR	Factor 1 "Development Cycle Time"	Factor 2 "Workforce Development"	Factor 3 "Trusted External Relationships"	Factor 4 "Business Practices"	Factor 5 "Proactive Relationship Building"	Factor 6 "Digital Practices"	Factor 7 "Empower Decision Making"	Overall OA Estimate
5025	WN - Agile Combat Support Division	WNZ	3.34	4.01	4.28	3.33	4.20	4.43	4.05	3.95*
5110	RV - Space Vehicles	RVO	4.47	4.39	4.91	4.30	4.80	4.47	3.81	4.45
5275	HPW - 711 Human Performance Wing	RHM	3.05	4.29	4.31	4.11	4.05	3.91	3.74	3.92*
5350	HPW - 711 Human Performance Wing	RHD	3.42	4.05	4.34	4.67	4.58	4.28	3.63	4.14*
5775	HPW - 711 Human Performance Wing	RHC	4.24	4.58	4.92	4.22	5.12	4.51	3.94	4.50*
6100	LP - Propulsion Directorate	LPZ	3.39	3.89	4.01	4.00	4.42	4.51	3.47	3.95
6250	AZ - Acquisition Excellence Directorate		4.72	5.54	5.47	3.96	5.45	5.09	4.37	4.94*
6375	RD - Directed Energy	RDF	7.00	6.50	6.83	6.50	6.50	6.33	5.50	6.45
6405	RD - Directed Energy	RDM	4.43	4.26	5.19	4.13	5.19	4.73	4.39	4.62
6530	RD - Directed Energy	RDK	4.00	3.50	5.00	3.50	4.17	4.17	4.50	4.12*
6645	AQ		4.95	5.42	5.59	4.31	5.52	5.10	4.93	5.12
6755	WL - Mobility Directorate	WLI	4.50	5.75	5.22	4.17	5.00	5.25	3.92	4.83
6865	WL - Mobility Directorate	WLN	3.28	4.31	4.76	3.68	4.66	4.52	3.74	4.14*
6980	WL - Mobility Directorate	WLS	3.77	4.51	4.51	3.70	4.84	4.62	4.32	4.32
7105	WL - Mobility Directorate	WVB	3.81	3.96	4.48	4.39	4.75	4.56	3.30	4.18
7210	EB - Armament Division	EBA	3.32	4.98	4.95	4.54	4.76	4.70	3.83	4.44
7315	EB - Armament Division	EBD	4.83	4.73	5.46	4.64	5.58	5.10	4.94	5.04
7420	EB - Armament Division	EBG	3.53	4.75	5.19	4.21	4.76	4.63	4.35	4.49
7525	EB - Armament Division	EBH	3.84	4.27	4.65	4.34	4.99	4.85	4.40	4.48
7630	EB - Armament Division	EBJ	3.79	4.85	4.52	4.27	5.12	4.58	3.64	4.39
7735	EB - Armament Division	EBM	3.71	5.27	4.77	4.50	4.97	4.88	4.34	4.63
7840	EB - Armament Division	EBS	2.37	5.16	4.89	3.94	4.94	4.19	2.90	4.06
7945	EB - Armament Division	EBW	4.04	4.66	4.99	3.81	5.16	4.82	3.99	4.50
8110	EB - Armament Division	EBY	3.50	5.38	4.80	4.54	5.18	4.97	4.06	4.63
8220	HN - C3I & Networks Division	HNA	3.99	4.98	4.83	3.70	5.11	5.23	4.00	4.55
8325	HN - C3I & Networks Division	HNC	4.04	4.48	4.84	4.26	4.73	4.54	3.93	4.40
8430	HN - C3I & Networks Division	HNI	4.15	4.28	4.82	4.27	4.98	5.07	4.35	4.56
8535	HN - C3I & Networks Division	HNJ	4.08	4.67	5.29	4.06	5.10	4.53	4.25	4.57*
8640	HN - C3I & Networks Division	HNS	3.60	3.76	4.12	3.76	4.30	4.83	2.40	3.82*
8745	WW - Fighter & Bomber Directorate	WWM	3.75	4.67	4.81	4.12	4.99	4.85	4.15	4.48*
8850	WW - Fighter & Bomber Directorate	WWQ	3.54	4.67	4.47	4.00	4.80	4.74	4.00	4.32*
8955	WW - Fighter & Bomber Directorate	WWZ	3.50	4.65	4.75	3.96	4.68	4.91	4.21	4.38*
9140	ACC	601 AOC/ISRD	0.00	5.00	0.00	2.00	3.33	1.00	4.33	2.24
9245	PACAF	607 AOC/ISRD	4.32	5.11	4.97	2.83	5.34	5.07	4.22	4.55*
9350	AFCENT	609 AOC/ISRD/TARGETS	2.89	5.00	5.00	4.17	5.22	4.44	3.00	4.25
9455	AFSPC	614 AOC/ISRD/ISR OPS	3.02	4.13	4.30	4.11	4.63	4.79	3.48	4.06
9560	ACC	624 OC/ISRD/ACF	3.00	3.78	3.74	3.20	3.89	4.93	3.42	3.71
9670	WN - Agile Combat Support Division	WNA	3.88	5.00	4.93	4.26	4.91	4.54	4.11	4.52
9780	WN - Agile Combat Support Division	WNK	3.60	4.70	4.51	3.83	4.85	4.81	4.48	4.40
9890	WN - Agile Combat Support Division	WNM	4.28	5.10	4.96	4.80	5.32	5.23	4.61	4.90

* Items marked with an asterisk were calculated using less than 10 independent respondents.

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14. ABSTRACT

There is an ongoing demand for organizations to become more agile in order to prosper amongst their competitors. Many organizations, including the United States Department of Defense (DoD), have declared a renewed focus towards organizational agility. This research begins by providing a suitable and formal definition of organizational agility (OA) by exploring and analyzing relevant scholarly literature on the subject. Existing methods to measure OA are examined and summarized, and their current limitations are highlighted. Previous studies to find characteristics associated with organizational agility are examined and the Q-sort method was employed to discover, analyze and eliminate redundant items from the data set, ultimately resulting in 64 unique characteristics. Exploratory factor analysis (EFA) and was applied to a preliminary study with over 250 respondents representing 13 organizations to establish the structure of a latent construct to measure OA along with the individual characteristics necessary to calculate its factors. A second study, this time representing 40 organizations and with over 1,100 respondents, used confirmatory factor analysis (CFA) to confirm and validate the latent construct, its factors, and the fundamental questions necessary to measure OA. Lastly, the principles of convergent and discriminant validity were applied to test the validity of the OA model. Overall, this research contributes a model to proactively measure OA utilizing a 20-question questionnaire, allowing leaders the insight necessary to improve their organizations and to be prepared to capitalize on innovative opportunities.

15. SUBJECT TERMS

Organizational Agility, Flexibility, Measure Development, Q-sort, Metrics, Latent Construct

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