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ACQUISITION RESEARCH PROGRAM
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Analysis of the Remain In Place Policy

December 2020

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Thesis Advisors: Dr. Robert F. Mortlock, Professor
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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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ABSTRACT

The current materiel return process for the Navy is to have a broken depot-level repairable (DLR) part removed and turned in to the local supply system before requesting a new piece of equipment. If the unit fills out the appropriate paperwork with adequate justification, the maintainer is able to leave the piece of equipment in its original location until its replacement arrives. The current operating procedure forces the maintainers to open and close the system twice, which may result in an additional tag-out of the system. This research proposes to decrease the steps for maintainers in repairing broken equipment by allowing them to automatically leave the DLR within the system until the new piece of equipment arrives to reduce redundancy and increase safety when tag-outs are required. By implementing this alteration, the Navy could decrease time spent by the maintainer, reduce installation errors, and minimize wear and tear on the system. Upon completion of this research, the authors identify the costs, benefits, and possible risks associated with the implementation of an automatic remain-in-place policy and provide their recommendations on how to improve the current process.

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ABOUT THE AUTHORS

LT Michael Hagan graduated from the Virginia Military Institute in Lexington, VA, in 2014 with a degree in Economics and Business. After graduation he served onboard the USS COLE (DDG 67) as the Ordnance Officer. His second tour was onboard the USS SIROCCO (PC 6) as the Operations Officer. After the COLE he is currently at the Naval Post Graduate School. He married his wife Kathryn in July 2016, and they currently have two children. In his free time, LT Hagan does woodworking and goes hiking with his family. After graduation in December 2020, he will be reporting for Department Head School at Surface Warfare Schools Command (SWSC) Newport, RI, then Department Head School at Dhalgren, VA. After Department Head school, he will be reporting to the USS CHANCELLORSVILLE (CG 62), Yokosuka, Japan, as the Weapons Officer.

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LIST OF ACRONYMS AND ABBREVIATIONS

2M	Miniature/Microminiature Electronics Repair
BCM	Beyond Capable Maintenance
CCA	Circuit Card Assemblies
CNP	Common Naval Packaging
COG	Cognizance Symbol
DLR	Depot-Level Repairable
DOP	Designated Overhaul Point
DSP	Designated Support Point
EM	Electronic Modules
eRMS	Electronic Retrograde Management System
ICP	Inventory Control Point
MTR	Manual Test and Repair
NRFI	Not Ready for Issue
NSN	National Stock Number
O	Organizational
RFI	Ready for Issue
RIP	Remain-in-Place
TRS	Tag-out Record Sheet
TUM	Tag-out User's Manual

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I. INTRODUCTION

The first chapter of this project introduces the current system, goals, focus, research questions, process, and concludes with a summary of the chapters to follow. The intention of the introduction is to inform the reader of what the research of this project covers.

A. CURRENT SYSTEM

The current materiel return process for the Navy dictates that a broken depot-level repairable (DLR) part of advice code 5G must be removed and turned in to the local supply system before a replacement can be ordered. The maintenance unit is permitted to leave the broken DLR—also known as the carcass—within the system until the replacement arrives if the unit obtains a remain-in-place (RIP) chit. A RIP chit is the local supply documentation that authorizes maintainers to allow the DLR remain in place until the replacement part arrives. The current operating procedure forces maintainers to choose between lengthy paperwork required to obtain a RIP chit or a redundant maintenance operating procedure.

Per NAVSUP Systems Command, DLR parts are categorized as "Navy-managed items which, based on unit cost, annual demand, difficulty of repair, or other economic considerations, have been selected by cognizant inventory managers for special inventory control. DLRs must be returned to the designated support point (DSP)/designated overhaul point (DOP) when they are beyond capable maintenance (BCM) at the authorized maintenance activity for refurbishment" (Naval Supply Systems Command [NAVSUP], 2015). These pieces of equipment that are denoted as beyond capable repair by the shipboard maintainer are known as a not ready for issue (NRFI) carcass (NAVSUP, 2015).

Per NAVSUP Systems Command, DLRs are identified by "advice codes 5A, 5D, 5E, 5G, 5S, 5W, 5X, 5R, 5V, 5Y, 52, 53, 54, 56, and 57" (NAVSUP, 2005, p.A1-1). Advice codes "provide coded instructions to supply sources when such data is considered essential to supply action and entry in narrative form is not feasible" (NAVSUP, 2005, p.A1-1). They allow units that are requisitioning items and warehouses to talk to each other without filling out a long list of instructions—such as advice code 2L, which allows each side to state, "Quantity reflected in the quantity field exceeds normal demands; however, this is a confirmed valid requirement" (NAVSUP, 2005, p. A1-1) without having to write all of that out or provide a long explanation.

There are two types of advice codes: inter-service, assigned by the Department of Defense (DOD), and intra-service, assigned by the service concerned (NAVSUP, 2005). All 80 of these advice codes are found in Appendix I of *NAVSUP Publication 485, Volume II* (NAVSUP, 2005). The Navy has 31 intra-service advice codes, 5A through 5Z (except 5I and 5O) and 52 through 59 (NAVSUP, 2005). The focus of this project is on repairs assigned with an advice code of 5G. Advice code 5G is an exchange certification for DLRs:

> (1) Requested item is a mandatory turn-in repairable for which an unserviceable unit will be turned-in on an exchange basis under the same document number as that used in the requisition.
>
> (2) Requested item is compressed gas for which an empty cylinder will be turned-in on an exchange basis. (NAVSUP, 2005, p. A1-6)

B. PROJECT GOALS

This project analyzes the possible advantages and disadvantages of allowing maintainers the authority to leave the carcass of DLR parts with advice code 5G within the system without the submission of a RIP chit until the replacement arrives. This policy change could decrease the maintainer's time spent on repairs, reduce installation errors, and minimize the wear and tear on the system itself. However, due to the nature of the DLR program, this alteration will delay the return of DLR carcasses to be refurbished, thus reducing the financial incentives of the DLR program. Therefore, the financial trade-off between the reduced rate of advice code 5G parts being returned and the time saved of unit-level personnel was investigated.

C. PROJECT FOCUS

The focus of this research is specifically on the implications that the current RIP policy has on unit-level maintainers onboard ships in the surface Navy. Although this was the focus of the research, the recommendations of the research could be applied with minor modifications to the air and subsurface communities listed in the recommendation portion of this project. The authors decided to focus on the implications of the RIP policy on the unit level, as other studies have already been conducted upon the larger level organization of the

Navy—such as a study conducted by the RAND Corporation in 2014, *DOD Depot- Level Reparable Supply Chain Management* (Peltz et al., 2014). According to this study, "DLR supply chain management appears to be done relatively effectively across the services. In particular, there does not appear to be any single process improvement opportunity for dramatically reducing inventory requirements" (Peltz et al., 2014, p. xxviii). Although Peltz et al. (2014) came to this conclusion for the overall DLR supply chain management of the Navy, they did not investigate the specific implications that the RIP policy has on the efficiency at the unit level. As a result, the authors investigate the ramifications associated with the RIP policy.

D. RESEARCH QUESTIONS

This project intends to answer the following questions:

(1) What are the effects of the implementation of an automatic RIP for advice codes of 5G within the surface fleet?

To answer this question, the authors focused on implications relating to *money*, *time*, *manpower*, and *equipment lifespan*.

(2) What is the threshold/identifier for DLRs to be switched over to another advice code if not all 5Gs should be automatic RIP?

To answer this question, the authors focused on implications relating to *money*, *availability*, and *manpower intensive*.

(3) What areas of policies/instructions need change?

To answer this question, the authors focused on implications relating to clarification, not specified, increased policy, and amount of unity/ similarity between commands.

E. PROJECT PROCESS

This project follows the general format of the identification of a possible area of issue within the surface Navy's supply of DLR parts. The first step to further distinguish this area of study was to discuss with current naval supply officers at the Naval Postgraduate School in Monterey, CA. The discussion took place with supply officers who had a total experience covering the surface, subsurface, and air communities. This allowed for a better focus area to be developed, which drove the project to the RIP subject.

The second step was to conduct a literature review, mainly covering the *NAVSUP Publication 485* (NAVSUP, 2005, 2014) but also including other projects and studies, such as the study conducted by the RAND Corporation analyzing the DOD's DLR Supply Chain Management (Peltz et al., 2014). This drove the project even further to specify the type of RIP DLR parts to advice code 5G. The literature was referenced throughout the project to gain further understanding.

The third step, data collection method, was conducted through a survey. The survey questions were driven by the author's research questions mentioned in Chapter I, Section D and by the literature review. The data was compiled into an Excel spreadsheet for statistical study; put into multiple formats, such as graphs; and quantified into mean, median, mode, and other relevant statistical methods to discover anything of statistical note. Additionally, an open-ended question was put in place to provide nonquantifiable data or any other information that the subject matter experts wanted to include.

The analyzed data was then compared to the literature reviewed to compose the analysis. The research questions were then brought back into view to drive the focus of the analysis and to answer each question. The answers to the research questions helped the authors to form the recommendations of this project.

This project is broken down into the following chapters:

Chapter I: Introduction covers the current system in place for advice code 5G parts and the RIP system in a higher-level focus; defines the project's goals, research questions, and process; and provides a summary of each chapter.

Chapter II: Background covers why the DLR system exists and gives a more detailed overview of the processes within it. Chapter II also describes the process of the maintainer and supply department on board a ship for an advice coded 5G carcass.

Chapter III: Literature Review covers the instructions, studies, articles, and other literature reviewed and utilized in this project. Furthermore, it identifies the reasoning for each use and why it was reviewed.

Chapter IV: Data Collection Method covers the methods this project utilized to collect data, discusses any possible biases and their prevention, and defines the null and alternative hypotheses.

Chapter V: Data Analysis covers the actual data collected and how the data were analyzed, utilizing portions from the previous chapters. Chapter V also addresses the steps taken to achieve the results, which are also given within the chapter.

Chapter VI: Recommendations covers the recommendations from this project based upon the research questions provided in Chapter I, Section D, incorporating the data analysis and literature review from Chapters III and V. Additionally, this chapter provides recommendations for further study that were outside the scope of this project.

Chapter VII: Conclusion covers additional remarks and key points drawn from this project and provides a final summary of the project.

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II. BACKGROUND

The background of the DLR system is separated into four subsections: Establishment of the DLR System, Current Process of Depot-Level Repairables, Process of the Maintainer, and the Process of the Supply Department. The intention of this chapter is to inform the reader why DLR system is vital to the Navy but how its implementation leads to redundancy for the maintainers.

A. ESTABLISHMENT OF THE DLR SYSTEM

The DLR process was created as an avenue to combat the ever-increasing cost of maintaining ships, aircraft, and a plethora of other capital-intensive Navy technology and equipment. Within the DLR process, specific parts are identified as being cheaper to refurbish and resupply to the fleet than to replace with new parts. The carcasses of these parts, commonly known as not ready for issue (NRFI) parts, are returned either from the fleet through the supply system and turned over to the original manufacturer, such as Raytheon or General Dynamics, or to depot-level maintenance for repair (Carr & Wilcox, 2006). Upon completed refurbishment, the DLR is then reissued to the operational fleet as a ready for issue (RFI) part. This simplified process can be thought of as a closed loop system, depicted in Figure 1.

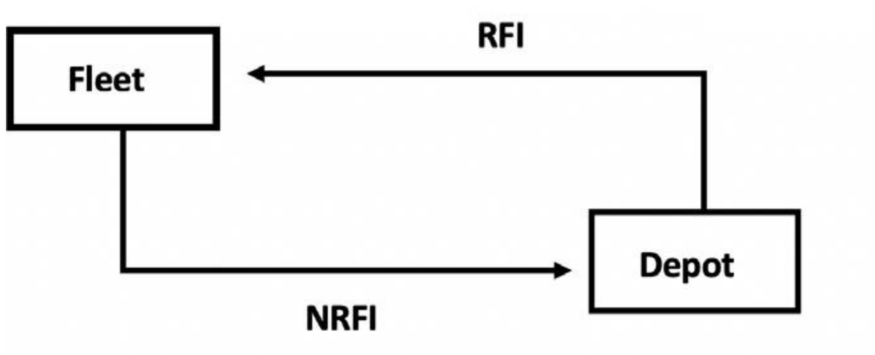

Figure 1. Basic DLR Chain. Adapted from Carr and Wilcox (2006, p. 2).

When discussing the acquisition of DLR parts, the price paid is referred to as standard price or net price, depending if the DLR is a new or refurbished item. The price paid for a brand-new component straight from the manufacturer, such as Raytheon or General Dynamics, is known as the standard price. Meanwhile, the net price is the price paid by ships for a refurbished DLR part (Carr & Wilcox, 2006, pp. 2-3). The difference between standard price and net price is known as the carcass turn-in credit. With regard to carcass turn-in credit, the requisitioner is given carcass value credit so long as the DLR returned has the same national stock number (NSN) as the DLR that was originally issued. An individual who returns a DLR carcass that does not match the NSN from the issued part will be charged the net price of the DLR issued so long as the DLR returned is an authorized substitute. This means that if the ship tries to request an upgraded component it may not necessarily receive credit (NAVSUP, 2015, p. 8-63).

B. CURRENT PROCESS OF DEPOT-LEVEL REPAIRABLES

Having covered the basic reasoning for the establishment of the DLR system, the authors now focus on the current process for DLR items within the unit level of the surface Navy. This process generally proceeds in the following way. A piece of equipment breaks and is noticed by a sailor through random discovery, preventive maintenance, or some other system indicating failure. The part is viewed to see if it is repairable through the Miniature/ Microminiature Electronics Repair (2M) process onboard (NAVSUP, 2015, pp. 8-61-8- 62).

