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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

A CASE STUDY IN DESIGN THINKING APPLIED THROUGH AVIATION MISSION SUPPORT TACTICAL ADVANCEMENTS FOR THE NEXT GENERATION (TANG)

by

Donald E. Turner III

December 2017

Thesis Advisor:	Frank J. Barrett
Second Reader:	Richard Bergin

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In November of 2016, over 40 Naval Aviators from various platforms in the United States Navy and United States Marine Corps converged on Defense Innovation Unit Experimental in Mountain View, California, to participate in Aviation Mission Support Tactical Advancements for the Next Generation. For the next four days, participants and facilitators engaged in a design sprint utilizing Design Thinking methods to generate the maximum number of innovative concepts in the area of Aviation Mission Support. By the end of the fourth day, 28 robust concepts had been prototyped and prepared focused on pre-flight, in-flight, and post-flight support.

As innovation becomes a higher priority for the Department of Defense, effective tools and processes are needed that allow the organization to innovate from within. This is an examination of the research, execution, and follow-on developments supporting the Design Thinking event explored through Case Study methods. Additionally, the lenses of change theory, design attitudes, and the design mindset are applied to the case to identify unique processes and outputs resulting in otherwise unexplained phenomena. This case study is intended to serve as an examination for Department of Defense leadership to better understand applications of Design Thinking as a means to spur innovation.

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A CASE STUDY IN DESIGN THINKING APPLIED THROUGH AVIATION MISSION SUPPORT TACTICAL ADVANCEMENTS FOR THE NEXT GENERATION (TANG)

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MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

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ABSTRACT

In November of 2016, over 40 Naval Aviators from various platforms in the United States Navy and United States Marine Corps converged on Defense Innovation Unit Experimental in Mountain View, California, to participate in Aviation Mission Support Tactical Advancements for the Next Generation. For the next four days, participants and facilitators engaged in a design sprint utilizing Design Thinking methods to generate the maximum number of innovative concepts in the area of Aviation Mission Support. By the end of the fourth day, 28 robust concepts focused on pre-flight, in-flight, and post-flight support had been prototyped and prepared.

As innovation becomes a higher priority for the Department of Defense, effective tools and processes are needed that allow the organization to innovate from within. This is an examination of the research, execution, and follow-on developments supporting the Design Thinking event explored through case study methods. Additionally, the lenses of change theory, design attitudes, and the design mindset are applied to the case to identify unique processes and outputs resulting in otherwise unexplained phenomena. This case study is intended to serve as an examination for Department of Defense leadership to better understand applications of Design Thinking as a means to spur innovation.

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LIST OF ACRONYMS AND ABBREVIATIONS

AGNOSTIC	Agile Navigation Oriented Spectral Transfer of Information and Communication
ALTITUDE	All The Info That U Desire Effortlessly
AMiE	Aviation Mission Environment
AMS	Aviation Mission Support
APL	Johns Hopkins Applied Physics Lab
ARVIS	Augmented Responsive Visual Interactive System
CAVU	Collaborative Airspace Visual Universal System
CDD	Capability Development Document
CNAF	Commander, Naval Air Forces
COMANDR	Centrally Optimized, Mined, Automated Neural Data Repository
DIUx	Defense Innovation Unit Experimental
FUSION	Fully Unified Seamless Integration Operational Networks
GMPS	Global Mission Planning System
HIVE	High Immersive Virtual Environment
HMW	"How Might We"
KBC	Knee Board Card
KPP	Key Performance Parameter
OPNAV N98	Office of the Chief of Naval Operations, Director, Air Warfare
PEO U&W	Program Executive Officer Unmanned Aviation & Strike Weapons
PMA-281	Program Management Activity-281
PRO	Personalized Retention + Optimization
PUNCH	Pre/Post-flight Unified Naval Combat Habitat
RAD	Rapid Agile Development
RAIDER	Responsive Artificial Intelligence Debriefing and Reporting
RAMPS	Reviewable Aviation Mission Planning System
RIP	Rapid Innovation Process
RUMP	Real-time Updated Mission Planning
SAMMS	Signature Awareness Minimization, and Multi-platform Scoring

SECKSIEGOOSE	Secure Enhanced Communications and Knowledge for Situational Integration and Execution – Gifted Omniscient Omnipresent Sentient Entity
SKINSUIT	Sensory Kit with Integrated Neural System User Interface
SWIFT	Scalable Worldwide Integrated Flight Templates
TAC APP	Tactical Application Store
TANG	Tactical Advancements for the Next Generation
Tech Expo	Technology Exposition
Tech Tac Tours	Technology/Tactical Tours
TIE	Tactical Integrated Execution
WOPR	Wargaming Optimal Planning and Replanning

I. INTRODUCTION

A. BACKGROUND

Tactical Advancements for the Next Generation (TANG) began through the combined efforts of a former active duty submarine officer, a white paper, and the desire for innovation from senior U.S. Navy leadership.[1] The intent was to, from the lower ranks to the higher, influence change in the development of equipment and practices to better reflect the changing face of junior sailors and officers. Linking this desire to the single concept of innovation was instrumental in further shaping how the desired end would be achieved. The design thinking process would be the test bed to generate innovation, and the submarine community would be the focus of effort as well as the team members responsible for innovating. The results of this initial effort were staggering and TANG had gained a foot in the door as one of the U.S. Navy's vessels of innovation.

At the time of this thesis's composition, the Johns Hopkins Applied Physics Lab (APL) in partnership with the U.S. Navy has completed their 12th TANG on topics ranging from Aviation Mission Support, to Food Services and Sailor Toughness. This thesis is intended to provide a case study of the applications of design thinking at Aviation Mission Support TANG.

B. PREVIOUS TANG RESEARCH

In total there have been two Naval Postgraduate School (NPS) case study theses on U.S. Navy innovation events as well as other works examining the leveraging of the newest generation of sailors. The original case study was conducted by Navy Lieutenant Commander (LCDR) Thomas J. Hall which introduced "Participative Design Processes" when describing utilizing active duty personnel in the design thinking process.[2] LCDR Hall's study of the events with the very first TANG as well as the eventual prototype

[1] Thomas J. Hall, "A Case Study of Innovation and Change in the U.S. Navy Submarine Fleet" (master's thesis, Naval Postgraduate School, 2012), 35–36, https://calhoun.nps.edu/handle/10945/27840.

[2] Ibid., 7.

development and implementation sparked an academic and professional interest in the work of the TANG team from APL.

Similarly, LCDR Kevin L. Johnston and Marine Captain (Capt) Robert W. Featherstone provided a case study examining Executive TANG detailing not only innovative solutions, but also the change management aspect of making innovation effective within the U.S. Navy submarine community.[3]

1. A CASE STUDY OF INNOVATION AND CHANGE IN THE U.S. NAVY SUBMARINE FLEET

In December, 2012, LCDR Thomas J. Hall published a thesis examining the U.S. Navy Submarine Force's successful attempt to generate innovation among junior officers (O-3 and below) and enlisted (E-6 and below) in a forum that spanned multiple ships, rates, and rankings. This initiative that would eventually become Tactical Advancements for the Next Generation was traced back to three individuals Josh Smith, John Stapleton, and then Vice Admiral (VADM) John Richardson.[4]

Josh Smith, working at Johns Hopkins APL, wrote and distributed a white paper throughout APL discussing the potential gains in utilizing open-minded Junior Officers (JOs) and sailors in the fleet.[5] Smith's thoughts were an aggregate of his experiences as a submarine officer, and numerous discussions he had with peers as many exited active service in the submarine force.[6] The white paper sought to leverage active duty personnel to improve the design of technology by employing the submarine watch team as a whole.[7] Despite minimal attention outside of Smith's organization, APL's Director of Technology Strategy for submarine advanced development programs thought the white paper was a good idea and in line with the submarine community's identity.[8] That

[3] Kevin L. Johnston and Robert W. Featherstone, "A Case Study of Introducing Innovation through Design" (master's thesis, Naval Postgraduate School, 2014), https://calhoun.nps.edu/handle/10945/41398.

[4] Hall, "Innovation and Change in the U.S. Navy Submarine Fleet," 50.

[5] Ibid., 35–36.

[6] Ibid., 35–36.

[7] Ibid., 35–36.

[8] Ibid., 45.

director, John Stapleton, saw the potential for Smith's idea to echo the character and leadership of the founder of the nuclear navy, Admiral Hymen J. Rickover.[9]

While John Stapleton was not a minority at APL in his support for Josh Smith's white paper, the reception outside of APL was significantly colder at times.[10] This proposal for JOs and enlisted designing weapons and technical systems was outside the acquisitions and development culture within the submarine force.[11] Upon hearing that the Silicon Valley design firm IDEO was considered as a contracted support for Smith's idea, numerous active and retired personnel sent emails and made phone calls opposing this initiative.[12] It seemed that despite the efforts of Smith and support of Stapleton, this idea may not gain any traction.

Five months following the publishing of Smith's white paper, VADM Richardson took over as Commander, Submarine Forces for the Navy.[13] Prior to taking command, VADM Richardson met with the Google CEO and was impressed by Google's ability to rapidly design and prototype a solution for a specific need the Admiral had mentioned, within 20 minutes.[14] VADM Richardson desired to see this same rapid innovation and development in his forces as well as leveraging the "free training of millennial generation of sailors and officers."[15] This idea from VADM Richardson stuck with the Commander of DEVRON 12, whose mission was to "develop, evaluate, and disseminate tactics to the fleet."[16]

In a meeting with the Commander of DEVRON 12, John Stapleton with other APL directors delivered Smith's white paper as an answer to VADM Richardson's call

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[9] Hall, "Innovation and Change in the U.S. Navy Submarine Fleet," 45.

[10] Ibid., 46.

[11] Ibid., 46.

[12] Ibid., 55.

[13] Ibid., 47.

[14] Ibid., 47.

[15] Ibid., 49.

[16] Ibid., 49.

for leveraging the newer generation of submariners.[17] What followed was the engaging of large private technology organizations as well as IDEO to develop what would become the first TANG.[18]

Once support was established to conduct an innovation exercise utilizing JOs, LCDR Hall goes on to describe the careful crafting of the TANG event. This included permission and funding to work with IDEO, careful selection of forum attendees, educating civilians from IDEO on the submarine culture and lifestyle, prototyping the workshop itself, conducting a rehearsal, and building the necessary guidelines to ensure the success of forum.[19] With all of the careful preparation the TANG emerged as a success with four ideas receiving immediate attention, three of which were deemed feasible and one of which replaced a periscope manipulator with a cheaper and more intuitive Xbox controller with which most JOs and enlisted sailors have some immediate familiarity.[20]

2. A CASE STUDY OF INTRODUCING INNOVATION THROUGH DESIGN

In December 2014, LCDR Kevin Johnston and Captain Robert Featherstone published their thesis providing a case study of Executive TANG, a design thinking event aimed at leveraging the knowledge of post-command submarine officers to better incorporate technology to the unique world of a submarine commander.[21]

Following the success of the initial TANG event, Navy leadership wanted to pursue an Executive TANG event despite the uncertainly of a decidedly different pool of participants, using post-command officers rather than enlisted and junior officers.[22] The pliability of participants was a concern given the very autonomous nature of their work which drove fears that 27 individuals could not come together to work through the design

[17] Hall, "Innovation and Change in the U.S. Navy Submarine Fleet," 50.

[18] Ibid., 50–54.

[19] Ibid., 59–73.

[20] Ibid., 79–80.

[21] Johnston and Featherstone, "Introducing Innovation through Design," 76.

[22] Ibid., 76.

thinking process.[23] To address these concerns, the combined IDEO and APL team conducted a pilot event in Groton, Connecticut, with nine participants and the draft design challenges with the intent of condensing the process into a single eight-hour day.[24] The test event produced three well-received ideas; while there was some initial skepticism from the hand-selected participants, IDEO and APL leaders were highly enthusiastic that the Executive TANG event would be successful and the process would work with a larger group over the course of four days.[25]

Despite the enthusiasm that emerged from the Executive TANG pilot event in Groton, some insights were gained by the facilitation team that would better organize the insights and challenges for the main event. For example, prior to the pilot event 11 insights were broken into three groups: Leadership, Systems, and Data and Information.[26] Following the pilot event these were consolidated to two groups: "Systems and Information Flow" and "Command" this in addition to reducing the 11 insights down to nine.[27] As within the TANG design thinking process, insights are used to develop the design challenges traditionally emerging in the form of a question always beginning with "how might we…." From the nine insights, five "How Might We" (HMW) design challenges emerged:

- How might we capture lessons learned and improve feedback?
- How might we measure the tactical performance of the crew on a day-to-day basis?
- How might we leverage information flow up the chain of command?
- How might we better coordinate competing operational priorities?
- How might we keep tactical interfaces simple and standardized?[28]

[23] Johnston and Featherstone, "Introducing Innovation through Design," 85–86.

[24] Ibid., 86.

[25] Ibid., 88–89.

[26] Ibid., 89–90.

[27] Ibid., 90.

[28] Ibid., 91–92.

Executive TANG commenced September 9, 2013, with participants arriving for registration and participation in the Technology Exposition or, Tech Expo.[29] Throughout the first day, participants were allowed to mingle as well as to meet representatives from the tech expo who were demonstrating their respective organizations' newest technology, the intent being to inspire TANG participants rather than conducting sales.[30] Following the tech expo TANG participants were addressed by the Commander of Submarine Developmental Squadron (DEVRON)-12 and introduced to the TANG facilitators from Johns Hopkins APL and IDEO.

Day two of Executive TANG included an address from the Commander of Submarine Forces U.S. Pacific Fleet as well as an introduction to the design thinking process and development of insights and questions.[31] Participants broke out into assigned groups to develop questions with the assistance of APL and IDEO facilitators, as well as conducted interviews of members in other groups as a mechanism to practice empathy and listening, key traits in design thinking practitioners.[32] The second half of day two brought participants back to their groups where ideas developed earlier in the day were further explained, and participants were able to vote on the HMWs that were best able to achieve the intent of the TANG.[33] With each group establishing its focus of effort through the voting process, facilitators began practice brainstorming by asking simple HMW questions and encouraging as many ideas as possible followed up by a brainstorming session focused on the HMWs on which participants had previously voted.[34] The focused brainstorm ideas were then selected for rapid prototyping, as a means to physically demonstrate the ideas generated. Day two concluded with "share backs" in which groups were asking to provide a one-minute brief on the ideas generated

[29] Johnston and Featherstone, "Introducing Innovation through Design," 92.

[30] Ibid., 92–93.

[31] Ibid., 96–97.

[32] Ibid., 98–100.

[33] Ibid., 102–104.

[34] Ibid., 104.

through brainstorming to entire TANG group, purposefully exposing participants to the wide variety of concepts being developed.[35]

Day three of Executive TANG commenced with a working breakfast as well as further refining remarks from Commander DEVRON-12 narrowing the target on which he wanted the participants to aim their efforts.[36] With a clearer intent and focus fresh in their minds, TANG participants took to developing their day two concepts with additional brainstorming and prototyping which would be shared and provided feedback on, in 5–7 minute presentations midway through the day.[37] With the completion of concept feedback and lunch, participants began a new round of brainstorming this time including junior officers from Submarines in the NS Pearl Harbor area. Day three concluded with a visit from Commander Submarine Forces Pacific and individual briefs to him from the participant groups.[38]

Day four commenced with participants having an hour to refine concepts, prototypes, a new requirement of skits associated with their ideas, all before once again presenting ideas to the group as a whole.[39] In total, eight concepts were briefed with skits addressing needs identified by both participants and the theme of Executive TANG.[40] The conclusion of the event included addressed from an IDEO facilitator and Commander DEVRON-12 as well as an opportunity for participants to provide feedback on the entire TANG experience and processes, a mechanism to help improve future iterations.[41]

Johnston and Featherstone's work provide insights into both alternative problem solving methodology as well as alternative change management views detailing the design thinking processes with the gradual acceptance of the process from more senior

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[35] Johnston and Featherstone, "Introducing Innovation through Design," 104.

[36] Ibid., 105–106.

[37] Ibid., 106–107.

[38] Ibid., 108–111.

[39] Ibid., 111.

[40] Ibid., 114.

[41] Ibid., 115–116.

leaders. While the malleability of junior officers and enlisted personnel was leveraged in the success of the initial TANG, Executive TANG demonstrated the design thinking process's wider application within the submarine community.

C. PURPOSE

The purpose of this thesis is to provide an in-depth examination of the activities and processes support the execution of Aviation Mission Support (AMS) Tactical Advancements for the Next Generation (TANG). This thesis will provide a look at the original planning considerations, objectives, personnel selection, interactions, and outputs of the TANG conference providing landmarks to base further design thinking exercises upon. This case study will serve as both a record and medium by which to glean lessons learned in the development and implementation of a team tasked with applying design thinking to develop solutions to capabilities shortfalls.

D. PROBLEM

The Department of Defense (DOD) lacks case studies centered on Navy Aviation technology customization utilizing design thinking, a topic applicable to all branches of the armed forces and the respective communities within. A close examination and study of the application of design thinking will unlock greater understanding of the processes to employ concepts critical to maximize the capabilities of implementing policies and technologies.

E. RESEARCH QUESTIONS

This research will be guided by the following question: How can the Navy successfully employ the principles of organizational change theory and design thinking to develop innovative solutions that meet the individual's operational needs?

To answer this, the research will incorporate the following additional questions to both enrich understanding, and create an initial template of successful change innovation through design thinking:

1. How does the design process facilitate innovation in the Naval Aviation community?

2. What individual and group interactions were essential to pivoting the forums in the direction of successful application of change theory and design thinking?

Due to the purely qualitative approach and application of this research, a hypothesis is not appropriate to propose as a portion of this thesis work.

F. RESEARCH METHOD

The proposed research is a qualitative case study relying on published literature based in both historical and theoretical organizational change and design thinking tenants and models. While existing peer-reviewed articles surrounding this topic are less frequent than a more technical focus of study, the body of literature published in this area by respected and noted authors provides sufficient background to develop understanding of relevant processes and their respective applications. With this research, the case study will be able to highlight both the successful and failed utilization of existing change and design methods. In addition to the exploration of existing schools of thought, the research will enable a focus on unconventional methods employed by the forum to further extend accepted practices.

The methodology will begin by first examining case study methods as a means to determine the most appropriate approach to employ given the opportunity to experience firsthand, the events of the case study. Case study research will not be limited to development and creation, but will also include interview methodologies, three person triangulation to draw ground truth from interaction, and observation techniques. Following the case study methods, organizational change management theory research will provide both a historical and contemporary lens to appraise the techniques employed by the TANG forum leadership. This understanding will allow accurate and efficient tracking of forum participant transition from Navy Sailor to design thinking innovator, providing the groundwork for future forums. Finally, design thinking theory and facilitation research will analyze current standard practices expounding understanding of

the practices employed by the facilitators of the TANG forum. This better understanding will enable more thorough analysis throughout the case study of how innovations began in inception and developed into fully articulated proposals.

The application of research into case study methods, organizational change, and design thinking will produce a consolidated case study of how Aviation Mission Support TANG and Resiliency TANG developed personnel into a design thinking team capable of innovation and the application of that innovation. To accomplish this, primary and secondary sources will be utilized, observing the forum from its development through the entirety of its execution as well as follow on actions taken from the TANG outputs.

G. PROPOSED DATA, OBSERVATION, AND ANALYSIS METHODS

Limited data will be available and appropriate to conducting follow on research activities largely due to the qualitative nature of this thesis. Most, if any, data point will be tied to quantifiable information about forum participants and organizers as well as any relevant data to provide further background information on concepts developed throughout the TANG events. Observation will be one of the two most significant methods employed in this thesis research. The primary researcher will attend the forums as well as any post-forum daily activities to observe the interactions and group dynamics of participants and leadership. This will include interviews of forum personnel, and audio and visual recordings of interactions, and interviews with forum organizers. All observations are intended to develop an accurate picture of the development and execution of TANG while minimizing intrusion into the process and eliminating impacts from questioning the designs in development. The end goal of all observations and interviews is a focus on process with some attention to outputs. Analysis of observations will be driven by existing literature on change methods and design thinking. The analysis will focus on successful implementation, failed implementation, modified implementation, and how participants were able to work within the limitations provided.

H. POTENTIAL BENEFITS, LIMITATIONS, AND RECOMMENDATIONS

This research is beneficial in providing an analysis of how change theory and design thinking are employable within DOD organizations as a means to capitalize on

continued technology implementation. While few case studies exist examining the implementation of design thinking to achieve innovation, several exist that examine cost-cutting design to meet capabilities. This research will serve as another potential bridge between cost-saving and design thinking to provide an in-depth look into how to implement the latter.

The broad-based application of this case study is potentially hindered by the specificity of personnel involved. Much like previous case studies into design thinking surrounding highly technical and specialized communities, this research will also focus on a DOD community that is highly unique relative to the broad spectrum of the armed forces. Additionally, the nature of work with aviation often creates issues with maintaining an unclassified classification for published results. To the maximum extent possible, this thesis will stray from the technical details and processes that would cause the document to require a more strict distribution while still capturing the entire process.

The primary recommendation that will emerge as a result of this research is the future guidelines when conducting innovation forums. With continued research into more DOD innovation events, further implementation of the findings within this thesis could influence the acquisition processes, operational procedures, or simply maximize the efficiency of equipment and personnel at lower levels of command.

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II. LITERATURE REVIEW

A. INTRODUCTION

An extensive literature review was conducted focusing on the fields of qualitative research and the case study methodology, change management within organizations, and design thinking. These three areas of study were selected based upon the nature of the research and the observed activities, interactions, and implications of the Aviation Mission Support (AMS) TANG forum.

Observational methods were utilized in this research to build the case study resulting in minimal obtaining of quantitative data. The observational nature paired with the lack of quantitative data developed a need to examine and understand qualitative research methods as well as the most appropriate method to utilize. The case study emerged as the most appropriate qualitative research method which focused research efforts into case study development and writing.

A large enabling factor of AMS TANG was the shift in organizational culture for the participants transitioning from the traditional structures of the Naval Aviation community to the world of design thinking. The created a need to research organizational change theory and practice providing a lens from which to examine if and how change occurred. Furthermore, an understanding of change management allows some extrapolation of any successes in AMS TANG to developing a culture of innovation within the DOD.

The final focus of this literature review is design thinking, its methodologies, and its appropriate applications. Design thinking was the primary method utilized to innovate and develop prototypes in the TANG process and understanding the pillars of design thinking is essential to future innovation efforts. Furthermore, many of the leaders and facilitators of AMS TANG were design thinking professionals having worked extensively with industry leaders in the field. Routing out its core principles will enable success in future DOD innovation endeavors.

B. CASE STUDY METHOD

1. Introduction

Case study research is qualitative in nature, enabling researchers to record certain events and understand that chronicle. Typically, research that involves a great deal of human interaction and observation are presented as case studies in an effort to accurately depict events. Many researches avoid qualitative case study research as its results and conclusions tend to be specific to the parameters of the study and therefore lack a generalizable and concrete broad application. Prior to conducting this research, a comprehensive review of options was conducted to ensure the appropriate method was applied providing the maximum possible understanding of the events in AMS TANG.

2. Qualitative Research: Background

Qualitative research finds its origins in grounded theory stemming from Symbolic Interactionism and Pragmatism.[42] Though grounded theory and qualitative research remain different fields of study the consensus is that evaluation of both fields of study should be evaluated by modified quantitative canons.[43] Despite this recommended modification to the conventional body of rules, the relative value of qualitative and quantitative research has been long debated by members of the research community.[44] This debate is not baseless as, at their foundations, these two methods of inquiry represent two distinct paradigms. Utilizing specific contexts, qualitative researchers seek to understand and explain phenomena.[45] On the other side of the spectrum are qualitative researchers whose methodology focuses on experimental methods intended "to test hypothetical generalizations."[46] The distance between the two fields of study is also regarded as valuable link that must be made to improve the overall body of knowledge.

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[42] Juliet Corbin and Anselm Strauss, "Grounded Theory Research: Procedures, Canons and Evaluative Criteria." *Zeitschrift für Soziologie* 19, no. 6 (1990): 418–427.

[43] Ibid., 418.

[44] Michael Quinn Patton, *Qualitative Evaluation and Research Methods* (Thousand Oaks, CA: Sage Publications, 1990), 23.

[45] Marie C. Hoepfl, "Choosing Qualitative Research: A Primer for Technology Education Researchers," *Journal of Technology Education* 9, no. 1 (Fall 1997).

[46] Ibid.

The role of researchers is to identify "contemporary fact," but these facts should be shared with "the human scholar" in order to develop insights into these contemporary facts.[47]

This quest to understand this phenomenon is what has developed into modern qualitative research, a field which is still somewhat undefined. There is the more broad definition of exclusion that describes qualitative research as "any kind of research that produces finding not arrived at by means of statistical procedures or other means of quantification."[48] Using these seemingly boundless terms opens a great deal of research to be considered qualitative while more recent definitions narrow the scope focusing on the cognitive aspect of qualitative research. John Creswell provides a more focused definition that qualitative research is "a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem."[49] Creswell also demarcates the types of qualitative research including narrative research, grounded theory research, phenomenological research, case studies, and ethnographies.[50]

3. Selecting a Qualitative Research Method

In selecting a research method, the research environment and objectives of the inquiry contribute greatly to the ultimate determination. In researching AMS TANG, the situations met conventional criteria that 1) research questions asked how and why, 2) no control was required of behavioral events, and 3) contemporary events were the focus of the study.[51] With these conditions met, ensuring AMS TANG research fits within the definition of a case study is equally important. The research should "[investigate] a

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[47] Lee J. Cronbach, "Beyond the Two Disciplines of Scientific Psychology," *American psychologist* 30 (1975): 671–684.

[48] Anselm L. Strauss and Juliet M. Corbin. *Basics of Qualitative Research Techniques* Sage Publications, 1998. 10–11.

[49] John W. Creswell, *Research design: Qualitative, Quantitative, and Mixed Methods Approaches*, (Thousand Oaks, CA: Sage Publications, 2013), 4.

[50] Ibid., 125.

[51] Robert K. Yin, "Case Study Research: Design and Methods." (Thousand Oaks, CA: Sage Publications, 2009), 9–10.

contemporary phenomenon in its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident."[52]

Employing this definition, the context of AMS TANG and its innovative outputs pulls the research closer to a case study determination; however, a more specific definition may be required to make the ultimate decision. Another way of defining a case study is as "a strategy of inquiry in which the researcher explores in depth a program, event, activity, process, or one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time."[53] This more descriptive definition provides more delineated parameters from which a best suited qualitative approach can be concluded.

The context of AMS TANG includes social interactions resulting in a phenomena occurring within the confines of a specific time and place. The previously considered definitions solidify the use of a case study when conducting this research specifically to answer how the events of AMS TANG created a culture of innovation and how this culture can be captured and spread with DOD-wide applications. Without any control over the events of AMS TANG, the "how" question emerges as the driving focus of the research.

4. Designing and Executing a Case Study

Once the case study method has been selected as the preferred style of inquiry, a six-step process should be utilized to develop the case study.[54] These six steps are intended to be iterative allowing for flexibility and adjustments throughout the course of the research and are displayed in Figure 1.

(1) Plan: This first step requires the researcher to identify a situation that requires a case study over other research methods, understand what defines case study inquiry, understand any strengths and weaknesses in

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[52] Yin, *Case Study Research*, 16.

[53] Creswell, *Research Design*, 13.

[54] Yin, *Case Study Research: Design and Methods*, 1–206.

conducting a case study, and make the final determination to do a case study.[55]

(2) Design: In the second step, the researcher defines the "unit of analysis," builds propositions, theory, and related issues to generalize findings, identifies case study design, and tests this design for against criteria for quality.[56]

(3) Prepare: Step three includes skills honing as a case study researcher, training and developing protocols for the specific case study, screening candidates and selecting final cases, conducting pilot case studies, and obtaining approval for human subjects research.[57]

(4) Collect: The fourth step focuses the researcher on multiple sources of evidence as well as the triangulation of evidence from various sources, the assembly of data, the careful maintenance of that data, as well as considerations for care of data from electronic sources.[58]

(5) Analyze: Throughout step five, the researcher must be cognizant of opposing interpretations and explanations of the analysis. The analysis itself is conducted by organizing and displaying the data in various ways; watching closely for any concepts, insights, or promising patterns; developing an overarching analytical strategy; and considering multiple analytic techniques.[59]

(6) Share: The final step of building a case study requires the researcher to define their audience and from this definition, develop visual and textual materials, provide sufficient evidence for readers to come to their own conclusion, and review until the case study is done well.

[55] Yin, *Case Study Research: Design and Methods*, 2.

[56] Ibid., 26.

[57] Ibid., 70.

[58] Ibid., 102.

[59] Ibid., 132.

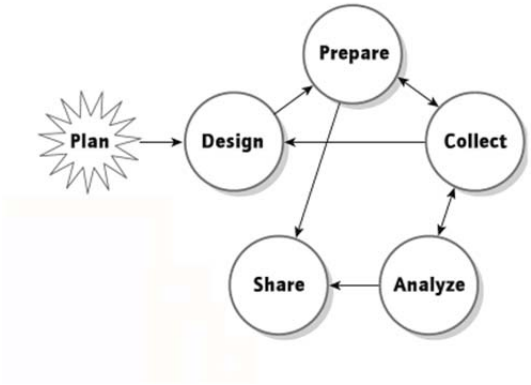

Figure 1. Six-Step Case Study Model.[60]

Focusing on the iterative nature of Yin's processes, researchers must be able to "move in and out of the literature before, during and after the case study has begun," in an effort to avoid a strict following of sequence.[61] This firm adherence to sequence can diminish the results of the case study, so the importance of understanding the simultaneous occurrence of method and analysis in case studies should not be overlooked.[62] Three stages of iterative processes are recommended to coincide with Yin's six step processes allowing researchers to flexibility to adapt their case study appropriately as required.

1. Describing Experience: For this stage, it is recommended that researchers develop interview scripts that drive "the interviewer closer to eliciting experience and meaning" as additional interviews are conducted.[63] Multiple sources of data should be considered prior to conducting interviews to create an early understanding of experiences as well as hone in on specific definitions for experiences.[64] Lastly, the data gathered

[60] Yin, *Case Study Research: Design and Methods*, 1.

[61] Donna M. Zucker, "How to Do Case Study Research," *Teaching Research Methods in the Humanities and Social Sciences* 2 (August 2009).

[62] Ibid.

[63] Ibid.

[64] Ibid.

should be mapped to distinctly and accurately provide the source of the data, an essential task to support the next stage.[65]

2. Describing Meaning: This stage returns the researcher to literature to describe meaning associated with the experiences. Meaning is mapped to three levels: symbols, events, and life.[66] Symbols can include words, acronyms, or even images and is considered the foundation for establishing meaning.[67] The next level is events (which can also include people and things), which is built from the symbols level.[68] While symbols can have multiple interpretations, events can provide various interpretations from various people, making event capturing essential to describing meaning.[69] The final level of meaning is the "meaning of life" which is considered a holistic view of the world built upon the previous two levels.[70] In studies, the middle level of events has proved to be the most useful; however, the context of the case study will dictate which level of meaning provides the greatest contribution.

3. Focus of the Analysis: Stage three builds upon the outputs of describing the experience and describing meaning. The intent is to build a logical progression detailing how researchers developed their conclusions from the activities in steps one and two.[71] Generalizing the discovered social phenomena to other situations is an ideal outcome however, the conditions of the case study will dictate the relevance of the analysis and how generalizable it is.[72]

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65 Zucker, *How to do Case Study Research*.

66 Patricia M. Burbank, "An Exploratory Study: Assessing te Meaning in Life Among Older Adult Clients," *Journal of Gerontological Nursing* 18, no. 9 (1992): 19–28.

