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Managing Complex Problems: A Synthesis of Research on Army Design Methodology and Strategic Thinking

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This report describes a synthesis of findings from ARI's research program on design and strategic thinking. A systematic examination of ten research reports was conducted to identify key insights that emerged across the research efforts. Findings, implications, and recommendations for the Army include: using an alternative framework like "managing complex problems" to communicate the concepts of design and strategic thinking to operational forces; providing Soldiers with practical tools and resources that support managing complex problems; expanding the set of skill-building exercises that allow Soldiers to practice key skills and core activities associated with managing complex problems; assessing skills and activities associated with managing complex problems; taking steps to evolve the organizational culture to be more supportive of the mindsets, behaviors, and skills associated with design and strategic thinking.

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MANAGING COMPLEX PROBLEMS: A SYNTHESIS OF RESEARCH ON ARMY DESIGN METHODOLOGY AND STRATEGIC THINKING

EXECUTIVE SUMMARY

Research Requirement:

Army leaders in the 21st century face conditions of unparalleled complexity. Increasingly, Army leaders are tasked with managing operational environments that are multi-faceted and highly dynamic, and often conducted in the "gray zone," where the nature of the conflict itself is unclear (ISAB, 2017). These exceedingly complex environments are placing unprecedented demands on our military leaders. While technical capability and combat power were key differentiators in past conventional force-on-force conflicts, key differentiators in today's conflicts are mental strength and agility (Kay, 2016). Army leaders need advanced cognitive and behavioral skills to make sense of, and manage the ambiguous and complex problems the leaders face, and to lead their units effectively. To make effective decisions, leaders need to be able to think holistically, recognize connections and linkages, anticipate the 2nd and 3rd order effects of decisions, question assumptions, visualize how situations might evolve into the future, and convey their understanding to others.

Responding to the need for Army leaders who can effectively make sense of and manage complex operational problems, the Army introduced Army Design Methodology (ADM) into doctrine in 2010. Army doctrine defines ADM as "…a methodology for applying critical and creative thinking to understand, visualize, and describe unfamiliar problems and approaches to solving them" (Department of the Army, 2015, p. 1-3). Soon after ADM doctrine was introduced in 2010, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) initiated a multi-year program of research on design thinking, the Army Design Methodology, and strategic thinking. The ARI research program has encompassed a set of research studies to identify challenges and requirements related to development and sustainment of behaviors and advanced cognitive skills associated with design and strategic thinking. The goal of the effort reported here was to provide an overarching analysis, synthesis, and integration of findings from the design and strategic thinking research program, and to offer recommendations to the Army based on key insights from the program.

Procedure:

In support of the research requirement, the research team conducted a systematic examination of ARI's program of research to extract key insights that emerged across the set of research studies. The analysis and synthesis process was comprised of iterative cycles of report or product review, analysis, discussion, synthesis, and documentation—conducted both individually and as a team.

Findings:

There were several prominent findings that emerged across the various research efforts. A core finding from the research program was that language associated with strategic thinking and design is an impediment to enhancing these capabilities in the Army. Use of alternative frameworks for communicating to operational forces about the concepts (for example, "managing complex problems") may hold promise for sharing relevant insights. The second finding was that

design and strategic thinking share related knowledge, skills, and abilities (KSAs), which can serve as an organizing structure for training and education, assessment and performance management, and practical guidance. The third finding was that Soldiers should be developing design and strategic thinking skills early in their career, with exposure to alternative perspectives. Fourth, there is a need to develop valid and reliable assessment tools for design and strategic thinking capabilities. Fifth, Soldiers need exposure to practical tools and resources that support managing complex problems. The final prominent finding was that Army culture should become more actively supportive of key behaviors, mindsets, and advanced cognitive skills associated with design and strategic thinking.

Utilization and Dissemination of Findings:

The research findings and products can benefit a variety of stakeholders, including current and emerging Army leaders interested in preparing themselves and their units for managing complex problems in operational settings, and those interested in creating unit climates that encourage the mindsets and behaviors associated with design and strategic thinking. Several of the research products have been developed for use by instructors who teach advanced cognitive skills related to design and strategic thinking in their classrooms, and by individual Soldiers or unit commanders who wish to develop these advanced cognitive skills for themselves or their units. Finally, the findings can be useful to policy makers dedicated to Army talent management, and to those wishing to pursue additional research related to preparing Army leaders for managing complex problems.

MANAGING COMPLEX PROBLEMS: A SYNTHESIS OF RESEARCH ON ARMY DESIGN METHODOLOGY AND STRATEGIC THINKING

CONTENTS

Introduction

Operational Need

While the scenario of a large scale conventional war remains a potential threat, the nature of U.S. involvement in conflict over the past 25 years has involved more ambiguity and less clarity in terms of geographic lines of control, or clear, singular enemies with equally clearly defined objectives. The realized threats and conflicts have involved unconventional, asymmetric warfare waged by enterprising individuals and groups in shifting alliances. This environment is characterized by complexity, chaos and competition (Amerson & Meredith, 2016).

Army leaders in the 21st century are increasingly tasked with managing multi-faceted and highly dynamic operational environments marked by political, economic, military, cultural, and diplomatic factors that interact in unpredictable and complex ways. These messy, complex environments have become more prevalent with the emergence of strategic competition short of armed conflict. Our adversaries' tactics of "corruption, predatory economic practices, propaganda, political subversion, proxies…," are cited as threats that must be countered in the National Defense Strategy (Department of Defense, 2018, p. 5). Novel asymmetric tactics such as cyberwarfare and the employment of social media bots, along with a new generation of technologies (e.g., drones and advanced electronic warfare modalities), only add to the Army's challenges.

These exceedingly complex environments are placing unprecedented demands on our military leaders. While technical capability and combat power were key differentiators in past conventional force-on-force conflicts, in today's conflicts the key differentiators are mental strength and agility (Kay, 2016). Army leaders need advanced cognitive and behavioral skills to make sense of and manage the ambiguous and complex problems they face, and to lead their units effectively.

Responding to the need for Army leaders who can effectively make sense of and manage complex operational problems, the Army introduced Army Design Methodology (ADM) into doctrine in 2010. Around the same time that ADM was introduced in doctrine, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) initiated a multi-year program of research on design thinking, ADM, and strategic thinking.

Army doctrine defines ADM as "…a methodology for applying critical and creative thinking to understand, visualize, and describe unfamiliar problems and approaches to solving them" (ATP 5 -0.1 July 2015, pp. 1-3). The primary purpose, therefore, of design thinking is developing conceptual plans for operations and eventually integrating with detailed planning through standard Army processes (Greer, Banach, Karrasch, Sackett, & Griffin, 2018). Strategic thinking, meanwhile, is a cognitive skill construct more independent of particular methods and processes. There is no doctrine to guide Army leaders in defining strategic thinking; nor is there a commonly accepted definition available in the extensive research literature (Grome, Crandall, & Dominguez, 2013; Sackett, Karrasch, Weyhrauch, & Goldman, 2016). However, ARI has adopted the following definition of strategic thinking developed by the Strategy Education Community of Interest (SECoI): "The use of a set of cognitive processes to synthesize an

integrated perspective, envisioning and pursuing a desired future state" (Weyhrauch, manuscript in preparation).

The ARI research program has encompassed a varied set of research studies to identify factors related to the development and sustainment of behaviors and advanced cognitive skills associated with design and strategic thinking. An additional goal of the program has been to generate research-based recommendations and solutions to address Army challenges related to design and strategic thinking.

Synthesis of Research

The goal of the effort reported here was to provide an overarching synthesis of findings from ARI's research program on design and strategic thinking to inform future research and to provide research-based recommendations to the Army. The findings are drawn from the 10 research reports resulting from the ARI research program. The 10 reports are presented in Table 1 along with a brief description and main research focus of each.

Table 1

ARI Program of Research on Design and Strategic Thinking

Report	Primary Topic Addressed	Description
Incorporating design into Army operations: Barriers and recommendations for facilitating integration (Grome, Crandall, Rasmussen, & Wolters, 2012).	Design	The report identifies and describes challenges and barriers that have impeded broad acceptance of ADM by the operational force, along with recommendations and suggestions for addressing organizational barriers.
Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers (Wolters, Grome, & Hinds, 2013)	Strategic Thinking	The Compendium includes chapters authored by 13 military and non-military experts in areas related to strategic thinking, along with an introductory chapter and final synthesis and integration chapter. The Compendium addresses how the U.S. Army can more effectively develop, assess, and retain strategic thinkers.
Identification of the requisite knowledge, skills and abilities for design (Wolters, Conrad, Riches, Brusso, Nicely, Morath, & Keller-Glaze, 2014).	Design	The report offers a framework for understanding the knowledge, skills, and abilities (KSAs) that facilitate design thinking along with recommendations for training and leader development.
An integrated planning system: Commander and staff handbook	Design/ Other	The handbook presents examples of best practices in the integration of

(Greer, Banach, Karrasch, Sackett, & Griffin, 2018).		conceptual and detailed planning and identifies and describes planning practices that will support execution and integration of ADM, the Military Decision Making Process, and Troop Leading Procedures within the operations process.
A design team evaluation framework (Challans, Rochelle, Challans, Dessert, De Soto, Schneider, Buck, & Metcalf, 2014).	Design	The report describes a framework for assessing the performance of individual members of design teams, including the key performance indicators of conditions, actions, processes, and outcomes that support optimal design team performance.
Best practices in military design teams (Grome, Crandall, Metcalf, Laufersweiler, & Strouse, 2015).	Design	The report examines the challenges that planning teams encounter in executing ADM and practices for managing those challenges to optimize the performance of design teams in operational contexts.
Enhancing the strategic capability of the Army: An investigation of strategic thinking tasks, skills, and development (Sackett, Karrasch, Weyhrauch, & Goldman, 2016).	Strategic Thinking	The report describes a research effort to identify and understand strategic thinking requirements and development in the Army, including the KSAs necessary for effective strategic thinking. The report also offers recommendations for leader development and changes in Army culture.
Developing metrics of performance for the Army Design Methodology (Poeppelman, Beaubien, Metcalf, Pritchett, Henderson, Vick, Domeshek, & Weyhrauch, unpublished manuscript).	Design	The manuscript describes an evaluation framework and set of metrics for evaluating the design processes and performance of Army planners, and the effectiveness of the planners' efforts to implement ADM.
Visualizing complex problems (Greer, Caldwell, Crandall, & Grome, unpublished manuscript).	Other	The manuscript identifies visualization tools and capabilities that support understanding of complex problems in operational environments, along with recommendations for education, leader development, and technology approaches to improve visualization skills.
Strategic thinking skill-building exercises (Grome, Crandall,	Strategic Thinking	The manuscript describes an effort to help Army leaders enhance their

Karrasch, Sackett, Santos, Goldman, & Greer, 2020).		ability to manage complex operational problems through development of advanced thinking skills. The manuscript includes descriptions of the research foundations, development, and formative evaluation of four exercises intended to build and reinforce cognitive and behavioral skills that underpin the ability to think strategically.

