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EFFECTIVE PROGRAMMATIC SOFTWARE SAFETY STRATEGY FOR US NAVY GUN SYSTEM ACQUISITION PROGRAMS

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by

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The System Software Safety Technical Review Panel (SSSTRP) is tasked with reviewing the software safety processes and practices of US Navy software-intensive Gun System acquisition programs from the early stages of the acquisition process. As these systems grow in complexity and as Open Architecture (OA) is implemented, the acquisition and demonstration of safe software is becoming a more challenging task?often resulting in unexpected safety risks, schedule delays, and cost overruns. This research presents an approach to mitigate common risks in this domain from the Program Management level. This approach focuses on analyzing historical weapon system SSSTRP data to identify trends that could lead to a strategy to increase software safety as well as reduce unexpected findings at the SSSTRP. This research effort is still in the early stages, but data are being collected, and progress is being made. The goal of this paper is to increase awareness of both the problem and the research effort that is attempting to mitigate the common effects felt by Program Managers.

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Effective Programmatic Software Safety Strategy for US Navy Gun System Acquisition Programs

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Abstract[1]

The System Software Safety Technical Review Panel (SSSTRP) is tasked with reviewing the software safety processes and practices of US Navy software-intensive Gun System acquisition programs from the early stages of the acquisition process. As these systems grow in complexity and as Open Architecture (OA) is implemented, the acquisition and demonstration of safe software is becoming a more challenging task—often resulting in unexpected safety risks, schedule delays, and cost overruns. This research presents an approach to mitigate common risks in this domain from the Program Management level. This approach focuses on analyzing historical weapon system SSSTRP data to identify trends that could lead to a strategy to increase software safety as well as reduce unexpected findings at the SSSTRP. This research effort is still in the early stages, but data are being collected, and progress is being made. The goal of this paper is to increase awareness of both the problem and the research effort that is attempting to mitigate the common effects felt by Program Managers.

Background

The United States Navy (USN) formed the Weapon Systems Explosive Safety Review Board (WSESRB) in 1968 as a result of the tragic fire onboard USS FORRESTAL (CV 59). The

[1] This work was supported in part by ARO under project number P-45614-CI and in part by NAVSEA under project number 09WX11455.

subsequent investigation recommended an independent review process be established. The report highlighted the need to ensure explosives safety requirements are met for all munitions introduced to the Fleet. WSESRB members participate in numerous weapons system safety-related meetings, technical reviews, and working groups.

The WSESRB's responsibility is to review the overall safety aspects of each weapon system, explosive system, and related system to ensure that weapon system safety requirements are satisfied. Having assessed the degree of compliance with existing criteria, the WSESRB provides an assessment of the adequacy of the safety program and makes recommendations on the advancement of the item to the next stage in the acquisition cycle to the program manager, program sponsor, Chief of Naval Operations (CNO), and the Milestone Decision Authority (MDA).

At the discretion of the WSESRB Chairperson, special WSESRB Technical Review Panels (TRPs) may be established to review specific safety aspects requiring special expertise (e.g., ordnance-related software safety) of weapon systems. These TRPs are scheduled and led by an appointed TRP Chairperson and have at least two other designated members. Naval Systems Commanders, when requested by the WSESRB Chairperson, may identify a member to serve on TRPs. These members are familiar with the responsibilities of their Systems Commands and respective program requirements and have expertise in the applicable area of the TRP. Other members and technical advisors, chosen for their expertise, are appointed at the discretion of the TRP Chairperson. Software System Safety Technical Review Panel (SSSTRP) is one of these special WSERB TRPs.

Recommendations made by TRPs will be presented to the Program Office and the WSESRB at the conclusion of the TRP meeting; however, they do not become official until reviewed and endorsed by the WSESRB. The WSESRB may accept, modify, or reject the recommendations of the TRP. The results of the WSESRB action on the TRP recommendations will be provided to the Program Office.

Naval Surface Warfare Center (NSWC) Dahlgren Division acts as a principal activity for system safety support to the WSESRB, as well as chairing the SSSTRP and other TRPs as assigned. These assignments include: (1) developing and recommending, with WSESRB approval, TRP review criteria and related data, (2) coordinating meetings of the SSSTRP with members and program offices, (3) assisting the program office in tailoring TRP review criteria for each type of program and current program phase, (4) identifying qualified technical advisors to participate in the TRP, and with the WSESRB chairperson’s concurrence, arranging for their participation, (5) scheduling meetings of the TRP at the request of the WSESRB chairperson, and (6) providing a summary report of the findings and recommendations of the SSSTRP TRP to the WSESRB.

