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THESIS

**DEPOT LEVEL REPAIRABLE (DLR) 5G AND 5S
ADVICE CODE COST ANALYSIS**

by

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and Ryan J. Storrusten

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ADVICE CODE COST ANALYSIS**

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ABSTRACT

The DOD uses Depot Level Repairables (DLRs) to fix and maintain a variety of weapon systems. These DLRs are among the most closely managed and scrutinized items in the supply system for the U.S. Navy, tracked by operational Commanders, supply commands, manufacturers, maintainers, and others. While each of these entities track certain metrics it is difficult to visualize the entire process flow to identify costs and process improvement opportunities, and to assess the process on various management metrics. This capstone project focuses on the differences between 5G and 5S Advice Code DLRs. The project identified the entire DLR management process, contextualized every cost and who pays the cost, tradeoffs, and benefits at each step for the varying parties. This project lays the foundation for further research by describing the full picture of DLR management in order to increase effectiveness, readiness, and cost to better manage DLRs and service Navy customers.

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TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	BASICS OF DEPOT LEVEL REPAIRABLES.....	1
B.	PROJECT FOCUS AND GOALS.....	2
C.	RESEARCH QUESTIONS.....	4
D.	SCOPE	5
E.	ORGANIZATION OF THESIS	5
II.	LITERATURE REVIEW	7
A.	NAVSUPINST P-485, NAVSUPINST 4440.182C, COMNAVSURFORINST 4400.1A, OPNAVINST 4400.9D, AND ERMS DESK GUIDE	8
B.	DOD DEPOT-LEVEL REPARABLE SUPPLY CHAIN MANAGEMENT PROCESS EFFECTIVENESS AND OPPORTUNITIES FOR IMPROVEMENT.....	10
C.	ANALYSIS OF THE REMAIN-IN-PLACE POLICY	12
D.	DEPOT LEVEL REPAIRABLE CARCASS TRACKING AND THE ELECTRONIC RETROGRADE MANAGEMENT SYSTEM.....	13
III.	THE CURRENT DLR SYSTEM	15
A.	OVERVIEW OF ADVICE CODES.....	17
B.	HOW A DLR GETS AN ADVICE CODE	18
C.	DLR END USER PROCESS.....	21
D.	DLR SUPPLY CHAIN MANAGEMENT	23
E.	REMAIN IN PLACE REQUESTS.....	26
IV.	COST CATEGORIES.....	29
A.	LABOR COSTS	30
B.	REPAIR COSTS	31
C.	COST OF NEW RFI DLRS: INITIAL AND OBSOLESCENCE.....	31
D.	REQUISITION PROCEDURE COSTS BASED ON ADVICE CODES.....	33
E.	INCORRECT ADVICE CODE COSTS.....	33
1.	RIP Request Costs If Incorrect Advice Code Is Caught Before NRFI Removal	33
2.	Additional Costs if Incorrect Advice Code is Not Caught Before NRFI Removal	35
F.	STOCKOUT COSTS.....	35

G.	CANNIBALIZATION COSTS.....	36
V.	CONCEPTUAL TRADEOFFS: 5G VS. 5S BENEFITS AND CONSEQUENCES	37
A.	5S ADVICE CODE BENEFITS	38
1.	Partial Mission Capable	38
2.	Personnel and Equipment Risk Mitigation	39
B.	5S ADVICE CODE CONSEQUENCES.....	40
1.	Turn-in Delay to Repair Facility	40
2.	Cost and Benefit Tradeoff to Mitigate Risk of Stockouts	42
C.	TAGOUT LABOR BENEFITS & CONSEQUENCES.....	43
1.	Tagout Labor Consequences: 5G Scenario I and II	43
2.	Tagout Labor Consequences: 5S Scenario I and II	44
3.	Prior Research on Tagout Labor.....	45
D.	ADDITIONAL COSTS OF RIP REQUESTS.....	46
E.	CANNIBALIZATIONS.....	47
VI.	DATA REQUIREMENTS FOR FUTURE RESEARCH	51
A.	DATA PERTAINING TO LABOR COSTS	51
1.	Labor at Unit for Tagout and Ordering	52
2.	Labor in Warehouse for Inventory Management.....	52
3.	Labor for RIP Request	53
B.	DATA PERTAINING TO REPAIR COSTS	53
C.	DATA PERTAINING TO COST OF NEW RFIS.....	54
D.	DATA PERTAINING TO STOCKOUT COSTS	55
E.	DATA PERTAINING TO CANNIBALIZATION COSTS	56
VII.	CONCLUSION AND RECOMMENDATIONS.....	59
A.	SUMMARY OF CONTRIBUTIONS.....	59
B.	FOR FUTURE RESEARCHERS SEEKING TO FOLLOW UP	60
1.	Partial Mission Capability	60
2.	Stockouts.....	60
3.	Tagout Labor.....	61
4.	RIP Request Process	61
5.	Cannibalizations.....	61
6.	Data Source Collections.....	62
	LIST OF REFERENCES.....	63
	INITIAL DISTRIBUTION LIST	65

LIST OF FIGURES

Figure 1.	Carcass Process Flow for 5G and 5S Advice Code DLRs.....	16
Figure 2.	Assigning a DLR as 5G or 5S.....	20
Figure 3.	5G and 5S Advice Code End-User Process Flow by Weapon System.....	21
Figure 4.	Steady-State DLR System.....	24
Figure 5.	DLR Requisition Process.....	25
Figure 6.	RIP Request Process Chart. Adapted from NAVSUP (2023).	28
Figure 7.	Cost of New RFIs: Initial and Obsolescence Upgrades.....	32
Figure 8.	5S Delayed Turn-In to Repair Pipeline.....	41

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LIST OF ACRONYMS AND ABBREVIATIONS

Ao	Operational Availability
ATAC	Advanced Traceability and Control Team
CNSL	Commander Naval Surface Forces Atlantic
COG	Cognizance Symbol
DLA	Defense Logistics Agency
DLR	Depot-Level Repairable
eRMS	Electronic Retrograde Management System
FY	Fiscal Year
GS	General Schedule
IM	Item Manager
ISEA	In-Service Engineering Agent
LS	Logistics Specialist
NAVSUP WSS	NAVSUP Weapon Systems Support
NAVSUP	Naval Supply Systems Command
NIIN	National Item Identification Number
NP	Net Price
NRFI	Not Ready for Issue
NSN	National Stock Number
OEM	Original Equipment Manufacturer
OFRP	Optimized Fleet Response Plan
OPTAR	Operating Target
RFI	Ready for Issue
RIP	Remain-in-Place
RTAT	Repair Turn-Around-Time
SCM	Supply Chain Management
SM&R	Source, Maintenance, and Recoverability Code
UP	Unit Price
2M	Miniature/Microminiature Electronic Repair

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I. INTRODUCTION

Depot Level Repairables (DLRs) are an everyday fact of life for U.S. Navy units. They can be a cause of both elation and frustration as they are almost always tied to critical weapon systems required for mission success. DLR management is a nebulous process with many stakeholders that have different priorities. This chapter introduces this project's research questions, which are intended to codify this process into digestible information that can be used for process improvement, cost savings, and improved mission readiness.

This research project primarily focused on DLRs under two advice codes, 5G and 5S. The most common advice codes used in the DLR process. The first advice code, 5G is identified in the NAVSUP P-485 Volume II as a one-for-one mandatory turn-in repairable that requires the NRFI part to be turned in as a one-for-one exchange when submitting a requisition for an RFI DLR. The second advice code, 5S, is for Remain-in-place (RIP) DLRs. The guidance in the NAVSUP P-485 directs that a 5S DLR is a mandatory turn-in repairable where a not-ready-for-issue (NRFI) DLR will be turned-in once a ready-for-issue (RFI) part is received.

The following sections present the basic overview of the DLR system and processes, define the common advice codes used in the DLR system, explain the research questions, the importance of these research questions and their potential impacts, define the scope of the research. This chapter concludes with an outline of the chapters that follow. This introduction is intended to inform the reader of the topics covered in this research project and how this research project is organized.

A. BASICS OF DEPOT LEVEL REPAIRABLES

The Navy uses a part classification system to identify DLRs that can be economically repaired either by qualified Sailors, contractors, or the original equipment manufacturer (OEM). NAVSUP P-485 Volume I identifies repairable parts as DLRs (Naval Supply Systems Command [NAVSUP] 2022a, p. 8-82). The concept is that, rather than paying the standard price, which is the full price to manufacture a new item, the end user requisitioning the DLR can pay the net price, which is the price to repair the failed

part (NAVSUP, 2022a, p. 8-83). In order to pay the net price, the end user must have the NRFI DLR, otherwise known as a carcass, available to turn into a repair facility. The NRFI DLR is then repaired at a designated facility and is returned as an RFI DLR to either fill an end-user requisition or to replace an RFI DLR that was issued to fill the original requisition. This concept has a specific upfront benefit of being cheaper, and potentially allows an end user to receive an RFI DLR faster by repairing the NRFI carcass rather than waiting for the OEM to manufacture a brand new one. This capability also allows for the repair of existing DLRs that may not be manufactured anymore, and Naval Supply Systems Command Weapons System Support (NAVSUP WSS) can then maintain available DLRs for less supported weapon systems that are facing obsolescence.

DLRs must be managed more closely than non-DLR consumable parts due to the one-for-one turn-in requirement in order to save costs and maintain inventory availability for future part failures. This close management of DLRs creates more burden on the unit-level supply department, the end user that needs the DLR to repair a failed or degraded piece of equipment, and NAVSUP WSS in managing the overall DLR program and processes. For example, the end-unit supply department must meet 100% inventory accuracy for all DLRs in stock and requisitioned, amongst other metrics tracked by their higher echelon commands. The end-user needing the DLR must not only repair and replace the failed equipment that houses the DLR but is also responsible and accountable to maintain control of all DLR carcasses in equipment they manage in order to maintain required 100% inventory accountability. The P-485 also highlights that NAVSUP WSS item managers are responsible for managing each DLR identified by a National Stock Number (NSN) throughout the DLR's life cycle, from initial inventory levels to issuing stock at various distribution centers, while also tracking the repair and subsequent return of RFI DLRs back into the supply system (NAVSUP, 2022a, p. 8-82).

B. PROJECT FOCUS AND GOALS

The focus of this research project is to identify the steps in the DLR process, identify and assess the associated cost categories, discuss cost trade-offs at the various steps, and determine data required to conduct a cost-benefit-analysis (CBA) at the various

steps in the DLR process. Since there are several stakeholders in the DLR process, and each one tracks different metrics, it can become cumbersome to fully grasp the process as there is currently no one-single reference that provides the wholistic view. Once the process is mapped out, the reader will get a comprehensive view of the entire DLR process. The end-user units considered in this research project are U.S. Navy Destroyers (DDGs), Cruisers (CGs), and the smaller Amphibious warships (LPDs and LSDs). They are referred to as the surface fleet throughout this research project.

The most common tradeoff considered by customers of the DLR process is between 5G and 5S advice codes. This has the most impact on the customer in the ordering process and can be a source of frustration as the advice code has implications and costs associated with it that will be discussed in Chapter IV. For this thesis, the cost-categories identification, and tradeoffs for 5G vs. 5S advice codes are the primary focus, including the RIP process that can be conducted to change an advice code from 5G to 5S under applicable circumstances.

The goals of this research project are to identify all cost-categories incurred at each point within the DLR process, identify trade-offs between those costs and procedures, and conduct a conceptual analysis of those tradeoffs that will provide the basis for conducting a CBA with appropriate data from stakeholders. This analysis will inform and assist NAVSUP WSS in determining future recommendations for policies or process changes that result in cost-savings or increased mission readiness for the surface fleet once a CBA is completed. To achieve these goals, it is essential to compile unbiased information from NAVSUP WSS, Commander Naval Surface Forces Atlantic (CNSL), Defense Logistics Agency (DLA), the Original Equipment Manufacturers (OEM), and depot level repair facilities that can accurately portray the whole picture of the DLR system.

To lay the foundation for conducting a CBA, the authors identified cost categories and drivers, as well as identified data needed to assess the costs. Once these are collected a tradeoff analysis can be conducted focusing on 5S and 5G coded DLRs based on which stakeholder benefits and how much weight that holds. Due to how large and complex the DLR process is, it is not possible to do a full CBA on the process with one thesis, so the goal of this project is to define the entire DLR process thoroughly including stakeholders,

costs, conceptual tradeoffs, and additional data requirements. Based on data collected for this thesis the authors will identify additional data required from each of the stakeholders to conduct a CBA across all steps in the DLR process. This thesis is to set the foundation for further research to gather the rest of the identified data required to develop a complete picture CBA across multiple future thesis projects.

C. RESEARCH QUESTIONS

This project intends to answer the following research questions:

- (1) What are the cost categories associated with the 5G vs. 5S determination for a DLR?

To answer this question the authors have mapped out the entire DLR system from the part being initially introduced into the NAVSUP supply system, requisition to end-units, repair of a broken DLR at designated repair facilities, and the refurbished DLR being returned as an RFI back into the overall NAVSUP supply system. This mapping will create a wholistic view of the entire process, providing an opportunity to capture every cost involved at each step in the DLR life cycle.

- (2) What are the tradeoffs across the identified cost categories associated with the 5G vs. 5S decisions?

To answer this question, the authors examined the cradle-to-grave requisition process from both the unit-level and NAVSUP WSS perspectives. In conducting the analysis, the authors examined tradeoffs between costs, both monetary and non-monetary, and benefits among each of the cost categories identified in the first research question. The tradeoff perspectives of each stakeholder were then analyzed. The unit-level perspective tends to gravitate towards increased unit-level readiness, while the NAVSUP WSS perspective is focused on fleet-wide readiness and fiscal responsibility. Other stakeholders are analyzed by how they impact the controllable stakeholders under the Navy. The tradeoff analysis covers all of the conceptual factors that could increase or decrease costs and readiness based on the cost categories examined in the first research question.

- (3) Based on the tradeoffs identified in the second research question, what data is required to conduct a cost-analysis across the entire DLR process?

To answer this question the authors analyzed the tradeoffs identified between cost categories associated with 5G vs. 5S advice codes to determine what data is still required and from what entities. The research also determined whether costs are monetary or not, and subsequently considered how to monetize some of the non-monetary costs to conduct qualitative analyses for every cost involved in each step of the DLR process.

D. SCOPE

This project is limited to surface ships that do not carry Navy Working Capital Fund (NWCF) stock onboard, and this project does not include nuclear or classified DLRs due to their controlled nature. This choice was made primarily for ease of access to data from NAVSUP WSS and to focus on the biggest population group possible and allowed the authors to analyze situations where the Navy has complete control, without bias from aviation, nuclear, or capitalized stock concerns. Capitalized stock on aircraft carriers (CVNs) and large amphibious warships (LHD/LHA) platforms is subject to more scrutiny by Defense Logistics Agency (DLA) and would not be fully controlled by NAVSUP WSS, but recommendations from this thesis should be useful for DLA-owned stocks as well.