67 Ibid., 22.

68 Ibid., 23.

69 Ibid., 25.

70 Ibid., 26.

71 Zucker, *How To Do Case Study Research*.

72 Ibid.

5. Conclusion

The research team for this thesis made several considerations into the circumstances and events of AMS TANG prior to deciding to employ the case study method. The ultimate intent of researching AMS TANG is to answer the question of "how," focused on a limited duration event of which no control is exercised by researchers. Additionally, the research is qualitative in nature given its focus on complex social interactions and the phenomena that result from these interactions. The lens of a case study will offer clues as to how the outputs of AMS TANG were generated while providing insights into the exchanges that contributed to these outputs.

C. ORGANIZATIONAL CHANGE THEORY

1. Introduction

Organizational change theory examines the growth, pivot, or adaptation of organizations based upon a diverse pool of potential driving factors without regard to the internal or external source of these factors. Understanding organizational change theory is essential to research into AMS TANG as an opportunity to understand how forums such as TANG can create a culture of innovation in the DOD.

Doing a review of the literature focused on change theory and change management comes with the underlying assumption that the DOD does not currently have a culture of innovation. This assumption is not addressed in the review of change theory literature; however, the literature is utilized to examine how the DOD could pivot toward an innovative ethos. The focus of the research into organizational change theory is an examination into first, change theory and its processes and second, changing organizations. This will provide a lens through which AMS TANG can be observed for how successful the forum was in changing the participants.

2. Group Change, a Three-Step Process

Kurt Lewin, considered one of the earliest examiners of change theory, conducted a great deal of research during and after World War Two that coincided with the general increase in social sciences. His research examined the influences of change, the duration

of change, and the durability of change by examining multiple dynamics ranging from pace cards in sewing factories to convincing mothers of the importance of milk in their newborn's diet.[73] Lewin examined the influences of change, the social interactions with and regarding those influences, and the lasting impact of any changes to try and both quantify change and determine the most efficient methods of achieving change.[74] Lewin's research would come to be the foundation of both group and organizational change theory.

a. Unfreeze, Change, Freeze

Often times efforts to change groups results in short-term gains after which, group performance returns to previous levels resulting in only a temporary change before a return to the perceived equilibrium or, status quo.[75] Assuming that the change objective did not exceed the capabilities of the group, this temporary change indicates that clear communication of the desired change is insufficient to create the desired lasting effect.[76] A failure to effectively communicate the new level of performance as the desired standard should, at a minimum be provided in addition to the introduction of the new levels.[77]

This lead Lewin to suggest that group change is a three-step process of "unfreezing the present level, moving to the new level, and freezing group life at the new level."[78] In unfreezing, the accepted performance of the group must be challenged and shown to be less effective or even ineffective in its current state. Doing so may require challenging foundational beliefs of a group, increasing tensions and causing a strong

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[73] Kurt Lewin, "Frontiers in Group Dynamics: Concept, Method and Reality in Social Science; Social Equilibria and Social Change," *Human Relations* 1, no. 1 (1947): 5–41.

[74] Lewin, *Frontiers in Group Dynamics*, 5–41.

[75] Ibid., 13–14.

[76] Ibid., 34.

[77] Ibid., 35.

[78] Ibid., 35.

emotional release. This release may require deliberate influence from external forces to strongly contest firmly held principles.[79]

Freezing the new change has the potential to be just as emotional for members of the group as the now established norm may not be acceptable by individual and group standards. Social dynamics can play a significant role in the freezing process of change as well as the delivery method of desired level, both of which impact the effectiveness of the altering of behavior.[80]

Understanding that the steps were discussed out of order, making the change following unfreezing is a step that varies greatly depending on the organization and the desired change level however how the procedure is done can have a tremendous impact on the size and lifetime of the change.[81]

b. The Impact of Group Decisions

When making the change, or "moving to the new level," Lewin made two significant discoveries after analyzing the interactions of housewives when introduced to the ideal of consumption fresh milk, orange juice, or cod liver oil. The analysis revealed change procedure impacts to both initial adoption and increase over time between groups of women who received either a lecture, or a group discussion.[82]

For the women who received information from a lecture on the benefits of increased fresh milk consumption, fewer than 20% reported an increase in usage after two weeks. This is compared to the women who went through a group discussion, of whom over 40% reported an increase in fresh milk consumption after only two weeks. This points to the value of a group determination that the desired change level is the right decision over simply being told why the new level is appropriate.[83]

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[79] Lewin, *Frontiers in Group Dynamics*, 35–37.

[80] Ibid., 36.

[81] Ibid., 34–38.

[82] Ibid., 36.

[83] Ibid., 36.

In the group of women who received instruction about orange juice consumption, the percentage of adopters was even higher, illustrating the superiority of group decision over individual instruction. The orange juice group also revealed that after four weeks, both the individual instruction and group decision groups showed an increase in orange juice consumption, indicating an ability for change to increase over time, regardless of the medium by which the new level is communicated.[84]

Lewin's change process would form the foundation for numerous studies into the social dynamics of change and the processes that make change the most effective. Despite providing tremendous insights into how change occurs, Lewin's research did not provide a guide to how to execute change, especially for large organizations.

3. Organizational Change

Planned change within large and small organizations is a process complex enough to require more attention and activities than Lewin's unfreeze, move to new level, freeze method to adjusting levels of performance. Having a process to conduct change within an organization is imperative to survival in a competitive world. This need for change is best described by John Kotter:

> The change problem inside organizations would become less worrisome if the business environment would soon stabilize or at least slow down. But most credible evidence suggests the opposite: that the rate of environmental movement will increase and that the pressures on organizations to transform themselves will grow over the next few decades. If that's the case, the only rational solution is to learn more about what creates successful change and to pass that knowledge on to increasingly larger groups of people.[85]

This assessment from Kotter, now two decades old, has yet to be disproven and his eight-step change model continues to be a standard both studied and practiced in organizations worldwide. It is this model that will be the locus of research on organizational change.

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[84] Lewin, *Frontiers in Group Dynamics*, 36.

[85] John P. Kotter, *Leading Change* (Brighton, MA: Harvard Business Press, 1996), 30–31.

a. Creating a Sense of Urgency

For an organization, urgency for change can come from multiple internal or external sources ranging from competition to a new organizational hierarchy however; regardless of the source, the sense of urgency is the initial step in leading change. The feeling need not be wide spread throughout an organization in fact, as little as 15% of members must feel the urgency in order to progress onto the next step.[86] Even with this small group supporting change, there are detractors to be mindful of within the organization.

Complacency can be the enemy of urgency within organizations, a mentality and general behavior that can be seen in any organization. Too often complacency is viewed as synonymous with contentment, an assessment that does not hold water. It is true that some forms of complacency can be attributed with overall satisfaction in how activities are progressing, companies that feel as though their struggles are the struggles of all members of the industry also display a sort of complacency. Another misconception about complacency is that it comes out of an unskilled workforce. Kotter found some of his students "linking ineptitude and complacency," something he found did "not fit well with [his] experiences."[87]

The sense of urgency is often a leadership responsibility or, at least a leader is in a much better position within an organization to create a sense of urgency. The creation of urgency "usually demands bold even risky actions that we normally associate with good leaders."[88] This role of a leader as a champion of change cannot be over stressed as a point of failure so early in the change process Kotter warns, "If top management consists only of cautious managers, no one will push the urgency rate sufficiently high and a major transformation will never succeed."[89]

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[86] Kotter, *Leading Change*, 35.

[87] Ibid., 38.

[88] Ibid., 42–43.

[89] Ibid., 43.

b. The Guiding Coalition

It is dangerous to believe the top CEOs that have guided their organizations to change, did so solely and without any assistance from within their companies. Individuals that remove road blocks on the path to change, take on change projects, and serve as cornerstones of change initiatives within the company, make up the guiding coalition that believe and support the change process.[90]

The guiding coalition must possess "the right composition and trust among members" to sufficiently support change initiatives.[91] Putting the team together requires focus in four key areas:

1) Position Power: This highlights a need for coalition members to be able to block adversaries of change through their position within the organization.

2) Expertise: Focus on bringing together competent but diverse members whose skills are relevant to the change effort. The diversity will encourage numerous points of view on the present tasks.

3) Credibility: Ensure the guiding coalition is filled with members of high reputation providing legitimacy to other employees.

4) Leadership: The group must contain leaders proven to be competent and capable at driving change initiatives.[92]

The most important aspect of building a guiding coalition is to ensure the team possesses both trust and a common goal. This is a challenge in larger organizations as many members have spent their careers operating within a single section and department which, over time has created a loyalty. Despite this obstacle, trust helps tremendously with developing the common goal and shared objectives, an ultimate road map to change.[93]

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[90] Kotter, *Leading Change*, 51–52.

[91] Ibid., 55.

[92] Ibid., 57.

[93] Ibid., 61–62.

c. Developing a Vision and Strategy

There are two parts to a vision within change management: the first is a clear image of the future that helps to provide a general direction, and the second is enumeration on why the vision should become a reality (i.e., why people should work toward that goal). The second part of a vision provides motivation to members of an organization to move beyond their current position and advance. Both aspects of vision help to coordinate individual and group efforts toward the end goal, sometimes in an expedited timeline.[94]

It is important to differentiate vision from other common change methods, specifically *authoritarian decree* and *micromanagement*. Most organizational leaders lack the instant and willing obedience to orders that dictators and monarchs enjoy making the authoritarian decree untenable. Utilizing this method rarely results in members breaking through the status quo to affect real change. Micromanagement may take members further beyond the status quo however there is no shared goal and why the goal exists. Instead, micromanagement is just a specific list of steps to achieve a leader's goal. Vision has shown to truly break through the status quo in effecting change in individuals and groups alike by providing both *what* and *why*.[95]

Much like the organizational change process, building a vision and strategy is not an individual effort. The initial vision may come from a single leader however it is quickly worked through the guiding coalition to be refined and practically developed into a strategy. This step is never completed in a single meeting and leaders should anticipate weeks, months, or years for a vision and strategy to be developed. Once complete, an organization will have "a direction, for the future that is desirable, feasible, focused, flexible, and is conveyable in five minutes or less."[96]

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[94] Kotter, *Leading Change*, 71–72.

[95] Ibid., 77–79.

[96] Ibid., 81.

d. Communicating the Change Vision

Once the vision is established, sharing the strategy throughout an organization is the next unique challenge. Considering the quantity of messages between management and employees over the course of a few months, vision communication accounts for less than one percent of total communications.[97] It is essential to deliver a clear and concise vision to the organization that stands out among the forest of all communications.

Kotter identifies several crucial factors to communicating the change vision which provides "focused, jargon-free information" that is void of "technobabble and MBA-speak."[98] By keeping the messaging simple and leveraging both analogies and "multiple forums," the change vision is expressed through several effective means while ensuring the most basic understanding of the desired goal.[99] Additionally, leading by example, solving inconsistencies, and allowing communication back and forth between leaders and employees ensures the entire scope of the vision has been grasped organization-wide.[100]

e. Empowering Employees for Broad-Based Action

The term "empowerment" has become somewhat cliché in organizations to the extent that it has lost its value in many ways; however, the action inspires leaders to help people become more powerful, a critical aspect of leading change. Empowerment requires the removal of formal and informal structures that make action difficult when trying to affect and impact change. These structures can limit resources, cause managers to doubt the vision, drive up costs, and hinder inter-organizational communication all as barriers to change.[101]

Additional obstacles to empowerment include managerial discouragement of change processes, inadequate or underutilized information systems, and an unskilled workforce. To overcome these difficulties an organization must dedicate time and

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[97] Kotter, *Leading Change*, 89.

[98] Ibid., 89.

[99] Ibid., 90.

[100] Ibid., 95–100.

[101] Ibid., 103–106.

resources to training and systems alignment. This will provide the necessary tools to ensure all members of an organization are equipped to handle large-scale transformations and the challenges that come with it.[102]

f. Generating Short-Term Wins

Vision and strategy in change management is often linked to the end state of an organization and while this connection is valid, a portion of strategy must be dedicated to short-term wins or, showing the smaller positive impacts of transformation that contribute to the larger objective. Too often within an organization, people become, "so caught up in big dreams that they [don't] effectively manage the current reality."[103]

Short-term wins should be tangible and visible enough to allow a significant number of people to see the victories and make their own assessment that the win is in fact, a win. Short-term wins must also unambiguous ensuring the credibility cannot be called into question thus diminishing the value of the win. Lastly, it must be directly linked to the vision and change effort preventing any dissenters from arguing false attribution. These characteristics allow for momentum to build or continue throughout the change process.[104]

g. Consolidating Gains and Producing More Change

The seventh step in the change process involves an examination of the interdependencies in an organization, and eliminating the unnecessary interconnections. This examination follows the thought process of business process reengineering in which redundant or irrelevant steps are removed from activities or procedures to make the organization more efficient. This drives an increase in change late in the process rather than a decrease, an effort that is aided by the previously generated short-term wins.[105]

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[102] Kotter, Leading Change, 108–109.

[103] Ibid., 118.

[104] Ibid., 121.

[105] Ibid., 132.

In this step, personnel directly supporting the change are increased, receive promotions to better influence change, and are also better trained. The increase in help provided by more personnel increases specific project management at lower levels as well as places change leaders in positions to continue momentum from executive levels. Something else to consider in this step is a certain amount of house cleaning to reduce difficulties in change efforts going into the final step.[106]

h. Anchoring New Approaches in the Culture

This step is arguably one of the most difficult in the change process as it involves the cultural shift of the organization. Kotter is adamant that the cultural change is the last step, not the first. Cultural sensitivity is important beginning with the first step and throughout the change process; however, it is not until the end that a shift occurs. This change is also very subjective at the end of the process as it is a fluid concept until the results of change efforts can be analyzed.[107]

Anchoring culture also requires a significant amount of dialogue within an organization to elicit confirmation that new norms and practices are actually beneficial and better for the group. In the event that dialogue cannot produce the desired cultural shift, sometimes removal of key people is a necessary step to solidifying the new ethos. Along with the removal of dissenters, promotion of people supporting the desired culture is key. By not adapting the promotion system to reflect the vision, leaders provide the old culture an opportunity to regain dominance.[108]

4. Changing to a Culture of Innovation

Culture is an aggregate of all facets on life including, "behavior, beliefs, values, language, and living practices," as well as the "pattern of values, traits, or behaviors of people."[109] These individual ways of life all play a factor in the innovative capacity of a

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[106] Kotter, *Leading Change*, 142.

[107] Ibid., 147.

[108] Ibid., 157.

[109] Paul Herbig and Steve Dunphy. "Culture and Innovation." *Cross Cultural Management: An International Journal* 5, no. 4 (1998): 13–21.

culture particularly a culture similar to the DOD's that is willing to incorporate new information, assume risk, has a unified cultural identity, and values education and experience.[110] Innovative capacity though, does not necessarily indicate a culture of innovation. Rather, it highlights the DOD as capable of innovation should it choose to embrace methodologies and practices. Later in the literature review, corporate innovative cultures are discussed in more detail, particularly aspects of the culture that are more conducive to innovation. This intent of this brief section is to map organizational change theory to a culture of innovation.

In conducting a review on corporate innovative cultures, there is little literature available that discusses organizations as large as the DOD. In some cases, large organizations are studied; however, the focus of the literature is on pockets of innovation within the larger organization. This makes it challenging to identify specific activities directly linked to transitioning larger organizations to a culture of innovation, supported by published literature.

Organizational change methodology serves as a means through which the DOD can obtain an innovative culture. The actions taken in AMS TANG will be connected to the eight-step change process while identifying what specifically are activities aimed toward building a culture of innovation.

5. Conclusion

This chapter discussed change at an individual, group, and organizational level beginning with the unfreezing, changing, and freezing model to affect individual behavior. Further examination of this method revealed successful application methods specifically in group change revealing that group discussion and decision is more effective than pure lecture. Finally, organizational change theory, which pulls some of its activities from individual and group change models, was addressed.

The individual and group interactions within AMS TANG were driven by the design process but this process can fail without conducting the necessary change

[110] Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (New York: Oxford University Press, 1992): 153–158.

processes in its participants. Activities conducted during AMS TANG focused on pivoting participants toward a design mindset ultimately facilitating innovation through group activities.

Change process and change management were examined to provide greater insights into *how* a culture of innovation can be established based on the underlying assumption that the DOD does not currently possess this culture throughout its branches. Review of Kurt Lewin's work provided insight into how to effectively influence change in groups while John Kotter's work gave a detailed road map of processes to influence change within organizations.

D. DESIGN THINKING

1. Introduction

The design thinking portion of this literature review will focus on the differences between design and design thinking, the processes and outputs of design thinking, and design thinking's role in in commercial organizations. This review and analysis of the literature is intended to focus on answering, "What is the design mindset?" to best understand the thoughts, actions, and behaviors that best support design thinking. Is the design mindset counterintuitive to deliberative and rational planning methods, or does the mindset align in many ways with conventional activities?

2. Design Thinking, not Design

Within the commercial world, there is some ambiguity when discussing the design of a product, and ambiguity driven by market competition focus on a product's meanings. The meaning of a product answers "why" a product is desirable or needed in contrast to "what" may be needed from a product. This juxtaposition of a "why" and "what" question is at the core of the two design definitions.[111]

To answer the "why" question, commercial organizations tend to focus on a product's physical appearance and ensuring the appearance is appealing and attractive.

[111] Roberto Verganti, *Design Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean* (Brighton, MA: Harvard Business Press, 2009), 23.

This is referred to as the "styling" of a product which, in some case studies, became a commodity of business when using this constrained interpretation of design. One such case is the Artemide manufacturing company based out of Milan, highly awarded and regarded within the design world for their modern designs, especially lamps.[112]

While developing a particular lamp, the Metamorfosi Artemide was challenged to maintain its prominent status in the design world while designing a lamp that was never intended to be seen. In developing Metamorfsi, designers entered one of their difficult phases focusing on light itself rather than the shape of the object, transitioning from why the lamp was desirable to what the lamp needed to do. This step toward function indicated a pivot in understanding that design goes beyond simply styling.[113]

What emerged in the Metamorfosi project was a new design strategy radically divergent from convention, differentiating the product from competing groups while developing new meanings for its products. The lamp itself was focused on human-centered light and the impacts of light on mood and human interaction.[114] This approach is closer to the focus and discipline of design thinking and its applications, a key component of this research and the events of AMS TANG.

The design thinking approach expands beyond the human-centered design of Metamorfosi and employs a process that leverages inherent abilities in any person to conduct design, essentially human-centered processes to develop human-centered products. Design thinking is described as "rely(ing) on our ability to be intuitive, to recognize patterns, to construct ideas that have emotional meaning as well as being functional, and to express ourselves in media other than words or symbols." This focus on human capabilities is an effective method that supports the design process.[115]

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[112] Verganti, *Design Driven Innovation*, 26.

[113] Ibid., 1.

[114] Ibid., 26.

[115] Tim Brown and Jocelyn Wyatt. "Design Thinking for Social Innovation IDEO." Development Outreach 12, no. 1 (2010): 29–31, 33.

3. Design Thinking

The origin of design thinking as a discipline stems from the field of consumer design expanding to accompany new fields and areas of focus. The design firm IDEO initially began with the development of consumer products ranging from a toothbrush to laptop design. In the early years of the 21st century, IDEO had begun to take on different challenges with companies seeking to better understand their clients including health care organizational restructuring and universities developing learning environments departing from conventional classrooms. This added scope of work IDEO brought in the focus of experience, not just product. This new field of design was commonly referred to as "design with a small d"; however, the expression never truly caught on. Instead, whenever David Kelley, co-founder of IDEO, was asked to discuss design, "thinking" regularly was added to the end of the term and the phrase stuck.[116]

a. A Source of Innovation

Tim Brown, co-founder of IDEO, argues that existing strategies and reliance upon technology as sources of innovation are not the only options available. Issues with these options range from unsustainability to lack of responsiveness in an increasingly demanding environment; however, a process that meets the necessities of both individuals and the collective presents a third option for innovation. Advantages to design thinking stem from its reliance upon characteristics and capabilities resident within most individuals and therefore not requiring extensive training or education. Inherent capacities such as intuition and pattern recognition are at the core of design thinking as elements that allow development of concepts that are both highly empathetic and functional.[117]

It is these ubiquitous human traits that differentiates design thinking in the design process from other sources of innovation and offers the alternative strategy. Brown reasons that running businesses solely through emotions and intuitions can be just as dangerous as exclusively using a logical-analytical approach. Design thinking emerges as

[116] Brown and Wyatt, *Design Thinking for Social Innovation IDEO*, 33.

[117] Tim Brown, *Change by Design* (New York: Harper Press, 2009), 39.

an integration of both strategies leveraging intuition while applying logical analysis creating a third option as a source of innovation.[118]

It is imperative to note that design thinking and innovation are neither mutually exclusive nor consistently imply one another. Innovation in a business sense is tied much closer to cost-effective recreation at scales appropriate to demands rather than simply creating something in a lab or controlled environment.[119] This speaks to innovation being a more practical application and while design thinking is more of an activity and process which enables innovation.

b. Innovation within an Organization

Through their body of research and reviews of literature, Govindarajan and Trimble found that businesses ultimately become more efficient over time and less innovative due to the tempo, strain of continuous business operations, and the satisfaction of investors. This supports their primary rule regarding innovation: that an organization's steady-state operations and innovation are continuously and unavoidably in competition. The obvious conflict is attributed to wanting success today and in the further future; however, this can only partially account for the struggle between ongoing projects and innovation. Assigning resources for long-term efforts and projects while tackling immediate challenges has been a standard practice for senior managers and executives.[120]

Govindarajan and Trimble go on to suggest that there is a more entrenched reason for current operations and innovation to be at odds, the culture that creates success and drives tasks to be "*repeatable* and *predictable*," coming close to how Senge defined innovation as discussed earlier.[121] It is important to clarify, though, that Senge offered a definition of innovation as something that is scalable and cost-effective, implying that innovation is a precursor to the culture of successful businesses.

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[118] Brown, *Change by Design*, 39.

[119] Peter M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Double Day, 2006), 5–6.

[120] Vijay Govindarajan and Chris Trimble, *The Other Side of Innovation: Solving the Execution Challenge* (Brighton, MA: Harvard Business Press, 2010), 174.

[121] Ibid., 11., and Senge, *The Fifth Discipline*, 5–6.

The competition between performance and innovation is similar to James March's examination of how organizations adjust their processes, a conflict he describes between "exploration" and "exploitation."[122] Exploration is akin to innovation and even features "innovation" as one of its characteristics. Exploitation is on the opposite end of the spectrum that seeks to make an organization as efficient as possible with its known processes. March draws attention to similar issues as Govindarajan and Trimble such as resource allocation as well as business priorities established by the culture of an organization.[123]

4. The Design Mindset

With better understanding of the roles and conflicts associated with innovation inside and organization, exploring the mindset of design will provide greater insights into how to best adapt organizational culture. Armand Hatchuel took on the arduous task of further developing design theory and contrasting it with works of Herbert Simon, who is self-described as obsessing solely on decision making.[124] While the compared topics are not easily associated, the connection comes from Simon's focus on how individuals identify solutions to problems from a vast array of possibilities, and Hatchuel sought to explain the different methods by which those decisions are constructed.[125]

To best illustrate the difference between the approaches, two cases discuss social interactions and decision making. Case 1 is a group of friends looking to see a movie, and case 2 is a group of friends looking to throw a party. In case 1, the movie group, this is a problem of "bounded rationality" in that there are a finite number of solutions the group can come to while going through their decision making process. In case 2, the party group, the group may go through a similar decision making process but the outcomes are

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[122] James G. March, "Exploration and exploitation in organizational learning," *Organization science* 2, no. 1 (February 1991): 71–87, 71.

[123] Ibid., 74–76.

[124] Armand Hatchuel, "Towards Design Theory and Expandable Rationality: The Unfinished Program of Herbert Simon," *Journal of Management and Governance* 5, no. 3 (2001): 260–273, 261–262.

[125] Ibid., 261.

infinite. The dissimilarities between the two are how case 1 is arriving at a decision, and group two is constructing its decision.[126]

Hatchuel refers to this difference as "expansions of the initial concept," and argues that the party group's problem is not "vague, and ill-structured" as Simon would have suggested.[127] Rather the beginning idea of the party is well-structured enough to allow for "conformity to usual party standards, or for innovative suggestions."[128] "Expandable rationality" is what Hatchuel comes to label the problem of case 2, an opportunity to innovate and explore the infinite possibilities of what a party could be.[129]

Case 2 begins to form a base for design mindsets and how the problem space should be considered for organizations with a design mindset, the "ability to manipulate (individually and collectively) infinitely expandable concepts" is at the core of this design mindset.[130] This mindset supports Simon's research into design as a function of managers, but also "critiques" Simon's assertion that "we could capture complex problem-solving, even creativity, in terms of simple heuristics and satisficing criteria," implying acceptance of alternatives rather than developing infinite options.[131]

a. Design as a Function of Management

Hatchuel's cases examined rationality of problem spaces and the applications of design in these social scenarios, but did not push his cases into the world of business and industry. To make the connection to the world of business and managers, Simon is revisited with his assertion that design is the purview of managers and that the actions of managers are less oriented toward decisions and tend to take on a design orientation more often.[132] The design mindset enables this orientation however the "design attitude" as

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[126] Hatcheul, *Toward Design Theory*, 264.

[127] Ibid., 264–265.

[128] Ibid., 265.

[129] Ibid., 266–268.

[130] Ibid., 268–269.

[131] Ibid., 269.

[132] Herbert A Simon, *The Sciences of the Artificial*, (Cambridge, MA: MIT press, 1996), 144.

described by Boland and Collopy takes the mindset from a social interaction to a managerial practice.[133]

One aspect of the design mindset in management is the formal and informal education of individuals in leadership positions. By emphasizing the selection of options through progressive problem solving analytics, the focus on training managers to develop new alternatives through design is lacking.[134] This is further evidenced by the "limited and narrow vocabulary" utilized when picking from alternatives that has caused an extinction of design vocabulary in many professionals.[135]

This contrast between solution decisions and solution designs is the focus of the argument for a design attitude over a decision attitude. Boland and Collopy argue that the fundamental difference between the two is the mindset when attempting to solve a problem. A manager with a decision attitude sees the solution to a problem as "a set of alternative courses of action from which a choice must be made."[136] Bringing the decision attitude to bear on a problem comes with the underlying assumption that generating the alternatives is the simple task, and selection of an alternative is more difficult often relying on heuristics to develop alternatives.[137] Conversely, a manager with a design attitude "assumes that it is difficult to design a good alternative, but once you have developed a truly great one, the decision about which alternative to select becomes trivial."[138]

The language used by Boland and Collopy may seem biased against a manager with a decision attitude, implying the impacts of these managers is a hindrance to an organization. Their perspective is quite the opposite however as the argument suggests "that now is the time to incorporate a better balance between the two approaches to

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[133] Richard J. Boland and Fred Collopy, *Design Matters for Management*, (Palo Alto, California: Stanford Press, 2004), 4.

[134] Boland and Collopy, *Design Matters for Management*, 7–8.

[135] Ibid., 4.

[136] Ibid., 4.

[137] Ibid., 4.

[138] Ibid., 4.

problem solving in management practice and in education."[139] What is missing from Boland and Collopy's discussion is at what level of management this balanced attitude is best suited for an organization. It can be assumed that any level of decision authority should have both approaches well-practiced and available, but as previous TANG research has suggested, innovation in design does not always come from managers making a decision. Design innovations have come from low-level employees and chief executives alike, especially at IDEO, a firm specializing in design thinking and innovation.

b. Helping the Design Mindset throughout an Organization

To better understand what aspects of an organization enable a pervasive design mindset, Amabile, Fisher, and Pillemer examined the ethos of IDEO, describing the atmosphere as a "culture of helping."[140] Within the context of the literature, "helping" is not an industry-specific term intended to present a unique capability or ethos whose implied capability is applicable to innovative organizations. Rather, "helping" is the layman's word for providing assistance with whatever project or activity is present.[141]

Within companies that are considered the highest in performance, support among peers on projects is considered a standard practice, often yielding the greatest results.[142] This support is not as simple as willingly sharing the burden; rather, it is a combination of "experience and expertise that improve the quality and execution of ideas."[143] This is especially true at IDEO where experience and expertise are spread widely throughout the organization both horizontally and vertically. An individual's position in the hierarchy of leadership has no influence over their ability to help or their access to help. This invites

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[139] Boland and Collopy, *Design Matters for Management*, 4.

[140] Teresa Amabile, Colin M. Fisher, and Julianna Pillemer. "IDEO's Culture of Helping." *Harvard Business Review* 92, no. 1–2 (January-February 2014): 3, 54–61.

[141] Ibid., 4–5.

[142] Ibid., 3.

[143] Ibid., 3.

the newest employee to seek out an executive for assistance and often the opposite occurs as well.[144]

When considering experience and expertise, limiting help to individuals with a focus on your problem can be surprisingly hindering, as evidenced by the case of Harry Nyquist:

> Workers with the most patents often shared lunch or breakfast with a Bell Labs electrical engineer named Harry Nyquist.' Nyquist was particularly skilled, it turned out, at asking good questions. At first glance Nyquist seems to be the helping hero of that organization. But many of those lunches probably occurred because he was invited by someone who was working on a complex problem and needed a sounding board. There are two sides to every helping encounter, and both must be encouraged and supported.[145]

The story of Harry Nyquist was supported by a survey of IDEO employees. When asked what characteristics of a colleague made them the most helpful, "trust and accessibility matter much more than competence."[146]

While the interactions between groups and individuals of an organization are tremendous contributors to building and maintaining a design mindset, the role of senior leadership and technology should not be ignored. Helping is an activity that must be practiced at all levels of the organization, not just communicated as the vision of the organization. The process and practice of helping is reinforcing of behavior rather than simply written as a mandate.[147] Another input from leadership is the allowance of free time to contribute to helping and not focusing simply on maximizing productivity and outputs.[148] This recommendation may come off as counterintuitive to most business practices that stress efficiency to bolster productivity; however, the gains from allowing "ad hoc assistance…reinforces messages exhorting people to help their colleagues."[149]

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[144] Amabile, Fisher, and Pillemer, *IDEO's Culture of Helping*, 4.

[145] Ibid., 4.

[146] Ibid., 6.

[147] Ibid., 5.

[148] Ibid., 6–7.

[149] Ibid., 7.

Information technology systems also play a role in the helping culture of IDEO, although not in the conventional way. Tools such as video teleconferencing and email are regularly used; however, "fancy collaborative software tools and other technologies," were not considered necessary or even helpful to the desired principles.[150] This is not to say that technology does not support or sustain the helping culture; however, personal interactions are far more helpful for IDEO.

The business of IDEO is design and innovation making them an ideal case to examine how the design mindset is maintained within an organization. Because the primary focus of IDEO is nested in the design mindset, its practices and culture are not necessarily translatable to all organizations; however, the helping culture is translatable, especially in problem solving whether the approach is a decision attitude or a design attitude.

5. Conclusion

In a conventional organization, design is the purview of managers that have the option to approach a problem as having many solutions to pick from, or a problem as having a solution that needs developing. However, the activity of design is not something that should be exclusive to managers; rather, it should pervade an entire organization for any individual or group that has the capacity to make decisions. These individuals and groups should not shy from seeking help vertically or horizontally with their decision development, and leaders should make themselves available for help just as easily as seeking help from lower-ranking personnel.

Design thinking is a process that will enable decision makers to develop new and unique solutions to problems, and design thinking is best applied with the design mindset. A thought process that relies less on heuristics and sees the greatest challenge to solving a problem as developing the right solution, rather than making a decision from a list of alternatives. The design mindset encourages the expansion of infinite possibilities and seeks to customize the right option for challenge at hand.

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[150] Amabile, Fisher, and Pillemer, *IDEO's Culture of Helping*, 7.