The "2M and Module Test and Repair (MTR) program supports testing and repair of circuit card assemblies (CCA) and electronic modules (EM) at the Fleet O-level and Fleet I-level" (Naval Sea Systems Command [NAVSEA], n.d.). Ships fall into the Fleet O (organizational) portion of the 2M system. To become 2M-qualified, sailors go through certification granted by NAVSEA following the *Certification Manual for Miniature/ Microminiature (2M) Module Test and Repair (MTR) Program* (NAVSEA, 2011). Each ship is to have a 2M program established, but not all may have the same capabilities due to the ship type (Chief of Naval Operations [CNO], 2010). If the part is not able to be repaired through 2M, it is then identified by unit-level maintenance personnel by its NSN. This allows the maintainer to identify whether the part is a DLR through the cognizance symbol (COG). A COG is a Navy-specific, two-digit code with a number followed by a letter used as intra-Navy advice codes. "This field serves a dual purpose. An advice code may be entered by the requisitioner to provide coded instructions to supply sources when such data is considered essential to supply action. When the requisition is processed, a status code is inserted in this field to provide the recipient(s) of status with information regarding action taken" (NAVSUP, 2003, p. 32).

DLR items are listed and identified by NSN, COG, and material control code (E, G, H, Q or X), and as such the maintainer and units supply department must follow the DLR process when 2M is not able to repair the part within the unit (NAVSUP, 2015, p. 8-61). If the part is deemed a DLR, it can then be ordered from the supply system under one of the following advice codes: 5A, 5D, 5E, 5G, 5R, 5S, 5X, 5V, 5W, 5Y, 52, 53, 54, 56, 57, 58, 59, or other advice code, which then must be followed by clear text such as "REQUESTED ITEM ONLY WILL SUFFICE. DO NOT SUBSTITUTE/INTERCHANGE." These advice codes are required for requisitions of mandatory turn-in DLR items (NAVSUP, 2015, p. 8-62). If the advice code is 5G, the unit must quickly decide to turn in the carcass (as required for a 5G part) or to keep the carcass installed until the replacement is received by completing a RIP chit. A part with the advice code of 5G is stated as an exchange certification:

> (1) Requested item is a mandatory turn-in repairable for which an unserviceable unit will be turned-in on an exchange basis under the same document number as that used in the requisition.
>
> (2) Requested item is compressed gas for which an empty cylinder will be turned-in on an exchange basis. (NAVSUP, 2005, p. A1-6)

The decision to maintain the item within the system is typically due to the system itself being unable to function, or at least to maintain some functionality, without the broken part remaining within the system.

If the unit decides to remove the part immediately, the maintainer will extract the DLR carcass and turn it over to the local supply department. Once the supply department receives the carcass, they will release the order status off ship for a replacement. Supply will then send the carcass to the local depot to be refurbished or scrapped, depending on the extent of damage incurred. In Section C, the ramifications of removing the part immediately are discussed in more detail.

If the unit decides to keep the carcass in place until the replacement arrives, the maintenance division is required to write a RIP chit with adequate justification to the supply department. This process only occurs for items not already listed by the inventory control point (ICP), which establishes a list of automatic RIP DLRs as dictated by OPNAV Instruction 4400.9D (CNO, 2017). The paperwork and the actual process on board the ship is individualized per ship but follow steps similar to the following:

1. Member from the DLR carcasses division fills out the paperwork required by the supply department for the RIP approval.
2. Maintainer orders replacement part. (Supply does not release or approve part within Relational Supply [RSUPPLY] until RIP approval by the Commanding Officer or carcass is turned in.)
3. Route the RIP chit to the commanding officer (approval between DLR carcasses division to the CO varies between ships).
4. Deliver approved RIP to the supply department.
5. Supply recodes ordered part to advice code 5S, denominating the RIP status within the supply system, including a reasoning for RIP status within the system.
6. Supply system orders replacement part.
7. Supply receives new part and informs maintainer.
8. Maintainer removes carcass.
9. Carcass delivered to supply and exchanged for new part.
10. New part is installed.
11. Supply sends carcass off ship to be repaired.

C. PROCESS OF THE MAINTAINER

The removal of a broken DLR requires varying degrees of effort and time, dependent upon the system in which the DLR resides, location within the ship, timing of the degradation, cycle the ship is currently in, and where the ship is located. The maintainer's first job in removing the carcass is to identify the effects of its extraction. Will leaving the carcass within the system until the new DLR arrives cause more failures down the line, or if the carcass is left in place, will the system continue to operate at a lower efficiency? This information is gathered from technical publications and from experience by the maintainer, but the ultimate decision to keep it within the system will reside with the CO.

Dependent upon instructions that can be found within technical manuals, the DLR may require a tag-out prior to extraction of the carcass. A *tag-out* is the process in which a system or part is isolated from electrical current, liquids, gases, heat, or mechanical components, as defined by the *Tag-Out User's Manual* (TUM) (NAVSEA, 2016) for the safety of personnel while installing, removing, or repairing a system or part. If a tag-out of the system is required, the process usually proceeds in four steps (NAVSEA, 2016). Figure 2 shows the general flow of the tag-out process.

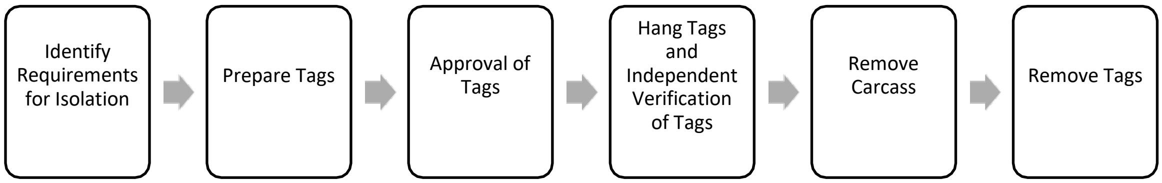

Figure 2. General Tag-Out Process

1. Determine Specific Tag-Out Requirements

With the assistance of system diagrams found within the technical manuals and diagrams for the system, the maintainer identifies which valves and/or switches must be opened, closed, or unplugged to isolate the part from variables that may harm the personnel, system, or ship. The amount of isolation is directly correlated with the number of inputs to the part and the extent of danger the hazard possesses. Hazards can include "high temperature (200 °F or more), high pressure (1000 psi or greater), sea connected systems (except lines less than ½ in nominal pipe size inboard of the backup valves), hull penetrations below the maximum anticipated waterline (except mechanical and electrical penetrations designed for single closure [e.g., shaft or cable penetrations]), fluids with flash point below 200°F, oxygen level, toxic vapor (e.g., dry cleaning fluid, photo-chemical fluids, and phosphate ester hydraulic fluid)—all requiring double barrier protection" (NAVSEA, 2016, pp. G-1-G-4). The more isolation, the longer it will take to make the proper arrangement.

2. Classification of Tags

The second step is the preparation of the tags by the maintainer, who uses the identification to determine the amount of tags, tag-type, and what is written on the tags (NAVSEA, 2016, p. 4-8). There are two type of tags: danger and caution. The use of danger tags occurs to "prohibit the operation or removal of equipment that could jeopardize safety of personnel or endanger equipment, systems, or components. Caution tags provide temporary special instruction(s) or indicate that unusual action must be exercised to operate the equipment. Caution tags state the specific reason that the tag is installed" (NAVSEA, 2016, p. 4-8).

3. Placement of Tags

Once the appropriate type of tag is written, the maintainer seeks approval from the authorizing officer (or the CO if required by their standing orders). The authorizing officer (or CO) reviews the tags, the explanation of how the system is to be isolated, and the diagrams to determine whether the isolation plan is adequate with regard to safety and operational effectiveness. If the authorizing officer does not believe the isolation plan is adequate, changes will be required before proceeding with the tag-out process. Once the tag-out is approved by the authorizing officer, serial numbers are issued to each tag to differentiate them. The maintainer then displays each tag in the proper location (as specified on the tag), and proceeds in turning the valve, pushing the button, or unplugging the system as stated on the tag. After closing the system, the maintainer returns to the authorizing officer. An independent individual, who did not help with creating the tags, is required to verify that the tags are in the proper location and the tag-out was executed properly. The individual tasked with verifying the tag-out process then returns to the authorizing officer with the findings from their verification. Each of these individuals—the authorizing officer, the individual completing the tag-out, and the individual tasked with verifying the tag-out—signs the tags and the tag-out record sheet (TRS) to ensure accountability. Once the system has been correctly tagged out, the maintainer is able to extract the carcass from within the system (NAVSEA, 2016, p. 8- 17).

4. Removal of Tags

Once the carcass of the DLR is extracted, the maintainer signs within the TRS that the maintenance that required the tag-out has been completed. After the maintainer signs the TRS, the authorizing officer is required to sign that they confirm the maintenance has been completed. Once the authorizing officer and maintainer have signed and completed the steps within the TRS, the tags may be removed, and the equipment is turned back into the cleared position or condition as indicated in the Clearance Position/Condition on the TRS for each of the tags to be removed (NAVSEA, 2016, p. 18-19). Next, the maintainer physically removes the tags and returns them to the authorizing officer for proper disposal. "Upon return of the TRS and the individual tags, the authorizing officer must verify that the proper tags were removed, and documentation of their removal is completed on the TRS" (NAVSEA, 2016, p. 19). The authorizing officer updates the applicable valve status board(s) and then destroys the detached tags (NAVSEA, 2016, p. 19). This tag-out process is required a second time once the replacement DLR arrives from the local supply system, going through all the steps shown in Figure 2.

When a tag-out is not required, the part may be removed without any of the above steps required in a tag-out. Figure 3 shows the process when a tag-out is not required. However, the extraction of the carcass may still require higher-level approval, depending on the system affected by the failed DLR. An example of this could be a required approval by the CO if the maintenance causes a weapon system to be nonoperational during its maintenance. Once the carcass is removed from the system, it is closed to prevent further damage.

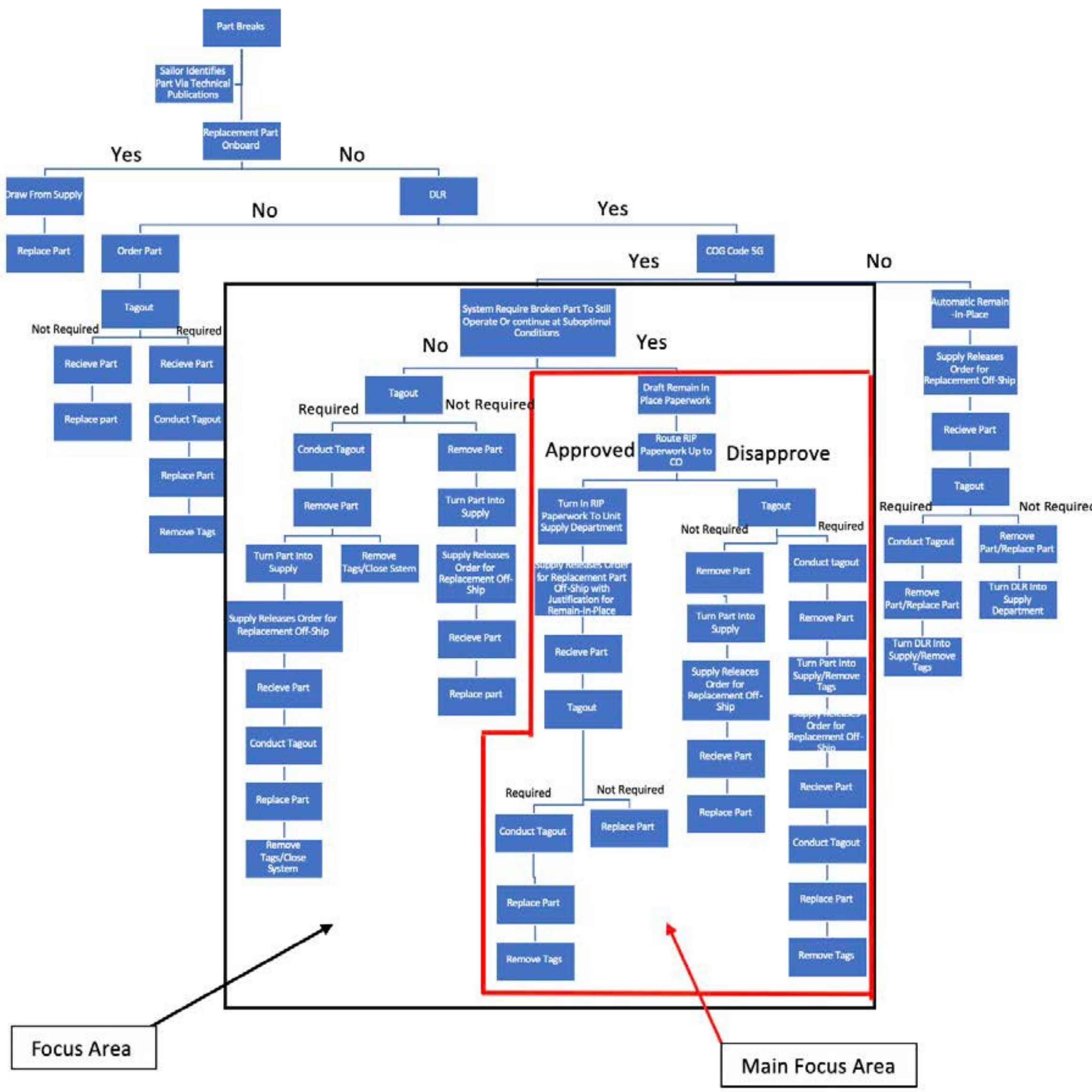

Figure 3. Carcass Flow Chart

As previously discussed, the time required in the extraction of a compromised part varies based upon the location, the system the DLR is in, and the possibility of a tag-out. However, the removal process of a DLR with a 5G advice code could require additional time due to the nature of the repair process, causing the maintainer to repeat maintenance steps—specifically, the tag-outs.

Later chapters discuss the costs and benefits associated with shifting some DLR parts with an advice code to automatically remain in their location until a replacement arrives.

D. PROCESS OF THE SUPPLY DEPARTMENT

Once the part has been removed, the next step is for it to be given over to the ship's supply department. The supply department performs several actions required by *NAVSUP Publication 485* (NAVSUP, 2014), including tracking the DLR parts, processing the paperwork, and packaging and delivering or mailing the DLR to a designated overhaul point (DOP) or designated support point (DSP; Carr & Wilcox, 2006, p. 9). The supply officer specifically creates a local instruction on the turn in of DLR parts (NAVSUP, 2015, pp. 1-13-8-69). The general steps for the supply department for a RIP carcass are shown in Figure 4.

