Size Matters: How Big Should a Military Design Team Be?

A Monograph
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While the literature on the size of small groups and teams is extensive, there is little research on design team sizes and no formal research or analysis on the size of a military design team. This monograph investigates the optimal team size and composition for the military design team. The monograph is a multidisciplinary survey that draws from design theory, organization theory, leadership theory, social psychology, psychology, and anthropology. The results of the survey indicate that the ideal size of a military design team is five to six people; however, the team can be effective up to a size of nine. The findings also demonstrate that 20 team members create an inefficient team. The use of cross-functional or X-team structures provides a basis for the team structure and composition. The military design team will most likely be cross-functional in some manner due to the diverse educational background of its members and the joint and combined nature of military operations and organizations. However, the use of the X-team structure holds the most potential due to its external focus. This enables the design team to leverage resources external to the team and develop a design concept that provides best fit to their unique operational context.

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Abstract

SIZE MATTERS: HOW BIG SHOULD A MILITARY DESIGN TEAM BE? by MAJ Michael L. Hammerstrom, United States Army, 75 pages.

While the literature on the size of small groups and teams is extensive, there is little research on design team sizes and no formal research or analysis on the size of a military design team. This monograph investigates the optimal team size and composition for the military design team. The monograph is a multidisciplinary survey that draws from design theory, organization theory, leadership theory, social psychology, psychology, and anthropology. The results of the survey indicate that the ideal size of a military design team is five to six people; however, the team can be effective up to a size of nine. The findings also demonstrate that 20 team members create an inefficient team. The use of cross-functional or X-team structures provides a basis for the team structure and composition. The military design team will most likely be cross-functional in some manner due to the diverse educational background of its members and the joint and combined nature of military operations and organizations. However, the use of the X-team structure holds the most potential due to its external focus. This enables the design team to leverage resources external to the team and develop a design concept that provides best fit to their unique operational context.

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INTRODUCTION

When humans gather in social groups for a specific purpose, the complex dynamical interactions between actors can give the group a life of its own. The social group has emergent properties that are not merely the sum of its parts. For example, a football team may have a culture, an identity, and a signature style of play that endures over generations, long after all of the original players have retired. Suppose that we think of this "social life" of a team, a committee, or a group as a plant. Like a plant, a team has a lifecycle: teams take root, consume resources, differentiate and grow, flower, bear fruit, wilt, and eventually die. If they are successful, before they die they will scatter their seeds, out of which new teams can sprout. Like plants, teams are subject to selective pressure from their environment. If the team is too small, it may be too fragile to survive the loss of one or two of its members in a hostile climate. If the team becomes too large, it may exhaust the local nutrient supply and collapse under its own weight. Between too small and too big, there are teams that are "just right." These teams are resilient, they thrive in their environment, and they bear many fruits. How do teams grow, and what size team is just right?

British naval historian C. Northcote Parkinson first used this analogy of a social group as a plant in 1958. Parkinson's committees have similar characteristics to teams as each are groups composed of multiple individuals that share a common purpose and both have an organic lifecycle. According to Parkinson's Coefficient of Inefficiency, the ideal size of the plant is five members.[1] Parkinson states that, "With that number the plant is viable, allowing for two members to be absent or sick at any one time."[2] The membership is typically four specialists along with a leader of some sort that understands all of the four specialty areas, which is similar to the military

[1] C. Northcorte Parkinson, *Parkinson's Law or the Pursuit of Progress* (London: John Murray, 1957), 32.

[2] Ibid.

and management concept of span of control. Even though the plant is healthy, Parkinson observes that the number will soon increase to seven or nine.[3] He asserts that of the nine members, two are silent members and various new roles emerge that are different from the original roles and responsibilities of the members.[4]

At this point, the team is beginning to subject itself to a law of growth or political inflation. More people will start to join the team who claim special knowledge or the team will allow them to join because the nuisance that they make convincing members of their contribution. Soon, the team's membership will expand to 20 in order to satisfy everyone associated with the group. Like any plant, there will be parts that receive sunshine (visibility to and attention of the leadership), while others will be lower on the plant and may wilt and not contribute to the health of the plant. The problem of getting the group to meet at the same place, date, and time increases as the team's size grows. When this overgrowth of the plant begins to occur, the five members that actually have the expertise and decision-making power will meet prior to the team's meetings to make the required decisions due to the dysfunctional nature of the swollen team. The multitude of various groups' representatives, who have no decision-making authority and limited contribution to the team, will continue to add to the number of the committee. Ironically, the team no longer makes decisions or products due to the increased size from the unobstructed expansion of the membership. In Parkinson's scenario, the committee membership can quickly grow to over a thousand people. However, the committee or team is now defunct and another body picks up the functions that the original committee of five members formerly conducted. Parkinson states that the committee [or team] loses power throughout the process as the membership increases.[5]

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[3] Ibid.
[4] Ibid.
[5] Ibid., 32-38.

The Coefficient of Inefficiency applies to the appropriate size of a military design team and its effectiveness. Parkinson's satire written in 1957 first brought attention to many of the principles and phenomena associated with small group dynamics that social psychology is still attempting to understand and define today. It turns out that Parkinson's satirical observations on the growth of teams and the point at which they become inefficient are only partly in jest. Recent empirical research confirms Parkinson's original insight.[6] His study of the British Navy in the mid 20th Century has immediate implications for the military design teams of today.

Military Design Team Size and Structure

This monograph investigates the optimal team size for the military design process. While the literature on the size of small groups and teams is extensive, there is little research on design team sizes and no formal research or analysis on the size of a military design team. The intent of this monograph is to begin an active discourse on the optimal size of a military design team to further the efforts to incorporate the use of design into military activities, independent of the individual skill sets of the members of the military design team. Significant literature exists on small group dynamics and the conditions that affect the outcomes from these groups. However, very little literature or study exists on the optimal or recommended size of a design team and even less exists on the military design team.

Design as a field of enquiry that provides potential resolution to complex problems has been recognized as a distinct intellectual endeavor since 1962.[7] However, the formalization of

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[6] Peter Klimek, Rudolf Hanel, and Stefan Thurner, "To How Many Politicians Should Government Be Left?" in the Cornell University's arXiv e-print library, http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.2202v1.pdf (accessed March 5, 2010).

[7] Nigel Cross, "Forty Years of Design Research," *Design Research Quarterly* 2, no. 1 (January 2007): 3, http://www.designresearchsociety.org/joomla/component/option,com_wrapper/Itemid,138/ (accessed September 15, 2009).

design education and the actual design process is a "relatively recent phenomenon."[8] Lawson highlights that traditionally, "craftsman designed objects as he made them which worked well for stable problems, however if the situation suddenly changes then the craft process likely provides an unsuitable result".[9] As the craft process of educating traditional design is inappropriate for dynamic problematical situations, the articulation of the design process is allowing design to address complex dynamical problems, as well as its education in the classroom. Education of design is facilitating its incorporation within the U.S. Army as a potential means of responding to the multitude of contemporary complex problems.

The U.S. Army is actively pursuing the potential for the use of design to address the complexity of the operational environment and to satisfy the need for greater strategic thinking at all echelons.[10] The use of teams is common within the US military for planning and executing a myriad of activities. Consequently, the military is comfortable with the use of small teams to solve complicated problems. The complexity of the operational environment requires responses by the U.S. Army with an increased, shared understanding of the environment, the problem, and potential solutions.[11] The U.S. Army is developing and experimenting with techniques for incorporating the design process into the U.S. Army.

The U.S. Army design methodology assumes the existence of a design team.[12] However, the current research does not address the most effective composition and group size for a military design team. The U.S. Army must understand the considerations for choosing the design team

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[8] Bryan Lawson, *How Designers Think: The Design Process Demystified*. 4th ed. (Oxford: Architectural Press, 2006), 6.

[9] Ibid., 23.

[10] Department of the Army, TRADOC Pamphlet 525-5-500, *Commander's Appreciation and Campaign Design*, Version 1.0, (Fort Monroe, VA: U.S. Army Training and Doctrine Command, January 2008), 4-30.

[11] Department of the Army, Field Manual Interim 5-2 (FMI 5-2), *Design* (Draft), (Washington, DC: Headquarters, Department of the Army, 20 February 2009), 27.

[12] Department of the Army, Field Manual 5-0 (FM 5-0)*, The Operations Process (Final Approved Draft)* (Washington, DC: Headquarters, Department of the Army, 25 February 2010), 3-6.

size if design is to be successfully applied in the field. A better understanding of effective design team composition will enable the U.S. Army to create the most appropriate organization to support the design methodology. The commanders in the field expect some informed recommendations about the initial formation of a design team. At a minimum, this should include the recommended design team structure and size. This would help commanders to understand the design team's requirements and increase the effectiveness of the resulting team.

The design team size and structure are two of the critical variables that directly influence the potential for success of the design methodology to provide the appropriate outcome. The design team is an attempt to incorporate expertise beyond that of a single designer to address a complex problem in a more comprehensive manner. The social psychology, sociology, and business management literature contains multiple theories and a significant body of research on team size. The past and current literature provides a base of knowledge for investigating the most appropriate size of a design team. A study of team size and its impact on small group dynamics will provide insight into how to best form and structure a military design team.

The School of Advanced Military Studies (SAMS) graduate is a likely candidate to provide the informed recommendation and subsequent justification to the commander. Due to the U.S. Army's requirement for manning and training an effective force, the U.S. Army must understand the design team's requirements and the U.S. Army's obligations to support the commanders' design teams. This research into the size and composition of an effective design team is an important step towards expanding the organizational understanding and operationalization of design within the U.S. Army.

Organization

This monograph is organized into an introduction, four main sections within its body, and the conclusion section. Section one introduces design methodology and the nature of the problems facing military design teams. Section two provides an overview of the potential

contribution of a military design team for the U.S Army. Section three discusses the topic of the optimal size of a military design team. This discussion includes supporting material on transaction channels, psychological literature on group size, anthropological information on human cognitive limitations, and observations and research on the span of control. The fourth section provides an overview of two team types that are applicable to the structuring of military design teams. The team types are Cross-functional Teams and X-teams. Each type of team provides a different structure for the military design team. The conclusion consists of a summary, recommendation, and opportunities for further research.

WHAT IS DESIGN?

Design Methodology

Many military commentators argue that the contemporary military operational environment is becoming increasingly complex. Ilachinski was one of the first theorists to argue that, "…land combat is a complex adaptive system. That is to say, that land combat is essentially a nonlinear dynamical system composed of many interacting semi-autonomous and hierarchically organized agents continuously adapting to a changing environment."[13] The U.S. Army Field Manual 3-0 describes the operational environments by stating that, "This doctrine pertains in an era of complex local, regional, and global change leading to both opportunities and risks. This risk component of this change manifests in certain trends that drive instability and a continuing state of persistent conflict."[14] The problems facing the military are complex, adaptive, unique, ill-structured, multi-scale, coercive, and dynamic. The difficulty of these problems means that, "The nature, depth, and breadth of ill-structured problems make it impossible to provide detailed

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[13] Andrew Ilachinski, *Land Warfare and Complexity, Part II: An Assessment of the Applicability of Nonlinear Dynamics and Complex Systems Theory to the Study of Land Warfare*, CRM 96-68 (Alexandra, VA: Center for Naval Analyses, July 1996), 3.

[14] Department of the Army, Field Manual 3-0 (FM 3-0), *Operations* (Washington, DC: Headquarters, Department of the Army, February 2008), 1-1.

doctrinal planning guidance relevant to all threats…Thus, the best joint doctrine can hope for is to address "how to think" about ill-structured problems without dictating "what to think" about them."[15]

This increasing complexity of global situations is a significant challenge to the perceived success of current and future military endeavors. The use of design is evolving within the U.S. Army as an approach to respond to these situations discussed by Ilachinski and the various challenges that are continually emerging from a dynamic operational environment. Design is a way of "gaining a more nuanced and deep understanding of the operational environments enabling more effective decisions on how we should employ the instruments of national power to affect change."[16] As a portion of the TRADOC Pam 525-5-500 definition of design states, design is the, "…act of working out the form of something (visualizing), requiring considerable research, thought, modeling, and iterative adjustments…"[17] This definition implies the investment of considerable effort and time. The use of the design methodology is to form something for an intended purpose.[18] According to U.S. Army doctrine, "Design is a methodology for applying critical and creative thinking to understand, visualize, and describe complex, ill-structured problems and develop approaches to solve them."[19]

WHY A DESIGN TEAM?

The importance of a design team to provide the functions inherent in design is both subtle and obvious. The use of teams is not a new concept but the use of the team for purpose of design is a more recent area of interest and study. Lawson discusses the recognition of the individual in

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[15] T.C. Greenwood and T.X. Hammes, "War Planning for Wicked Problems: Where Joint Doctrine Fails," *Armed Forces Journal* (December 2009/January 2010), 20, http://www.afji.com/2009/12/4252237/ (accessed March 15, 2010).

[16] Department of the Army, Field Manual Interim 5-2 (FMI 5-2), 1.