Key Findings and Associated Recommendations

The following sections present the prominent findings that emerged across the various research efforts conducted within ARI's design and strategic thinking research program. Each finding is presented, followed by a description of the finding. Where appropriate, connections are made between the findings and related academic literature. Following discussion of each key finding, implications and recommendations for the Army are provided.

Communicating About Design and Strategic Thinking in the Army

A core finding from the research program is that the language and terminology associated with design and strategic thinking pose considerable barriers to development, acceptance, and application of these skills. Findings on this topic are of two types. First, there is a lack of a shared language regarding design and strategic thinking, and the skills and behaviors they involve (Grome et al., 2013; Sackett et al., 2016; Wolters et al., 2014). These issues are, in part, due to the lack of theoretical frameworks driving research on these topics. The wealth of constructs, construct labels, and competing definitions contributes to confusion related to what design and strategic thinking are, and why design and strategic thinking matter to the operational force. The tangle of concepts and terminology is also prevalent in the academic literature, where common definitions or prevailing theories regarding design or strategic thinking are lacking (Grome et al., 2013; Sacket et al., 2016), and where constructs and labels often overlap (e.g., strategic thinking, strategic planning, strategy and strategic thinker) (Wolters, 2013).

The second finding for this topic is that terminology related to design in particular has a negative connotation. For example, research on organizational barriers to implementing design found that language associated with ADM was consistently described as complex and elitist, particularly to the operational community, inhibiting Soldiers from seeing the operational relevance of the activity (Grome et al., 2012). Similarly, some Soldiers hear the term "strategic thinking" and disregard its relevance to them. These Soldiers presume that strategic thinking only applies to activities at the strategic level of war, as opposed to describing a skill set that is relevant across multiple roles and echelons. For some audiences, simply using the term "design" or "strategic thinking" creates an adverse reaction and immediately closes people off to engaging with the topic.

The findings suggest that the Army faces a considerable challenge in strategic messaging around these important concepts. There is a need to make statements, recommendations, and share practical guidance based on scientific findings in a way that is non-academic, operationally-oriented, and that resonates with Soldiers so they can see the relevance to their work. Again, this is not a challenge unique to the Army. The challenge of translating empirical findings into practical insights that resonate with performers in a variety of work contexts has been well-documented in the literature (Anderson, Herriot, & Hodgkinson, 2001; Beer, 2001; Green & Seifert, 2005; Panda & Gupta, 2014; Popoola, Peter, & Ilesanmi, 2012; Shapiro, Kirkman, & Courtney, 2007).

When communicating with Soldiers about design and strategic thinking, avoidance of jargon-heavy and overly-academic language is key. To share insights and guidance with the operational force, the Army should use messaging that is simple, accessible, and that "sticks" (Heath & Heath, 2007). Similarly, training and performance support relevant to design and strategic thinking should be communicated using ordinary, layman's language. In addition, there is potential value in messaging that is goal-focused and action-oriented, and that clearly and concisely addresses the purpose or operational needs that strategic thinking and design capabilities serve. Given that complex operational environments are a central impetus for why the Army needs to strengthen its design and strategic thinking capabilities, shifting messaging to the concept of "managing complex problems" may be a viable frame for communicating about design and strategic thinking – particularly to the operational force. This way of framing information about strategic thinking and design is currently being used and evaluated in a digital, practical resource called the Managing Complex Problems (MCP) Resource, which is a companion piece to this synthesis report (Grome, Weyhrauch, Polander, Laufersweiler, & Crandall, in preparation).

In a related vein, the Army should reserve most discourse on theoretical aspects of strategic thinking and design for the academic or research environment, where detailed definitions and distinctions among constructs are important and conceptual terminology is appropriate. In the research context, there may also be benefit to using the frame "managing complex problems" as an organizing structure for future research. Though "managing complex problems" is potentially a promising way to frame strategic messaging related to design and strategic thinking, the expression should undergo evaluation to assess whether and how it resonates with Soldiers, and whether refinements to the construct are needed to enhance its operational relevance and impact.

Commonality Between Design Thinking and Strategic Thinking

Prior to the current effort at synthesis, there had been little attention given to the interrelationships among the major constructs studied under ARI's research program – including how the constructs are connected, how they are similar, and how they are distinct. Instead, design and strategic thinking had been studied in parallel, in separate research efforts, and treated as distinct, independent constructs. The integrative analysis reported here has provided an important opportunity to systematically compare and contrast the findings associated with each major construct. Based on that analysis, there appears to be significant overlap, both in how the constructs have been described and in the critical role the constructs play in managing complex

operational environments. The following sections describe: a) outcomes of the analysis of findings related to core tasks and activities that support strategic thinking and design, and b) descriptions of the synthesis of results regarding the knowledge, skills, and abilities (KSAs) that contribute to strategic thinking and design.

Core Activities. Descriptions of the tasks, strategies, and activities involved in strategic thinking and those involved in design were catalogued, and sorting methods were used to identify categories of activities. The analysis revealed significant similarity between the tasks and activities involved in strategic thinking and design, and a common set of activities was identified. The core activities are presented in Table 2. These activities are the essential components involved in the management of complex problems, from both a strategic thinking perspective and a design perspective. Incident accounts suggest that the core activities are iterative and fluid rather than components of a linear, sequential process. The activities pertain both to individuals and to teams engaged in strategic thinking and design efforts. The core activities provided a useful framework for classifying the tasks associated with design and strategic thinking, which are ultimately conducted in service of making sense of and managing complex problems.

Table 2
Core Activities Involved in Managing Complex Problems

Core Activity	Description
Recognizing complexity	Army leaders sometimes underestimate the complexity of the problems they face, and implement solutions that are not a good fit. Recognizing complexity means being prepared to step back and consider that a situation or issue may not be as straightforward as it might appear and requires a closer look.
Understanding complex problems	Effectively managing complex problems requires a deep and thorough grasp of the nature of the problem and the environment in which it occurs. Developing a comprehensive understanding involves investing time and resources into critical thinking, reflection, discourse, information gathering, visual thinking, and considering the problem from multiple perspectives.
Envisioning potential solutions to complex problems	The process of developing insightful plans encompasses the exploration of different ways to connect current understanding of a problem and its situational context to possibilities for addressing the problem.
Capturing and conveying insights	Key to managing complex problems is finding ways to represent and communicate insights and holistic understanding of the problem to decision makers and other stakeholders.
Collaborating with others	Collaboration is a fundamental component of managing complex problems. Working with a team or informal network gives access to multiple perspectives and provides opportunities for discourse. Collaboration expands the base of available knowledge for constructing a deeper understanding of the problem, and for visualizing ways to address it.

Knowledge, skills, and abilities (KSAs). ARI sponsored two research projects focused specifically on KSAs. One project studied the KSAs associated with strategic thinking and also identified tasks and activities that require strategic thinking (Sackett et al., 2016). The other research project provided findings on KSAs associated with ADM (Wolters et al., 2014). Of the remaining research studies in the program, none had identification of KSAs as a primary research focus. However, many of the reports contain subsets of findings specifically about KSAs or pertinent to KSAs.

A detailed analysis of the individual KSA findings reported in the research studies was performed to examine similarities and differences between KSAs associated with strategic thinking and those associated with design. Despite some differences in methodology, sampling, and terminology, the comparative analysis found considerable overlap between Sackett et al.'s (2016) findings on strategic thinking KSAs and Wolters et al.'s (2014) findings on design KSAs. In addition, the KSA findings from the three research reports on strategic thinking[1] and six research reports on design provide further convergent evidence of the similarity of strategic thinking and design KSAs, as well as verification and replication of findings from the Sackett et al. (2016) and Wolters et al. (2014) research studies (see Table 1). The additional research studies also allowed identification of a few elements (e.g., curiosity) that were not identified in either of the KSA studies.

One portion of the KSA analysis was an effort to categorize the KSAs into higher-order categories. The categories were useful for organizing and integrating findings across the dataset, and the categories provided a macro-level classification of KSA elements. The KSA categories are: cognitive, knowledge, interpersonal/team, communication, and personality. A summary of the findings from the comparative analysis is presented in Table 3 (see Appendix A for detailed findings from the analysis). The first column of Table 3 contains the set of combined strategic thinking and design elements derived from the comparative analysis, organized by KSA category.

As depicted in Table 3, KSAs required for strategic thinking and those required for design correspond closely. Correspondence is greatest for the cognitive KSAs, but is evident in the other KSA areas as well. This finding is an important one, because the finding suggests that leader development in service of strategic thinking is likely to directly benefit Army design capabilities as well. The comparative analysis has been a valuable opportunity to look for similarities and differences, and to arrive at a set of categories, terms, and descriptors that could contribute to adoption of a consistent lexicon going forward.

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[1] One of the two reports on strategic thinking is the Compendium (Wolters et al., 2013), which includes an overview, individual chapters, and a final integrative chapter. For the KSA analysis, the overview and final chapters were reviewed (Grome et al., 2013; Wolters, 2013), as they contained syntheses of findings across the rest of the material.