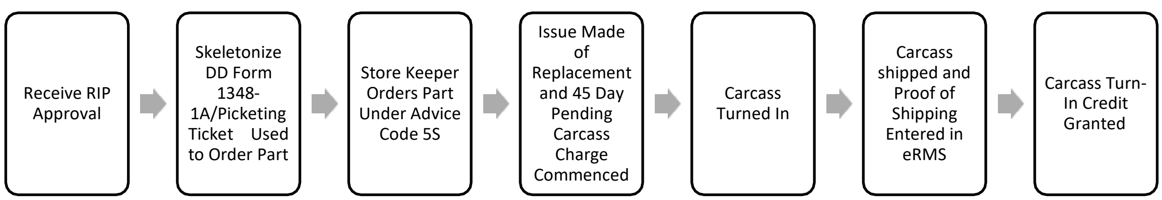

Figure 4. RIP Supply Department Process

The first part normally carried out with the receival of the carcass is the approval of the newly ordered replacement within RSUPPLY. If the 5G carcass RIP is approved, the issuing storekeeper enters the notation "RIP ITEM. TURN-IN NOT REC'D" in data block 29 of the DD Form 1348-1A. The skeletonized DD Form 1348-1A or picketing ticket is used to order the part within RSUPPLY and is retained in the DLR suspense file while awaiting receipt of the RFI item file copies of the issue request for the replacement item. "When the requisitioned replacement item is received, the responsible department head or work center supervisor is promptly informed of the requirement for turn-in of the replaced repairable"

(NAVSUP, 2015, pp. 8-63-8-64). The RIP documentation with CO's approval is also kept on file. After the required entries have been made, the issuing storekeeper gives a copy of the DD Form 1348-1A to the requester, with instructions to return it with the departmental turn-in of the NRFI DLR once it has been replaced (NAVSUP, 2015, p. 8- 66). The storekeeper, within RSUPPLY, orders the part under advice code 5S for any RIP carcasses (NAVSUP, 2015, p. 8-91).

Form 1348-1A and any other required forms, dependent on the type of carcass, are filled out by hand if the Electronic Retrograde Management System (eRMS) is not available. The paperwork is completed in accordance with *NAVSUP Publication 485* and attached to the carcass packaging, to be shipped upon retrieval of the NRFI carcass in accordance with *NAVSUP Publication P700: Common Naval Packaging* (NAVSUP, 2015, pp. 8-71-8-92). The timeframe for this depends upon being a RIP or not and the type of activity. For a RIP, the tracking clock does not start until the issue is made. After the issue is made, the pending carcass charge—in which the full price is charged—occurs at 365 days for industrial activities, 120 days for submarines, and 45 days for all other activities. The timing stops upon entering a proof of shipment document within the tracking system NAVSUP WSS In-Transit Accountability (NITA) or upon receipt of the carcass (NAVSUP, 2015, pp. 8-71-8-92). This ends the unit-level supply side of DLR carcass turn- ins and ordering unless issues arise, such as improper shipment or loss of tracking. Figure 5 is a graphical illustration of the supply department's decision tree.

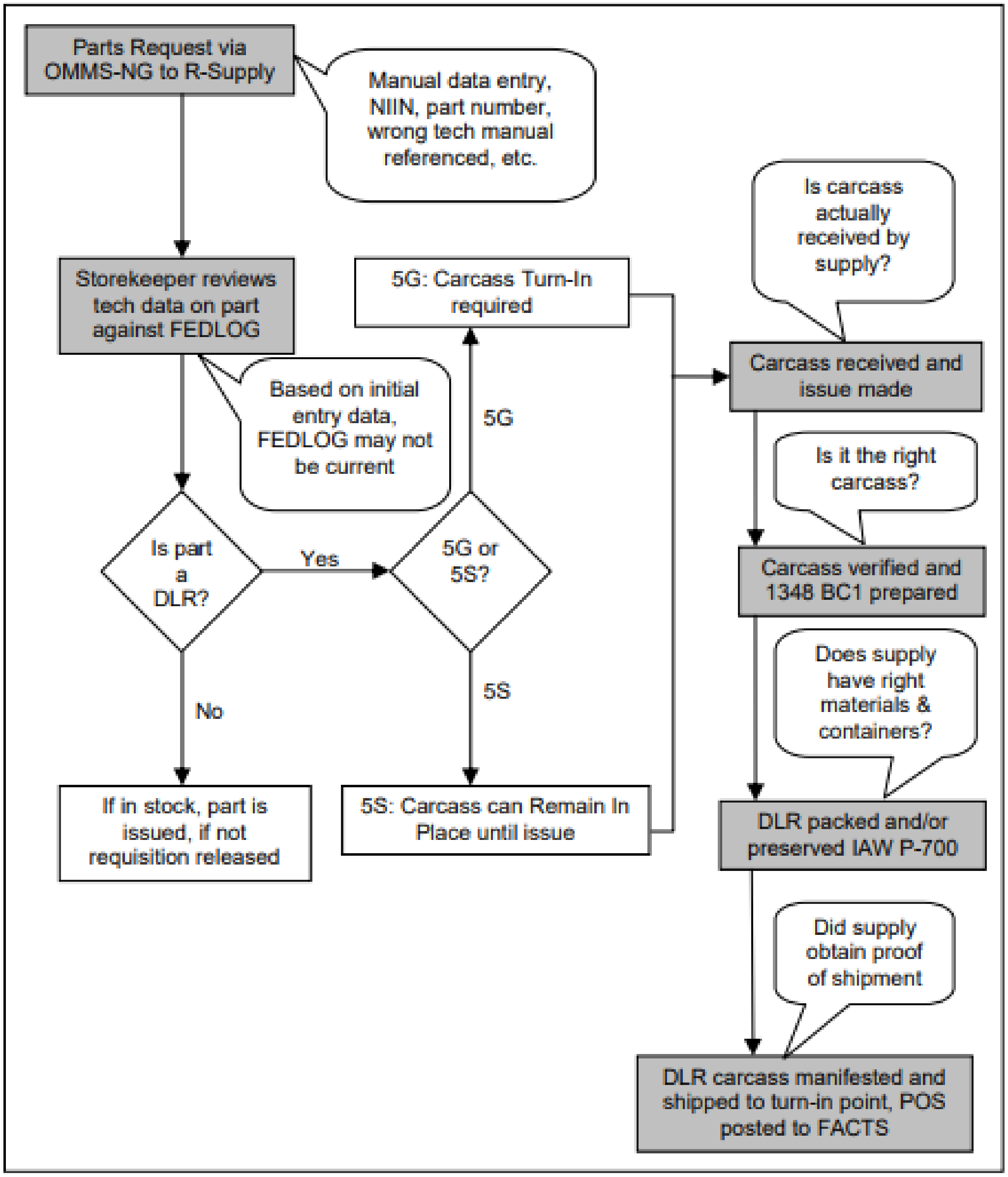

Figure 5. Activity DLR Decision Tree. Source: Carr and Wilcox (2006).

III. LITERATURE REVIEW

This chapter provides a review of the literature used to develop and support this project. Only the literature applied to this project is discussed in detail; however, the sources reviewed went beyond what is covered.

The investigation began by broadly searching for information relating to the topic, and slowly narrowing this information to more specific sources. These specific sources were reviewed thoroughly as important information relating to the thesis questions were discovered. The initial search began with key sets of words such as:

- Depot-Level Repairable
- Remain-in-place
- Tag-out System
- Advice Codes Navy
- USN Ship Maintenance

After weeks of diligent research, the main sources that were used to support and develop this project were the *Naval Supply Publication 485 Volumes I* (Naval Supply Systems Command, 2015) *and II* (NAVSUP, 2005), Naval Sea Systems' *Tag-Out User's Manual* (Naval Sea Systems Command, 2016), and *Depot Level Repairable Carcass Tracking and the Electronic Retrograde Management System* (Carr &Wilcox, 2006). Other relative literature reviewed includes: OPNAV Instruction 4400.9d: *Depot Level Repairable Item Management* (CNO, 2017); *Certification Manual for Miniature/Microminiature (2m) Module Test and Repair (MTR) Program: Organizational, Intermediate, and Depot Level, Revision II* (NAVSEA, 2011)*;* OPNAV Instruction 4700.7M: *Maintenance Policy for United States Navy Ships* (CNO, 2019)*;* and *DOD Depot-Level Reparable Supply Chain Management Process Effectiveness and Opportunities for Improvement* (Peltz et al., 2014).

Naval Supply Publication 485 Volume I: Operational Forces Supply Procedures establishes the United States Navy's procedures for all operational forces (Naval Supply Systems Command, 2015). *NAVSUP P-485 Volume I* covers "organization and administration; material identification; material procurement; material receipt, custody, and stowage; material expenditure and shipment; inventory management; packaging and transportation; special material; financial management; and navy disbursing operations" (Naval Supply Systems Command, 2015). Chapter 8, Part D of *NAVSUP P-485 Volume I* describes the procedures and policies for DLR parts, including the description of the types of DLRs, how to requisition, and concludes with shipping and ending the process for the operational unit (Naval Supply Systems Command, 2015). Chapter 8, Part D of *NAVSUP P-485* is the most comprehensive resource for identifying the steps a sailor must adhere to, with regard to the supply system, on any surface ship. This resource was heavily reviewed to identify each step and procedure, to ensure they are written clearly to avoid any confusion.

NAVSUP P-485 Volume II, is the appendices for both Volumes I and III, focuses on the advice codes of parts (NAVSUP, 2005). Appendix I listed all official advice codes for the Department of Defense organizations and their definitions. The review determined if any advice codes required further clarification, anything was missing, and identified which advice codes the project needed to concentrate on (NAVSUP, 2005).

Naval Sea Systems Tag-Out User's Manual (*TUM*) establishes the responsibilities, training and qualifications, and the procedures of preparing, conducting, and completing tag-outs for the Department of the Navy (Naval Sea Systems Command, 2016). This project reviewed the *TUM* for the procedures a sailor must adhere to when a DLR requires a tag-out. The purpose in investigating this was to understand the additional time that accompanies a tag-out when a DLR designated 5G does not have a RIP status (Naval Sea Systems Command, 2016).

Depot Level Repairable Carcass Tracking and the Electronic Retrograde Management System was a project published in 2006 from the Naval Postgraduate School (Carr &Wilcox, 2006). Although this project was completed 14 years ago, it holds much relevance to the procedures today and established a good starting point for this project. Carr and Wilcox (2006) did exceptionally well in breaking down the DLR process and included a thorough explanation of the DLR process. Furthermore, their project highlighted many of the issues, before many of the other publications, allowing for a baseline to see improvements within the DLR system. Their project, although written as a developed case, provided analysis and background information of the DLR system, Advanced Traceability and Control (ATAC) system, and the Electronic Retrograde Management System (eRMS) at the time (Carr &Wilcox, 2006).

OPNAV Instruction 4400.9D Depot Level Repairable Item Management provided policy and assigned responsibilities for the management of DLRs (CNO, 2017). The instruction provided a solid reference point of where *NAVSUP P-485* derived its policies for DLRs and who set the guidelines. The instruction is mostly a broad stroke in setting the policy and is more focused on directing which organizations within the Navy are responsible for setting the more detailed policy (CNO, 2017).

Certification Manual for Miniature/Microminiature (2M) Module Test and Repair (MTR) Program: Organizational, Intermediate, and Depot Level Revision II covers, in detail, the certification process for the 2M program (NAVSEA, 2011). The instruction was reviewed for the purpose of learning more about what it takes for a surface fleet sailor to qualify, requalify, lose qualification, and maintain qualification within the 2M program. The process for DLRs requires that, if capable by the unit, the carcass must be repaired via the 2M program onboard rather than sending all DLRs shoreside for maintenance (NAVSEA, 2011).

OPNAV Instruction 4700.7M Maintenance Policy for United States Navy Ships set policies and established responsibilities for planning, executing, and evaluating maintenance of U.S. and foreign navy ships (CNO, 2019). This instruction sets a broad set of policies, assigning responsibilities to different positions within the Navy to set more specific policies where needed. Its instruction clarifies the priorities for the Department of the Navy, as well as who sets the more specific policies regarding depot-level maintenance (CNO, 2019).

The RAND Corporation conducted a study in 2014 titled *DOD Depot-Level Reparable Supply Chain Management Process Effectiveness and Opportunities for Improvement,* identifying the strengths and weaknesses of the DOD's current supply chain management, with a specific focus on DLR parts (Peltz et al., 2014). It included analysis ranging from unit level to DOD-wide in the Army, Navy, and Air Force. However, within RAND's published study, the overwhelming focus was on higher level of management effectiveness and seemed lacking on the unit level. This reading established a good reference point of how the DLR process operated in 2014. This landmark allowed the authors to compare how the DLR process operated in 2006, in Carr and Wilcox's project, and in 2014 with RAND's study. The addition of the Army and Air Force in this study helped to provide other non-Department of the Navy policies that could possibly be implemented (Peltz et al., 2014).

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IV. DATA COLLECTION METHOD

This chapter includes the methods this project used to collect data, discusses any possible biases and their prevention, and defines the null and alternative hypotheses. This chapter revolves around the survey that was distributed to sailors stationed onboard a cruiser and destroyer stationed in San Diego, CA.

A. SURVEY

The primary collection of data was based upon the use of surveys issued to personnel aboard a destroyer and a cruiser located at Naval Station San Diego, composing of 30 sailors in various departments. This survey is shown in Figure 6. The attempt was to achieve a minimum sample size of 100 survey responses based off 339,448 active-duty personnel within the Department of the Navy (DON), to achieve a low p value leading to significance of the statistical test undertaken in this work. Due to the nature of surveying individuals within the operational fleet, the response rate was unfortunately much lower than the authors would have liked at 30 responses. After speaking closely with the contact for disseminating the survey, the authors believe the reasoning for this is due to the high tempo of these individuals' day-to-day lives, and an optional survey was just another task for them to complete. The authors also believe that the response rate was lower than originally expected due to the limited knowledge base of individuals with regard to DLR parts and not having enough exposure with these parts and their maintenance to be able to complete the survey.

A survey was chosen in addition to a thorough review of the policies provided in DOD and DON instructions to give a current unit-level survey as of July 2020 to make a better comparison between what policy is stating and what units are practicing. The surveys were distributed on a volunteer basis and disseminated by division officers onboard their respective ships.