E. ORGANIZATION OF THESIS

This thesis is broken up into several main areas. First, we discuss relevant literature that was reviewed to develop a complete picture of the DLR system. Following the literature review the thesis lays out the background of the current DLR process and stakeholders involved. The entire DLR management processes are mapped out to ensure that no steps or factors are missed in the research analysis. Cost categories for each step mapped out in the DLR process are identified and examined in Chapter IV. A conceptual tradeoff chapter subsequently analyzes how cost-categories are impacted through tradeoffs that balance monetary and non-monetary costs and readiness. The subsequent chapter then details data requirements that are still required to fully conduct the trade-off analysis. Lastly, the thesis concludes with findings and recommendations for future research to

create a wholistic cost-analysis for the DLR program regarding advice code 5G vs. 5S decisions.

II. LITERATURE REVIEW

The authors have read and analyzed the following publications, articles, and theses to gain background information on the current DLR process:

- NAVSEAINST 4790.8D (NAVSEA, 2021)
- NAVSUP eRMS Desk Guide (NAVSUP, 2017)
- NAVSUPINST P-485 (NAVSUP, 2022a, 2022b)
- NAVSUPINST 4440.182.C (NAVSUP, 2023)
- COMNAVSURFORINST 4400.1A (SURFOR, 2017)
- COMNAVSURFORINST 4400.12 (SURFOR, 2019)
- OPNAVINST 4790.14B (CNO, 2013)
- OPNAVINST 4400.9D (CNO, 2017)
- OPNAVINST 4440.19G (CNO, 2021)
- DOD DIRECTIVE 4151.18 (DOD, 2004)
- DOD Depot-Level Repairable Supply Chain Management Process: Effectiveness and Opportunities for Improvement (Peltz et al., 2014)
- Analysis of the Remain in Place Policy (Hagan & Ohman, 2020)
- Depot Level Repairable Carcass Tracking and the Electronic Retrograde Management System (Carr & Wilcox, 2006)

The Navy instructions are the current policies that dictate how to manage DLRs from end unit up to NAVSUP. This information is vital to know how the system currently operates. The RAND study (Peltz et al., 2014) was conducted as a DOD level view of how well DLRs are managed by the military. The RAND report does not focus on specific

branches or expand on the overall process that includes end unit users. The NPS thesis by Hagan and Ohman (2020) explores specific end unit labor costs to the customer and recommends process improvements. All of these are foundational to process improvement of the DLR management system, but none have an all-encompassing view of NAVSUP's responsibilities for the Navy. Carr and Wilcox were a primary source of information for the Hagan and Ohman thesis and discussed the implementation of an online interface to track DLR carcass movements known as Electronic Retrograde Management System (eRMS). Our thesis intends to focus on potential improvements that are within the Navy's control and analyze all steps and stakeholders within the entire DLR program.

A. NAVSUPINST P-485, NAVSUPINST 4440.182C, COMNAVSURFORINST 4400.1A, OPNAVINST 4400.9D, AND ERMS DESK GUIDE

The listed U.S. Navy instructions in this subsection are all guidelines in DLR management. These documents are vital to understanding the full breadth of DLR management and identifying how the current system functions. Once every step is identified it will lay the foundation for a cost benefit analysis. All these instructions include metrics to measure how well a Supply department is at managing their material programs and also include guidance on DLR management at the unit level.

The publications were issued under the direction of Commander Naval Supply Systems Command, Command Naval Surface Forces Command, and the Office of Chief of Naval Operations. The NAVSUP P-485 is the publication that directs all requirements for Supply Department operations fleet-wide, covering all advice codes and applicable procedures, cognizant codes (COGs), as well as all other requirements for requisitions, inventories, documentation requirements, and much more that is outside of the realm of this research project (NAVSUP 2022a, 2022b). The NAVSUP P-485 also describes 5G and 5S advice codes, specifying that if a DLR is 5G then the carcass is required to be sent from the end unit for repair after an RFI DLR is requisitioned; or if a DLR is 5S then the carcass is allowed to remain in the equipment system of the end user until the RFI is received by the end unit (NAVSUP, 2022b, pp. A1-6–A1-7).

NAVSUPINST 4440.182C presents the Remain-In-Place Policy and Procedures instruction issued by NAVSUP WSS. This provides a RIP process for Aviation and Maritime DLRs managed by NAVSUP WSS. The instruction outlines the procedures for how and when advice codes are determined, various advice code requests that can be made if an end-unit requests a change, and the process involved in a RIP request change that includes a process flow chart that encompasses multiple entities in the Navy to determine if the change is valid (NAVSUP, 2023, pp. 2–3, Enclosure 3). This request is sent to NAVSUP WSS to be adjudicated between the engineers at Naval Sea Systems Command (NAVSEA) and the item manager at NAVSUP WSS to change the advice code from a 5G to a 5S by meeting safety, operational functionality, or specialist knowledge criteria (NAVSUP, 2023, Enclosure 2). If a RIP request is approved, it changes the advice code for that DLR for that specific type of ship in the fleet.

The COMNAVSURFORINST 4400.1A is the Surface Force Supply Procedures Manual and guides all supply operations in Commander, Naval Surface Forces (COMNAVSURFOR) ships. The policies and procedures in this instruction are mandatory for all COMNAVSURFOR afloat commands (Commander, Naval Surface Force United States Pacific Fleet/Commander Naval Surface Force Atlantic [SURFOR], 2017, p. 1). This instruction expands upon the P-485 and clarifies requirements in further detail and provides additional requirements for the surface fleet. This instruction clarifies procedures for handling different advice codes, timelines for receipt of NRFI carcasses, and requirements for the unit level supply department to maintain inventory accuracy of DLRs, and other requirements that are critical but outside of the scope of this research project.

The OPNAVINST 4400.9D is the Chief of Naval Operations Depot Level Repairable Item Management instruction. The purpose is to provide policy and assign responsibilities for the management of DLRs (Office of the Chief of Naval Operations [CNO], 2017, p. 1). This instruction applies to all activities who manage, control, process, or use DLRs with material control codes H, E, X, G, Q (CNO, 2017, p. 1). These material control codes are only important to this thesis as another identifying marker to see if a National Item Identification Number (NIIN) (condensed version of the NSN) is a DLR or

not. The individual material control code variation does not impact the analysis of advice codes being conducted in this thesis.

The Electronic Retrograde Management System (eRMS) is a web-based application developed by NAVSUP, NAVSUP WSS, and NAVSUP Business Systems Center. Users who handle, ship, and track DLRs are intimately familiar with this application. eRMS provides the user with documentation and visibility which is used to identify the DLR that will be returned to the supply system as either an RFI or NRFI DLR. In the application the user can communicate with NAVSUP WSS regarding delayed turn-in requests, DLR charges, discrepancies, or any miscellaneous events that require a response from NAVSUP WSS.

Reviewing the four instructions together provided a more wholistic view of the DLR process, procedures, and policies that direct the current DLR process. Reviewing and analyzing these instructions was beneficial in providing a collective view of requirements from both the Type Commander (TYCOM) level and end-user level in analyzing the DLR process costs and opportunities. These instructions heavily informed Chapter III in this thesis in compiling a thorough picture of the DLR management process.

B. DOD DEPOT-LEVEL REPARABLE SUPPLY CHAIN MANAGEMENT PROCESS EFFECTIVENESS AND OPPORTUNITIES FOR IMPROVEMENT

The RAND Corporation study titled “DOD Depot-Level Reparable Supply Chain Management Process Effectiveness and Opportunities for Improvement” was conducted in 2014 and focused on identifying and analyzing the strengths and weaknesses in the supply chain management of DLR parts across the Department of Defense to include the U.S. Airforce, U.S. Army, and U.S. Navy (Peltz et al., 2014, p. 2). This report was extremely useful and significant for giving a wholistic view of the DLR management system but was too broad of a scope for our research questions. The authors will focus on what Navy entities can change and monitor. The RAND study is the closest analysis to our research focus.

The RAND study's analysis employed multiple approaches and assessed reasons for customer shortfalls where demand was greater than supply, process improvement opportunities, and included a total cost viewpoint for supply and maintenance in forecasting inventory levels that support depot repair and production (Peltz et al., 2014, pp. 117–118). The research took a DOD point of view to analyze these areas. The analysis provided a framework to provide a foundation for our research on a cost-benefit analysis between DLR inventory levels and operational availability for parts needed for fleet readiness, which is explored in Chapters III, IV and V.

While the research was DOD-wide and heavily focused on the services, the recommendations and process improvements still apply to the U.S. Navy and for the scope of this thesis. The RAND project concluded that DLRs are managed relatively well by the service branches from an overall view (Peltz et al., 2014, p. iii). Specifically, RAND noted it was difficult to find excess inventory that was due to avoidable circumstances or poor supply chain management (SCM), and that most excess DLR stock was due to long lead times of phasing out obsolete DLRs for weapon systems that had been upgraded (Peltz et al., 2014, p. xxviii). The authors of the RAND article went on to say that the broadest DLR SCM issues stem from part supportability and degrading customer support (Peltz et al., 2014, p. xxix). Part supportability means that the DLR is effectively being managed with minimal stockouts and effective repair support, and degrading customer support means that customer feedback and requests are being addressed in a timely manner. This is a great lead-in for this thesis as parts supportability is a big factor in DLR management that is within the control of NAVSUP WSS to improve. Long lead times for new weapon systems contracts and changes to OEM servicing contracts are not discussed in this thesis but is a common topic amongst the Naval Postgraduate School contracting cohort. By focusing on cost drivers that NAVSUP WSS has control of specific actions can be analyzed to improve the DLR process.

A major recommendation from the RAND report is that the Department of Defense should take a total cost assessment approach that includes supply, maintenance, and repair costs (Peltz et al., 2014, p. iii). To aid in this, the service branches should quantitatively estimate the costs of parts shortages for DLA to integrate into the trade-off between

shortage and inventory-holding costs in planning optimum safety-stock levels (Peltz et al., 2014, p. xxix). This wholistic approach is something that will be examined in this thesis to help advance this line of query to better support the customer and support fiscal constraints. NAVSUP policies that are currently followed can be proven effective or altered with more data to base decisions on. Unlike other publications we researched, the RAND report did talk about advice codes and life cycles of requisitions. While the advice codes were mentioned there were no recommended changes to the current advice code classification system. Furthermore, the report accurately describes the USN's policy as a "pull" system with some small exceptions, meaning stock responds based on demand that exists for the system and not "pushed" to units based on anticipated demand (Peltz et al., 2014, p. 52). Pull is more fiscally conservative than push systems, but it does mean that there can be a delay to replenishing stock levels if demand spikes consistently. With a pull system it is critical to ensure that the current DLR policy is as efficient as possible to balance minimizing stockouts against minimizing inventory costs.

C. ANALYSIS OF THE REMAIN-IN-PLACE POLICY

The NPS thesis by Hagan and Ohman was a specific drill-down on customer interactions using DLRs with 5G and 5S advice codes. This thesis was written from the perspective of the end user (customer) of the DLR process. It had good research and data to put forward but did not expand the scope of the cost-benefit analysis enough to see the full picture. There are many other costs associated with the DLR process besides the Sailor labor costs considered in their thesis, which we explore in Chapter IV.

In Hagan and Ohman's (2020) thesis, the authors recommended a change to the current DLR RIP policy. Their primary source of previous research was a thesis called Depot Level Repairable Carcass tracking and the Electronic Retrograde Management System (Carr & Wilcox, 2006) published by NPS. Carr and Wilcox explained the DLR process in depth and highlighted problems with the DLR system while recommending changes to improve the system.

Hagan and Ohman originally set out to collect unit data from DDG and CG ships stationed in San Diego, CA by survey. The survey was primarily done to get data based on

the ship's internal process for turning in 5G and 5S DLRs and the impact this had at the unit level. Due to the COVID-19 pandemic, only two ships participated in the survey, and 30 individual Sailor responses were recorded.

Hagan and Ohman found that Remain-In-Place (RIP) would save costs on the unit level by time saved during the maintenance tag out process required to remove and install DLRs during the ordering process. If the DLR was coded for RIP, the maintenance team saved time with the removal process, however this did not consider other tag-out scenarios that can refute this claim. This will be discussed further in Chapter V. The financial cost saved was calculated based on the pay of two assumed E-5 Sailors multiplied by the difference in time taken between a 5G or 5S coded DLR (Hagan & Ohman, 2020, pp. 36–37). It was proposed that there was a potential cost savings of \$21.95 per DLR if it was 5S instead of 5G (Hagan & Ohman, 2020, p. 37). The authors gave a recommendation of conducting larger studies to see if there is a cost ceiling that it would be financially beneficial to place an automatic 5S advice code.

We noted while reading Hagan and Ohman's thesis that while their claim that RIP 5S advice codes save labor costs for the end unit in the DLR process it did not account for costs incurred in the overall process. There was no accounting for the operational readiness of managing DLRs and financial cost to the Navy for delaying the turn in of the carcass. Maintenance turnaround time was also not factored in which could have a significant impact on the cost/benefit analysis of having a default 5S advice code for DLRs. There were also assumptions made on how many tagouts occur for each advice code which is explored in Chapter V. Because they did not consider the broader trade off costs and consequences of changing a DLR from 5G to 5S it can lead to unintended consequences to the Navy based on their recommendation. This thesis aims to provide a bigger picture.

D. DEPOT LEVEL REPAIRABLE CARCASS TRACKING AND THE ELECTRONIC RETROGRADE MANAGEMENT SYSTEM

Carr and Wilcox wrote this thesis in 2006 when eRMS was first starting to be introduced in the fleet. The focus was on the previous method of tracking DLRs through multiple outdated systems that did not communicate with each other to eRMS as an all-in-

one management system. The eRMS system increased efficiency and is still the system in use for the Navy to manage DLRs in 2023.

Their thesis provided a general overview of the NAVSUP P-485 and process flow of the DLR program. However, it was only a basic overview and did not provide a wholistic picture of the DLR process, so did not create a foundation to establish all of the cost-categories involved or the different advice codes and their implications. This thesis had no information or research conducted on costs or on the categorization of DLR advice codes. As a result, we found that this literature was not suited as a solid foundation for analyzing costs across the DLR program or tradeoffs of 5G vs. 5S advice codes, and we did not use this thesis to provide any information or data to help further our research and conclusions.

III. THE CURRENT DLR SYSTEM

DLRs are a massive part of supply chain management for the U.S. Navy. The process of ordering DLRs to maintain weapon systems is critical to mission readiness and the flexibility every commander needs to act swiftly in contested environments. It is scrutinized by customers for its sometimes-painful process and carefully watched by Supply departments to ensure that accountability and traceability is always available. With the management and consequences of this process being scrutinized by so many organizations, it would be advantageous to break down the process into one document and describe it in plain language.