Table 3

Comparative Analysis of Strategic Thinking and Design Thinking KSAs[2]

KSAs Required for Strategic Thinking and Design	Strategic Thinking KSA Study (Sackett et al. 2016)	Design KSA Study (Wolters et. al 2014)	Additional Strategic Thinking Research	Additional Design Research
Cognitive Skills and Abilities				
Comprehensive Information Gathering	✓	✓	✓	✓
Learning & Adapting	✓	✓	✓	✓
Critical Thinking	✓	✓	✓	✓
Innovative Thinking	✓	✓	✓	✓
Thinking in Time	✓	✓	✓	✓
Systems Thinking/Holistic Thinking	✓	✓	✓	✓
Sensemaking		✓	✓	✓
Expertise				
Knowledge	✓			✓
Broad education/experience			✓	✓
Interpersonal Skills & Abilities				
Collaboration (team component)	✓	✓		✓
Collaboration (leader component)	✓	✓		✓
Communication Skills and Abilities				
Communication/ Sensegiving	✓	✓	✓	✓
Personality Factors				
Emotion regulation	✓		✓	✓
Curiosity			✓	✓
	✓	Indicates presence of content that aligns with the category; blank cells indicate absence of content.		

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[2] See Appendix A for more detail.

Implications and recommendations. The Army should consider shifting strategic communications away from "design" and "strategic thinking" to a focus on the core activities required for "managing complex problems." This approach to messaging has the potential to reduce the confusion and fragmentation surrounding current efforts to share research insights, and to educate and train Soldiers to be effective strategic thinkers and conceptual planners. The operational relevance of the core activities is readily apparent.

Similarly, the five core activities offer a potentially useful framework for organizing assessment, education, training, and practical guidance to support Soldiers in managing complex problems. Each core activity can serve as a basis for identifying training gaps and requirements. For example, attention to the core activities "understanding complex problems" and "envisioning potential solutions" can highlight the need to provide Soldiers with training and experiential opportunities in visual thinking and work with qualitative data that characterizes complex operational environments. The "collaborating with others" core activity underscores the need for assessments, training, and experiential learning activities that foster skills such as: building and leading teams with diverse perspectives and KSAs critical to managing complex problems, encouraging and engaging in dissent, creating team climates where team members feel psychologically safe (Edmonson, Kramer, & Cook, 2004; Edmonson & Lei, 2014) to express disagreement, and guiding team members in discourse and creation of a systems perspective. Finally, the Army could use the core activities as a basis for collecting and disseminating examples of how Army leaders have conducted these activities successfully, in service of managing complex operational environments.

The Army should consider using (and evaluating) the macro-level classification of KSAs to inform a coordinated program of instruction, development, and assessment designed around development of critical KSAs. Given the high correspondence between strategic thinking and design KSAs, distinguishing between design and strategic thinking as separate, distinct constructs and activities may not be warranted, at least for practical purposes (e.g., for development of training, practical guidance, performance support, and assessment). At the very least, the findings suggest that Army programs devoted to developing the KSAs identified here will benefit the Army in building both strategic thinking and design capabilities.

The importance of design KSAs for Army leaders is reinforced by Army doctrine. However, the importance of strategic thinking throughout the Army has not been similarly positioned through doctrine, and is sometimes seen as an intellectual exercise by the operational force. The evidence from this synthesis effort suggests that strategic thinking and design have many common elements. That evidence may help to bolster recognition of the importance of strategic thinking capabilities and why they matter, along with research-based recommendations for what the Army can do to upgrade its strategic thinking capabilities.

Early and Diverse Development

Evidence from the research examined suggests that the Army is strong in providing students with a conceptual understanding of design and strategic thinking activities (particularly with respect to strategic thinking; Sackett et al., 2016). But conceptual understanding is not sufficient for Soldiers to demonstrate the desired skills and behaviors, or to do so in a consistent manner.

The Center for Creative Leadership distinguished between horizontal development and vertical leadership development (Petrie, 2014; 2015). Horizontal development focuses on helping leaders to acquire knowledge, skills, and competencies. Horizontal development is about *what* one thinks. Vertical development, on the other hand, focuses on advancing leaders' thinking capabilities. Vertical development is focused on *how* one thinks. Petrie argues that most leadership development programs tend to focus on horizontal development. However, both types of development matter and need to be addressed concurrently. Petrie asserts that vertical development is particularly important in today's volatile, uncertain, complex, and ambiguous (VUCA) world, because vertical development builds leaders' capability to think in more complex, systemic, and interdependent ways (Petrie, 2015). Petrie has also described three primary conditions of vertical development: "Heat experiences, colliding perspectives, [and] elevated sensemaking" (2015, p. 3). "Heat experiences" for leaders involves complex situations that disrupt their typical way of thinking and prompt a search for new ways to make sense of a given challenge. "Colliding perspectives" involves exposure to different worldviews in order to challenge leaders' mental models and increase the number of perspectives through which leaders can view a given challenge. "Elevated sensemaking" refers to engagement with a coach, mentor, or process to help with conceptual integration and synthesis, making sense of the experiences and different perspectives (Petrie, 2015).

ARI's program of research has begun to address vertical development related to management of complex problems through creation of an initial set of practical exercises that can be used in educational or operational settings to build skills associated with design and strategic thinking (Grome et al., 2020). These exercises provide "heat" experiences to push the individual's thinking skills forward, but also provide the opportunity for group activities, feedback, and reflection. Through the exercises, the participants can learn new ways of thinking and making sense of the problem. However, this is just a first step and will be most useful if the exercises are part of a broader, integrated strategy that includes education and training, performance support, communications, and change champions – working in tandem to help these behaviors and mindsets take hold.

Several of the research efforts in the design and strategic thinking program also emphasized the value of diverse educational experiences, including those that occur outside the Army. In fact, except for the School of Advanced Military Studies (SAMS), the programs and experiences that are identified by many Army leaders as most productive for development of strategic thinking and ADM capabilities currently occur outside of professional military education (PME; e.g., Wolters et al., 2013). Wong and Gerras (2013) describe the importance of more diverse educational experiences as follows:

One way in which Army officers have broadened their frames of reference is through advanced civil schooling. Removing officers from the military culture and sending them

to civilian graduate schools reaps many benefits. Civilian graduate degrees develop frames of reference not only through the actual course content, but also by immersing student officers in environments where professors could be Marxists, fellow students could be pacifists, and neighbors could be anarchists—not the types of people that Army officers typically associate with. And yet it is the exposure to differing frames of reference that allows Army officers to refine their own outlooks and assess their role in the larger military institution and society (Wong & Gerras; 2013; p. 73).

These rich educational experiences – often referred to as "broadening experiences" – include exposure to other cultures that occurs with foreign travel and participation in civilian graduate programs of study. The broadening experiences address one of the key conditions for vertical development – "colliding perspectives." There are consistent calls for "broadening experiences" that include coursework in civilian institutions. Yet the number of Army leaders seeking those opportunities appears to be declining (Wong & Gerras, 2013) and it has been suggested that the pursuit of civilian education (particularly civilian graduate degree programs) may actually be an impediment to career advancement within the Army (Grome et al., 2013).

In addition, the research studies consistently report that, for Soldiers to be prepared to manage complex operational environments effectively, the Army must begin developmental efforts much earlier in Soldiers' careers than it currently does. The critical importance of starting earlier pertains to the KSAs needed for design and strategic thinking, as well as broadening experiences, educational programs, and experiential learning (Greer et al., in press; Grome et al., 2013; Sackett et al., 2016; Wolters et al., 2014).

One reason for starting earlier is that by mid-career, many Soldiers adopt an Army mindset that is action-oriented, uncomfortable with discourse, accustomed to linear, quantitative approaches to planning and decision making, and resistant to change (Barno & Bensahel, 2016; Schmidt, 2013). The extensive research literature on the development of expertise is relevant to this topic, offering models of learning and acquisition of complex skills involved in effective performance of a wide range of skilled activities (e.g., surgery, chess, weather forecasting, nursing, command and control) as well as cognitive skills such as decision making, planning, and sensemaking (Crandall, Klein, & Hoffman 2006; Klein, 1998). Research on expertise suggests that simple exposure to a topic or field of endeavor is necessary but not sufficient to develop advanced skills. Another reason for starting earlier pertains to the time, effort, deliberate practice, repeated exposure, and accumulation of experience that is required for development of advanced skills – including advanced cognitive skills (Ericsson, Charness, Feltovich, & Hoffman, 2006).

Implications and recommendations. The Army should look beyond its own schoolhouses to foster development of the knowledge and skills Army leaders need for effective design and strategic thinking. Broadening experiences can foster considerable learning, enhanced diversity of perspective, and help emerging leaders develop the skills they will need to manage complex problems. Given the rich developmental opportunities that broadening experiences can provide Soldiers, they need to be encouraged and rewarded, and associated barriers (e.g., longer time for promotion) removed. A shift in the focus and structure of Army PME will require a significant amount of planning, support from higher Army echelons, and an integrated and

comprehensive strategy to ensure consistency of content and curricula across the various schools and courses. Development of courses that introduce Soldiers to skills associated with managing complex problems earlier in their careers would provide a foundation for more rapid development of relevant KSAs.

Early exposure to opportunities to learn about and practice requisite skills will result in current and future Army leaders who are better prepared for the types of problems and operational environments they will inevitably encounter, and the assignments and complex problem sets they face in current assignments. Delaying education and training for strategic thinking and design until mid-career or later leaves leaders poorly prepared to manage complex operational environments (Sackett et al., 2016). Postponing development of these skills also allows attitudes and mental models that may be counter to design and strategic thinking to become entrenched and impervious to development.

Army education and training needs to combine teaching Army leaders *what* to think (horizontal development), with emphasis on *how* to think (vertical development). There is a considerable difference between teaching concrete concepts/skills and ensuring that Soldiers know *how* to apply these concepts and skills in managing complex and uncertain situations. Separate but related, there is a significant need for faculty development and support that occurs in parallel, to ensure that instructors have the knowledge, skills, and tools to adjust their teaching styles and curricula to help soldiers learn *how* to think, as well as *what* to think.