E. CONCLUSION

From this literature review, there are several links between the events and outcomes of Aviation Mission Support TANG and the academic research into the fields of design, design thinking, and organizational change. The case study in the next chapter will provide lessons that are generalizable to other organizations within the DOD as well as the DOD at large when attempting to build an innovative culture.

There is tremendous value in understanding the underlying theories and practices that support both design thinking and organizational change management. The following chapter presents a case that applies these theories to generate innovative technological concepts through processes far outside the conventional practices and cultural norms.

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III. AVIATION MISSION SUPPORT (AMS) TACTICAL ADVANCEMENTS FOR THE NEXT GENERATION (TANG)

A. THE ELECTRONIC KNEEBOARD CARD

Program Management Activity-281 (PMA-281) is the U.S. Navy's office supervising the acquisition and maintenance of aviation strike planning and execution systems.[151] "Strike" is a multi-service or joint term meaning an attack to damage or destroy an objective or capability.[152] One of the primary tools at a pilot's disposal to execute a strike mission is the Knee Board Card (KBC), generally speaking a packet of papers often strapped to the leg of a pilot while conducting a mission, as seen in Figure 3. The contents of a KBC vary between missions and platforms due to diversity in language, tasking, and capabilities; however, the general content is standardized throughout the U.S. Navy's aviation community.[153] Information such as checkpoints, radio frequencies, formations, and execution checklists are common to find on a pilots KBC, making the KBC essentially a script of the upcoming mission.[154] This stack of well-organized papers, the content of which has been well defined through generations, offers pilots an opportunity to make adjustments throughout the conduct of a mission by simply writing on the sheets for any updates or changes.[155] Despite the tradition of paper cards supporting aviation missions, technology advances and initiatives to become less dependent on paper drove a need to develop an identical or improved capability to the KBC, without the paper.

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[151] Naval Air Systems Command, accessed March 31, 2017. http://www.navair.navy.mil/index.cfm?fuseaction=home.display&key=D0B91B0C-3FA3-4ECA-BADE-CA8F7C3A9825.

[152] Joint Staff. "Joint Publication 3–0: Joint Operations." (2006).

[153] Naval Aviation Warfighting Development Center (NAWDC) instructor, interviewed by Donald Turner, November 13, 2016.

[154] Ibid.

[155] Ibid.

Figure 2. Paper Kneeboard Card.[156]

1. From Paper to Tablet

PMA-281 recognized a need to transition from paper to an electronic capability and began pursuit of "digital forms of paper products" as well as "increased functionality for mission execution (beyond paper)" to support strike planning and execution.[157] The office identified shortfalls caused by the cost of printing and shipping, the weight and space occupied by the KBC, slow access and search times, no customization of viewing printed data, and the transition of product providers to digital formats as justification to explore the use of tablet devices in the cockpit.[158] Apart from the recognition of the required transition, KBCs are also considered a safety of flight concern with the amount of clutter it produces in the cockpit as a desire to use tablet capabilities to increase the situational awareness of pilots over paper products.[159]

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[156] "Kneeboards," accessed June 12, 2017, http://www.helicoptersonly.com/contents/en-us/d38.html.

[157] PMA-281 (2013). *PMA-281 JMPS Electronic Kneeboard (EKB) Program Overview* [PowerPoint slides]. No online source.

[158] Ibid.

[159] Ibid.

The introduction of the Electronic Knee Board (EKB) into the cockpit has been an incremental building process beginning in Fiscal Year 2013 (FY13) with unclassified tablets, this first iteration being known as Configuration 0.[160] Since FY13, Configuration 0 has been updated to expand its capabilities prior to the release of Configuration 1 or, Joint Mission Planning System (JMPS) EKB, which will increase the capabilities of Configuration 0 and include new features to better improve the utility of the tablet.[161]

2. Joint Mission Planning System

Joint Mission Planning System (JMPS) is a software system designed for aviators to plan their missions, providing input into stand-alone computers and outputting mission-specific planning factors directly into the aircraft.[162] From PMA-281 directly "JMPS provides the information, automated tools and decision aids needed to plan aircraft, weapon, and sensor missions rapidly and accurately. The system loads mission data into aircraft, weapons and avionics."[163] Every type, model, and series of strike aircraft in the U.S. Navy incorporates JMPS into its pre-mission loadout, making it a common thread throughout the U.S. Navy's aviation community regardless of the squadron or pilot. JMPS to a layman would be the equivalent of

> Getting ready to take a trip in a car, sitting down at your computer to input destination, stops, headlights and windshield wiper parameters, and radio stations of the trip. This information must then be loaded to the car keys before the car can start. And oh, by the way, if you think someone might cut you off on your trip, you need to input that you may want to use your middle finger.[164]

This metaphor offered by a NAWDC instructor, while a bit extreme, does point out the high level of involvement JMPS has in mission planning and execution. The

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[160] PMA-281, *PMA-281 JMPS Electronic Kneeboard (EKB) Program Overview*.

[161] Ibid.

[162] Naval Aviation Warfighting Development Center (NAWDC) instructor, interviewed by Donald Turner, November 13, 2016.

[163] PMA-281. (Publication date unknown). *Strike Planning and Execution Systems*. Retrieved from http://www.navair.navy.mil/index.cfm?fuseaction=home.display&key=D0B91B0C-3FA3-4ECA-BADE-CA8F7C3A9825

[164] Naval Aviation Warfighting Development Center (NAWDC) instructor, interviewed by Donald Turner, November 13, 2016.

above example may provide the impression that a pilot has little opportunity to deviate from a mission plan once it is input in JMPS which is not the case, rather deviation from a mission plan can cause degradation of capabilities.

JMPS permeation of all strike communities drove PMA-281 to integrate the system into the EKB Configuration 1 development to include a more platform specific approach to EKB development.

As previously mentioned, one draw to development of the EKB concept was the opportunity for customization of tablet, a feature that is regularly taken advantage of in the commercial world as well as in the world of private citizens. Development of this customization would be challenging for the PMA-281 office given the distance from fleet operating forces, this even with the presence of active duty pilots in the PMA-281 office. A need emerged to have a large forum from which the end users could help to generate requirements for the future of the EKB.

B. BRINGING THE TANG TEAM ON BOARD

Johns Hopkins Applied Physics Lab (APL) TANG team was contacted by PMA-281 with the desire of conducting an Aviation Mission Support TANG with an emphasis on the Electronic Knee Board. As the APL lead understood the charge,

> The primary goal of our team's effort will be exploring and innovating the way the aviation community conducts mission planning before, during and after the flight. Our focus is on creating operator centered concepts for the Electronic Knee Board and other existing systems, as well as novel solutions to unmet user needs.[165]

To achieve this endstate, the APL team would partner with other strategy and design thinking consultants would spend six months conducting research in the form of interviews, observations, and team synthesis to help develop insights, questions, and design challenges.[166]

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[165] AMS TANG Applied Physics Lab Lead, personal communication, April 21, 2016.

[166] Ibid.

1. The AMS TANG Research Team

Facilitation of AMS TANG was co-led by the Johns Hopkins Applied Physics Lab (APL) Design Corps and design thinking consultants conducting Naval Aviation research in the form of interviews, observations, and analogous research findings. In the months leading up to AMS TANG, the team had traveled together or independently to nine Naval and Marine Corps Air Stations to meet with and discuss Aviation Mission Support with the leaders and executors of this mission. The research team consisted of the following personnel:

- APL Lead: Former Active Duty Surface Warfare Officer (now reservist)
- Consulting Lead: Former IDEO employee of 15 years
- Consulting SEAL: 26 years' active duty as a Navy SEAL, now runs a technical advisory company
- APL Engineer
- APL Advisor

In addition to the interviews and observations conducted with operating forces pilots, the research team also sought analogous inspiration from commercial and civil enterprises.

2. Analogous Inspirations

Analogous research is a method by which APL and its consulting counterparts develop an understanding of how technology has affected commercial industry or, in some cases, government organizations.[167] It is an examination of technology's ability to provide competitive advantage to organizations that might have similar applications to the design challenge. The output of analogous research and inspirations traditionally comes in the form of a question intended to link the challenge of the studied organization to the challenge of the design team.

[167] AMS TANG Consulting Lead, interview by Donald Turner, November 15, 2016.

The AMS TANG research team incorporated ten analogous findings to TANG participants to spur creativity and thought into design concepts:

a. The National Football League

Talking with National Football League (NFL) players and team representatives, the research team was curious as to the inspiration behind the sideline changes from large binders of play and formations, to now position coaches and coordinators carrying tablets. More importantly, what impact this change in information devices had on gaining competitive advantage during games?

The research team found that real-time information flow through tablets was essential to allowing players to adapt at the speed of the game to unfamiliar formations and activity from the opposition.[168] This emerged as the question, "How can technology support dynamic planning and re-planning?"[169]

b. Lucasfilm

The research team interviewed the animators with Lucasfilm, an organization that was one on the cutting edge of computer generated graphics with the original *Star Wars* trilogy. At the time of its supremacy, Lucasfilm possessed proprietary software to do its animations with which its animation team was very familiar. Over time, as other film studios and software firms began to develop and standardize animation software, Lucasfilm remained loyal to its own proprietary software.[170] This led to issues with hiring animators, as a great deal of time was spent learning the proprietary software and its variance from what was considered more standard ultimately costing Lucasfilm time and money.[171]

In time, Lucasfilm adopted more standard animation software and has benefitted from the transition while still providing quality content in its projects. This loyalty to its

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[168] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[169] Ibid.

[170] Ibid.

[171] Ibid.

proprietary software led the research team to ask, "How might we develop tools that allow us to focus on what's important?"[172]

c. Morgan Stanley

The research team spoke with Morgan Stanley as an example of an organization that cannot fail to operate securely in the financial world. The team discovered that Morgan Stanley employs individuals as well as encourages its own employees to develop ways of causing mayhem within the company.[173] This encouragement comes in the form of team dedicated to discovering weaknesses in company security by offensively attacking its financial network.[174] Morgan Stanley was regarded as an example of "technology and team dynamics for crisis management."[175]

Far from the world of trade and financial management is the U.S. Navy Aviator; however, the notion that interruptions or failures in operations have catastrophic consequences is a shared concern. Also, with the EKB and increased electronics and networking of modern strike aircraft, network and cyber security is a concern for the aviator now as well. This concern led the researchers to ask, "How do you plan for a threat when don't know what it is or where it's coming from?"[176]

d. Electronic Arts

Electronic Arts (EA) is an entertainment software company that specializes in games, content, and online services and is known mostly for its development the blockbuster brands as *The Sims*, *Madden NFL*, *FIFA Soccer*, *Battlefield*, and *Plants vs. Zombies*.[177] Simulators are already a large part of the U.S. Navy Aviation community as a part of initial training, refresher training, and mission rehearsal; however, these simulators are scripted to specific mission parameters and designed to mimic the cockpit

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[172] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[173] Ibid.

[174] Ibid.

[175] Ibid.

[176] Ibid.

[177] Ibid.

as is.[178] The research team was curious how feedback is provided from simulator usages and what was ultimately done with the feedback and how this compared with EA's approach to game development and design.[179]

The immersion of user interfaces and user experiences in gaming came to the forefront of the research team's thoughts in drawing from EA, potential benefits for AMS TANG.[180] The resulting question was, "How can we leverage game design to build intuitive planning tools?"[181]

e. DroneDeploy

Members of the research team met with DroneDeploy, a small software company that specializes in drone mapping of the physical world.[182] Primarily envisioned as a farming tool, DroneDeploy could, at the activation of an app, conduct an agricultural survey of farmland and crops to include analysis of the healthiest and underperforming crops and identification of space not being maximized.[183] The company has since expanded to provide services to construction, mining, surveying, and inspections significantly reducing the cost, time, and in some cases safety risk associated with these activities.[184]

Like simulators, unmanned aircraft and their potential benefits in providing a mission enhancing competitive advantage are not an unfamiliar technology to U.S. Navy Aviators. Also like simulators, the development and application of unmanned aircraft has been an effort to duplicate or simulate an existing capability whether that is strike, Intelligence, Surveillance, and Reconnaissance (ISR), or Assault Support.[185] The research team identified how DroneDeploy did not simply replicate a capability, but

[178] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[179] Ibid.

[180] Ibid.

[181] Ibid.

[182] Ibid.

[183] Ibid.

[184] Ibid.

[185] Ibid.

rather augmented it and was curious about "the role of unmanned aircraft in augmenting the human."[186] Fascinated with the abilities of DroneDeploy, which are all available with minimal input from the user, the research team asked, "How can you augment your [mission] with the touch of a button."[187]

f. Oculus

Though not a new technology, virtual reality has seen tremendous advances in its application and capabilities in recent years, something the research team noted as a step beyond simulators.[188] Virtual reality is "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment."[189] This is not to be confused with augmented reality which is "an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device."[190] This distinction is important as both play a role in AMS TANG but are fundamentally different in application for aviators. Oculus specializes in virtual reality devices to include headsets, headphones, and hand controllers which members of the research team saw high potential applications to the aviation community.

To a certain extent, aviators experience augmented reality already in the form of Heads Up Displays (HUDs) and, on some platforms, targeting devices on the helmet. Taking this application one step closer to supporting the aviation mission, the research team how "virtual/augmented reality [provides] natural ways to interact with information" bringing the team to ask "How might we create immersive planning experience?"[191]

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[186] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[187] Ibid.

[188] Ibid.

[189] Ibid.

[190] Ibid.

[191] Ibid.

g. New York Police Department (NYPD) Counter-Terrorism Bureau

Talking with the NYPD Counter-Terrorism Bureau, members of the research team learned about the information system built and developed in an attempt to provide real-time crime information throughout the city.[192] The privately funded development and implementation of this system involved the installation of thousands of microphones throughout the city feeding information to its control center where computer analysis is conducted outputting relevant data.[193] The system is so advanced that if it detects a gunshot, it can pinpoint where the weapon was discharged as well as likely trigger pullers based on information of who is in the area, resulting in the dispatch desk being aware of the gunshot prior to a citizen dialing 9–1–1.[194] The research team was very impressed by the capabilities and outputs of this system, but was more moved when the story of its development was revealed as a joint design venture between the technology company and the police officers themselves.[195]

The "pride and co-development" was something the research team associated closely with the successful implementation of the system.[196] While the outputs of the system had few parallels, the personal investment of the officers utilizing the system was equally important to the technology. This led the team to ask, "How might pilots design the system of the future?"[197]

h. Samsung

Samsung is a company known for its electronics and smart appliances ranging from phones to vacuums and most items in between. The research team spoke with Samsung about its connected devices and was surprised to learn how invested the company was into the *Internet of things*.[198] The Internet of things (IOT) is concept

[192] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[193] Ibid.

[194] Ibid.

[195] Ibid.

[196] Ibid.

[197] Ibid.

[198] Ibid.

receiving attention outside of Samsung as well which discusses everyday devices having Internet Protocol (IP) addresses and being able to connect to the Internet as well as send and receive data.[199] If the future of Navy equipment is that everything has an IP address, the potential application of the *Internet of things* begged the question, "How can the IOT enable a netted Navy and connected battlespace?"[200]

i. Singularity University

The final analogous insight came from Singularity University, an organization with a mission "to educate, inspire, and empower leaders to apply exponential technologies to address humanity's grand challenges"; the application of this mission manifests in "leveraging emerging technologies like artificial intelligence, robotics, and digital biology."[201] It was the artificial intelligence applications that caught the research team's attention particularly, as this has been identified as a potential third *offset strategy* for the DOD.

In 2014, the development of a third offset strategy was announced by then Secretary of Defense Charles "Chuck" Hagel as a means to advantage the U.S. military in a conflict with a near-peer adversary.[202] The intent of an offset strategy is to provide a technological capability that can win a war, but primarily to deter one from happening. The first offset strategy is widely regarded as the development of atomic and nuclear weapons and the second is considered the combined abilities of precision-guided munitions and intelligence, surveillance, and reconnaissance capability.[203] Both of these capabilities developed for and by the U.S. military made the relative size of the force irrelevant in conflict. By having atomic and nuclear weapons, potential enemies of the United States could not consider larger armies or navies to be a strategic advantage.

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[199] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[200] Ibid.

[201] "Hi, We're Singularity University," Singularity University, accessed May 1, 2017, https://su.org/about/.

[202] Hagel, Charles, "Secretary of Defense Speech," *Reagan National Defense Forum Keynote*, November 15, 2014. https://www.defense.gov/News/Speeches/Speech-View/Article/606635/.

[203] Ibid.

Similarly, precision weapons and better intelligence meant that large stockpiles of weapons would no longer be an advantage due to needing fewer weapons to accomplish the same task.

No third offset strategy is currently recognized; however, several fields are considered as potential contributors to development including, "robotics, autonomous systems, miniaturization, big data, and advanced manufacturing, including 3D printing."[204] Identifying all of the potential applications of artificial intelligence would be a cumbersome task for the research team, so the lens of Aviation Mission Support was reapplied to ask the question, "How can we enhance the pilot's ability to plan?"[205]

3. Testing the Concepts

As identified by previous TANG case study theses, a pilot or rehearsal event is traditionally held prior to actual execution. This benefits the facilitators in tweaking or refining design challenges, processes, and focuses of effort during the actual TANG event. To run the pilot event for AMS TANG, the APL and Design Consultant team would also gain an additional observation that had not been captured in the previous eight trips to Air Stations: the interaction of the entire wing in pre-flight, flight, and post-flight actions. With only a month to go prior to AMS TANG, the team prepared to visit Fallon, Nevada, to run its practice TANG.

C. AIR WING FALLON

Located an hour from both Carson City and Reno, Nevada, is Naval Air Station (NAS) Fallon, home to Naval Aviation Warfighting Development Center (NAWDC) and within NAWDC the famous TOPGUN school, considered one of the greatest aviation schools in the world.[206] NAS Fallon also hosts the significant training event Air Wing Fallon which is the final land-based training event for an entire Aircraft Carrier Air Wing

[204] Hagel, *Secretary of Defense Speech*, *Reagan National Defense Forum Keynote*.

[205] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[206] "Naval Air Station Fallon," Commander, Naval Installations Command, Accessed March 31, 2017, https://www.cnic.navy.mil/regions/cnrsw/installations/nas_fallon.html.

prior to embarking aboard their respective ship.[207] With four bombing ranges, an electronic warfare range, and a runway totaling 14,000 feet in length, NAS Fallon is ideally suited to conduct large-scale aviation training exercises, the primary of these exercises is Air Wing Fallon (AWF).[208] With access to such diversity in aviation platforms as well as instructors and participants in the TOPGUN program, NAS Fallon during the conduct of an AWF training exercise would be the ideal location to conduct an AMS TANG rehearsal.

1. Air Wing Fallon Day One

The AMS TANG research team arrived to NAS Fallon early in the afternoon on Tuesday October 4, 2016, to conduct administrative activities as well as coordination with local sponsors and participants. The primary location of the NAS Fallon research was the NAWDC building, a large facility surrounded by a high fence with only a single entry point. Cell phone storage lockers and tables for personal bags and purses are present in the foyer of the facility, indicating to the team that personal electronic devices are not permitted within the building.[209] Relieving themselves of all such devices, the team proceeds to check in with security personnel so that each member's security clearance could to be verified and identification badges could be issued. [210]

Present near the security desk is a PMA-281 representative, an active duty pilot and graduate of Top Gun. The representative, having spent a lot of time at NAS Fallon, being intimately familiar with the NAWDC facility, and working previously with the research team, was an ideal guide to navigate both the complex facility and potential participants in an AMS TANG rehearsal.[211] In addition to the PMA-281 representative, the team was met by a staff member of NAWDC who had also worked with the AMS

[207] "Naval Air Station Fallon," Commander, Naval Installations Command, Accessed March 31, 2017, https://www.cnic.navy.mil/regions/cnrsw/installations/nas_fallon.html.

[208] Ibid.

[209] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[210] Ibid.

[211] Ibid.

TANG research team and was the lead coordinator in ensuring the APL personnel received all the required support.[212]

With introductions made, the research team provided the intent and envisioned gains from the trip to the two representatives, accounting for any last-minute shifts in priorities or desired outcomes. While a great deal of coordination had occurred to make this final research trip to NAS Fallon occur, the constant refinement process of developing a TANG forum requires planners to be flexible in their focus. Following the trip purpose refinement, the research team was given a tour of the NAWDC facility and introduced to other key individuals as well as coincidentally seeing personnel who had been previously interviewed when conducting AMS TANG research.[213]

The tour and minor introductions were the last event of the first day, this largely due to the high tempo of training during the conduct of an Air Wing Fallon (AWF) exercise. The research team was aware of this particular challenge but saw value in being present regardless.[214] "Everyone (the pilots) was constantly moving. No one was stopping. No one was resting. Everyone had somewhere to be and something to do. There was a controlled chaos to it all," said a member of the Research Team.[215] Short of deploying on an aircraft carrier, this was the closest the research team would come to watching aviation mission planning and the associated support structures in real time, making AWF an essential source of insights and questions to fuel the design thinking challenges for AMS TANG. Based on the tempo, the clear challenge of the research team's visit would be in finding individuals with sufficient time to be interviewed, as well as sufficient diversity and quantity of participants to conduct an AMS TANG rehearsal.[216] The tempo also revealed just how impactful technology could be to Naval Aviators not simply from a perspective of reliance, but more importantly from the perspective of capabilities improvement. Seeing the activities the pilots were conducting

[212] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[213] Ibid.

[214] Ibid.

[215] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[216] AMS TANG Consulting Lead, interviewed by Donald Turner, November 14, 2016.

and the duration of time associated with these tasks, the research team understood how new technologies could drastically change the ground aspects of Aviation Mission Support.

Before departing for the first day, the research team convened again in the NAWDC foyer to discuss the following day's schedule and planned activities. Having the first event scheduled to begin at 0600 was met with some initial groans; however, the APL lead was able to bring everything back on track quickly by covering the range of available observations and assigning team members to cover down on the over eight events occurring during AWF.[217]

2. Air Wing Fallon Day Two

The research team began day two with the morning briefing for Advanced Training Phase (ATP) 6, a multi-aircraft multi-platform strike mission rehearsal exercise aimed at integrating multiple capabilities of the Air Wing.[218] This was an opportunity to see the culminating efforts of the previous afternoon's planning pulled together into slide shows presented to all participating entities. The room was filled with pilots from various type, model, and series aircraft to include E-2 Hawkeyes for command and control, E/A-18G Growlers for electronic warfare, and various F/A-18 fighter-attack platforms.[219] The content of the briefing was more general, mission-oriented with minimal time spent lingering on a single platform's tasking or activities.[220] Throughout the briefing, the research team notes the references to and uses of Knee Board Cards (KBCs) and what portions of the brief spur activity among the personnel in attendance to better understand what information is not readily available as well as what the pilots deem most important to retain from the briefing.

> Execution checklists, egress headings, altitude restrictions, all these things can change between when they printed the paper and the final brief. No

[217] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[218] Ibid.

[219] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[220] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

> one wants changes when it's their brief, but if it's not your mission you just pen (the changes) in.[221]

Briefed items such as intelligence updates received minimal active note taking while others such as fighter package and the aircraft and formation were met with much more activity.[222] When asked why some content warranted the additional consideration, one F/A-18 pilot responded, "Most of the information remains the same from the first mission to the last. The deviations and what could potentially change in the cockpit is something I need to have with me."[223]

Following the morning briefing with all APT-6 participants, the aviators broke out into smaller, platform- and mission-specific groups to conduct detailed briefing relevant to their respective tasking.[224] While observing the attack brief, one member of the research team noted the information exchange and flow between the briefers, usually the mission commander, and the individuals receiving the brief. Identified first and foremost was the content of the slides, particularly the intuitive displaying of information while still providing a large quantity of information on a single chart.[225] Mission specific items such as the Rules of Engagement (ROE) were presented to the pilots first with the legal parameters, and then as a simple addition equation with the components that grant an authorization to release weapons. This seemingly natural way was not something that rapidly emerged, rather it was developed over time and gradually adopted according to one F/A-18 pilot,

> We need to show the laws as written, but it is much easier for me to have a three-step checklist in my head to know that I am allowed to shoot. This, plus this, and then fire. We didn't always show the ROE this way, but someone simplified it for us to make it easier.[226]

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[221] Anonymous F/A-18 Pilot, interviewed by Donald Turner, November 14, 2016.

[222] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[223] Anonymous F/A-18 Pilot, interviewed by Donald Turner, November 14, 2016.

[224] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[225] Ibid.

[226] Anonymous F/A-18 Pilot, interviewed by Donald Turner, November 14, 2016.

Despite the impressive show of intuition in the presentation of the brief, there were also challenges which stemmed from *version control*, or versions of specific information presented through multiple mediums. One particular instance was the variance between aircraft formations on the slide show and the information on the pre-printed Kneeboard Cards, a discrepancy that caused a disruption in the brief and delay in its completion.[227] The response of the pilots in the briefing was one of acceptance of the inevitable, that there would almost always be a difference between the two information sources and that time spent correcting the problem should be accounted for in planning.[228]

With all small unit briefings complete, it was time for the Air Wing to begin preparing their aircraft for execution of ATP-6. The nature of the exercise prevented the research team from observing it directly however one of the mission debrief rooms was made available for the team and the PMA-281 representative. The debrief room appeared much like a small movie theater with stadium seating for over 60 people, a large screen in the front, and computer stations beneath the screen.[229] To the right of the room was a podium and wall-mounted whiteboard pre-arranged and labeled "score card."[230] From this room the research team was able to view a two-dimensional live-action map of pilots conducting ATP-6 as well as hear the communications being conducted between pilots in aircraft.[231] It was in this same room that the research team was able to observe the pilots conducting a debrief of their just-completed ATP-6 exercise.

The debrief consisted of a review of all actions and responses that occurred during the exercise as seen on the theater screen with audio playback of the voice communications.[232] In the room, individual pilots explain what happened and the thought

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[227] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[228] Ibid.

[229] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

[230] Ibid.

[231] Ibid.

[232] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

process that went with it.[233] If a mistake was made, it is openly explained and cash is then passed from the individual who made the mistake to the front of the room.[234] In one instance, an E-2 pilot erroneously called out the location of an adversary over the radio. After the mistake was confirmed, the pilot passed a five dollar bill to the debrief leader.[235] The PMA-281 representative explained this tradition is simply "beer money" or rather, an offer to buy a beer from the pilot who made the mistake to the pilot who dealt with the consequences.[236]

The debrief concluded with pilots self-assessing their individual and collective performance before the scores are taken to the Wing leadership.[237] At this point, the research team did an informal debrief along with the PMA-281 representative on the day's observations to collect new insights and perspectives.[238] Chief among these insights was a narrowed focus on collaborative mission planning, networking, and the future of Joint Mission Planning System (JMPS) and how the design challenges and questions might be better tailored to this focus.[239] Lingering briefly on the topic of JMPS, one member of the research team offered a quote captured from one of the pilots regarding issues with Aviation Mission Planning, "JMPS is a two-dimensional planning tool in a four-dimensional world."[240]

3. Air Wing Fallon Day Three

Day three for the AMS TANG research team began with a much more forgiving morning timeline to include adequate time for breakfast at the base Morale, Welfare, and Recreation (MWR) facility.[241] Over breakfast, the research team discussed the day's

[233] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[234] Ibid.

[235] Ibid.

[236] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[237] Ibid.

[238] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[239] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[240] Research Observation, DIUx Mountain View, CA, November 15, 2016.

[241] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

activities and potential observation opportunities with the recommended division of labor from the APL leader.[242] The team then took a tour meant to provide insight into the actions of a pilot following completion of mission planning activities through arrival to their aircraft including a walk through the hangars.[243]

The tour was provided by the PMA-281 representative, taking the research team from rooms in the NAWDC building containing JMPS software, to an F/A-18 hangar and showing where the JMPS information is put into the aircraft.[244] In the presence of the aircraft the research team inquired about the differences between F/A-18 models ranging from A-F and what that difference means to the pilot flying the aircraft. This prompted one F/A-18 pilot to comment, "Flying a Super Hornet isn't hard, in fact it pretty much flies itself. But flying the plane isn't the hard part, it's the hundred other things I need to be doing in the cockpit that make this hard."[245] The balance between flying and piloting was further illustrated by an F/A-18 pilot:

> Earlier model jets required a lot more from the pilot to maneuver. You had to manage your stabilizers and ailerons to get the aircraft to go where you wanted while ensuring you didn't overstrain yourself or the plane. Now you just tell the aircraft where you want it to go and it will figure out the best way to get there. But that's just flying. That doesn't account for flight paths, communications, weapons, ex checks (execution checklists), and whatever is changing on the fly. In flight school over half of what they taught us is what to do when something goes wrong, so flying the plane is low on my cognitive processes when on mission.[246]

Completing the tour, the research team then broke into pairs to observe mission planning for the next training evolution. This included observing the individual platform communities conducting their respective detailed planning, as well as the room which held a representative from each platform to conduct collaborative planning.[247] The collaboration room featured a central table and desks with laptops lining the walls as well

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[242] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[243] Ibid.

[244] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[245] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[246] Anonymous F/A-18 Pilot, interviewed by Donald Turner, November 14, 2016.

[247] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

as a whiteboard on one side, and a projector screen opposite the whiteboard wall.[248] From this small room, pilots built their slide brief for the training exercise going that afternoon as well as entered the mission parameters into JMPS to eventually put into their aircraft.[249] Kneeboard Card contents are also finalized in this room before the final product is pushed to the printer and rushed to a copy machine to mass produce the documents for all participating pilots.[250] The room consistently buzzes with activity and, given the room's small size and high number of personnel working therein, the research team quickly found itself more harmful than helpful in its presence and opts to conduct observations elsewhere.[251] This room was the central point of mission planning from collaboration, to KBC development, to confirmation brief building. If the researchers were looking for a place to capture how planning systems integrate into Aviation Mission Support, this was the place.

With most of the observations and interviewing done in the early afternoon, the research team is happy to conclude the day three a little early especially with many members being jet-lagged still from the cross-country flight.[252] While their presence in the NAWDC building would come to an end in the early afternoon, a change in plans for the wing would drive a need for the research team to work a little later than planned. The plan alteration came from the Wing Commander and his intent to end Air Wing Fallon a day early, meaning the research team would need to execute a TANG rehearsal the next morning, and not Friday as originally planned.[253]

4. Air Wing Fallon Day Four—AMS TANG Rehearsal

The research team took the afternoon of day three to develop and refine existing and new concepts applicable to the TANG rehearsal presentation and concepts.[254] The

[248] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

[249] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[250] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

[251] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[252] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

[253] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[254] Ibid.

team had brought printed concept posters containing "how might we…" questions intended to spark design challenges for the group and members set themselves to task in preparing a room within the NAWDC building for the rehearsal.[255] With the majority of the Air Wing making final preparations for departure, access to personnel would be very limited, potentially impacting the diversity of the participants. Ultimately two F/A-18 pilots, one SH-60 pilot, one E-2 pilot, and a U.S. Navy Surface Warfare Officer were available to conduct the rehearsal.[256]

The room itself was the same room utilized for collaborative planning in Air Wing Fallon events, the same laptops and work stations line the walls with the long table in the center.[257] Standing eye level on the walls were large sheets of paper common to turn charts and centered on these sheets are the concept cards brought by the research team.[258] 11 total concept cards were placed on the walls and doors and the paper beneath the cards was divided by drawn lines into four quadrants allowing the participants to respond to four basic prompts for each concept: I like…, I wish…, Questions…, Concerns….[259] The concept cards themselves each contained a question beginning with "How might we…" as well as an artist's drawing depicting the subject of the question with images such as *R2D2* from the Star Wars franchise and pilots standing around a three-dimensional hologram.[260]

The utilization of the planning room was a fortunate coincidence as it was provided, not requested. Having the rehearsal participants in a space they immediately associated with mission planning and planning systems could give researchers a 'warm' start to the rehearsal.