The SSSTRP's primary focus is to investigate whether the vendor's software engineering processes properly identify and address the risks associated with the implementation of their product. The following list represents the SSSTRP's areas of focus within the software development process:

- Software Development Process Essentials
    - Software Development Plan
    - Configuration Control Management

    - Requirements Management
    - Safety Involvement
        - Change Boards
        - Trouble Reports
        - Build Reviews
        - Test & Integration Plans

Vendors are required to submit Technical Data Packages (TDPs) that contain documentation that details the vendor's quality control procedures associated with the following engineering processes:

- Software Engineering
    - Software Development Plan
    - Software Architecture Design
    - Software Interfaces
    - Software Detailed Design
    - Software Testing & Integration Plans
    - Software Verification & Validation Plans
    - Software Build Schedule
    - Build Milestones
    - Build Functionality
- Specialty Engineering
    - Configuration Management
    - Requirements Management

The actual components of the TDP are made up of the project documentation submitted by the vendor. The vendor submits the following documents as the TDP:

- System Program
    - System Description
    - Program Organization
    - Program Schedule
    - Concept of Operations
- Software Program

    - Software Development Plan
    - Software Build Plan
    - Software Configuration Management
    - Software Requirements Management
    - Software Change Board Control
- System Safety Program
    - System Safety Program Plan
        - Integrated Safety Schedule
        - Safety Organization
            - Roles & Responsibilities
            - IPT (Cross Product Team) Interactions
        - Software Safety Analyses Descriptions
        - Hazard Tracking System
        - System Safety Working Group (SSWG)
- Current Safety Status
    - Preliminary Hazard List (PHL)

The vendor's responsibility during the SSSTRP presentation is to identify the risks associated with its products relative to all stages of the software lifecycle. The vendor is also required to present the associated mitigation strategy for each risk. Software risks can be found via the following analysis techniques:

- Functional Hazard Analysis (FHA)
- Software Requirements Analysis (SRA)
- Preliminary Design Analysis (PDA)
- Detailed Design Analysis (DDA)
- COTS Analysis
- Code Analysis (CA)
- Software Test Results Analysis (STRA)

Problem Statement

Current and active US Navy gun system acquisition programs are more complex than their predecessors. The systems being acquired are much more software-intensive and present

a much greater challenge with respect to understanding and mitigating the risks associated with Navy gun safety. Navy gun systems are much more software-intensive than previous generations due to the increasingly complex requirements for centralized command and control (C2). In order to adapt to new technologies, the Navy has engaged the Open Architecture (OA) concept. Although the OA approach is much more flexible, there are inherent risks associated with it. The Navy acquisition community, specifically the SSSSTRP process, needs to adapt to this new OA environment and standardize the SSSTRP processes.

Significant effort is required to put together a TDP for SSSTRP review. The SSSTRP panel finds issues in the vast majority of systems that come before it. Such findings need to be addressed prior to WSESRB concurrence on the overall program. Typically, every system going in front of the WSESRB and SSSTRP is handled on a strictly individual basis by its respective vendor and Program Managers (PMs). PMs ideally want their programs to be well prepared for the SSSTRP so there are no unexpected surprises resulting in safety hazards, schedule delays and/or cost overruns. However, Navy gun system PMs do not have a good handle on what the trends are in the findings from system to system, and there is always a desire to reduce the programmatic risk involved in passing the reviews.

If commonalities or trends in SSSTRP findings were identified, they could be analyzed—leading to a better programmatic strategy to generate safe systems. This would also result in a minimal number of hurdles during the SSSTRP review, and the end result would be beneficial to all parties involved.

Research Approach

Our proposed strategy for identifying trends in SSSTRP findings on weapon-system-related acquisition programs is to initially meet with PMs, US Navy safety community members, and system developers to discuss experiences and lessons learned. We can also gather data from informal meetings and discussions and analyze it to find more quantitative sources of information.

In addition to collecting data from various participants from the acquisition community, we will also request and analyze TDPs, SSSTRP reports, and WSESRB data related to recent navy gun system acquisition programs. We expect this information to yield quantitative data that can assist us as we identify trends across different acquisition programs. Due to the nature of the OA initiative, we should be able to derive trends specific to OA software-intensive systems from the data, as well.

The third step in this research approach is to analyze the SSSTRP process itself with the goal of quantitatively determining the consistency of the process. This information is a vital data-collection objective because specifics in the consistency of the SSSTRP process from system to system should correlate with similar results for similar cases being presented to the panel.

Our fourth step in this research approach is to connect the identified lessons learned and trends in SSSTRP data reports with data on the SSSTRP process itself. This step is essentially the point at which we can begin to derive conclusions and recommendations. Relationships in the data will primarily focus on how to most effectively reduce programmatic risk in guiding a weapon system acquisition program through the SSSTRP process smoothly. In this assessment, we will pay particular attention to system characteristics that will be consistent throughout future programs, such as OA software.