Survey on PART NAME Depot Level Repair Part

Please answer the following questions to your best ability:

1. How much total time on average is required in removing the part and closing the system out? If not applicable, write none. (Example 1 hour and 20 minutes)
_____________Hours _____________Minutes

2. How much total time on average is required in tagging out? If not applicable, write none. (Example 1 hour and 20 minutes)
_____________Hours _____________Minutes

3. How much total time on average is required in drafting a remain in place (RIP) chit? If not applicable, write none. (Example 1 hour and 20 minutes)
_____________Hours _____________Minutes

4. ***Supply Only*** How much time on average is required in inputting the remain-in-place data into the supply system for a part? If not applicable, write none.
(Example 20 minutes)
_____________Minutes

5. How much experience on a scale from 1 to 10 do you have with this part? 1 being none to 10 being very experienced.
1 2 3 4 5 6 7 8 9 10

6. How much experience do you have with the depot level repair parts process? 1 being none to 10 being very experienced.
1 2 3 4 5 6 7 8 9 10

7. How much experience do you have with your current command's depot level repair parts process? 1 being none to 10 being very experienced.
1 2 3 4 5 6 7 8 9 10

8. How much experience do you have with your current command's remain in place form? 1 being none to 10 being very experienced.
1 2 3 4 5 6 7 8 9 10

9. Has your organization noted any concerns, benefits, or issues with the current remain in place policy? If yes, please describe them briefly below:

Figure 6. Ship Survey

With regard to the structure of the survey, no specific part was chosen to gain a better average time for all DLRs rather than a specific time based off a single part. As each part would require a different amount of time based on part type, location of the part, the command's local policies, number of maintainers available, and skill of those maintainers, the average time allows for a more accurate number to use as a base value that the authors can set as the mean value for a standard bell curve to draw understanding from and ultimately reach a conclusion with reasonable assurance. Although a specific part would have enabled a more accurate understanding of the removal time, it would only be accurate for the chosen part, and the authors would have had to make more assumptions to fill in the quantities for all other DLRs.

With regard to the second question of the survey, tag-outs were included, as they represent a significant step within the removal of DLR carcasses to be returned. The current system requires the tag-out procedure to occur a minimum of two times if a RIP status is not approved by the CO or the maintainer decides against completing a RIP chit.

The third question of the survey was included to help understand how the other questions of the survey factored into the amount of time it takes to write a RIP chit. The authors' hypothesis is that an individual who responded with high numbers to questions 5- 8 will respond that the amount of time to write a RIP chit is less than an individual who responded lower to questions 5-8.

Similarly, questions 5-8 were included as the authors expected to find an inverse relationship with time and experience level. The authors expected to find that a maintainer that has worked with a particular part more frequently would have a reduced time for tag-outs and removal compared to an individual with less experience. The expectation was similar for the experience levels of the DLR process and RIP current command process, but with less of an impact on time.

Finally, Question 9 was left open ended to gain insight into any issue's questions 1- 8 would not be able to address because of the limited answer choices. The question was designed to elicit responses from the subject matter experts on any benefits or issues they have observed with the current RIP process. The question was desired to provide further insight that the data and literature review did not show.

B. LIMITATIONS AND BIAS

One limitation of this survey is that only ships ported in San Diego were used. The policies between the various fleets were not radically different in process, with the main differences being in the reporting structure. The main limitation with this is that the ships themselves, the internal quality of personnel, and the command processes will vary with each ship. To counter this limitation, the authors attempted to distribute this survey to multiple ships to increase the likelihood of a well-made average. The fleet location is not a huge limitation, as within fleets, the ship commands vary depending upon the personnel within the organization.

Another limitation was that the survey was distributed by division officers to their sailors. If they did not frame the reasoning for the survey correctly or already held a bias toward the system, it could have affected the sailor filling out the survey. The mitigation for this was that the authors provided an email that listed the reasons for the survey and answered basic questions. Additionally, the survey was completed anonymously to relieve any pressure a sailor may have felt if it was conducted with a known participant.

Other areas that may have disrupted the survey results were those of cognitive biases from survey participants and researchers. Participants may have a confirmation bias based on seeing the system already in a certain light or wanting to rate themselves higher or lower due to their self-esteem. The authors attempted to counter this bias by having a larger number of survey participants to create a better standard bell curve. Escalation of commitment may have also been present in our research, as the survey was given out to multiple ships in different phases of a ship's life cycle, ranging from dry-dock to post advance phase, resulting in different possible pressures of time to complete the survey. To prevent this, each participant was given three weeks to respond to relieve any perceived pressure, in addition to the survey being voluntary. Finally, anchoring bias could have affected the data, mainly in the experience section of the survey, by the participant weighing their experience-selected number compared to the first experience question. This was countered again by the distribution of multiple surveys to give a standard bell curve of answers.

A halo effect may also have occurred in some surveys, as a person may draw a general or negative perception based on a single instance, creating a desire to skew the surveys to their perceived desired results of the project. One counter of the survey was to conduct the survey within various commands to offset a command that may have driven someone or a collection of individuals to have a negative halo effect, thereby creating impartial survey answers.

The distribution to multiple commands and the use of anonymous completion also limited the possibility of group cooperation on the survey, in which one individual might fill out the survey for multiple individuals, or in which multiple individuals might take the survey together and one person's answers are affected by another's.

C. HYPOTHESIS

This project investigated the removal of the RIP policy for advice coded 5G DLR parts to an automatic RIP policy. The null hypothesis would be that the current system has no statistical significance between the hours, manpower, or money saved for the proposed change and the current policy. The alternative hypothesis would show a statistical significance, showing the proposed implementation would have a significant enough impact to hours, manpower, or money saved to be reviewed for possible implementation.

The achievement of a null or alternative hypothesis does not indicate the necessity of the addition of policy changes such as a reduction in paperwork, standardization, or training. This project utilized the review of the policies and surveys holistically to identify these key areas and to determine whether they required any improvement or change. The survey provided possible indicators with Questions 5 through 8 specifically. Selections of numbers lower than 5 were assumed to be lower than meeting the Navy training standard, which was taken at a minimum of 5 or above.

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V. DATA ANALYSIS

This chapter further builds on the information included in Chapter IV: Data Collection Methods, by analyzing the data that was collected. It is broken down into the eight following sections: survey responses, survey questions, general survey results, data analysis summary, percentage of total time for questions 1-3, the impact of a RIP, experience levels, and times compared to experience.

A. SURVEY RESPONSES

As discussed in detail in Chapter IV: Data Collection Methods, the authors were able to secure only 30 survey responses from sailors onboard a destroyer and cruiser in San Diego. Although this is not ideal, the authors believe that the correlations found by analyzing the data will remain true; however, the accuracy of the analysis will be broader than desired.

The raw data from the survey responses was transcribed into an Excel document that can be found within the Appendix titled Table 2. By closely examining the spreadsheet, the reader can identify the specific DLR part the sailor is referencing, along the leftmost column, corresponding to the answers selected for Questions 1-8. The following portion provides a discussion of the responses to each question and how the authors analyzed the responses.

B. SURVEY QUESTIONS

Within this section, the authors dissect each survey question and reveal the responses received, as well as the statistical summary utilized to best represent the information received.

(1) Question #1: How much total time, on average, is required in removing the part and closing the system out?

The responses received from Question 1 rely heavily on the DLR part selected. The total time to remove the DLR part and close out the system ranged anywhere from 10 to 1,200 minutes. In order to analyze the responses for Question 1 most accurately, the authors felt it would be best to use the median time, 145 minutes, for removing and closing out the system. The reason for utilizing the median rather than the mean is the mean, 225.89

minutes, includes outliers within the data set. The "Aegis SWS Pump," for instance, requires 1,200 minutes to remove and close out, whereas the next most time consuming DLR part to remove and close out requires 600 minutes. To produce reliable correlations and use these correlations to produce well-supported recommendations, the authors believe it is best to use the median with respect to Question 1.

(2) Question #2: How much total time, on average, is required in tagging out?

Analyzing the responses received from Question 1, the authors quickly noted that one of the respondents inserted "N/A" into the section for the time required. The authors inferred that the "Electronic Switch" does not require a tag-out when conducting maintenance, and as a result listed it as requiring 0 minutes for a tag-out. The authors believe it would be most accurate to use the mean within the analysis for Question 2. The rationale for using the mean, rather than the mode or median, is the same rationale as Question 1, except in this instance the authors believe it is best to include the outlier of 0 in the analysis. It is an important outlier, as it drastically reduces the "average" time in extracting a DLR for refurbishment as a tag-out is not required for this specific DLR. As this report analyzes the trade-off between time spent on maintenance and the cost of these individuals' time, it is pertinent to the analysis to include this outlier.

(3) Questions #3: How much total time, on average, is required in drafting a remain-in-place (RIP) chit?

As the surveys were distributed to sailors with differing levels of knowledge and experience, the best measurement to use in analyzing the average time required to draft a RIP is the median as again with Question 1 DLRs such as the "Aegis SWS Pump," created outliers. Utilizing the median seems to show a better representation of all individuals completing a RIP, regardless of their experience level to show a good approximation of how long it would take to complete a typical RIP. Due to these factors, the authors will be using the median of 37.5 minutes moving forward with the analysis. Question #4: *Supply Only* How much time, on average, is required in inputting the remain in place data into the supply system for a part?

As denoted by this question, only those individuals in the supply system should answer this question. In total, the authors received eight responses to this question with the mean, median, and mode within one minute of each other. As a result, the average time for inputting the remain-in-place data into the supply system takes 30 minutes.

(4) Question #5: How much experience on a scale from 1 to 10 do you have with this part?

This question was included to get a clearer understanding of if the responses to questions 1-4 were due to the experience of the individual submitting the response. On average, the individuals believed that they had a 7/10 level of experience working with the DLR that they mentioned. From the responses received, with respect to Question 5, the mean, median, and mode were +/- .5 from one another, and as a result, 7/10 is an accurate measure of the average experience of maintainers with respect to the stated DLR parts.

(5) Question #6: How much experience do you have with the depot level repairable process? 1 being none, 10 being very experienced.

The answers to this question allowed for the determination of how much knowledge these individuals have regarding the general DLR process for the Navy. The reasoning for having both Question 6 and Question 7 was to determine the relationship between an individual's knowledge of the general DLR process and their ship specific DLR policies.

(6) Question #7: How much experience do you have with your current command's depot level repairable process? 1 being none, 10 being very experienced.

Like Question 6, the necessity of this question in the survey is to provide a distinction between an individual sailor's knowledge of Navy-wide DLR processes with their respective ship's DLR processes. As different departments and different COs have differing requirements for the DLR process, this question was included in the study to ensure comprehensiveness. Question #8: How much experience do you have with your current command's remain-in-place form? 1 being none, 10 being very experienced.

This question provided the ability to analyze whether one's experience effected the length of time in routing of a RIP and/or the experience level's effect on other areas of the DLR RIP process. The assumption is that sailors with more experience with the RIP process should need less time to complete and route the RIP.

(7) Question #9: Has your organization noted any concerns, benefits, or issues with the current remain-in-place policy?

This question was provided as an open-ended, voluntary question to allow for anything the respondents were unable to include in questions 1-8. This question was specifically asking for responses that have to do with the entire organization to avoid any responses that would be specific to only an individual part.

C. GENERAL SURVEY RESULTS

Table 1 lists the mean, median, mode, and standard deviation for questions 1-8.

Table 1. Q1-Q8 Mean, Median, Mode, and Standard Deviation of Aggregate Responses

	Question 1 (Minutes)	**Question 2 (Minutes)**	**Question 3 (Minutes)**	**Question 4 (Minutes)**	**Question 5 (Experience)**	**Question 6 (Experience)**	**Question 7 (Experience)**	**Question 8 (Experience)**
Mean	225.892	67.5	78.393	29.375	7.071	7.103	7	6.793
Median	145	60	37.5	30	7.5	7	8	8
Mode	30	60	30	30	7	10	8	9
Standard Deviation	244.387	36.943	88.432	6.455	2.257	2.479	2.463	2.771

D. DATA ANALYSIS ASSUMPTIONS

Due to the nature of surveying operational individuals, there were certain assumptions that were necessary to make. This section divulges the assumptions that were made prior to the analysis of the data received. Data for Questions 1,5,6,7, and 8 had all the data filled out for each survey, and time or experience level assumptions were not required.

- Question #2: How much total time, on average, is required in tagging out?

All responses of "N/A" regarding Question 2 were assumed as requiring 0 minutes, or not requiring a tag-out for maintenance. When producing the analyzed charts, or data results, the insertion of 0 was included. However, it is relevant to note that only 1 out of the 29 responses for Question 2 had the response of "N/A."

- Question #3: How much total time, on average, is required in drafting a remain in place (RIP) chit?

Any survey response that was left blank was populated with 30 minutes. This number of minutes was chosen as the previous mode was 30 minutes prior to the change of the data producing the analyzed charts and data results. The mode was chosen as the authors deemed this the most likely time to have occurred based on the data. This manipulation resulted in a change of the mean from 45 minutes to 37.5 minutes change. It is relevant to note that only 2 out of the 29 responses received left this question blank.

- Question #4: *Supply Only* How much time, on average, is required in inputting the remain in place data into the supply system for a part?

As noted in Question 4, this question was only to be completed by individuals in the supply department. As a result, 22/30 of the responses inserted "N/A" into this question as they are not within the supply department of their ship. The analysis directly related to this question took only the data points of the 8/30 responses to this question. This was done to ensure a more accurate representation of the RIP process times for Naval Surface Ships Supply Departments.

E. PERCENTAGE OF TOTAL TIME OF QUESTIONS 1-3

Figure 7 was created by aggregating the times for questions 1-3 from Table 1 and then dividing these values by the value corresponding to the cell. The purpose of Figure 7 is to determine how much the removal of the carcass (Question 1), tag-out (Question 2), and the writing of a RIP (Question 3) takes of the total time for the removal of a carcass. Question 4 was not included in Table 2 as the question relates only to supply department personnel.

