Improving Tools and Techniques for Obsolescence Management in Defense and Space Microelectronics Systems

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Abstract — *The rapid evolution of the defense and aerospace industry has created the needs of procurement specialized electronics, this along with technological evolution, market changes, international relationships, environmental policies and planned obsoletes from government entities, suppliers and manufacturers create an environment of uncertainty for the design, manufacture and sustainment of high reliability space and defense microelectronics, assemblies, and subassemblies. Organizations have the need to strategy the approach to obsolescence. Here is why the Department of Defense has invested heavily in development of supply chains process and procedures that aim to mitigate and provides a standardized guide to tackle material shortage and obsolescence impacting national defense. The intention of this paper is to present a systematic approach on how to improve the "Assess" phase from the Diminishing Manufacturing Sources and Material Shortage Guidebook with the application of Lean Six Sigma tools and theory, helping on the removal of barriers to accomplish successful obsolescence mitigation.*

Key Terms *– Diminishing Manufacturing Sources and Material Shortage, Electronics Sustainment, Obsolescence, Process Improvement.*

INTRODUCTION

Obsolescence, as a definition, can be simply defined as the unavailability status for a service, product, or material, meaning that the product or service is no longer available or supported by the original manufacturer, even though the product itself may still be able to fulfill the design intent. For example, in the consumer electronics market one can visit the case of cell phones. Cellphones have an expected life cycle of around 3 to 5 years, with an estimated developing time of around 2 years. For contrast a Department of Defense (DoD) system has an expected life cycle of 10 to up 30 years, and a developing time of around 6 to 8 years, meaning that the entire life cycle of a consumer electronics falls just within the develop time of high reliability space or defense system.

The Nokia 3310, released in September 2000, has the reputation of being one of the most reliability handheld phones in the market, but it was only supported for 5 years. One of the main reasons for this life spam is that the Nokia 3310 uses the Global System for Mobile communications (GSM) standard 2G technology to transmit and received data. This technology was good to transmit small data packages like text and voice, but it falls short when the demand of higher data increases creates the necessity of more band wide and capabilities.

With the advance of technology, the 3G networks were developed. This technology allows higher density of data transfer capabilities. There was no change in the circuitry use on the Nokia 3310, but it was simply not compatible with the requirements of the 3G communication.

This example shows how obsolescence can impact a product and consumer, forcing consumer and manufacturers alike to mitigate the obsolescence of the product one way or another.

For manufacturers there was a need of improved technology capable of meeting the improve of wireless communication, in addition the analysis of the commercial viability cost vs profit; and for the consumer, the investment in a new product compatible with the current wireless infrastructure that allow them to stay connected.

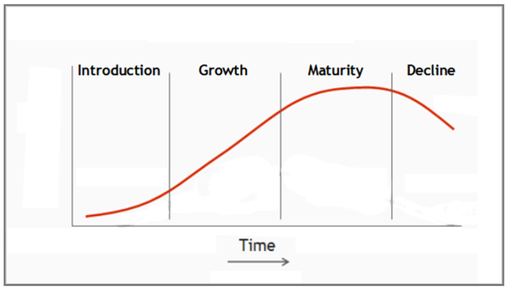

Figure 1
Phases of Product Life Cycle

The space and defense electronics sector are not strangers to these concepts. Space and defense technology need to be able to mitigate obsolescence effectively but often their stake is higher. Due to the rapid pace and changes in electronic technology, design teams sometimes are forced to make changes while still in the early design phases of the product development. These issues can trigger major changes in designs, adding delays to the already lengthy process, sometimes, impacting released dates for systems used in national defense.

Changes in design often means changes in multiple supporting circuitries and supporting sub systems as well. For example, wafer fabrication alone involves 500 processing steps with associates lead times of 6 months and test and qualifications can take the same amount of time making the process of fabricating microcircuits almost a year. If a wafer of a specific dimension changes or goes obsolete the only viable option is a different wafer with a different dimension, it means that now designers need a supporting circuitry capable to manage a difference in power delivery, in addition to a more efficient cooling to manage the heat of more processing power. If they add a similar issue with multiple electrical, electronics and electromagnetics (EEE) components and printed circuit boards (PBA's), things can be complicated in a hurry.