The end result of this research will be to create a deliverable that can be used by PMs to more effectively manage their OA-based acquisition system programs. A side deliverable will be an analysis of the SSSTRP process and recommendations on how personnel involved in the safety community can improve it.

Current Research Status

Data collection has been a time-consuming task, but progress is ongoing. From October to December 2008, we conducted both project-scope refinement and meetings with safety and acquisition community members. We established relationships with the Naval Gunnery Project Office, NSWC Port Hueneme Division (PHD) Detachment Louisville, NSWC Dahlgren and Naval Ordnance Safety and Security Activity (NOSSA). We also discussed specifics of the process with a majority of players in the community and compiled information on the process itself. Any stakeholders we have missed are encouraged to contact us.

Along with SSSTRP and WSESRB process data, we received recent gun-system-related SSSTRP reports through a request from the Naval Gunnery Project Office to NSWC Dahlgren. For research purposes, we also have had access to reports deemed releasable by the Navy from the past six years. TDPs were not made available for more detailed analysis due to the sensitivity of the majority of the programs. The above-mentioned data were received in February 2009, and our primary focus has been to determine what information is most useful for analysis. Collaboration has taken place with NOSSA personnel to determine how to break down and classify findings from the SSSTRP reports. The analysis is ongoing, but research is still in the early stages at this time.

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- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

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- Contracting Government Procurement Functions
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- Past Performance in Source Selection
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- USAF Energy Savings Performance Contracts
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- Indefinite Reenlistment
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Logistics Management

- Analysis of LAV Depot Maintenance
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- ASDS Product Support Analysis
- Cold-chain Logistics
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- Diffusion/Variability on Vendor Performance Evaluation
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- Lean Six Sigma to Reduce Costs and Improve Readiness
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- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
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Defense Acquisition in Transition

6TH ANNUAL ACQUISITION RESEARCH SYMPOSIUM

Software Safety Strategy for US Navy Gun System Acquisition Programs

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Background

- US Navy weapon and combat system acquisition programs are evolving
  - Drive to implement Open Architecture (OA)
  - Increasing levels of software complexity
- Acquisition and demonstration of safe software becomes a more challenging task
  - Increased safety risk, cost & schedule overruns
  - Difficulty proving system safety to independent review boards

Problem

- There is no standard methodology in place for program managers to follow regarding software safety
  - Current management practice varies from program to program
  - Reactive vs. proactive evaluation approach
  - Focus of this research: gun systems software safety

Software Safety Program Management Strategy Needed

- Methodical and effective approach
- Strategy goals
  - Reduce average number of safety issues
  - Improve process for handling issues encountered
  - Reduce surprises encountered during SSSTRP and WSESRB

Developing the Risk Management Strategy

- Identify common risks…
  - Among current gun system acquisition programs
  - For future OA software-based gun systems
- Develop mitigation strategies to address each common risk
- Combine into a program management level software safety risk management strategy

Identifying Common Safety Risks for Today's Gun Systems

- Conduct survey, discuss experiences & lessons learned
  - Program Managers & Safety Community Members
- Analyze SSSTRP process:
  - Panel members
  - Characteristics of systems being reviewed
- Research OA / COTS Specific Risks

Identifying Common Safety Risks for Today's Gun Systems (cont)

- Obtain SSSTRP reports on recent gun system acquisition programs
- Extract & catalog findings from each report
  - Categorize findings into project management and safety management areas
- Analyze data, identifying common risks & trends
  - Identify OA-related issues

Organize Findings from SSSTRP data

- Project Management
  - Project Planning
  - Requirements Management
  - Integration & Testing
  - Configuration Management
  - Validation & Verification
  - Risk Management
  - Deployment & Maintenance
- Safety Management
  - System Safety Program
  - Software Safety Program
  - Safety Risk Management
  - Safety Verification / Audits
  - Hazard Tracking
  - COTS, GOTS, NDI
  - Sim, Stim, Emulation

Category definitions are evolving via collaboration with various members of the DoD systems safety community