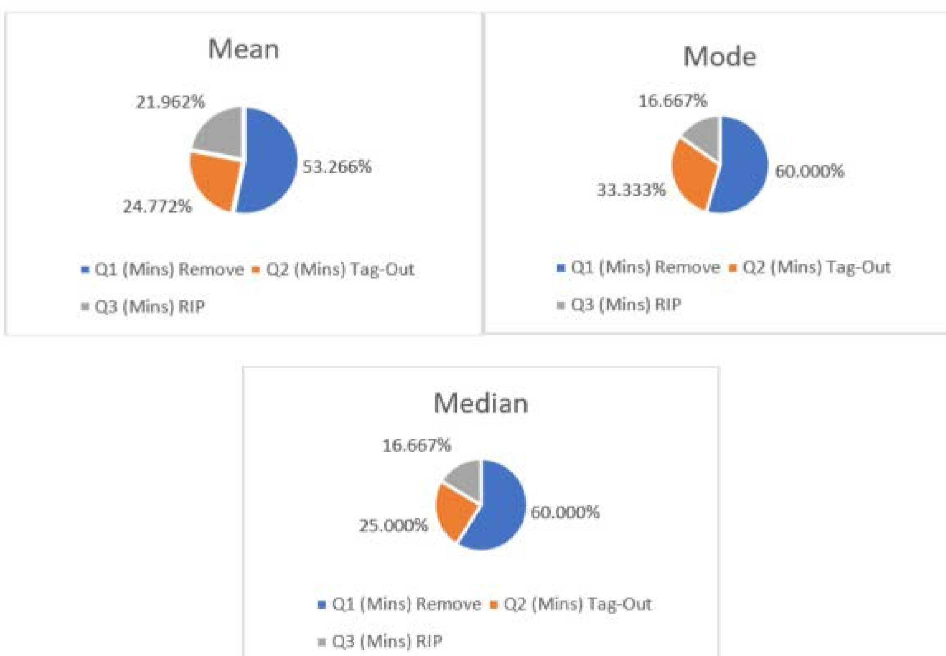

Figure 7. Percentage of Total Time for Questions 1-3

As shown in Figure 7, survey results indicate that the removal of the carcass requires the most time, the tag-out process the second most time, and the writing of a RIP the least amount of time. This information allows the project to more accurately determine how much weight each part of the process has when moving forward with analysis and recommendations. Although the carcass removal is the most time intensive activity of the three, it is also the most difficult to reduce as there are many variables that go into the removal of a carcass, such as the type of part and location.

F. IMPACT OF THE RIP

This section analyzes the time required to replace an advice code of 5G carcass under three different maintenance avenues for DLRs. First is the current system when a RIP is not completed, the second is the current system when a RIP is completed, and third is this project’s proposed system of an automatic RIP status being granted for advice code 5G DLRs.

The data analysis in this section used the mean values from Table 1, as the mean provides a strong representation of the overall data collected. As each process requires removing the part, the time of the NRFI carcass extraction is excluded in the calculations for simplification.

Under the current system, when a RIP is not completed, the maintainer is required to complete two full tag-outs, first to extract the carcass, and again after the replacement arrives to insert it within the system. In the current system, when a RIP is completed, the maintainer is required to complete the RIP process, tag-out the system once, and extract and replace the DLR after the replacement arrives. Finally, this project’s proposed system would require the maintainer to simply tag-out the system once, remove and replace the NRFI DLR simultaneously and without requiring the RIP process.

The estimated times based on each type’s mean are calculated in the Estimated Time Require for DLR Maintenance section.

1. Estimated Time Required for DLR Maintenance

Current System with No RIP
67.5 minutes tag-out × 2 tag-outs = **135.00 minutes**

Current System with RIP
67.5 minutes tag-out + 78.393 minutes RIP = **145.89 minutes**

Proposed System
67.5 minutes tag-out = **67.50 minutes**

An analysis of these three options for DLR maintenance reveals that the current system with RIP requires the most time to complete, at 145.89 minutes, closely followed by the current system with no RIP, at 135 minutes, and finally, this project's proposed system with 67.5 minutes. This analysis indicates that a change to a new system where DLRs with advice code 5G are automatically given RIP status would, on average, reduce time spent on maintenance. The difference between each system shows an additional story. The difference between the current system with a RIP and the proposed system finds 78.39 minutes saved. Likewise, the current system with no RIP contrasted with the current system with a RIP results in a savings of 10.89 minutes. This lower number is surprising, as the paperwork and process are simpler than the requirements of a tag-out. The longer process may act as a deterrent to unnecessary RIP statuses, but this does not seem to be purposely done when reviewing each policy.

2. Estimated Cost Differences

The differing times to complete maintenance calculated in Section 1 can be used to analyze cost for each maintenance method. For this project's purposes, several assumptions are made to estimate cost as the individuals conducting the maintenance vary greatly depending upon the difficulty, size, and personnel available. For these assumptions, the authors assume that a hypothetical DLR replacement requires two E-5's who have three years of service, and work on average 70 hours per week (Seck, 2017). According to the 2020 pay charts, the base pay for an E-5 with more than two years of service is $2,634 per month (United States Congress, 2020). The assumptions of the monthly base pay of $2,634 and a 70-hour work week, allowed the determination of their cost to the Navy on a per- minute basis (United States Congress, 2020).

Further, assuming there are 4.43 weeks in a month (Rapid Table, 2020) and multiplying this value by the 70-hour work week, supplies the number of hours worked in a month—310.10 hours. Then, converting 310.10 hours to minutes by multiplying this value by 60 minutes results in 18,606 minutes worked per month. To achieve the cost per minute of an E-5 with more than 2 years of service, 18,606 minutes worked per month was divided by the monthly base pay of $2,634 to obtain $0.14 per minute per E-5 with more than 2 years of active duty service.

Applying this to the time differences from the Estimated Time Required for DLR Maintenance section can further assume the cost difference per system by employing the assumptions as:

Current System No RIP/Current System RIP:

2 E-5s ($0.14) × 10.893 minutes = $3.05 Cost Difference per DLR

Current System No RIP/Proposed System:

2 E-5s ($0.14) × 67.5 minutes = $18.90 Cost Difference per DLR

Current System RIP/Proposed System:

2 E-5s ($0.14 per minute) × 78.393 minutes = $21.95 Cost Difference per DLR

The difference in cost shows two things: the proposed system saves on average more money per DLR then the other two intrinsically, and the RIP process costs the Navy an intrinsic average value of $3.05 every time a carcass is given a RIP status rather than following the current system. These cost comparisons are only made to be able to do dollar-for-dollar comparisons, as the DON does not actually pay these differences. The equation does not take into account the other benefits and costs of a RIP system, such as the ability to use a system even if degraded or the lag in retrieval times for the carcass to be refurbished.

By making another assumption that each ship within the Navy has an average of four DLRs to be replaced per day and multiplying this value by the current number of ships (290) comes to a total of:

Current System No RIP/Current System RIP:
$3.05 Cost Difference/DLR × 4 DLR/Day × 290 ships = $3,538 Cost Difference/Day

Current System No RIP/Proposed System:
$18.9 Cost Difference/DLR × 4 DLR/Day × 290 ships = $21,924 Cost Difference/Day

Current System with RIP/Proposed System:
$21.95 Cost Difference/DLR × 4 DLR/Day × 290 ships = $25,462 Cost Difference/ Day

The results in a yearly cost difference are $1,291,370, $8,002,260, and $9,293,630 respectively. The yearly cost difference can be used to determine whether the man-hours saved are a worthwhile investment. The current system with RIP and the proposed system difference of $9,293,630 can dictate that any change in the current policy for advice code 5Gs and RIP status with the additional information of the financial/readiness costs because of DLR delays to the unit should only be implemented if the projected cost is $9,293,630 or lower a year. Additionally, a review for a change in what advice code 5Gs are considered an advice code 5G should be conducted to try to further minimize the yearly cost difference of $1,291,370 between the current system with and without a RIP. The review should focus on changing the advice code of advice code 5Gs to other more suitable advice codes to reduce the amount of carcasses that result in the additional costs of an average $3.05 additional intrinsic cost per DLR and average of 10.89 minutes of additional manhours per DLR caused when the maintainer chooses to gain a RIP status for the carcass.

3. Inference of the Means

The next step in the analysis was to discover how far the survey sample data would go with a ninety-five percent significance level. The data from the surveys for Questions 2 and 3 were compared using Microsoft Excels t-Test: Paired Two Sample for Means after removing any parts with no data responses, as shown in Appendix Table 2. The hypothesized values were shown as:

H_o = Current System Does Not Result in More Time for RIP Carcass

H_a = Proposed System Results in Less Time for RIP Carcass

μ_1 = Current System Mean Time in Minutes

μ_2 = Proposed System Mean Time in Minutes H_o: $\mu_1 - \mu_2 \leq D_o$

$$H_o: \mu_1 - \mu_2 \leq D_o$$

$$H_a: \mu_1 - \mu_2 > D_o$$

in the case where:

$$D_o = 0$$

$$H_o: \mu_1 - \mu_2 \leq 0$$

$$H_a: \mu_1 - \mu_2 > 0$$

The following criteria was used for the interpretation of the p-values:

Less than 0.01 there is overwhelming evidence to conclude H_a is true
Between 0.01 and 0.05 there is strong evidence to conclude H_a is true
Between 0.05 and 0.10 there is weak evidence to conclude H_a is true
Greater than 0.10 there is insufficient evidence to conclude H_a is true

First, the hypothesized mean difference was set to zero within the t-Test: Paired Two Sample for Means with variable one set as the current system and variable two the proposed system. Variable one was considered to be the aggregate time of two tag-outs and the RIP for the individual part. The sum of each part was put into a separate column labeled. This column was used as the input values within excel for variable one. Variable two was the sum of time to conduct one tag-out for the individual part. The tag-out time column was the variables entered into excel.

The results of the hypothesized mean difference of zero for the t-Test using a reject H_o at $\alpha = .05$ level of significance was a one-tailed p-value of 0.000000358. Such a small p-value showed that based on the survey data and the criteria, there is overwhelming evidence to conclude H_a is true and that H_o is rejected. The meaning of this conclusion is that the proposed system is shorter on average than the current system. The shorter time means more time freed for the maintainer.

As the H_o was rejected, next was to determine how many minutes could be saved on average and guarantee with reasonable assurance based on the data and rejecting H_o at $\alpha = .05$ level of significance. The same data as variables as used for the hypothesized mean difference of zero was used, but random numbers starting with the rounded whole difference between $\mu_1 - \mu_2$ was used (150 minutes). The hypothesized mean difference was reduced until obtaining a one-tailed p-value just below .05, which was 110 minutes. The one-tailed p-value of 0.04627343 for 110 minutes. The meaning of this is that with a reasonable guarantee and a reject H_o at $\alpha = .05$ level of significance the new system should on average save up to 110 minutes off the current systems total time for a RIP carcass.

The same test was also run for a hypothesized mean difference of 25, 50, and 75 minutes. The results of the test can be found in the Appendix Figures 27-31 in addition to the

0 and 110 hypothesized mean differences. The one-sided p-value results in the same order were 0.00000561069, 0.000094699, and 0.001527964.

G. EXPERIENCE LEVELS

Survey Questions 5-8, which asked the sailors to rank themselves on a scale of 1- 10, with 10 being the highest, were included to analyze the relationships between their responses to see if anything could be identified outside the change of policy suggested to streamline the process. The data points were put into a scatter plot with two questions per chart using Microsoft Excel. The data was then analyzed using a linear trend line and R^2 to show how much each experience drove the others variance. Each graph was then compared to these statistical methods. Figure 8 shows the survey results for each part given for Questions 5-8 as a visual comparison of all experience type and part responses. It showed that for the most part experience levels in one area were similar to others, meaning someone with low experience tended to have low experience in the other three areas of experience.

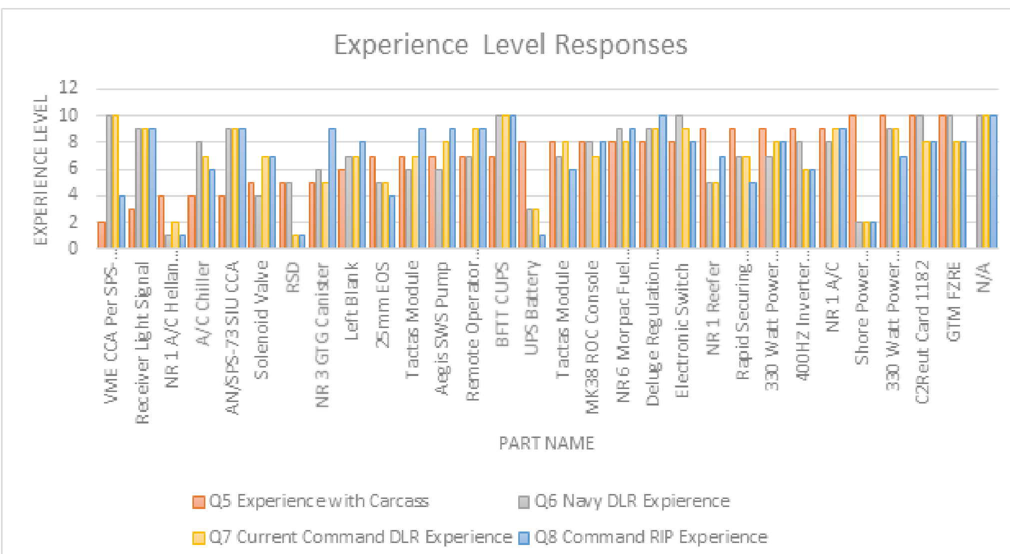

Figure 8. Experience Levels

This analysis generated one strong positive relationship, two moderate positive relationships, and three negligible positive relationships. The best way to conceptualize the strength of the relationship between these variables is by the linear trend line slope. The flatter the slope, the weaker the relationship between the two variables. Aa slope of 1, would indicate a wholly positive relationship. The R^2 based off the linear trend line explains to what extent the variance of one variable explains the variance of the second variable (Hayes, 2020). The stronger the R^2 in this case the more one experience type's levels variance explains the other experience type's levels of variance. Within our analysis, there were no negative relationships. The slope of the line of best fit and R^2 is shown in Figures 9 through 14. The R^2 value criteria was determined to be:

Strong: $0.7 < R^2 \leq 1.0$

Moderate: $0.4 < R^2 \leq 0.7$

Weak: $0.2 < R^2 \leq 0.4$

Negligible: $0.0 > R^2 \leq 0.2$

The strongest R^2 from the analysis exists in responses to Question 6 and Question 7 shown in Figure 9. These responses are about the current command DLR experience and the Navy-wide DLR experience. The R^2 of 0.7149 deduces that a person experienced with their current command's DLR process is likely to be at a similar knowledge level of the Navy-wide DLR process and the variance is explained by approximately 70% by the other experience level type. This strong positive R^2 may also indicate that local command instructions and policies seem to be well aligned with the more extensive Navy policies making it easier for a sailor to know how the local unit operates.

