1. Read: “Lewis Spacecraft Mission Failure Investigation Board Final Report”, 12 February 1998, <http://spacese.spacegrant.org/Failure%20Reports/Lewis_MIB_2-98.pdf>

For this NASA case study, *prepare to discuss* in class, the second step in DMAIC, Measure (do not turn this in):

* + Identify a problem to be solved in the Lewis mission failure case study
  + Identify appropriate **measures** that would **validate** the problem and any solutions
  + Identify **baseline data** that would need to be collected
  + (IF YOU"RE NOT LIVE, THEN YOU MUST DISCUSS THIS IN THE DISCUSSION GROUPS in Canvas)

1. For **your selected case study**, submit a draft of *your* “Define” section (see Syllabus) of a suitably small process to make an improvement to – NOT the entire program office, program, or systems engineering process – a focused, relatively tiny, *part* of a process within your selected case study. Later you will discuss how you measure what you’re changing, what the improvement will be, etc. This is merely *defining* what this part of the PROBLEM is.

“Define the Problem”. 3-4 pages.

* + Define the project purpose and scope – the problem to be solved or improved. Include a Project Charter (C6σGBH, p. 95).
    - Problem statement guidance: <http://www.dummies.com/how-to/content/how-to-write-a-problem-statement-for-six-sigma.html> (anyone who seems not to have looked at this will have 5 points deducted)
  + Define the *existing* processes (that you will suggest a change to) using a SIPOC or equivalent representation.

# Introduction

## Document Purpose/Problem Statement

Revisiting Lockheed Martin’s (LM) Systems Engineering (SE) process of the Theater Battle Management Core System (TBMCS), an integrated air command and control (C2) system that performs standardized, secure, automated air battle planning and execution management for Air Force, multi-service, and allied commanders in theaters of operation worldwide, revealed many underlying issues surrounding its execution through every phase of the product lifecycle. A case study authored by folks from The MITRE Corporation and Lockheed Martin Integrated Systems and Solutions (LM-ISS) detailed five key systems engineering learning principles: requirements definition and management, system architecture, system/subsystem design, system integration, and validation and verification. The aim of this document is to revisit the actions taken by both the contractor and government leading to less-than-ideal SE practices and problems arising throughout the lifecycle which could improve general practices moving forward. Many problems contributed to schedule setbacks, drawing over-budget, and lack of technical progress. The intent of the following sections is to analyze the system as a whole to target one specific problem within the TBMCS, with the ultimate goal of enlisting definitive steps for improvement.

As mentioned, five SE learning principles contributed to progress impediment:

1. The lack of definitive requirements set forth by both LM and the government’s military forces from the initial design phases and throughout the product lifecycle caused vague and lax building and testing standards, drove the project over-budget and over-schedule, and foreshadowed a lack of accountability by both parties. The lack of operational requirements set the program back a minimum of 4 years.
2. The system architecture needed further definition at lower levels to improve its system design and development details. Misalignment between LM and the government’s organizations caused frequent issues with software reuse with commercial software products. As a result of the layered architecture, migration to modern technologies was difficult and did not support significant system evolution from the legacy system.
3. The complexity of legacy applications, misunderstood maturity and complexity of commercial and third party software products, and lack of understanding of system employment by the user all hampered the system’s design and subsystems’ design.
4. The complexity of the system caused problems with system integration, stemming from lack of detail in the system architecture, mandates to use government-furnished equipment that was incompatible with commercial off-the-shelf products, the oversight needed for third party software product integration, and difficulty testing external system interfaces.
5. Validation and verification were difficult due to a lack of firm requirements baseline. No clear measures of success were set and often tests were run in parallel to meet schedule deadlines, ultimately affecting the inability to replicate the operational environment prior to acceptance test.

The complications arising from software collaboration between the government’s organizations and LM caused significant software integration delays of 6-18 months early in the product lifecycle with estimates between $5-$30 million for the amount the program overspent in software training in an effort that foreshadowed lax building and testing standards. The lack of software training processes contributed to technical progress impediments, schedule delays, and budget overdraws.

Analysis of these SE principles will guide the reengineering process to practical systematic improvements that in retrospect could improve the schedule, budget, and technical progress. Significant attention will be given to the process for deciding on what the root cause(s) was so the process for improvement is driven by definitive metrics and follows a logical pattern. Relating back to the faults of the TBMCS, further details will break down what lessons could be learned for future contract work with the government’s military forces.

## Document Scope

The detailed analysis of the TBMCS encompasses all systems, subsystems, components, both hardware and software, third party products, both hardware and software, contractors, and government associations pertaining to TBMCS traceability. The Process Reengineering document fulfills documentation for any activities associated within the TBMCS lifecycle and any organizations associated with the TBMCS system. All activities, products, processes, tools, controls, integration technologies, proprietary information, intellectual property, security measures, key personnel, and safety guidelines associated with the TBMCS systems, subsystems, and components are retained within the scope of this document, even if not directly referred to. By doing so, the systems engineering approach from design through retirement can be controllably studied for imperfections in the SE process LM and the government’s military organizations used. Although third party applications may be studied in how they relate to the TBMCS system, the system’s studies must directly relate to the impact on the system under scrutiny.