[17] Department of the Army, TRADOC Pamphlet 525-5-500, 39.

[18] Ibid.

[19] Department of the Army, Field Manual 5-0 (FM 5-0), 3-6.

the traditional design process throughout much of his book. He uses the examples of famous architects such as Le Corbusier and Frank Lloyd Wright to illustrate the perspective on design as an individual art.[20] Design teams, that seek a systemic and shared understanding, emerged from the recognition of the complexity of many situations that require appropriate responses.[21] The responses from the design process develop from the implied tension created by interpersonal relationships.[22] The requirement of the group members to use negotiation and consensus involves conflict and cooperation among ad hoc coalitions and individuals.

This exposure to different perspectives and the tension created by opposing viewpoints is a key source of individual and collective learning.[23] Lawson recognizes that his book discusses design from an individual perspective with the exception of one chapter.[24] He states in the chapter on "Designing with others" that team activity is often characteristic of the design process.[25] The team activity behaves in a manner that is beyond the abilities of the collective individual talents.[26]

However, the value of multiple disciplines or diversity within the team is questioned by Van Der Vegt and Bunderson. They argue that, "…although diversity in functional assignments was associated with greater external communication, which was in turn associated with greater innovation, the direct effect of functional diversity on innovation was negative. Furthermore, there is no consistent evidence that expertise diversity is associated with higher performance, and some evidence has demonstrated a negative relationship…In other words, exposure to a diverse set of backgrounds, experiences, and perspectives within a team may not always promote team

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[20] Lawson, 25.
[21] Department of the Army, TRADOC Pamphlet 525-5-500, 15.
[22] Lawson, 237.
[23] Gerban S. Van Der Vegt and J. Stuart Bunderson, "Learning and Performance in Multidisciplinary Teams: The Importance of Collective Team Identification," *Academy of Management Journal* 48, no. 3 (June 2005): 534.
[24] Lawson, 234.
[25] Ibid., 234.
[26] Ibid., 242.

innovativeness or team performance and may, in fact, detract from both."[27] However, their findings did support that expertise diversity of team members can be a key activator of intra-team learning.[28] This learning may then promote overall team effectiveness. Scot Page argues convincingly that,

> The evidence speaks clearly: *diversity produces benefits* (cognitively diverse societies, cities, and teams perform better than more homogenous ones), f*undamental preference diversity creates problems* (public goods are under provided and people don't get along), and, finally, *collections of people with diverse cognitive toolboxes and diverse fundamental preferences have higher-variance performance* (they locate better outcomes and produce more conflict).[29]

The arguments point to the fact that a diverse team has potential to outperform a more homogeneous team, however there are challenges in forming a team where the potential for conflict is less than the benefit gained from the team. The members have to be able to place the purpose of the team as the priority beyond personal preferences. Scot Page also highlights the importance of diversity since, "…breakthroughs require serendipity. That serendipity arises from diverse preparedness…The more tools we amass through training, refine by experience, and filter through our identities, the better."[30]

Much of the literature of teams appears to reinforce the importance of creating a small team in order to recommend things, make or do things, and to run things.[31] The military design team must be able to produce a design concept using any medium that can be used by the planners to produce detailed military plans that address adaptive, complex situations. Lawson provides additional thoughts on the diverse responsibility of design teams by stating, "One of the essential difficulties and fascinations of designing is the need to embrace so many different kinds

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[27] Van Der Vegt and Bunderson, 534.
[28] Ibid.
[29] Scott E. Page, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Princeton, NJ: Princeton University Press, 2007), 299.
[30] Ibid., 312.
[31] Jon R. Katzenbach and Douglas K. Smith, "The Discipline of Teams," *Harvard Business Review* 71, no. 2 (March-April 1993): 111.

of thought and knowledge." [32] A team provides the structure to bring the various ideas, thoughts, and knowledge together so that the creative capacity of the group increases.[33]

An important distinction that Katzenbach and Smith make is that there is a difference between a team and other forms of working groups. They argue that the working group members focus on individual performance goals, standards, and accountability. Also, working groups do not take responsibility for results other than their own individual efforts so that the working group members do not develop incremental performance contributions.[34] By the nature of the design process, the need for the group formed to execute the process must be able to perform effectively beyond the concept of a working group. Apparently, the use of a team is required.

However, one of the common sense findings of Katzenbach and Smith that is often overlooked is the proper application of basic team principles such as size, purpose, goals, skills, approach and accountability.[35] The lack of focus in these areas can contribute directly to a lack of team performance. Apparent from their findings, the size of the design team seems to be a variable aspect to the effective outcome of a team. They describe that "Groups become teams through *disciplined action*. They *shape* a common purpose, *agree* on performance goals, *define* a common working approach, *develop* high levels of complementary skills, and *hold* themselves mutually accountable for results."[36]

In respect to size and structure of a military design team, several requirements are applicable. The adaptive nature of the complex environment requires the military design team to be at least as adaptive and dynamic as the environment. The team will have to use the fewest

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[32] Lawson, 13.

[33] Glenn M. Parker, *Cross-functional Teams: Working with Allies, Enemies and Other Strangers* (San Francisco, CA: John Wiley and Sons, 2003), 613.

[34] Katzenbach and Smith, "The Discipline of Teams," 113.

[35] Jon R. Katzenbach and Douglas K. Smith, *The Wisdom of Teams: Creating the High-Performance Organization* (Boston, MA: Harvard Business School Press, 1993), 3.

[36] Ibid., 14.

possible members since military organizations will always have the constraint of available manpower for the number of activities required to be accomplished. This means that an optimal military design size will be the team composed of the least number of members, which provides adequate and appropriate response options to satisfy the commander's expectations. The evaluation of the team based on the outcomes from the use of design methodology is subjective, so an exploration of effectiveness of small teams based on size is required to provide a baseline for a military design team.

While the commander is a key figure in the military design methodology, the commander may choose the option of forming a design team. The design team provides the commander a means to review relevant information from multiple sources such as directives, documents, data, previous guidance, subject matter experts, and operational experience.[37] The design process "…reduces reliance on individual genius by giving all commanders the conceptual tools necessary to create unique organizational solutions for complex missions."[38] Within this monograph, the design team is inclusive of the commander, however the commander is not counted as a core member of the design team, since he is not expected to be in attendance all of the time. Due to the intensive time requirements of design, the commander will typically have only periodic opportunities to participate in discourse with the core design team. The core design team consists of personnel who perform the required discourse activity in order to develop a better understanding of the complex situation within the team, which includes the commander. However, successful discourse and shared understanding requires the active and frequent participation by all team members. Gill argues that when considering military design teams:

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[37] Department of the Army, Field Manual Interim 5-2 (FMI 5-2), 19.
[38] Ibid., 4.

> The commander should give careful consideration to the size of the design team. Although design can be performed by individuals, the methodology is intended for teams, because the purpose is to provide collective effort to support the commander's intuition.[39]

In addition, the military design team will have to respond to a variety of unique, complex situations. Greenwood and Hammes provide further insight into the requirements facing a military design team when they state:

> Given the nature of the problems facing 'design teams'—generally a subset of a larger joint planning group (JPG)—the composition of these teams will be substantially different than in years past. Problems such as nation building and humanitarian relief frequently require a host of outside experts—health specialists, economists, city planners, financial analysis, religious scholars, women's rights advocates, anthropologists—to augment the traditionally insular and predominately military JPGs.[40]

The literature provides the basis of the military design team, which is composed of multiple individuals with varied background, experience, and training. The members will have to be competent in a range of disciplines that apply political, military, economic, social, infrastructure, and information systems (PMESII) among others to the situations presented by the operational environments. Gill's School of Advanced Military Studies Monograph provides an initial discussion of the size for a military design team and makes several recommendations of the design team composition. However, the focus of this monograph is design team roles and supporting software, rather than the issue of design team size.[41] This study of the optimal team size for the military design team expands Gill's recommendations in order to explore a potential for the optimal size of a design team.

Designer as a Team of One or More

"Ever since Vitruvius' first century treatise on architecture, we accept axiomatically that a designer must know a little bit more about everything because design work requires varied

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[39] Jonathan B. Gill, "Enabling Design," (Master's Thesis, Fort Leavenworth, KS: School of Advanced Military Studies, Command and General Staff College, May 2009), 19-47.

[40] Greenwood and Hammes, 22.

[41] Gill, 19-47.

knowledge and an outstanding capability for mental integration and synthesis."[42] Who does better in design: an individual or a team? Sparse research is available that demonstrates quantitatively that team design is superior to an individual's response. The research by Gabriela Goldschmidt indicates that an individual acts as a team, but a team does not act as an individual designer.[43] The team can share or split responsibility while learning and using specialized knowledge. The individual designer can only use himself for knowledge and cannot utilize their teammates for additional information. However, the design process appears to be similar for the individual and a team.

Goldschmidt states that several problems exist in assessing productivity in terms of design. Productivity, she asserts, is associated with creativity and expertise. Productivity is the ability to take short cuts and reduce the amount of labor. Gobet and Simon's work on templates in chess memory supports this concept of expertise.[44] Goldschmidt focuses her research on the productivity of the design process by the individual and the team. She summarizes a section from Max Wertheimer's book, *Productive Thinking.* She states that, "…thinking is productive when it gives rise to genuine ideas, when it brings about the transition from a blind attitude to understanding, when one comes up with creative ideas, however modest the scope or the issue."[45] The concept of developing a rich understanding is a key concept to design. Since situations where the design methodology applies are typically ill-structured problems comprised of multiple interacting complex adaptive systems, the shared understanding earned through the design methodology leads to productivity.

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[42] Gabriela Goldschmidt, "The Designer as a Team of One," *Design Studies* 16, no. 2 (April 1995): 189.

[43] Ibid.

[44] Fernand Gobet and Herbert A. Simon, "Templates in Chess Memory: A Mechanism for Recalling Several Boards," *Cognitive Psychology* 31, no. 1 (August 1996): 1-40, http://bura.brunel.ac.uk/handle/2438/1339?mode=full&submit_simple=Show+full+item+record (accessed December 2, 2009).

[45] Goldschmidt, 194.

In an effort to quantify productivity, Goldschmidt uses linkography, a system that notates moves and the links among them. "The meaning of 'move' in designing is akin to its meaning in chess: a design move is a step, an act, an operation, which transforms the design situation relative to the state in which it was prior to that move."[46] Her research team argues that "an effective design process is characterized by a high ratio of interlinking among its moves."[47] Using linkography, they identify critical moves, which are moves that are link-intensive. The critical moves typically occur seven times to create a "structural representation,"[48] which is a design concept that satisfied the basic requirements of the situation. She theorizes that this number is linked to Miller's theory on short-term memory (discussed below) and the amount of information that can be retained in connection to the next move. Therefore, they use the seven moves as the baseline for the number of critical moves in their analysis. They discover that in seven critical moves the group and the individual results from the design process are almost identical.[49] Goldschmidt reaches the conclusion that the demonstrated productivity using their methods, while only using one sample set, cannot claim whether the team or an individual is always equally productive. However, the measurable cognitive parameters are similar for individuals and team.[50]

Goldschmidt's research demonstrates that:

> When a team acts together, implicit or explicit roles are created for the team members, along disciplinary or behavioral lines….The single designer must therefore assume production of all types of moves, whereas in a team situation he/she could develop a permanent or an ad hoc 'expertise' in the production of a certain type of moves…that takes advantage of the strongest capabilities of all participants in order to advance toward the best possible results.[51]

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[46] Ibid., 195.
[47] Ibid., 196.
[48] Ibid.
[49] Ibid., 201.
[50] Ibid., 202.
[51] Ibid., 208.

The disadvantage in terms of productivity of a team for military design is that the team will require more time to generate discourse in order to develop the critical moves and understanding. The productivity advantage of teams is that diverse perspectives, experiences and disciplines provided by different team members allows discourse that synthesizes multiple perspectives and exceeds the limitations of any individual. The immediate use of multiple disciplines and expertise is not available to the individual designer who must answer his or her questions within the same move in the interactive process used by design methodology.

Although this research does not show a definitive advantage for teams compared with an individual, for the purposes of this monograph we will assume that design is performed by a team. The commander already has a means for developing an individual appreciation of a situation using battle command. Design is an extension of battle command that leverages collective intellect to understand a complex ill-structured problem situation. While it is possible for an individual to design, it is unlikely that a commander would choose to task a single less-experienced subordinate to design the commander's planning guidance and intent in isolation, when the commander has invaluable contextual understanding gained from battlefield circulation. Therefore, in a military context, we assume that the commander will actively engage with at least two or more designers to augment his or her personal understanding. We assume military design takes place in a design team.

