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Advancing Post Mission Data Collection and Analysis Using a Sociotechnical System Design Approach

Holness, Karen; Bee, Richard; Considine, Joshua; Friedemann, Kevin; Hallenbeck, Tyler; Heinzer, David; Junghans, Charles; Moran, Daniel

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NPS NRP Executive Summary

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NAVAL RESEARCH PROGRAM
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ADVANCING POST MISSION DATA COLLECTION AND ANALYSIS USING A SOCIOTECHNICAL SYSTEM DESIGN APPROACH

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Project PI: Dr. Karen Holness, Professor of Practice, NPS, GSEAS, Department of Systems Engineering
Additional Author/Authors: None
Student Participation: Cohort 311-171A Capstone Project Team # 3: Richard Bee, Joshua Considine, Kevin Friedemann, Tyler Hallenbeck, David Heinzer, Charles Junghans, LCDR Daniel Moran (USN)

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Research POC Name: Mr. Richard Holcomb
Research POC Contact Information: Phone: 703-695-1487; Email: richard.r.holcomb.ctr@navy.mil

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EXECUTIVE SUMMARY

Project Summary
Using a sociotechnical system (STS) approach, this research evaluated various aspects of post mission data collection and analysis for F/18 flight training events. The project principal investigator (PI) initially conducted in-person interviews with Subject Matter Experts (SMEs) on this process. Using the interview responses, an initial STS process and variance analysis was performed, resulting in a set of system capability requirements. These requirements and an initial process model were provided to a seven-member team of Naval Postgraduate School (NPS) systems engineering distance learning students. For their capstone project, the team conducted their own stakeholder and pilot representative interviews and created additional process models and entity relationship diagrams. The capability requirements provided by the PI were included in their feasibility assessment of design alternatives they created. After ranking the design alternatives with a Pugh matrix, task completion times for the highest scoring alternatives were further evaluated using simulation software and statistical analysis, resulting in a recommended automated event detection configuration. The PI also interviewed four F/A-18 pilot instructors, and incorporated the data into updated variance, function allocation, and requirements analyses that integrated the previous results completed by the PI and the capstone team. The PI proposed a set of system performance requirements that reflected proposed training site workspaces containing recommended hardware, software, and personnel configurations. These results are expected to be revisited in the planned FY19 Naval Research Program (NRP) study to further explore the policy, environmental, and organizational impacts on the conduct of F/18 flight training events.

Keywords: *naval aviation; flight training events; post mission analysis; human performance; sociotechnical systems; systems engineering*

Background
The needs analysis phase of the systems engineering (SE) process typically includes some level of gap analysis. The differences between the "as-is" state of the current system, compared to a desired "to-be" state of the system forms the basis for capability requirements that drive the remaining SE phases to design, build, test, and field a new system configuration.

As defined by Taylor and Felten (1993), any organization, including service organizations, that (1) uses technology in its processes to convert inputs to outputs (e.g., has a technological subsystem); (2) uses people to coordinate process activities and to maintain the integrity of the organization itself (social subsystem); and (3) accounts for factors external to the organization and their impacts on its processes, inputs, and outputs (environmental subsystem), is in fact a sociotechnical system. The majority of systems used within the Navy, Marine Corps, and Department of Defense (DoD) that require human interaction with hardware and software to execute a mission or concept of operations (CONOPS) can be

considered STSs. This includes post mission analysis systems as well. The process of conducting a post mission data collection and analysis involves human-human discussions supported by human-software interactions to retrieve and assess mission execution data.

Key elements of STS analysis methodology includes (1) an evaluation of the current hardware/software/human configurations and processes used, (2) an investigation into known process variances and current mitigations of those variances, and (3) a function allocation assessment to determine which parts of the process would be better executed by humans versus automation.

A challenge for human systems integration (HSI) is the development and implementation of measurable HSI specific performance requirements at the platform or "whole-system" level, and their addition to the system capability and SE requirements documents used to design/build/test the required system. By leveraging standard processes and guidelines for developing performance requirements, HSI and STS requirements for post mission data collection and analysis would identify the critical human-human and human-automation interactions, based on the identified key variances and the function allocation analysis. With valid supporting data on expected system performance, these requirements can be justified and translated into other programmatic metrics such as system cost and schedule via separate cost-benefit analyses.