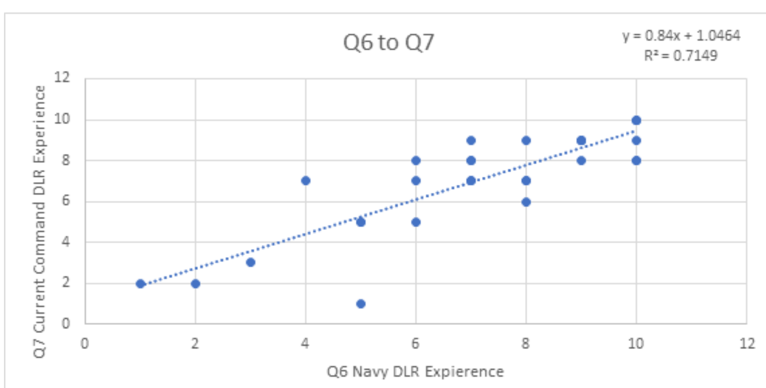

Figure 9. Experience Q6 versus Q7

Questions 7 and 8, compare current command DLR experience with the current command RIP experience. This had a moderate positive relationship between the two variables, shown in Figure 10. The reason these responses had a moderate correlation is likely due to the writing of a RIP occurs less frequently than DLRs are repaired by a department, and the person conducting the RIP process is typically the division officer and not the enlisted member. Also, there may be a lack of training or a fading of knowledge over time because there are fewer encounters with the RIP process compared to the DLR process.

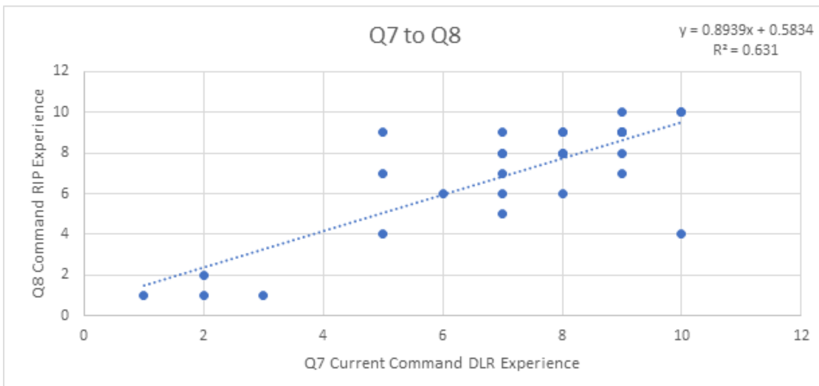

Figure 10. Experience Q7 versus Q8

Questions 6 and 8, generated another moderate relationship as shown in Figure 11. Figure 11 compares Navy DLR experience to the current command RIP experience. When compared to the R^2 of Figure 10, the weaker correlation is most likely due to the policies being less similar to one another. The typical sailor conducting the process possibly added to the weakening.

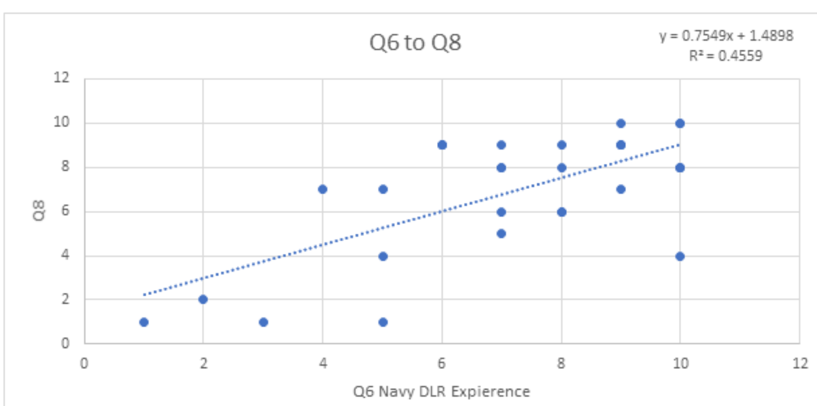

Figure 11. Experience Q6 versus Q8

The R^2 values that were generated between Question 5, experience with the carcass, and the other experience questions showed weak to negligible relationships shown in Figures 12- 14. The relatively weak R^2 values revealed that the amount of experience an individual has with a piece of equipment does not explain any other experience levels in general. The reasoning for this might be that a maintainer is not the individual responsible for conducting the supply portion of the DLR process.

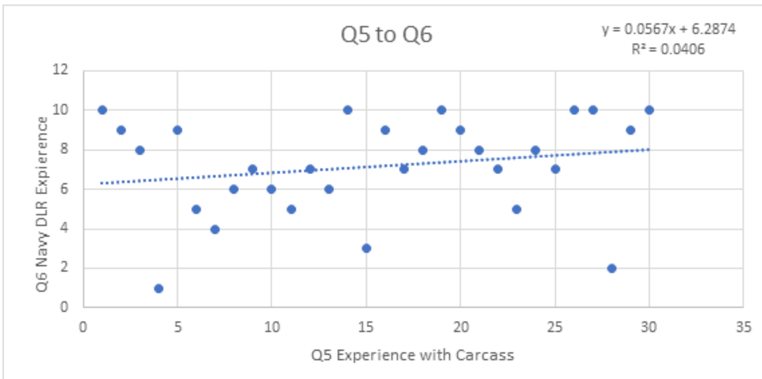

Figure 12. Experience Q5 versus Q6

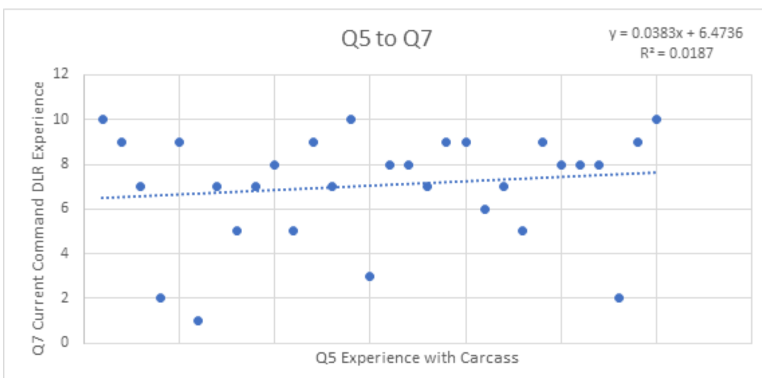

Figure 13. Experience Q5 versus Q7

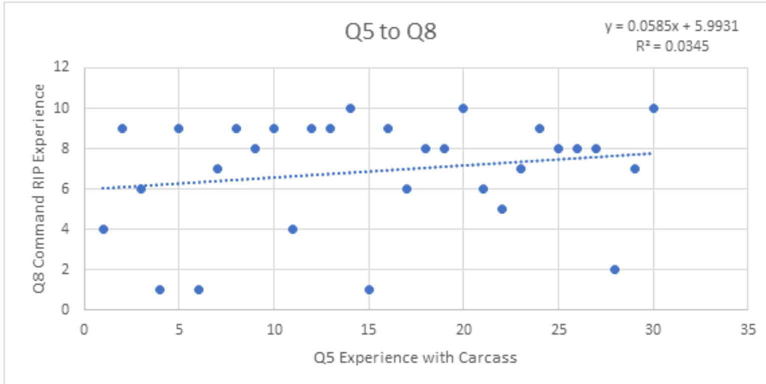

Figure 14. Experience Q5 versus Q8

H. TIMES COMPARED TO EXPERIENCE

Similar to Section G, this section analyzes the possibility if anything outside the proposed policy change could streamline the process to reduce time. Any responses within the data that were not complete were removed from this section of data analysis. The criteria for strength of the relationship remains the same as in Section G.

Strong: $0.7 < R^2 \leq 1.0$

Moderate: $0.4 < R^2 \leq 0.7$

Weak: $0.2 < R^2 \leq 0.4$

Negligible: $0.0 > R^2 \leq 0.2$

When comparing the time to remove the carcass, tag-out the system, or the RIP with the individual's experience, there was almost no relationship as shown in Figures 15- 26 within the Appendix. The R^2 ranged from 0.00002 to 0.1502, with 8 positive and 4 negative relationships. This was a surprising revelation, as it was originally assumed that a strong relationship exists between tag-out time and an individual's experience with the carcass. The expectation was that individuals who had more experience with a part would require less time in tagging out the system as their past experience would speed up the process. As found in this project, this was not the case.

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VI. RECOMMENDATIONS

Within this chapter several proposals are given based upon the research conducted. This chapter is divided into policy recommendations, shipboard recommendations, and further study recommendations.

A. POLICY RECOMMENDATIONS

The first policy recommendation is for the DON to identify a maximum dollar amount for DLRs to be considered an automatic RIP. Cost level is based on a comparison to the manpower costs, and time costs per average advice code 5G DLR. The assumption of opportunity costs between the freeing up of maintenance personnel in time and the additional time to receive a replacement part should be included. The policy should expressly state a continuation of the expedient delivery of the DLR upon receipt. This policy would additionally reduce the manpower issues faced in the fleet today by increasing the hours available for other tasks, as shown in Chapter V: Section F: Impact of the RIP, that showed a mean of 78.39 minutes of work freed for other tasks when compared to the current system with a RIP and tag-out required.

The second policy recommendation would be for the Navy to institute a standard RIP to turn into the supply department. The current process requires each command to generate their own documentation for maintainers to allow DLR carcasses to RIP. Creating a standard RIP would enable sailors to transfer to a new command and already be familiar with the paperwork rather than having to relearn it at each new command. In addition, an electronic format for the standard RIP would be ideal for reducing transfer errors and time required to complete the request compared to the current system of routing the paperwork physically.

B. SHIPBOARD RECOMMENDATIONS

As for shipboard recommendations, the Navy needs to emphasize the purpose of DLRs to operational individuals. The purpose of the DLR system should go beyond the Navy's cost savings and focus on how it affects ships' combat readiness. Emphasis should be put on the fact that when implemented efficiently, the DLR process should not diminish the rate of receiving replacement parts onboard. When presented to maintainers that the promptness of their turn-in will directly relate to the timeliness of their receiving of a replacement, this should increase the efficiency of the DLR process. This clarification ties the DLR process to the individual maintainer and makes its effects feel personal and less about the dollar amount they will never see.

The second recommendation relating to the fleet is the training of division officers on the DLR process's importance and purpose at an earlier stage. While distributing the surveys, many of the division officers contacted were hesitant to distribute the surveys to sailors on their ship as they had limited understanding of DLRs. The project's research created a better understanding and appreciation for the DLR process's effectiveness and necessity. However, a project should not have to be completed to understand the process. Instead, as the DLR process is vital to a ships' combat effectiveness, it should be taught more heavily at Basic Division Officer's Course. Currently, DLRs are brought up to division officers at BDOC, but often glossed over as a topic taught in the fleet.

C. FURTHER STUDY RECOMMENDATIONS

Further research on this subject should be conducted with a larger sample size to ensure fewer sample size errors. If future students were to build on this research additional survey questions regarding specific DLR and RIP policies should be added to test the respondent's knowledge level compared to what they record as their experience level. This alteration could unveil more particular causes of DLR and RIP issues for surface Naval commands.

A second recommendation for further studies would be an analysis of a cost breakdown of DLRs. This analysis would determine if the system of RIP could be broken down into categories of high, medium, and low-cost items. The distinction between high, medium, and low-cost DLR items could help the Navy supply system better contract and determine what should qualify as a DLR. This comparison could determine if the adjustment to an automatic RIP for advice code 5Gs outweighs the costs specified in this project and at what price level the switch should occur.

Lastly, it would be beneficial to have another thesis investigate the trade-offs that occur by allowing DLRs to RIP and the cost of the delay to the depot for refurbishment. As discussed in detail throughout this thesis, the DLR process relies heavily on individuals in the fleet returning DLRs through the supply system promptly. An analysis of this trade- off was beyond the scope of the project and thus not researched.

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VII. CONCLUSION

The Navy's current materiel return process dictates that a broken DLR part of advice code 5G must be removed and turned into the local supply system before a replacement can be ordered unless a RIP status is submitted. The maintenance unit is then permitted to leave the carcass within the system until the replacement part arrives. This current operating procedure forces maintainers to choose between completing lengthy paperwork required to obtain a RIP and a redundant maintenance operating procedure. This project investigated an alteration of this current procedure to grant advice code 5G DLRs automatic RIP status.

To gain evidence about whether this alteration to the RIP policy would be beneficial, the authors distributed surveys to a destroyer and cruiser stationed in San Diego, CA. The results of these surveys helped answer some questions and raised new questions about the system. The literature review findings revealed a complex problem of readiness, costs, and manpower is resolved by comprehensive policies that balance all three factors into a mostly straightforward process at the unit level. The only issue is the need for a standard paperwork format for maintainers to deliver to supply.

The data generated by the survey identified that experience levels used in the study had a negligible impact on the amount of time it takes to remove a carcass, conduct a tag-out, or perform the RIP process. Additionally, the experience level impact of one area or another area of experience examined, on the other hand, showed more correlation and possible causation. This result indicates that training in one area of skill studied should drive better experience within another area of expertise of those studied due to the close relationship of tasks. Additionally, experience levels in each area generally predicted the experience level in other areas. The experience levels furthermore showed training was creating the desired experience level for unit level personnel of about 7 for all experience levels surveyed.

Finally, data indicates that an automatic RIP process for advice code 5G saves an average of 78 minutes of work compared to the current system when a tag-out and RIP are required. This benefit, if imposed, would also reduce the workload on supply, saving additional time. This project's main recommendation for the DON is to use this report as starting point for future research into identifying whether this benefit, especially in the time of more restrictive manning, outweigh the dollar and readiness costs to the DON.

Questions 1-3, which follow, were outlined in the introduction of this project. Now, having completed the project, the authors present their findings.