As part of refocusing education and training, the Army needs to provide Soldiers with greater opportunity for hands-on, experiential learning. This learning includes opportunities to practice applying skills in the context of core activities associated with managing complex problems in safe environments and opportunities to receive feedback and engage in reflective practice. Soldiers also need opportunities to work with skilled mentors or coaches who can help the Soldiers make sense of the complex operational environments they encounter. Coaches and mentors can help Soldiers develop the Soldiers' strategic thinking skills by the coaches and mentors articulating their own cognitive processes and the approaches the coaches and mentors have found useful for managing complex problems (Brown, Collins, & Duguid, 1989). Job aids that support mentors to do this important task more effectively can enhance the learning that can occur between mentors and mentees and are readily available (e.g.,https://hlc.harvard.edu/ compass-coaching-and-mentoring; http://www.mentoring.org/program-resources/national-mentoring-resource-center/).

A critical need is for Soldiers to extend practice beyond the classroom so that requisite skills, behaviors, and mindsets become reinforced and integrated into the way units operate (Casey, 2013; Cross, 2013; Goldman, 2013; Lave & Wenger, 1991). Opportunities for practice in multiple contexts – inside and outside the classroom – can deepen skills in important ways and help promote overall cultural change, as current and emerging leaders recognize their importance and value in managing complex operational environments.

The Army should continue development and evaluation of tools for practicing the skills associated with managing complex problems. The set of skill building exercises developed as part of the ARI research program (e.g., those for sociocultural systems thinking, reflective

thinking, questioning) need to be expanded to encompass a larger, more comprehensive set of foundational skills. The tools for practicing skills should continue to be assessed, refined, and improved to enhance the impact on Soldier skill development. The current set of exercises were developed for use in both classroom and field settings and for self-development. This multi-use feature should be sustained in future exercise development.

Finally, the Army can enhance its efforts to foster strategic thinking and design by reaching outside of the Army to other branches of the military and to the commercial, industrial, health care, and academic sectors. These other sectors have recognized the importance of design and strategic thinking and have encountered many of the same challenges regarding education, training, skill development, culture change, and the dearth of assessment tools that the Army is facing (McCauley, 2016). These other sectors have by no means solved all the issues surrounding the development of great strategic thinkers. However, there are valuable insights, lessons learned, training approaches, and tools available in this wider circle. The Army needs to take advantage of organizational knowledge outside its boundaries.

Assessment Tools for Design and Strategic Thinking Capabilities

Two research studies conducted in the program focused specifically on developing research-based assessment instruments (Challens et al., 2014; Poeppelman et al., in press). Even with these contributions, there continues to be a lack of theoretically grounded, useful, operationally-relevant assessment tools. Several of the research reports provide detailed discussion of the issues surrounding assessment and the barriers to moving forward (e.g. Goldman, 2013; Grome, 2013; Sackett et al., 2016). However, these research reports also describe alternatives for addressing those challenges. Moreover, the Army is not alone in its need for such tools, or the lack of them. The commercial, industrial, and healthcare sectors face similar challenges as the Army: how to tell that an individual has potential, has requisite knowledge and skills, and can perform based on that knowledge and skill.

Despite the difficulties inherent in building a suite of assessment tools, the availability of valid and reliable assessment tools is a lynchpin for enhancing the Army's capability in skills associated with managing complex problems. Assessment results not only drive selection and placement, and identification of training and educational gaps and needs, but the act of assessment also sends the message that a given set of skills is important and is valued within the Army. As noted by Ariely (2010), "Human beings adjust behavior based on the metrics they're held against. Anything you measure will impel a person to optimize his score on that metric. What you measure is what you'll get" (para. 5). Assessing skills associated with managing complex problems will help to shift the Army's culture by signaling that these skills are important and valued.

Valid and reliable assessment tools for skills associated with managing complex problems also offer the benefit of establishing a consistent set of criteria and lexicon that Soldiers and Army leaders can use to understand and evaluate their own and their staff's development. Without a shared set of standards across the Army, both development and recognition efforts run the risk of being poorly calibrated. Army leaders may believe that they 'know it when they see it,' but what they know and see may differ markedly across leaders.

Without some form of assessment, the validity of any given leader's recognition of ability is unknown. In fact, Sackett et al. (2013) report that Army leaders had little to say when asked about assessment of strategic thinking, suggesting that there is a significant gap to be filled, even in use of informal criteria.

Absent a consistent set of criteria, the components discussed earlier that are so important to developing strategic thinking skills (e.g., education, broadening experiences, incentives, assignments) are extremely difficult to develop across the Army. Assessment tools would provide a foundation for building out the capability the Army wants and needs. Sophisticated, multi-variable instruments would be great, but simple checklists and rating instruments that are empirically based, and available across the Army, would be a significant contribution. Without access to such tools, the Army lacks a way to focus its enhancement effort or to advance that effort across the organization.

Implications and recommendations. Given the key role of assessment in enhancing the requisite skills and reinforcing the value of those skills to the Army, recommendations include the following:

Given the challenges involved in assessing a construct such as strategic thinking, it may be productive for the Army to orient its efforts toward development of assessment tools that focus on management of complex problems. One approach would be to build on findings from the ARI research program to develop assessment instruments that encompass measurement of KSAs required for managing complex problems, as well as performance on core activities associated with managing complex problems (e.g., identifying complexity, understanding complex problems, envisioning potential solutions, collaborating, conveying insights). Assessments should be primarily formative in nature, to guide identification of skill gaps and developmental needs and to provide a basis for improving individuals' abilities in managing complex problems.

Ideally, assessments should be conducted at various points throughout Soldiers' careers. Valid and job-relevant assessments should be incorporated into performance evaluations, linked to incentive and reward systems, and selection processes. Providing incentives and rewards for those who perform well on these assessments will underscore the importance of these skills to the Army. One possibility for embedding assessments of skills associated with managing complex problems is within the Officer Evaluation Report (OER) system. The OER would be a mechanism for identifying current and emerging leaders with skills in managing complex problems as a basis for promotion or assignments to further develop those skills. Another mechanism by which assessment tools can be made available for self- or Commander-based assessment is the Center for the Army Profession and Leadership's Self-Development portal.

Practical Tools and Resources

To effectively engage in strategic thinking and design-type activities, Army personnel need an array of practical tools and resources that help them to both develop their understanding of a problem or situation, and to communicate their understanding to others. Not surprisingly, because these are different activities, they require different types of supporting tools.

Currently, the tools Soldiers most commonly use for developing understanding are simple and do not involve digital technologies. Examples include whiteboards, markers, and post-it notes. These tools provide flexibility and the ability to quickly co-create and revise with minimal investment of time and effort. These simpler, low technology tools also allow Soldiers to avoid the cognitive interference that many report experiencing with computer-based tools (Greer et al., in press). Greer et al.'s (in press) research study of visualization processes and tools found that "Nearly every participant considered analog visualization tools and capabilities to be more powerful than technological solutions for both individual and collective visualization of complex problems" (p. 31). In general, participants viewed digital technologies as unsupportive of, or an impediment to their efforts to understand a problem or situation (Greer et al., in press).

This finding may seem counter-intuitive given the current societal investment in and engagement with information technologies, particularly in the workplace. However, people's preference for simpler, non-digital tools aligns with research on the ways in which drawing, sketching, and other representational techniques support development and refinement of mental models. The act of constructing a representation of a problem, situation, or system appears to support the cognitive work involved in developing or extending one's mental model of that problem, situation, or system (Goldschmidt, 2007; Liu & Stasko, 2010). Moreover, these activities can provide critical support for teams working collaboratively to develop shared understanding. Co-creation of visual representations both shapes the way teams think about a problem or task, and serves as external representation of the team's shared mental model(s) (Fiore & Schooler, 2004; Bockelman-Morrow, & Fiore, 2013).

One important set of tools needed for making sense of – and managing – complex problems are visual thinking tools. Mental imagery has been thought to be important to cognitive activities such as problem-solving since the earliest days of psychological science (Kosslyn, Thompson, & Ganis, 2006). Visual thinking is essentially the process of using mental imagery to seek greater understanding of a problem as part of introspection. Visual thinking *tools* are anything that supports the creation of rich mental images. Horn (1998), Brown (2014), and Sibbet (2010) have described the critical role that drawing and visualization tools play in helping individuals and teams to think holistically and differently about complex problems. Visual tools support the development of different perspectives on a problem set that are important for understanding complexity. As Sibbet noted, "Without [visual thinking] tools, groups are very handicapped in thinking about anything that is very complex" (Sibbet, 2010, p. 4). A challenge is that the Army – and society more broadly – places limited value on teaching visual language and how to effectively use a combination of words, shapes, and images to articulate and make sense of complex issues and effectively convey meaning (Horn, 1998; Brown, 2014). Cultural stereotypes about drawing and use of a visual language persist, which pose obstacles to learning and understanding (Brown, 2014). In addition, some people are reluctant to use informal tools that require drawing or sketching because they believe they lack drawing skills. This limitation

can inhibit those individuals from making sense of complex problems through visualization. In reality, effective visualization requires no artistic skill (Horn, 1998; Brown, 2014).

The value of visual tools for making sense of complex problems should not be underestimated. As noted by Sibbet (2010), use of visualization tools can help drive new perceptions, can help shift what people can and cannot see in a complex situation, and help groups achieve new levels of understanding that they might otherwise not be able to achieve. Visual thinking enables deep thinking and enhances the capacity for people to explore, learn, develop unique insights, problem solve, and innovate (Brown, 2014). Drawing tools are particularly beneficial for elevating thinking about complex subject matter when information density is high, which is often the case with complex operational problems facing Soldiers. Using drawing tools to think visually can also help individuals and groups to envision and share potential future scenarios as they work through complex problems (Sibbet, p. 67).

For purposes of communicating complex problems *outside* of the team, Army personnel rely most heavily on PowerPoint. Although it is readily available and widely-accepted by Army audiences, PowerPoint can pose limitations to effectively communicating about complex problems. For example, over-reliance on use of text and bullet points can over-simplify and limit one's ability to convey important inter-relationships, communicate understanding, or support critical think about a situation (Zweibelson, 2012). PowerPoint presentations are generally useful for selling ideas, not necessarily for encouraging deep thinking or alternative views. The mere listing of information in bullet-point fashion sends the message of: "here are the facts."