The rehearsal began with an introduction to what TANG is to include its history and its origins as well as an introduction to what design thinking is and how the process

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[255] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[256] Ibid.

[257] APL Research Team Member, interviewed by Donald Turner, November 14, 2016.

[258] Ibid.

[259] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[260] Ibid.

works.[261] The rehearsal participants were then educated on funding sources for prototyping TANG outputs rapidly, essentially expediting the early phases of the acquisitions process.[262] The process of making technology purchases within the DOD carries a reputation among DOD members of being a slow, bureaucratic effort that often results in underperforming equipment and programs. The early phases of acquisitions involve determining what capabilities a purchase should have and requesting bids and prototypes from the defense commercial industry. In the case of AMS TANG, these early phases of determining what the technology should do and waiting for companies to write lengthy proposals would be essentially bypassed by the developments and outputs of TANG.

Following the overview of why the research team was there and what it hoped to accomplish, participants were shown the culmination of all collected research and observations from the team to include the analogous inspirations like EA Sports, Singularity University, etc.[263] The APL lead discusses the structure of a pilot's development beginning with branding, recruiting, and training and ending with execution and developing a community.[264] It was explained that supporting execution through design thinking will be the focus of this TANG as well as what other aspects of a pilot's structure can be leveraged to improve execution.[265]

The TANG rehearsal then turned to solicit feedback from the participants in the form of a simple word association exercise prompted by the question, "what do you think of when you hear the word JMPS?"[266] The participants, in receive mode up to this point, were initially hesitant to reveal their thoughts however with one F/A-18 pilot saying "Cumbersome," the room began to warm to the efforts of the research team.[267]

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[261] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[262] Ibid.

[263] AMS TANG Consulting Lead, interviewed by Donald Turner, November 14, 2016.

[264] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[265] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[266] AMS TANG Consulting Lead, interviewed by Donald Turner, November 14, 2016.

[267] Ibid.

Additional input began to come in, "a necessity," "JMPS is the afterthought in mission planning," and "I'm gonna load my card with the stuff I need and go fly."[268] The research team and participants now invigorated by the growing passion in the room, the conversation pivoted slightly to maintain a neutral balance toward mission support. The APL lead offers that on a trip to Marine Corps Air Station Yuma, the comments about JMPS were slightly more positive quoting one pilot as saying "JMPS allows planners to plan complex problems and the software supports it."[269]

The TANG rehearsal continued, discussing integration of Electronic Kneeboard Cards and potential improvements to JMPS which drove participants to digress into discussions of Information Assurance concerns, JMPS remaining a platform and not an application, and a concern over the iterative approach to improving and updating JMPS.[270] The platform versus application distinction was made based on JMPS requiring its own computer within most squadrons. Though JMPS is technically an application, its classification, time requirements, and importance to mission planning and execution cause many squadrons to have a "JMPS computer," so labeled because it is the sole computer in a squadron with the program and that is the identified computers sole purpose. Without intending to do so, both participants and the research team had pivoted the rehearsal event from a focus on Aviation Mission Support, to JMPS.

In the course of a design thinking event, tangents, digressions, and *rabbit holes* do occur in the focus of conversation. The research team, not intending to slow the pace of idea and insight generation was not quick to bring the focus back to mission support, but rather let the conversation develop on its own.[271] This allowance was quickly rewarded by the E-2 pilot in the group asking to clarify if the TANG event was about "Aviation Mission Support" or "Aviation Mission Planning Support," which oriented the conversation back to the presentation and allowed the research team to transition the

[268] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[269] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[270] Ibid.

[271] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

rehearsal.[272] This transition brought to light the design challenges for the participant, often referred to as the "How might we…?" questions intended to provide baseline guidance for design thinking activities. Design challenge questions such as, "How might we improve the logistics of shared knowledge" and, "How might we make planning systems as intuitive as flying" were provided to participants along with context and, in some cases, examples of follow-on questions to further clarify meaning.[273]

The brief concluded with a picture of a Joint Strike Fighter encouraging participants to think of future systems and requirements as the rehearsal transitioned into its next phase, the review of the concept cards. In this portion of the rehearsal, participants were asked to view all concept cards posted on the wall and communicate feedback to the research team regarding the clarity of the words and images as well as any thoughts participants had that may add to the content of the card.[274] Post-it notes and black sharpie markers are provided as a mechanism to provide the feedback, allowing the research team to have a written record of the participants' thoughts.[275] The participants were hesitant at first given many of their unfamiliarity with this type of exercise, but they are soon actively moving throughout the small room after being assured that the only rule to the exercise was that 20 minutes was the limit to review all 11 concept cards.[276]

As the participants moved about the small room, reading and commenting on the wall-mounted concept cards, several questions are asked of the research team to clarify an idea or to give an example of the question.[277] The research team enthusiastically answered all questions with the caveat that the question be written on a post-it note and stuck to the concept card in the *questions* quadrant.[278] This was participants' opportunity to gain greater understanding of what the TANG team was trying to achieve while also

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[272] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[273] Ibid.

[274] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[275] Ibid.

[276] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[277] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[278] Anonymous F/A-18 Pilot, interviewed by Donald Turner, November 14, 2016.

building awareness of how far the scope of this project spread. The posters served as a starting point of ideas from which a dialogue could grow.

Upon reaching the 20-minute time limit, participants confirmed that every member had not reached every concept card; however, every concept card had received multiple comments, which pivoted the rehearsal to a feedback discussion.[279] The research team moved from card to card with the participants reading some of the feedback aloud, asking for clarification if necessary or elaboration on comments that could be further developed. This process spurred further discussion between the research team and participants as well as brought forth more sticky notes from both groups as conversation would spark a new thought.[280] Once all concept cards were reviewed the rehearsal transitioned to its next phase. Figure 2 is an example of the Airborne Offensive Coordinator Concept Card with comments and votes.

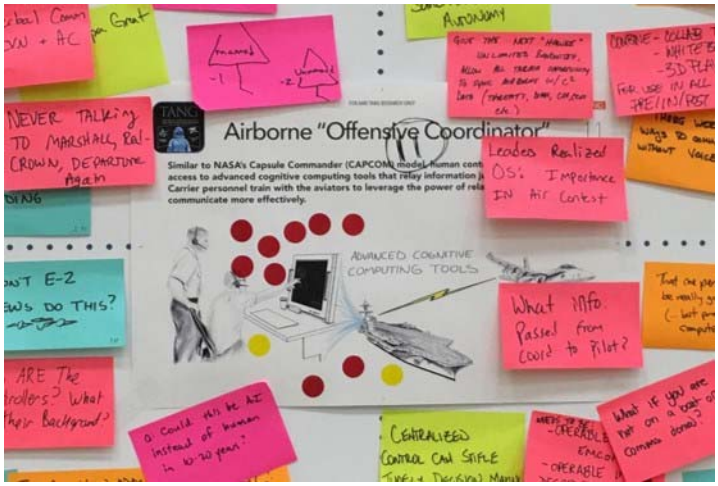

Figure 3. Airborne "Offensive Coordinator" Concept Card

With concept review complete, it was now time for participants to vote on the concept cards to determine which were liked best and which were liked least. Colored dot stickers, roughly the circumference of a quarter were dispersed throughout the room ensuring a participant only received one single color, but multiple participants could

[279] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

[280] Ibid.

receive the same color.[281] While voting, participants were instructed that voting multiple times for the same concept was allowed and even encouraged if a voter felt strongly about a topic.[282] To vote against a topic, a participant would simply not place a dot on the card indicating that thoughts were either neutral or negative to the topic.[283]

Rehearsal participants were given five minutes and five dots to vote on concept cards, a generous time period as votes quickly accumulated and the voting period ended early.[284] This transitioned the research team to conduct a vote tally and vote review to inquire as to the inspirations that drove participants select the winning topics. Why the participants chose that topic and how strongly the participants felt about it were discussed as well as the topics that received the fewest votes.[285] The research team placed significant emphasis on why voters took action, but a near second place was inaction or, why some topics did not receive voting support. After the highly voted topics and scarcely voted topics were discussed, the research team inquired as to which concept card should "go away entirely" and why.[286]

Following completion of voting and voting reviews, the research team asked participants for general feedback on the rehearsal and anything that might be improved for AMS TANG execution. The response was overwhelmingly positive with one F-18 pilot even stating, "This was super interesting. I thought I would come for 45 minutes and duck out, but here I am two hours later with more to say."[287]

The TANG rehearsal had concluded and the team prepared to return to APL and their respective homes before collecting their thoughts, research, findings, and insights. The APL and consulting team had only 39 days to synthesize a week's worth of observations and conduct a full TANG event.

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[281] AMS TANG Consulting Lead, interviewed by Donald Turner, November 14, 2016.

[282] Ibid.

[283] Ibid.

[284] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

[285] AMS TANG Consulting Lead, interviewed by Donald Turner, November 14, 2016.

[286] AMS TANG Consulting Lead, interviewed by Donald Turner, November 14, 2016.

[287] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

D. AVIATION MISSION SUPPORT (AMS) TACTICAL ADVANCEMENTS FOR THE NEXT GENERATION (TANG)

From 14–17 November, 2016, warfighters, stakeholders, technology exposition (tech expo) representatives, and core TANG facilitators numbering around 160 total, conducted a design thinking forum at Defense Innovation Unit Experimental (DIUx). The intent of AMS TANG was to utilize design thinking practices to innovate unique current and present ideas focused on the future of aviation mission support. This was the culmination of months of research and observations to generate as many concepts and prototypes as possible in a short amount of time.

1. Defense Innovation Unit Experimental

Located in Mountain View, California near San Jose in the heart of Silicon Valley is Defense Innovation Unit Experimental (DIUx), a small organization dedicated to innovation within the Department of Defense. DIUx's mission statement is to "[increase] DOD's access to commercial technology, with the ultimate goal of accelerating innovation into the hands of the men and women in uniform."[288] Rebooted in 2015 by then Secretary of Defense Ash Carter, DIUx serves as an "innovation startup" of the DOD, meant to leverage the speed at which commercial technology is developed to improve the capabilities of the armed forces.[289] When driving to DIUx one will see signs for organizations considered at the forefront of technology solutions to include Oracle and Google. In addition to this bombardment from commercial technology companies, directly across from DIUx is NASA's Moffett Field and the Ames research center, unavoidable to see with mammoth shuttle and aircraft hangars as well as the NASA emblem emblazoned on the hangars high above any trees. It is easy for a visitor to feel a sense of leading edge innovation and technology implementation before even stepping into the DIUx facility.

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[288] Defense Acquisition University, *2017 Acquisition Insight Days*, May 2, 2017 Retrieved from https://www.dau.mil/locations/midwest/p/2017-Acquisition-Insight-Days-Breakout-Topic-Descriptions

[289] Fred Kaplan, "The Pentagon's Innovation Experiment," *MIT Technology Review*, December 19, 2016, https://www.technologyreview.com/s/603084/the-pentagons-innovation-experiment/.

2. AMS TANG—Final Preparations

The day prior to AMS TANG participants' arrival, the core facilitator team made up of 25 APL and consulting personnel arrived to DIUx to conduct a setup of the facility in preparation for the following day's activities. Two large gathering areas were made available to the TANG team, one an auditorium with seating for over 200 and the other, a large open room with a ceiling around 30 feet.

In the auditorium, stadium seating overlooks ground floor area with a podium and large projection screen. Flags from every state line both side walls and acoustic sine-wave paneling makes up the remainder of the wall space. Two cameras are mounted at the beginning of the mezzanine level of the auditorium pointed toward the podium and screen in the front of the room. The large open room has the look and feel of an elementary school gymnasium with linoleum floors and muted earth-tone painted walls. In a pure coincidence, this large room also has dimensions comparable to a small aircraft hangar, an unintended perk for the TANG team.[290]

The TANG team went about their business of setting up reception tables with registration paperwork, consent forms, and individual TANG-specific kits for all attendees. Name badges were printed for all in attendance, one side containing the individual's preferred name in large bold print and beneath it, the person's first and last name. The other side has the individual's first name in large bold print with the first and last name beneath it. Also on the badge was an emblem indicating which group the attendee was assigned to: Aces, Jokers, Kings, Deuces, Jacks, Unicorns, and Skybox. This badge was then placed on an AMS TANG lanyard and aggregated with the other supplies in the TANG kit which included a pad of neon-colored post-it notes, a black sharpie marker, a small TANG notebook, and a sticker for the individual's assigned group.

In the large room, members of the TANG team were putting together breakout room kits in large plastic bins. These kits were more-robust versions of the individual hand-outs and contained additional prototyping supplies such as rulers, box cutters,

[290] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

construction paper, hot glue guns, etc. Elsewhere in the large room, the TANG team was building display walls consisting of eight feet tall and four feet wide black foam board resting on stands to keep them erect. These boards were being populated with reference materials and AMS TANG specific concepts to include the design challenge concept cards, the design thinking process, and wave-top TANG information.

In the early afternoon, a synchronization meeting was planned for the core TANG team to be led by the APL lead and the consulting lead however, traffic and flight delays proved problematic for all members of the team to arrive, delaying the meeting for over an hour. The time delay was not wasted though as setup refinements continued throughout the TANG areas, ensuring seating was maximized in the auditorium, badges were laid out alphabetically, and small group leads going over warm up exercises and *ice breakers* to encourage participation within their respective groups. Within the large room post-it notes were placed along the walls annotating where tech expo companies were to set up their display stations, while other team members worked on their laptops.

When the final TANG team members arrived the APL and consulting leads were able to commence a synchronization meeting. In the meeting the discovery deck is reviewed, a 130-chart slide show containing all previous research and all challenges and objectives for AMS TANG. While 130 slides can seem overwhelming, the contents of the slides were not substantial and each plenty of time was made available to take in the information. Many slides were simply a color-washed photograph with a single sentence or question meant to spur critical thinking. This utilization and stylizing of a slide show was a distant departure from traditional briefing methods TANG participants were accustomed to, a potentially welcomed deviation from the military cultural norm. Throughout the discover deck team members ask questions, ask for clarification, or point out typos or formatting issues. All feedback was responded to by the two leaders with some being immediately addressed and others being "taken under advisement."[291]

With the completion of discovery deck review, the two TANG leaders go throughout the room and introduce any new member of the TANG core team which was

[291] Research Observation, DIUx Mountain View, CA, November 13, 2016.

met by applause and cheering from the group. The response of the TANG team to new members was indicative of the high energy level possessed by the facilitators as well as the desire to keep attitudes as positive as possible from the beginning of AMS TANG. After introductions, the team reviews the next day's schedule with an emphasis on the morning time constraints to finish setup prior to the arrival of participants, the first day of AMS TANG.

3. AMS TANG—Day One

Starting at 0730 TANG team members arrived to DIUx to complete the setup of the auditorium and the large room. The two TANG leaders move throughout both rooms attending to final details and overseeing the work of other team members. Soft music is played in both the auditorium and large room providing background noise to the methodical work being performed. Beginning at 0900, technology exposition (tech expo) representatives begin to arrive and set up their stations in the large room giving the area the feel of a multi-million dollar science fair.

a. The Tech Expo

Within the space of the large room or, hangar room, 17 commercial and government technology-focused companies set up their technology displays. Germane Systems, a company that focuses on ruggedized computers and storage systems; Naval Sea Systems Command (NAVSEA); ESRI, a mapping software company; Adobe; NetApp, a data software and storage company; Monterey Technologies, Inc., a human factors engineering and Human-Systems integration firm; SRI International, an advanced research and development company; Vocera, a secure communications and collaborations organization; Pixlogic Inc., a visual analysis technology firm; Intuit TurboTax; Avatar; and the Office of Naval Research (ONR), with its Matador Strike Group Defender application and hardware among others were present to inspire TANG participants. In Figures 4 through 7 are shown AMS TANG participants interacting with Tech Expo personnel and their exhibits.

Figure 4. Participants Receive a Briefing at the Technology Exposition.[292]

Figure 5. AMS TANG Participant Interacts with Augmented Reality Glasses at the Technology Exposition.[293]

[292] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[293] Ibid.

Figure 6. AMS TANG Participant Interacts with Touchscreen Display Design for Submarines at the Technology Exposition.[294]

Figure 7. AMS TANG Participant Interacts with Technology Exposition Presenters.[295]

[294] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[295] Ibid.

The tech expo is meant to inundate TANG participants in current technology trends and capabilities with the hope that it generates insightful ideas during the design process. Throughout the hangar room, tables are set up adorned with covers carrying the company emblem while display boards, televisions, and prototypes of designs are set up behind, in front, and on top of the tables. Many of the companies represented provide interactive modules for participants to utilize including touch screens and wearable technology. This booth and display technique was not a presentation method unique to AMS TANG as many of the representatives from the tech expo reported that this was their fifth or more TANG event.[296] And while the presentation of the tech expo was more designed to generate sales, company representation understood that their purpose was to inspire creativity in the TANG participants.[297]

b. Arrival and Commencement of TANG

At 1300, TANG participants began to arrive and check in with the TANG team. Participants would aggregate around old friends, familiar faces, and classmates from their undergraduate or flight school programs. Call signs were exchanged and small trash talking and banter as is custom within the community ensued as participants were encouraged to explore the hangar room and tech expo while awaiting the beginning of the TANG.

Attendees also receive their group assignments based upon their platform and their purpose in attending AMS TANG:

- Deuces: Electronic warfare focused, primarily comprised of E/A-18G Growler pilots and Naval Flight Officers (NFOs)
- Jacks: Anti-Submarine Warfare focused, primarily comprised of MH-60 Seahawk, P-3, and P-8 pilots and NFOs

[296] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[297] Tech Expo Representative, interviewed by Donald Turner, November 14, 2016.

- Kings: Overland assault and attack helicopter platforms, primarily comprised of MH-60 Seahawk, MV-22 Osprey, AH-1 Cobra, and UH-1 Huey pilots
- Aces: Strike and Command and Control (C2) focused, primarily comprised of F/A-18 Hornet and E-2 Hawkeye pilots and NFOs
- Jokers: Stakeholders including attendees from PMA-281, TOPGUN, Navy Air Warfare component (N98), and DIUx
- Skybox: Observers of AMS TANG and individuals with experience in the acquisition process. Also, some senior leadership representing Navy Aviation.

The day's official activities began in the auditorium where attendees were welcomed by an APL TANG team member and introduced to the TANG process and its history. The schedule was covered as well as a brief introduction to the tech expo which was intended to show participants "the art of the possible."[298] Following the brief introduction, attendees are addressed by the director of DIUx who went on to highlight the purpose of DIUx and the advantages of conducting a TANG in the home of the DOD's bid for innovation success.

After the DIUx director concluded remarks, the Commanding Officer (CO) of NAWDC was video-teleconferenced into the auditorium to address all TANG attendees. With some initial connection difficulties resulting in no sound, the NAWDC CO took the opportunity to break any frustrations in the room utilizing visual humor. Taking models of planes and imitating the act of flying, chuckles and laughter was prevalent throughout the room until the sound issues were fixed.

Once full connectivity was established the candid and pointed discussion began with by offering direction and guidance for what the expectations were and the anticipated outputs from AMS TANG. Ensuring the focus was on track with intent, the NAWDC CO instructed, "I want 'mission-oriented' mission planning, not 'platform-

[298] Research Observation, DIUx Mountain View, CA, November 14, 2016.

oriented' mission planning" and that outputs should support "a fully integrated mission across all platforms."[299] This was to say that, rather than determining how a mission would be executed based on the specific type of aircraft, the preference would be to determine what the mission needed to accomplish and then select the aircraft. Transitioning the focus from what the system should do, the NAWDC CO offered that "an average user should be able to knock out mission planning in a few minutes" and summed up all thoughts into one word "intuitive."[300]

Following the teleconferenced remarks attendees are asked to break out into their assigned groups to meet their leaders and fellow group members. In the Aces (Fixed-wing strike and C2) group, participants are greeted and set on their first task by the Aces facilitators, "we need a team chant."[301] The objective of this team chant was to have something to respond with the group name was called out in the auditorium or hangar room, building a sense of unity, pride, and ownership of the group. The group facilitators expressed that it was not an immediate requirement, but by the time the tech expo was complete, Aces should have a team chant to identify themselves.

Groups then set about conducting introductions of all members in which the individual's name, home town, and an answer to one of two questions: if you were a tool, what tool would you be and why and; if you could have dinner with any famous person, who would it be and why. Ensuing introductions was a question to prime the group toward an AMS TANG focus, "what do you expect from TANG."[302] One F/A-18 strike pilot said, "I came thinking we would be focused on mission planning, but from the [NAWDC CO's] talk, it seems so much broader" while another F/A-18 strike pilot offered "What [mission planning] is going to look like 10 years from now and further."[303] Another F/A-18 strike NFO offered, "We don't want JMPS version 1.1."[304]

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[299] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[300] Ibid.

[301] Ibid.

[302] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[303] Ibid.

[304] Ibid.

Aces facilitators pivoted the group meeting to the next activities and asked if there were any lingering question from participants, in response to which there was only one, "Are we going to have a concrete plan?"[305] Facilitators assured the participants that, "We are providing a solid idea core for developers" and that in the tech expo participants should "Look at the technology and get inspired."[306]

Following this initial group phase all groups were ushered from the auditorium to the hangar room to participate in the tech expo, a process equated to *speed dating* by the TANG leads. Groups were assigned a specific starting point including tech expo stations or display boards showing the design process and concept cards. For six minutes groups would receive short briefings and be allowed to ask questions of presenters or utilize any technology brought to the forum. At the completion of the six minutes, the TANG team played "*Top Gun* anthem" signaling it was time to move on to the next station.

Throughout the tech expo, light snacks were provided to attendees and as the tech expo progressed and groups moved throughout the hangar room, participants exchanged ideas and asked questions of the presenters. No booth was identical with some relying on slide shows, others on videos, and still others on demonstrations to show their respective products. Many presenters cued in on JMPS as a topic of discussion while others such as TurboTax showed interfaces related to tax season. While not immediately apparent why an online application aimed at tax preparation was present, facilitators quickly pointed out the intuitive interfaces used by TurboTax which made it simple for even the layman to get online and do their taxes. It was not uncommon to see a TANG participant linger at a station after the rotation music was played either to continue a conversation or ask an emerging question related to the displayed technology. With time running short, the APL TANG leader made the decision to cut the tech expo short and return attendees to the auditorium for a guest speaker. The shortened time meant that eight stations would be missed by participants; however, presenters were willing to remain in and around the hangar should any individual wish to return and receive a briefing.

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[305] Ibid.

[306] Ibid.

Back in the auditorium all attendees took their seats for a guest speaker an executive from Pipeworks Software, a video game design firm in Oregon. The guest speaker began the lecture by introducing the "intersection of the game world and real world" leveraging the "ubiquity" of the increasing game-playing population.[307] The rapid improvement and availability of virtual and augmented reality devices and networks was argued as creating geosocial networks of people connected to a place or friends through augmentation. Additionally, embracing the growth of broadcasting gaming and *twitch*, an ability to record and share online video game clips was offered as having an analogous future application for aviation. The key advantage offered by twitch was for the observers to see everything the individual playing the game could see thus immersing themselves in every aspect of the game with the exception of holding the controls. This was in contrast to the debriefing tools used at Air Wing Fallon involving a two-dimensional map and icons slowly moving across the screen.

Following the guest speaker, members of the Jokers and Skybox groups pair up across their respective groups and link up with the TANG participant groups, sometimes referred to as the *warfighters* to interact over food and refreshments at the remainder of the tech expo. Within these discussions, groups discuss how pilots interact with physical and data objects, an idea much like coordinates on a map and the physical point on the ground that corresponds. Other discussions include maintaining a cockpit mindset throughout the coming days so as to always focus design efforts on the tasks of the pilot. As these discussions and conversations dwindled, participants continued to peruse tech expo exhibits and socialize internally and externally to their groups until 1730 when participants begin to depart for the evening.

With TANG attendees leaving for the day, tech expo presenters begin to pack up their exhibits and the TANG team begins to transform the hangar room from the look of science fair, to a staged theater. Chairs were brought in and aligned in rows leaving the center aisle clear and tables were set up lining the side and back walls. In the front of the room nearest the entrance and exit doors, a small stage was set up with a projector screen

[307] Research Observation, DIUx Mountain View, CA, November 14, 2016.

behind it establishing this room as a new place to present ideas and concepts. With setup nearly complete, the TANG team ends activity for the day to get ready for day two.

4. AMS TANG—Day Two

A light breakfast was provided the morning of day two which was taken advantage of by half of the attendees. Assigned groups for the participants were not asked to meet before the first scheduled activity and individual participants reflected this by socializing with friends outside their respective assignments. A presenter from the tech expo had optioned to stay for the duration of the TANG was discussing the benefits and purpose of TANG to some participants. This being the presenter's 11th TANG event, the energy level remained high as thoughts were offered on the process and outcomes. "Who said Silicon Valley is the only place where innovation occurs" the presenter rhetorically asked participants from various groups.[308] While discussing the advantages of AMS TANG and the support it receives from both the Chief of Naval Operations and Naval Aviation Systems Command (NAVAIR), the presenter offered that, "when you have the center and both guards blocking, all of sudden I'm in the secondary."[309] This comment spurred more discussion from participants about the acquisition process and expressions of disbelief in the feasibility of AMS TANG outputs making it into or through the acquisition process. This prompted on tech expo representative to concede that, "Nowhere in the [Assistant Secretary of the Navy for Research, Development, and Acquisition's] job description is a mandate to innovate. I don't think the message is getting through to the [Program Executive Officers]."[310]

a. Discovery Deck Brief and Concept Feedback

Once all participants had arrived and were seated in the auditorium the two TANG leaders began to brief the discovery deck. This was the first time attendees were exposed to the months of travel, research both analogous and directly of Naval Aviators,

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[308] Research Observation, DIUx Mountain View, CA, November 15, 2016.

[309] Anonymous Tech Expo Presenter, interviewed by Donald Turner, November 15, 2016.

[310] Ibid.

and observations conducted by the TANG team. One such observation about the three phases of mission planning is shown in Figure 8.

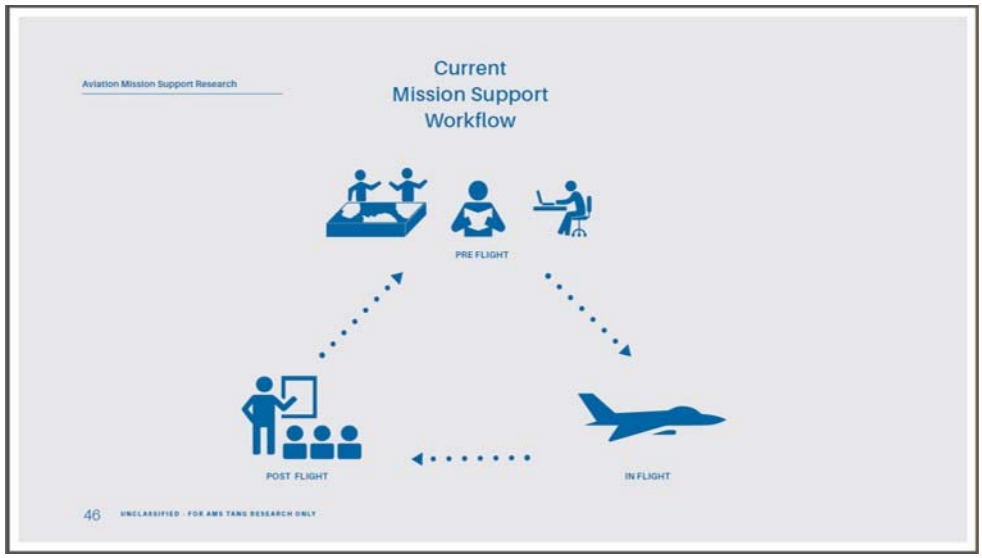

Figure 8. AMS TANG Discovery Deck Mission Support Flow Diagram.[311]

This was also the first group-wide introduction to the design thinking process as shown in Figure 9.

[311] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

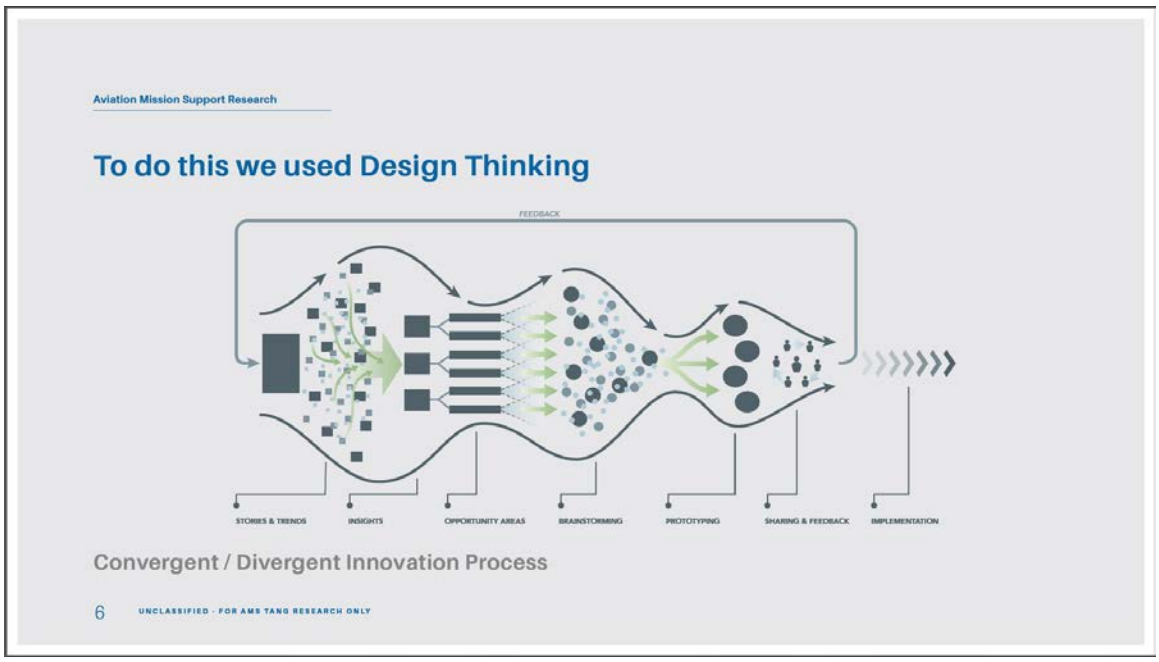

Figure 9. AMS TANG Discovery Deck Design Thinking Process.[312]

To ease the abhorrence to 130 slides, the two TANG leaders promised to move through presentation "rapid fire" to get to the next activities.[313] The discovery deck passed with no interruption or questions, which allowed the TANG leads to introduce the first design thinking exercise to all groups, notes on concept cards. Identically to the AMS TANG rehearsal at NAS Fallon, participants were asked to write comments and questions on the provided post-it notes that fell into one of four categories: I like…, I wish…, Question, Concern. Participants could do this for any of the eleven concept cards now placed in the front of the auditorium and were given ten minutes to do so. After a few minutes of only TANG team members approaching the boards with comments, the *warfighters* began to provide feedback, gradually growing in numbers until the boards began to fill with note cards. As the commenting period ended some stragglers rushed to provide final-moment input to the boards and with the final participant returning to their seat, the commenting period expired. Figure 10 is the completion of all TANG participants brainstorming on every presented design challenge.

[312] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[313] Research Observation, DIUx Mountain View, CA, November 15, 2016.

Figure 10. Group Brainstorming Results

b. Introduction to Voting

Next, concept voting was explained to participants. Voting would be an event restricted only to the pilots and *warfighters* in the room in which voting dot stickers were provided to individuals and they could vote on their favorite concepts. Much like Air Wing Fallon, voting for a topic multiple times was allowed and abstaining from a topic was the equivalent of finding it less interesting or a bad concept. After a ten minute voting period, TANG team members tallied the votes up and brought forth the winning four concepts:

- Collaborative Mission Planning
- Data Reduced Cloud Environment for Updates
- Improved Auto-population of inputs
- Playback of information[314]

These concepts would be addressed late by the individual groups in breakout sessions as the design thinking process was applied.