The current system for depot-level repairable (DLR) requisitions demands that the failed part, the NRFI DLR, must be removed from the operating system and turned over to the organization's Supply Department for shipment to a storage facility or into the repair pipeline (NAVSUP, 2022a, p. 8-87). The repair pipeline process consists of the repairing entity (the OEM or a Depot Level Repair Facility) receiving the NRFI DLR from shipment, repairing the DLR, and returning it back to a warehouse or a Navy end unit as an RFI DLR available to the fleet. This flow involves multiple entities that include the Advanced Traceability and Control Team (ATAC), NAVSUP WSS, IMs, depot-level repair facilities, and DLA distribution centers. In Figure 1 there is an illustration of the carcass process flow for 5G and 5S advice code DLRs. The primary difference between 5G and 5S is when the NRFI carcass enters the process flow and is highlighted in the figure. A 5S DLR carcass is shipped and does not enter the process flow until after the RFI is received by requisitioning ship.

If a DLR is requisitioned by a unit, it will be subject to two-tier pricing (NAVSUP, 2022a, p. 8-83). If there is no carcass (NRFI DLR) available for turn in due to loss, damage beyond repair capability, or incorrect part, then the unit will be charged the full unit price (UP) of the DLR because a brand new DLR must be acquired to replace the lost or damaged DLR. If the carcass is turned in, then the end unit is charged the net price (NP), or the exchange price, which is the cost for the DLR to be repaired by a repair facility to become RFI. The difference, or delta, between the UP and the NP is known as the carcass charge.

Carcass charges deplete the Operating Budget of the ship (SURFOR, 2017, p. 335). Depending on where the ship is in the Optimized Fleet Response Plan (OFRP), the life cycle of the ship that includes deployment, sustainment, certification, and repair cycles throughout, the carcass charge will use funds that are reserved for other maintenance or repair actions, and will have a significant impact to operational readiness since unit level budgets are funded based on current mission requirements in the OFRP (SURFOR, 2017, p. 91). The amount of carcass charges incurred by a unit is a metric tracked by NAVSUP WSS and the Type Commander (TYCOM) as a measure of the units' effectiveness at managing these parts on behalf of the greater supply system. This is also how the TYCOM assesses the health of the DLR materiel management by Supply Officers onboard afloat vessels.

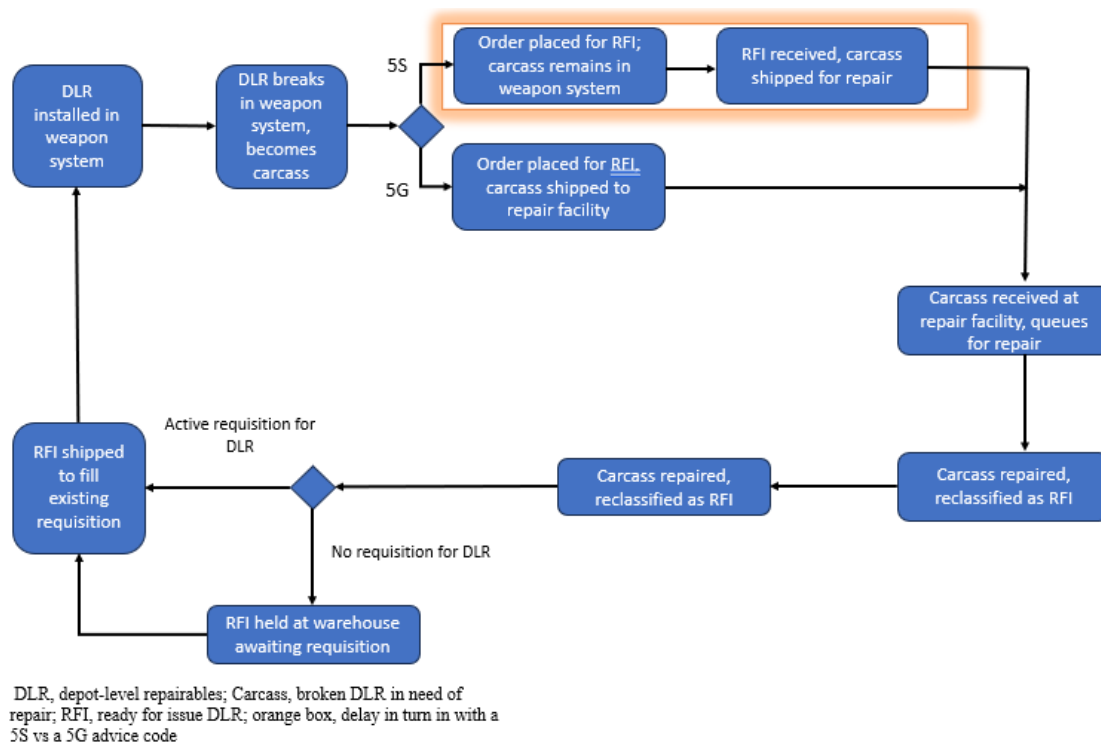


Figure 1. Carcass Process Flow for 5G and 5S Advice Code DLRs

NAVSUP WSS categorizes DLR parts based on unit cost, annual demand, difficulty of repair or timeline, and other economic factors based on item managers' control

of special inventory (NAVSUP, 2022a, p. 8-82). The NRFI, or failed, DLRs are shipped to various depot repair locations to be refurbished at a cheaper cost than procuring new parts so that RFI DLRs can be returned to the fleet. ATAC is the entity that the end-unit ships the carcass to, and then ATAC determines which repair facility or OEM the NRFI is shipped to for repair. The repair turn-around-time (RTAT), inventory levels, and monetary value of the parts can have significant impacts on the fleet—which is why NAVSUP WSS has designated each DLR with certain advice codes.

Each end unit in the Navy has allowances for DLRs that are set by the TYCOM. NAVSEA (for surface ships) dictates how many DLRs must be initially outfitted, and NAVSUP WSS is responsible for sustaining repairable parts to ships throughout their life cycle. Stock is determined by preventative and reactive maintenance demands for DLRs. If there is a DLR that is supposed to be on board, it will either be initially outfitted or must be ordered at standard price (if lost by inventory) to support shipboard operations. Initial outfitting is when a DLR is issued by NAVSEA to the ship as stock to support a new weapon system that has been installed onboard.

A. OVERVIEW OF ADVICE CODES

According to NAVSUP WSS, DLRs are identified by advice codes that “provide coded instructions to supply sources when such data is considered essential to supply action and entry in narrative form is not feasible” (NAVSUP, 2022b, p. A1-1). Advice codes are established by Hardware Systems Commands (HSCs) during the initial procurement for new weapons systems for every DLR in the supply system, and these codes determine when the NRFI DLR must be turned over to the organization’s Supply Department (NAVSUP, 2023, pp. 1–2).

The three most common advice codes used are 5G, 5S, and 5A. DLR requisitions for 5G advice code items require that the NRFI DLR at the end unit is turned in before submitting the requisition for an RFI DLR. Advice code 5S allows the NRFI to remain in the operating system while the replacement part is ordered and until the RFI DLR is received and used to replace the NRFI DLR. 5S DLRs still require the supply department to verify the carcass part number to ensure the correct DLR is being ordered prior to

requisitioning, and this may require the equipment to be tagged out and removed from operation for a brief period depending on the equipment. Advice code 5A indicates the NRFI DLR was surveyed as either missing or damaged beyond repair. 5A requisitions result in a carcass charge to the organization's operating budget as the unit must pay the UP instead of the NP, and it results in one less DLR in the repair pipeline pool for future requisitions in the fleet.

A requests to deviate from the 5G advice code turn-in requirement is known as a Remain-In-Place (RIP) request. These requests must be submitted via email to NAVSUP WSS for approval and cannot be delegated to a lower authority. There are individual exceptions to allow keeping a 5G carcass in place if there is a pending RIP request sent to NAVSUP WSS for processing (NAVSUP, 2023, pp. 2–3). This is coded as an advice code 52 (delayed carcass return), but advice code 52 can only be used after a RIP change request has been submitted (NAVSUP, 2023, p. 3). Without advice code 52, unit level DLR managers from each ship can delay the NRFI turn-in to ATAC up to 30 days to avoid carcass billing charges (NAVSUP, 2022a, p. 8-109). After the unit level delay extension has been used, the unit can also request an additional delay through the appropriate TYCOM. The TYCOM Force DLR Manager can request to extend the delayed turn-in from NAVSUP WSS due to extenuating circumstances such as being deployed with no ability to off-load the NRFI DLR.

It is important to note that the NAVSUP WSS policy states that any DLR that is identified by a customer as RIP worthy, and subsequently changed to a 5S advice code by NAVSUP WSS and the HSC, must also adjust inventory stock levels. NAVSUP WSS will budget to increase inventory stock levels to allow for necessary delays of carcass returns (NAVSUP, 2023, p. 3).

B. HOW A DLR GETS AN ADVICE CODE

Advice codes are assigned during the procurement phase and are required to be annotated in the Provisioning Technical Documentation (PTD) for the contract and identification of RIP-approved DLRs. During this process the advice code must be approved by the HSC, otherwise known as the Systems Command (SYSCOM) that is

procuring the hardware (NAVSUP, 2023, pp. 1–2). The primary HSCs are NAVSEA, Naval Air Systems Command (NAVAIR), and Naval Information Warfare Command (NAVWAR).

The current process for coding a DLR with an advice code is to get a determination from either NAVSEA for surface ships or NAVAIR for aviation parts. The OEM will recommend how many DLRs the Navy should initially procure, factoring in demand and repair turnaround times for the DLRs. This process involves the OEM, NAVSEA, and NAVSUP WSS to ensure that the initial code is immediately available for new DLRs introduced into the supply system. If all the stakeholders do not find a sufficient reason to code the DLR as 5S then the default code is 5G. The reasoning for coding a DLR as 5S would be that removal of the DLR from the end unit equipment would cause a hazard to the overall system, a hazard to personnel, requires external support for removal and replacement of the DLR, or if the equipment has degraded operation if the carcass remains and no operation if the carcass is removed (NAVSUP, 2023, Enclosure 1). Figure 2 depicts a decision tree of these reasons for assigning a DLR as advice code 5S.

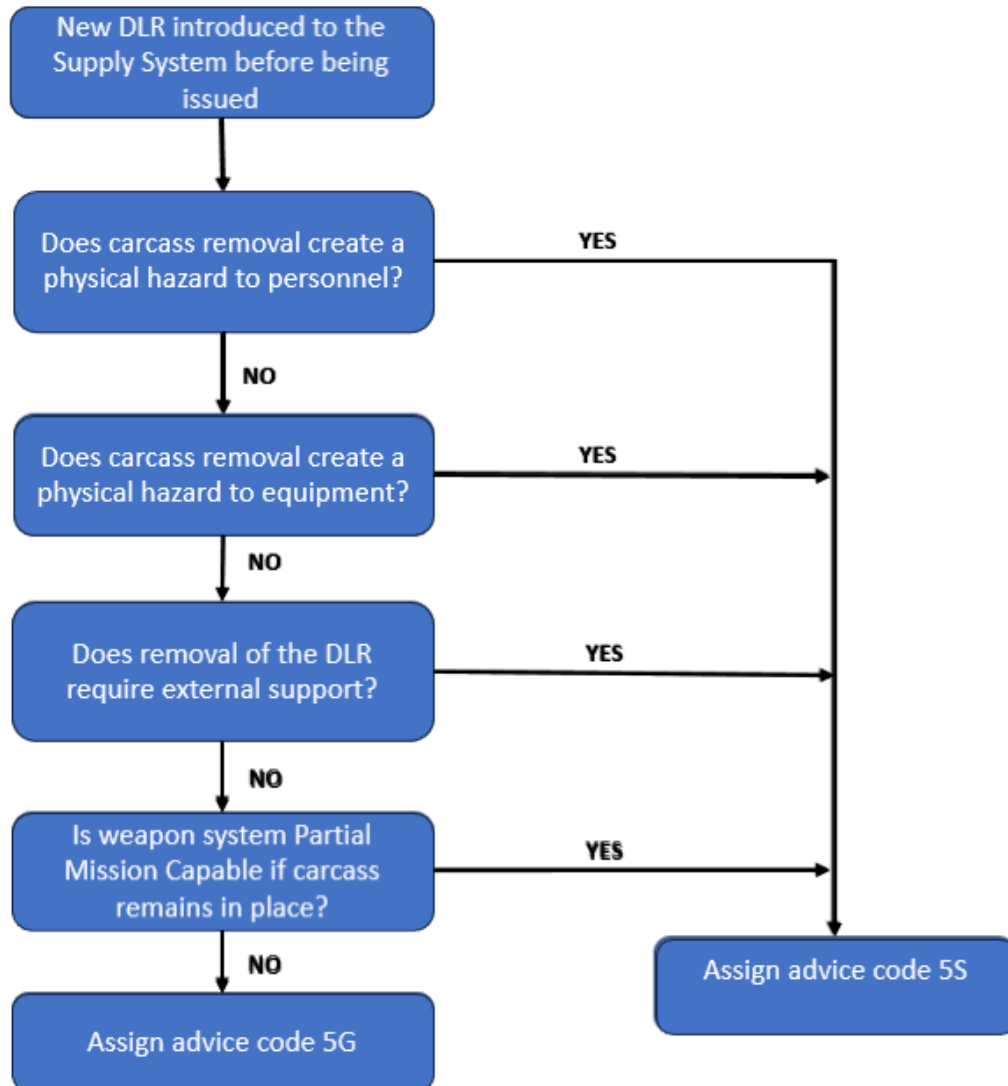


Figure 2. Assigning a DLR as 5G or 5S

From the authors' experience, maintenance personnel prefer to keep 5G DLRs in the system to reduce their workload. If a DLR is coded 5G and fulfills safety concerns, or damage to equipment, then the end unit can submit a RIP request to the item manager and NAVSUP WSS to change the advice code to 5S. The Supply Officer of the end unit writes the request with input from the equipment operators and then sends the request to the item manager, and at this point the advice code can change to 52. The RIP request must be processed by NAVSUP WSS within 30 days of receipt of the RIP request for maritime DLRs (NAVSUP, 2023, p. 3). NAVSUP WSS's goal is a 100% response rate with an 80%

on-time response rate (NAVSUP, 2023, p. 3). If the In-Service Engineering Agent (ISEA) at the HSC agrees with the RIP request justification, the advice code is changed for the DLR NIIN for all end users by NAVSUP WSS. If it is rejected, then the end unit must comply with the 5G code to avoid consequences from the TYCOM and NAVSUP WSS.

C. DLR END USER PROCESS

The primary concern for the end user is whether an advice code is 5G or 5S. The difference occurs after the DLR breaks in the weapon system. DLRs assigned as 5G result in a weapon system that is not operational, and the RFI replacement is not requisitioned until the NRFI carcass has been turned into supply department. 5S DLRs may allow a weapon system to remain operational in a degraded state in many cases, but also allows for the RFI replacement to be requisitioned immediately without removal and turn-in of the NRFI carcass until the RFI is received onboard. Figure 3 depicts the different process flow for the end user based on assigned advice code of the DLR in the weapon system.