In addition to visualization tools, several of the practical recommendations made in the design and strategic thinking research program point to the need for performance support tools (McManus & Rossett, 2006) for Soldiers. One form of performance support is a set of products containing practical guidance that provides research findings in a useful, operationally-relevant, and user-friendly format. Such products can help make research insights accessible to Soldiers and support them in performing the activities and practices associated with design and strategic thinking. Too often, research solutions do not effectively bridge the research-practice gap and end up sitting on a shelf, with little-to-no return on investment (Schatz, 2016). One reason for this gap is poor communication and limited support for early adoption. Another reason for the gap is the lack of an advocate or champion for the solution.

Implications and recommendations. Provide Soldiers with a wider variety of visualization tools that they can use and manipulate to augment whiteboard sketching and sensemaking of complex problems. An example of a simple and cost-effective resource is a toolkit that contains tangible items such as shapes, connectors, images, and other visual forms that Soldiers could use to visualize complex problem sets without being inhibited by concerns related to drawing ability. This type of toolkit has been used in multiple domains as a means for collaboratively making sense of complex problems, conveying understanding, and developing innovative solutions (Liem & Sanders, 2013; Sanders, Brandt, & Binder, 2010; Sanders & Stappers, 2014).

Emphasize and reinforce the value of sketching and drawing to explore ideas. One way to do this is to integrate drawing/sketching into coursework so students gain comfort with creating

visualizations and begin to understand how it can help them make sense of complex problems. Education should address how to integrate words, images, and shapes to effectively convey meaning (Horn, 1998). Reinforcing the value of drawing can and should also be done at the unit level by Commanders and other leaders via modeling the use of visual tools and encouraging Soldiers to use them to make sense of complex operational problems.

Workspaces should be provided that support both individual reflection and collaboration, shared visualization, and sensemaking. The physical workspace impacts individual and team performance and collaborative work (Papautsky, Crandall, Grome, & Greenberg, 2015; Sanders, 2013, Vischer, 2007; Vischer, 2008). Physical workspaces should be available that are conducive to teams engaging in sensemaking of complex problems. This includes features such as ample whiteboards and/or wall space for using visual tools to explore problems collaboratively, space for both individual and group reflection, and configurable seating and tables.

Continue developing and building upon practical tools and resources that translate empirical findings into practical terms that Soldiers can leverage to support their work in operational settings. As part of developing these tools, ensure mechanisms are in place to effectively move solutions into practice. Facilitating the transition from Army research solutions to practice requires greater attention to identifying proponents, using strategic messaging and outreach, and providing adoption support. Specifically, this transition effort requires identifying a champion and proponent organization to help drive strategic messaging and outreach, to help Soldiers and other targeted users understand the value of the research solutions, and to ensure the sustainability of solutions over time. A useful model for the Army to consider is one used by the Army Distribution Learning (ADL) Initiative, which has created an Outreach strategy and associated Outreach team to facilitate the transition of research to practice. Without champions or outreach to help people become aware of the products, it is unlikely that the resources will be used or have the intended impact. Messages can be disseminated through vehicles such as proponent organization websites, webinars, emails, press releases, or public media. Coupling strategic communications with support for adoption (e.g., workshops, conferences) could go a long way in ensuring that the valuable research solutions and research-based resources are used and have the expected impact for their intended user communities.

Cultural Support for Design and Strategic Thinking

The effect of organizational culture on the Army's strategic thinking and design capabilities is one of the strongest and most consistent findings within the ARI research program reports. Organizational culture refers to the shared values, attitudes, assumptions, and meanings that characterize an organization. Organizational culture drives how an organization's members behave, think, and interact with one another, and the members' beliefs about what is expected, supported, and rewarded by the organization (Schneider, Ehrhart, & Macey, 2013). Several authors suggested that the biggest impediment to embedding the practices and mindsets associated with design and strategic thinking into the Army is the Army's culture itself (Greer et al., in press; Grome et al., 2015; Grome et al., 2012; Sackett et al., 2016; Wolters et al., 2013; Wolters et al., 2014).

Across research studies, findings consistently point to the Army culture as a significant barrier to development and demonstration of strategic thinking and design-related behaviors and skills in its leaders. Army norms and values of respect for hierarchy, obedience, and deference to a commander's judgment may, in some cases, run counter to behaviors and mindsets that effective design and strategic thinking require. For example, questioning assumptions, critical thinking, dissent, candid discourse, and recognition that important insights can come from any rank (Grome, Crandall, Rasmussen, & Wolters, 2012; Grome, Crandall, Metcalf, Laufersweiler, & Strouse, 2015; Sackett, Karrasch, Weyhrauch, & Goldman, 2016). Moreover, several of the research studies point to a disconnect between the Army's junior leader development priorities and the advanced cognitive skills necessary for strategic thinking and design. Bethel (2013) described the disconnect as follows: "In academia, and in major businesses, strategic thinkers are sought after and hired because their skills matter to leadership and help drive the bottom line. Unfortunately, within the Department of Defense (DoD), they are often seen as a threat to the status quo and are suppressed." (p. 55).

The emphasis on linear, reductionist, and analytic thinking in the Army also runs counter to the activities required for design and strategic thinking, which relies more heavily on integrative and holistic thinking. These preferences are not unique to the Army culture. Research on the impact of national culture on cognition have noted that American society as a whole tends to favor analytic, linear, and reductionist ways of thinking (Nisbett, Peng, Choi, & Norenzayan, 2001) over non-linear and holistic styles of thinking and consideration of connections and interdependencies.

The research findings also suggest that the Army's action orientation and focus on rapid response and short-term tactical success may run counter to the skills and mindsets it is trying to foster with design and strategic thinking. Again, this proclivity toward action, and focus on results and visible accomplishments is not necessarily unique to the Army. It tends to characterize American society as a whole, as described in seminal work by anthropologists Kluckholn and Strodtbeck (1961). However, effective strategic thinking, visualization, and design processes take time and deep thought, and outcomes are generally slower to achieve and to see. There is a critical need for Army leadership to think carefully about how to balance the time required for in-depth thinking against the Army's proclivity for action and focus on near-term tactical solutions (Greer et al., in press; Grome et al., 2013; Sackett et al., 2016). Clearly, both are important. However, "the current benefit/reward system in the United States military emphasizes short-term/immediate tactical success and is inherently impatient, unwilling to wait for a strategy to play out and to evaluate its long-term success" (Bethel, 2013, p. 56).

Implications and recommendations. The research findings suggest multiple recommendations for the Army. At a macro-organizational level, the Army should take steps to evolve its culture into one that actively supports and encourages the behaviors, mindsets, and advanced cognitive skills needed for its leaders to be prepared to manage the challenges associated with complex operational problems. To do so will require a holistic and integrated strategy that addresses several factors required for successful organizational evolution, including: leadership alignment, strategic communications, champions, education and training, rewards and incentives, and assessment. Without a purposeful, integrated strategy to transform the Army culture, the behavior and mindsets associated with use of design and strategic thinking to manage

complex problems are unlikely to flourish. Instead, they will meet ongoing resistance and are likely to be confined to isolated pockets within the Army. Some specific recommendations are:

For the behaviors, mindsets, and skills associated with design and strategic thinking to gain traction, Army leaders need to be aligned on the importance of these skills. Only through alignment at the highest levels of leadership on the need and importance of these skills will other aspects required for successful organizational evolution (described next) be possible.

The importance and value of the skills associated with design and strategic thinking need to be communicated on a consistent basis by Army leadership, champions, and key stakeholders. As described earlier in this report, the messaging around the behaviors and skills associated with managing complex problems (e.g., their value to the Army and its mission) needs to be simple, concise, accessible to multiple audiences, and reinforced on a regular basis. Key principles associated with managing complex problems also need to be consistently communicated and reinforced. For example, Army leaders need to reinforce the notion that, under some circumstances, the Commander may not be the smartest or most knowledgeable person in the room. Senior Army leaders must continuously emphasize that the behaviors and mindsets associated with design and strategic thinking are the core of what will make the Army great and that leaders at every level need to be practicing and developing the associated skills.

Army leaders must model the desired behaviors. Leaders at all levels must embrace mindsets, principles, and behaviors associated with managing complex problems and reflect it in how they think, talk, and interact. For example, Army leaders must demonstrate that they are willing to listen to and consider a range of perspectives, including opinions that diverge from their own, and to engage in discourse and debate. In addition, Commanders and higher headquarters need to support units and teams that are working beyond the short-term fix (Greer et al., in press). Having leaders who model the desired behaviors will send a strong message that the skills and behaviors are desired and will be supported.

Soldiers need education and training on the cognitive skills and behaviors associated with managing complex problems. As described earlier in this paper, Soldiers need experiential learning opportunities and broadening experiences to expose them to alternative points of view, beginning early in their careers. Soldiers also need opportunities to practice foundational skills associated with managing complex problems (e.g., questioning, discourse, systems thinking, reflection, thinking in time) in safe environments in which they can reflect and receive feedback. Army leaders need to continuously foster skill-building among their Soldiers by providing opportunities for their units and staffs to engage in skill development and by modeling self-development for their units (Sackett et al., 2016).

Commanders and leaders need support and training in how to establish a climate of trust and psychological safety (Edmonson & Lei, 2014) within their units and teams. They need to actively encourage the mindsets, behaviors, and skills necessary for managing complex problems. Leaders need training and guidance in how to do this – including how to model and be receptive to dialogue, questioning of assumptions, inquiry, and active discourse required for design (Greer et al., 2018; Grome et al., 2012). For example, Army leaders must foster an environment of collaborative learning and acknowledge failures as rich opportunities for learning

(Synder, 2016; Wolters, Conrad, Riches, Brusso, Nicely, Morath, & Keller-Glaze, 2014). Evolution in mindsets and behaviors at the unit or team level can help to create an overall cultural shift in the Army at large.