SIZE OF A MILITARY DESIGN TEAM

Internal Dynamics

One definition that best describes a team is, "A team is a small number of people [or group of people] with complementary skills who are committed to a common purpose,

performance goals, and approach for which they hold themselves mutually accountable."[52] While the "right size" of a team depends on the purpose or specific tasks of a team, the research and literature form a set of guidelines as to the size. Lawson quotes Hare, who highlights the interactive nature of small groups:

> There are then in sum, five characteristics which distinguish the group from a collection of individuals. The members of the group are in interaction with one another. They share a common goal and set of norms, which give direction and limits to their activity. They also develop a set of roles and a network of interpersonal attraction, which serve to differentiate themselves from other groups.[53]

This is similar to Katzenbach and Smith's earlier distinction, except that Katzenbach's team is called a group by Hare, while Katzenbach's working group is Hare's collection of individuals. For the purposes of this monograph, Katzenbach and Smith's terminology is more useful, but Hare's insights are still of value. As Lawson and Hare describe, interaction and communication are important aspects to the success of the design team. The small group literature leads to a conclusion that a team can be too small or too large to be effective independent of the task, purpose, or common goals. Since the situations that a military design team may be asked to develop a response to are limitless, the focus of our research into team size will firstly investigate the number of team members independent of the task or purpose of the specific team.

Evidence on Group and Team Size

As Figure 1 illustrates, Professional Communications, Inc. has collected data on 2,267 teams throughout the United States, ranging from teams that drill oil wells to developing new medical devices. Whereas most scientific experiments on team size have relatively small sample sizes and take place under controlled and artificial conditions, this extensive database provides insight into the size of teams that are able to survive and operate in real world conditions. Their

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[52] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, 45.

[53] Lawson, 243.

data shows that the most frequent team size is between five and eight people. The average team size is about nine people. The propensity of the teams to average around five to eight members appears to be related to the number of transaction channels. The data is remarkably consistent with Parkinson's claims that five is a healthy size for a group and that the Coefficient of Inefficiency reduces group effectiveness, explaining why only a small fraction of teams are larger than 20.

Interestingly, A.V. Graicunas discovered similar finding in 1933 and is quoted to say, "No superior can supervise directly the work of more than five or, at the most, six subordinates whose work interlocks"[54] Urwick also stated that Graicunas theorized that the more interactions that occur between subordinates, the more complex and difficult the job of the supervisor or manager.[55]

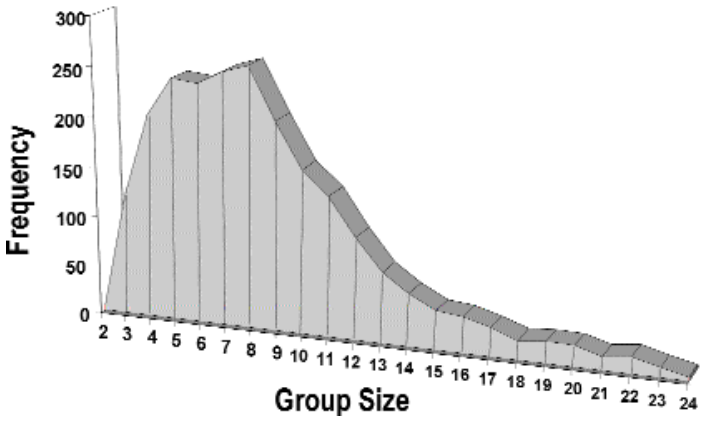

Figure 1. Group Size Actual Experience, n=2,267 teams. *Source*: Beatrice J. Kalisch and Susanne Begeny, "Improving Patient Care in Hospitals: Creating Team Behavior," *Journal of Organizational Engineering* 6, no. 1 (October 2005): 4.

Major General Scales notes that, "Prior to Desert Storm, Gen. Norman Schwarzkopf created a small cell of four majors and a colonel to act as his intimate 'Brain Trust' to plan his

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[54] Lyndall F. Urwick, "The Manager's Span of Control," *Harvard Business Review* (May- June 1956): 41, http://users.skynet.be/fa572372/The%20managers%20span%20of%20controll.pdf (accessed February 8, 2010).

[55] Ibid.

campaign."[56] The "Brain Trust" team appears to reinforce a phenomenon observed by a Hackman and Vidmar study. Their study demonstrates data generalized over three types of cognitive tasks and two different populations in the laboratory.[57] This data simply records what team size members of the groups preferred. They used satisfaction scores to determine the optimal team size. Most members are comfortable to be in teams of 4.6 members.

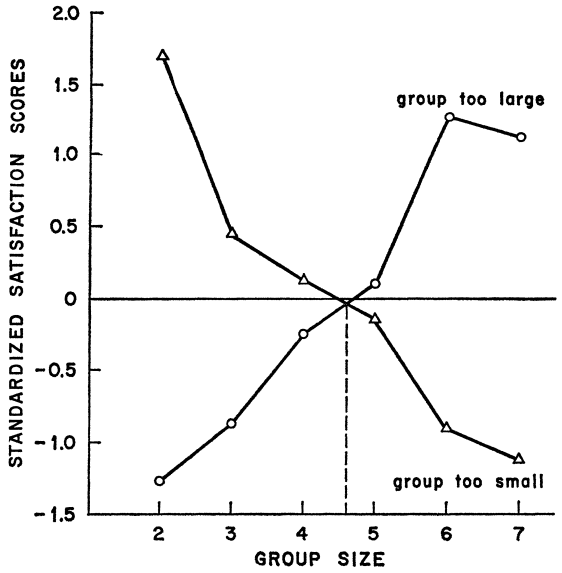

Figure 2. Reported Satisfaction with Group Size. *Source*: J. Richard Hackman and Neil Vidmar, "Effects of Size and Task Type on Group Performance and Member Reactions," *Sociometry* 33, no. 1 (March 1970): 48, https://www.jstor.org/pss/2786271 (accessed November 29, 2009).

The members of the smaller groups reported feelings of exposure while the members within the larger groups described dissatisfaction due to conflict-and-coordination problems. However, there is evidence that the task type may have a contributing role in the feelings and satisfaction of the groups. The interactions and performance of the group members may change as

[56] Robert H. Scales, "Return of the Jedi," *Armed Forces Journal* (October 2009) http://www.afji.com/2009/10/4266625 (accessed January 26, 2010).

[57] J. Richard Hackman and Neil Vidmar, "Effects of Size and Task Type on Group Performance and Member Reactions," *Sociometry* 33, no. 1 (March 1970): 49, https://www.jstor.org/pss/2786271 (accessed November 29, 2009).

the demands of the task change.[58] Such task differences may create varying requirements from each member during production, exploration, development, or creativity processes.

Theodore Caplow makes a distinction of group categories describing a small group as typically being in the size range of two to about twenty people; however, groups can range to about one hundred members.[59] He makes another distinction between primary groups and non-primary groups within a small group. When conditions allow each member to interact individually with every member, it is a primary group. A non-primary group exists when the conditions of individual interaction are not met. The primary group is typically comprised of two to about twenty people while a non-primary group can be three to about 100 members.[60] Most societal organized groups are small groups. Face-to-face interaction is a common characteristic of small groups, which allows the group to exercise power without delegation.[61] Caplow's finding reflects a similarity to Parkinson's Coefficient of Inefficiency in terms of the formation of small groups or teams and the relative size of the small group.

Caplow states that a medium group, 50 to 1000 members, requires a formal organizational structure, its day-to-day activities are controlled by the activities of internal cliques; individuals have very limited influence over the group so they have a tendency to form coalitions of cliques.[62] These characteristics are not conducive to the design process and the use of discourse to develop shared understanding of the environment, the problem, or the responses that form potential solutions.

The limited amount of design literature that discusses design teams indicates using smaller teams along with other stakeholder involvement. This literature describes a construct

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[58] Ibid.
[59] Theodore Caplow, "Organizational Size," *Administrative Science Quarterly* 1, no. 4 (March 1957): 484-506.
[60] Ibid., 484-506.
[61] Ibid., 487.
[62] Ibid., 488.

similar to a primary group along with the addition of a non-primary group that has some participation and contribution at various stages of the design process. Lawson states that Ian Richie, "…advanced the argument that design teams need to be 'about the number of people who can basically communicate well together'. He favours a design team of about five people"[63] The ability of the group to communicate is extremely important for the design group to develop and understand their environment, problem, and goals. Early in the design process, the group must share concepts and agree on words to be used so the required amount of communication between members is significant throughout the design process.

John James asserts that a small human group is defined, "…as one in which the members, integrated by direct communication demands, interact functionally and continuously toward the achievement of an end."[64] This highlights once again the importance of integration to a small group along with identification of the goal or ends. James also states that, "…the structure resulting from such interaction is a unitary system of relationships in which the factor of size (number of participants) is one of the determinants of the system." John James conducted an investigation of the size determinant of small groups. He determined that the mean group size ranges from 4.7 to 7.8.[65]

An interesting aspect to his research is that he differentiated from action-taking and non-action-taking subgroups among the small groups. The action group is the members that participated actively in the group versus a part of the group solely based on membership. John James found a mean group size of 6.5 for action-taking subgroups and 14 for non-action-taking subgroups. A president for a large bank, or bank secretary, in James' study explains this finding, "'We have found,' wrote the [bank] secretary, 'that committees should be small when you expect

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[63] Lawson, 249.

[64] John James, "A Preliminary Study of the Size Determinant in Small Group Interaction," *American Sociological Review* 16, no. 4 (August 1951): 474.

[65] Ibid.

action and relatively large when you are heading for various points of view, reactions, etc.'"[66] James' research also indicates that groups will meet informally to discuss common problems if group sizes are below the mean and groups of two, three or more are typical of *ad hoc* meetings dependent on the need. James notes that, "In the course of the field work the author noticed that groups of 5 and above were very unstable and rather quickly divided into subgroups."[67] James' conclusion is that freely forming groups with continuous interaction average about three members with a range of about two to seven members. While design teams are more structured than the freely forming groups, the data may demonstrate the size of groups that people are most comfortable forming spontaneously to discuss information. This demonstrated propensity means more energy is required to maintain a design group of greater size. In addition, the design team is an action-taking group in terms of John James' inferred description. Accordingly, the action group demonstrates similarities to Cowen and Miller's work of three to four members for spontaneous grouping and 6.5 or 7 for more organized action-taking groups.

Limits to Growth: Transaction Channels

So far, we have found very good consistency across the literature that the best teams are small teams. Empirical and experimental evidence suggests that the best teams range between five and nine people, and certainly are not larger than 20. This raises the question: why are the best teams so small? Intuitively, we may expect that if two heads are better than one, then more is always better. The bigger and more complex the problem, the larger the team should be. However, there are at least three factors that limit effective team size, which we will now explore. The first of these factors is the number of transaction channels.

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[66] Ibid., 475.
[67] Ibid., 477.

Caplow describes four interactive types to illustrate the relational complexity of small groups. His first type, which is the simplest form, is the Interactive Type Number 1:

$$PR = \frac{N(N-1)}{2}$$

Caplow describes this equation as, "Each member has a potential relationship with every other, excluding himself."[68] Figures 3 and 4 illustrate Caplow's interaction of members as described by the Interactive Type Number 1 and the increase in interactions or transaction channels. The potential relationships (PR) in the small group quickly increases compared to the group size (N) which produces the following series: [69]

N =	2	3	4	5	6	7	…
PR =	1	3	6	10	15	21	…

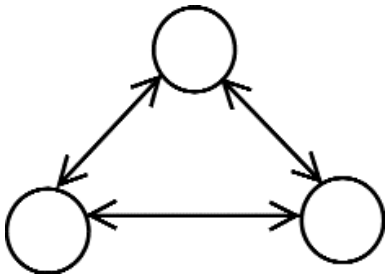

Figure 3. Three person group-3 channels. *Source:* Beatrice J. Kalisch and Susanne Begeny, "Improving Patient Care in Hospitals: Creating Team Behavior," *Journal of Organizational Engineering* 6, no. 1 (October 2005): 3.

[68] Caplow, 491.
[69] Ibid.

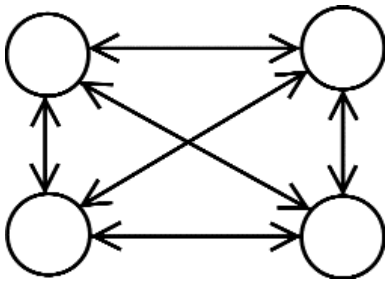

Figure 4. Four person group-6 channels. *Source*: Beatrice J. Kalisch and Susanne Begeny, "Improving Patient Care in Hospitals: Creating Team Behavior," *Journal of Organizational Engineering* 6, no. 1 (October 2005): 3.

Caplow's Interactive Type Number 2 describes the pair relationships plus all of the individual and combination relationships. Number 2 shows the individuals within a small group must deal with each member as well as cliques and coalitions, comprised of pairs and possible triads, within the small group. The formula for Interactive Type Number 2 is:

$$PR = \frac{N}{2} \times (2^N - N - 1)$$

The potential relationships (PR) for the group as a whole quickly increases compared to the group size, which produces the following series: [70]

N=	2	3	4	5	6	7	…
PR=	1	6	22	65	171	420	…

Interactive Type Number 3 considers the relationships within a small group that include a combination of subgroups. [71] Caplow describes this comparison as, "—relationships between an individual member and a combination, and relationships between combinations."[72]

N =	2	3	4	5	6	7	…
PR =	0	3	15	55	180	546	…

[70] Ibid., 492.
[71] Ibid., 493.
[72] Ibid.