[314] Research Observation, DIUx Mountain View, CA, November 14, 2016.

c. Brainstorming

The attendees were next given an introduction to the brainstorming method in the form of a brief given by a former IDEO employee now a member of the APL TANG team. While the discovery deck introduced participants to the design thinking process, this brief was the beginning of detailed instruction for execution. In the span of five minutes, the presenter introduced the seven rules of brainstorming along with examples of how these rules are followed correctly and how they are broken. Additionally, the instructor showed images of what good brainstorming looked like, words on a note were good, large words on a note were considered better, and best was large words with a picture included to best illustrate the concept trying to be conveyed.

The brainstorming rules are designed to maximize the output over a short period of time through focusing ideas, limiting distractions, and supporting all ideas regardless relevance or outlandishness. The rules were established by IDEO in its design thinking processes and are applied verbatim to the TANG process. Those seven rules are:

1. Defer judgement
2. Encourage wild ideas
3. Build on the ideas of other
4. Stay focused on topic
5. One conversation at a time
6. Be visual
7. Go for quantity[315]

Following the brainstorming brief, groups were directed to move to their breakrooms, classroom sized areas within the DIUx building containing all the brainstorming and prototyping supplied provided by APL. In the room with the Jacks (Anti-Submarine Warfare), the TANG facilitators echoed the contents of the auditorium brief and provided further details of how the brainstorming process would go. The Jacks'

[315] Research Observation, DIUx Mountain View, CA, November 14, 2016.

facilitators were a team comprised of both APL and consulting leadership providing an intended but unique dynamic for members of the Jacks' group.

Many members of the APL TANG team were former active duty service members with time in service ranging from four to over 20 years.[316] This active service experience was less frequent among the facilitators coming from the consulting business with some exceptions to include a retired Navy SEAL Captain. The two TANG leaders, one from APL and one from consulting, maximized the dynamic of one service member and one non-service member to leverage both creative experience and service experience to provide credibility to participants as the two worlds collided within the TANG construct.

While discussing brainstorming activities in the breakout room, one facilitator emphasized to the group that, "Post-it notes are your voice. Your ideas do not exist anywhere else."[317] To warm the 13 Jacks participants up, the facilitators offered a simple and basic design challenge, to come up with 50 ways to get a cat off of a roof. The Jacks' facilitators brought a large display board to the center of the room with a blank piece of paper on it and wrote, "How to get a cat off a roof."[318] Initially, participants wrote single words such as "ladder" and "tree" on post-it notes and placed them on the display board. After some constructive corrections from the facilitators to draw pictures as well, participants began to incorporate images with their ideas and ideas began to flow with both realistic and less conventional concepts.

The urging of participants to draw pictures follows the adage *a picture says a thousand words*, thus providing participants with an opportunity to be more descriptive on a single Post-Its note. This method of drawing pictures also saves time in later stages of the design thinking process providing participants with more information and requiring less follow-up dialogue on provided ideas. At around 40 ideas, the inertia of the exercise began to dwindle giving way to some of the most unconventional ideas including a gun

316 APL TANG Facilitators, interviews by Donald Turner, November 14, 15, 16, 2016.

317 Research Observation, DIUx Mountain View, CA, November 14, 2016.

318 Ibid.

that shoots nets, and a "kitty cannon" that shoots other cats onto the roof until the original cat does not have enough room and comes down.[319]

With the Jacks group primed, facilitators switched topics briefly to ask for feedback on the TANG process. From the start of TANG to where the participants were in the process, facilitators asked what stood out the most. Nearly all responses focused on the discovery deck briefed earlier in the morning. "Using the right sleep to increase individual capabilities while decreasing manpower," "Using a single data point (blood pressure) to predict sepsis," and "The Sergei Bubka example of accepting the bare minimum really hit home" were just some of the responses received.[320]

In the Discover Deck, the AMS TANG Consulting Lead told the story of Sergei Bubka, a world-record holding pole vaulter originally representing the Union of Soviet Socialist Republics and then Ukraine.[321] Bubka was regarded as a ground-breaking pole vaulter in that he excelled far beyond his nearest competition and regularly broke his own records. To inspire continued excellence, Nike offered to sponsor Bubka by offering him $100,000 every time he broke the world record for pole vaults.[322] He went on to break the record several times by the minimum allowable margin to receive his payout only to eventually show diminishing abilities with age. In time, Bubka retired only to have his record broken by a vault that many speculated he could have easily cleared in his prime.[323] Because Bubka only did the minimal improvements to maximize his earnings from Nike, the world never knew just how talented he really was.

The facilitators then pivoted the group back toward the design thinking process and deciding which concepts to brainstorm. Concept cards on display boards are brought to the front of the room and the facilitators re-introduce the "How might we…" design challenges to participants. After the concepts were briefed voting stickers were distributed to participants and some displays were taken out of contention before voting

[319] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[320] Ibid.

[321] Ibid.

[322] Ibid.

[323] Ibid.

commences. The facilitators explained that concepts fit into one of four larger categories: Foundation, Pre-flight, In-Flight, and Post-Flight and that to collectively generate as many ideas as possible, some groups would take two categories and other groups would brainstorm the remaining two categories. For the Jacks, only Foundation and Pre-Flight would be eligible for voting in the current iteration.

The Jacks' voting processes revealed three winning design challenges, two in the Foundation category and one in the Pre-Flight category. From Foundation, "How might we make updating a no brainer?" and "How might we make planning tools as intuitive as Google Maps, TurboTax, or Uber?" emerged as winners and from Pre-Flight, "How might we enable team-based collaborative planning?" was victorious. One at time the group took to brainstorming how to answer these questions with some new ideas and concepts, and some analogous ideas and concepts.

The first design challenge attacked by the Jacks was to make updating a no-brainer. The initial context assumed by the group was that this applied to JMPS software which drove initial discussions. Gradually, facilitators were able to broaden the scope of the challenge to include activities and technology outside the scope of JMPS. With the newly opened aperture, participants began to brainstorm ideas including removal of users from "the mix," a capability to push and pull updates, and even utilizing drones to conduct updates. Following the brainstorming session, the facilitators began to pull Post-It notes from the concept cards to group them into similar concepts or ideas. As this grouping was being done, the facilitators explain that by grouping these together as shown in Figure 11, it would make for an easier and more focused effort during the next phase.

Figure 11. Members of the Kings Grouping Brainstorm Ideas Together.[324]

The second design challenge was to make intuitive planning tools along the lines of ubiquitous applications and software. Brainstorming ideas began to flow more freely while working on this concept to include utilizing machine learning and artificial intelligence to create an interactive planning tool that builds a plan catered to the pilot. Another idea was something titled *IntelUber* that was able to scour intelligence sources for relevant updates based upon the intended flight plan. An MH-60 pilot recommended stealing commercial interfaces rather than developing something new and another MH-60 pilot suggested an ability to view all historical flight plans and borrow ones that were nearly identical and required minimal changes. During this second concept brainstorming session, participants started to diverge from the brainstorming rules manifesting in judgement and side discussions during the process. The facilitators were prepared for just such occurrences and quickly brought the group back to the process with minor distraction.

The third design challenge was enabling team-based collaborative planning, a concept easily relatable to JMPS for the Jacks participants. Brainstorming revealed more analogous as well as new ideas to answer the question, including an ability to request

[324] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

friends, and submit requests, to these friends, for information in a networked collaborative planning space. Another idea was to develop a multi-platform (capable of providing services to multiple type/model/series aircraft) tool or application to do planning. One frustrated P-3 pilot offered an idea to develop a "Commander's intent translator app," which received laughter from the group, and another P-3 pilot offered, "Why do I have to plan at all, how about voice controlled planning?"[325] By this third brainstorming session, participants were naturally grouping ideas on Post-It notes as they were placed on the concept card.

The first rounds of brainstorming now complete, the facilitators transition the Jacks to voting with one facilitator joking, "Now you can judge each other."[326] Each participant was given six dots to vote on the three concept cards with the recommendation of voting on specific ideas or groups of ideas to neck down what would pass to the next phase of the design thinking process.

d. Prototyping

The Jacks' workspace was adjusted from a meeting space to work space with the arranging of four 3′ by 5′ tables, chart paper, black Sharpie markers, and more Post-It notes. While previously the room had resembled an elementary school classroom, the room now looked much more like an art class with the highest-voted brainstorm idea boards remaining against the wall opposite the entrance. Figure 12 is a prototyping station within the Jacks' breakout room. While the previous vote allowed a certain degree of anonymity for participants, it was time for individuals to put their names to concepts determining who would be assigned to which prototyping effort.

[325] Research Observation, DIUx Mountain View, CA, November 14, 2016.

[326] Ibid.

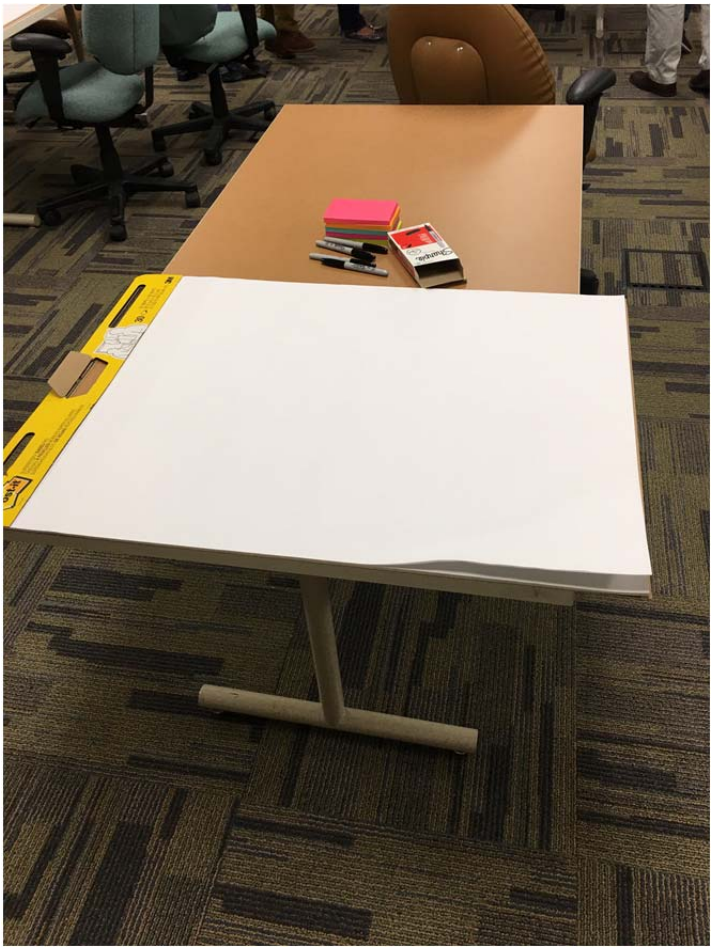

Figure 12. Prototyping Station

The prototyping process or, more specifically, the rapid prototyping process is a design thinking procedure by which inexpensive construction materials such as string, cardboard, construction paper, and markers are provided to build a rough and unscaled model of an idea with which participants can interact with. Much like a picture being worth a thousand words, these prototypes allow fellow TANG attendees and leadership to better envision the use of concepts developed during the design thinking process. Figure 13 is the materials provided for prototyping.

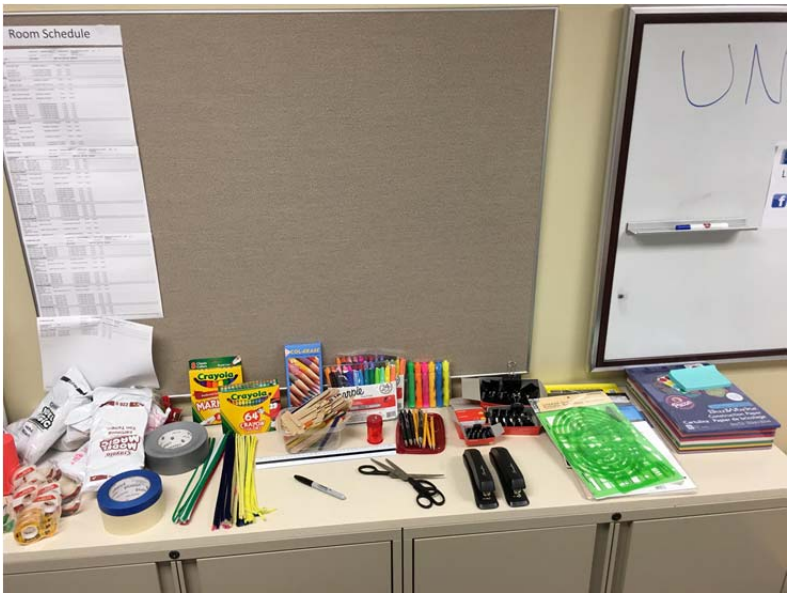

Figure 13. Prototyping Materials

The biggest emphasis from the TANG facilitators to participants was that some sort of object be utilized, no matter the concept. If the concept was an application, then a prototype of the user interface as well as the tablet or computer the application was accessed through would need to be built. This emphasis aligns with the goal of design thinking and its human-centered focus, valuing human interaction with concepts over the efficiency of engineering.

Within the Jacks' workspace, participants wrote their names on Post-It notes and were asked by facilitators to place their names next to one of the three top concepts developed in brainstorming which they would like to prototype. With minimal hesitation, individuals began to approach the boards and self-select for the prototyping effort. Once all participants were finished, the boards revealed a strange outcome of the self-selection; the concept receiving the highest number of votes from participants had only one volunteer to take from concept to prototype. The highest voted concept was not a slim margin of victory as it was clear from the number of voting dots and the number of voters that most participants had voted for the idea, some multiple times. However, participants felt no compelling draw to want to manifest it into something in the physical world.

This lack of volunteers would be problematic for facilitators as ideally three to four participants work on an individual prototype and at a bare minimum, two participants. One facilitator standing behind the participants as they faced the board drew focus to this under-volunteered concept and asked for people willing to switch their names to help with prototyping, which received some reluctant acceptance eventually balancing out team numbers. The curious indifference as to why there was initially only one volunteer was explained by one TANG facilitator with over 10 years working for IDEO,

> We do care a great deal as to why the most popular idea was the least popular when it came to prototyping. But we don't have a lot of time to get these concepts from the boards to something we can interact with and the priority is getting good prototypes and skits.[327]

Despite the teams now being balanced, the prototyping effort began very slowly for participants with all groups seeking some sort of clarification from facilitators. The biggest gap in understanding as well as a common thread for all groups was the perspective of the prototypes, "are we making these from the perspective of the cockpit? The Ready Room?" asked one MH-60 pilot.[328] This distinction was important for the participants as is would determine how to interact with prototypes. "I can have a much more complex array of options if I am working on something in the Ready Room or doing mission planning, but in the cockpit I need something simple and easy to navigate" said one MH-60 pilot.[329]

In all cases, TANG facilitators offer that the perspective is up to the participant, where they think it would be most beneficial and where it would make the most sense. Among the groups there was a common dissatisfaction with the uncertainty of this answer, to which some participants responded with a long, drawn out "Okaaaay."[330] As to why there was some dissatisfaction with the wide latitude of the facilitators' responses,

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[327] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 15, 2016.

[328] Research Observation, DIUx Mountain View, CA, November 15, 2016.

[329] Ibid.

[330] Ibid.

one participant offered, "Sometimes it's nice just to be told what to do."[331] With little of the confusion clarified, participants nevertheless began developing prototypes in earnest to prepare for skits the following day.

Within one group, a group developing an application for community rating and reviewing of After Action Reports (AARs), a leader emerged between the three participants identifying tasks as well as taking charge of marker utilization and directing the focus of ideas. Other groups were able to provide a more collaborative environment with all participants shaping the prototype design by asking hypothetical *what if* questions. Across all groups, an occasional mention of the futility of the TANG effort due to the acquisition cycle served as a temporary distraction, but never for longer than two minutes as members were able to keep focus and on track. Figure 14 is the beginning of this group's prototyping effort.

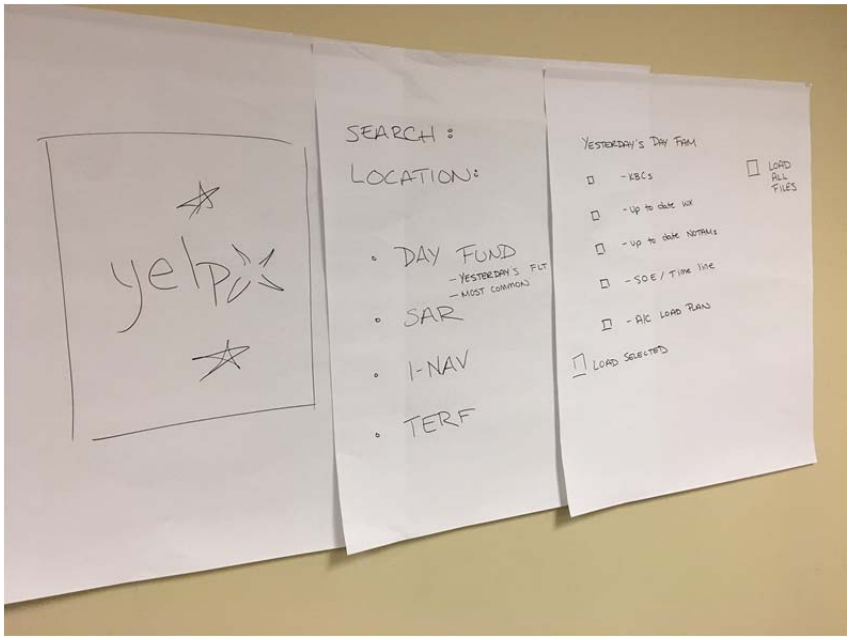

Figure 14. Concept Development in Prototyping

Participants would regularly refer back to the concept cards as a reference for their respective prototype and facilitators would move between the groups providing

[331] Anonymous MH-60 Pilot, interviewed by Donald Turner, November 15, 2016.

amplifying guidance to steer efforts, remind participants of the exhibits displayed at the Technology Exposition, as well as write down new ideas on Post-It notes. "This is normal," said one TANG facilitator and member of the APL team, "this is the first time many of these guys have knowingly participated in prototyping and it's with a newly developed idea, the first few minutes are going to be a little scatter-brained."[332]

True to the facilitator's prediction, within twenty minutes the participants' focus began to narrow specifically toward the design challenge 'how might we…' questions that were the basis of the original brainstorm. Prototype inspiration was gathered from multiple sources ranging from the tech expo to commercials seen on television and concepts in movies. Some groups even sought inspiration from the smart phones in their pockets to determine not just application capabilities, but application interfaces.

With such a heavy application focus, TANG participants struggled throughout the initial prototyping phase determine the answer to, how might we prototype technology software that consists solely of buttons and images on a touch screen? This interaction proved to be a defining moment between facilitators and participants with regard to the roles each held in the design thinking effort. While previously, participants were unhappy with the open-ended responses facilitators provided, in their struggle to prototype applications facilitators asked pointed questions and made direct comments to better narrow the scope of participant thinking. When asked how to prototype and application, one facilitator simply asked, "do you mean an app on your phone, an app on your computer, or an app in something like *Alexa*."[333] Later, after activities had concluded for the day, a participant remarked, "I was too busy thumbing my phone in my pocket to even think about all the apps and platforms out there."[334] The facilitator had, with a single question, pivoted the thoughts of participants from "how to make a phone out of cardboard?" to "how do I want to interact with this application?".

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[332] APL TANG Facilitator, interviewed by Donald Turner, November 15, 2016.

[333] Research Observation, DIUx Mountain View, CA, November 15, 2016.

[334] Anonymous MH-60 pilot, interviewed by Donald Turner, November 15, 2016.

A potential limitation to the prototyping effort was no clearly defined prototyping process for participants to follow. Recalling the brainstorming and voting activities, participants were explained first what the activity was and then how it would be accomplished. Accomplishing brainstorming and voting could be broken down into a procedure or checklist if a facilitator was so inclined. Discuss ideas on a topic for a specific amount of time within these stated rules of brainstorming activities. Likewise with voting, a specific amount of material was provided with amplifying guidance as to how to use the materials to accomplish an objective. Dissimilarly, prototype development is an activity but not necessarily a process in that there are materials and an end objective, but no distinct method by which to achieve that objective.

In the absence of a clear procedure to follow, many participant groups planned and executed their respective prototype builds following a common methodology mostly akin to mission planning that was seen at Air Wing Fallon. An overall objective was established and individuals within groups were tasked out to develop their portion of the prototype while maintaining open communication with group members. This practice was rarely deviated from which allowed groups to work in concert, while also within their respective area of the team.

As prototyping efforts continued through the afternoon, created materials grew from every team having at least one cardboard *iPad* in every group to one group building a cardboard airplane to better show how a pilot would interact and interface with an application while in the cockpit. Another group employs large turn chart paper to indicate new screens on a tablet device when interacting with the device. Figure 15 is the wearable cardboard airplane in development.

Figure 15. Wearable Airplane Prop

After 90 minutes of prototyping, a Jacks facilitator stopped all work on models to bring the group back together for practice in presenting the prototypes. In the aggressive effort to better define their concepts as well as build an accurate representation of the concept, no group had spent a great deal of time developing or discussing a presentation. This Jacks-only rehearsal served as an opportunity to force the attention to the development of a presentation. Because concepts would be shown to all members of AMS TANG to include sponsors and senior leadership from both the military and industry, the presentation held exceptional value beyond simply the concept. A presentation was a way to demonstrate the concept in action usually and preferably in the form of a skit. Skits provided the opportunity to show how concepts would interact in the real world as imaged by TANG participants, in essence a use case scenario rather than simply a list of specifications or capabilities.

To conduct these presentations, groups moved to a mostly empty corner of the room and all non-performing members of the Jacks either say or stood to watch and listen. Skits were a commonplace which often elicited laughter as well as a numerous

comments and questions. Following each presentation, performers remained on the hastily identified "stage" to receive feedback on both the concept and the presentation. The organization of the feedback was no different than any other event in that all questions and comments should fall into one of four categories: I like…, I wish…, Question…, Concerns….

With fresh feedback literally in hand—taking the form of Post-It notes—all concept groups within the Jacks returned to prototyping as well as refining their presentations. During this continued work time, a camera crew complete with a boomed microphone entered the Jacks workspace letting the facilitators know that it is time to create the concepts' "sizzle reel." The sizzle reel for concepts is comparable to a teaser trailer for a movie in that it is short and provides just enough information to give context and pique the interest of its viewers. Props and music are available for use in the sizzle reel and it seemed the only hard and fast requirement was for the name of the concept to be both said aloud, and visible on camera.

Groups varied in their respective approaches to how to perform the sizzle reel with some opting for humor and others opting for tight-budgeted sounds and special effects. With only a single camera crew and several concepts spread across multiple groups within AMS TANG, groups had minimal time to prepare and if a take was not perfect reshoots were limited. In addition to meeting with all groups, the camera crew must then quickly take all the correct shots, download the content, add music when appropriate, edit the takes to ensure they begin and end on time, then accurately name and re-test all film footage prior to the TANG dismissing for the evening.

Sizzle reel filming requires only one reshoot per group and as quickly as the camera crew arrived, they departed to link up with another team in another room for more filming. With skits developed and now the sizzle reel filmed, concept groups within the Jacks now had the remainder of the afternoon to continue prototype development and presentation scripting.

e. The Sizzle Reels

At five in the evening of day two, all participants and facilitators of AMS TANG convened in the auditorium for the end of day announcements. Fatigue was evident across the faces of many participants, many of whom seemed eager to conclude the day's activities. In traditional TANG fashion, one APL TANG leader and unofficial Master of Ceremonies (MC) sought to raise the energy level within the auditorium by doing a call and reply of the various team names. "JACKS" the MC called loudly into the microphone, which was met with a deflated "of all trades."[335] Unperturbed by the low energy, the MC offered the Jacks a second attempt at the call and response game, which was met with at least more volume and likely more energy.

With the undivided attention of the auditorium, the MC set the atmosphere for the sizzle reel, which introduced AMS TANG to the concepts that would be presented tomorrow. Some Reels caused an uproar in laughter while others were met with passionate nodding in agreement with the idea. Each video was followed with hushed discussions as though new ideas were suddenly coming to participants for their own respective prototypes. Following the completion of all sizzle reels, the schedule for tomorrow was reviewed which indicates the beginning of deliverables from the participants.

5. AMS TANG—Day Three

Excitement preceded the beginning of the third day of AMS TANG with the presentation of ideas as well as a second round of brainstorming and concept development. Participants, facilitators, and sponsors alike arrived with anticipation on their faces in the hopes that new directions for Aviation Mission Support would be revealed by the design thinking processes.

TANG participants arrived to a buffet style breakfast in the hangar room and an opportunity to spend close to an hour refining concepts, prototypes, presentations, and skits. The hangar room itself was transformed from the tables and displays of the

[335] Research Observation, DIUx Mountain View, CA, November 15, 2016.

technology expo to rows of chairs and a stage elevated a foot off the floor. Long tables still line the sides of the large room; however, the space has been transformed into a theater of sorts with the stage centered along the entrance wall. It is upon this stage that the first group prepared to present its concept to AMS TANG.

a. AMiE, TacApp, and WOPR

The first prototypes presented were all from the Aces group, the group comprised primarily of strike and command and control aircraft. Prior to the first group presenting, the APL TANG MC laid down the ground rules for skits and the comments that would follow. Each group had seven minutes to present their idea and immediately following, all members of AMS TANG whether facilitators, participants, tech expo representatives, or sponsors could comment on the idea and the skit. In the seven minutes following, commenters were permitted to provide feedback at a microphone, down left of the stage, within the four feedback categories: I like…, I wish…, Concern, and Question. In addition to the verbal feedback, commenters must write a concise version of their feedback on a post-it and place it on a feedback board adjacent to the microphone. During the feedback portion, the presenting group does not respond immediately; rather, the presenting group must say "thank you" to all comments thus preventing a dialogue on a specific topic and maximizing the amount of constructive criticism given by the audience. Table 1 is a consolidated list of the concepts created and presented by the Aces.

Table 1. Aces Prototypes after First Round of Brainstorming.[336]

Concept Acronym	Concept Title	Concept Description
AMiE	**A**viation **Mi**ssion **E**nvironment	A system of interconnected, cloud-based mission data repositories that store aggregated data at multiple classification levels for mission support
TacApp	**Tac**tical **App**lication Store	A new acquisition process that enables an Apple App Store-like competitive, free market-based gallery to allow for rapid iterative development and fleet feedback
WOPR	**W**argaming **O**ptimal **P**lanning and **R**eplanning	Mission support system that automates the creation of courses of action through a Monte Carlo wargaming simulation in a virtual environment

AMiE (pronounced like "Amy") was the first concept presented to the group which focused on automatic updates to the Joint Mission Planning System (JMPS). Participants conveyed through a skit, a pilot sitting down to plan a mission and receiving a notification through JMPS that it was time for an update, much like an iPhone receives update notifications from its application store (app store). The performing pilot mimicked on his cardboard iPad, pushing an update button and walking away allowing JMPS to self-update while he worked on other tasks, completing the skit.

The AMiE skit was less about functionality, and more an indication of the simplicity and level of autonomy the Aces members envisioned for their concept. One AMiE presenter, an F-18 Pilot described the difficulties,

> We have a loose understanding of how (applications) on our phones work, but most of us know exactly how bad it is to update JMPS. I don't know that a skit was needed to demonstrate that I want JMPS to update as easily as Facebook on my phone, but the idea is simple yet effective enough to save time.[337]

[336] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[337] Anonymous F/A-18 pilot, interviewed by Donald Turner, November 16, 2016.

Time being saved was valuable to this particular group, particularly the time it takes to receive JMPS update discs through conventional mail and input changes into the JMPS computers. Untimely updates or training and operational tempo can lead to JMPS updates not being installed and older versions being used simply to continue meeting demands for aircraft.

While the skit was a demonstration of the capability, the presentation was where the true details of the idea were laid before the audience. Following the skit, members discussed further the functionality they hoped for utilizing comparable existing technologies including being able to set JMPS computers to update automatically while connected to a secured network.

This being the first presentation, many participants were hesitant to be the first to provide feedback, something that seemed to be anticipated by the facilitators and TANG leadership. As if on cue, several facilitators lined up behind the microphone with Post-it notes ready to provide their feedback. Comments ranged from liking the simplicity of the idea to asking about the feasibility of in-flight updates. This proved to be a fairly typical trend throughout presentations, with comments ranging from slight modification to improve the concept to radical proposals changing the physical world dynamic of the design challenge.

Following AMiE was the *TacAppStore* as well as *WOPR*, two additional concepts developed by the Aces team. The TacAppStore answered the question, "what if (Junior Officers) could peruse the options along with flag officers?"[338] The TANG participants were seeking a method by which mission support software, applications, and capabilities could be centrally housed and users of all ranks could read reviews and vote much like the Apple Application Store.

The WOPR broke away from the applications focus AMiE and TacAppStore and opted instead to look at leveraging hardware to improve Aviation Mission Support. Utilizing both simulation software and virtual reality goggles, WOPR provided pilots

[338] Research Observation, DIUx Mountain View, CA, November 16, 2016.

with an opportunity to run their flight plans through several simulations, essentially war game, and subsequently brief their mission plan in virtual reality.

While AMiE was met with light comments from TANG participants, WOPR seemed to be the concept that spurred both participants and facilitators alike to bring forth their ideas for improvements. Dozens of audience members stood with multiple notes in hand eager to provide support as well as minor tweaks to WOPR nearly causing the MC to cut people off from going up to the microphone for fear of going over time. The WOPR idea had unofficially broken the ice and stirred a renewed passion in the participants.

It was not immediately clear what specifically about WOPR invoked such a response from attendees due to no line of comments or questions staying to specific subject or aspect of the prototype. What was impactful about WOPR to one participant was not necessarily impactful to another participant which indicated no specific trend other than a passion for the concept. The previous other concepts briefed by the Aces were new to Naval Aviation and had tremendous potential benefits to the fleet however, both concepts described the repurposing of known technology to the benefit of the aviation community. WOPR conversely sought to bring in a technology that was less familiar to the audience in a way that would immediately improve mission execution through the use of simulation.

b. FUSION, PUNCH, and SWIFT

With everyone in attendance wide awake and eager to see more content developed by participants in attendance, it was the Deuces' turn to present their concepts. The Deuces, primarily comprised of Electronic Attack pilots as well as some Command and Control pilots, were able to provide more than additional ideas. The Deuces brought a new perspective to brainstorming. Table 2 is a consolidated list of the concepts presented by the Deuces.

Table 2. Deuces Prototypes after First Round of Brainstorming.[339]

Concept Acronym	Concept Title	Concept Description
FUSION	**F**ully **U**nified **S**eamless **I**ntegration **O**perational **N**etworks	A network-based planning ecosystem that leverages a common data fabric and virtual machines to unify mission planning efforts across all functions and security levels
PUNCH	**P**re/post-flight **U**nified **N**aval **C**ombat **H**abitat	A virtual simulation platform to test and rehearse mission plans and conduct post-mission reconstruction and "what-if" analysis
SWIFT	**S**calable **W**orldwide **I**ntegrated **F**light **T**emplates	A mission support system that leverages an intuitive user interface, automatic data synchronization, and machine learning to streamline the mission planning experience

Depending on an individual's aperture, the Naval Aviation community can reveal several smaller communities within itself not unlike subspecies. To an outsider, Naval Aviators can seem to be one large group of similar individuals all with the sole purpose of flying airplanes. This may seem an obvious observation, but considering that often times the small sub-grouping an outsider may do is fixed-wing or rotary-wing, a great deal of the culture and community is missed. This subculture within the aviation community is what benefitted AMS TANG when designing its groups to be mission-focused. When the Aces presented their concepts, the ideas generated came from the perspective of the strike aircraft or, in the general sense of mission execution, the heavily supported aircraft and pilots. With the deuces brainstorming efforts, any bias would come from the perspective of aviators that traditionally fill a supporting role or, the individuals that enable the strike aircraft to perform their mission.