Improving the Army's strategic thinking and design skills and activities requires an organizational culture that consistently encourages and reinforces behaviors and mindsets associated with those capabilities. The Army needs to evolve its system of promotion and reward in a way that provides clear incentives and recognition for excelling in strategic thinking and/or design-related behaviors and skills (Grome et al., 2012; Grome et al., 2013). As an institution, the Army must demonstrate that it values diverse ways of thinking and points of view, and seeks to build a force that is considerably more diverse in its abilities and perspectives than the highly "homogeneous force" (Sackett et al., 2016, p. 34) that characterizes the current Army. The Army can achieve this outcome by conducting a detailed analysis of its incentive and rewards systems to identify where and how the current systems align with or undermine the behaviors and mindsets associated with design and strategic thinking. Based on that analysis, incentives and rewards systems can be brought into better alignment to ensure that needed capabilities are being reinforced, rather than discouraged.

Finally, the Army should commit to ongoing cultural assessment, to measure whether and how the Army's cultural values shift over time, and whether changes are in the desired directions. Assessments should offer a picture of the organization's current cultural values, and how those values do or do not align with the advanced thinking skills and behaviors needed in its leaders. A variety of culture assessment instruments exist that the Army could leverage (Jung et al., 2009; Taras, Rowney, & Steel, 2009). Assessment tools the Army might consider using include the Organizational Culture Inventory (OCI; Cooke & Szumal, 2000) and the Cultural Values Assessment (CVA; Barrett, 2006).

Conclusion

The Army is challenged – and will continue to be challenged – by the complexity of the environments in which it operates. ARI's program of research on design and strategic thinking has offered many important insights with respect to managing complex problems, and the strategic thinking and design skills that support that endeavor. However, in reading individual reports and products, it can be difficult to grasp the big-picture view and determine the key takeaways for the Army that have emerged from the program of research. The goal of the synthesis effort reported here has been to provide that big picture view by culling the most noteworthy findings across the program of research. Results of the synthesis have identified a number of fruitful areas for future research. Findings from the synthesis also have provided a number of practical recommendations for the Army to consider that could significantly enhance its efforts to embed the behaviors, mindsets, and skillsets associated with design and strategic thinking throughout the Army.

Taken together, the findings point to the need for a holistic approach to encourage, develop, reinforce, and sustain the mindsets and skills needed for the Army to effectively manage operational complexity. The Army needs to address that challenge from multiple angles including communications and messaging, doctrine, education and training, performance support

resources, assessment, and focused attention to evolving its organizational culture. A holistic approach, driven by senior Army leadership, will enhance Army readiness and capacity, and enable Soldiers to manage the continued challenges of multifaceted, dynamic, and complex operational environments.

References

Amerson, K., & Meredith, S. (2016). The future operating environment 2050: Chaos, complexity and competition. *Small Wars Journal*. http://smallwarsjournal.com/jrnl/art/the-future-operating-environment-2050-chaos-complexity-and-competition

Anderson, N., Herriot, P., & Hodgkinson, G. (2001). The practitioner-researcher divide in industrial, work and organizational (IWO) psychology: Where are we and where do we go from here? *Journal of Occupational and Organizational Psychology, 74*(4), 391-411. https://doi.org/10.1348/096317901167451.

Ariely, D. (2010, June). You Are What You Measure. *Harvard Business Review. 88*(6), 38. https://hbr.org/2010/06/column-you-are-what-you-measure

Barno, D., & Bensahel, N. (2016). *Six ways to fix the Army's culture*. Retrieved from https://warontherocks.com/2016/09/six-ways-to-fix-the-armys-culture.

Barrett, R. (2006). *Building a values-driven organization: A whole system approach to cultural transformation*. Butterworth Heinemann, Elsevier.

Beer, M. (2001). Why management research findings are unimplementable: An action science perspective. *Reflections, 2*(3), 58-63. https://doi.org/ 10.1162/152417301570383.

Bethel, S. (2013). Recruiting, training, and developing Strategic Thinkers. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers* (pp. 55-66). (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Bockelman-Morrow, P., & Fiore, S. (2013). Team cognition: Coordination across individuals and machines. In J. D. Lee and A. Kirlik (Eds.), *The Oxford Handbook of Cognitive Engineering: Vol. 1, Foundations, Perspectives and Cognitive Issues* (pp. 200-215). Oxford University Press.

Brown, S. (2014). *The doodle revolution: Unlock the power to think differently*. Penguin Publishing Group.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1)*, 32-42. https://doi.org/10.3102/0013189X018001032

Casey, A. (2013). Creating an organizational culture to support strategic thinking. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers* (pp. 102-118). (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Challans, T., Rochelle, J., Challans, C., Dessert, J., De Soto, O., Schneider, J., Buck, J., & Metcalf, K. (unpublished contractor report). *A design team evaluation framework.*

Cooke, R., & Szumal, J. (2000). Using the organizational culture inventory to understand the operating cultures of organizations. In N. Ashkanasy, C. Wilderom, & M. Peterson (Eds.), *Handbook of organizational culture and climate* (pp. 147–162). Sage Publications, Inc.

Crandall, B., Klein, G., & Hoffman, R. R. (2006). *Working minds: A practitioner's guide to Cognitive Task Analysis*. The MIT Press.

Cross, T. (2013). Implementing a culture of strategic thinking in the U.S. Army. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers* (pp. 119-136). (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Department of the Army (2015). Army Design Methodology (Army Techniques Publication 5-0.1). https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/atp5_0x1.pdf

Edmondson, A. C. (2004). Psychological safety, trust, and learning in organizations: A group-level lens. In R. M. Kramer & K. S. Cook (Eds.), *The Russell Sage Foundation series on trust. Trust and distrust in organizations: Dilemmas and approaches* (pp. 239-272). Russell Sage Foundation.

Edmondson, A. C., & Lei, Z. (2014). Psychological safety: The history, renaissance, and future of an interpersonal construct. *Annual Review of Organizational Psychology and Organizational Behavior, 1*, 23-43. https://doi.org/10.1146/annurev-orgpsych-031413-091305

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (2006). *The Cambridge Handbook of Expertise and Expert Performance*. Cambridge University Press

Fiore, S. M. & Schooler, J. W. (2004). Process mapping and shared cognition: Teamwork and the development of shared problem models. In E. Salas & S.M. Fiore (Editors). *Team Cognition: Understanding the factors that drive process and performance* (pp. 133-152). American Psychological Association.

Goldman, E. (2013). Strategic thinking: Requirements, Development, and Assessment. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers* (pp. 32-54). (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Goldschmidt, G. (2007). To see eye to eye: The role of visual representations in building shared mental models in design teams. *CoDesign: International Journal of CoCreation in Design and the Arts, 3*(1), 43-50. https://doi.org/10.1080/15710880601170826.

Green, L. A., & Seifert, C. M. (2005). Translation of research into practice: Why we can't "just do it." *Journal of the American Board of Family Practice, 18*(6), 541-545.

Greer, J., Banach, S., Karrasch, A., Sackett, A., & Griffin, M. (2018). *An integrated planning system: Commander and staff handbook.* (Research Product 2018-10). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD1055096).

Greer, J., Caldwell, C., Crandall, B., Grome, A., & Sackett, A. (unpublished contractor report). *Visualizing complex problems.* (Technical Report). : U.S. Army Research Institute for the Behavioral and Social Sciences.

Grome, A., Crandall, B., & Dominquez, C. (2013). Exploring strategic thinking: A synthesis and way ahead. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers* (pp. 248-264). (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences.

Grome, A., Crandall, B., Metcalf, K. A., Laufersweiler, D., & Strouse, R. (2015). *Best practices in military design teams*. (Technical Report 1349). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Grome, A., Crandall, B., Rasmussen, L., & Wolters, H. (2012). *Incorporating design into Army operations: Barriers and recommendations for facilitating integration*. (Technical Report 1954). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA559673).

Grome, A., Crandall, B., Karrasch, A. I., Sackett, A., Santos, A., Goldman, E., & Greer, J. (2020). *Strategic thinking skill-building exercises*. (Research Product 2020-03). U.S. Army Research Institute for the Behavioral and Social Sciences.

Grome, A., Weyhrauch, W. S. Polander, E., Laufersweiler, D., & Crandall, B. (2020). *Conveying Research Insights to the Operational Force: Development of the Managing Complex Problems Resource*. (Research Report 2028). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD1109770).

Heath, C., & Heath, D. (2007). *Made to stick: Why some ideas survive and others die.* Random House.

Horn, R. (1998). *Visual Language: Global communication for the 21st century*. MacroVU Press.

International Security Advisory Board. (2017). *Report on gray zone conflict*. Department of State.

Jung, T., Scott, T., Davies, H., Bower, P., Whalley, D., McNally, R., & Mannion, R. (2009). Instruments for exploring organizational culture: A review of the literature. *Public Administration Review, 69*(6), 1087-1096.

Kay, L. (2016). Managing the gray zone is a gray matter challenge. *Small Wars Journal*. http://smallwarsjournal.com/print/48721.

Kluckhohn, F. R., & Strodtbeck, F. L. (1961). *Variations in Value Orientations*. Row & Peterson.

Kosslyn, S. M., Thompson, W. M., & Ganis, G. (2006). *The case for mental imagery.* Oxford University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Liem, A., & Sanders, E.B.-N. (2013). Human-centred design workshops in collaborative strategic design projects: An educational and professional comparison. *Design and Technology Education: An International Journal, 18*(1), 72-89.

Liu, Z., & Stasko, J. (2010). Mental models, visual reasoning and interaction in information visualization: A top-down perspective. *IEEE transactions on visualization and computer graphics*, *16*(6), 999-1008.

McCauley, D.H. (2016, 2nd Quarter). Rediscovering the art of strategic thinking. *Joint Force Quarterly, 81*, 26-33.

McManus, P. & Rossett, A. (2006). Performance support tools: Delivering value when and where it is needed. *Performance Improvement, 45*(2), 8-16. https://doi.org/10.1002/pfi.2006.4930450204

Nisbett R.E., Peng K., Choi I., & Norenzayan A. (2001). Culture and systems of thought: Holistic vs. analytic cognition. *Psychological Review, 108*(2), 291–310. https://doi.org/10.1037/0033-295x.108.2.291

Panda, A., & Gupta, R. (2014). Making academic research more relevant: A few suggestions. *IIMB Management Review, 26*(3), 156-169. https://doi.org/10.1016/j.iimb.2014.07.008

Papautsky, E., Crandall, B., Grome, A., & Greenberg, J. (2015). A case study of source triangulation: Using artifacts as knowledge elicitation tools in healthcare space design. *Journal of Cognitive Engineering and Decision Making, 9*(4), 347-358. https://doi.org/10.1177/1555343415613720.