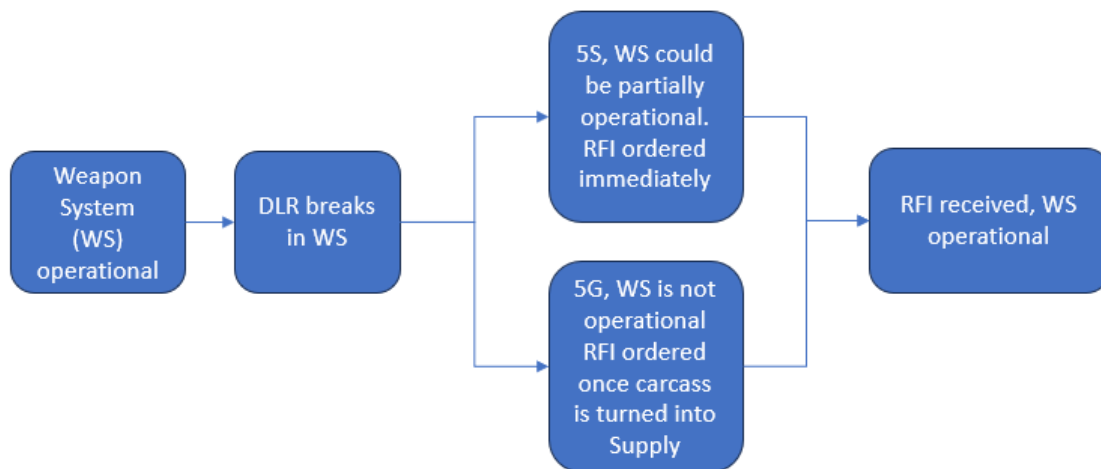


Figure 3. 5G and 5S Advice Code End-User Process Flow by Weapon System

Normally, there are several steps that are taken before the end user determines a replacement DLR is required regardless of advice code. The equipment operator will either

get an equipment fault error code or the system will not perform as intended. The equipment operator will notify the maintenance personnel that specialize in fixing that piece of equipment. Once the maintenance personnel start their troubleshooting process, they will narrow down their search by isolating and testing several pieces of equipment until they are certain which part is faulty. Once a piece of gear is removed from the system the maintenance person will see if it can be repaired locally at the Miniature/Microminiature Electronic Repair (2M) shop. According to Hagan and Ohman (2020), if the part is unable to be repaired through the 2M shop, the maintainer must order a replacement DLR.

Once the order is placed internally, the requisition will be forwarded to the supply department. At this point, the Logistics Specialists (LS) will do a technical edit to verify the part number, NIIN, nomenclature, COG, standard price, net price, and material control code to ensure it is a DLR. The LSs will coordinate with the maintenance personnel so they can turn over the NRFI DLR to the supply department. Depending on the monetary value of the DLR, the maintenance person might have to get signatures from the Commanding Officer, their Department Head, and the units Supply Officer. Once the appropriate signatures are obtained (if required) the maintenance person will bring the documentation and the NRFI and will physically turn the part over to the DLR LS. The LS will match the NRFI DLR to the specifications from the technical edit they performed. If it is a match the LS will sign the maintenance person's Repair Parts Petty Officer (RPPO) log stating, they took control of the NRFI. If the part does not match the information from the technical edit, the LS will return the NRFI and request the maintenance person to verify their requirement to ensure they ordered the correct part. Important to note with this process is that some carcasses must be removed from the weapon system to verify the part number as part of the technical edit, which can cause more labor on the maintainer with equipment tagouts to safely verify the carcass. This is explored more in Chapter V under tagout labor benefits and consequences.

After the correct part is verified and received by the DLR LS, they will review the urgency of need that was assigned to the requisition. If the part is urgent, the DLR LS will review the ship's operating budget to ensure there's enough funding to cover the net price

cost of the replacement DLR. At this point, the requisition will be assigned a document number which will be used to track the replacement RFI, as well as the NRFI, and will expend funds from the ship's operating budget. The LS will release that requisition from the ship and will transfer the Military Standard Requisitioning and Issue Procedures (MILSTRIP) into the Enterprise Resource Planning (ERP). After the requisition is in the ERP system, carcass tracking begins. The LS managing DLRs will package the NRFI and get it ready for shipment to ATAC.

D. DLR SUPPLY CHAIN MANAGEMENT

In Figure 4 there is an illustration of the steady state DLR system, or what the process looks like without going into the details of the requisition itself. New DLRs are contracted to create a population of pullable stock to meet anticipated demand, based on the OEM and manufacturer of the higher-level assembly weapon system. DLRs are then warehoused and sometimes moved to forward-stocked locations based on demand. If the DLR expires on the shelf it is sent to the depot level repair facility to be refurbished, and if condemned it is then sent to DLA Disposition Services for proper disposal and the population of DLRs is examined to ensure there are enough RFI DLRs to meet demand.

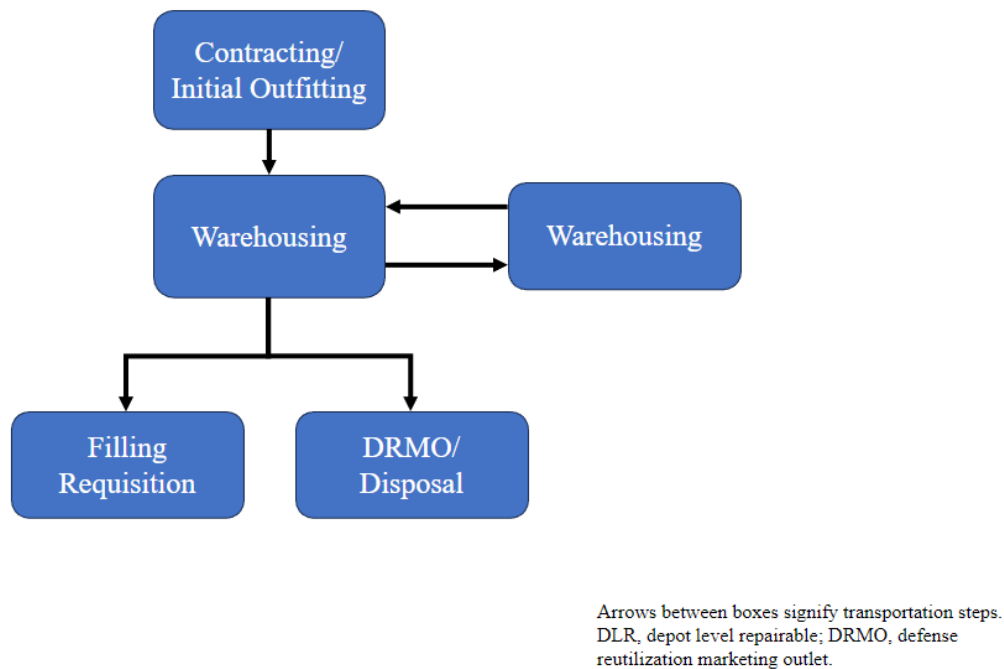


Figure 4. Steady-State DLR System

In Figure 5 there is a more in-depth flow chart of the requisition process for a DLR. “In stock” refers to whether the ordering end-unit has the DLR available in their stock or must order it from a warehouse separately. If there is no RFI DLR available, then the lead time to deliver an RFI to the end user will include the repair time for an existing broken carcass. The biggest difference in the DLR process from a traditional consumable requisition is that the carcass must be sent for repair as long as there is a carcass available to send.

For surface ship DLRs, control of ship’s maintenance falls under NAVSEA (Peltz et al., 2014, p. 114). There are six Regional Maintenance Centers (RMC) and four public shipyards that fall under NAVSEA that facilitate ship repair, which does include DLR maintenance. Notably, there are separate warfare centers including Crane, Carderock, and Newport. There are three levels of maintenance: organizational, intermediate, and depot level. However, small surface ships that are the focus of this research are only capable of completing organizational level maintenance; intermediate and depot level maintenance requires outside support. DLRs are coded with a Source, Maintenance, and Recoverability

code (SM&R) that states which level of maintenance is required to conduct repairs (NAVSUP, 2022a, p. 8-82). Most depot level repairs to systems are conducted during shipyard availabilities.

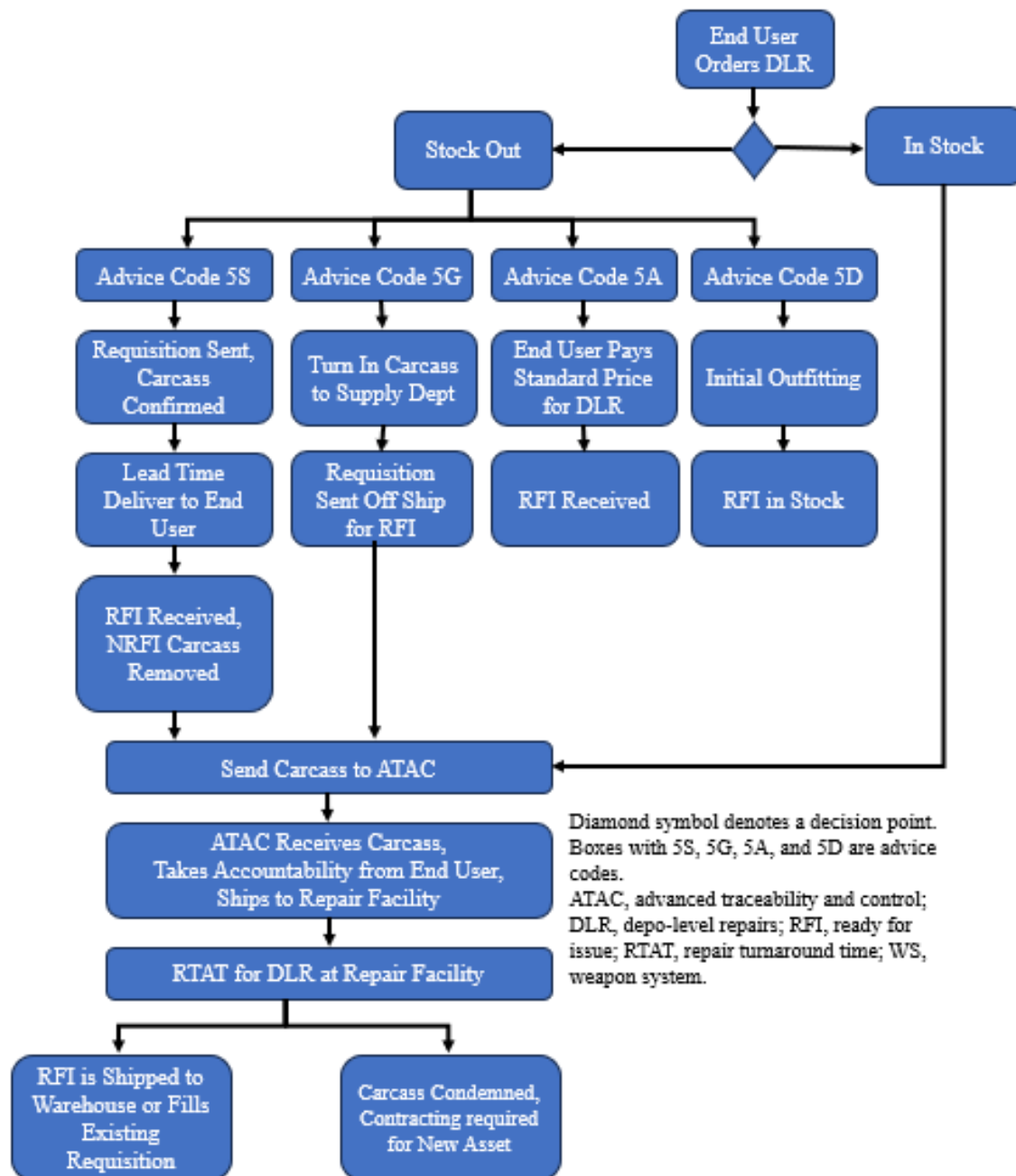


Figure 5. DLR Requisition Process

RMCs perform repair and return actions for DLRs to ships. In the DLR repair system, this function is the minority action for DLR repairs. The most common process for repairing DLRs is the “repair and stock” tasking that is managed by the local RMC (Peltz et al., 2014, p. 116). This process takes a NFRI DLR and returns it to a contracted OEM or OEM approved repair facility for refurbishment. This contract is managed by the governing RMC for the afloat DLR.

NAVSUP WSS is accountable for the physical DLRs in the Navy Supply System. Item managers at NAVSUP WSS are assigned groups of DLR NIINs and track inventory, readiness, advice code, repair status and any other relevant data (Peltz et al., 2014, pp. 92–93, 111). The Navy utilizes ERP as a centralized system for tracking all aspects of item management. This also includes tracking estimated failure rates for DLRs estimated by the DLR engineers, known as technical replacement factor and best replacement factor to assist in estimating when DLRs will need to be replaced (Peltz et al., 2014, p. 117).

DLA plays a role with all U.S. Navy parts. While NAVSUP WSS is ultimately in control of the DLRs, DLA controls the majority of DLR warehouses throughout the world. DLA also has started purchasing DLRs from commercial suppliers after NAVSUP WSS has determined that procurement is required (Peltz et al., 2014, p. 120).

E. REMAIN IN PLACE REQUESTS

RIP requests are requests that come from an end unit to change the advice code of a DLR from 5G to 5S. RIP requests come about when a customer believes a DLR should be 5S but is currently assigned as 5G. The end unit sends the RIP request to NAVSUP WSS, and they forward the request with unit’s reasoning to the HSC engineers, generally NAVAIR or NAVSEA ISEA teams, to determine whether or not the advice code should be changed (NAVSUP, 2023, pp. 1–3). In order to submit the RIP request, the DLR must meet at least one of the 5S criteria (partial functionality, safety concerns, damage to equipment, or external support required to remove and replace) Then it will be confirmed or denied by the HSC ISEA. Once a determination is made the DLR either becomes 5S or remains 5G, and this changes the code for DLR in the greater supply system for all Navy ships that are the same platform as the requesting unit. This many-step process is illustrated

in Figure 6. The downside is that this request process can take weeks to resolve. The authors did discover that there is an advice code 52 that can delay a turn in while it is being adjudicated without the ship being billed for the unit price. Due to lack of functional knowledge of this advice code this action is considered an exception rather than a regular practice. Being able to submit a requisition for a 5G RFI under advice code 52 while awaiting a RIP adjudication is a clear benefit to the end unit. It allows the weapon system to be repaired sooner by avoiding delays in submitting the requisition. This advice code can be manually put into a requisition being made by an end user and will be adjudicated based on the inputs of the RIP request approvers. This was an unknown option to the authors and no data was found as to whether it is used often in the fleet. The RIP policy is outlined in the NAVSUPINST 4440.182C Remain in Place Policy publication (2023).