FUSION was the first prototype presented, which took on the challenge of planning missions in a collaborative environment. At NAS Fallon, the AMS TANG research team witnessed how the collaborative workspace for planning was so physically

[339] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

small, it was at times a hindrance to effective collaboration as well as time management. In their planning processes, the group workspace offered room for just one or two individuals from each platform and capability to be present, often requiring planners to leave the room to seek expertise elsewhere. The information outside of the planning room could range from aircraft availability, to a technical specification unknown by the present planner. Regardless of the network access, not all required knowledge was available in the small collaborative planning space. FUSION was a concept that sought to mitigate the physical space shortfall by leveraging existing technology and infrastructure to plan in a collaborative environment.

PUNCH followed a similar thought process as *WOPR* in running several simulations and war games to determine the most suitable plan for mission accomplishment with one significant difference. PUNCH sought to use existing flight and mission data to run the simulations seeking the help of Artificial Intelligence (AI) and Machine Learning to develop new mission profiles that have not been shown to an enemy before. The overall goal of PUNCH was to not only generate the best plan for a mission, but for that plan to be unpredictable to an opposition that is familiar with aviators' tactics.

SWIFT was the final concept developed by the Deuces which premiered an AI persona utilized like Kit (the car) from the *Knight Rider* television series or Jarvis from the *Iron Man* films. SWIFT could conduct individual or collaborative mission planning as well as adjust mission plans in-flight with minimal effort on the part of the pilot. When it came time for comments on the SWIFT concept, the line was once again very long as this was the first idea to incorporate a talking AI as well as dynamic planning in-flight.

Inevitably with large quantities of commenters and comments, some ideas end up being repeated. The commenters in line waiting for their turn at the microphone would sometimes have upwards of five or six Post-it notes stuck to various fingers and parts of their hands and wrists. While commenting on the Swift prototype, the TANG MC had to introduce a new rule to commenting, if it has been previously stated, simply say "dup" (short for duplicate) and put that Post-it on the comments board. This helped to cut down on the time used for comments; however, Swift was still challenging the imaginations of the audience, which led to significant quantities of feedback.

c. CAVU, TIE, RAIDR, and RAD

Following a 15-minute "bio break" allowing participants to use whatever facilities required, the Kings were the next group to present the results of their brainstorming efforts. Kings consisted primarily of ground support aircraft ranging from attack helicopters such as Marine Hueys and Cobras, to assault support aircraft such as MH-60s and Ospreys. While the Deuces provided a new perspective on how attack platforms are supported, the Kings would provide the perspective of support to ground troops, a deviation from the presentations of the previous two groups. In addition to the departure from mission focus, the Kings also provided a departure from the military branch that had been presenting. The Kings had the highest number of Marine Corps aviators within its ranks, which provided a deeper cultural change beyond mission focus. Table 3 is a summary of the Kings' prototypes.

Table 3. Kings Prototypes after First Round of Brainstorming.[340]

Concept Acronym	Concept Title	Concept Description
CAVU	**C**ollaborative **A**irspace **V**isual **U**niversal System	Google Docs-like distributed and collaborative mission support software platform
TIE	**T**actical **I**ntegrated **E**xecution	Suite of applications to enable mission execution, awareness, and assurance across a Netted Navy in contested environments
RAIDR	**R**esponsive **A**rtificial **I**ntelligence **D**ebriefing and **R**eporting	Knowledge creation and dissemination system enabled by deep learning receipt and processing of flight and mission data
RAD	**R**apid **A**gile **D**evelopment	Mobile support teams of software and application developers embedded with warfighters for rapid solution iteration and testing

[340] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

The Marine Corps possesses a tribe-like culture that is instilled in all of its personnel regardless of rank or specialty. Common slogans and jargon are regularly expressed within the Marine Corps such as "every Marine is a rifleman," and "once a Marine, always a Marine." While the previously mentioned phrases are common to hear outside of the Marine Corps, a very common credo to hear within the Marine Corps is for every job to support the "grunts" (infantry). This mindset provides a single focus of effort for all Marines to include aviators, that every action taken should directly or indirectly facilitate the success of the infantry. Within the Marine Corps aviation community, this principle manifests itself in pilots seeking not only to make their planning more effective, but making it easier for troops on the ground to plan for aviation. This unique cultural perspective's influence was made clear in some of the King's prototypes by most concepts containing some aspect of integration with ground troops.

CAVU was a tool to conduct "collaborative mission planning through execution," meaning collaboration occurs with both aviation and ground forces during planning as well as execution allowing for both personnel in the sky and on the ground to mutually adjust to the constantly evolving battlefield.[341] Using the tagline "Cluster Fixed," a play on the common phrase indicating a situation that has deteriorated nearly to the point beyond salvaging due to mishandling, the CAVU team demonstrated how continuous collaboration can reduce some of the causes of poor execution as well as mishaps and miscommunications between air and ground forces.

In a unique approach to prototype presentations, the same individuals who presented CAVU transitioned immediately into *TIE* another concept intended to work in conjunction with CAVU, without soliciting any feedback on their CAVU idea. To present TIE, the Kings acted as both pilots and ground troops in a scenario meant to mimic an ongoing firefight on the ground. The ground actors mimicked firing weapons while one of the actors took out his cardboard tablet to see what Close Air Support (CAS) aircraft were in the area. This action was later described as identical to seeing what Uber cars are

[341] Research Observation, DIUx Mountain View, CA, November 16, 2016.

in your area before requesting a ride through the application. Within the skit, the ground actors then selected their desired platform through the tablet and commenced to input CAS 9-line information into the tablet.

The CAS 9-line is a standard report format between ground troops and pilots while requesting close air support utilized heavily within the Marine Corps. While traditionally communication between ground forces and aircraft is performed by a Forward Air Controller (FAC) or Joint Tactical Air Controller (JTAC), the 9-line is taught to all Marine Corps officers and most combat arms specialties. Within a 9-line report starting positions, locations of friendly forces, target location and marking, attack heading, and other relevant data is passed to a pilot prior to utilizing any force on combatants.

After the ground actors imitated inputting the 9-line information into the tablet, the ground actor flipped the tablet over revealing a new screen with a Quick Response (QR) Code generated from the 9-line information. The actors behaving as pilots then indicated they could see the QR code and had received the 9-line information through "scanners." The CAVU and TIE group went on to further describe their vision of visual communication between air and ground forces without the need for radio transmissions in a communications degraded environment to include utilizing drones as visual communication relays to send messages throughout the battle space.

Both CAVU and TIE proved to be both very popular and thought provoking for the audience as comments and questions poured from participants and facilitators alike and, for the first time, the MC had to stop further comments and instruct the audience members to simply place their notes on the feedback board.

The two remaining Kings concepts were *RAIDR* and *RAD*, two new prototypes that ventured into aspects of Aviation Mission Support not previously presented. RAIDR was described as a debriefing tool that allowed for collaborative debriefing with both the pilots who flew the mission and the ground personnel who were supported by the mission. The potential to utilize a three-dimensional map or virtual reality goggle for viewing the debrief was presented. RAD was a concept to rapidly acquire and field new

hardware and software to the end users essentially expediting the acquisitions process putting the newest technology in the hands of the warfighter.

This research will not discuss the acquisitions process in great detail as it is not the focus of AMS TANG or the case study. It is worth noting however, the perception among TANG participants that the acquisitions process is too slow to provide the newest technology to members of the armed forces. Throughout numerous brainstorming sessions and prototype builds, discussion would often deviate to acquisitions and the futility of developing these prototypes as many of the ideas would never see interest or would be fielded too far into the future for the technology to provide a competitive edge. Despite these off-topic discussions occurring often, participants would quickly return to their focus to the task at hand of innovating ideas for the near and distant future of Aviation Mission Support.

d. RAMPS, Oracle, RUMP, and UberDeath

The final group to present was the Jacks, the Anti-Submarine Warfare and Sea-basing platforms. *RAMPS* took the familiar approach of developing military software capabilities from successful commercial applications. In the case of RAMPS, the mimicked application was Yelp, the restaurant review application that allows users to rate restaurants on a scale of one to five stars, and to write short reviews. RAMPS sought to capitalize on the familiarity and popularity of Yelp for pilots to rate and review flight plans in an online database. Table 4 is a description of the prototypes developed by the Jacks.

Table 4. Jacks Prototypes after First Round of Brainstorming.[342]

Concept Acronym	Concept Title	Concept Description
RAMPS	**R**eviewable **A**viation **M**ission **P**lanning **S**ystem	A crowdsourced knowledge sharing platform of products that includes ratings and comments from the user community
None	Oracle	A one-stop shopping experience that provides on-demand expert support for improved planning and communication
RUMP	**R**eal-time **U**pdated **M**ission **P**lanning	Efficient data synchronization architectures and processes that push only relevant changes and updates to the user
None	UberDeath	An objective-based planning application that connects resources, assets, and tactics to achieve warfighter desired outcomes

"No points are awarded for originality in the military. If you're doing something, odds are it's been done before and someone wrote it down," said one of the RAMPS developers.[343] "Plagiarism is a way of life in the fleet," offered another member of team RAMPS.[344] The standardization of training, exercises, and to a certain extent deployments within the armed forces has created quarterly, semi-annual, annual, and even biennial cycles of events that are repeated. With these events being nearly identical to produce identical results, it is common for written instructions as well as data from these events to be reused with minor adjustments as a method to save on work time. This is plagiarism previously discussed, finding a previous version of something already done and making minor changes to reflect the present mission. With their nod to using others work as a baseline, the creators of RAMPS had unknowingly created two new concepts, one of a database for all flight plans and the other as means to peer-review and elevate the best plans within that database.

[342] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[343] Anonymous MH-60 pilot, interviewed by Donald Turner, November 16, 2016.

[344] Ibid.

Oracle followed RAMPS, which was a concept focused on interfacing with the Joint Mission Planning System (JMPS), and the difficulties many pilots experience while utilizing JMPS. Finding inspiration in the live chat support function offered with Kindle electronic reader devices, the Oracle team presented a skit featuring a pilot conducting mission planning in JMPS while in a live online chat room with a tech support individual walking them through their JMPS issues.

Leveraging a well-known name for their next prototype, the Jacks presented *RUMP*, a software application that is able to break down flight and mission data into more manageable pieces. RUMP would allow pilots to view data not as a completed product, but rather any portion of data that is relevant to the current mission or mission planning. The Jacks' vision for RUMP was to not only provide this data to the pilot, but also to any supported ground units as well as the Tactical Operations Center that is executing command and control over the mission in near real-time. "We are often saturated with data," said a RUMP presenter, "I don't know how we determine what data is relevant and for whom while flying at a hundred miles per hour, but I think in time we can teach a computer to help us out."[345]

The final Jacks prototype as well as the final prototype from the first round of brainstorming was *UberDeath*, pitched with the tagline, "death on demand through collaborative mission planning."[346] Much like the *TIE* concept presented by the Kings group, UberDeath utilized an application interface from which aircraft were selected for mission tasking. A tremendous difference between UberDeath and TIE though, was that UberDeath was designed for senior leadership such as admirals.

Within their skit, the Jacks had an admiral sitting with a tablet selecting a target, the threat, rules of engagement, and other mission parameters before sending the information off to the strike group. The strike group then would determine the appropriate assets to achieve mission success. Rather than the information simply

[345] Anonymous MH-60 pilot, interviewed by Donald Turner, November 16, 2016

[346] Research Observation, DIUx Mountain View, CA, November 16, 2016.

populating for the strike group for action, the admiral's orders would also automatically populate into JMPS and other relevant software to streamline mission planning.

Now complete with all presentations, participants were released for lunch and told to be ready to restart the design thinking process in the afternoon.

e. Feedback from Facilitators and Stakeholders

Not all of the prototypes and presentations were equal in the eyes of participants, facilitators, and stakeholders as evidenced by various quantities of feedback and the occasional applause for a very well-liked concept. Regardless of any unofficial ranking determined by group enthusiasm, all ideas would be presented to TANG sponsors and further examined by the APL team for delivery to decision makers and controllers of funding. With this equity of ideas in mind, facilitators and stakeholders were still very eager to share which concepts stuck out in their minds and generated some excitement for the future.

One APL facilitator was very pleased with RAD, WOPR, and SWIFT,

> RAD was a low-tech solution focused not on future technology, but existing technology. Rather than focus on what we don't have and could use in the near future, it was working with the tools in hand…WOPR was just awesome, and SWIFT I will forever love for their sizzle reel.[347]

The SWIFT sizzle reel featured a close-up of a mustached pilot talking to his AI counterpart off screen and being called by a less than flattering call sign found humorous by all.

A stakeholder and representative of the Naval Innovation Advisory Council (NIAC) focused on two prototypes specifically,

> TIE had a clear concept explanation to include the skit which really captured the desired functionality. Its visualization is something that is going to stick with me…WOPR was an incredible moon shot and to me was the most forward thinking of all the concepts.[348]

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[347] APL Facilitator, interviewed by Donald Turner, November 16, 2016.

[348] Anonymous NAIC attendee, interviewed by Donald Turner, November 16, 2016.

The “moon shot” was a nod to the popular phrase “shoot for moon,” meaning the concept had a low probability of quick success, but would at least jump start future thinking.

Representatives still present from the tech expo were also eager to share their thoughts on the prototypes as well as the productivity of the TANG in general. “These ideas are meeting the talent with an appropriate capability,” said one tech expo representative.[349] Another representative at his seventh TANG offered that, “the quality of people (at the participant level) is much greater here than I’ve seen…the personnel selection was right.”[350]

This ‘personnel selection’ was a nod to the process by which volunteers were solicited and selected by the APL TANG team. The traditional process of soliciting volunteers within the U.S. Navy and Marine Corps involves the release of an official message, usually through the Automated Message Handling Service (AMHS). This medium is considered to be “the commander’s voice” as access to the service is tightly controlled and users must have completed multiple hours of training as well as pass an exam prior to receiving access. AMS TANG’s solicitation message originated with PMA-281, the DOD sponsor for the event, and was sent out to Air Wings across the Navy.. In looking for eager participants, the AMHS message contained a brief description of the event, and coordinating instructions ranging from the dates of AMS TANG to the attire attendees should wear.

While the AMHS message was an official means of requesting TANG participants, informal coordination and communication was done well in advance of the message release. As is the case with most requests for support messages, significant coordination is conducted ahead of time to ensure what is requested in the message is available and will be provided upon the release of the message. In the case of AMS TANG, throughout the research process members of the research team met with and interviewed several pilots that seemed to show an aptitude for brainstorming as well as an

[349] Tech Expo representative, interviewed by Donald Turner, November 16, 2016.

[350] Tech Expo representative, interviewed by Donald Turner, November 16, 2016.

eagerness to participate in the TANG event.[351] In many cases, these informed and eager pilots became the personnel provided from the fleet to participate in AMS TANG.

f. Concept Posters

Following the lunch break, participants began filling out concept posters back in the breakout rooms initially used for brainstorming and prototype building. Among the Kings group, participants familiarized themselves with the design of the concept board to focus final prototype refinements. The physical poster was another 8’ x 4’ black cardboard rectangle with the concept poster framework glued to its surface. At the top of the framework was a large rectangle spanning the width of the framework for the concept title much like a marquee at a theater, and much like a theater its size and location immediately drew in a viewer’s focus. Beneath the concept title rectangle was another rectangle just as large reserved for the storyboard. In this location, participants could storyboard their skit or presentation to amplify that it is the concept did and how it did it, or even diagram a use case of the prototype at work. The ultimate purpose was simply to illustrate how the concept should be used. Figure 16 is the concept poster for *RAIDR* in development.

[351] AMS TANG APL Lead, interviewed by Donald Turner, November 16, 2016.

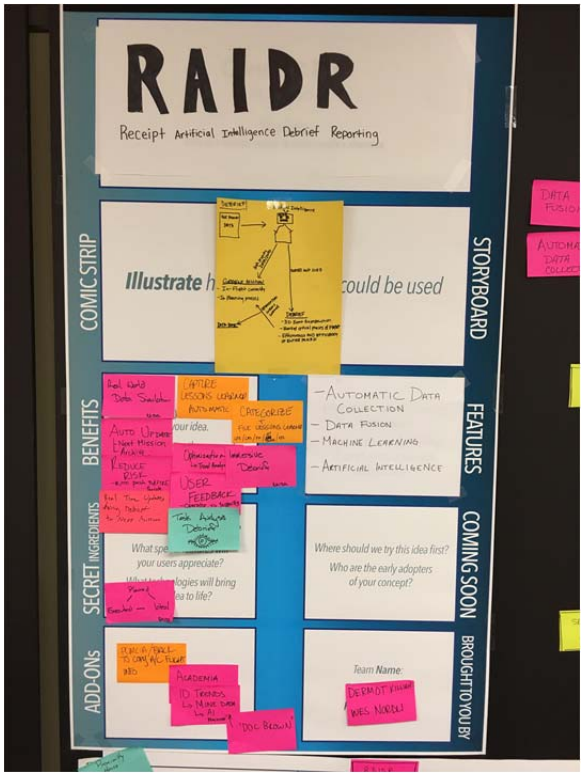

Figure 16. RAIDR Concept Poster

Moving downward along the concept poster, the framework was split into two vertical columns each containing three squares for further details about the prototype. The left column began with a square dedicated to the *benefits* which detailed what positive gains in capabilities the concept provided once developed. Participants could use a short narrative here or simply a bulletized list to present the increased performance. Beneath *benefits* was *secret ingredients*, a section that sought to explain what unique inputs would differentiate the prototype from similar systems or systems of systems. This section briefly describes what special input or output makes the concept something fresh and something new answering the question "what technologies will bring your idea to life."[352] The final square in the left column was *Add-Ons*, a block dedicated to what external capabilities are needed or could be provided from this core idea which could range from an external data transport technology, to implementing fleet learning directly to the school house.

[352] Research Observation, DIUx Mountain View, CA, November 16, 2016.

Where the left column squares of the concept poster took a development and application focus, the right column squares were much more akin to a 30 second television advertisement providing highlights of the prototype. The top square, titled *Features*, was where participants put the eye-catching buzzwords found within their concept. Items such as "Automatic data collection," "Data fusion," "Machine learning," and "Artificial intelligence," were listed on the *RAIDR* concept poster as features that might stick out to a decision maker. Beneath *Features* was *Coming Soon*, a shortened version of movie previews showing the script "Coming soon to a theatre near you." Much like these old film trailers, the *Coming Soon* box needed to provide where the prototype should first be seen. Asking "where should we try this idea first," and "who are the early adopters of your concept," this portion of the concept poster relied on TANG participants to recommend who is best suited to receive and employ the new concept.[353] The third and final square of the right column was solely for attribution in which the creators put their respective group name and their individual names.

In the Kings Concept Poster build, participants reviewed the categories within the framework and began to discuss what should go into the left column relying heavily on the Post-it notes from the initial brainstorm session as well as feedback received following the skits and presentations. Post-it notes were pulled directly from one board to another to avoid losing anything in translation as well as avoid redundant efforts in the time-constrained environment. TANG participants struggled through the process though due to no formal instruction on how to fill out the board or what the purpose of the board was until finally one Kings facilitator offered, "if I want to buy it, what would I be buying" as a guiding question.[354]

Concurrent to the Concept Poster build was the senior leader briefing worksheet, a more narrowed focus of the contents of the Concept Poster resulting in a more refined product. Depending on the number of groups and participants in a TANG event, dozens of concepts can be developed in great detail to include hours of recorded footage. While APL retains all of the source materials and records of the process, the briefing worksheets

[353] Research Observation, DIUx Mountain View, CA, November 16, 2016.

[354] Ibid.

eventually became a PowerPoint presentation shown to an admiral with only one slide per concept. It is this snapshot of the ideas generated which will persuade leaders whether to pursue concepts or shelve them for the future.

g. Brainstorming and Prototyping – Round 2

As recently developed experts of the TANG design thinking process, participants began the processes over in the afternoon of day three, returning to the original design challenges or, *How Might We…* questions presented on days one and two. Within the Kings breakout room participants began this brainstorming session by reflecting first on the prototypes already developed. Facilitators challenged participants by asking which concepts presented legitimately answered the design challenges, and if the prototypes did answer the challenge, how did it answer the challenge. This opening line of thought centered the Kings on what problems may have been solved, and what problems were only partially solved. What *How Might We…* questions were still unanswered and is there a design challenge that was not among the initial recommendations from the TANG team?

The facilitators' prompts paid dividend within the Kings group as a new design challenge emerged from the team after re-examining their prototypes and presentations. Upon reflection, the Kings realized that many of their concepts had an underlying problem they were trying to solve: how do we quickly communicate in a communication challenged environment? The challenged environment took on many problems from many sources ranging from ensuring communication was not jammed to, ensuring no information is lost in translation. In the Kings *TIE* concept, a QR code was used to transfer close air support information in the event that radios did not work but also ensuring no information was misheard. This prompted the Kings to ask, "How might we passively coordinate a mission?"[355]

The second round of brainstorming was much more efficient than the first with participants following the rules with the ease of seasoned professionals. Participants moved to place Post-it notes on the boards while succinctly describing their idea and

[355] Research Observation, DIUx Mountain View, CA, November 16, 2016.

quickly returned to their seated or standing position. This second round possessed almost a synchronized flow between participants sharing their ideas in a rhythm not unlike watching improvisational jazz. Almost as though anticipating a predecessor's last word, the next person was on their feet and moving to the board with a new idea. After the first few Post-it notes were placed, participants began to self-organize their ideas into groups without prompting. There was mutual anticipation in the room while simultaneously feeding and building off of each other's ideas.

In the first round of brainstorming, it was common for facilitators to place a note up when an extended pause may have occurred between ideas. The second round possessed no such lag and facilitators only interjected to broaden the scope of the discussion when participants' thoughts became too narrow. One of these facilitator prompts was the concept of the third *Offset Strategy*, a concept applicable to the strategic level of war.

The newly presented perspective broadened the scope of brainstorming for the Kings and two topics were selected for prototyping one based on ergonomics of flying and the other based additional methods of communicating in a degraded environment. With two concepts to develop, the Kings split in half and began to go through the prototype process for the second time in as many days.

One group immediately began to further separate and organize Post-it notes from the brainstorming session as an idea organization tactic while capturing as many ideas from the brainstorm as possible. While this grouping occurred the other Kings group determined that incorporating PowerPoint into their presentation would be the most effective means of showing the prototype in action. The idea of using PowerPoint was met with hesitation by all group members including the individual that suggested it, likely due to the aversion to the Microsoft Office product many military officers have. Any concerns were eased by indicating that PowerPoint would only be used to create the scene of the skit and not to convey specifications of the concept.

The PowerPoint group immediately broke out into smaller groups or individuals to develop physical prototypes as well as develop the presentation; however, the

difficulty of quickly developing graphically elaborate images with limited expertise quickly revealed itself. While this was not anticipated by the participants, the TANG facilitators had encountered this challenge before and were ready with their in-house graphic artist and design team. Two artists were present throughout AMS TANG with the primary duty of turning the concepts into realistic and understandable images in an electronic medium. "This is awesome," commented one member of the Kings while working with the graphic artist explaining both the ideas becoming visual and the availability and opportunity to work with an artist.[356]

The prototyping continued through the afternoon with groups building props, discussing the human interfaces, and capturing as many ideas from brainstorming as possible. Late in the afternoon, the Kings stopped prototyping efforts to conduct the internal share and do very rough versions of their presentations. This late in the afternoon the lower energy level of participants was evident in slower transitions and ease of distraction while performing tasks as well as both skits featuring a pilot sitting in a staged cockpit while other group members talked through the concept.

Participants understood their own low energy level and attributed it to two factors primarily, "We put all this effort in yesterday and got all this feedback. Why aren't we perfecting our design instead of cutting us off?."[357] The frustration over not being able to continue working on initial prototypes was echoed by another participant, "Who we are, is to want to implement the feedback."[358] This desire to implement feedback is not a trait exclusive to Naval Aviators or the military in general; however, it does describe the desire to seek improvement based upon outside recommendations. One of the foundations of military inspections and evaluations is to determine was can be improved so that an individual or organization can work to increase skills and capabilities. Much like the post-training debriefs conducted at Air Wing Fallon, the debrief outputs were not lost as soon as the pilots left the room. Rather the comments were taken as a call to action to not repeat mistakes and improve in the future.

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[356] Research Observation, DIUx Mountain View, CA, November 16, 2016.

[357] Anonymous C-130 pilot, interviewed by Donald Turner, November 16, 2016.

[358] Anonymous AH-1 pilot, interviewed by Donald Turner, November 16, 2016.

Despite their frustrations, the participants understood that AMS TANG was not a training evolution or inspection meant to improve unit effectiveness. Participants understood that AMS TANG was intended to generate ideas for the future of Aviation Mission Support. "I get that time is better spent doing more prototyping," offered one participant, "we won't be solving all of the problems with one idea in four days."[359]

Where some participants blamed frustration as the cause for the low energy, others saw mental fatigue as the culprit. "I don't ever think this way, it's not how I do my job on a day-to-day basis," commented a participant on the entire design thinking process.[360] Another participant was less descriptive as to why and more descriptive as to what when offering that, "my brain is fried."[361]

h. Concluding Day Three

Participants gathered in the hangar room to conclude the third day by watching another round of sizzle reels and going over the following day's schedule. Prior to every AMS TANG-wide briefing, the high energy MC would call out the groups' names in an attempt to hear the group responses. Because groups were able to establish their own responses at the beginning of AMS TANG, by the third day it had become a natural thing to hear. For example, the MC would shout "ACES" and all members of the Aces would reply, "UP YOURS….LEEVE."[362]

Up to this point of AMS TANG, the first group called out by the MC had a soft response attributed to not being prepared to hear their name suddenly. However, the second group called upon would be ready and respond with equal enthusiasm and energy of the MC. The end of the third day was by far the most challenging for the MC to elicit the decibels of response considered the standard. Energy depleted, the TANG participants needed a few rounds of call and response before meeting the satisfaction of the MC.

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[359] Anonymous C-130 pilot, interviewed by Donald Turner, November 16, 2016.

[360] Anonymous E-2 pilot, interviewed by Donald Turner, November 16, 2016.

[361] Anonymous F/A-18 pilot, interviewed by Donald Turner, November 16, 2016.

[362] Research Observation, DIUx Mountain View, CA, November 16, 2016.

With focus restored, the follow day's schedule was reviewed as well as details for the no-host social provided that evening. As participants filed out, TANG facilitators set to doing some minor cleanup and arranging of the room in preparation for the following morning's presentations as well as a brief synchronization meeting to cover their specific timeline.

6. AMS TANG—Day Four–The Final Day

Following the previous day's work and no-host social, participants arrived the morning of the fourth day with a mix of both excitement and weariness; however, nearly all were carrying cups of coffee. The hangar room was prepared for another round of presentations and as participants took their seats for announcements, the quantity of personnel was lower despite there being some new faces in the room. "Work happens and life happens, but we have a great core here and can continue to produce" explained a TANG facilitator when asked about the decrease and change in participants.[363] The work happenings ranged from being on a weekend flight schedule to a ship conducting movement and the life happenings included the addition of a family member, all considered widely to be good reasons to leave TANG early.[364] The new individuals present were representatives from Defense Innovation Unit Experimental (DIUx), PMA-281, and other Stakeholders eager to watch the second round of presentations.

a. Social Lessons Learned and Life in the Skybox

The preponderance of attendees to the no-host social were pilot participants and TANG facilitators; however, a few members of the Skybox and Jokers group (topic sponsors, stakeholders, and even some tech expo representatives) also attended to interact with other participants and simply blow off steam from three long days of design thinking. For some of the members of the Skybox and Jokers, attendance to the social proved to be enlightening as pilots willingly shared their issues and concerns that were driving their brainstorming efforts. "I had now idea that (EA-18G) Growlers can't

[363] AMS TANG APL Facilitator, interviewed by Donald Turner, November 17, 2016.

[364] Research Observation, DIUx Mountain View, CA, November 17, 2016.

communicate in planning," explained a stakeholder from the Skybox referencing the physical space and network limitations Growler pilots sometimes face when trying to conduct mission planning.[365] Another stakeholder was surprised to learn "these (pilots) are dealing with the exact same issues I dealt with 15 years ago. It seems everything around them has gotten better except for planning tools and in some cases the tools are worse."[366]

These issues, at least 15 years old, were the problems of collaborative planning between platforms for different missions including not having sufficient space for all relevant planners, having a single mission planning computer per squadron, and briefing products having to be assembled one at a time. The briefing products issue is much like a 100 piece puzzle that must be assembled quickly however the pieces are disbursed between 20 people. The puzzle can only be assembled in one location and only one piece holder can be with the puzzle at a time. The diminished planning tools was more a nostalgic comment echoed by some more senior participants at Air Wing Fallon, "give me a whiteboard and marker and I will happily do mission planning over utilizing JMPS and PowerPoint."[367] These members of skybox among others grew more passionate when sharing their discussions with the pilots in TANG which built to a momentum going into the final day of AMS TANG. While attendance to the social may linked to a low energy morning for some, the lessons learned from the pilots were invigorating for others as members of the skybox were poised to complete their own design challenge.

The Skybox and Jokers breakout room was much larger than any of the other breakout rooms to accommodate for the much higher amount of participants. Two rooms, previously divided by a moveable wall were used and tables capable of seating six people were spread throughout one side, while the other side contained rows of desks covered with computers. Much like the breakout rooms for the pilot participants, prototyping materials covered tables along the wall and the 8' x 4' boards were stood vertically along any open wall space.

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[365] Anonymous, interviewed by Donald Turner, November 17, 2016.

[366] Anonymous, interviewed by Donald Turner, November 17, 2016.

[367] AMS TANG Consulting Facilitator, interviewed by Donald Turner, November 14, 2016.

With such a large group from a variety of backgrounds the facilitators for the Skybox and Jokers were the APL Lead and the Consulting Lead, the two individuals with the most research background into AMS TANG as well as a high level of combined experience in the design thinking process. Facilitating the Skybox and Joker groups posed two social challenges not faced by facilitators working directly with pilots. First was the potential for ageism between the facilitators and participants. Among the pilots, TANG facilitators were almost always older in age which is customary in a teacher student relationship. In the Skybox, participants were potentially less inclined to follow the teachings and advising of a facilitator younger than they were. The second social challenge was the lack of a unified military culture within the Skybox and Jokers which featured a variety of backgrounds from various military branches or no service at all. Military training and service generates a social dynamic between leaders and subordinates akin to a mentor and mentee. This dynamic manifests itself differently between the branches as well as the communities within branches; however, outside of the Skybox and Jokers, facilitators only needed to adjust to a single dynamic. This was not the case for the AMS TANG APL Lead and Consulting Lead.

b. How Might We Better Support AMS TANG

In the Skybox and Jokers breakout room participants had gone through brainstorming the initial design challenges much like the pilots in the other groups however, the Skybox and Jokers would not make any prototypes based on their brainstorming. Participants instead needed to develop their own design challenge focused on how to actually make the rapid prototypes into a reality and how to turn ideas into actions. "We need to separate ourselves from the acquisition process," suggested a member of the Jokers indicating a desire to not rely on standard methods to further develop the prototypes.[368] Discussions of the acquisitions process had driven participants off topic numerous times to include side-bar discussions during brainstorming and with the challenge of expediting this DOD procedure, it was understandable why it was at the forefront of everyone's thoughts.

[368] Research Observation, DIUx Mountain View, CA, November 17, 2016.