Findings and Conclusions

This project responded to the OPNAV N9 Warfare Systems' NRP topic NPS-18-N142, titled "Advancing Post Mission Debrief and Data Collection"; it expressed an interest in investigating automation options to support these processes. The use of STS and SE methodologies provided additional perspectives on the factors that impact the ability of F/A-18 flight training event personnel to capture, analyze, store, and share performance assessment data.

To achieve the research objective and answer the research questions, the Principal Investigator for the project, also the author of this report, initially conducted in-person interviews with two flight training event SMEs. The Naval Postgraduate School Institutional Review Board (IRB) reviewed the interview protocol and determined their conduct was not human subjects research.

Each interview lasted no more than 1.5-2 hours. Using the responses from these interviews, an initial STS process and variance analysis was performed, resulting in a set of aircrew performance measurement (APM) system capability requirements. These capability requirements reflect the fact that the current data collection and analysis process relies heavily on human observations, handwritten notes, and data manually entered onto paper scorecards and gradesheets. There is a layering of information and interpreted data that is entered on the handwritten notes, gradesheets and scorecards. During the course of the data consolidation and analysis process, this information and data is revisited multiple times, and may be edited, when new information and data is obtained from the aircrew, instructors, and other relevant personnel participating in the flight training event.

These requirements and an initial process model were provided to a seven-member team of NPS systems engineering distance learning students. For their capstone project, these students were asked to do the following: (1) perform a comprehensive literature review and trade study on post mission data collection and analysis, and available software tools to support mission debrief of flight training events, (2) create system requirements based on a set of stakeholder capability requirements to be provided no later than 31 March 2018, and (3) use model-based system engineering to identify feasible system design options with increased levels of automation that address the stakeholder capability requirements.

To complete their project, the capstone team conducted their own stakeholder and pilot representative interviews (also NPS IRB determined as not human subjects research). Using this data, they created process models and entity relationship diagrams in the CORE software. The APM capability requirements provided by the PI were included in their analysis as part of a feasibility assessment for the design alternatives they created. After ranking their design alternatives with a Pugh matrix, task completion times for each of the highest scoring alternatives were further evaluated using the CORE simulation engine. The average times from the subsequent simulation runs were analyzed using a single factor Analysis of Variance and Fisher's Least Significant Difference method. Based on these results, one design alternative was recommended. A final capstone report was created to complete their SE degree requirement.

Finally, the PI also interviewed four F/A-18 pilot instructors, and incorporated the data in an updated STS analysis that integrated the previous results completed by the PI and the capstone team. From these results, a workspace located near the airfield/hangar at a training site was proposed. This workspace would contain at least one workstation dedicated to capturing all relevant aircraft and aircrew data needed to evaluate the aircrew and flight training event performance metrics. An alternative workspace dedicated to all briefing, coordination, data exchange, and data analysis activities was also proposed. The PI created a set of system performance requirements that reflected proposed training site workspaces and their recommended hardware, software, and personnel configurations. The requirements can be used by the topic sponsor to further evaluate current technologies that are considered as candidate improvements to current training site hardware and software configurations.

Recommendations for Further Research

The analyses performed in this study are subjective and reflect the understanding of personnel outside of the flight training event process. Therefore, it is worth revisiting the variance coding and the function allocation analysis with the same and additional pilot instructors, flight training event SMEs, and F/A-18 stakeholders to better reflect their inputs into the proposed STS redesign. It is also worth updating the CORE model to reflect any changes to the proposed APM system configuration that results from these additional inputs. A follow-on study to this project was approved for FY19 funding by the NRP. The goal of the NPS-19-N119-A study is to evaluate the organizational and environmental STS interactions necessary to engineer and implement an improved STS design for F/A-18 flight training events. An in-

depth evaluation of the current internal and external systems that influence the planning, resourcing, and execution of F/A-18 flight training events will be conducted, including an assessment of policy, guidance, requirements, and organizational interactions. Proposed modifications to these environmental interactions in support of the STS requirements provided in this report are the expected deliverables of this FY19 project.

References & Acronyms

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aircrew performance measurement (APM)
concept of operations (CONOPS)
Department of Defense (DoD)
human systems integration (HSI)
Institutional Review Board (IRB)
Naval Postgraduate School (NPS)
Naval Research Program (NRP)
principal investigator (PI)
sociotechnical system (STS)
subject matter experts (SMEs)
systems engineering (SE)