Is for these reasons and others that some designs can take up to 10 years from beginning to the point of hardware production. Making changes in hardware technology and software is very noticeable.

DoD systems, in general, are expected to have a long-life cycle making the concept of system-compatibility and back-compatibility one of vital importance. Not having integration withing systems can impact their ability to stay relevant with evolving standards, not to mention the challenge of systems sustainment when moving through the Product Life Cycle phase.

Changes in politics and international relationships can influence as well on sourcing and procuring materials. An example of this is the COVID-19 pandemic in 2020 that forces the shutdown of multiple manufacturing organizations like semiconductor foundries disrupting supply chains and creating an increase in lead time, cost, and reduction in workforce. In this period, production decreases significantly and the demand continues in a steady increase making it impossible the fulfillment of demand and the proactive management of certain components and materials.

Most of the times Original Equipment Manufactures (OEM) are responsible for new technology development and held accountable for managing and mitigate all obsolescence within the contract product life cycle parameters [1].

After ending the contractual requirements usually withing the Maturity Stage and per Standard Related document 26 (SD-26) buyers, in this case, DoD organizations are task to sustain the system and manage all related obsolete issues withing the pieces components subsystems and systems (Figure 1).

To these effects the United States of America designate the Defense Logistics Agency (DLA), under DoD umbrella, as the lead organizations for the development of strategies that will mitigate material issues. Their main Mission as state in their official web site is to [5] "identify, influence develop, manage, and provide access to standardization processes, products, and services for warfighters, the acquisition community, and the logistic community to promote interoperability, reduce total ownership costs, and sustain readiness." Under DLA, there is a program that focuses on obsolescence management. This program is called Defense Standardized Program (DSP). They oversee and implement all procedures to mitigate Diminishing Manufacture Sources and Supplies (DMSMS); all their focus is to improve readiness, schedule, and to reduce cost. They accomplish this by creating a standardized handbook to manage all the aspects of DMSMS.

The DMSMS Handbook or DS-22 highlights the most effective, proactive practices being used across DoD to help program managers reduce the risk of obsolescence. The guidebook presents basic methodology to assist program managers with establishing DMSMS programs and analyzing the results regarding the basic parameters of cost, schedule, and performance. Per the handbook, this process is organized [2] into 5 manageable steps: *Prepare, Identify, Assess, Analyzed, and Implement* (Figure 2). DMSMS Risk Management Process Map. Each step will focus on an area of opportunity and how organizations can develop a proactive process to make sure they maintain defense and space system in an operation readiness and warfighter status.

Phase 3, Assess or Health Assessment Methodology: Resolution Timing and Levels, focuses on the health of the product withing the *Maturity* Life Cycle phase of the product.

The health assessment of the product often provides deep comprehension of current and future hardware and software obsolescence issues.

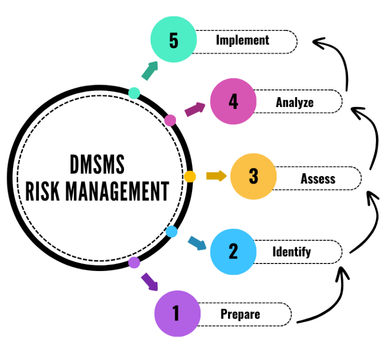

Figure 2
DMSMS Risk Management Process Map

Objective

The main objective of this research aims to improve the step 3 "Assess" of the DMSMS Risk Management document (SD-22) and provide feedback on how to improve this phase process, using DMAIC and Leand Six Sigma. This document uses the term "improve" with a holistic approach of reducing solution lead time, decision making time, reducing the associate cost, increase life cycle of systems, subsystem, keeping same or better equipment performance and pedigree. Obsolescence issues often can take multiple months to solve and sometime required multiple teams to review and provide disposition for technical design changes, making DMSMS a tremendous challenge to overcome.

Methodology

This project will address and suggest a possible systematic approach to improve the current DMSMS Risk Management (SD-22) resolution road map process.

Using the concept of Lean Six Sigma and [4] DMAIC: Define, Measure, Analysis, Improvement, Control, the researcher will measure the processes withing the "Assess" phase of the DMSMS Risk Management Tool to calculate the theorical efficiency of the Assess process focusing mainly on the Sustainment phases (Figure 4).