Interactive Type Number 4 is the sum of all the relationships comprising the interactions of a small group. The single formula that describes this Interactive Type is:

$$PR = \frac{3^N - 2^{N+1} + 1}{2}$$

Caplow describes this interaction phenomenon. "As the following series shows, the increase in the number of relationship accelerates with small increases in group size, and a point is very soon reached where it is impossible for all the potential relationships to be realized."[73]

N =	2	3	4	5	6	7	…
PR =	1	6	25	90	301	966	…

The difficulty begins when the group members cannot maintain the required relationships for communication and the exchange of information. Once the members are unable to communicate effectively, the team is no longer efficient; the trap described by Parkinson begins to occur. The relevance of the various members decreases as well as the relevance of the team. However, the potential of an expanded network to provide additional support or expertise to a small team is demonstrated through Caplow's interaction formulas. As each member has interactions with the small group, the members are normally interacting with a larger community or people external to the small group, which greatly increases the number of interactions influencing a small group or a design team as demonstrated by Figure 5.

[73] Ibid.

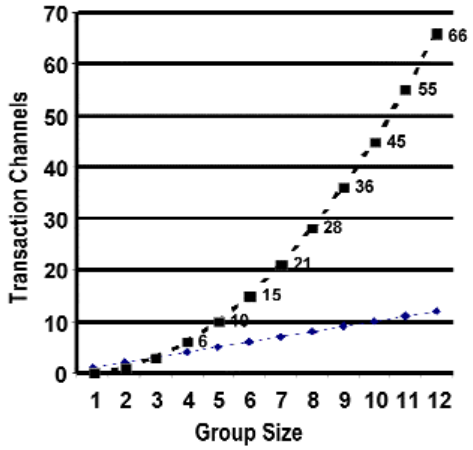

Figure 5. Group Size vs. Transaction Channels.[74] *Source*: Beatrice J. Kalisch and Susanne Begeny, "Improving Patient Care in Hospitals: Creating Team Behavior," *Journal of Organizational Engineering* 6, no. 1 (October 2005): 3.

Kalisch and Begeny describe the relationships between group members as transaction channels, which are proactive and reactive action to each of the other members in terms of communication, influence, and expectations. They describe a cost incurred by each transaction channel, which imposes an overhead burden whenever an additional member joins the team. They also state that the normative team size is five to 12 people.[75] The variation between the group size and transaction channel differs more dramatically after four team members. This evidence further suggests a significance of the numbers of four and five in terms of capacity of humans and the impact of the limited capacity. The research and data indicates a propensity of teams to form around the range of five to nine members.

Limits to Growth: Short Term Memory

The limits on team size are also supported by the psychological literature. It also demonstrates that the team size independent to the task of the team has significant impact on the

[74] Beatrice J. Kalisch and Susanne Begeny, "Improving Patient Care in Hospitals: Creating Team Behavior," *Journal of Organizational Engineering* 6, no. 1 (October 2005): 3.
[75] Ibid., 3.

outcome produced by the team. The psychological research demonstrates that the human cognitive system has limitations on its ability to process information, in particular its short-term memory capacity. These limitations can potentially be minimized by the forming of teams or groups, which typically perform better than individuals on intellective problems[76] or in highly information loaded or complex situations.

The literature on team size is extensive; however, there are several concepts that provide a baseline for the current literature on small groups that focuses on the number of members for a small team that is independent of individual skills or qualifications. While the term, "small", in respect to "small teams" is open to much debate within the literature, the one often-cited work is an address by George A. Miller to the Eastern Psychological Association in 1956. The title of the piece was, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." Applied to a multitude of items, Miller's address may have contributed to the use of seven digit telephone numbers and even is applied to power point presentation techniques.[77]

Miller's address infers the use of the Shannon and Weaver Model for communication between members of a group or team. Obviously, communication between individuals is a complicated process, which uses integrated signals and symbols in multiple mediums using the various senses. "Shannon and Weaver originated this idea, defining communication as a process in which one mind uses messages to affect another mind."[78] Shannon and Weaver works similar

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[76] Patrick R. Laughline, Erin C. Hatch, Jonathan S. Silver, and Lee Boh, "Groups Perform Better Than the Best Individuals on Letters-to-Numbers Problems: Effects of Group Size," *Journal of Social Psychology* 90, no. 4 (2006): 644.

[77] Jeff Atwood, "The Magical Number Seven Plus or Minus Two," Coding Horror: Programming and Human Factors Blog, entry August 14, 2006, http://www.coding horror.com/blog/2006/08/the-magical-number-seven-plus-or-minus-two.html (accessed November 11, 2009).

[78] Steven R. Corman, Angela Trethewey, and Bud Goodall, "A 21st Century Model for Communication in the Global War of Ideas: From Simplistic Influence to Pragmatic Complexity," Report #0701 (Arizona State University: Consortium for Strategic Communication, April 3, 2007) 3, http://comops.org/article/114.pdf (accessed March 17, 2010).

to a telephone with a transmitter or sender and a receiver. The sender sends a message that has to be encoded using various symbols such as language, pictures, body language, etc. The receiver then must decode the message within the context of their reality. However, distortion or infidelity may occur along the channel of communication, affecting the message, which causes the receiver to misinterpret the message and creates failure in forming a common understanding. The model represents the channel or conduits of information, which passes between members of a team. Each member as they gain understanding must accurately communicate their information in a way that allows for a shared understanding. A clear channel increases the fidelity of the message so the message can be received, however the, "…listeners create meanings from messages based on factors like autobiography, history, local context, culture, language/symbol systems, power relations, and intimate personal needs. We should assume that meanings listeners create in their minds will probably not be identical to those intended by the receiver."[79] This means that the message contains a great deal of information as well as requiring the listener to use a great deal of assumptions and experience to interpret the message. This cognitive requirement of communication and the use of channels to communicate are considerations with Miller's address and several other authors.

Miller's famous psychology experiments studied one-dimensional absolute judgment and the potential limitation of short-term memory. Miller's research and experiments showed that the information or communication channel, which is observer of the stimuli, demonstrate a performance of almost perfect to five or six stimuli. However, the results demonstrate a performance decline as the number of stimuli increases. The stimuli used in the experiments required a decision between likely alternatives, such as identification of various tones and taste

[79] Ibid.

intensities. This evidence leads to the concept of a channel capacity[80], which is a limit to the amount of information given by an observer about a stimulus.

Miller argues that the number seven applies to these described judgments and that people may have some limitation built by learning or by the physiological design of the nervous system. After making this conclusion, Miller addresses the simple fact that people can accurately identify one of several hundred faces or one of several thousand words. He proposes an explanation may be in the greater number independently variable attributes of the stimuli from these examples. Faces and words differ in many ways. The potential design is that the more information known on an item or artifact may contribute to a more accurate identification and ability to express a greater amount of information about that stimuli or artifact. Lawson describes design as a process based on conversation and perception,[81] which appears supported by Miller's findings.

In addition, Miller discusses immediate memory span in his famous address. Memory span typically refers to the longest list of items that a person can repeat back immediately after random presentation in correct order. However, Miller suggests that research shows a direct relationship of immediate memory to the number of items, which he states is around the average number of seven. The argument continues in that the memory span can increase with learning because the observer can group various pieces of information into a package that they can retain, which he called a chunk[82] or intelligent grouping.[83] The chunk performs the function of maintaining a greater amount of information for the observer to be able to remember based around the learned ability to package information. He described the observer's ability to organize

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[80] George A. Miller, "The Magical Number Seven, Plus or Minus Two Some Limits on Our Capacity for Processing Information," *Psychological Review* 101, no. 2 (May 1955): 344, https://spider.apa.org/ftdocs/rev/1994/april/rev1012343.html (accessed November 29, 2009).

[81] Lawson, 265.

[82] Miller, 353.

[83] Nelson Cowan, "The Magical Number 4 in Short-term Memory: A Reconsideration of Mental Storage Capacity," *Behavioral and Brain Sciences* 24, no. 1 (2000): 143, http://web.missouri.edu/~cowann/pubs.html (accessed March 17, 2010).

information and combine them into a chunk as recoding.[84] So the bigger the chunk the more information can be retained.

Based on the research, experience and learning has a positive effect on the ability to form chunks of information, so experience doing design may allow individual to better respond to situations that are more complex. The more exposure to information and stimuli the more easily the observer or designer can package greater amounts of information and a more comprehensive understanding can be created and maintained in the designers' memories. The Gobet and Simon research tends to suggest that experts can search possibilities and more quickly determine the next moves along with consequences.[85] As with chess, this evidence supports using a formal team that learns from the experience of doing a particular function such as design. A formal design team would have the benefits of more experience developing responses for the particular situations that face the assigned command.

One technique that Miller discusses is the importance of linguistic recoding and its connection to thought processes and memory, but he makes it clear that more research is needed to determine if a direct connection exists. However, this potential connection of increasing understanding and processing information using vocabulary and language to describe a complex situation is compatible. The process of chunking and recoding may attribute to the success of the use of discourse, which is an organized way of talking, writing, and acting, in design. The FMI 5-2 defines discourse within design methodology as "an essential technique for learning." Greenwood and Hammes state: "Shared discourse yields better problem understanding and results in improved planning guidance."[86] Krippendorff adds: "Discourses are organized ways of talking, writing, and acting accordingly. Discourses direct the attention of community members, organize

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[84] Miller, 351.
[85] Gobet and Simon, 1-40.
[86] Greenwood and Hammes, 22.

their actions, and construct the worlds they see, speak of, or write about." [87] The use of language and narrative[88] provides a means for the designers to incorporate a larger amount of information into their minds and allow more relationships to be considered. Miller even states,

> When there is a story or an argument or an idea that we want to remember, we usually try to rephrase it 'in our own words.' When we witness some event we want to remember, we recreate by secondary elaboration the details that seem consistent with the particular verbal recoding we happen to have made. [89]

Lawson provides further amplification of the importance of conversation and the narrative as a design tactic.[90] The telling of the story develops and provides consistency to a design and provides a means of negotiation between the problem and solution frame as well as provide a scene setter for the situation frame as part of the design process.[91] The use of chunking along with narration may be a learned activity.

Miller's work is not only a pivotal piece for psychology, but also has direct application to design as the design team. Members of a design team may need to understand that humans may have a limited ability to collect and maintain information at any particular moment. Since complex problems by their nature involve more information due to the interaction and integration of an almost infinite amount of variables, the design team members must overcome these potential limitations of the individual's memory. The use of a team to address the complex situations and to provide the ability to maintain the multiple frames required for the design process appears to be a valid technique to compensate for the limited capability of the individual. The inference made from Miller's work is that people tend to work best with about seven items. The "magical" number seven is to be inclusive of the number of relationships or transaction

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[87] Klaus Krippendorff, *The Semantic Turn: A New Foundation for Design* (New York: Taylor and Francis Group, 2006), 11.
[88] Lawson, 267.
[89] Miller, 354.
[90] Lawson, 267.
[91] Ibid., 267-274.

channels between individuals at any one time. Due to the constraints of our memory, individual team members may only be able to keep track of a finite amount of interactions of seven plus or minus two with the other members in a group or team. Jeff Bezos, the CEO of Amazon, recommends his "two-pizza" rule, which provides further support for the applicability of Miller's cognitive limitation of five to nine items for interpersonal interactions. Bezos' rule states that if a team cannot be fed with two pizzas then it is too large. This may contribute to Amazon's demonstrated success in business and on the internet.[92]

George Miller offers as a final thought in his address the following examples of the power of number seven and its power connectivity to human experience:

> What about the seven wonders of the world, the seven seas, the seven deadly sins, the seven daughters of Atlas in the Pleiades, the seven ages of man, the seven levels of hell, , the seven primary colors, the seven notes of the musical scale, and the seven day of the week? What about the seven-point rating scale, the seven categories for absolute judgment, the seven objects in the span of attention, and the seven digits in the span of immediate memory? For the present I propose to withhold judgment.[93]

Other researchers have argued that Miller's work is a rough estimate and a rhetorical device instead of a capacity limit.[94] Cowan summarizes evidence from various researchers that demonstrate a storage capacity mean value of three to five chunks. Cowan contributes the larger number found by Miller was possibly due to his focus on increasing the capacity of the memory through chunking or intelligent grouping. The results of the research on short-term memory have been controversial due to considerable differences of opinion and interpretation.[95]

Cowan describes the findings of several studies from the mid-1990s that highlight the role of long-term memory and an association with the ability to form chunks of information.

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[92] Jia Lynn Yang, "The Power Of Number 4.6: Researcher Find Too Many Players Can Spoil The Team. The Elusive 4.6 Proves To Be The Right Number," *Fortune*, June 12, 2006. http://money.cnn.com/magazines/fortune/fortune_archive/2006/06/12/8379238/index.htm (accessed February 5, 2010).