Petrie, N. (2014). *Vertical Leadership Development – Part 1: Developing Leaders for a Complex World*. Center for Creative Leadership.

Petrie, N. (2015). *The How-To of Vertical Leadership Development – Part 2: 30 Experts, 3 Conditions, and 15 Approaches*. Center for Creative Leadership.

Poeppelman, T., Beaubien, J., Metcalff, K., Pritchett, C, Henderson, J., Vick, R., Domeshek, E., & Weyhrauch, W. (unpublished contractor report). Developing Metrics of Performance for the Army Design Methodology.

Popoola, A., Peter, A. & Ilesanmi, P. (2012). A Survey of the Challenges of Translating Research Results into Classroom Practice on the teaching of Mathematics in Secondary Schools. *Journal of Sociological Research, 3*(2), 388-398. https://doi.org/10.5296/jsr.v3i2.2566

Sackett, A. L., Karrasch, A. I., Weyhrauch, W. S., & Goldman, E. F. (2016). *Enhancing the strategic capability of the Army: An investigation of strategic thinking tasks, skills, and development* (Research Report 1995). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD1006147).

Sanders, E. (2013). Creativity in strategic thinking. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers* (pp. 150-172). (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Sanders, E.B.-N., Brandt, E., & Binder, T. (2010, November 29 - December 3). *A framework for organizing the tools and techniques of participatory design* [Paper presentation]. 11th Biennial Participatory Design Conference, Sydney, NSW, Australia. https://dl.acm.org/doi/10.1145/1900441.1900476

Sanders, E.B.-N. & Stappers, P. (2014). Probes, toolkits and prototypes: Three approaches to making in co-designing. *CoDesign: International Journal of CoCreation in Design and the Arts, 10*(1), 5-14. https://doi.org/10.1080/15710882.2014.888183.

Schatz, S. (2016). *Outreach strategy and implementation plan*. (Unpublished manuscript). Advanced Distributed Learning.

Schneider, B., Ehrhart, M, & Macey, W. (2013). Organizational climate and culture. *Annual Review of Psychology, 64*, 361-388. https://doi.org/10.1146/annurev-psych-113011-143809

Shapiro, D., Kirkman, B., & Courtney, H. (2007). Perceived causes and solutions of the translation problems in management research. *Academy of Management Journal, 50*(2), 249-266. https://doi.org/10.2307/20159853

Sibbet, D. (2010). *Visual meetings: How graphics, sticky notes and idea mapping can transform group productivity*. John Wiley & Sons.

Snyder, J. (2016). *Learning organization models and their application to the U.S. Army.* (Research Report 1998). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD1036965).

Taras, V., Rowney, J., & Steel, P. (2009). Half a century of measuring culture: Review of approaches, challenges, and limitations based on the analysis of 121 instruments for quantifying culture. *Journal of International Management, 15*(4), 357-373. 10.1016/j.intman.2008.08.005

Metcalf, K.A. (unpublished contractor report). *Army Design Methodology: A guide to assess your implementation of the Army Design Methodology*. U.S. Army Research Institute for the Behavioral & Social Sciences

Vischer, J. (2007). The effects of the physical environment on job performance: towards a theoretical model of workspace stress. *Stress and Health, 23*(3), 175-184. https://doi.org/10.1002/smi.1134

Vischer, J. (2008). Towards and environmental psychology of workspace: How people are affected by environments for work. *Architectural Science Review, 51*(2), 97-108. https://doi.org/10.3763/asre.2008.5114.

Weyhrauch, W. S. (in preparation). *Strategic thinking: Definition and competency model.*

Weyhrauch, W. S. (2017). *Development and Preliminary Validation of the Strategic Thinking Mindset Test (STMT)*. (Technical Report 1361). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD1044580).

Wolters, H. (2013). Exploring strategic thinking: An introduction. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers*. (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA577290).

Wolters, H., Conrad, T., Riches, C., Brusso, R., Nicely, K., Morath, R., & Keller-Glaze, H. (2014). *Identification of the requisite knowledge, skills and abilities for design*. (Technical Report 1339). U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA601309).

Wong, L, & Gerras, S. (2013). Developing Army strategic thinkers. In H. Wolters, A. Grome, & R. Hinds (Eds.), *Exploring strategic thinking: Insights to assess, develop, and retain Army strategic thinkers*. (Research Product 2013-01). U.S. Army Research Institute for the Behavioral and Social Sciences.

Zweibelson, B. (2012). How PowerPoint stifles understanding, creativity, and innovation. *Small Wars Journal*. http://smallwarsjournal.com/jrnl/art/how-powerpoint -stifles-understanding-creativity-and-innovation-within-your-organization.

Appendix A

Detailed KSA Analysis

       The ARI research program sponsored two research studies focused specifically on KSAs. The research study conducted by Sackett et al. (2016) focused on strategic thinking, planning, and the tasks and activities that require strategic thinking. Wolters et al. (2014) focused on design (or design-like) experiences and the roles and functions, work processes and products, and specific cognitive skills involved in those incidents.

       Taken together, findings from the two research studies generated a large body of detailed descriptive data on KSAs. To identify convergences and discrepancies, the research team performed a comprehensive examination of the individual findings from all studies. Despite some differences in terminology, the comparative analysis revealed considerable overlap in the KSAs required for strategic thinking and for ADM. The analysis employed a sequential process that involved:

- an examination of the taxonomies, category descriptions, and examples contained in the Sackett et al. (2016) and Wolters et al. (2014) studies;
- determination that there was significant alignment between the two studies;
- examination of KSA-related findings from the remaining research studies in relation to the categories derived from the Sackett et al. (2016) and Wolters et al. (2014) studies; and
- identification of areas of overlap and areas where findings did not align.

       Despite some differences in methodology and sampling there appears to be considerable overlap between Sackett et al.'s (2016) findings on strategic thinking KSAs and Wolters et al.'s (2014) findings on design KSAs. In addition, findings from three research studies on strategic thinking (Grome et al., 2013, 2016; Wolters et al., 2013), and six studies on design (Challens et al., 2013; Greer et al., 2018; Greer et al., in press; Grome et al., 2015; Grome et al., 2012)[3] provide further convergent evidence of the similarity of strategic thinking and design KSAs as well as verification and replication of findings from the Sackett et al. (2016) and Wolters et al. (2014) research studies.

       More specifically, the research team noted that the terms chosen as category labels did not always align. However, when the team focused on how categories were defined and described, there was considerable consensus regarding the KSAs associated with both design and strategic thinking. Consensus across the studies is particularly strong for the cognitive skills and abilities categories.

       In addition, Sackett et al. (2016) reported that many KSAs associated with strategic thinking were rarely mentioned in interviews with Army leaders, or only mentioned in response to interview probes. Sackett and her colleagues suggested that many critical KSAs may not be well-understood or valued, and went on to describe implications for Army leader development. In their study of design KSAs, Wolters et al. (2014) found similar gaps, noting that responses to

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[3] Although the KSA analysis included only reports and research products developed within ARI's program of research, researchers had conducted additional analyses for the Army Design Methodology Commanders Resource (U.S. Army, 2012) on data collected as part of that effort. One analysis and set of findings focused specifically on KSAs and that material is included in the comparative analysis described here.

questions about the design process were variable and often not about process at all. Both sets of authors concluded that the gaps in knowledge and understanding identified in their respective studies represent an impediment for Army leaders' development of requisite skills.

The combined results do suggest a few additional categories to augment the taxonomy developed by Sackett et al. (2016). Specifically, the Sensemaking category employed by Wolters et al. (2014) received support from several of the research studies on strategic thinking and design. There was also convergent support for breaking apart the 'Knowledge, Background, and Experience' category employed by Sackett et al. (2016) into two separate categories: 1) Knowledge and 2) Background and Experience. Several of the research studies on design reported a cluster of elements related to design competency such as "curious, inquisitive, possessing an investigative mindset, and eagerness to learn." This set of findings led the team to add a sub-category within 'Personality Attributes' labeled "Curiosity." Finally, there were a small number of elements that, in the research team's view, did not fit any of the categories.

These items all pertain to aspects of thinking (e.g., balance of linear and non-linear thinking, directional thinking, deep thinking) and were placed in an "Other/Miscellaneous" category.[4]

It seems reasonable to attribute the remaining discrepancies to differences in methodology and research focus across the various research studies. For example, given that Wolters' and colleagues' (2014) research focused specifically on incident accounts of Army design projects and activities, it is not surprising that participants did not volunteer descriptions of their own knowledge or educational experiences in their incident accounts.

The high correspondence between strategic thinking and design KSAs suggests that distinguishing between design and strategic thinking as separate, distinct constructs and activities may not be warranted. At the very least, the findings suggest that Army programs devoted to developing the KSAs identified here will benefit the Army in building both strategic thinking and design competencies.

The research team organized results into a macro-level classification of factors: cognitive, knowledge, interpersonal/team, communication, and personality. A summary of the comparative analysis findings (with combined strategic thinking-design categories listed in the first column) is presented in Table 1.

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[4] A research study not included as part of the synthesis effort, conducted by Weyhrauch (2017), also identified characteristics of thought needed for effective design, including humility, flexibility, inclusiveness.