The Assess phase, also called the Health Assessment Methodology in the DS-22 focused on Proactive DMSMS Monitoring, Monitoring Inventory Levels, Resolution Prioritization and Budgeting Programing.

Then this paper will demonstrate the utilization of these improving tools focusing on process improvement, always focusing on the organization requirements. In this case, correct obsolescence resolution and mitigation with the lowest impact to system readiness.

Is important to mention that this project is intended to present a possible way to improve a real process. There is no implementation phase due to the academic nature of this paper.

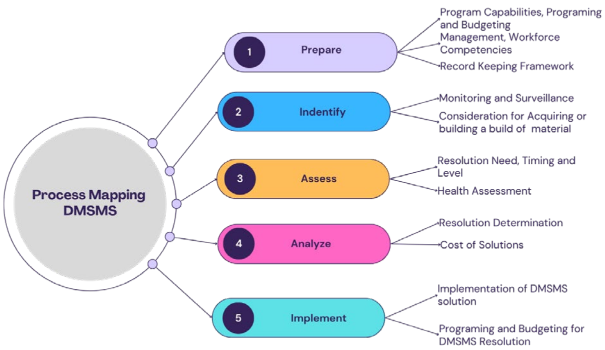

Figure 3
Detailed Process Map

Define Phase

To properly address the Define phase of this project, the researcher will be using the Specific, Measurable, Achievable, Relevant and Timely (SMART) method along with DMAIC. Each step will be reviewed and will focus on the main areas of opportunity.

What is the main problem for the Assess implementation phase? Per the DMSMS (DS-22) handbook, the ***Assess*** or Health assessment Methodology has an area of opportunity [2] "The information necessary may not be centralized and the qualitive of the data can vary as a function of where it is found", meaning that often for design and sustainment of a system there is not just one repository of information capable of giving all the information about a component, sub-systems, and system.

How is this problem measured? This is measured by [2] "breaking out individual items, documenting, by year, the starting quantities balance, predicted actual usage, and ending quantity balance of that item over a certain time frame." The program manager or action owner needs to be able to know the current health of your system from the top-level system to the lowest level component.

Can the metric be improved? Metrics for every process can be improved. In this case, if the product owner is focusing on managing proactive obsolescence, having the correct information before it can create a need that cannot be fulfilled. This information enables the pertinent program office to plan and estimate components and system with high risk of becoming obsolete before it happens.

What can be considered and improved? Based on what this paper previously discussed, and improvement could be a reduction in the solution time, in addition to a true proactive approach that enable the design or sustainment team to cover the demand for the entirety of the product life cycle not having line down or equipment out of commission due to issues with DMSMS.

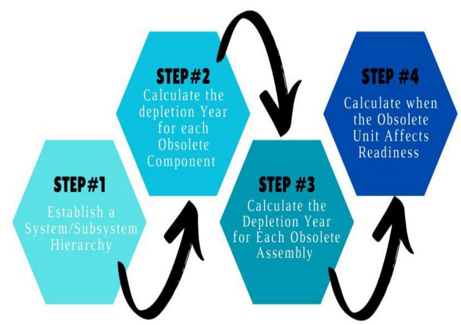

Figure 4
Assess Methodology

Measure Phase

On this phase, the paper will stablish a process to gather all the necessary data. Due to the theoretical nature of this project, the data will be based on qualitative data points. In addition, for simplicity's sake, the focus of this paper will be on the Mature to Decline phase of the product life cycle, specifically the Sustainment phase of the product.

To be able to correctly measure the Assess process, this project will be dividing each of the 4 areas of the methodology and measuring individually in their own merits, measuring the efficiency and complexity of each step individually. The cause-and-effect matrix diagram will provide means of data gathering for further analysis. [4] The cause-and-effect matrix or X-Y Diagram will provide numerical relationships between process inputs and customers output helping in the identification of priorities in a well-organized fashion. The output variable or voice of the customer (VOC) will be used. A customer using managing DMSMS issues and using the SD-26 as reference would want to have a Proactive DMSMS management, the ability to Monitoring Inventory Levels, the ability to have a Resolution Prioritization and the infrastructure to effectively Program and plan Budgets. The priority rating was assigned as shown in (Table 1). The highest priority given to the Monitoring of Inventory Levels is given to this output variable because the demand will drive the mitigating actions. The lowest priority score is given to Programing and Budgeting even though this output variable is still critical, there are arrangements that can be done to be able to implement funding for resolution if the needs exist.