Through more brainstorming, a *How Might We…* began to take shape for the participants: "How might we get ideas to (Naval Aviation Warfighting Development Center) better and create a culture of innovation?" This challenge took on the dual focus of streamlining the flow of ideas to an authority that can implement the ideas as well as building a culture of innovation within the Naval Aviation community. While traditionally design challenges are not two-part questions, participants greatly benefited from a more narrow focus of their brainstorming and prototyping efforts. The first part of the design challenge needed some massaging from participants and facilitators due to its wording indicating a more business process reengineering focus, and what emerged was the question, "How might we digitize/network the design thinking process?" a question that challenged participants to develop a system that would support the creation, development, and delivery of innovative ideas from the fleet to NAWDC. This became the output the Skybox and Jokers owed to both APL and the pilots working on their own concepts in other rooms.

c. Round 2 of Presentations: Sweet Spot, FLITR, Tech Tac Tours, and PRO

Once again participants and facilitators filed into the hangar room to view skits and presentations developed from the second round of brainstorming. Despite the lower energy upon arrival in the morning, participants were now wide awake and eager to introduce new concepts and prototypes built from a more experienced position. Table 5 provides concise descriptions of the Jacks' prototypes following the second round of brainstorming.

Table 5. Jacks Prototypes after Second Round of Brainstorming.[369]

Concept Acronym	Concept Title	Concept Description
None	Sweet Spot	Short-range, wireless data link for secure transfer of standardized post-flight sensor data, automated debrief analysis and report generation for ship and short platforms
None	FLITR?	A Twitter-like web application to provide a user-customized lessons learned feed to the fleet
Tech Tach Tours	**Tech**nology/**Tac**tic al **Tours**	A leadership-endorsed exchange program for warfighters and civilians to foster a broader understanding of fleet needs and enable faster and more informed design and development decisions
PRO	**P**ersonalized **R**etention + **O**ptimization	Personalized physiological enhancements for optimal debrief and sleep experiences using real-time biomedical monitoring and data.

The Jacks were the first group to present leading with their concept of *Sweet Spot*, a prototype that focused on flight data and what is done with it. Sweet Spot Servers offered an automatic download of flight data which was then incorporated into a Virtual Reality system to conduct post-flight debriefs and After Action Reports. Sweet Spot Servers also featured *Sweet Spot Light*, an expeditionary capability for squadrons to take on deployments. Sweet Spot gained its name from the intersection of three circles in Venn diagram: Servers, Big Data, and Artificial Intelligence. The skit closed by members of the Jacks asking where these three areas of technology met, "In the sweet spot!."[370]

Next from the Jacks was *FLITR*, a concept drawing inspiration from the popular social media tool Twitter. FLITR took a different approach to improving Aviation Mission Support and focused on the high volume of information pushed to squadrons and their pilots as well as the delay that can occur with this information push. The FLITR

[369] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[370] Research Observation, DIUx Mountain View, CA, November 17, 2016.

prototype allowed pilots to set up accounts and customize their preferences in terms of what information is first displayed to them including accident and mishap reports, as well as specific events that may have occurred. The Jacks envisioned this as a tool to quickly debrief the entire fleet of pilots on relevant information without struggling through layers of command and official messaging. Additionally, FLITR would be adaptive over time, further tailoring information flow to the specific user.

Following FLITR, the Jacks premiered *Tech Tac Tours,* which was another deviation from technology-driven prototypes. Much like the tech expo at the beginning of AMS TANG, Tech Tac Tours sought to deliver technology and development companies to pilots in the fleet forces.. Within Tech Tac Tours pilots, especially junior officer pilots, would receive exposure to emerging technology directly from the manufacturer while commercial developers and their engineers would have access to pilots, improving both communities' understanding of what the other was doing. Tech Tac Tours' desired outcome was improved design to technology fielded and increased awareness of capabilities within the commercial sector.

The Jacks finished their second round of presentations with *Pro,* a prototype aimed at maximizing the biological efficiency of pilots while in the cockpit. Pro featured an interface linked to a pilot's flight suit and helmet in order to monitor vital signs and other biological readings the pilot produced. The data generated would develop an overall health profile for the pilot to determine if more sleep may be needed or dietary changes were recommended. Pro would ultimately generate a maximum of focus, energy, and reaction times creating a more effective pilot. Influences of analogous research from Singularity University were evident in Pro as participants sought to leverage specific health data points such as pulse and blood pressure to determine the efficiency of the pilot. In the TANG team's analogous research, Singularity University was able to predict Sepsis in hospital patients by monitoring heart rate alone.

The physical dimension of Aviation Mission Support was largely ignored during the first round of brainstorming as participants focused toward communication and planning systems. Pro served as the first example participants examining the physical

interaction of a pilot while flying, a trend which would continue through the second round of prototypes.

d. AGNOSTIC, ARVIS, and GMPS

The first concept presented by the Kings was *AGNOSTIC*, a method to ensure communication and navigation assurance during missions. The presentation opened with an audience poll asking about degradation of communication assets and their impact to mission execution, which received near unanimous agreement in the form of hands raised, knowing smiles, nods, and even a few vocal affirmations. With their audience primed, the Kings moved directly into their skit which featured a pilot flying at night and struggling to navigate and communicate when suddenly a meter diameter cardboard moon appears. Comically exclaiming, "Oh wow, there's the moon!" the pilot proceeded to gain its position and effectively navigate.[371]

This was at the core of AGNOSTIC, named as such for its indifference to how navigation and communication occurs, just that it does occur. The concept used celestial navigation from the stars and moon for navigation and potentially the moon for communication, weather permitting. Table 6 provides a description of ARVIS as well as the other Kings' prototypes presented following the second round of brainstorming.

[371] Research Observation, DIUx Mountain View, CA, November 17, 2016.

Table 6. Kings Prototypes after Second Round of Brainstorming.[372]

Concept Acronym	Concept Title	Concept Description
AGNOSTIC	**A**gile **N**avigation **O**riented **S**pectral **T**ransfer of **I**nformation and **C**ommunication	A suite of agile data transfer, communication, and navigation options coupled with electromagnetic modeling and mapping capabilities for sustained operations in a contested battlespace
ARVIS	**A**ugmented **R**esponsive **V**isual **I**nteractive **S**ystem	Dynamic in-flight mission support system enabled by synthetic vision and haptic feedback
GMPS	**G**lobal **M**ission **P**lanning **S**ystem	Integrated and collaborative mission support network that provides real-time information exchange across all services and classifications.

The next concept from the Kings was *ARVIS*, a name drawn from the partnered Artificial Intelligence in the *Iron Man* films. ARVIS was described as a haptic bodysuit worn by the pilot that allowed the aircraft to communicate with the pilot utilizing the sense of touch. "You learn to feel the bird after a while," described an F/A-18 pilot, "you get what you can see on your displays and there are some alarms and audible stuff, but you eventually learn how the plane is flying by feeling it."[373] This feeling of the plane is a more natural feedback for most pilots rather than pre-programmed responses and outputs. It was the goal of ARVIS to include the sense of touch as a feedback mechanism, leveraging what most pilots already utilize in the cockpit. Figure 17 is the interior of an F/A-18 Super Hornet cockpit showing the more advanced instrument panels and displays.

[372] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[373] Anonymous F/A-18 pilot, interviewed by Donald Turner, November 17, 2016.

Figure 17. Interior of Advanced F/A-18 Super Hornet Cockpit.[374]

At the completion of the ARVIS presentation, TANG participants were eager to provide feedback, especially the AMS TANG Consulting Lead. The Consulting Lead regularly commented on prototypes with perspective changing questions and challenges with one particularly standing out relating to ARVIS, "what would it look like if you were to wear your plane?."[375] Until this point, many participants had taken the question lightly joking about jetpacks and wingsuits; however, ARVIS was a first step toward the intended idea behind the wearing an airplane. The Consulting Lead outwardly expressed joy and excitement when thanking the Kings for taking on the challenge, and they would not be the last group to do so.

[374] "Boeing Builds Super Hornet Digital Displays for Possible 2015 Upgrade," Defensetech, September 17, 2012, https://www.defensetech.org/2012/09/17/boeing-builds-super-hornet-digital-displays-for-possible-2015-upgrade/.

[375] Research Observation, DIUx Mountain View, CA, November 17, 2016.

The final concept from the Kings was *GMPS*, an acronym for the Global Mission Planning System, a dedicated global planning capability. GMPS was envisioned as a replacement to JMPS by networking all platforms and allowing the planning system to work in a denied or degraded communications environment. GMPS had a dedicated global reach and would employ any and all available communications assets both terrestrial and satellite to maintain a persistent availability.

e. ALTITUDE, SKINSUIT, and SECKSIEGOOSE

Following a 15-minute break, the Aces took the stage to present their concepts beginning with *ALTITUDE*, a new mission planning prototype. ALTITUDE would utilize dynamic data inputs paired with machine learning to adapt missions in real time without a need to land and reprogram the air craft or even reprogram the mission in flight. Because ALTITUDE updated dynamically and in near real time, the concept would alleviate the need for both Kneeboard Cards and Electronic Kneeboard Cards. This prototype found its inspirations from just-in-time logistics, a method of support that provides needs and capabilities on demand. Table 7 contains a condensed description of ALTITUDE and the other prototypes presented by the Aces.

Table 7. Aces Prototypes after Second Round of Brainstorming.[376]

Concept Acronym	Concept Title	Concept Description
ALTITUDE	**All** **T**he **I**nfo **T**hat **U** **D**esire **E**ffortlessly	A cross-platform, synchronized database to consolidate, store, and manage static and dynamic data to support on-demand mission support
SKINSUIT	**S**ensory **K**it **I**ntegrated **N**eural **S**ystem **U**ser **I**nterface **T**echnology	A technology-enhanced flight suit that leverages physiological data and performance feedback to create a real-time coach enhancement to aviators
SECKSIEGOOSE	**S**ecure **E**nhanced **C**ommunications and **K**nowledge for **S**ituational **I**ntegration and **E**xecution – **G**ifted **O**mniscient **O**mnipresent **S**entient **E**ntity	A personal Artificial Intelligence system to reduce mission planning execution time by synthesizing complex sensor data, providing guidance, and supplying real-time feedback and debriefing

Turning their focus to the biology and psychology of pilots, the Aces next presented *SKINSUIT*, a new flight suit concept. This flight suit doubled as physical health monitor for pilots and a cognitive monitor much like the *PRO* concept developed by the Jacks. Working with the aircraft, SKINSUIT would monitor when the pilots physical or cognitive performance was affecting the mission to allow for safer flights and reduced pilot error.

SECKSIEGOOSE was the final Aces concept presented, the name paying homage to the character from the film *Top Gun*. Up to this point of AMS TANG, Artificial Intelligence had been discussed several times and incorporated into numerous prototypes. This AI incorporation traditionally was in planning systems or to a certain extent augmenting the pilot through physical or a system interaction. SECKSIEGOOSE introduced a new form of human-machine interaction, an AI as a co-pilot.

[376] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

SECKSIEGOOSE was a personal AI belonging to each pilot that was partnered with the pilot beginning in flight school and would follow the pilot throughout its career. This AI would be part of a self-sustaining and self-healing network of AIs that could share information increasing the overall intelligence of all AIs on the network. This concept of pairing an AI with a pilot brought a flood of commenters to the microphone with most loving the idea and others eager to take the idea a step further. "What happens to the AI when a pilot retires," "Does the pilot get to take the AI home," and "Do the AIs advance in rank with pilot and therefore outrank other AIs," were just some of questions about SECKSIEGOOSE's life outside of the cockpit. Regardless of love for the idea, or curiosity about the AI it was clear the notion of pilot-machine pairing was seen more fundamentally different than AIs serving human needs.

f. COMANDR, SAMMS, and HIVE

The final group to present was the Deuces made primarily of members from the Electronic Warfare pilot community. Leading off was *COMANDR*, an analytical tool aimed at improving awareness of influences and factors in mission planning and execution. COMANDR was essentially an actively managed data repository containing flight data, communications, and mission plans from all flights. Within this repository big data analytics, machine learning, and Artificial Intelligence would be utilized to find hidden relationships between all data points. Any hidden relationships and trends would help mission planners determine how factors and parameters influence one another highlighting any predictability in aviation tactics. Table eight provides a concise description of COMANDR as well as the other prototypes produced by the Deuces from the second round of brainstorming.

Table 8. Deuces Prototypes after Second Round of Brainstorming.[377]

Concept Acronym	Concept Name	Concept Description
COMANDR	**C**entrally **O**ptimized, **M**ined, **A**utomated **N**eural **D**ata **R**epository	An Artificial Intelligence-based interactive knowledge repository that gathers, sorts, manages, and analyzes platform data to provide tailored, mission-specific information and recommendations to the operator
SAMMS	**S**ignature **A**wareness, **M**inimization, and **M**ulti-platform **S**coring	A pre-flight, in-flight, and post-flight system for optimizing and reducing signatures across all spectrums
HIVE	**H**igh **I**mmersive **V**irtual **E**nvironment	Effect-based mission management environment leveraging UAVs and Artificial Intelligence through interactive control and deep immersion

Next after COMANDR the Deuces introduced the audience of participants to *SAMMS*, a signature analysis concept. SAMMS stood out as a unique concept from both rounds of brainstorming for two primary reasons. First, SAMMS was the first prototype to consider the entire electromagnetic spectrum as a potential vulnerability turned strength. The entire electromagnetic spectrum for the Deuces was not limited to radio frequencies, it also included light frequencies, as well as infrared frequencies. Any sort of wavelength emitted by an aircraft was within the scope of SAMMS. Much of the technology to sense these wavelengths exists already within the DOD but it is often so specialized that its use is broken into different communities within branches which contributed to the second unique aspect of this concept. SAMMS would combine these technologies and turn it on ourselves to determine what friendly aircraft are showing an adversary. This information would then be used to adapt mission planning and tactics thus improving effectiveness.

The final prototype introduced was *HIVE* or, the Highly Immersive Virtual Environment. Finding inspiration from the book and film *Ender's Game*, the Deuces presented a concept that focused on mission management rather than mission planning.

[377] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

The management aspect was seen as an individual controlling large quantities of aircraft in various swarms but never controlling any individual aircraft, only providing direction and tasking to the swarms. Though it was never explicitly stated, HIVE was the first prototype that offered unmanned aircraft as the solution with pilots not being in any cockpit, a not very popular idea given the audience.

g. Reactions from the Skybox and Jokers

Following the second round of presentations, participants of the Aces, Deuces, Jacks, and Kings returned to their breakout rooms and began working on their concept posters and participants in the Skybox and Jokers returned to their room to discuss round two of the prototypes. The first activity was to group the concepts into bins to better organize what the prototype hoped to achieve or the technology it included. The bins included Artificial Intelligence, big data, augmented personnel, cloud, radio frequency denied, uncertain planning solutions, collaboration, and quick wins. Though the quick wins bin did not have the name of technology sector or capability, its title was indicative of the current state of available technology. Within the quick wins bin, participants could put concepts that could easily be put into development based upon commercial or government capabilities.

With such a large number of participants and a desire to discuss the presentations among themselves, the APL Lead had a difficult time finding Skybox and Jokers members to participate in the binning process. With some coaxing some individuals came forward to the board and began separating concepts into the most suitable category which proved more challenging than originally thought. The *Sweet Spot Servers* prototype explicitly stated that it was the meeting of AI, big data, and servers (the cloud), which constituted three different bins for the Skybox and Jokers. Additionally, ‘quick wins’ was somewhat subjective and contained concepts from all of the bins resulting in quick wins being turned from a bin to a mark on the concept card.

Once binning was completed, participants began discussing individual concepts in more depth including what the requirements were to implement them. Rights to privacy as well as exposing the mistakes of individuals would require a cultural shift in the

aviation community. "How would they react? Would they be comfortable up front and then in time become an informed uncomfortable? Where do we draw the line?" asked a member of the Skybox.[378] "Some of the concepts would be closet destroyers," offered another member of the Skybox indicating that there would be nowhere to hide poor performance for pilots.[379] The room was split unevenly between participants that supported the use of analytics and those that did not, a conflict that would not be resolved before the end of AMS TANG.

h. Rapid Integration Process (RIP)

Following lunch the Skybox and Jokers returned to their breakout room for final refinements of their concept which would be presented that afternoon and be the final presentation of AMS TANG. Within the breakout room the interest of all participants had waned leaving a small group of five participants finalizing a prototype system and process for tracking innovative ideas from the fleet and ensuring ideas are seen by the right level of decision maker. As the participants discussed their solution their focus remains on supporting pilots and trying to develop a culture of innovation. "The worst thing you can say to the warfighter is, 'we're already doing that,'" commented a participant working on the final presentation.[380]

After doing an internal share of their prototype it was time to take the *Rapid Integration Process*, or RIP, to all AMS TANG participants, facilitators, and other attendees. Of the five Skybox and Jokers members that completed concept two took the stage presenting a step-by-step diagram illustrating a system that allowed pilots to submit innovative ideas and track their progress from submission until creation or dismissal. The audience seemed to have a difficult time following the processes which was affirmed by audience questions seeking more clarification on timelines and why particular steps existed.

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[378] Research Observation, DIUx Mountain View, CA, November 17, 2016.

[379] Ibid.

[380] Ibid.

One of the last commenters following the presentation was the Consulting Lead. While many positives were offered, some basic principles of Design Thinking and change management were reinforced with comments and questions. "Our goal is to create a culture of innovation," was said more as a reminder than a statement of a shortcoming.[381] In commenting on how ideas were treated within the RIP prototype it was offered that, "there are no bad ideas, just ideas that need to be reworked."[382] And finally, regarding the building of the new culture it was asked, "If you're trying to create a culture of innovation, how do you communicate? Celebrate wins?."[383]

i. Closing out AMS TANG

With all presentations complete, TANG facilitators took the opportunity to solicit feedback from participants on the entire AMS TANG forum. No topic was off the table ranging from the process, the leadership, the attendees, and even the provided meals. Participants eagerly lined up to comment, give thanks, ask questions, and make recommendations for future TANG forums. Apart from overwhelming praise, participants' suggestions included bringing in enlisted flight crew for their unique perspectives as well as maintainers as key portion of Aviation Mission Support. Preparatory materials were also recommended for future TANGs, allowing participants to properly frame their minds prior to arrival and thus creating a 'warm' start to TANG.

Led by the AMS TANG Master of Ceremonies, the forum officially closed the afternoon of November 17th. Following the completion of formal events, many participants lingered in the hangar room conversing with peers, adding their names to the contact board (leaving your contact details to keep in touch), and bringing questions directly to TANG facilitators, representatives from PMA-281, and DIUx. Despite the fatigue that began the day for many of the attendees, it seemed as though they were eager for more TANG.

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[381] Research Observation, DIUx Mountain View, CA, November 17, 2016.

[382] Ibid.

[383] Ibid.

E. CONCLUSIONS

This chapter provided the circumstances and events that enabled AMS TANG to generate 28 robust concepts and prototypes over the course of four days. The emphasis of the presented case was the activities and processes that enabled over 100 participants to learn and execute the design thinking process to develop innovative ideas at the AMS TANG forum.

IV. RESULTS AND ANALYSIS

A. INTRODUCTION

The results portion of the research will have two primary focuses first discussing what concepts from Aviation Mission Support (AMS) Tactical Advancements for the Next Generation (TANG), and second examining which aspects of change management and design theory were employed by TANG facilitators to generate these concepts.

Discussion of concepts in development will provide insights into both how AMS TANG concepts are selected for further development as well as impacts to development and acquisition processes. Analysis of these concepts will provide greater context from which the research questions can be answered in addition to opening the scope of the research into external factors that affect applications of design thinking. Additional insights gained can then be applied to analysis of applications of design thinking as well as understanding of how operational needs were met through the concepts.

An examination of the processes that enabled the development of new concepts will be compared against change theory and design theory to provide in-depth answers to the research questions. This analysis will aid in the development of conclusions aimed toward building a culture of innovation within the DOD. The development of concepts aimed at warfighter needs by utilization of design thinking methodologies is an indication of a new cultural approach to employing innovation.

This development of warfighter needs speaks to the central focus of building an innovative culture. Unique and dynamic solutions developed by the users, for the users, tailored toward current and future problem sets was the ultimate intent of AMS TANG. Within the confines of AMS TANG the a culture of innovation was created in a manner reflective of the eight-step change process however, the analysis will show through the larger community of the DOD the bid for organizational change is in its infancy as the guiding coalition was only recently created.

B. RESULTS OF THE CONCEPTS

All of the AMS TANG Design Thinking process plays a role in the future development of concepts, arguably the two most important steps are the building of concept posters and the concept grouping by members of the Jokers and Skybox. In the development of the concept posters, participants and facilitators provided details describing the internal and external functions of their prototypes ultimately allowing TANG facilitators to build a single chart snapshot of the new idea. Concept grouping was an activity conducted by key decision makers and stakeholders present in addition to the tech expo representatives that sought to segregate ideas based upon the technology required to support it as well as the maturity of that supporting technology.

1. Outputs of the Concept Posters

During AMS TANG participants and facilitators build large concept posters on 8′ x 4′ cardboard allowing the maximum amount of information on the prototype and associated feedback to be present. These concept posters would ultimately serve as the outbrief of results from AMS TANG provided to key decision makers with the decision authority and financial means to potentially fund ideas. In addition to key leaders the contents of the concept posters were provided to leaders in the technology industry to determine what was potentially feasible now and what would be feasible in the future as a means to moderate some of the enthusiasm of key leaders.

Immediately following AMS TANG, members of the APL team and external consultants set to work condensing the information of the concept posters into concept cards, one PowerPoint slide per prototype developed in AMS TANG. Figure 18 is the concept card developed for HIVE, the prototype developed by the Deuces group which drew its inspiration from the novel and film *Ender's Game*.

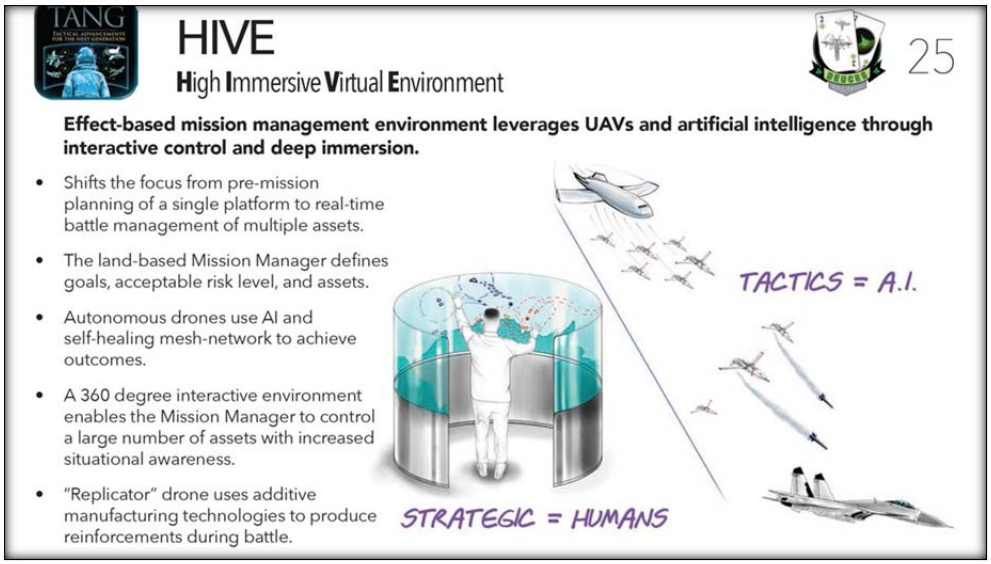

Figure 18. HIVE Concept Card Developed from Concept Poster.[384]

The HIVE concept was developed with the assumption that Unmanned Aerial Vehicles increase in both quantity and autonomy, essentially saturating the airspace over a conflict with aircraft. Rather than increasing the quantity of pilots, creating infinite opportunities for airborne collisions, participants of AMS TANG developed a concept that allowed a single pilot to control swarms of aircraft like a flock of birds aimed at a single objective.[385]

HIVE has yet to be selected for future development however the concept card provides some level of context to the prototype as well as how the idea would function in the real world. The description is paired with an image that is often more telling than just a list of capabilities and functions. In the case of HIVE, a user stands in a 270 degree curved display interacting with autonomous aircraft using only his hands. The imagery shows developers how the eventual users envision integrating with HIVE which is much more valuable than just performance parameters.

[384] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[385] Research Observation, DIUx Mountain View, CA, November 17, 2016.

2. Outputs from the Concept Grouping

Following each rounds of prototype presentations, the members of the Jokers and Skybox discussed the concepts presented by the participants with an emphasis on what could be done now and what ideas needed more time for technology to mature. Also considered were the potential costs associated with the prototype and if it could be developed with funds already appropriated to NAVAIR or DIUx or if the concept needed research and development funds from a larger budget. This binning of ideas was not intended to immediately exclude ideas, rather it was intended to identify what was ready now and what would take more time and development to bring to the warfighter.

This analysis of time and resources was only a part of the equation for the APL team with PMA-281. One of the purposes of any TANG event is to have the mission executors or, warfighters, express what is important to them in the execution of their duties. In the case of AMS TANG, the warfighters could not only express what would enhance their effectiveness, but also what would truly impact mission accomplishment. This metric of impact to mission became a second dimension with which APL and PMA-281 could segregate concepts. The final metric titles determined by the APL team were "Impact" and "Difficulty," as shown in Figure 19.[386] Once grouped, PMA-281 identified which concepts could be rapidly delivered to the fleet.

[386] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

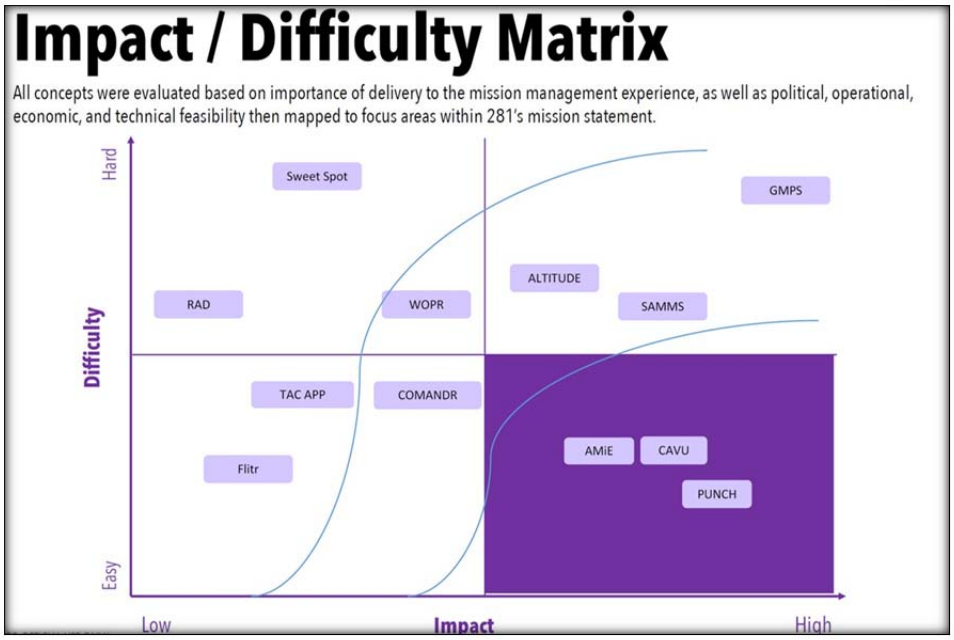

Figure 19. Impact/Difficulty Matrix for AMS TANG Prototypes.[387]

As Figure 19 illustrates, AMiE, CAVU, and PUNCH were determined to be the most feasible with the highest impact to Naval Aviators while concepts such as COMANDR, WOPR, ALTITUDE, SAMMS, and GMPS were also impactful, but would be more difficult to develop. These prototypes would receive the immediate attention and resources of APL, DIUx and PMA-281.

Impact was defined as the "importance of delivery to the mission management experience," which is to say its contribution to Aviation Mission Support.[388] Factors that influenced a concept's difficulty value focused on feasibility of development based on "political, operational, economical, and technical" factors.[389] Specifically AMiE, CAVU, and PUNCH introduced new approaches to data management, sharing, and utilization impacting all three facets of Aviation Mission Support: Pre-flight, In-flight, and Post-flight.

[387] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[388] Ibid.

[389] Ibid.

3. Turning Outputs into Progress

Beginning in early 2017, AMS TANG outputs and results began a traveling road show beginning with the Program Executive Officer for Unmanned Aviation and Strike Weapons (PEO U&W) and moving through the Director of Air Warfare (OPNAV N98) with a chance to brief the Commander of Naval Air Forces (CNAF).[390] In addition to the road show, APL explored opportunities to develop AMS TANG outputs DIUx and other industry partners "leveraging design sprint techniques with AMS TANG alumni."[391]

a. Using Concepts to Plan the Future

With time, fiscal appropriations, and technology all being finite and potentially limiting factors, not all AMS TANG concepts were immediately selected to move to into a prototyping phase. As Figure 19 illustrated, some ideas were not in the realm of possible now or did not have as immediate an impact as others however, this assessment did not exclude prototypes from being beneficial to the future of Naval Aviation.

In the acquisitions process for the DOD, key documents provide potential developers an idea of what capabilities a system will require should a contract be awarded. The first of these documents is the Capability Development Document (CDD) which provides attributes a system must be capable of performing should the system go into development. Through further research and development of items on the CDD, Key Performance Parameters (KPP) are generated which are more detailed and descriptive aspects of a system including specific quantitative capabilities.

From the 28 concepts developed during AMS TANG, at least eight concepts are included in the CDD for the Next Generation Mission Planner.[392] This inclusion ensures that the ideas generated by participants are brought to the forefront of the next major Aviation Mission Support system acquisition.

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[390] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[391] Ibid.

[392] Ibid.

b. Concepts in Development

With many of the AMS TANG outputs included in future systems for Naval Aviation, some concepts are currently in development with various government and commercial organizations. By leveraging co-funding ventures between government entities as well as attaching prototypes to current systems in development, APL and PMA-281 have begun the process of speeding desired capabilities to the warfighter.

Currently the prototype AMiE is under development as the one-stop shop for data allowing for automatic updates to systems and parsing of data. This concept is now called "Audit" however much of the functionality remains the same. Figure 20 is the concept card for AMiE.

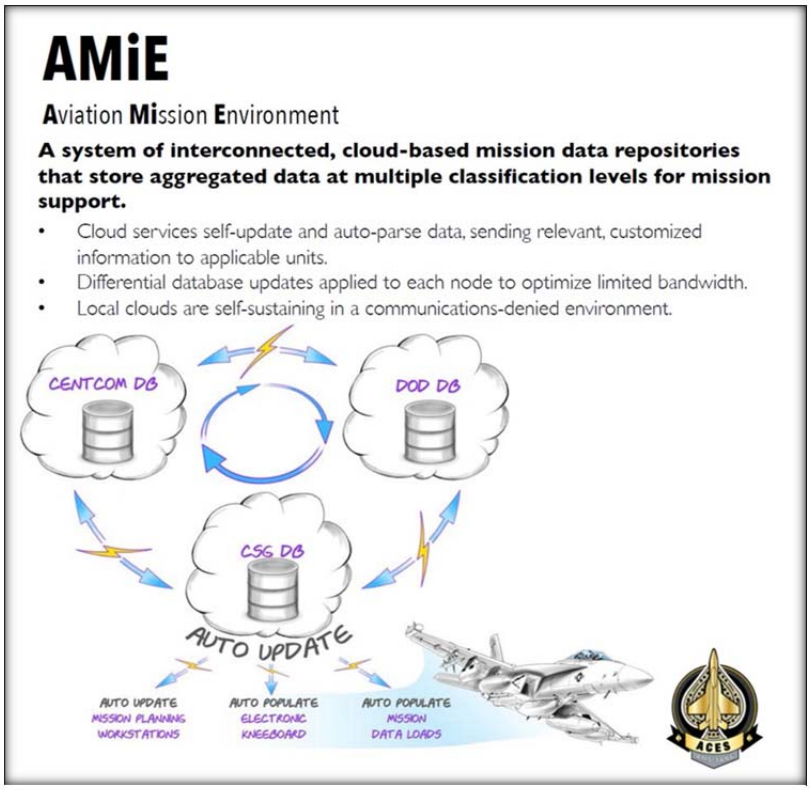

Figure 20. AMiE Concept Card.[393]

[393] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

As the concept card displays, AMiE provides access to data across all Naval Aviation forces and updates mission support applications automatically. In current practice, a pilot needs to receive an update compact disc in the mail, and spend a morning or afternoon updating the system. In preparation for a deployment, pilots struggle to access current policies, tactics, techniques, and procedures that govern operations overseas, something that is highly beneficial. Likewise, if a pilot is deployed, accessing information from garrison networks is equally challenging. With AMiE, systems update as seamlessly as smartphone applications and accessing information crucial to mission accomplishment is not impacted by the location of the pilot or the location of the data. Information availability is the same regardless of physical location, classification level, or connectivity speeds.