[93] Miller, 354.

[94] Cowan, 87.

[95] Ibid., 88.

There appear to be several factors that can affect the ability to increase the size of the chunk and one is whether the information is formed with a new association or a previous one.[96] The findings in this area of research seem to support that experts tend to form larger chunks of information. They do not process a larger number of chunks. The chunks tend to form cognitively in groups of three to four items. This use of chunking provides several advantages to an expert that is also applicable to a designer and especially to an experienced military designer. According to Gobet and Simon in their study of chess players, the expert chess player forms memories of chunks for the game, this provides:

> …a theory of the processes underlying chess skill. Skill, according to this theory, has two main components: ability to search the tree of possible moves and their potential consequences highly selectively, and ability to evaluate positions and to discover potentially strong moves. Both abilities are based on recognition of features (familiar chunks) on the chessboard. The search of the skilled player is guided by heuristics, or rules of thumb, that permit it to be restricted to a small tree of possibilities (usually less than 100). The heuristics, in turn, rest upon recognition of familiar patterns or chunks.[97]

Katherine J. Klein, a University of Pennsylvania management professor, acknowledges the impact of that particular numbers of members have on a team:

> With three, you suddenly have the opportunity to have power battles, two to one. There is some notion that three is dramatically different from two, and there is some sense that even numbers may be different from odd numbers for the same reason. My intuition is that by the time you are over eight or nine people, it is cumbersome and you will have a team that breaks down into sub-teams.[98]

The small group literature supports the number of four or five to be an equilibrium point which may indicate a linkage to Cowen's research, however the team' s task also affects performance.

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[96] R.S. McLean and L.W. Gregg, "Effects of Induced Chunking on Temporal Aspects of Serial Recitation," *Journal of Experiment Psychology* 74, no. 4 (August 1967), 455-459.

[97] Gobet and Simon, 4,

[98] Wharton School of the University of Pennsylvania, "Is Your Team Too Big? Too Small? What's the Right Number?" *Knowledge@Wharton* (June 14, 2006): 2, http://knowledge.wharton.upenn.edu/article.cfm?articleid=1501 (accessed February 18, 2009).

Interestingly, recent research shows that even with cabinets ranging from 5 to 54 members that "…all countries avoid cabinets with 8 members."[99]

Donald W. Taylor and William Faust conducted a study that involved a game of "Twenty Questions" that gradually increases specificity of a description until they arrive at the precise object. The study attempted to involve a type of problem solving that they thought was representative of everyday life. They also wanted to test whether increasing the number of people in a small group would reduce the solution time and increase efficiency and whether performance increases with practice as an individual or as a team.[100]

The questions about the efficiency of problem solving in relation to the team size showed that the performance of individuals was inferior to the groups of two and four. However, their evidence showed that the groups of two and four members required about the same number of questions to reach the solution. Also, the amount of elapsed time for the group performance was better than that of individuals. In terms of person-hours, the individuals fared better than the groups. Interestingly, the groups of two people performed better than the group of four in total amount of time in relation to each participant. The study did show a tendency for the groups of four to ask more questions prior to arriving at a correct solution than the two person groups.[101]

Taylor and Faust's study demonstrated that learning from practice occurred with insignificant differences among the individuals, two person groups, and four person groups. Their results demonstrate that, "Group performances were superior to individual performance in terms of number of questions, number of failures, and elapsed time per problem; but the performance of

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[99] Klimek, Hanel, and Thurner, 1.

[100] Donald W. Taylor and William L. Faust, "Twenty Questions: Efficiency in Problem Solving as a Function of Size of Group," *Journal of Experimental Psychology* 44, no. 5 (November 1952): 360.

[101] Ibid., 364.

groups of four was not superior to that of groups of two, except in terms of the number of failure to reach solution."[102]

Another study, one of three person and six person groups, shows that discussion quality was better in the three-person groups concerning appropriateness, openness, richness, and accuracy.[103] The researchers state: "This finding is of particular interest to practitioners because it suggests more complex projects may benefit from using much smaller groups."[104] This implies that a larger design team may not be the appropriate response to a perception of increased complexity of a situation. Therefore, more is not better, which may be counterintuitive. Design is an approach to address complexity, but the more complex a problem does not mean that the team must be larger. A small team may be a better choice to address the problem compared to a large team.

Limits to Growth: Evolutionary Context

In addition to the research on transaction channels and cognitive limitations, several anthropologists have commented on group size from an evolutionary perspective. Edward T. Hall describes the relationship between man's instructions and the methods and abilities of the central nervous system to store and retrieve information. He states that the

> …ideal size [of a working group] is between eight and twelve individuals. This is natural because man evolved as a primate while living in small groups. There are also a variety of compelling reasons why this particular size range is the most productive and efficient. Eight to twelve persons can know each other well enough to maximize their talents. In groups beyond this size the possible combinations of communication between individuals get too complex to handle; people are lumped into categories and begin the process of ceasing to exist as individuals. Tasks that can't be handled by a group of eight to twelve are probably too complex and should be broken down farther. Participation and commitment fall off in larger groups: mobility suffers; leadership doesn't

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[102] Ibid., 365.

[103] Paul B. Lowry, Tom L. Roberts, Nicholas C. Romano, Jr., Paul D. Cheney, and Ross T. Hightower, "The Impact of Group Size and Social Presence on Small-Group Communication: Does Computer-Mediated Communication Make a Difference?" *Small Group Research* 37, no. 6 (December 2006): 654 and 657.

[104] Ibid., 657.

> develop naturally but is manipulative and political….Clearly, group size is not everything, but it is significant.[105]

The importance of Hall's description is that the small group has a limit and beyond this size limitation, the efficiency decreases dramatically. The design team must be able to communicate in order to conduct discourse and to share each individual's understanding of the environment, problem, and potential solutions. The other interesting aspect is Hall's description of workgroups that are not necessarily teams. Teams have an increased requirement for communication compared with workgroups, due to increased reliance on group discussion, debate and decision.[106] Also, Katzenbach and Smith state that, "Work groups present fewer risks."[107] "The team option promises greater performance than the working groups. But it also brings more risk."[108] The risk may contribute to the ability of the working group to form into a larger group than a team since the requirement of communication within a working group is less than for a team.

Another anthropologist, R.I.M. Dunbar researched the potential connection of the neocortical size and group size along with the contribution of language and found that, "…the neocortical constraint seems to be on the number of relationships an animal can keep track of in a complex, continuously changing social world."[109] He also found evidence that conversational cliques formed within groups interacting in sizes of two to ten individuals.[110] His evidence also shows that "…the average number of people directly involved in a conversation (as speaker or attentive listener) reached an asymptotic value of about 3.4 (one speaker plus 2.4 listeners) and that groups tended to partition into new conversational cliques at multiples of about four

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[105] Edward T. Hall, *Beyond Culture* (New York: Anchor Books, 1977), 203.

[106] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, 89.

[107] Ibid., 90.

[108] Ibid.

[109] R.I.M. Dunbar, "Coevolution of Neocortical Size, Group Size and Language in Humans," *Behavioral and Brain Sciences* 16, no. 4 (1993): 681.

[110] Ibid., 690.

individuals."[111] Dunbar also found evidence that conversation provides more efficient bonding and that language and the ability to communicate contributes to the size of a group. The ability to communicate and maintain relationships is a continuous process that requires an investment of time and energy.[112]

Limits to Growth: Span of Control

The span of control is a related issue to the topic of group size. The difference between span of control and team size is the different topologies of the relationships. Figure 6 illustrates the typically span of control with a leader who has five relationships or interactive channels with subordinates. Figure 7 shows the expected internal interactive channels of a military design team since typically each member contributes more equally to the effort so each member has five interactive channels to maintain.

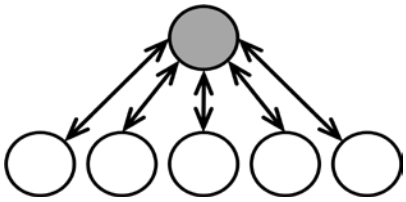

Figure 6. Typical Span of Control with a supervisor and five group members.

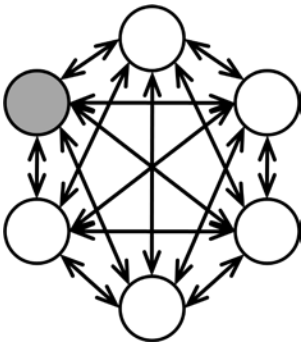

Figure 7. Internal Span of Influence with six group members.

[111] Ibid.
[112] Ibid., 681-682.

Despite the differences, findings from span of control research has implications for the effective span of influence that one design team member can have on the other members of the team. Because span of control issues are less complex than the interactions of team dynamics, span of control research provides an upper bound on effective team size.

General Sir Ian Hamilton developed the widely accepted military concept of the span of control. He developed his theories from observation of commanders and leaders, who throughout history have continually dealt with finite amounts of time, energy, and span of attention. In studies of British military leaders, Hamilton developed a principle for any military organization that states, "The average human brain finds its effective scope in handling from three to six other brains."[113] Hamilton's figures are the accepted "rule of thumb" for span of control. [114] He also asserts a rule that, "…the smaller the responsibility of the group member, the larger may be the number of the group—and vice versa."[115] Span of control in the context of the military is more hierarchical than the earlier described teams or groups, which had multiple transaction channels. However, the concept of the span of control was based on a central figure such as a commander and the number of subordinates that he could effectively control. However due to the highly interactive nature of the military design team, each member of the team can have a similar number of relationships that they will have to foster. The term for a design team member may be span of effectiveness or influence instead of the span of control but the limitations are similar.

Hamilton is supported by Kalisch and Begeny's research considering 178 CEO teams in 1999, which showed that the CEO had 6.7 direct reports. The implied group size was eight

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[113] Ian Hamilton, *The Soul and Body of an Army* (London: Edward Arnold and Company, 1921), 229.

[114] Fred Nickols, (2003) "The Span of Control and the Formulas of V.A. Graicunas," www.nickols.us/graciunas.pdf (accessed March 17, 2010).

[115] Hamilton, 230.

people. Their data showed group sizes of five to eight for CEOs and general managers among 36 major international firms.[116]

Another influential author on the issue of span of control is Lyndall Urwick, who applied the idea of span of control to the manager. He argues that the top management has new functions that are increasing as organizations have grown. As the team size increase then the amount of time decreases, the lack of time available to reflect will have a negative impact on the learning capability of a design team. Urwick states that "One of the biggest tasks confronting the manager is that of reducing his overload of less important daily duties, thus giving him time for reflection as well as for the personal contacts with his organization…."[117] This selection highlights the need for leaders to have the time to reflect to learn, which is considered an important aspect to education and design as highlighted by Donald Schön.[118] Urwick discusses a conversation with A.V. Graicunas about their thoughts on relationships in organizations. Graicunas developed the managerial concept that the, "…superior, in dealing with his subordinates, must keep in mind not only the direct relationship between himself and each subordinate as an individual but also his relationships with different groupings of the subordinates."[119]

The problem is that while the direct relationships increase at a proportional rate with each additional member, the groups and cross relationships increase geometrically. Graicunas' theories for business mirror the results of Caplow's research. Urwick explores a few of the opposing perspectives to span of control, which argue for flatter, decentralized organization and he describes a "dilemma between morale and efficiency."[120] Urwick shares his observations that the

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[116] Kalisch and Begeny, 4.
[117] Urwick, 39.
[117] Kalisch and Begeny, 4.
[118] Donald A. Schön, *Educating the Reflective Practitioner* (San Francisco, CA: John Wiley and Sons, 1987), 301-302.
[119] Urwick, 40.
[120] Ibid., 42.

span of control principle is frequently violated, but when the principle is not considered then the worst organizational problems seem to occur. Urwick states,

> There is no greater stimulant of morale than a collective consciousness of efficiency. There is nothing which rots morale more quickly and more completely than poor communication and indecisiveness—the feeling that those in authority do not know their own minds. And there is no condition which more quickly produces a sense of indecision among subordinates or more effectively hampers communication than being responsible to a superior who has too wide a span of control.[121]

Another important observation on the cognitive task of supervision made by Urwick is his "Commanding Machine." He makes the observation of a successful Division Commander in 1917-1918 who had 18 direct subordinates. He admits that this high number obviously violates his span of control principle. Despite this apparent difficulty, the commander only spent a few hours a day in his office. The military system accounted for the violation of this principle by use of a general staff, as a core team, for routine business. This meant that the subordinates had the right to go directly to the general, but only if the need was of high importance. The military's system for the chain of command allows the general to have:

> ...only six immediate subordinates who usually approached him directly—the three Brigadiers General in charge of infantry brigades, the Brigadier General of Artillery, and his two principal staff officers….The effect of this system was that while the Commander's nominal span of control was 18 persons, his actual span of control—the number of people with whom he had constant personal contact on business matters—was only 6.[122]