Voice of the Customer						
Output Variables (Y's) Causes	Proactive DMSMS Monitoring	Monitoring Inventory Levels	Resolution Prioritization	Programming and Budgeting	Total Value	Total Value (%)
Priority (Output Rating)	7	9	6	5		
Input Variables (X's)						
Cost Impact	3	9	3	7	22	18.49%
Scheduel Impact	8	7	3	3	21	17.65%
Availability	7	9	4	5	25	21.01%
Readiness Impact	9	9	5	4	27	22.69%
Hierarchy	6	5	9	4	24	20.17%

Table 1
Cause and Effect Matrix

As shown in the Cause-and-Effect Matrix it can identify a key input in the process, like Readiness and Availability. These two factors are directly related to what can be considered a proactive approach to DMSMS monitoring and systems demand management.

Analysis

The third step is analysis. During this step, the idea is to investigate the data collected and analyze and determine where the gap or non-value-added steps on the current process. As shown previously, this project will continue using tools taken from the Lean Six Sigma theory.

It is known that the higher priorities for the customer base on the data are Proactive Monitoring and Inventory Monitoring, better known as Demand. In this section of this paper the Failure Mode and Effect Analysis (FMEA)will be use; this tool will provide a step-by-step approach for identifying all possibles failures on theses process in detail to further understand how the process is set up (Table 2) and (Table 3).

Process Step / Input	Potential Failure Mode	Potential Failure Effects	Severity
What is the process step and Input under Investigation ?	In what way does the Key Input go wrong ?	What is the impact on the Key Output Variables (Customer Requirements) ?	
Proactive DMSMS Monitoring	Only open obs. action reactively	Delays in resolution and potential line stop or system down	8
	No having OEM's engagement in the monitoring process	Missing key resources to actively track issues, increase work load on current sustainment	7
	Program Office not being able to manage surveillance activities	Missing opportunities of on-time mitigation, delayed resolution	9
	No processes or system in place to monitor obsolescence	Not able to validate issues with obsolescence, only reactive resolution	10
Monitoring Inventory Levels	Not knowing the demand of a product	Missing the view of the big picture, missing opportunity to solve issues	9
	Having wrong demand	Work toward non issues or missed entire issues	7
	Not able to track demand real time	Delay's in decision making toward	6
Resolution Prioritization	Not having a priority or hierarchy	Missing the view of the big picture	5
	No visibility on top level assembly	Not knowing how this may impact functionality wide	6
	No visibility on lower level assembly	Miss possible mitigation opportunities	6
Programing and Budgeting	eanly process to approve the work hours to solve the issu	Time equal to more cost and reduce system capabilities	7

Table 2
FMEA Section A

Using this tool, we can in an organize matter assign Risk Priority Number (RPN) for the processes withing the overall Health Assessment process. Clearly the process with the higher RPN fall withing Monitoring Inventory Levels> Not knowing correct demand for components, sub-systems, and systems. Second Higher RPN fall withing the Proactive DMSMS Monitoring> Not having a tool to manage early detention.

Potential Causes	Occurence	Current Controls	Detention	Risk Priority Number
What cause the key input to go wrong ?		What's are the current controls and procedures ?		
No having the PCN on time	5	DMSMS Handbook of best practices	5	200
Contract no develop the way they should be from the start	5	DMSMS Handbook of best practices	3	105
The management of the program office in charge of materials has not assigned or develop a software or tool able to manage the asset correctly	5	DMSMS Handbook of best practices	5	225
Not tools to manage or resources	5	DMSMS Handbook of best practices	6	300
Not having and system or planned demand in a fashion that can be review by the managing office	5	DMSMS Handbook of best practices	8	360
Not having and system or planned demand in a fashion that can be review by the managing office	5	DMSMS Handbook of best practices	8	280
Delay on system integrations	5	DMSMS Handbook of best practices	7	210
No centralized system with component , sub-system and system hierarchy	5	DMSMS Handbook of best practices	6	150
No centralized system with component , sub-system and system hierarchy	5	DMSMS Handbook of best practices	6	180
No centralized system with component , sub-system and system hierarchy	5	DMSMS Handbook of best practices	6	180
Missing planning aspect from program office	5	DMSMS Handbook of best practices	7	245