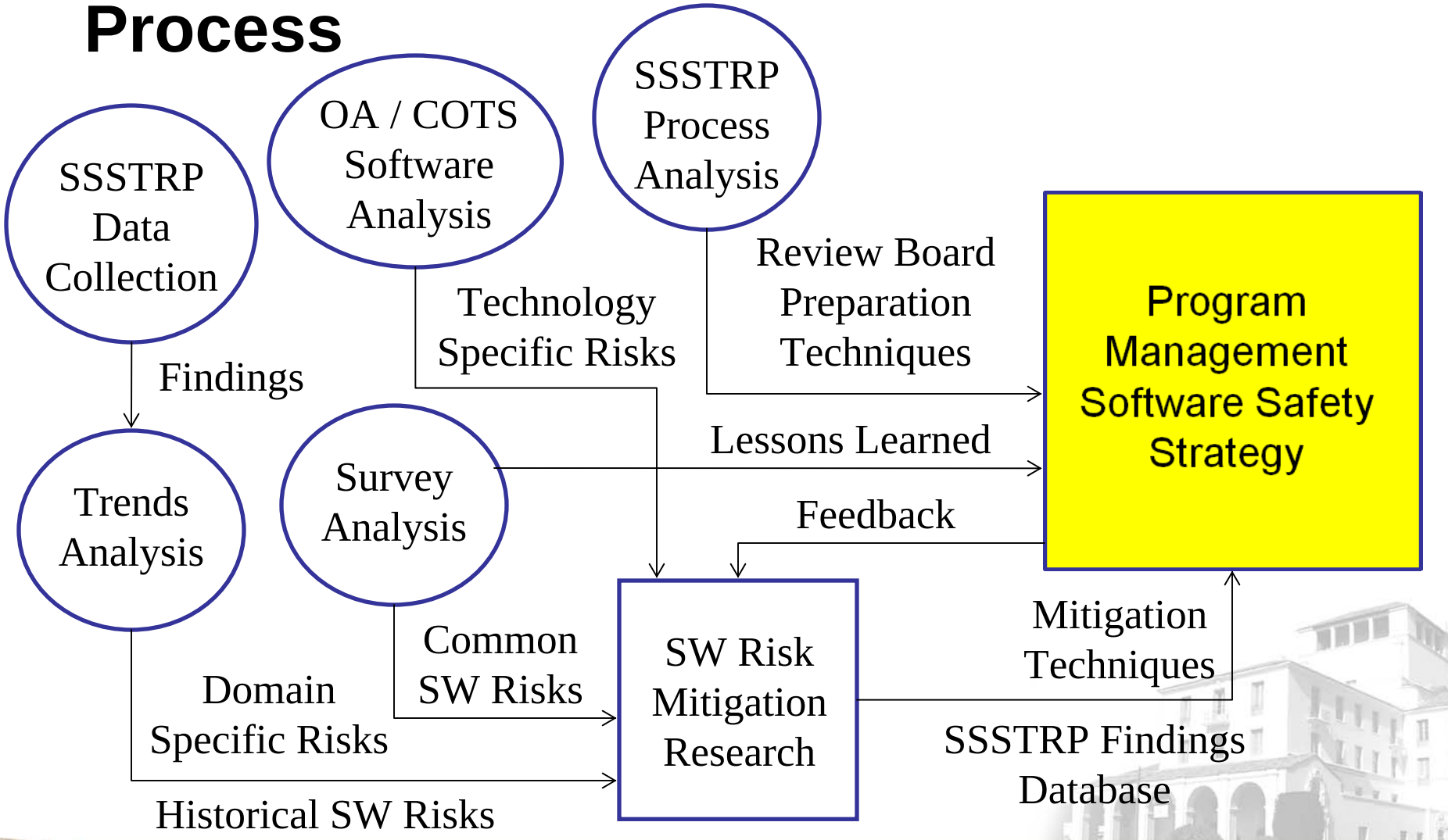
Developing Risk Mitigation Strategies

- Identify successful actions used to resolve historical issues
- Apply existing/proven risk mitigation methodologies from OA and PM domains
- Develop custom techniques if needed
- Continue a centralized SSSTRP findings database to track future opportunities

Developing Risk Mitigation Strategies (cont)

- Combine risk mitigation methodologies and techniques into a program management methodology
- Provide methodology and assessments of the content to program managers for review and use
- Acquire feedback if possible to improve methodology

Software Safety Strategy Development Process



Data Collection in Progress

Filename N3C5-G-10-146-1912.PDF
MK 34 MOD 4 - USS Bunker Hill (CG-52)
Purpose:

Concurrance to conduct structural test firings.

Finding Summary:

- Incorporate accurate data into software test build. (Insufficient Testing)
- Perform safety assessment after the modifications have been made.
- Verify and Validate software before structural testing
- Incorporate safety schedule into program schedule

- Perform interface safety assessment between training system and weapon.
- Show that all safety risks have been accepted in accordance to DoDI 500.2
- Establish a Hazard Tracking Database
- Provide status of prior SSSTRP Findings.

Comments:

The SSSTRP took exception to the fact that this program decided to seek concurrance to conduct structural test firings with software that was still under development. I suspect that the previous version of this software had been accepted by the SSSTRP but safety assessments need to be performed and presented to the SSSTRP. Also, the risks associated with the changes needs to be determined.

Example of data extracted from an SSSTRP report for current gun programs

Several years of historical SSSTRP data under analysis so far

Questions?