U.S. Army doctrine contains guidelines for the span of control. The span of control outlined in the U.S. Army's FM 6-0, "…refers to the number of subordinates or activities under a single commander."[123] The commander that has to have more detailed supervision of their subordinates will have less span of control than if they are giving generalized orders with purpose and intent. However, the U.S. Army manual states that the more fluid and fast-changing the

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[121] Ibid., 43.
[122] Ibid., 46.
[123] Department of the Army, Field Manual 6-0 (FM 6-0), *Mission Command: Command and Control of Army Forces* (Washington, DC: Headquarters, Department of the Army, 11 August 2003), 5-24.

situation, the fewer subordinate elements a commander can supervise closely."[124] Dependent on the situation, "…commanders can effectively command two to five subordinates….as the number increases, commanders, at some point, lose the ability to consider each unit individually and begin to think of the units as a single, inflexible mass."[125]

The U.S. Army doctrine reflects similar conclusions as Cowen, Caplow, and the other researchers. There appears to be a limitation to the capacity of humans to maintain awareness of a finite amount of information and relationships at a particular time. This limitation of control is as applicable to military design teams as it is to any other military command or element. Several military officers participating in a design methodology application experiment during Unified Quest 2005 discovered during an exercise that, "For UQ 05[Unified Quest 2005], a team consisting of six members was found to be an acceptable and workable number of participants. Clearly, too many members would be unwieldy, and too few would not create the diversity of skills and opinions necessary to foster meaningful discourse."[126] According to Colonel Dawson's experience of leading a military design team at U.S. Army Central Command, ARCENT, his opinion is that, "Personally, I think 6 to 8 in the core group is right. We started with 6 military members and 2 contractors…That was a good number, when you start thinking about people coming and going and requirements to break into two man teams, as needed."[127] Both experiences reflect the use of six members as an adequate number for a military design team. Some feel that small groups are unstable and that team identity does not manifest in groups smaller than five:

> In my experience the smallest viable group size seems to be somewhere in the range of 5 to 9. Looking smaller, we see that a group of 2 can be tremendously creative (ask any parent), but often has insufficient resources and thus requires deep commitment by both parties. Notably, often the

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[124] Ibid.
[125] Ibid.
[126] William T. Sorrells, Glen R. Downing, Paul J. Blakesley, David W. Pendall, Jason K. Walk, and Richard D. Wallwork, "Systemic Operational Design: An Introduction," (Master's Thesis, Fort Leavenworth, KS: School of Advanced Military Studies, Command and General Staff College, 2005), 30-31.
[127] Colonel Matthew Q. Dawson, email message to author, November 20, 2009.

> difficulty of a 2-person business partnership is compared to that of a marriage. A group of 3 is often unstable, with one person feeling left out, or else one person controlling the others by being the "split" vote. A group of 4 often devolves into two pairs.[128]

Team Size Summary

Why are small teams so effective? The psychological literature suggests that humans have an innate limitation on memory and cognitive ability beyond a particular number. The majority of the research suggests that the number is four to seven items at one time. The transaction channel research demonstrates that a threshold develops due to the increases of complexity of the relationships within the group with a markedly increased difficulty between six and seven channels. The expanding complexity increases the amount of energy required to maintain the relationships, while diverting the energy away from responding to the situation. According to the anthropologists' work, evolution pertains to small groups of eight to twelve. The literature suggests that the military design team must maintain a membership of at least four and less than nine. The optimal number appears to be five and possibly six members depending on the situation.

STRUCTURE OF A MILITARY DESIGN TEAM

Success from the Beginning

Size is not the only characteristic to consider when forming a military design team. The use of teams to solve problems is nothing new and history is full of examples of success and failure in the use of teams. Obviously, the use of teams in the U.S. military is important and a common occurrence. Katzenbach and Smith observe that

> …the same team dynamics that promote performance also support learning and behavioral change, and do so more effectively than larger organizational units or individuals left to their own devices.

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[128] Chrisopher Allen, "The Dunbar Number as a Limit to Group Sizes," Life With Alacrity Blog, entry posted March 10 2004, http://www.lifewithalacrity.com/2004/03/the_dunbar_numb.html (accessed January 31, 2010).

> Consequently, we believe teams will play an increasingly essential part in first creating and then sustaining high-performance organizations.[129]

The U.S. Army is by its nature required to be a high-performance organization since failure has tremendous impact on the United States, our allies, and the rest of the world.

The military design team is a recent development. The lack of clear examples of successful military design teams requires an inspection of small group and team theory and other examples of high-performance teams. While the size of the team is a pragmatic guide, a team also requires, "…meaningful purpose, specific performance goals, common approach, complementary skills, and mutual accountability."[130]

The issue of complementary skills of team members is not as important as many people think. The impact of the skills and talent appear to be minimal if other factors are present. Katzenbach and Smith claim that a "…common error is to overemphasize the skills in team selection."[131] Their research shows that none of the teams they studied had all of the skills required from the formation of the team. However, the teams did work to improve personal learning and development of the individual members. If the team had focus on the purpose and performance goals for the team, then the teams identified and developed the required skills for success. The team members also had an increased sense of individual accountability to the other members within the team, which promoted learning.[132] This concept of accountability to the team is important to the military design team since the team will be facing ambiguous situations and each situation will require significant learning. Schön highlights the predicament of learning to design. "The paradox of learning a really new competence is this: that a student cannot at first

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[129] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization,* 16.

[130] Ibid., 45.

[131] Ibid., 48.

[132] Ibid., 89.

understand what he needs to learn, can learn it only by educating himself, and can educate himself only by beginning to do what he does not yet understand."[133]

Jim Collins supports the idea of the "right" individuals, which are capable of identifying and learning, on the team. Based on empirical research, he claims that what he defines, as "…good-to-great leaders understood three truths."[134] The first truth is that starting with "who" instead of "what" allows a team or organization to more easily adapt to a changing world. The needs of the design team to adapt to a changing world are reflected in this statement by Collins. He is concerned that people will join the team because of "where it is going", however if people join the team because of the other people who are on the team, the team can adapt more easily. The second truth is that if the "right" people are on the team, then team members will need less supervision and will be self-motivated. This internal motivation lends support to the accountability requirement for a successful team identified by Katzenbach and Smith. Katzenbach and Smith state that, "Far too many leaders overemphasize selection…with the exception of some advanced functional or technical skills, most people can develop needed skills after joining a team."[135] Collins' third truth is that"…if you have the wrong people, it doesn't matter whether you discover the right direction, you still won't have a great company."[136]

The need to provide an environment that promotes and compensates for getting the "right" people to join the military design team is important for it to be successful. Also important for a successful team besides identifying the "right" people for the design team is the elimination of the "wrong" people. The work on a design team is rigorous, the individuals must be able to motivate each other, and having people that will learn and improve tends to motivate the other

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[133] Schön, 93.

[134] Jim Collins, *Good to Great: Why Some Companies Make the Leap…and Others Don't* (New York: Harper Publishers, Inc., 2001), 42.

[135] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, 120.

[136] Collins, 42.

members to improve their performance in kind. The "right" people as described by Collins has "…more to do with character traits and innate capabilities than with specific knowledge, background, or skills."[137] The character traits highlighted by Collins are, "character, work ethic, basic intelligence, dedication to fulfilling commitments and values." [138]He also promotes the concept of placing the "…best people on the biggest opportunities, not the biggest problems."[139]

The School of Advanced Military Studies' Draft Student Text "introduces the four big ideas of design: learning, difference, systems, and social creation."[140] When selecting members for a military design team, the four big ideas must be a consideration. The members must have an open mind, be comfortable with differences of opinion, think holistically, and work as team players. In other words, the members must be able to think within multiple disciplines and understand the importance of different perspectives to solve complex adaptive problems and make the most of opportunities.

Team Types

There are two current team concepts that have direct application to military design teams, cross-functional teams and X-teams. These teams focus on maintaining a small size and working with diverse team members while encouraging collaboration and coordination. The main difference is that the cross-functional team focuses more internally while the X-team focuses externally in respect to their emphasis on expertise and networking. The cross-functional team emphasizes a clear team goal and plan from the formation of the team while the X-team searches externally for its purpose and potential solutions.

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[137] Ibid., 64.
[138] Ibid., 51.
[139] Ibid., 58.
[140] Alex Ryan *et al*., *The Art of Design: Student Text Version 2.0, School of Advanced Military Studies (Draft)* (Fort Leavenworth, KS: Command and General Staff College, 2010), 23-32.

Cross-functional Teams

A cross-functional team, also called a multidisciplinary team, or an interdisciplinary team in academia, is a, "…group of people with a clear purpose representing a variety of functions or disciplines in the organization whose combined efforts are necessary for the achieving the teams' purposes."[141] However, the collection of diverse and talented people does not always produce performance and effectiveness. Also, according to some, the idea of disciplines as intellectual structures or organizations is beginning to dissolve.[142] One reason is a realization that complex problems transcend the boundaries of the disciplines. Glenn Parker explores this phenomenon within the sciences: "Palmer highlights an added feature of scientific work—researchers tend to work on problems not in disciplines. Problems are focal points where disciplinary social worlds intersect." [143] The Sigma Xi methodology classifies problems according to their degree of multidisciplinarity:

- *Problems of the first kind*: intellectual problems in a traditional discipline;
- *Problems of the second kind*: multidisciplinary problems that are basically intellectual not policy-action in nature but cannot be successfully undertaken within boundaries of one discipline;
- *Problems of the third kind*: distinctly multidisciplinary problems generated increasingly by society and distinguished by relatively short-time courses calling in some cases for a policy-action result and in other cases for a technological quick fix.[144]

The literature describing interdisciplinary, multidisciplinary, and transdisiciplinary research and teams provides further understanding of the potential for the use of multiple disciplines working concurrently and sequentially to develop solutions. The applicability and emphasis of multidisciplinary solutions are applicable to the problems potentially posed to military design teams. The Sigma Xi methodology appears to lack the identification of problems

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[141] Parker, 6.

[142] Peter Weingart and Nico Stehr, *Practising Interdisciplinarity* (Toronto: University of Toronto Press Incorporated, 2000), 13.

[143] Parker, 613.

[144] Weingart and Stehr, 13.

that are preexisting, adapting, and enduring, however Sigma Xi does support a weakening of disciplinary boundaries as the problems fall into the third category, which are more complex. This weakening emphasis on disciplinary boundaries supports the use of multidisciplinary or transdisciplinary teams. The strict use of disciplines to address problems creates cognitive boundaries or barriers to problem solving. The theory of common ground when discussing interdisciplinary or multidisciplinary teams suggests that individuals with different perspectives must negotiate when they communicate and is the summation of a series of assumptions, beliefs and knowledge.[145] The outcome may result in the development of a common language over time, which is the key for the team to better understand the other members and the problem.

Due to the growing acceptance of difference contributing positively to the effectiveness of a design team, the use of multiple discipline teams is gaining favor among various organizations. The use of diversity is an accepted technique for the development of the design team. Problem solving teams have been comprised of interdisciplinary, multidisciplinary, and transdisciplinary members, but multidisciplinary or interdisciplinary teams are the most common. Each type of team has unique strengths and weaknesses when applied to the design process. Katzenbach and Smith state that, "In any situation requiring the real-time combination of multiple skills, experiences, and judgments, a team inevitably gets better results than a collection of individuals operating within confined job roles and responsibilities."[146]

Military design draws on a variety of theories and terminology, and this mix is unique depending on the demands of each individual problem situation.[147] The requirement for this variety of perspectives and theoretical frameworks leads to the conclusion that a multiple discipline team of some type is needed. For military design, the concept of cross-functional teams

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[145] Ibid.

[146] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, 15.

[147] Department of the Army, Field Manual Interim 5-2 (FMI 5-2), 5.

is the most inclusive team concept that describes the team characteristics without describing the particular nature of the disciplines involved within each team.

Due to the common acceptance of diversity of expertise contributing positively to the effectiveness of a team, the use of multiple discipline teams is gaining favor among various organizations. The use of diversity is an accepted technique for the development of the design team. Problem solving teams are becoming more commonly comprised of interdisciplinary and multidisciplinary members.

The keys to using cross-functional teams to solve complex business problems according to Parker are:

- A leader with a creative vision
- Freedom from unnecessary restriction, including the freedom to fail
- A wide range of diverse opinion
- An openness on the part of the team members to new ideas[148]

The weakness of the cross-disciplinary team concept as described by Parker and others is the lack of focus on bringing in the external networks of the members and incorporating their information, knowledge, and ideas into the team. The focus is very similar to the traditional business teams that emphasize internal team dynamics and training.

The cross-disciplinary team faces the same forces discussed above to grow beyond their usefulness and "…seem to be particularly prone to the problem."[149] In parallel to Parkinson's observations, Parker describes the rationalizations for teams that outgrow effectiveness and become too large because:

- More team members mean more ideas.
- The bigger the team, the more important the project.
- A big team means my job as team leader must be big and important.
- We can't leave anyone out.
- Team meetings are good educational forums. They provide a good opportunity to orient and train junior staffers.