The retrospective analysis inspected throughout the duration of the TBMCS program will capture LMs SE process for problem development and base recommendations on the unbiased findings.

## Document Update

By revisiting flaws in the SE process utilized by LM and the government, contrasting evidence may come to light on what impacted the cost, schedule, and technical progress of the system. At each instance, the Process Reengineering document may undergo revisions as seen fit to accurately reflect the discovery of new information. Periodical revisions capture the integrity of the Process Reengineering document to thoroughly analyze the TBMCS system.

The completion of the process reengineering draft will add new material on a weekly basis, following a timely order of the Table of Contents (TOC). Each week, the focus will largely revolve around the addition of new material but editing previously drafted sections of content may occur on an as-needed basis. Any revisions will be documented and undergo official review for entry on a bi-weekly bias where a new revised draft will be released.

## Program Summary

### Program Objectives and Scope

To monitor the reengineering process, objective thresholds and measurements are set. By analyzing the intricate flaws in one of the key systems engineering learning principles, a more well-rounded understanding can determine measures to be taken in the future to prevent reoccurrence. The TBMCS system will be studied as a whole before decomposition into the smaller, more manageable Problem Statement to show how the system-level problems interact with the problem studied herein. No problem exists within a bubble and the reengineering process intends to capture as much indirectly related factors as possible. The accountability of the Problem Statement’s analysis depends on the ability to detail the relationships between all interacting variables.

The process reengineering document intends to devote sufficient attention and time needed to ascertain the impact a number of issues arising throughout the lifecycle had on the ability for LM to deliver an on-budget, timely, and quality product to the government. While a significant burden lies on LM for the quality of the final product delivered, the government’s relationship will be examined to show the struggles of collaboration between LM and the government in this particular instance.

Limitations on the analysis mostly stem from the challenges to retrospectively analyze a system and on the limited documentation available. By studying the system post-deployment, problems under scrutiny may only seem relevant looking back and would go unnoticed in real-time. Documentation only covers certain perspective on what the issues around the TBMCS were and are by no means an exhaustive, all-encompassing list, inherently carrying bias based on who the authors were relative to identifying problems. In addition, the TBMCS system can mostly be studied from the limited manufacturing perspective, not the operational perspective due to the amount of classified information not being readily available.

Although the process reengineering document will be independently evaluating process improvements in the TBMCS system to apply to defense and commercial projects moving forward, the document will consult other documentation sources for gathering data and understanding the TMBCS system. The sources of information contained herein to assist with the reengineering process support the residing analysis and conclusions.

### Project Summary and Deliverables

Key milestones of the reengineering process will chronologically show the progress in developing a process improvement. Major phases following a Lean Six Sigma approach consist of the subsequent activities:

1. Define – April 6th, 2020
2. Measure – April 13th, 2020
3. Analyze – April 20th, 2020
4. Improve – April 27th, 2020
5. Control – May 4th, 2020
6. Organizational Learning and Leadership – May 12th, 2020

The deadlines represent analytical processes but do not encompass the scope of all activities needed to understand the TBMCS reengineering process. During the lifecycle study of the TBMCS, periodic assessments will dictate any schedule adjustments for sections requiring further analysis.

### Technical Description

Understanding the TBMCS system starts with allocating plenty of time for retrieving relevant information related to the TBMCS and consuming as much of that information as possible. While effective analysis does not necessarily require exhaustive documentation to be studied, the confidence in relaying effective recommended solutions relates back to how extensively the problem(s) could be studied. While the main focus of the process reengineering document will be on improvement measures related to communications between LM and the government, trade studies will reveal a logically following solution to the identified root cause(s). Problems affecting progression metrics that were intended to guide the TBMCS design process and further on will be explored to determine their cross-functional relationships. Without proper processes in place to examine potential systematic problems, the technical program measures could not be realized. Each subsystem and aspect of the system critical to LM for delivering its product on-time and on-budget will receive their own allocated trade studies. From the trade studies, the impact the root cause(s) had on each aspect of the system can be better understood.

While the intent of the process reengineering document is to analytically determine definitive measures for direct process improvement within the implementation of the TBMCS program, some sections will contain information pertinent to the technical details of the subsystems. The technical details provided for various aspects of the system will be instructively placed in context to relate back to the overarching general improvement concept. Technical details will aim to further comprehension of the system’s interactions where intuitive understand lacks. Technical details may include processes, tools, software, hardware, system-level design concepts, subsystem-level design concepts, SE concepts, and business development concepts.