Table 3

FMEA Section B

Improved

After determining and measuring the gaps between *What it is* and *What it should be*, this project can move forward with clear understanding of areas to improve. The idea is to propose a systematic process that would help in the improvement of the current processes. Is clear, as mentioned, on multiple occasions, early notice and the correct demand of a product change are the most important aspect when fighting DMSMS issues. To improve processes, a tool commonly used is Poke-Yoke, better known as Error proofing and "5 Why Analysis Summary". The Poke-Yoke is a tool that helps in the implementation of design features for a product or process that would help in the removal of errors. In this case, the intention is to be able to improve the Assess phase and to have a complete system Health assessment to proactively monitor obsolescence, proactively monitoring demand and inventory levels with a process that will force itself to correct any error or remove waste withing.

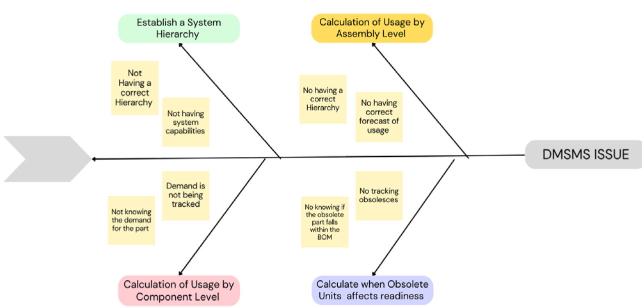

Figure 5
Error Proofing

5 Why Analysis

Why doesn't the organization have a robust early detection system (Proactive)? Infrastructure cost, changes in chain of command, not having the right documentation no tracking correctly.

- Why these factors are issues?
- Why there is not an infrastructure built to track demand?
- How is managing the bill of materials?
- Why there are not an automatic early detection system? Build in early detention and planned pieces component health assessment. No open repository for EEE components to track individual health and methods to force the supplier to contractual agreement that force them to have a unify notification centers like GIDEP.
- Why there are not a government early detection system like GIDEP?

After reviewing the data from the project, the data shown that a standardized method control by software is needed to improve the process and remove the human error factor from equation or "waste" of the process. To accomplish this, this project will suggest the developing a across the board software integration platform that would automatically receive the feedback from the supplier Year to End of life of piece component and will notify the program office of the risk involve in the component in addition to suggested alternates for the substitution of the part. With this system, program manager or action owners will be able to tackle early detention along with issues of demand. The software will be able to react equally in all the DoD organization, minimizing delay and human errors improving defense operation life cycle systems and subsystem.

Controls

The final phase is to develop and implement controls to measure the implementation phase. In this case and due to the academic purpose of this project, the control phase will not be executed. But if implemented, the target metric should be the resolution cycle time for DMSMS issue since detected to implementation on the systems would be a good starting point. Due to uncertainty in possible obsolescence issue, program manager should track issues per platform to assess the health by system not necessarily by department.

CONCLUSION

Answering the main problem statement of this project, it has shown a treading on the most important area or the areas on which focused is needed, the most are the creation of a proactive obsolesces alert system and the ability of piece component health monitoring. With the implementation of these controls within the process, it would be possible to accurately track and monitor the behavior of certain technologies and how the market is evolving. Thanks to the techniques and theory discussed and learning through the Manufacturing Engineering program, this project was able to develop and perform informed analysis on how with the right time and resources could be easily implemented in a real-life scenario. DMSS issues are inevitable, and they are expected to happen in a systems life cycle; for this reason, is important to have knowledgeable resources capable of implement processer to safeguard [4] "program cost, schedule, system performance and ultimately warfighter readiness and lethality". This is proof that Lean Six Sigma is necessary to help develop engineers and prepare them to face the reality of design, develop, manufacture, test, and sustain the high reliability space industry.

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