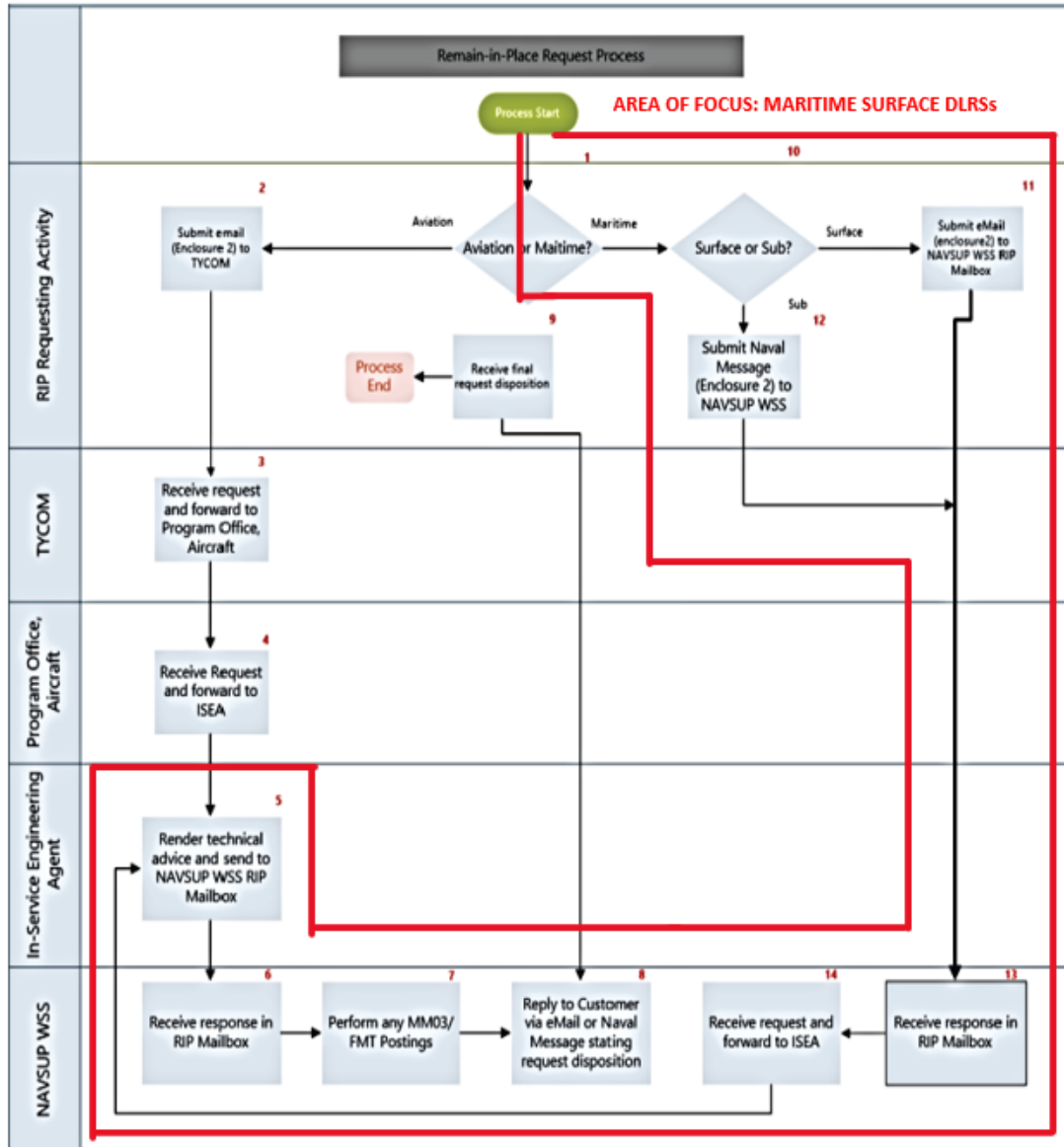


Figure 6. RIP Request Process Chart. Adapted from NAVSUP (2023).

IV. COST CATEGORIES

In Chapter III we showed that there are many steps in the management of DLRs. Each stakeholder in the process has different priorities that do not always overlap. Supply commands focus on carcass management to keep the overall availability of each DLR healthy, and repair facilities and customers always want more DLRs available to repair and use in the most efficient way. Contracting wants to minimize the cost in the initial outfitting and life cycle support, while OEMs want to have long term business with their weapon systems and associated DLRs. Operationally, commanders want to ensure their weapon systems stay functional and up to date. With so many stakeholders with different points of view and differing goals it is hard to measure the overall cost of DLR management, and who should bear those costs. None of the publications available to Supply Officers have all these costs listed and are able to really show the full picture of the cost of managing a DLR.

Using Figures 1–6 in Chapter III, an analysis was conducted on each area of the DLR process flow chart for each activity to assess the cost categories associated throughout the DLR repair cycle. This chapter further examines the cost categories in detail that include, labor costs incurred at various points in the DLR process, repair costs, costs of new RFI DLRs, requisition procedure costs based on advice codes, and incorrect advice code costs. To be thorough and give a wholistic picture of the DLR process, there are additional costs that are important to acknowledge even though they are not within the scope of a 5G vs. 5S tradeoff analysis. The costs involved do not vary between the two advice codes. These three categories are shipping costs, holding costs, and condemnation costs and will not be discussed as these will not provide a tradeoff to analyze.

Each section in this chapter identifies costs that were different between 5G and 5S DLRs. Each cost category identified three focus areas: defining the cost, what drives the cost, and who bears the cost. These points are used to inform the tradeoff analysis in the subsequent chapter.

A. LABOR COSTS

This subsection lays out and defines the various labor costs involved in the DLR process, explains the drivers of labor costs, and sets the scene for which stakeholders may bear the labor costs. However, since labor costs affect nearly every cost category in the DLR process it is important to separate them out to be discussed in more detail.

Labor costs can be calculated based on counting the amount of personnel that are required to manage a DLR, from handling, shipping/receiving, warehousing, procuring, condemning, and overall management of the DLR. Labor costs are incurred in a multitude of ways; labor costs increase if personnel take additional steps during the DLR removal and installation process, and decrease if removal is avoided. Labor costs will also be affected by an increase in demand as an increase will require increased amounts labor. Labor costs are also incurred if RIP is required for incorrect 5G advice codes, and labor costs are incurred to process RIP requests and to contract and procure additional DLRs if Advice Code 52 is approved.

The primary driver of labor costs is the amount of time that is required to manage the DLR at each step where labor is involved. A warehouse storing a DLR will have many other parts to manage, and the labor cost will rise, and fall based on the amount of business and inventory stored at the location of storage. If more engineers are required at a depot level repair site, the cost of labor will increase. Each step that has human involvement has labor costs and that labor cost is driven by the demand of the item, urgency of the item, and amount of personnel hired by each site.

Where the burden of labor costs falls is based on which stakeholder owns the labor locations in that step of the DLR process. Warehousing is paid for by both NAVSUP WSS and DLA depending on who owns the warehouse, and repair labor is paid by the OEM of the DLR at their repair facility. While the owner of the site pays the immediate cost of labor, there is a contracting cost that includes line items for labor that is paid for by NAVSUP WSS as part of the life cycle logistics costs to have the DLR in circulation. The end user also pays for the labor to submit a RIP request, and other stakeholders have increased labor costs based on a RIP request.

B. REPAIR COSTS

Repair costs are those costs that include labor, costs of repair for additional damage, tooling costs, subcomponents required for repairs, and test and evaluation after the repair is complete. Repair labor costs at the OEM repair facilities, as discussed in the previous labor section, are examined further in this subsection. This labor cost could be variable depending on the frequency of repairs, the queue of backlogged NRFI awaiting repair, and urgency of the parts being repaired if the warehouse RFI inventory is depleted. These are very similar between 5G and 5S advice codes but are necessary to mention due to the risk of causing additional damage to the NRFI when multiple tag outs are required.

Repair cost drivers are based on who performs the repair and how much support is available for the repair. DLRs are repaired at OEM owned depot level maintenance facilities. The severity of this cost driver varies based on demand, urgency, and facility capacity. To maintain OEM support for long term repair capabilities, it must be funded through the contracting process to ensure the OEM maintains enough capacity to meet demand.

The stakeholder paying this cost is NAVSUP WSS. The OEM will pay the cost for their own repair facilities, but payments for the repair service are made to the OEM through the repair contract from NAVSUP WSS.

C. COST OF NEW RFI DLRs: INITIAL AND OBSOLESCENCE

Initial outfitting of DLRs for end-units is a cost managed by NAVSEA for new weapon systems that are procured, regardless of whether the DLR is coded as 5G or 5S. The procurement of spare repairable parts for operations, maintenance, and sustainment of the weapon system is a cost managed by NAVSUP WSS as the overall manager of the DLR process.

Costs of new RFI DLRs are driven by new weapon systems being brought online for surface ships. The spare repairable part costs are driven by increases in demand due to unforeseen failure rates and life cycle repair changes. NAVSEA bears the cost burden for initial outfitting of RFI DLRs for new weapon systems that are brand new to the fleet. Once the new weapon system is installed on the ship, NAVSUP WSS bears the cost burden for

spare repair parts to maintain operations and sustainment of the weapon system throughout its life cycle. In cases where it is determined that additional DLRs are required during the life cycle, NAVSUP WSS will pay the cost of procuring new RFI DLRs at the standard price.

Similarly, obsolescence results in cost impacts to the DLR process for both the old and new weapon system. If a weapon system gets upgraded or replaced, DLRs associated with the now obsolete system will need to be turned in for disposal. This will incur shipping and disposal costs. The new weapon system that has been upgraded for replacement will incur the same initial outfitting costs and sustainment costs that are incurred by both NAVSEA and NAVSUP WSS. This iterative process is depicted in Figure 7.

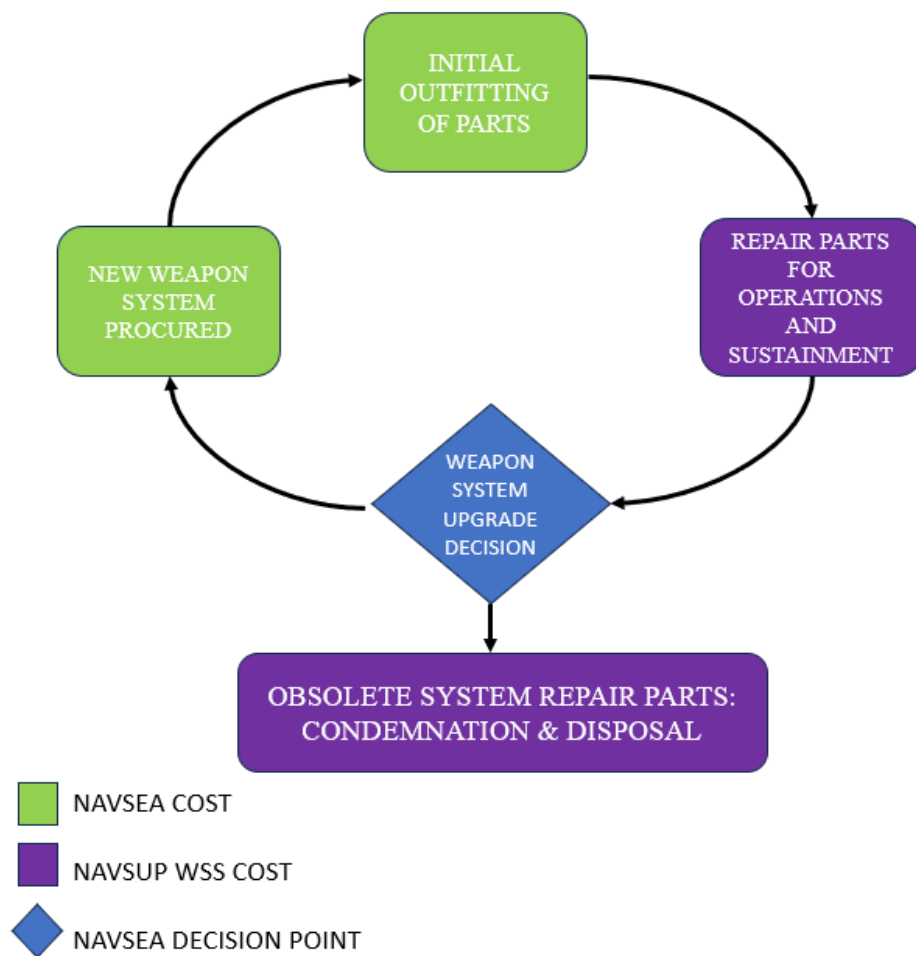


Figure 7. Cost of New RFIs: Initial and Obsolescence Upgrades

D. REQUISITION PROCEDURE COSTS BASED ON ADVICE CODES

The requisition procedure costs are primarily labor costs that are involved in the NRFI removal and replacement process, documentation requirements, and the initial carcass turn-in process to the supply department at the unit.

These costs are driven by the advice code assigned to the DLR. The advice code will determine if an immediate tagout is required, which comes with increased labor costs for the maintenance user at the end unit responsible for the weapon system. In some cases, it is necessary to tagout and remove equipment for a 5S advice code for verification if the part number is not visible from the outside. In these instances, the tagout labor has then been doubled as the maintenance unit will have to tagout the equipment twice to have the part RIP. Details about the labor incurred for tagouts under different scenarios are discussed in Chapter V. An additional cost driver in this labor results from RIP requests submissions, but this specific driver is discussed in greater detail in the following subsection of this chapter.

The end unit is the stakeholder that bears the cost burden for requisition procedure costs. The labor hour costs are shared between the ship's supply department personnel and the maintenance personnel.

E. INCORRECT ADVICE CODE COSTS

Incorrect advice code costs occur if a DLR is initially coded as 5G when it should have been properly coded as a 5S. These costs may happen if the incorrect code is caught before or after NRFI removal. Each of these categories is identified below.

1. RIP Request Costs If Incorrect Advice Code Is Caught Before NRFI Removal

In instances where the end-unit has determined that a DLR has been incorrectly coded as 5G, a RIP request will be submitted. The cost of correcting a misclassified advice code is mainly administrative in nature for labor, but also includes the cost of delaying a carcass turn in while waiting for the RIP request to be adjudicated. This delay can significantly impact mission readiness since the NAVSUP WSS goal allows for up to 30

days to respond to requests (NAVSUP, 2023, p. 3), and requires only an 80% compliance to meet that 30-day goal. The cost impact of this delay depends heavily on whether or not there are ample RFI DLRs available for immediate issue, the importance of the downed warfare area of the ship, and what phase of the OFRP that the unit is operating in.

Cost drivers for RIP requests also impact labor costs at both the unit level and NAVSUP WSS and ISEA levels. At the unit level the RIP request must be completed and submitted jointly by the DLR Manager and Division Officer that owns the broken DLR, then reviewed and approved by the Leading Logistics Specialist (LS) and Supply Officer (SUPPO) before being submitted to NAVSUP WSS. The unit level cost is incurred regardless of what determination is made regarding the request. Once the RIP request is received by NAVSUP WSS, the request must be reviewed by NAVSUP WSS and subsequently forwarded to the HSC ISEA responsible for the equipment (NAVSUP, 2023, p. 2). The HSC must then perform a technical review and decide if the DLR will remain as a 5G mandatory turn-in or should be changed to an authorized 5S advice code, and then provide this determination back to NAVSUP WSS. NAVSUP WSS personnel must then record any changes in advice codes in the Navy Electronic Retrograde Management System (eRMS).