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[148] Parker, 19.
[149] Ibid., 168.

- Having large teams means having fewer teams, which translates into a reduced need for coordination and lower administrative overhead costs.[150]

Obviously, the military design team will most likely be cross-disciplinary in some manner due to the diverse educational background of its members and the joint and combined nature of operations and organizations with the military. The issue of maintaining the appropriate team size of the military design team directly affects the effectiveness of the team. In terms of team productivity, Parker quotes,

> Louis Fried, vice president of information technology for SRI International, who has studied project teams, found that 'in groups of five members or less such task oriented communication can consume from 10 percent to 30 percent of each member's time. As the number of people in the group increases beyond five, members must spend more of their time communicating and may eventually reach an upper limit of approximately 90 percent[151]

Some common tactics exist that ensure maintaining a small team so that Parkinson's Law does not overwhelm effectiveness. The first tactic is the use of discipline in the size of the team since someone must be able to make the call on the team's organization and membership. This means that as people are added, then others must be eliminated from the team. One recommendation made by Parker is that a core team form from cross-functional members that represent the critical subject-matter experts for a particular task. He recommends that this core team have five to eight members.[152] Once again echoing Parkinson, the ability and resources should be available to break into smaller groups as required or appropriate to maintain effectiveness and these smaller groups typically function as work groups.[153] If the proper size of the team is not maintained then the following unintended consequences tend to occur among the

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[150] Ibid., 161.
[151] Ibid., 164.
[152] Ibid., 167.
[153] Ibid., 168.

teams members to varying degrees: decreased team productivity, decreased team member involvement, and decreased participation and trust.[154]

One of the commonsense findings of Katzenbach and Smith that is often overlooked is the proper application of basic team principles such as size, purpose, goals, skills, approach and accountability.[155] The lack of focus in these areas can contribute directly to a lack of team performance. Apparent from their findings, the size of the design team seems to be a variable aspect to the effective outcome of a team.

Design draws on a variety of theories and terminology unique for an individual problem situation. [156] The requirement from design for variety leads to a conclusion that a multiple discipline team of some type and size is the most appropriate response for the use of the design process. Lawson states that designers, "…come to understand problems and get ideas about solutions though a process that is conversation-like"[157] He goes further to highlight that the design progresses through conversations and various methods of communication between team members. Once again, the importance of the transaction channels and the team members' ability to communicate and maintain effective relationships affects the military design team's effectiveness.

X-teams

While Collins analyzes successful organizations by focusing on senior leadership, Ancona and Bresman instead focus on the role of small teams in organizational success. Ancona and Bresman's empirical study of successful and unsuccessful teams leads them to identify X-Teams, which they claim have, "…emerged to help firms solve complex problems, adapt to

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[154] Ibid., 164.
[155] Katzenbach and Smith, *The Wisdom of Teams: Creating the High Performance Organization*, 3.
[156] Department of the Army, Field Manual Interim 5-2 (FMI 5-2), 5.
[157] Lawson, 265.

changing conditions, innovate, and gain competitive advantage." [158] As military design teams are also established to solve complex problems, adapt to changing conditions, innovate, and compete in a coercive environment, the techniques, structure, and lessons outlined by the X-Team concept may provide invaluable insights for the development of military design teams. Since the examples of successful military design teams are limited, the examples and concepts provided by Ancona and Bresman are representative of considerations for the development of a military design team and selecting its members.

Ancona and Bresman studied many business teams in different sectors to determine why some teams succeed while other teams failed or declined. The interesting finding from their research was that many teams that failed had talented and committed people on the teams.[159] The requirement for X-Teams is based on the argument that organizations cannot use teams that focus internally when an innovation-driven and adaptive adversary or competitor can make changes so quickly that they can neutralize the advantages of your organization. Ancona and Bresman argue: "When organizations are faced with complex problems and resources are dispersed, leadership needs to be distributed across many players, both within and across organizations, up and down the hierarchy—wherever information, expertise, vision, new ways of working together, and commitment reside."[160] While this will require internal focus to develop and find the "right" people with the organization, the focus is also to external organizations and individuals. The team and leadership work concurrently to balance and combine the internal and external focus so the team can best meet the requirements of the project.

The X-Team is different from a traditional team in three ways:

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[158] Deborah Ancona and Henrik Bresman, *X-Teams: How to Build Teams That Lead, Innovate, and Succeed* (Boston, MA: Harvard Business School Press, 2007), 9.
[159] Ibid., 2-3.
[160] Ibid., 6.

- First, to create effective goals, plans, and designs, members must go outside the team; they must have high levels of *external activity*.[161]
- Second, X-teams combine all of that productive external activity with extreme execution inside the team. X-teams develop internal processes that enable member to coordinate their work and execute effectively while simultaneously carrying out external activity.[162]
- Third, X-teams incorporate *flexible phases*, shifting their activities over the team lifetime. Netgen team members first engaged in exploration—learning about customer needs, top management expectations, and their own passions about what they wanted to create. Then they moved on to exploitation—actually developing software that customers wanted and competitors did not yet have. Finally, they engaged in exportation—transferring their product to another part of Microsoft and learning form their experiences.[163]

The teams have to be structured in a particular manner in order to execute the three phases. Ancona and Bresman describe this structure as three "X-Factors."[164] The X-Factors are extensive ties, expandable tiers, and exchangeable membership.[165]

Extensive Ties

The extensive ties are relationships and networks with weak and strong links that are external to the team and more importantly external to the particular organization. The external network provides a means for teams to "…go beyond their boundaries, coordinate their activities, and adapt over time."[166] External ties could provide the team or a military design team a means to develop robust discourse, and leverage external expertise and perspectives.

FM 5-0 states that, "In addition to the organizations within their command, commanders also collaborate with civilian and other military organizations in the operational area to better understand their perspectives and build unity of effort."[167] FMI 5-2 provides more detail on the commander and the design team in, the section titled, "Participants Must Question the Limits of

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[161] Ibid., 7.
[162] Ibid.
[163] Ibid., 6-7.
[164] Ibid.,7.
[165] Ibid., 7-8.
[166] Ibid., 7.
[167] Department of the Army, Field Manual 5-0 (FM 5-0), 1-7.

Existing Knowledge."[168] However, the section only mentions the commander conducting discourse or dialogue with his design team and staff with little or no discussion of individuals from outside the military. The document does state that the commander must create a shared understanding with superiors, peers and subordinates which, "…often include joint, interagency, intergovernmental, and multinational leaders."[169] While the discussion ends with the brief statement about a few others who may participate in the discourse, the discussion must be extended to more external ties such academics, host nation individuals, and other stakeholders who can assist with the process of, "…constantly question the limits of existing knowledge and critically evaluate prevailing public presumptions and paradigms."[170]

An example of the importance of external contacts to a military practitioner of design is the experience of General Albert Coady Wedemeyer, who formulated the U.S. Army's Victory Plan of 1941. He skillfully utilized his early experiences from his education in Germany, his later career experience, and a network of other individuals. Wedemeyer's use of external expertise is highlighted by Kirkpatrick: "It goes without saying that Wedemeyer had a lot of help."[171] Wedemeyer, while receiving credit for the plan, had a network of officers supporting his planning effort to write the plan. The network of officers, the commander and the officers inside and outside of his staff section, provided required expertise to the common objective of developing the plan. He also had access to relevant government agaencies and the Princeton Demographic Center in order to get the statistics required to make his strategic estimate.[172]

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[168] Department of the Army, Field Manual Interim 5-2 (FMI 5-2), 10.
[169] Ibid.
[170] Ibid.
[171] Charles E. Kirkpatrick, *An Unknown Future and Doubtful Present: Writing the Victory Plan of 1941* (Washington, DC: Center of Military History, 1992), 57.
[172] Ibid., 7.

Lawson mentions the importance of the participation of others in the design process and highlights the clients, user groups, and legislators.[173]These various stakeholders represent multiple external organizations, whose satisfaction with the design will ultimately determine whether the design is judged a success or a failure. This heterogeneous group creates tensions because of differences in their interests. The need to surface and then resolve tensions leads to discourse and negotiation. Lawson supports the use of external engagement in design projects because it is essential to the success of the design process.[174] The tensions provide the requirement for negotiation and discourse to occur and help to generate the emergence of a solution.[175]

Greenwood and Hammes offer the recommendation that the problems facing military organizations "require a different team of planners."[176] As mentioned in the section above, "Why a design team?" expresses the need for an increased focus on external participants in the military design methodology. Recall that Greenwood and Hamme stated:

> —the composition of these teams [design teams] will be substantially different than in years past. Problems such as nation building and humanitarian relief frequently require a host of outside experts—health specialists, economists, city planners, financial analysts, religious scholars, women's rights advocates, anthropologists—to augment the traditionally insular and predominantly military JPGs.[177]

They further explain that the, "current practice slights the role external agencies play in the planning process."[178] The inclusion of the various stakeholders within the early discourse allows for a more comprehensive response to the adaptive, complex problems facing the military and design or planning groups.

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[173] Lawson, 236-241.
[174] Ibid., 250-257.
[175] Ibid., 252.
[176] Greenwood and Hammes, 22.
[177] Ibid.
[178] Ibid.

Anacona and Bresman discuss the teams that appear to have the most successful responses or outcomes to complex, adaptable situations. They state that the successful teams are effective in conducting external activity. They stress that the teams must "…understand others' expectations and continue to update their information about key stakeholders. They need to know where critical information and expertise reside, both inside and outside the organization"[179]

The X-team's extensive ties are required for three key tasks. They are scouting, ambassadorship, and task coordination.[180] Scouting is simply going out, gathering, and discovering information and knowledge that may apply to their project or goal. This includes fact-finding, which in a military design team is essential for developing the environmental frame. The second activity of ambassadorship is the maintenance and formation of support from superiors, peers, and the formation of coalitions with other groups, teams and individuals. Management of superiors is particularly important. Ambassadorship helps to identify potential adversaries to the team's efforts.[181] The adversaries identified during this task are analogous to the obstacles that Katzenbach and Smith warn can hamper the realization of high-performance teams.[182] Within the military design methodology described in FMI 5-2, this is known as the system of opposition. The third activity is task coordination: lateral and horizontal interdependencies of the team with other elements. This is an obviously important role for a military design team. Within the military design methodology, task coordination will be essential to gaining the external support needed to mobilize the system of transformation articulated in the operational approach. However, the use of X-team activities does produce some turbulence within the team, especially during the early formation of the team. During one of the studies, a team that

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[179] Ancona and Bresman, 65.
[180] Ibid., 14.
[181] Ibid.
[182] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, 85.

was using the more integrated or external focus, "…felt more confused, like less of a team, and unsure about what they were doing together as a team. Therefore, the internal focus does help people feel safe, directed, and satisfied with their progress. But over the long term, this early satisfaction turns on itself—and performance suffers."[183]

Table 1 illustrates the differences between a traditional team that has an internal focus, which is predominately on internal team dynamics and the externally focused X-Team, which looks external for innovation and focus. Ancona and Bresman found that the X-team produced better results than the traditional teams. While the traditional team performed well in the short-term, the X-teams were able to continue performing well beyond the lifecycle of the traditional team.

Table 1. The internal [traditional team] versus the integrated approach [X-team]

	Sam's "internal" team (Southeast) [Traditional Team]	Ned's "integrated" team (Northwest) [X-team]
Primary goal	Create an enthusiastic team	Understand the needs of the external regions
Secondary goal	Inform the region of what the team has decided	Create team cohesion and organization
Team building	Come together as a team by learning about each other and sharing knowledge	Come together as a team while learning about the region
Initial amount of interaction with the environment	Low	High
Source of information used to map the environment/task	Inside team; old, secondary sources	Outside team; new primary sources
Type of interaction with the environment	One way: inform	Two way: diagnose/feedback/invent
Overall focus	Build a team	Help organization implement a new strategy

Source: Deborah Ancona and Henrik Bresman, *X-Teams: How to Build Teams That Lead Innovate, and Succeed* (Boston, MA: Harvard Business School Press, 2007), 30.

The potential of external networks is an important aspect for the development of appropriate responses to complex and adaptive situations and the military design methodology.

[183] Ancona and Bresman, 31.

The various authors demonstrate that future military literature must include an enhanced discussion of this important aspect of design. The current military documentation understates the value of the external perspective to increase the understanding of the environment and the problem. The military design teams must look beyond its own organizations and must be inclusive of alternative viewpoints and embrace discourse among the various stakeholders. The downward spiral of a team can occur in all teams. If the team does not get out and see the environment and the changes that are occurring then their information and assumptions that they are using will be obsolete or wrong. The U.S. Army's commanders go outside the headquarters, see the battlefield or the environment, and do battlefield circulation to inform their estimate of the situation. If the military design team does not or cannot communicate with external sources of information and have similar access to the situation then the team will not be able to meet the commander's expectations accurately. The team will "start from behind.[184] The integrated team that was successful felt that understanding the environment was more important than developing a quick solution or answer.