WOPR, the concept that generated a high volume of feedback during AMS TANG, went through the DIUx Commercial Solutions Opening process which asks commercial vendors for potential solutions for development of prototype concepts.[394] During this process, 20 companies provided pitches for how they would produce WOPR which was down selected to four pitches and eventually one pitch was selected.[395] As of the writing of this thesis, WOPR is in an 18-month build phase for a beta prototype with funding coming from both NAVAIR and DIUx.[396] Figure 21 is the concept card developed for WOPR following AMS TANG.

The advantage of WOPR is that it simulates having hundreds of hours of experience in aviation planning. Currently, pilots rely on doctrine and practical knowledge to develop flight plans. This can be the experience of an individual or an aggregate of multiple pilots. Pilots often labor for hours, pouring over multiple courses of action while attempting to determine the most ideal method.

With WOPR, tasks and objectives can be combined with numerous variables to determine the optimal course of action. What previously took countless man hours and

[394] AMS TANG APL Lead, interviewed by Donald Turner, August 15, 2017.

[395] Ibid.

[396] Ibid.

years of experience, is now a matter of inputting data and awaiting outputs from WOPR to make the ultimate determination.

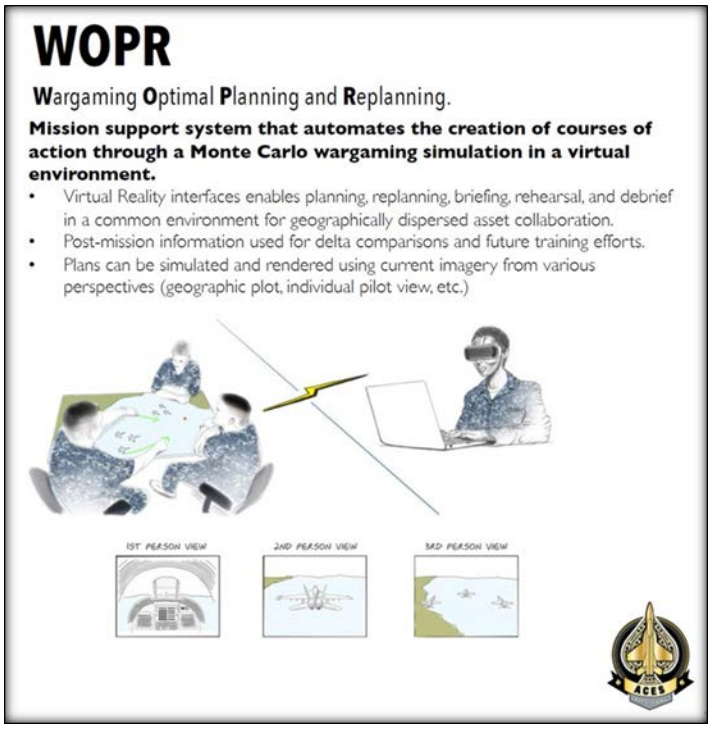

Figure 21. WOPR Concept Card.[397]

In the development of PUNCH, APL took a less common approach to bring the concept to fruition. Recalling that PUNCH offered aviators an opportunity to simulate mission plans as well as debrief missions in a virtual environment, this concept reminded the APL team of a concept developed in a previous TANG, specifically the Integrated Air Missile Defense (IAMD) TANG.[398] Originally titled DySSCO (pronounced "Disco") which stood for Dynamic Selectable Scalable Capability Optimization, the now titled Operational Mission Planning Table provided "a common data layer and a fused 3D visualizer allowing the warfighter to adjust fidelity, risk, and threat posture."[399] The now, unofficially named, "Disco Table" provided missile defense planners a virtual

[397] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[398] AMS TANG APL Lead, interviewed by Donald Turner, August 15, 2017.

[399] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

environment from which mission planning could be conducted as shown in Figure 22, the original DySSCO concept card.[400]

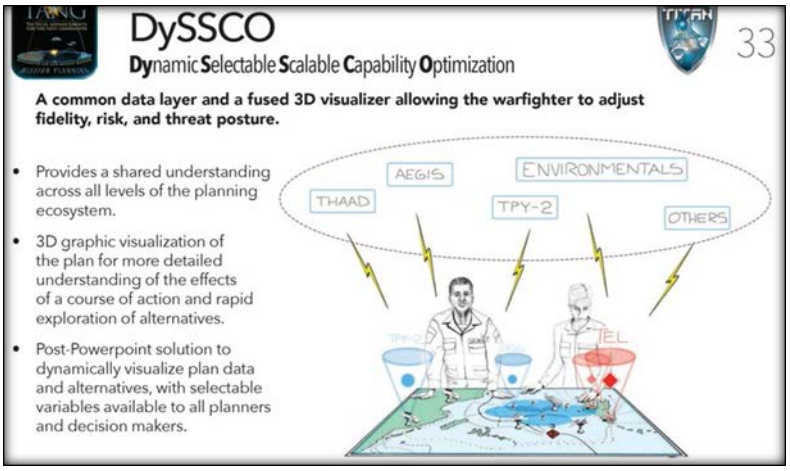

Figure 22. DySSCO Concept Card from IAMD TANG.[401]

Given the similar theme between DySSCO and PUNCH in that both sought a virtual environment within which planners could both simulate and debrief, there was an opportunity to capitalize on a project underway. While PUNCH was illustrated much differently than DySSCO, as shown in Figure 23, the fundamental core of a virtual planning environment remains unchanged. Furthermore, given that both concepts will potentially run on a similar platform, integrating aviation with missile defense can become a more intertwined mission without hurdles caused by different hardware and software.

PUNCH provides an opportunity for pilots to virtually rehearse a mission, execute the mission, and virtually debrief the mission following the three phases of Aviation Mission Support: Pre-flight, In-flight, and Post-flight. In current practice, pre-flight rehearsals consist of two-dimensional static PowerPoint slides aggregate into long briefs. Aircraft icons change position from slide to slide to indicate movement through time and space which is meant to provide an image of the mission in execution. The post-flight

[400] AMS TANG APL Lead, interviewed by Donald Turner, August 15, 2017.

[401] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

debrief is only slightly more capable with moving icons on a two-dimensional screen and audio recording of radio communications providing some level of context to the moving icons.

PUNCH completely reimagined this process allowing pilots to rehearse in conditions as near execution as feasible. In preparation for a mission, an aviator now loads the mission parameters into PUNCH and places simulator glasses in front of their eyes. The mission is flown virtually as many times as necessary before entering the cockpit. Following the mission, pilots gather together again with their virtual simulation glasses and relive the execution phase with the freedom to pause and restart the playback conducting *what if* analysis to determine what can be improved.

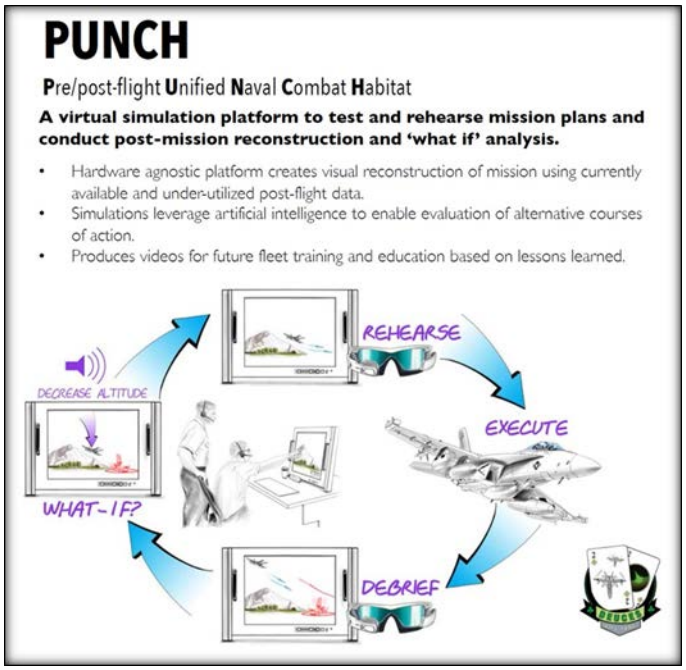

Figure 23. PUNCH Concept Card.[402]

As of the writing of this thesis, two additional concepts, RAIDR and COMANDR, have been identified for development but are awaiting funding, which will likely become available in the fiscal year.[403]

[402] AMS TANG Applied Physics Lab Lead, personal communication, August 21, 2017.

[403] Ibid.

c. Wakes of Innovation

A wake of innovation is imagery used "to depict an innovation as emerging in and traveling across an innovation space, much as a wake travels through water."[404] This describes a side effect of innovation in that when different groups are connected organically or by means of a specific undertaking, an innovation in one group will likely cause an innovation in other connected groups.[405] This phenomenon was an unexpected output of AMS TANG that resulted in NAVAIR reexamining how the vision for Aviation Mission Support is communicated and explored internal and external to the organization.[406]

> About three weeks or so after we wrapped on the [AMS] TANG event, NAVAIR took a look at all the concepts, took a look at the research findings, and the discover deck, and then looked at their mission and vision and said, "we have to reimagine what we are talking about here and how we are communicating that to everybody." So we created this thing called a "Vision Quest."[407]

The Vision Quest was method by which NAVAIR could provide clearer intent to PMA-281 specifically in the realm of Aviation Mission Support. PMA-281 changed its perspective on aviation mission planning expanding widening the aperture to redefine mission planning into a "comprehensive mission management experience."[408] Aviation mission management became an ecosystem of tools with various attributes all essential to the total experience rather than loosely connected software and hardware built to integrate laptops in planning spaces with the physical aircraft systems.[409] This new ecosystem accounted for the different phases of a mission, how pilots receive data, how pilots interact with data, and how pilots interact with one another within squadrons and

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[404] Richard J. Boland Jr, Kalle Lyytinen, and Youngjin Yoo, "Wakes of Innovation in Project Networks: The Case of Digital 3-D Representations in Architecture, Engineering, and Construction," *Organization Science* 18, no. 4 (August, 2007): 631–647, 631.

[405] Ibid., 631.

[406] AMS TANG APL Lead, interviewed by Donald Turner, August 15, 2017.

[407] Ibid.

[408] Ibid.

[409] Ibid.

between other types, models, and series of aircraft.[410] The Vision Quest asked of PMA-281, "What's the mission and the vision?"[411]

No specific concept or research finding could be identified as the single catalyst prompting the development of the Vision Quest. It is more likely that in addressing the various design challenges of AMS TANG, participants showed NAVAIR and PMA-281 that mission support goes beyond laptop computers and aircraft. Holistically, the concepts illustrated a cradle to grave experience of an aviation mission and the desired technologies to support the ecosystem. The innovations of AMS TANG created a wake that influenced a response from connected organizations.

C. ANALYSIS OF AMS TANG

The analysis of the AMS TANG events will focus first on change theory both from the perspective of group change and organizational change. The literature of Lewin and Kotter will serve as the foundation from which change will be discussed. The analysis will then examine design theory with an emphasis on Design Thinking and the Design Mindset.

1. Change Management

AMS TANG provides a unique opportunity to observe a small but diverse cross section of the DOD from the beginning of the change process to near the end. While the Naval Aviation community within the DOD is unique in its own right, the diversity in platforms, mission sets, and even Navy and Marine Officers at AMS TANG provides a more enterprise view of the organization. The prospect of examining both the change of a microcosm of Naval Aviators within the AMS TANG events and the grander change within the Naval Aviation community is a particularly profound opportunity.[412]

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[410] AMS TANG APL Lead, interviewed by Donald Turner, August 15, 2017.

[411] Ibid.

[412] Johnston and Featherstone, "Introducing Innovation through Design," 129.

a. Unfreezing and Freezing the Pilots

The literature review revealed that group change is the process of unfreezing behavior, changing behavior, and freezing in the new behavior. While this is a simplification for the benefit of making the steps easy to understand, the fundamental principle remains constant. Going deeper into group change theory revealed that group decisions influence more change than simple lectures, and the effects and reach of change can increase over time.

To successfully execute AMS TANG, facilitators had the significant challenge of unfreezing the mental models and heuristics so common to aviators. With so much of their training aimed toward what to do when there is an emergency and the remainder of training focused toward specific tactics, techniques, and procedures, the actions of pilots while flying can be argued as reflexive. Some TANG participants even suggested that the act of flying was very low their personal cognitive processes and other tasks in the cockpit were more demanding of their focus.

Breaking this practice of relying on reflexes and mental shortcuts to decisions was essential to the success of TANG and, it was uniquely accomplished through the design thinking process. Once in the group workspaces, the first brainstorming activity executed by the Jacks was to think of 50 ways to get a cat off of a roof.[413] This activity began breaking participants free of their decision attitudes, picking from a known list of alternatives, and moved mindsets toward a design attitude, developing unique solutions.

This transition from decision to design was not an instantaneous event in the room beginning from the first idea on a Post-Its note, rather the uncommon problem paired with the required quantity is was ultimately began the process of change. The need to remove a cat from the roof is not necessarily a common problem, but it was a problem that could be widely sympathized with regardless of a person's background. Because the problem was easily understood and somewhat relatable, it did not take significant critical thinking to begin developing solutions. It was an uncommon but relatable problem that did not require high levels of understanding.

[413] Research Observation, DIUx Mountain View, CA, November 14, 2016.

The problem space turned out to be only a portion of the equation as quantity of ideas was equally important to the unfreezing process. In a room full of ten or fewer people, to ask for ten ideas on how to remove a cat from a roof could result in ten very plausible solutions based on personal or other experience. The number 50 however, forced participants to run out of conventional ideas and break into the unconventional with ideas such as the "kitty cannon," meant to launch enough cats onto the roof that insufficient space would force the original cat off the roof.

The problem space paired with the volume demand was critical to the unfreezing of decision mindsets, but how the unfreezing was conducted can be linked to its ultimate success. As previously mentioned, group discussions tend to influence more change when compared to an individual or group lecture. By doing the exercises with the group allowing participants to bring forth ideas freely and rapidly, some even building off the ideas of others, a small consensus can come to form. This became especially apparent in the design challenge brainstorming sessions as participants would feed off of one another's ideas developing an idea dialogue beyond simply writing down suggestions.

It was during the design challenge brainstorming sessions that the change was made in the participants. The "How Might We" questions were addressed without regard to the immediately possible and ideas began to incorporate what would be considered science fiction in the world of entertainment. In some cases as mentioned in chapter three, groups developed new design challenges while working through their current challenge thus expanding the problem space further to incorporate more ideas.

Freezing in the change is difficult to assess with participants and the Naval Aviation community in its entirety. It can be argued that for the participants of AMS TANG, maintaining both a design and decision attitude is probable but that cannot be extrapolated to the entire enterprise. The tempo witnessed by the research team at Air Wing Fallon is not likely to slow sufficiently to allow employment of the design processes. It is far more likely that participants will embrace the change when the situation allows for it or dictates it.

b. Following the 8 Steps

The literature review examined Kotter's 8-step change process for organizations diving into specific tasks and actions intended to improve the change process and increase the likelihood of success. From the lens of AMS TANG alone, several of the initial steps were conducted by the facilitators from APL as well as the consultants. A sense of urgency was established by PMA-281 funding AMS TANG and both the guiding coalition and development of a strategy were handled by the research team. In the form of briefs and activities, the change vision was communicated however, it was not until the second day with brainstorming activities were the participants given the power to take action.

Short-term wins were accomplished after the first round of brainstorming and following the presentation of these prototypes more wins were gained following the second round. Coming into the final step of the change process, anchoring the culture, assessing the depth of change is challenging. While the new culture within AMS TANG was certainly anchored in the participants and facilitators, these newly changed individuals would soon be divested back to their former cultures in which the design mindset could be the minority.

A far greater opportunity for analysis exists when broadening the scope of the organization to Naval Aviation from the purview of NAVAIR, PMA-281, and the enterprise made up of all the pilots and support personnel. The call to action for innovation maintains similar origins at PMA-281. The decision to sponsor a design thinking event to innovate ideas for the future of Aviation Mission Support may not indicate urgency at first glance. However, the act of dedicating funding to a project of this magnitude speaks more to its importance than any urgency.

As a result of AMS TANG, the guiding coalition for Naval Aviation was built in the form of the participants and stakeholders. Most participants will return to their respective commands and not be in a senior leadership position immediately but, over time these individuals will ascend in rank thus promoting members of the coalition that believe in the vision.

Prior to AMS TANG, PMA-281 may have believed that the vision and strategy was ready for dissemination however like Kotter suggests, the vision must be vetted through the guiding coalition.[414] It is this point in the change process toward a culture of innovation that Naval Aviation currently sits. Recalling the Vision Quest as a result of a wake of innovation, PMA-281 is now reevaluating its vision for Aviation Mission Support as a result of the outputs from its guiding coalition. This vision development is essential to the continued efforts of its change process however, it did not prevent the organization from performing subsequent steps in the process.

Running concurrently to strategy and vision development, NAVAIR, in joint effort with APL and DIUx, has put innovative concepts into prototyping and development. This signifies the generation of short-term wins, especially if these concepts are delivered to testing or training commands for the community to experience.

Bypassing steps in the change process is not strictly forbidden; however, deferring steps for later consideration can have consequences. Without a change vision and strategy, the process can become aimless and eventually suffer catastrophic failure. The current efforts of PMA-281 do not indicate a desire to skip parts of the process, rather the current status of the change is solely the result of new insights provided by the guiding coalition. Despite the strong beginning and short-term wins in a small amount of time, this analysis cannot yet say, whether the organizational change will be effective.

2. Design Thinking

Some aspects of the design mindset were discussed in the change management analysis however, these aspects will receive more attention and focus in this section. The design mindset and its role in AMS TANG were critical to its successful production of 28 concepts. To better understand what fostered this attitude the design thinking events of AMS TANG will be discussed to understand how these conditions can be recreated.

[414] Kotter, *Leading Change*, 81.

a. Fostering the Design Attitude

The literature review described the difference between a decision attitude and a design attitude with the former being an analysis of alternatives and the latter being the designing of alternatives. One assumption of a decision attitude is that identifying alternatives to a problem is easy while selecting the best solution is challenging. The decision attitude has a near opposite perspective in that designing the best solution is the challenge while selecting the best design is simpler.

Transitioning participants to the design attitude was accomplished early in the brainstorming activities conducted with the breakout groups when participants were challenged to develop new and unique ways to remove a cat from a roof. This was sufficient to break from the decision attitude, but it did not on its own foster a design attitude.

The seven rules of brainstorming provided a foundation of support for maintaining a design attitude by allowing participants to speak freely uninterrupted, and pushing the boundaries of possible. Within the brainstorming rules there are acknowledgements to general politeness such as deferring judgement and only holding one conversation at a time. These rules exist primarily to maintain a level of civility during an aggressive and physically active activity. In brainstorming participants have a short period of time to generate a large quantity of ideas, put these ideas on a Post-Its note, and physically get up while talking and place it on a board. By itself the act of standing up and walking with a piece of paper is not taxing for most however, when combined with listening, thinking, writing, and drawing, the action can become somewhat complex.

The remaining five rules of brainstorming are the true support pillars of maintaining a design attitude. The encouragement of wild ideas creates an atmosphere of imagination which rests on the notion that it is easier to ground a concept later than try and boost an idea that is already normal. For participants that may not have as active an imagination, another rule of brainstorming is to build on the ideas of others which is very similar to the rules of improvisation. Individuals participating in brainstorming should

look at others' ideas with the mindset of *yes, and…* which does not remove components of ideas rather, it bolts on another feature to an idea.

To balance out wild ideas and ideas built on the thoughts of others, the rule of staying focused on the topic ensures the brainstorm remains locked into the task at hand and all efforts are put toward the design challenge. During AMS TANG, this rule was broken magnificently by groups pursuing new topics in their approaches to problems.

As previously mentioned in Chapter III, the Kings managed to come up with another design challenge during their second day of brainstorming. It was an impressive event which surprised the facilitators and caused the whole room to take a pause realizing that a challenge had given birth to another challenge. "It's like design thinking *Inception*," remarked an AH-1 pilot with the Kings, a reference to the film that features dreams within dreams.[415]

The metamorphosis of this new How Might We… question was only possible by breaking one rule, arguably two. While working on concept posters and brainstorming simultaneously, some members of the Kings working on the TIE concept poster became distracted looking at feedback and trying to also provide ideas to the group. The focus was split, violating brainstorming rules but, without looking at TIE and trying to answer how to communicate in a degraded environment, asking "how might we passively coordinate a mission," would not have been discovered.[416]

The potentially second rule broken in this event was the deference of judgement. During brainstorming, participants are free to ask for clarification on an idea providing everyone with a clearer picture of what is being suggested and possibly providing a second idea that builds upon the first. In some cases, this clarification allowance can be a double edged sword because the difference between asking a question and judging an idea can be as simple as tone and cadence in a person's voice. In the case of the Kings, it was not immediately clear to facilitators what the tone was when a participant asked another, "What do you mean quantum comms?" in reference to a theoretical

[415] Research Observation, DIUx Mountain View, CA, November 16, 2016.

[416] Ibid.

technology.[417] Without this question and the asker's misunderstanding of a new concept, the notion of coordinating missions without sending signals would not exist.

Equally important to the rules violations is the facilitators' willingness to allow the brainstorming rules to be broken and let the conversation stray. Abiding by the rules strictly will not result in a lesser product however, some leeway can lead to a tremendous discovery.

b. The Value of Feedback and Dialogue

Feedback and dialogue are two very separate but very critical aspects of the AMS TANG design thinking process as well as maintaining the design mindset. Recalling the feedback immediately following prototype presentations in chapter three, the groups that just finished presenting was required to stay on stage to receive comments and questions from the audience. The presenting group was not permitted to immediately address the comment, rather a simple "thank you" was the preferred response. Despite this rule about the feedback process and etiquette, some groups felt naturally inclined to answer a question or respond to a comment as is the nature of the Naval Aviator occupation and military members in general. When someone speaks asks a question, it traditionally merits a response.

Conversely, dialogue during AMS TANG was reserved for the breakout rooms and was kept almost entirely within participants which developed that specific prototype. This is the clear division between the two methods of communication. Feedback is from the masses, and dialogue is kept to the individual concept teams.

Feedback in the context of the design thinking process serves two significant purposes, providing outside perspective, and continuing the brainstorm. Leading up the presentations, participants were focusing on a single concept for close to four hours between designing the prototype, developing capabilities, and writing skits. Over the course of this period tunnel vision on a project can occur resulting in missing crucial details or even liking a concept too much. The perspective of a participant outside of the

[417] Research Observation, DIUx Mountain View, CA, November 16, 2016.

group is capable of seeing the larger picture while the owners of prototype are focused on the details. Additionally, outside perspectives can bring new biases to the project which can ultimately improve it.

In the brainstorming rules, participants are encouraged to build upon the ideas of others an activity that is very comparable to how feedback was conducted during AMS TANG. Comments that fell into the, I Wish… category were essentially saying, 'yes, and…' Particularly for participants that had grown weary of thinking about their own prototype, having a new round of individuals come in and brainstorm on the topic was very beneficial to improving the concepts.

During AMS TANG, dialogue had three distinct forms: social interactions, concept development, and brainstorming. The first two forms are somewhat common sense and accounted for the majority of the dialogue supporting the design mindset. Social interactions occurred during breaks, lags in the schedule, meal times, and when all members would gather for announcements and presentations. In these social gatherings, participants, facilitators, and members of the tech expo would share what their next concept was or what design challenge each was tackling. Ideas flew freely without any essence of competition or fear of attribution.

Dialogue within groups tended to be more structured and focused on the next concept and prototype however, ideas still flew freely and eavesdropping was not considered inappropriate. The third type of dialogue, brainstorming, was its own dialect that evolved over the course of AMS TANG.

Beginning with the very first brainstorming session in the breakout rooms, participants would accidentally interrupt one another, there were long pauses between ideas, and Post-It notes would be scattered about the boards in an unorganized fashion. These characteristics were understandable given that many participants did not know one another, and the activity was completely foreign to them. Brainstorming in those early sessions was individuals presenting their ideas within a group to ultimately create concept.

During the third day of AMS TANG, the brainstorming activities could not have been further from their beginnings. On day three once the brainstorming clock began, participants individually approached the board with ideas quickly describing the idea and returning to their seat ready to write again. Rarely would more than one person stand up at a time and there were virtually no pauses before time expired. It could be described as a well-choreographed dance between group members; however, this would not be an accurate simile. To say it was choreographed would be a disservice to the participants that had only seen the design challenge once before.

The most impressive aspect of the final round of brainstorming is that when participants spoke, one after another, their comments sounded like a conversation, not a series of very short stories. Furthermore, non-verbal communication was also rampant through the process as eye contact, head nods, and subtle hand gestures were used as naturally as spoken word. Participants were improvising well together to create new and original ideas for Aviation Mission Support.

Despite feedback and dialogue being so separate and distinct within AMS TANG, their relation was symbiotic in that without one, the other would suffer. Dialogue without feedback would result in a continued narrow-focused effort almost homogenous in its inputs. And feedback without dialogue would result in minimal incorporation of new ideas into the concepts. Both are required to support and maintain the design mindset throughout a design thinking exercise.

D. CONCLUSION

This chapter presented the outputs of AMS TANG as well as analyzed the events through the lenses of change theory and design thinking. Analysis of change management revealed the unique methods employed by facilitators to make changes within groups while the longevity of the change was discussed. Organizational change practices were used to frame the activities of AMS TANG as well as the efforts of NAVAIR and PMA-281. A focal point of design thinking analysis was maintaining the design attitude through brainstorming activities as well as the value of feedback and dialogue in sustaining the design mindset.

V. CONCLUSIONS

A. MAINTAINING THE DESIGN ATTITUDE

Within the Fleet Marine Force, planning is conducted utilizing the Marine Corps Planning Process. It is a sequential process designed to analyze a problem, develop potential solutions for a commander, and subsequently pick and execute a course of action. This process is taught to all officers and most Staff Non-Commissioned Officers and is considered the standard for how to plan missions.

Beginning with the receipt of an order, staffs begin to frame the problem focusing on what the objectives are, what is known about the enemy, what capabilities are at a unit's disposal, and what information is still needed to make the best possible decision on how to conduct the mission. Problem framing is often bound by time constraints, known and practiced doctrine for planning, and the resource limitations of the unit which makes problem framing both and art and a science.

From the outputs of problem framing the commander provides guidance on what courses of action he or she would like to see and, traditionally, no more than three courses of action are to be developed and with the commander's guidance. This transitions the staff into the course of action development stage in that rough ideas of how to execute the mission are shaped into more definitive plans.

In these beginning phases of the Marine Corps Planning Process, there is tremendous potential for applications of design thinking. In many ways, the process is set up to allow for a design attitude seeking to develop solutions rather than pick from alternatives. Unfortunately, the rigid framework of the process can be restrictive in nature preventing the free flow of ideas.

1. Framing the Question versus Framing the Problem

When going through the Marine Corps Planning Process, objectives are clearly stated and the staff goes to work figuring how to reach the objective and what resources are required to do so. This is often posed in the form of "we need to get to X with Y by Z

o'clock." This method of information exchange is valuable in its own right given that it conveys a sense of urgency and priority to the individual or individuals that are receiving the message.

This should be compared to how challenges are framed in the design thinking process of AMS TANG. Consider if the design challenges were worded differently than, How Might We… and, instead, began with, We Need To…. The concept posters would seem more demanding and narrowing reading, "We need to enable team-based collaborative planning." The immediate response of most would be to find the simplest and most reliable solution to the problem. Conversely, "How might we enable team-based collaborative planning?" invites new and innovative solutions to the table as you answer a challenge, not solve a problem.

B. INNOVATION, MORE THAN JUST WORDS

Many services are offering innovation challenges to their members seeking the next great idea or rough prototypes worth further investigating. Often times the submission format for these concepts is a document restricting the submitter to just what can be described on paper. It is difficult to see how AMS TANG could have been the success it was if participants were limited to just writing out their ideas.

1. Benefitting the Presenter

When limited to words, the developer of an innovative idea is not always forced to think through how a concept will look or how it interacts with users or the outside world. Utilizing only a write-up often ends in a list of capabilities that comes off more as specifications rather than a completely new prototype.

Beginning with a picture, an idea now escapes the restrictions of being a noun and a list of adjectives. This is paramount to why during brainstorming, participants are encouraged to draw pictures on Post-Its in addition to writing the idea down. The concept now becomes an entity that has some sort of physical form manifested into the creator's vision. Performing a skit provides even more to the creator as now the entity is

interacting with its user as well as the surrounding ecosystem. Through images and performances, a much richer concept takes shape for the creator of an idea.

2. Benefitting the Decision Maker

Some of the same benefits a creator enjoys from elevating the medium of delivery from words, to images, to performances, are also additive to the recipient of ideas. Words are limited in their ability to convey meaning as there are a finite amount and often times, words are skimmed through to find keywords.

While words are rarely unique, images and performances are much more telling of an idea's purpose and capabilities. It would take tens of thousands of words to completely and accurately describe a few quality images or a short five minute skit of an idea. For the decision maker, understanding what a concept is and how it interacts with the world is much more beneficial to determining if further resources should be applied to an idea.

C. CONCLUSIONS

The AMS TANG Case Study provided a glimpse into the research, activities, events, and outputs of a design thinking forum for Naval Aviators showing the preparation and actions that support a method of innovation. The format and activities of AMS TANG provide an avenue of approach for DOD and service leadership to take on the arduous challenge of promoting innovation throughout the armed forces culture. The call for service branches to innovate has become more common in recent years with various paths in use including online submissions, and events similar to AMS TANG. As the missions of the DOD grow increasingly diverse, having personnel throughout the armed forces skilled at the practices of design thinking is beneficial to maintaining a competitive advantage over adversaries abroad and in development back home.

In addition to a path toward innovation, this case study examined how change and change management is conducted within the Naval Aviation community, specifically with a focus on mission support. From this perspective, design thinking can be an appropriate tool to both develop new concepts and influence change within the

organization. Similarly, the developing and maintaining the design mindset was explored as a means to both bolster innovation and build a guiding coalition to support change and anchor new cultures.

D. RECOMMENDATIONS FOR FUTURE RESEARCH

With the closing of this research, there are now several case studies examining how design thinking and change management are employed through Johns Hopkins APL TANG projects. All of these case studies surround technical design challenges which ultimately can produce a tangible and quantifiable output. Further research into design thinking events which do not produce easily measurable results would be beneficial as this truly speaks to changing culture within the DOD.

Additionally, numerous other DOD entities and service branches are conducting their own innovation symposiums and unique efforts. A case study analysis of events into less developed innovation initiatives would be beneficial to ascertain other approaches to develop new concepts and ideas.

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