If the determination is made to change the advice code from 5G to 5S, additional costs will be incurred for contracting procurements. Due to the increased delay in retrograde return to depot level repair facilities, procurements to increase stock levels are required when an advice code is changed from 5G to 5S under the interim advice code 52 per NAVSUP WSS policy (NAVSUP, 2023, p. 3). The increase in stock levels results in a labor cost increase for contract specialists to procure additional parts, the HSC technical team determining the required quantity to increase stock levels based on RTAT and demand, and results in actual procurement costs at the standard price for the quantity determined by NAVSUP WSS and NAVSEA ISEA.

The total costs for RIP requests end up being shared across the end-unit customer, NAVSUP WSS, and NAVSEA as each will incur additional labor costs and NAVSUP WSS may also bear procurement costs if the RIP request is approved. Labor costs for the three stakeholders should remain relatively consistent over all DLR RIP requests, however

if additional procurements of DLRs are required the costs will vary based on the standard price of the DLR NIIN being adjusted.

2. Additional Costs if Incorrect Advice Code is Not Caught Before NRFI Removal

There are some DLRs that are required to remain in the higher-level assembly for safety of the crew or surrounding equipment, or because of the level of expertise that is required to safely remove the equipment. All the applicable reasons to make a DLR 5S are listed in Chapter II. The costs for failing to catch the incorrect advice code before removing the NRFI from the weapon system include potential injury or loss of life and preventable damage to the weapon system's other sub-components.

The drivers of this cost are how vulnerable the weapon system is to cascading failures, varying levels of danger created by a missing piece in the weapon system, and the difficulty of removing the DLR. These will be determined based on technical specifications for the weapon system and operational observations.

The end unit bears the costs in these situations that could result in a Sailor losing his or her life when in contact with a hazardous weapon system configuration and possibly damage to a weapons system.

F. STOCKOUT COSTS

Stockouts can occur with either DLRs or non-DLR parts and bring significant cost to the end user. Stockouts are caused by limited inventory which cannot meet demand. Primary drivers for stockouts are based on depth of the inventory for a DLR and frequency of demand. There are many models available to predict demand, but no model can perfectly predict how demand will change over the DLR life cycle. When demand exceeds supply inventory levels stockouts occur and can keep end units from completing required missions.

Due to the majority of DLRs being part of critical weapon systems, stockouts can lead to emergency measures to bring a weapon system online to keep end units operational. There are many factors to consider in who bears the cost of stockouts. End user units

requesting the DLR bear the most burden due to not having an operational weapon system. The TYCOM will bear the burden of not having operational end units to be utilized.

G. CANNIBALIZATION COSTS

Cannibalization refers to the removal of a functional used part from another system to replace the broken one, inherently giving precedence based on a unit's timeline in the OFRP tasking for the system with the broken part to be functional over another functional weapon system on a different platform. Removing a used functional part from a working system to install into a broken one is dangerous to both systems and to the health of the DLR being removed, transported, and reinstalled. It is a common adage in the Supply Corps that cannibalizations often lead to two broken systems instead of just one. Cannibalization activities are an indication of supply issues for critical DLRs that are monitored closely by both operational commanders and WSS. Cannibalization is not part of the official DLR process due to the risk incurred, but mission commanders and the TYCOM can direct end units to perform cannibalizations to meet mission requirements. It is a high risk and high consequence action that actively degrades the DLR inventory pool and complicates the DLR process by adding more parties to a single requisition.

If a cannibalization occurs, the donor unit will bear the burden of having to wait for a stocked-out DLR once the cannibalization has occurred. The TYCOM also bears a labor cost burden throughout the cannibalization process as they must approve the request and then track each cannibalization until the donor has received the replacement RFI DLR. If the DLR is broken during the cannibalization process, then all the burdens listed apply.

V. CONCEPTUAL TRADEOFFS: 5G VS. 5S BENEFITS AND CONSEQUENCES

When DLRs are assigned advice codes, 5G is the baseline and 5S is the exception based on predetermined factors of safety and operational functionality. The difference between the baseline 5G DLR and a 5S DLR results in conceptual tradeoffs. The 5G advice code procedure is ideal for the overall health of the inventory and decreasing materiel costs in the DLR management process. If a 5S exception applies, the risk of damage to equipment and personnel is reduced while costs and other consequences increase. The largest process changes between 5G and 5S are the delayed turn-in for a 5S and potential rework in tag outs that can occur with 5G. This chapter lays out the differences and conceptual tradeoffs between assigning a DLR as the baseline 5G or the 5S exception. These conceptual tradeoffs are based on the costs and benefits of assigning a DLR as 5S, failing to identify a DLR as 5S when it should apply due to the predetermined factors, and consequences that can impact the likelihood of cannibalizations.

Multiple factors go into the tradeoff analysis between 5G and 5S. Capacity in the OEM pipeline can be very influential in cost because if an advice code is changed to 5S, NRFI DLRs will be delayed in entering the repair pipeline which increases the overall downtime. This delay in the repair pipeline affects the return of RFI DLRs after the repair, increasing the risk of stockouts. One approach to mitigate increased risk of stockouts is the standard practice of acquiring more parts to increase inventory levels. This can be prohibitive depending on the standard price of the DLR and peripheral costs associated with changing the existing contract. If stockouts are already frequent based on demand or lack of availability of RFI DLRs for 5G DLRs, changing it to a 5S will only increase the amount of frustration in the process flow and create further increased risk for stockouts and further consequences such as cannibalizations. These variables must be accounted for to create a true conceptual cost benefit tradeoff analysis.

It is also required to assess the costs to determine whether there are specific characteristics or classifications that stand out for DLRs that would indicate that there is low risk or low financial cost to standardize a DLR as 5S initially. There may be specific

situations where it would be better to assign a 5S advice code regardless of the known risks if it is financially inconsequential. This is a common question asked by Navy customers and is worth examining to determine if there are “win-win” situations available to assign DLRs as 5S without meeting the criteria in the predetermined factors. If there are characteristics that can be identified that keep the costs associated with assigning a 5S advice code on parity with maintaining a 5G advice code, then it warrants conducting an analysis to find out what those characteristics are.

Differences in tagout labor are situational and depend on the weapon system’s partial functionality and ease of access to verify the carcass before ordering. This will be discussed in depth in section C of this chapter.

A. 5S ADVICE CODE BENEFITS

There are two primary benefits for DLRs that are assigned to the 5S advice code: partial mission capable (PMC) weapon systems and safety to personnel and equipment. Both categories have specific benefits associated with them, which are analyzed in the following subsections. There is a third benefit that is reduced labor for conducting tag outs of the weapon system, but this benefit is situational and will be discussed separately in section C of this chapter.

1. Partial Mission Capable

Under a 5S advice code, the NRFI DLR is permitted to remain in the weapon system in a degraded state because it allows the weapon system to maintain partial operational capability. This would allow other functions of the weapon system to still operate partially and allow a ship to perform some of its mission requirements that require this weapon system until an RFI part is received, installed, and tested. Having a ship with freedom of action allows combatant commanders the flexibility to assign any unit that has the capability they need to execute a mission.

Assessing the benefits for maintaining an operational weapon system in a degraded state is tied to operational functionality of that equipment’s warfare area and specific mission requirements for the surface ship. Warfare areas are identified as primary and

secondary mission areas that an end unit is required to report (e.g., air search radars on ballistic missile defense DDGs). The TYCOM receives readiness metrics updates on the status of their ships and whether they are fully mission capable (FMC), PMC, or not mission capable (NMC). These metrics capture which operational units can be sent on missions, only sent on certain missions, or unable to be sent on any. The higher the percentage of ships that are available for tasking, the higher the readiness level of the surface fleet. If allowing a DLR to remain in a weapon system allows a unit to remain PMC instead of becoming NMC, then it increases the ability to respond to dynamic force environments. Ultimately all Navy support systems (such as the DLR program) are designed to support mission readiness and freedom of action for military commanders.

One way to evaluate the benefits of a PMC weapon system is to categorize the benefits based on the functionality levels of the PMC weapon system. For example, determining the percentage of functionality that a weapon system has based on the use of 5S DLRs could be useful in determining the value of benefits from gained functionality. Clearly, 90% functionality in a PMC weapon system is more valuable than a DLR that only allows 10% functionality in a similar PMC weapon system. By assessing the benefits based on ranges of functionality, specific DLRs will have different benefit values associated with them. The weapon system functionality level should be able to be determined by NAVSEA ISEA. Monetizing the benefits of a PMC vs. NMC weapon system will be difficult but is necessary for a full financial cost-benefit analysis.

2. Personnel and Equipment Risk Mitigation

Mitigating risk to personnel is critical when there is a potential for injury, loss of limb, or even life. There are certain DLRs that can pose a great hazard to personnel based on the equipment they are in. Some DLRs must be de-energized before a Sailor can touch it. Other DLRs are positioned in places where a Sailor would have to wear a harness and go aloft to remove the part. There are also DLRs that are so heavy or bulky that a crane is required to remove them or DLRs where removal could damage additional equipment if higher level technical experts are not on site to assist in the NRFI removal and RFI installation.

Certain equipment on naval ships may be sensitive based on the complexity of the weapon system. For example, some DLRs are required to be calibrated, energized, or under handled under extreme pressure. Allowing an NRFI to remain in place minimizes the amount of time a weapon system is exposed to the elements and reduces the risk of further damage to additional equipment.

Monetizing the benefits of mitigating risk to personnel and equipment requires assessing several factors. First, the benefit of reducing personnel injury or death can be based off the value of a statistical life (VSL), which is approximately \$10 million according to most government standards (U.S. Department of Health and Human Services, 2021). The second benefit, mitigating equipment risk, could be calculated using the costs of the entire assembly that could be damaged due to removing a DLR that would otherwise keep the system whole, intact, and protected.

B. 5S ADVICE CODE CONSEQUENCES

There are consequences to assigning the 5S advice code that must be considered as well, and these are seen when examining the different repair timelines between the baseline 5G and 5S advice codes. The consequences that must be further analyzed begin with the turn-in delay to the OEM repair facility and include the direct effects of increased risk of possible stockouts, and subsequent decisions to mitigate the stockout risks that will incur costs.

1. Turn-in Delay to Repair Facility

Evaluating the costs and benefits of the delayed turn-in is a complex process that requires specific information from multiple stakeholders specific to the DLRs evaluated. The delayed turn-in of a 5S DLR is the main cause for all for all consequences and costs associated with assigning this advice code instead of 5G. Figure 8 depicts the 5G and 5S turn-in processes and highlights the timeline difference that drives initial consequences and follow on decisions that impact timeline and costs.

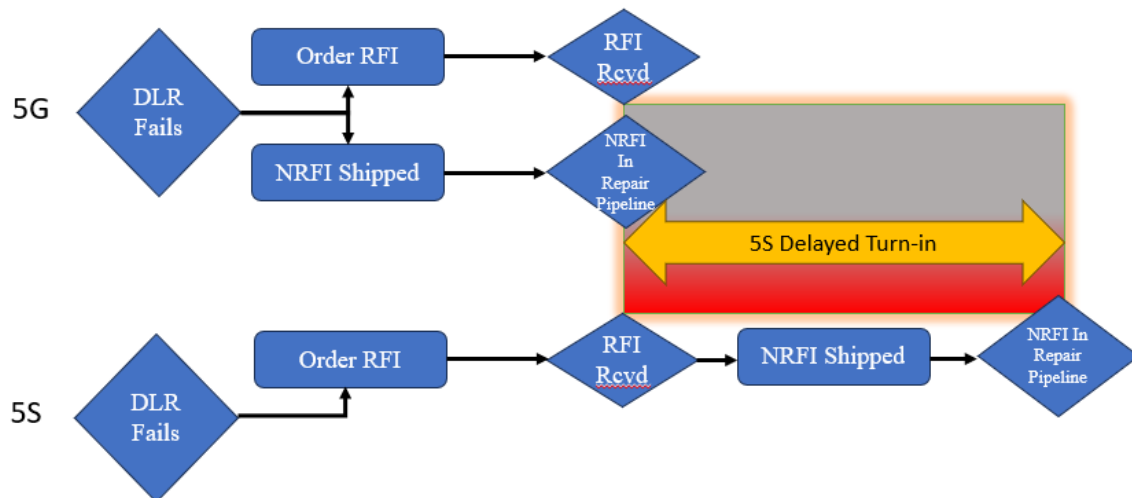


Figure 8. 5S Delayed Turn-In to Repair Pipeline

The known outcome of the delayed turn-in is that the NFRI DLR will not be shipped to the OEM repair facility until after the RFI is received on board. This means that the repair cycle from NFRI to RFI is delayed by the time it takes the for the RFI requisition to be received and installed by the end-unit and the time it takes to then package and ship the NFRI to the repair facility.

The turn-in delay for an NFRI DLR does not have a directly associated cost that must be assessed for the conceptual tradeoff analysis; instead, the delayed time to reach the repair pipeline results in effects and further decision points that will influence both the time to RFI and DLR costs. Direct effects of the delay can include increased lead times to return RFI DLRs into inventory causing increased risk of future stockouts for that DLR.

Stockouts are a possibility for any part in the supply system, but the factors that come with a 5S advice code mean that there is a higher risk of stockout than a 5G. A 5G advice code DLR has a faster RTAT than if the same DLR was advice code 5S due to the delayed turn-in of the NFRI to repair pipeline. If a 5G DLR is already experiencing stockouts, regardless of frequency, then making that DLR a 5S will only further exacerbate the stockout frequency. With increased risks of stockouts, mission readiness can be impacted if RFI DLRs are not available to fill weapon system requirements, and these impacts are addressed in the following subsection.

2. Cost and Benefit Tradeoff to Mitigate Risk of Stockouts

Increased risk of stockouts from the delay in carcass turn-in leads to a decision point to attempt to mitigate or avoid stockouts that will impact mission readiness of the surface fleet. The primary decision point is whether to increase the amount of RFI DLRs in the overall NIIN population to increase the number of DLRs in RFI inventory and thereby reduce stockouts. To minimize negative impacts to mission readiness by increasing available DLRs there are increased life cycle costs, not merely purchasing costs, that must be incurred if procuring additional DLRs.

The cost-benefit analysis for this secondary decision is based on the full life cycle costs of additional parts against the benefit of reducing stockouts. To quantify the tradeoff of reduced stockouts requires determining the magnitude of the reduction in stockout risk as well as the cost impact of a stockout. For example, how much reduction in mission readiness occurs based on a stockout? How would we assign a dollar value to a stockout? To weigh these actions against each other both the costs and benefits must be identified and have data collected on those drivers to formulate their relationship.