(1) What are the effects of the implementation of an automatic RIP for advice codes of 5G within the surface fleet?

As presented in Chapter V: Data Analysis, the cost difference per DLR for implementing an automatic RIP status for advice code 5G parts is $21.95. This value is derived from the reduction in maintenance of 78 minutes with the automatic RIP status. However, the implementation of an automatic RIP status for advice code 5G DLRs will reduce the efficiency of the materiel returns process as the depot is receiving NRFI DLRs for refurbishment at a reduced rate.

(2) What is the threshold/identifier for DLRs to be switched over to another advice code if not all 5Gs should be automatic RIP?

Due to the climate surrounding COVID-19, this project was unable to complete this additional analysis. Prior to the Department of the Navy making any changes regarding the findings of this project, the authors believe it would be best to first have another thesis focused solely on this subject. This would allow a comparison between the cost savings from reduced maintenance found in this project, and the additional cost imposed due to the delayed return of DLRs.

(3) What areas of policies/instructions need change?

As discussed in Chapter VI: Recommendations; subsection A, there are two policy changes that would benefit the Department of the Navy that were discovered within this research. First being the DON identifying a maximum dollar amount for DLRs to be considered an automatic RIP. This would allow for a clear distinction between what is the higher cost: maintenance, or the delayed return of DLRs for refurbishment. The second policy recommendation is to have standard RIP paperwork across the fleet. It is inefficient to have command specific RIP paperwork as it forces sailors who transition between ships, to relearn the RIP process. Similarly, this RIP paperwork should be completed electronically to reduce errors in transcribing the information.

VIII. APPENDIX

Table 2. Raw Survey Data

Part Name	Q1 (Mins) Remove	Q2 (Mins) Tag-Out	Q3 (Mins) RIP	Q4 (Mins) Supply RIP	Q5 Exp (Part)	Q6 (DLR Exp)	Q7 (CMD DLR)	Q8 (CMD RIP)
N/A	N/A	N/A	N/A	60	N/A	10	10	10
Aegis SWS Pump	1200	80	360	N/A	7	6	8	9
A/C Chiller	600	45	75	15	4	8	7	6
UPS Battery	440	60	30	N/A	8	3	3	1
400HZ Inverter Module	420	60	60	N/A	9	8	6	6
Rapid Securing Device Past System	390	75	60	N/A	9	7	7	5
GTM FZRE	390	120	120	30	10	10	8	8
RSD	360	60	45	N/A	5	5	1	1
NR 6 Morpac Fuel Valve	300	75	30	30	8	9	8	9
25mm EOS	270	90	30	N/A	7	5	5	4
Solenoid Valve	240	120	120	N/A	5	4	7	7
NR 1 Reefer	240	60	60	N/A	9	5	5	7
NR 3 GTG Canister	180	90	30	20	5	6	5	9
Remote Operator Console	180	90	30	N/A	7	7	9	9
NR 1 A/C	150	75	45	20	9	8	9	9
Tactas Module	140	80	10	N/A	8	7	8	6
MK38 ROC Console	135	60	30	N/A	8	8	7	8
C2Reut Card 1182	120	60	120	30	10	10	8	8
Receiver Light Signal	90	60	240	N/A	3	9	9	9
Tactas Module	90	120	180	N/A	7	6	7	9
NR 1 A/C Hellan Strainer	60	30	60	N/A	4	1	2	1
Left Blank	60	180	300	N/A	6	7	7	8
BFTT CUPS	60	30	30	N/A	7	10	10	10
Shore Power Breakers	45	30	30	30	10	2	2	2
Electronic Switch	45	0	30	N/A	8	10	9	8
VME CCA Per SPS-73(V)12 Radar	30	60	15	N/A	2	10	10	4
AN/SPS-73 SIU CCA	30	30	30	N/A	4	9	9	9
330 Watt Power Supply	30	20	10	N/A	10	9	9	7
330 Watt Power Supply	30	30	15	N/A	9	7	8	8
Deluge Regulation Card	10	45	10	N/A	8	9	9	10
Mean	225.8928571	67.5	78.39285714	29.375	7.071428571	7.103448276	7	6.793103448
Median	145	60	37.5	30	7.5	7	8	8
Mode	30	60	30	30	7	10	8	9