Strategic Thinking KSAs (Sackett et al., 2016)	Design KSAs (Wolters et al., 2016)	KSAs from other Strategic Thinking Research Reports[5]	KSAs from other Design Research Reports
COGNITIVE SKILLS AND ABILITIES			
Comprehensive Information Gathering • Scanning the environment • Seeking information from disparate sources • Open mindedness, suspension of judgment • Considering other perspectives • Research skills • Active listening	• Ability to be receptive to other sources of knowledge/ information. (from: **Adapting**)	• Environment-centered focus (10) • Information search, scanning (7); dynamic, interactive, and iterative scanning (10) • Openness to diverse perspectives (4)	• Environment-centered concern (5) • Perspective (eliciting different points of view from the group (1) • Generalist view (5) • Willing to listen to others and consider POVs that differ from their own (5, 9); perspective taking (12) • Open mindedness (3, 5); non-judgmental (3)
Action Learning • Iterative testing, continuous learning • Reflection and metacognition • Conceptual ability • Agility • Adaptability • Information/knowledge management	**Adapting** • Adjusting effectively to new information, requirements, conditions, or constraints • Maintaining an awareness of gaps in knowledge, skills, and tendencies (in self and others) • Ability to adapt past knowledge to current situations • Self-awareness of what	• Reflection/reflective thinking (7) • Conceptualizing/conceptual thinking (10) • Bias for adaptability (10) • Metacognitive ability (4), metacognitive thinking (7) • Cognitive flexibility (4, 7) • Learning, triple-loop learning (7)	• Reflection (1)/reflective thinking (3, 5) • Adaptive thinking (5) • Metacognitive thinking (5) • Cognitive flexibility (5, 12) • Self-awareness (3) • Iterative (able to explore in different directions) (1) • Development (able to make changes to earlier thinking) (1)

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[5] Numbers noted in table correspond to the following sources: 1) Challans et al. (2014), 2) Greer et al. (2014), 3) Greer et al. (in press), 4) Grome et al. (2013), 5) Grome et al. (2015), 6) Grome et al. (2012), 7) Grome et al. (2016), 8) Sackett et al. (2016), 9) U.S. Army (2012), 10) Wolters (2013), 11) Wolters et al. (2014), and 12) Grome et al. (2013)

		Testing (10); iterative assessment (7)	
Critical Thinking • Identifying the central and peripheral elements of a situation • Questioning, challenging assumptions • Comfort with nuance • Understanding meaningful connections and distinctions • Understanding limits of data	• Skill in thinking critically about situations or events (from: **Holistic Thinking**)	• Questioning (7, 10) • Meta-questioning (7) • Critical thinking (4); analysis (7)	• Critical thinking (1, 3, 5, 6) • Adept at following a line of reasoning and evaluating it for its value, efficacy, and relevance (5) • Inquiry (1) • Divergent thinking (more questions generated than answers) (1)
Innovative Thinking • Generating creative and novel ideas and approaches • Reframing understanding when existing concepts falter • Re-evaluating and challenging conventional norms	**Innovative Thinking** • Thinking creatively in order to address problems from a new perspective • Identifying one or more novel approaches to a problem • Fostering a culture of originality within the design team • Ability to see problems in new ways and avoid linear	• Qualitative thinking (4); qualitative mindset (10) • Creative thinking, innovative thinking, creativity, conditioned inventiveness (10) • Opportunistic thinking (10)	• Ability to work systematically with qualitative information (5) • Creative thinking (1, 3, 5, 6, 9); conditioned inventiveness (5); innovative thinking (6, 9) • Non-linear thinking (6) • Diversity (contribute multiple perspectives) (1) • Interpretation (curious about other ways of thinking) (1) • Contextual (new ideas) (1) • Novelty (new ideas) (1)
Thinking in Time • Understanding historical & contemporary contexts • Pattern recognition • Maintaining a long-term future perspective	• Knowledge of historical information and events relevant to the situation (from: **Sensemaking**) • Ability to adapt past knowledge to current situations (from: **Adapting)**	• Strategic foresight; anticipatory thinking (7) • A historical mind (the ability to use analogical reasoning/past examples to help solve today's problems) (4)	• Forward thinking (5) • Historical thinking (5)

• Anticipating 2nd- and 3rd-order effects	• Ability to reflect on past actions or events (from: **Holistic Thinking**)		
Systems Thinking • Identifying and comprehending complex and dynamic interdependencies between entities • Holistic perspective, synthesizing interdependencies into a concept of a comprehensive whole	**Holistic Thinking** • Conceptualizing and understanding adaptive relationships and interactions amongst varied entities or variables • Application of both critical thinking and systems thinking to develop hypotheses and formulate inferences regarding the problem space and its surrounding environment • Ability to understand complex and adaptive relationships among events and actors • Ability to build mental models that hypothesize the possible consequences of various courses of action • Ability to organize information by creating heuristics to suit the context	• Systems orientation (4) contextual thinking (4); enterprise understanding (4); thinking in context (4); systems thinking (7); systemic vision (10); holistic thinking (4) • Ability to generate hypotheses, hypothesis generation and testing (7) • Synthesis (7); synthetic thinking (4)	• Systems thinking (3); Systemic thinking (1, 5, 6); Holistic thinking (5); big picture thinking (5); systemic vision (5); complex problem solving (3); holistic thinking (1)
	Sensemaking • Ongoing synthesis of information from the surrounding environment into a meaningful understanding (i.e., frame or mental model) of the environment	• Ability to visualize (7, 10)	• Visual thinking, ability to visualize, thinking visually, mapping (1, 5) • Sensemaking (1, 5)

	• Understanding or frame that is continually maintained and enhanced • Ability to synthesize information to create new meaning or structure (frame) • Ability to seek evidence that does not conform to the current frame • Ability to hold and consider two distinct, and possibly competing, ideas in mind		
		Other Cognitive • Balance of linear and non-linear thinking styles (10) • Directional thinking (10)	**Other Cognitive** • Analogical reasoning/figurative thinking (11) • Detailed thinking (5) • Deep thinking (5) • Abstract thinking (3, 5) • Task-oriented (5)
EXPERTISE			
Knowledge • Broad general knowledge forming a foundation of awareness, e.g., of general history, global trends, geo-politics, socio-cultural forces, economics, military, technology, etc. • Deep knowledge of the context of a strategic problem, e.g., relevant groups, stakeholders, cultures, relationships, regional history, capabilities, processes, public opinion, etc.			• Being an expert in one's own field (9)

		Background & Experience	Background & Experience
		• Breadth of education and experience (4) • Opportunities to put strategic principles to practice via experiential learning (4)	• Having formal training in ADM and underlying theory (9)
INTERPERSONAL SKILLS and ABILITIES			
Collaboration (team) • Networking and relationship building	**Collaborating** • Communicating with and engaging others to apply design concepts in a productive environment • Management of group interaction and discourse, • Team development, and guidance • Ability to identify the perspectives of others in social situations • Ability to contribute to an environment where different views are encouraged and shared • Ability to listen • Ability to form collaborative networks to enhance team capabilities or knowledge • Ability to reconcile diverse perspectives		• Collaborating (5); collaborative effort (9) • Ability to coordinate (5) • Dialogue: converse w/ others as colleagues and demonstrate interest in learning from others (1) • Willing to speak up and share ideas (5) • Socially perceptive (5) • Instructive (5) • Willing to help others (5) • Recognition that the Commander may not always have the most knowledge about a complex/unfamiliar situation (6) • Creative tension: comfortable in differing from others, encourages members to challenge others (1) • Shared understanding: value the understanding in lieu of agreeing or liking (1) • Willingness to be critiqued (5)

Collaboration (leader)	(same as "**Collaborating**" above)		• Ability to read their team (5) (leader skill)
• Team building (e.g., team composition, identifying and balancing strengths and weaknesses) • Team leadership, managing conflict, interpersonal dynamics, climate, trust, consensus • Organization, project management			• Ability to recognize when the team needs a break (5) (leader skill) • Facilitating discourse/group discussion (6, 9) (leader skill) • Facilitative rather than autocratic (6) (leader skill) • Ability to work with disparate individuals and harness their cognitive abilities toward an effective outcome (9) (leader skill) • Dialogue/demonstrates interest in learning from others (1) • Skills required to build relationships and trust among staff members/team development (6) (leader skill) • Willing to entertain input from subordinates (6) (leader skill) • Open to feedback (6) (leader skill) • Aware of how the sponsoring org thinks (5) • Awareness (cognizant of changes in thinking (leader skill) (1) • Creative tension/encourages members to challenge others (leader skill) (1) • Creative tension/comfortable in differing from others (1) • Collaboration (1) • Charitable interpretation (listen actively to others) (1)
COMMUNICATION SKILLS AND ABILITIES			

Communication/Discourse	Sensegiving (p. 10)	• Sensegiving (7)	• Sensegiving (5); Sensegiving (leader skill) (1)
• Message tailoring, understanding the audience, creating narratives • Effective oral, written, and visual communication skills • Interpersonal tact and professionalism, especially during debate or disagreement • Candor and self-confidence • Concisely communicating complex issues • Narrative ability, storytelling, engaging an audience • Influence skills, persuasion, negotiation	• Maintaining and enhancing others' shared understanding • Assessing others' understanding (via questioning and active listening) • Clarifying to ensure continual alignment of shared understanding		• Ability to use language as a tool (5) • Able to break complex ideas into simple words and phrases (5) • Narrative: write a story that communicates to exterior audiences (1) • Ability to engage in visual thinking and sketching (3)/mapping (5) • Strong communication skills (verbal and written) (3) • Ability to negotiate (5) • Persuasive (5) • Shared understanding (distinguish understanding from consensus) (1)

PERSONALITY ATTRIBUTES and FACTORS

Emotional Regulation		• Affinity for teamwork (10)	• Affinity for teamwork (5)
• Self-awareness and self-control • Respectful of others • Intellectual humility, controlling the impact of personal biases, self-interest, and values • Understanding limits of control and responsibility		• Human-centered focus (10) • Tempered optimism (10)	• Human-centered focus (5) • Disciplined (5) • Willing to accept a less than perfect solution (5) • Self-governing practicality (5) • Humility (6) (leader skill) • Willingness to accept you do not know everything (6) (leader skill) • Open to being wrong (6) (leader skill) • Cultural sensitivity (3)

			• Comfort with ambiguity and unstructured/ ill-defined processes (5, 6, 9) • Facility for avoiding the necessity of choice (5)
			Curiosity • Curious/naturally curious/inquisitive mindset/inquiry: oriented toward the generation of questions rather than answers (5, 9) Inquisitive (6); possessing an investigative mindset and skills (9) • Eager to learn/enjoys learning/eager for knowledge (5, 9); having a desire to learn more (6)