The benefits of increasing the RFI DLR pool by purchasing new DLRs is that the risk of stockout is reduced. With more RFI DLRs in inventory, less stockouts occur and mission readiness for end units rises. This is the benefit the TYCOM cares about the most and receives the most attention. Once data is found for this the concept of marginal increases using sensitivity analysis could be used to calculate stockout percentage decreases. Mission readiness is a much more complex benefit to evaluate. Parts have a wide spectrum of impacts to the fleet, from very minor to severe degradations that cause a ship to be unable to operate at sea. Recommendations for calculating the benefits are to create several different categories to bin parts into based on ISEA recommendations for the degradation that an NRFI would result in.

The consequences of the 5S advice code for a conceptual tradeoff analysis can be evaluated based on two factors, full life cycle costs for acquiring additional DLRs and mission readiness impacts from increased stockout risks. First, procuring parts can be calculated by using the standard unit price multiplied by the number of DLRs to be

procured plus the cost of contracting labor and warehousing. The number of DLRs to be procured will be determined by NAVSUP WSS based on average demand and current inventory. If increasing the inventory on DLRs it is recommended that NAVSUP WSS must ensure it is focusing on DLRs that are at the lowest levels of readiness and demand to ensure no excess financial cost is incurred consequently.

There is also a related question to whether this increase in stock is considered when a new DLR is being procured and the logistics life cycle is thoroughly examined based on advice code before initial outfitting is decided. If the advice code is not decided until after the procurement is completed it could cause issues with stockouts from the beginning. This will be stated as a research topic in the Recommendations section of Chapter VII.

C. TAGOUT LABOR BENEFITS & CONSEQUENCES

Before continuing with advice code tradeoff discussions, it is important to define the assumptions regarding tagouts. Tagouts are the process of cutting off a piece of equipment from power to the rest of the ship to safely perform maintenance on de-energized equipment. The tagout process includes the original tagout to safely de-energize the equipment and clearing the tags after the maintenance is completed to safely re-energize the equipment to bring it back to normal operation.

There are many 5G and 5S advice code scenarios as they relate to tagouts. Supply department personnel must verify the part number on NRFI DLRs prior to requisitioning the RFI DLRs to ensure the correct DLR is being ordered, regardless of the advice code of the DLR, since DLRs require a one-for-one turn-in to mitigate potential carcass charges from incorrect requisitions.

1. Tagout Labor Consequences: 5G Scenario I and II

5G Scenario I is where there is only one tag out conducted during the 5G process because the weapon system cannot be tagged back in without the replacement RFI DLR. The system is tagged out when the carcass is removed, remains tagged out until the RFI is received and installed, then the tags are cleared to bring the system up for normal operation. An example of this would be a weapon system that cannot function or creates an

environmental hazard if brought online without a DLR in place requiring the weapon system to remain tagged out until the RFI is received and installed.

5G Scenario II is where two tag-outs are required because the weapon system can, and is required to, be safely brought back online between removal of the carcass and installation of the RFI. This would change the tradeoff analysis assumed for benefits of having a 5S code instead of a 5G because not only is there more labor involved, but there would be partial system functionality in the interim without requiring a 5S advice code. An example of this would be if there are two DLRs of the same type installed in the weapon system, and it can be fully operational without redundancy if the carcass is removed.

2. Tagout Labor Consequences: 5S Scenario I and II

Like 5G, there are situations where 5S advice codes only require one tagout. 5S Scenario I arise based on carcass verification. If the carcass is situated in a way that the carcass number can be identified without removing the part, then only one tag out is required. An example of this would be that the carcass's identifying part number (from the OEM) is visible while being connected to the system or has an identification plate attached to the carcass that can be verified by Supply Department before ordering the replacement RFI without removing the NRFI DLR from the weapon system.

Alternatively, 5S Scenario II applies if the carcass is not able to be verified while installed in the system, so that a tag out is required to verify the carcass before ordering the RFI. There will be a second tagout required once the RFI is received to remove the carcass again and install the RFI. An example of this would be if the part number is located at the bottom of a carcass that is not visible based on the configuration of the weapon system and would need to be fully removed from the weapon system to verify. In this scenario there are two tagouts required because the system would not remain down since the NRFI is required to keep the weapon system PMC. While multiple platforms could have the same weapon system it could be configured differently based on variation of structure and the installed location on each ship. This can provide changes in tagout labor based on the class and platform of the end unit.

3. Prior Research on Tagout Labor

In this specific case (5G scenario II), the Hagan & Ohman thesis is correct in that 5S advice codes would only require one tag out while 5G would require two, thus doubling the amount of end unit labor required for a 5G DLR.

Supply department personnel are often able to verify DLRs without having to tagout and remove the NRFI DLR if the part number is visible while the DLR is installed in the equipment. In these cases, an additional tagout is avoided since the supply department can verify the needed part without the DLR requiring removal from the weapon system. Avoiding this additional tagout not only reduces the chances of injury to personnel and further damage to other components in the weapon system, but also results in decreased labor required for the maintenance personnel conducting the repair.

A conceptual evaluation of benefits for this area of the DLR process was previously conducted in the Hagan and Ohman thesis (2020). The thesis identified differences in costs of labor between the 5G and 5S policies for DLR turn-ins. The analysis was conducted based on data gathered from two surface ships stationed in San Diego with feedback from the crew (Hagan & Ohman, 2020, p. 23). The results showed there were higher costs associated with the 5G DLR process than with the 5S process, and that significant savings on labor in the 5S process were observed. Specifically, their analysis determined that RIP 5S DLRs save \$21.95 in labor costs per DLR compared to 5G DLRs since the additional tagout is assumed to be eliminated (Hagan & Ohman, 2020, p. 37). Under their assumptions the total cost-savings were calculated by taking the average number of DLRs requisitioned per day on a surface ship multiplied by the total number of surface ships, and resulted in significant savings benefits that exceeded \$9 million.

However, the Hagan and Ohman thesis (2020) analysis assumed that 5S DLRs only require one tagout, and that 5G DLRs require two tagouts. This assumption matters because as listed above there are other cases in the tagout process that are independent of the advice code that will influence and could reverse the results assumed. Their analysis was valid in scenarios where that is true, however that does not apply to all DLR scenarios. The previous subsections (1 and 2) addressed the different scenarios that affect whether there are

multiple tagouts or not required, regardless of advice code. In order to create an effective cost-benefit analysis all these cases must be covered and how common each case is.

Ultimately these scenarios expand on the narrow scope of the Hagan & Ohman thesis and challenge the statement that 5S only requires one tagout while 5G requires two, as this is only true in certain situations. Due to these scenarios, there is no efficient way to predict a cost or benefit for tagout labor without classifying the DLR as one of the four scenarios. This also can only be truly identified once the DLR is installed at the end unit based on configuration of the weapon system at the end unit.

D. ADDITIONAL COSTS OF RIP REQUESTS

The decision to submit a RIP request to change a DLR from a 5G advice code to a 5S has costs that would not apply if the DLR was coded as a 5S from the start of the DLR's life cycle. If a RIP request is submitted, the broken DLR will remain in the end unit's weapon system and the RFI DLR will not be ordered until NAVSUP WSS has adjudicated the decision (NAVSUP, 2023, Enclosure 1).

The time delay for this decision will vary based on the workload of the stakeholders in the process but will result in delays to mission readiness and delays in the NRFI entering the repair pipeline until a decision is made on the adjudication by NAVSUP WSS. This delay will add additional time to the standard delayed turn-in for a 5S but is a one-time event if approved because after the adjudication is complete it will not be processed again. If the RIP request is denied, this additional time delay could occur more than once if other units submit additional requests.

During this time, the risks of stockouts increase. If the DLR is part of a critical weapon system, especially if the end unit is required to be operational while the RIP request is being processed, it can also result in an increased risk of cannibalizations that will be addressed in section E of this Chapter. It is important to acknowledge from Chapter IV that NAVSUP WSS has a goal to adjudicate the decision within 30 days of receiving the submission and a separate policy to increase the amount of stock of a DLR if it is changed from 5G to 5S due to the delayed NRFI return to the repair facility (NAVSUP, 2023, p. 3).

To evaluate the costs of the RIP change we must acknowledge the costs differences of the RIP request process compared to a DLR that was a 5S advice code from the beginning of its life cycle. A DLR that was initially outfitted to the fleet would be funded by NAVSEA, and any additional DLR acquisitions resulting from an approved RIP request would be funded by NAVSUP WSS. These can be compared against each other to determine whether to assign a part as 5S initially versus becoming a 5S during its life cycle through the RIP process. Another element to consider in the RIP request assessment is the risk associated with a 5G advice code that should have been classified as a 5S due to safety, damage capability, or partial operability. If the DLR is improperly coded, then those risks are not mitigated until the code is changed and could result in negative consequences. These consequences would then be compared to the cost that would be incurred if the DLR was determined to be a 5S at inception.

To evaluate the costs of RIP requests that stem from the DLR being incorrectly coded, there are several factors that must be considered. First, if the weapon system could be PMC with RIP DLR installed, the cost of the incorrect advice code can be analyzed by categorizing DLRs into different bin categories based on the functionality of the PMC weapon system that would have existed. Second, the incorrect advice code could also result in personnel injury or death, as well as damage to equipment. These costs can be assessed using the VSL for personnel injury or death and equipment repair or replacement costs for damaged equipment. Essentially, incorrectly coding a DLR as 5G when it should have been 5S will have costs equal to the benefits of a DLR that was initially coded as 5S as discussed in subsection A of this chapter.

E. CANNIBALIZATIONS

The cannibalization process is a complex issue that must be acknowledged and discussed in any analysis of costs and benefits of DLR advice codes. However, the cost analysis for cannibalizations involves very dynamic and unique situations that should be further researched separately in depth. Since this issue involves such a wide array of scenarios and can occur with any part regardless of advice code, the purpose of this subsection is to address where the cannibalization process intersects the DLR process. That

intersection occurs where there is increased risk for stockouts. Cannibalizations do not occur solely based on stockouts, but the vast majority do. As such it is necessary to touch on the subject, explaining how it impacts the costs and benefits discussed in this research project, and the cannibalization process that occurs.

Cannibalizations are not part of the DLR management process, but rather a decision that could be made due to increased risks of stockouts. DLRs can have an increased chance of stockout if inventory is not managed carefully based on advice code, and 5S coded DLRs have an increased risk of stockouts due to the delayed turn-in timeline if insufficient excess stock has been purchased. The decision to cannibalize another unit's operational equipment occurs when there is an immediate requirement to be filled for a critical weapon system that is preventing an end unit from being able to perform a mission requirement as discussed in Chapter IV. There are many materiel management decisions that can mitigate the use of cannibalizations outside of DLR management. The act of cannibalization is a signal to Navy leadership that the DLR being cannibalized is not being managed effectively even though it is vital to keep end units operational.

It is important to note that while cannibalizations are a codified Navy process, they are not part of the regular DLR management process. The Chief of Naval Operations has stated that "cannibalizations between active Fleet units must not be a normal peacetime practice and will be considered an acceptable option only after all other logistics support alternatives have been exhausted," (CNO, 2021, p. 2). They are the emergency procedure to ensure end units can perform mission requirements in extremis. Cannibalizations actively degrade the health of the DLR being cannibalized by frustrating the repair cycle and "equipment cannibalization and material diversion actions are disruptive and can have an overall negative impact on Force readiness," (SURFOR, 2019, p. 1).

Cannibalizations are tracked by all levels of the Navy's chain of command all the way to the Under Secretary of Defense quarterly as a signal of material condition health in the fleet (CNO, 2021, p. 7). There are continual arguments made to increase annual inventory by increasing congressional funding to avoid cannibalizations due to their extremely risky nature.

Donor selection for cannibalizations can help mitigate risks if an ideal donor is identified. An ideal donor is an end unit that is not operational and has time to receive their payback DLR before becoming operational, such as a ship that is in a maintenance availability or are in the process of being decommissioned (SURFOR, 2019, pp. 2–3). The risks associated with removal, shipping, and installation of used DLRs are the same despite the donor's source. It is also possible that cannibalizing from a ship in a maintenance availability could negatively impact the ship's ability to complete repairs and exit the availability on time.

While this topic is complex enough to be its own research project, advice codes do have an impact on the risk of cannibalization. It is necessary to determine where in the OFRP cycle the donor is, the value of the mission area for the requesting ship based on their current mission orders, increased labor costs for removal and installation on donor ship, and further consequences on an already strained OEM facilities if cannibalization is due to stockouts. Only after accounting for these factors can we gain a quantitative measure of the cost of cannibalizations and how much the increased risk of a 5S advice code could impact the health of a DLR.

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VI. DATA REQUIREMENTS FOR FUTURE RESEARCH

A thorough financial cost/benefit analysis of 5G vs. 5S advice codes will require a variety of data. In this chapter we highlighted data requirements, known data sources, and potential sources of other required data to aid in future research projects. This chapter identifies which entities are the gatekeepers for various data based on the type of data they collect and manage. It also specifies additional data that is still required to evaluate the wholistic DLR management process, but the originating source of this data is not known to the writers.

Since managing DLRs is a complex process with multiple scenarios and outcomes, this chapter highlights existing data and other potential data sources that will be required to conduct a CBA. There's a myriad of stakeholders that own separate functions of the DLR process, so knowing what sections they own and the data they collect is beneficial. The major claimants are SYSCOMs and the TYCOM, followed by repair facilities, ships, and lastly the individuals that work on the equipment. All these entities are crucial to the overall DLR program, and they provide unique data for the various steps in the DLR process that is beneficial to understanding the health of any particular DLR.

In Chapter IV, the cost categories were identified and there were several costs that were seen throughout multiple categories. Subsections in this chapter will identify data for those cost categories. These areas will provide valuable information and will be the starting point for additional research to complete a wholistic CBA on the DLR process.

A. DATA PERTAINING TO LABOR COSTS

As DLRs move through the repair pipeline, labor costs are incurred throughout the process at various steps. These labor costs include tagout and ordering, warehousing, and labor for RIP request. Repair labor will be discussed in subchapter B since repair labor is paid for as part of a total repair contract by NAVSUP WSS.

1. Labor at Unit for Tagout and Ordering

The data required to evaluate labor costs involved in a tagout and of a DLR requires the number of labor hours required to conduct the maintenance to remove the NRFI DLR, install the RFI DLR, perform required administrative tasks associated with documenting the tagout and maintenance, the number of maintenance personnel involved in the previous tasks, and the salaries of the maintenance personnel. To evaluate labor costs in ordering the RFI DLR it requires the labor hours required to research and identify the DLR required by the maintenance personnel, the labor hours for supply department personnel to tech edit the requisition request and send off-ship for fulfillment, conduct and document DLR verification, and the salaries of both the maintenance and supply department personnel involved in the ordering.