The reason why the military design teams must incorporate the X-team activities is an attempt to avoid the "downward spiral" shown in Figure 7.

[184] Ibid., 33.

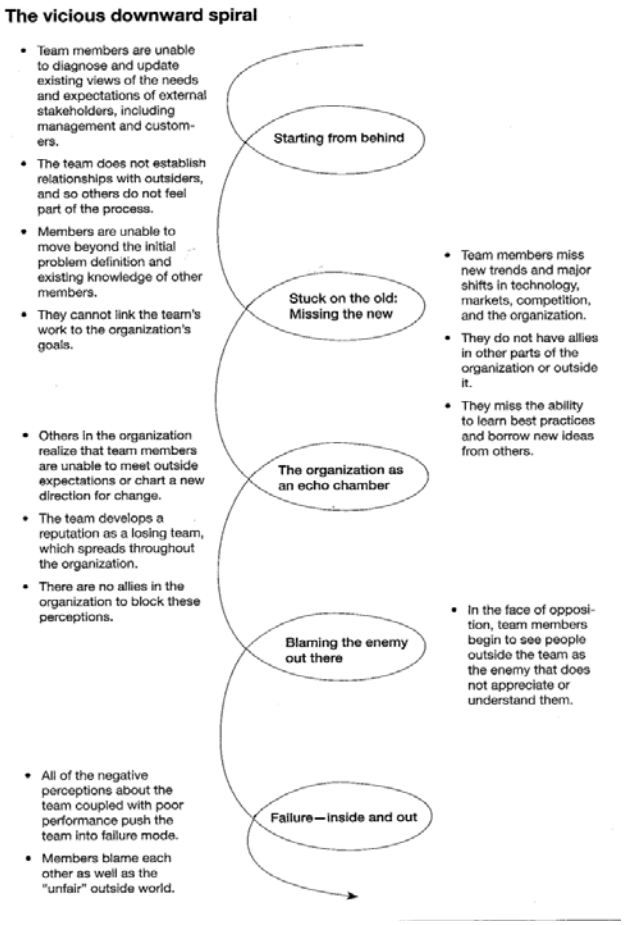

Figure 7. The Vicious Downward Spiral. *Source*: Deborah Ancona and Henrik Bresman, *X-Teams: How to Build Teams That Lead Innovate, and Succeed* (Boston, MA: Harvard Business School Press, 2007), 32.

The next phase in the downward spiral of a team is that without the continual searching of the environment while exploring new ideas and sources of information and knowledge, the team will stagnate. Also, the leadership may perceive the team as less relevant to their needs, and "…their actions were reactive rather than proactive. They were working hard but couldn't seem to get the right answers, and they didn't know why."[185] The interactive group's members acted as generalists and set aside their specialties to develop solutions and better identify the problems.

The subsequent phase begins with feedback from others. The traditional team's performance will quickly decline at this point since their ideas are not keeping pace with the

[185] Ibid., 35.

changing environment and the challenges that are known by their leadership and supervisors. However, the X-team is better able to bring new ideas and resources into the company or military organization that drive innovation, provide options to leadership, and allow them to make proactive decisions and choices.[186]

Soon the team that is in the downward spiral to failure will begin to reinforce the failure by blaming others, which further isolates the team from the rest of the organization. Since the traditional team started from behind in terms of required information and did little to open the conduits to relevant information and expertise, the isolation exasperates the lack of relevance and contribution of the team to the organization. Soon the reputation of the team's failure is associated with the individual members and the team will be broken apart. The X-team members many times will have positive reputations that provide additional opportunities for increased responsibility or promotion due to the perception of their contribution and performance.[187]

Expandability and Exchangeability

The expandable tiers system of X-Teams is an important concept for the military design team. The military design team needs to be able to structure itself to meet unique, complex challenges. The core of the military design team will consist of the team's leaders and the main coordinating body. The core members make the decisions, provide the design methodology experience, and provide a structure and resources required for the design task. The "operational members" are the subject matter experts and generalists that support the core group with "ongoing work" and provide expertise to the core group and the rest of the team. The operational members have close links to the core members and to each other.

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[186] Ibid., 36.
[187] Ibid., 37.

The "outer-net members" are part-time subject matter experts, typically from outside the organization, which are linked to the team but not to each other. This group of individuals can provide new insights and expertise to the team but their commitment to the team is weaker than that of the other members. Workgroups, external teams, and various organizations share information, intelligence, and expertise with the team, as well as providing more people that become a part of the teams through the inclusive culture required within a military design team. Ancona and Bresman describe the three-tier relationships of the X-team members through the following metaphor: "'pigs,' 'chickens,' and 'cows' to refer to core, operational, and outer-net team members. Think about a bacon-and-egg breakfast: the pig is very committed, the chicken is involved, and the cow provides milk that enhances the meal." The military design team will need a similar structure in order to incorporate external networks, coordinate external and internal activities, and meet the expectations of the commanders, other superiors, stakeholders, and its own members.

The operational members and/or the outer tier members may incorporate working groups or teams. The working groups focus on individual outcomes and the members may compete against each other. A team is different in that there is a sense of individual and mutual accountability.[188] The formation of a team requires trust in others and some people may not be inclined to operate as part of a team.[189] However, they may make excellent outer tier members due to their potential individual performance. The team performance curve is based on the amount of performance needed from a group, amount of commitment from the team members, a common purpose, and approach to the problem.

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[188] Katzenbach and Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, 89.

[189] Ibid., 90.

In addition, the design team may need to incorporate an exchangeable membership as recommended by Anacona and Bresman.[190] The increased ability to access external individuals and workgroups provides a potential pool of team members that may be added based on the task requirements, their interest, and their performance.[191] Over the lifetime of the military design team, the tasks will change along with the environment and nature of the problems so different sets of skills, networks, and experiences may be required.

The frequent cross-boundary movement of members provides a powerful catalyst for innovation, but can be difficult to manage and maintain an appropriate focus to produce a positive outcome. The ability to communicate and coordinate between the members and especially among the core members is so important. Anacona and Bresman highlight, "…the critical knowledge needed to beat the competition has become ever-more complex, fast advancing, and spread out. The knowledge teams need to accomplish their task increasingly cannot be found within the team or even in the company itself. Instead, these teams have found it critical to span their boundaries in pursuit of the knowledge they need."[192]

Ancona and Bresman admit that not all teams need to be X-teams and that some can be internally focused. If the team is part of an organization, if the team goals and the organizational goals align and adequate support is provided, if the required information and expertise is available, and if the team is not interdependent on other work within or external to the organization, then an X-team is not required or appropriate.[193] However, this is not the case with military design teams. The military design team may provide a realignment of an organization's goals and this may require information and knowledge from multiple agencies within the particular military organization and the other government agencies outside of the U.S. Army and

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[190] Ancona and Bresman, 8-9.
[191] Ibid., 149-150.
[192] Ibid., 55.
[193] Ibid., 9.

the Department of Defense. The U.S. Army desires that their military design teams are high-performing and successful so all of these considerations need to be examined and implemented into the emerging construct for a military design team. The military design teams, like X-Teams, must be able to reach out across functional, divisional, and organizational boundaries; challenging organizational assumptions; and provide ideas that will help the U.S. Army compete in a complex and dynamic world.[194]

Summary

There is growing awareness that the military operational environment is becoming more complex, and that traditional planning approaches do not adequately account for this complexity. In response to this challenge, the use of design is evolving within the U.S. Army in an effort to better address the challenges of this emerging environment.

The military design team is an option to address the challenges presented by the complex environment and a means to develop appropriate responses. The military design team provides support to the commander so that he or she can make the most informed decisions possible. This monograph investigates the size and structure of a military design team independent of the skills of the individual members of the team. While design has traditionally been done by individuals, the use of a design team provides the U.S. Army with the associated benefits provided by the diversity and potential shared understanding developed by teams.

An optimal size exists for the military design team. While the military design team literature is limited, the robust literature on small groups and teams provides several considerations for the size of a military design team. The exploration of using a military design team by the U.S. Army to respond to complex, adaptive problems is a recent development. The

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[194] Ibid.

U.S. Army must create a military design team based on the optimal size so that it creates the most appropriate organization to support the design methodology.

The research on group size compared to the number of transaction channels among the team members and the group begins to demonstrate the optimal size of a military design team. The propensity of the teams to average around five to eight members appears to be related to the number of transaction channels. The transaction channels reflect the opportunity to communicate between each of the team members. As the number of transaction channels increases, the ability to effectively communicate decreases and the amount of effort to maintain each of the relationships increases. Several studies reflect that five to eight is the optimal number for a group. Since a team has a higher requirement for communication due to the increased integration and focus on a common goal or purpose, a team must be formed considering the maintenance of a small number of members. The small number allows for the members to communicate and share their understanding of the problems which allows for learning and multiple perspectives of the situation.

The psychological research indicates that humans have a cognitive limitation of the amount of information that can be retained in the short-term memory. The implications are that the more members of the group or team the more difficulty an individual has in maintaining the various perspectives and information provided by the other members. The number of variables to consider when responding to complex problems requires the ability to consider the holistic picture of the environment, the problem, and potential solutions, which is provided through the other members' experience, training, and identity. Anthropologists have commented that humans form small groups since they allow the members to know each other's talents. There is a limit that when surpassed dramatically affects the efficiency of the small group. The ability to communicate is a potential connection to the efficiency of a small group. The span of influence reflects combination of the ability to communicate with the other members of a team, the number of interaction channels between members, and the cognitive limitations based on the amount of

information exchanged within the team. The span of influence seems related to the recommendation for span of control of two to five subordinates. The difference is that the members of a design team will typically not have a hierarchical relationship so that everyone's perspective, experience, training, and identity is considered when responded to a situation.

The use of teams to solve problems is nothing new and there are multiple examples of success and failure in the use of teams. The military design team is a recent development and requires an environment that provides for its success. The need for "right" people on the military design team size makes an environment that promotes and compensates the team members for success is an important consideration for a military design team. The structure of the team contributes to creating the positive environment that fosters the interaction and relationships of military design team members internally and externally to the team. The structure also affects the interaction of team members with the environment or problems that require appropriate responses from the team.

Two team structures, cross-functional teams and X-teams, have direct application to the military design team. These teams focus on a small size and work with diverse team members while encouraging collaboration and coordination. However, the cross-functional team structure focuses more internally while the X-team focuses externally in respect to their emphasis on expertise and networking. The X-Team provides external ties to expertise beyond the team members, the ability to expand the team, and exchangeability of the team's members as required to respond to a particular situation or problem. While the cross-functional team is a valid option, it has better chance to begin the vicious downward spiral due to an increased internal focus. The X-team structure provides military design teams the ability to reach out across functional and organizational boundaries, challenge assumptions, and provide ideas that support success in a complex and dynamic environment.

CONCLUSION

Recommendations

The military design team should consist of five to six core members who are aligned with the extreme internal execution coupled with a primary focus on external relationship as described in the X-Team concept. Obviously, this type of team will require an immense amount of trust and access to the commander as well as to the rest of the organization. Essential to success is having the "right" people compared to the importance of type of training or discipline of the individuals. While training and experience is important, the members must be willing to work for the common purpose of the team and be willing to learn and possess the ability effectively communicate with the other members of the team. The core members of the design team must be resourced in time, access, communication, and funding so that they can maintain and develop an external tier of expertise, talent, and knowledge as well as develop products and concepts that meet the commander's and their organization's needs. The external network is to be a trusted group of individuals and organizations that brings in new ideas, discourse, and provides a means to gain insight into the environment, potential problems, and possible solution.

Opportunities for Further Research

The recent exploration of the potential for military design teams and the development of design within military doctrine make the opportunities for further research to be limited only by the imagination. Although the research from civilian studies surveyed in this monograph provides useful guidelines for military design teams, the empirical research specifically studying military design teams does not exist. Experiments involving actual military design teams are needed to confirm that the more general findings from business, psychology, and anthropology hold within the specific context of the military culture, and for the specific tasks performed by military design teams. Further consideration of the roles, training, and resourcing of the military design team should be performed to support the selection of team members and the formation of the teams.

The recruitment through an assessment of the "right" people for design teams may be possible with the appropriate research. The assessment may include the aspects of intelligence, talents, training, experience, and identity of the individual team members. As the U.S. Army expands the use of design, the organization must be able to identify requirements for manning, training, and other resources such as facilities and equipment. One areas of primary interest is training that can enhance the team members' ability to communicate. A study of the physical environment that enhances success of a military design team also provides the U.S. Army an opportunity to understand how to enhance the design team's effectiveness. As the use of military design teams gains acceptance, the experience of members from various military design teams should be analyzed in order to capture the best practices and incorporate the experience into the U.S. Army. An accurate identification of the various aspects of a team's performance that contributed to a successful outcome should be considered so that members of successful teams are compensated appropriately. An exploration of the external networks that promote success for a military design team is another opportunity for improving the military design team. The U.S. Army may want to consider the advantages and disadvantages of a formal or standing design team compared to an ad hoc design team.

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