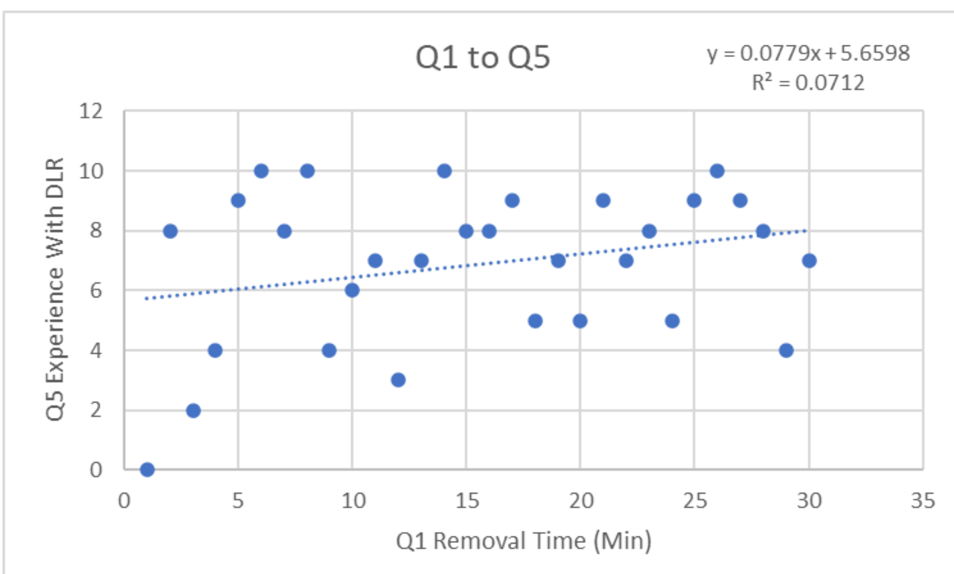

Figure 15. Relationship between Questions 1 and 5

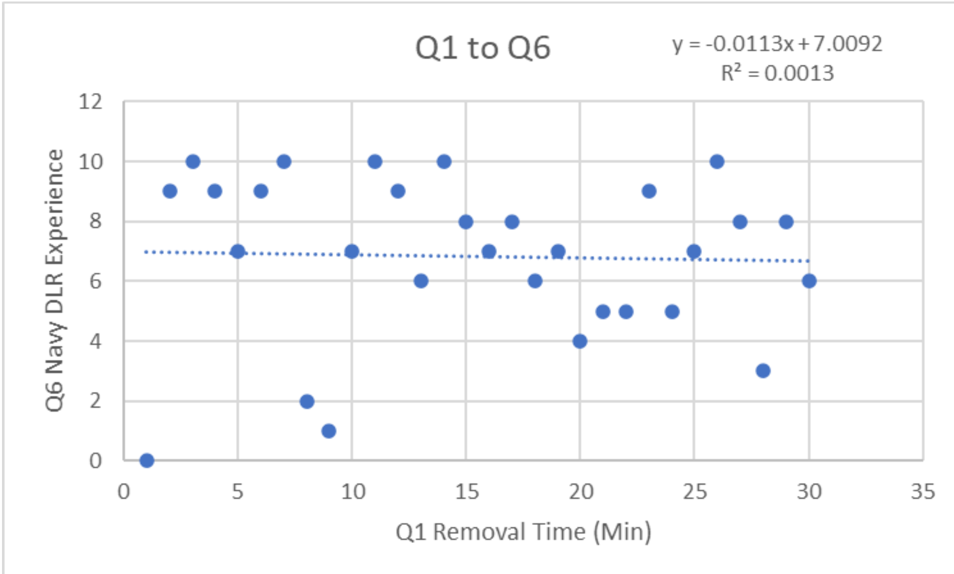

Figure 16. Relationship between Questions 1 and 6

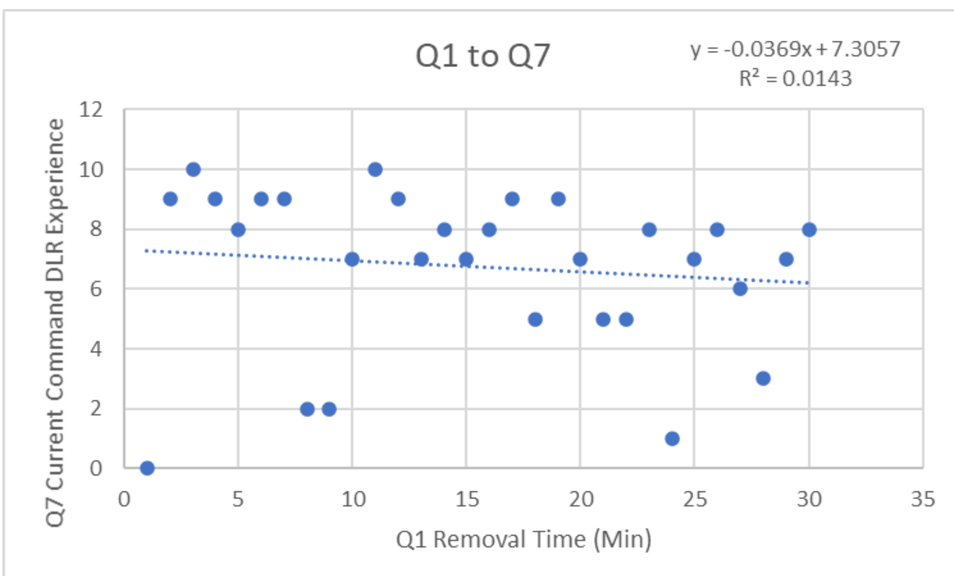

Figure 17. Relationship between Questions 1 and 7

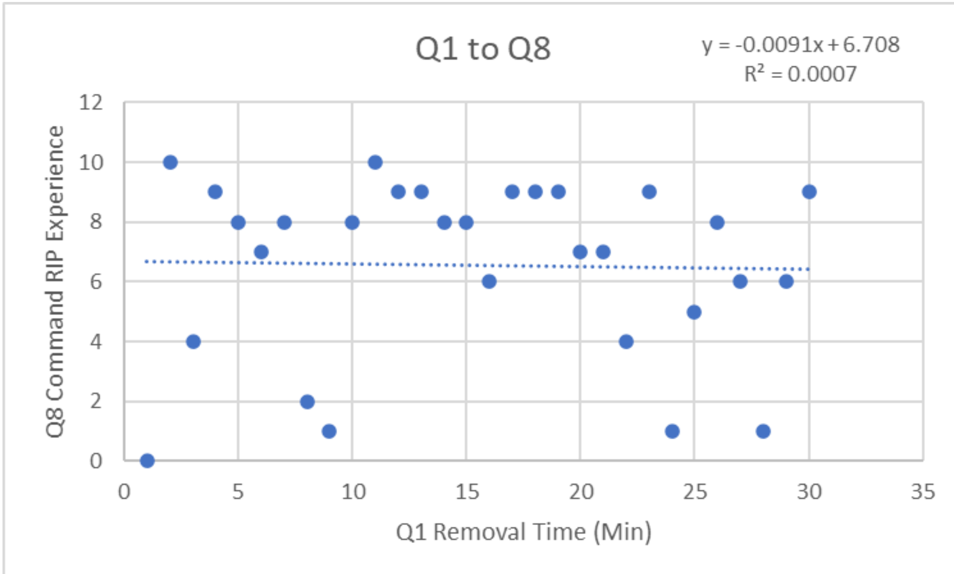

Figure 18. Relationship between Questions 1 and 8

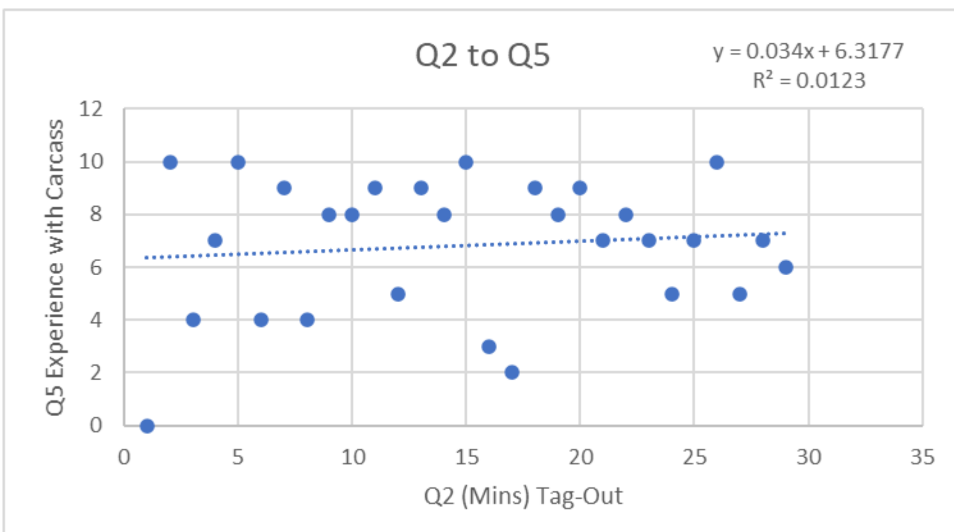

Figure 19. Relationship between Questions 2 and 5

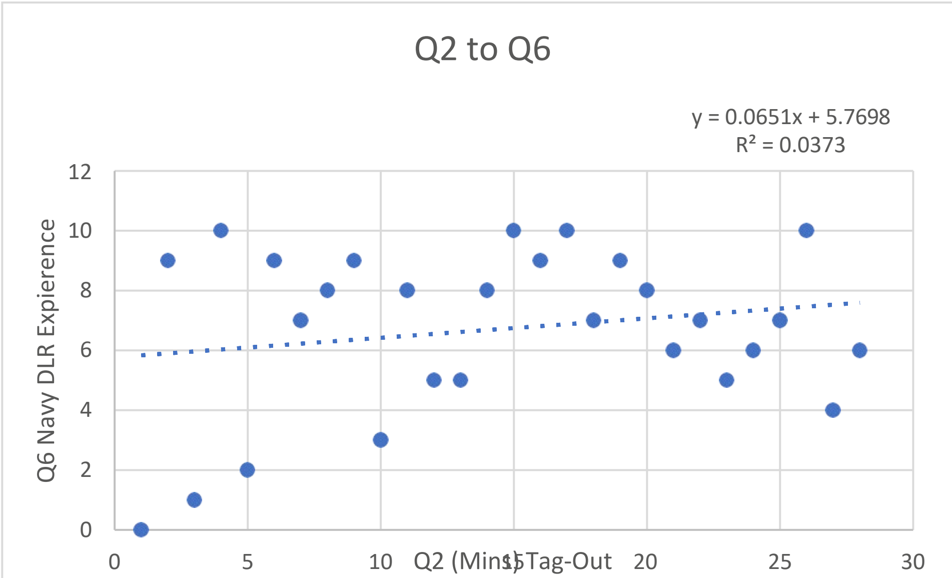

Figure 20. Relationship between Questions 2 and 5

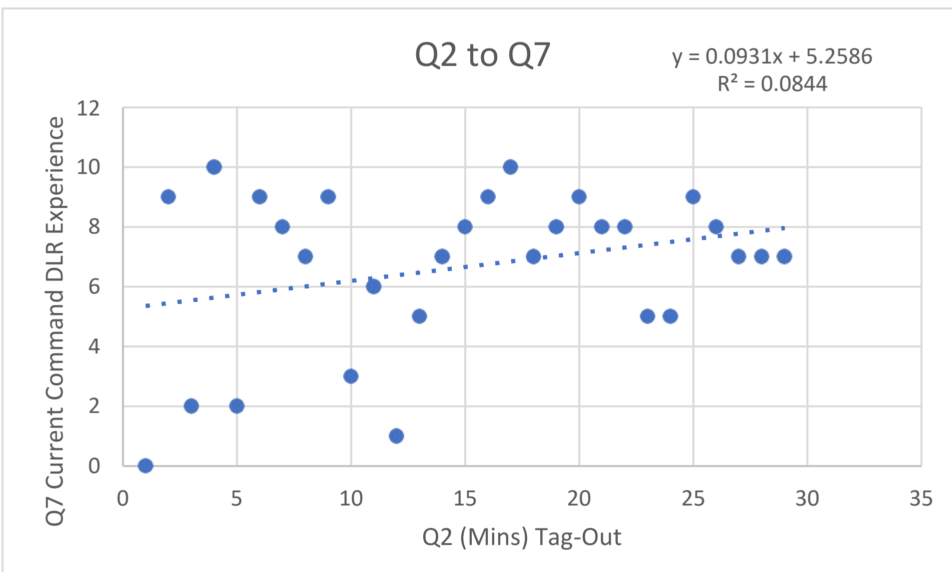

Figure 21. Relationship between Questions 2 and 7

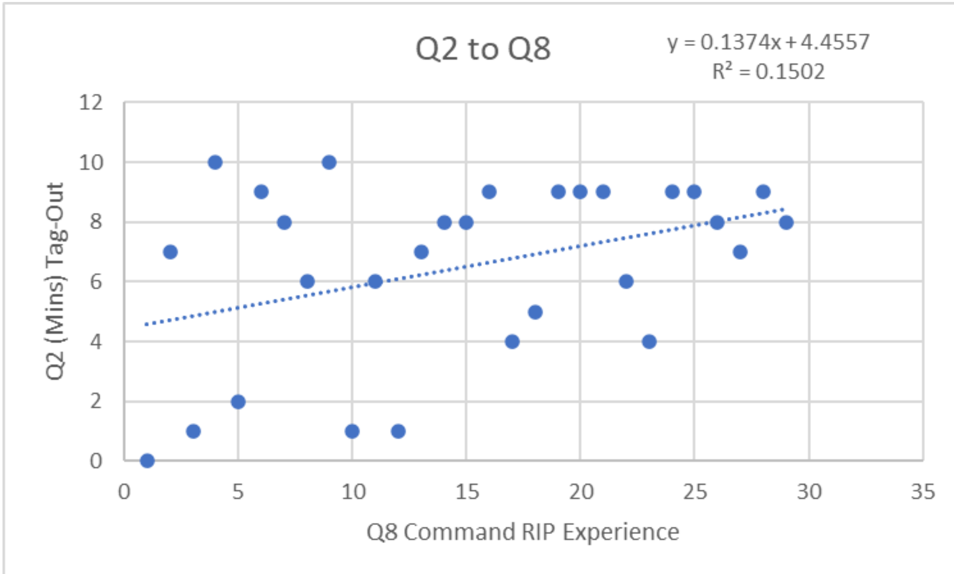

Figure 22. Relationship between Questions 2 and 8

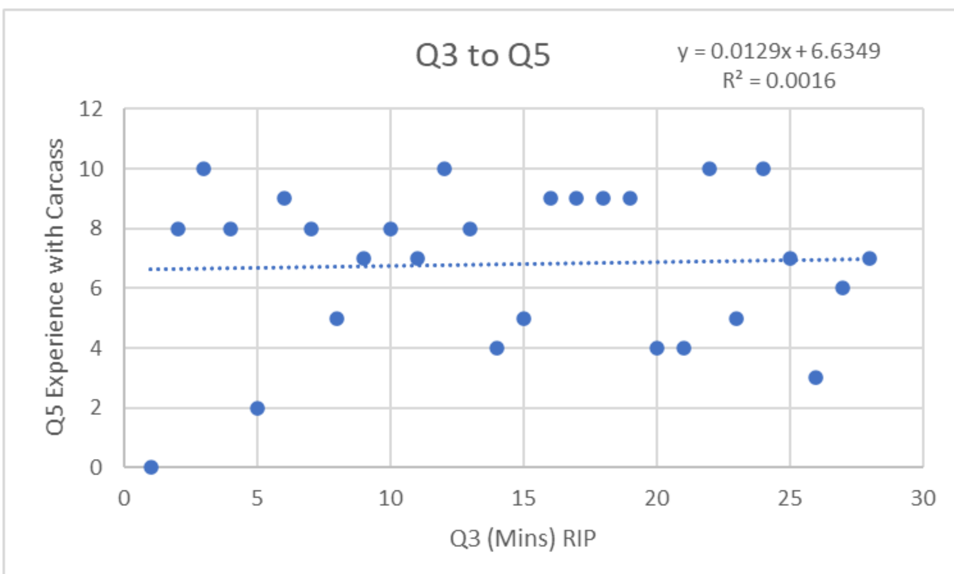

Figure 23. Relationship between Questions 3 and 5

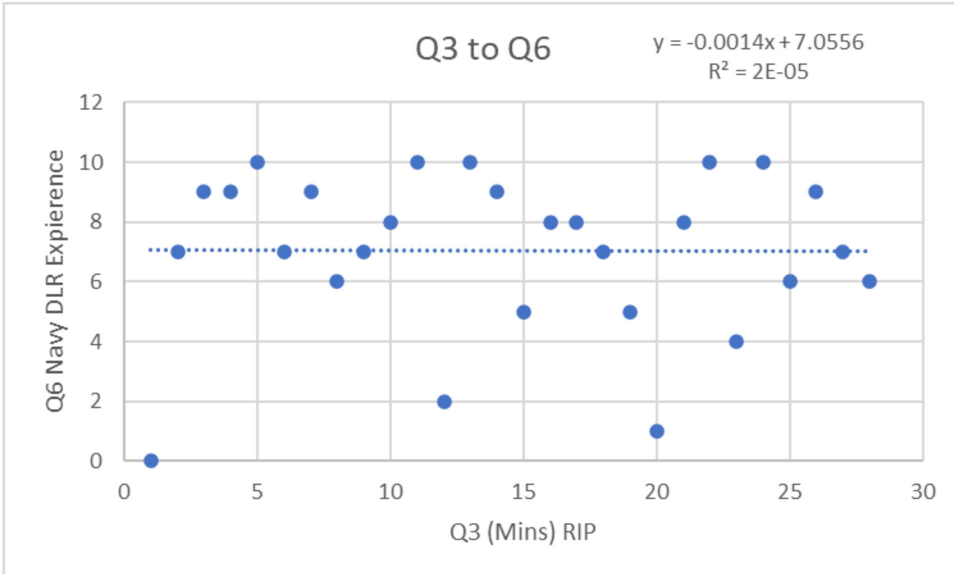

Figure 24. Relationship between Questions 3 and 6

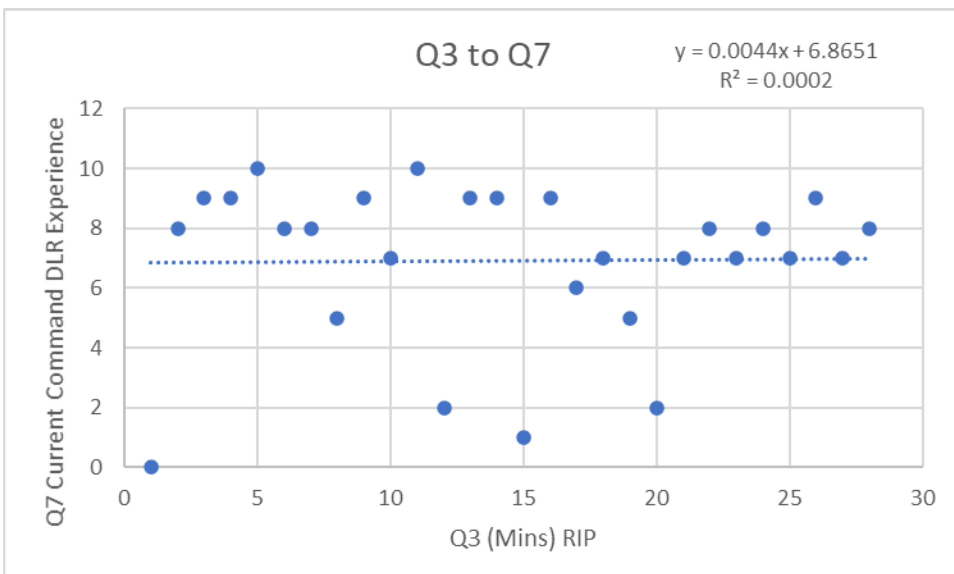

Figure 25. Relationship between Questions 3 and 7

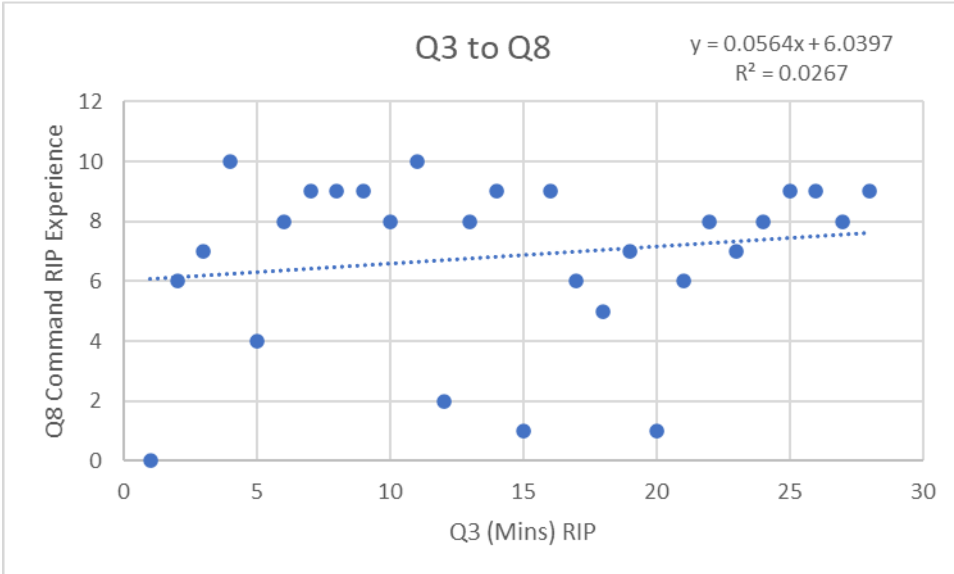

Figure 26. Relationship between Questions 3 and 8

t-Test: Paired Two Sample for Means

	Current System	*Proposed System*
Mean	218.6538462	68.65384615
Variance	21367.11538	1323.115385
Observations	26	26
Pearson Correlation	0.855004985	
Hypothesized Mean Difference	0	
df	25	
t Stat	6.559042042	
P(T<=t) one-tail	3.58E-07	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	7.16797E-07	
t Critical two-tail	2.059538553	

Figure 27. Hypothesized Mean Difference Results #0

t-Test: Paired Two Sample for Means

	Current System	*Proposed System*
Mean	218.6538462	68.65384615
Variance	21367.11538	1323.115385
Observations	26	26
Pearson Correlation	0.855004985	
Hypothesized Mean Difference	25	
df	25	
t Stat	5.465868368	
P(T<=t) one-tail	5.61069E-06	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	1.12214E-05	
t Critical two-tail	2.059538553	

Figure 28. Hypothesized Mean Difference Results #25

t-Test: Paired Two Sample for Means

	Current System	*Proposed System*
Mean	218.6538462	68.65384615
Variance	21367.11538	1323.115385
Observations	26	26
Pearson Correlation	0.855004985	
Hypothesized Mean Difference	50	
df	25	
t Stat	4.372694694	
P(T<=t) one-tail	9.4699E-05	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	0.000189398	
t Critical two-tail	2.059538553	

Figure 29. Hypothesized Mean Difference Results #50

t-Test: Paired Two Sample for Means

	Current System	*Proposed System*
Mean	218.6538462	68.65384615
Variance	21367.11538	1323.115385
Observations	26	26
Pearson Correlation	0.855004985	
Hypothesized Mean Difference	75	
df	25	
t Stat	3.279521021	
P(T<=t) one-tail	0.001527964	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	0.003055929	
t Critical two-tail	2.059538553	

Figure 30. Hypothesized Mean Difference Results #75

t-Test: Paired Two Sample for Means

	Current System	*Proposed System*
Mean	218.6538462	68.65384615
Variance	21367.11538	1323.115385
Observations	26	26
Pearson Correlation	0.855004985	
Hypothesized Mean Difference	110	
df	25	
t Stat	1.749077878	
P(T<=t) one-tail	0.04627343	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	0.092546861	
t Critical two-tail	2.059538553	

Figure 31. Hypothesized Mean Difference Results #110

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