When a DLR becomes NRFI on a naval vessel, the maintenance personnel document their work to remove the NRFI and install the RFI part, as well as the labor hours they spent on removal and installation (Naval Sea Systems Command [NAVSEA], 2021, p. 2-7). The labor is documented on either the Organization Maintenance Management System-Next Generation (OMMS-NG) or the Automated Work Notification (AWN), depending on which system is installed on their ship (NAVSEA, 2021, pp. 1-2–1-5). A file is created and transmitted off-ship to NAVSEA. While shipboard personnel maintain a local copy of their documented labor hours, NAVSEA is the likely source for fleetwide tagout labor data. An additional likely source for this information would be the TYCOM Force 3MC (Fleetwide Maintenance Program). The data source for ordering-labor is not tracked like the maintenance labor hours are. Instead, the likely source of this data would involve surveying maintenance and supply personnel at the end units.

2. Labor in Warehouse for Inventory Management

RFI parts require storage at NAVSUP and DLA warehouses to fulfill future requisitions or storage requirements. The data required to evaluate labor in warehouses for inventory management requires determining the amount of labor hours required for receiving, verifying, stowing, inventorying, issuing, and shipping RFI DLRs while documenting every action in an electronic information tracking system. Additionally, the

number of employees working at the warehouse, employees' salaries at the warehouse, and the number of parts managed at that warehouse to determine the costs for increasing or decreasing inventory levels. The likely sources for warehousing labor data would be NAVSUP WSS and DLA for their respective storage facilities.

3. Labor for RIP Request

Labor for RIP requests is broken down into two different categories: labor costs at the end unit and labor costs at the SYSCOMs. Evaluating labor costs at the end unit requires data that includes supply department personnel labor hours for the administrative work to validate the RIP justification, document the RIP request, and submit to NAVSUP WSS for adjudication. Additionally, data is required on how many supply personnel are involved in the RIP request process and the salaries for the various levels completing and approving the RIP request before it is sent to NAVSUP WSS. Data sources from end unit labor is recommended to come from surveying end unit supply department personnel since there is no known tracking mechanism for documenting RIP request labor at the end unit.

Evaluating labor costs for RIP requests at the SYSCOM level is very similar to the end unit as it requires data on labor costs. This data should capture the labor hours required by NAVSUP WSS personnel to process the request and forward to the correct ISEA team at NAVSEA (or the appropriate HSC if different), update the advice code following adjudication if the ISEA approves the DLR as RIP, and additional administrative functions that include follow-up to the end unit that requested the RIP. Data must also capture the labor hours involved by the HSC ISEA team to review and adjudicate the RIP request and send the official response back to NAVSUP WSS. For both NAVSUP WSS and the HSC ISEA personnel, it is necessary to identify how many personnel are involved and the salaries of each to calculate the labor costs. The data source for the SYCOM level is recommended to come from surveying the RIP team at NAVSUP WSS since there is no known tracking mechanism for documenting RIP request labor at the SYSCOM level.

B. DATA PERTAINING TO REPAIR COSTS

Once the NRFI part is received at the repair facility there are repair costs that are incurred. Repair costs include both labor and non-labor factors, however, NAVSUP WSS

contracts the entire repair process as a total repair contract. The data areas of concern for labor cost include repairing and replacement of subcomponents, test and evaluation, and packaging. Non-labor costs within the total repair contract include equipment cost, facility cost, subcomponent cost, shipping costs, and disposal of condemned DLRs. The data for these various cost factors requires input from the repair facility, the OEM, NAVSUP WSS, and DLA (Department of Defense [DOD], 2004, p. 6). However, the central source of data would likely be NAVSUP WSS as they manage the overall repair contract for each OEM.

C. DATA PERTAINING TO COST OF NEW RFIS

The cost of a new RFI depends on where the NIIN is in its life cycle. For example, if the new RFI DLR is part of a newly acquired weapon system than the life cycle costs for increased DLRs will be significantly higher than if a weapon system has been in use for over 20 years and will face obsolescence once an upgraded weapon system is introduced as a replacement in the fleet. This is a variable cost that must be considered in future cost research, and the data for where the NIIN is at in its life cycle can be obtained from NAVSEA since they have the data for when that DLR came into inception and what future replacement weapon systems are expected. Within these life cycle costs, it includes the costs to procure the RFI DLR, expected number of repairs and repair costs of each DLR in the sustainment pool, inventory management costs to warehouse the increased DLR inventory, and condemnation costs of each DLR.

For the purposes of data collection in this research project, the sources required will be broken up into new acquisition of a DLR, and either replenishment or increase in RFI inventory. For new acquisitions, the source of this data will come from NAVSEA (or the appropriated HSC if NAVSEA is not responsible) since NAVSEA is responsible for the initial outfitting to the fleet when a new weapon system is introduced to the fleet. Once the initial outfitting and contracting is complete for the weapon systems NAVSEA will provide a mean time to failure to be able to predict demand and the amount of new weapon systems that will be supported.

Based on the data provided to NAVSUP WSS by NAVSEA for future sustainment requirements, NAVSUP WSS will contract and procure additional RFI inventory for

sustainment as needed. It is unknown whether NAVSUP WSS factors in advice code when it comes to stocking RFI DLRs, but the cost to order a single RFI is based on the standard price of the DLR from the contract with the OEM. This data request should be requested through NAVSUP WSS since they are the SYSCOM responsible for working with the OEM to contract spare repairable parts based on the data provided by NAVSEA.

When a DLR is repeatedly stocking out NAVSUP WSS must decide on whether or not to increase the amount of RFI DLRs in inventory. If they decide to increase the inventory, NAVSUP WSS pays the standard price of the DLR multiplied by the amount of DLRs ordered. The source of this information will be NAVSUP WSS and will likely require input from both the Item Managers and the contracting teams involved in the acquisitions of additional RFI DLRs.

D. DATA PERTAINING TO STOCKOUT COSTS

The data required to evaluate stockout costs include the frequency of stockouts for each DLR and its assigned advice code, variability of demand for each DLR over a given time-period, the timespan of a stockout (how long an end unit must wait for an RFI when a stockout occurs), and the mission impact costs when stockouts occur.

In the preliminary stages of this research project, the authors received a database that tracks every DLR requisition, advice code, quarterly demand, RTAT, and current inventory levels. While this database did not include stockout numbers or the frequency of stockouts, the database did contain data requirements to begin determining demand variability. It is also important to note that the authors had not requested stockout information in this database either, but it is likely that NAVSUP WSS would be able to provide stockout frequency and demand variability data since they manage DLRs and maintain detailed metrics.

Evaluating mission impact costs of stockouts is very complex and challenging to determine. First, it is necessary to determine the consequence of the stockout and then the impact it has on mission readiness. For example, if the DLR stockout results in a ship being unable to get underway and complete any missions then the cost a stakeholder assigns it would likely be much more significant than if a DLR stockout only resulted in a loss of

redundancy in a secondary warfare area. The data required to determine these costs requires input from multiple sources, but this data will also be very subjective. The mission impact cost of a ship failing to get underway on time would likely have varying values if the TYCOM, Task Force Commander, Fleet Commander, or even the Geographic Combatant Commander were all surveyed and asked. The cost would also vary based on what current mission orders were impacted. Different DLRs, different mission sets for different end units, and different stakeholder impacts all result in mission impact stockout costs that vary greatly. The recommended source for this data is to survey the higher echelon commands that were listed. It is also possible that NAVSEA ISEA teams may be aware of which DLRs have a higher severity to mission degradation when an RFI fails.

The timespan of a stockout also affects the mission impact costs. For example, a stockout may only affect an end unit for one week before an RFI is available for fulfillment and mission readiness is restored. In more severe cases the timespan of a stockout may be several months. The greater the timespan of a stockout, the more significant the mission impact cost will be. Additionally, if the timespan of stockout is lengthy it may also lead to further cost consequences, such as cannibalizations, which are costs that would also need to be evaluated. Data requests for timespans for stockouts should be directed to NAVSUP WSS as they are the likely source that manages these metrics.

E. DATA PERTAINING TO CANNIBALIZATION COSTS

Cannibalizations are a frustrating procedure that result from unique situations since they are not a standard process. The general principle is that they should be avoided unless extreme situations occur (SURFOR, 2019, p. 1). Since cannibalizations are so complex it is important to narrow down where the data applies to this research project, and where cannibalizations intersect with the DLR process. Based on the process that this research has mapped out, that is where increased stockout risks affect DLRs.

The data to research this further includes determining how many cannibalizations involved DLRs, the advice code of the DLR cannibalized, if a stockout occurred, and the justification for the cannibalization to occur. Additional data may be required for further

research that could include where in the OFRP the donor was to incorporate secondary mission readiness impacts that result.

The owner of this data is not clear to the authors of this research project, but the best and most likely starting place is the surface fleet TYCOM since they are the approving authority for cannibalizations to be executed and they are the administrative trackers of cannibalizations. In the preliminary stages of this research project, the authors received some data from CNSL on cannibalizations. The data collected by the TYCOM included the donor ship, unit status, the required delivery date, the document number for the outstanding requisition, the status of the requisition, the equipment nomenclature, the casualty report number, casualty report rating, the NSN, justification for the cannibalization, and the adjudicating status (SURFOR, 2019, p. 8).

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VII. CONCLUSION AND RECOMMENDATIONS

DLRs are an important topic in the Navy to discuss with both Supply Officers and end-user customers that are performing the maintenance. Each stakeholder in the process has a preference because of how the process affects their organizations. Being able to clearly lay out the impact on each stakeholder, their responsibilities, and who bears the cost is vital before attempting to change the process. Three career supply officers wrote this thesis to work on a topic that we deal with daily, and yet still found ourselves tangled with the nuances and cascading effects that an advice code can have on cost and flow. This process needed to be clearly outlined, and the wholistic picture that encompasses all stakeholders and processes has been delineated. Laying the foundation for further research became our goal so that further research in specific areas would be able focus on specific stakeholders since the DLR process has so many complexities and unique scenarios.

A. SUMMARY OF CONTRIBUTIONS

The main contribution that this report adds to this topic is the baseline knowledge needed to start further research. Throughout researching this thesis, the authors discovered that there have not been many studies conducted on DLR management by the Navy. Costs are intertwined between multiple stakeholders that have different priorities. Cost categories were identified as they were related to specific stakeholders. Conceptual tradeoffs were identified to provide a general understanding of how specific decisions affect the cost categories. Our study dispels misconceptions about the DLR management process, such as the number of tagouts required having a direct association with the assigned advice code. It also helps focus attention on areas that would provide potential benefits to the greatest number of stakeholders.

The biggest takeaway is that this topic is that improving one part of this complex process without considering the bigger picture could be detrimental to the overall DLR management process. Because of this the topic needs to be researched more thoroughly to better serve the Navy's interests in balancing financial responsibilities and operational availability. The DLR process has many unique situations within the environment of DOD

supply chain management, and a quantitative analysis and cost benefit analysis would greatly benefit both customers and users of DLRs in the Navy. Using this report as a foundation, further research may derive the best decision possible for the Navy to manage its resources, while ensuring that all the stakeholders understand their interactions with each other and avoid making decisions that would improve short-term metrics at the expense of the long-term success of the DLR process.

B. FOR FUTURE RESEARCHERS SEEKING TO FOLLOW UP

To complete a wholistic CBA of the entire DLR process, there are several topics that will need to be researched. These topics are large and complex, and will likely require several studies to complete, so they have been divided into five different research topics below.

1. Partial Mission Capability

Partial mission capability is one of the main drivers of DLRs being assigned as 5S. However, identifying process flow improvements to be made for DLRs in PMC systems is valuable in this research. This topic would dive into the percentage of how many DLRs are coded 5S due to meeting PMC thresholds, determining the quantifiable benefits of maintaining a PMC piece of equipment onboard the ship, and analyzing the life cycle cost impacts for managing a 5S DLR that would have otherwise been deemed 5G. This research topic would also include factors in defining partial functionality for a weapon system, such as how much function is enough to be determined as PMC.

2. Stockouts

Research should also be conducted on the likelihood of increased stockouts to determine if there is a significant increase in risk of stockouts based on advice code. Additionally, if there is an increased risk it is important to determine how severe the risk is and where DLR management process mitigations could be implemented. An example could be gathering stockout information from NAVSUP WSS to narrow down how many were DLRs, what the assigned advice code was, and then comparing it to overall stockout numbers for DLRs requisitioned by the fleet. Using this research, it could be identified if

the stockout percentage is higher for 5S DLRs and where the process could be more efficient to avoid impacts to mission readiness. This topic would also require assessing the costs to mission impact based on severity of degradations to equipment.

3. Tagout Labor

Tagout labor costs and benefits is an area that was explored in the Hagan and Ohman thesis (2020) but based on this thesis research it was determined that there are four separate scenarios that affect this labor cost. Using these four scenarios, research should be conducted on these four different cases for 5G and 5S DLR tagout procedures. This research would analyze the likelihood of each case and analyze if there are process improvements that could be done to minimize labor while still adhering to the advice code restrictions. Conducting this research may include surveying ships to find out how many of each case are conducted during a specified time-period and finding bottlenecks in the process that are controlled by the Supply Department or NAVSUP WSS that could be changed to increase efficiency.

4. RIP Request Process

The current RIP process is frustrating to the customer and to the DLR managers due to delays and uncertainty of timelines to fix broken weapon systems. Analyzing the costs and benefits in this portion of the DLR program could result in process improvements that reduce delays in ships submitting requisitions for a new RFI part or manage risk mitigations to approving advice code changes at certain thresholds without a full ISEA review. For example, examining the benefits of an end unit being able to order RFIs immediately if the cost or demand of the DLR has negligible consequences on the overall DLR management process. Another example is investigating whether or not advice code 52 is used as intended by the fleet, and whether or not there could be a process improvement to streamline the DLR process that results in increased readiness and efficiency in the fleet.

5. Cannibalizations

Cannibalizations are a big enough topic to cover multiple theses with all the complexities associated with cannibalizations, but a DLR focus research could reveal

correlations between DLR advice codes and cannibalizations. This research would focus on the intersection between the increased risk of stockouts and cannibalizations that occurred, as well as what percentage of cannibalizations tracked that are DLRs. The research would then categorize the cannibalized DLRs as 5G vs. 5S and identify trends. This valuable research would also identify if the assigned advice code led to increased cannibalizations and other contributing factors that may require mitigation to avoid this process that has many detrimental consequences. Additionally, it may prove necessary in future research to determine the mission impact of equipment failures that warrant cannibalizations. In these cases, the TYCOM may also have casualty report information and the ISEA at NAVSEA may be able to provide a severity rating of the degradation.

6. Data Source Collections

Brought up in Chapter VI, data sources are vital for future research. Identifying these data sources would allow future researchers to gather appropriate data sets to be able to create quantitative formulas. The focus of this research would be identifying specific sources of data for the cost categories listed in Chapter VI. This should include specific contact information from the departments within companies/command. Some data will be unique to each DLR NSN, such as original equipment manufacturer. These data sources should be listed as a library or search engine that can be used to find the appropriate information, such as ONETOUCH or HAYSTACK GOLD. An example of data collection source is the NAVSUP WSS item manager for a DLR, who can provide average lead time, demand, inventory levels, and warehouse locations.

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