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STRATEGIC VESSEL SYSTEM MANAGEMENT FOR THE PUBLIC SAFETY VESSEL ENTERPRISE

by

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December 2019

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STRATEGIC VESSEL SYSTEM MANAGEMENT FOR THE PUBLIC SAFETY VESSEL ENTERPRISE

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ABSTRACT

This thesis reviews current practices for vessel acquisition in the public safety and homeland security fields, and evaluates agencies' strategic management of vessels as a means for improving planning and efficiency. The research explores parallel systems—including vehicle fleet maintenance and other vessel system planning—to establish best-practice anchors, against which it analyzes case studies from the Fire Department of New York, the Port of San Diego Harbor Police, and the U.S. Navy to evaluate how off-the-shelf or design-build strategies affect strategic management. The thesis then reviews additional requests for information to evaluate the current state of the public safety/homeland security vessel enterprise. The thesis concludes by presenting strategic best-practice anchors for moving forward in the maritime area of public safety assets. Establishing these best-practice anchors is the first step toward their wider use in the homeland security vessel enterprise.

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LIST OF ACRONYMS AND ABBREVIATIONS

CBRNE	Chemical, Biological, Radiological, Nuclear, Explosive
FDNY	Fire Department of New York
FEMA	Federal Emergency Management Agency
FFG	Fast Frigate
FLIR	Forward-Looking Infrared
GAO	Government Accountability Office
GSA	General Services Administration
LCS	Littoral Combat Ship
LSD	Dock Landing Ship
NOAA	National Oceanic and Atmospheric Association
PSGP	Port Security Grant Program
RFI	Request for Information

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EXECUTIVE SUMMARY

As a result of the post-9/11 focus on homeland security, ensuring the security of our waterways has become far more important. This means that public safety agencies need access to maritime vessels to conduct homeland security tasks. In the past, agencies adapted recreational or fishing vessels to conduct these tasks.[1] Now, the public safety vessel industry is coming to market with many purpose- or mission-based designs for vessels that will help agencies fulfill a variety of homeland security missions. At the same time, the public safety industry has transitioned to an all-hazards approach based upon Port Security Grant requirements, which has influenced the design of these vessels.[2]

Based on the current state of the industry, challenges lie ahead for the public safety vessel enterprise, particular for agencies that wish to maintain or procure a vessel fleet. Currently, there is little to no literature documenting best practices for public safety vessel systems; moreover, agencies are still buying boats that are ill-suited for the roles they are meant to play. Many agencies strive for quick, off-the-shelf solutions created to comply with government grant performance periods, but do not thoroughly adapt these designs or consider a design-build approach that can help them create a vessel that best suits their needs. The result is an inefficient product that must be further adapted or is underutilized. Additionally, agencies continue to view vessels, when it comes to acquisition, as a linear asset, failing to properly project operational periods, retirement dates, and replacement schedules. This linear view places them into a reactive posture to address vessel failures with little forward planning. Additionally, agencies continue to rely heavily, if not solely, on government grants to finance public safety vessel assets, creating a risk of dependence on these grants.

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[1] Lisa J. Huriash, "Fort Lauderdale Upgrades its Water Response with Fireboat 49," *South Florida Sun Sentinel*, December 3, 2017, http://www.sun-sentinel.com/local/broward/fort-lauderdale/fl-sb-lauderdale-fire-rescue-boat-20171130-story.html; "Vancouver's Quick Response Boat," City of Vancouver, Washington, accessed October 12, 2018, https://www.cityofvancouver.us/fire/page/vancouvers-quick-response-boat.

[2] Scott Regen, "A Rundown of Key Federal Grants Programs," *EHS Today*, March 16, 2004, https://www.ehstoday.com/fire_emergencyresponse/ehs_imp_12415.

Public safety vessels are unique because the nature of their job, and their funding mechanism, require an all-hazards design. Some vessels may have very specific missions, such as fire vessels, while others may need to be multi-mission-capable—for example, officers at the Port of San Diego Harbor Police are both police officers and marine firefighters, and so their vessels must be multipurpose.[3] With such purpose-driven design needs, the old practice of adapting other platforms—such as fishing or recreational boats—may not fulfill public safety missions. Public safety fire vessels will be held to government (both state and federal) standards for fire vessel requirements, as well as standards from the National Fire Protection Association. Police vessels may be held to other standards, such as environmental regulations for government vessels, as well as operational needs for depth, range, or speed.

There is little literature that guides the management, building, and procurement of public safety vessels; to fill this gap, this thesis reviews general principles from the fields of shipbuilding, industrial planning, and vehicle fleet operations to identify best-practice anchors that can be used to evaluate current systems. This evaluation method can be used as a guide to create similar processes in the public safety vessel enterprise.

The research found that public safety agencies can plan more effectively by paying attention to vessels' life cycles. Life cycle costing can help agencies create a realistic cost of ownership for a given vessel system and can help them determine when the cost of maintaining a particular vessel system will exceed budgetary constraints, signaling an optimal time to move to a new vessel system.[4] Life cycle costing can allow agencies to create a fiscal roadmap in the vessel's lifespan, which will help with overall planning.

Additionally, by reviewing parallel systems, the research identified five best-practice anchors for vessel systems management. These anchors are: mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and

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[3] "Harbor Police Functions," Port of San Diego, accessed November 9, 2019, https://www.portofsandiego.org/public-safety/harbor-police/harbor-police-functions.

[4] O. Dinu and A. M. Ilie, "Maritime Vessel Obsolescence, Life Cycle Cost and Design Service Life," *IOP Conference Series: Materials Science and Engineering* 95 (2015): 2, https://doi.org/10.1088/1757-899X/95/1/012067; Sal Bibona, "How to Calculate Optimal Replacement Cycles," Fleet Financials, January 23, 2015, http://www.fleetfinancials.com/155875/how-to-calculate-optimal-replacement-cycles.

disposal considerations. These anchors can be used to evaluate public safety vessel systems and help agencies find areas in need of improvement. Using the anchors, this thesis evaluated two public safety vessel systems, one of which used a design-build approach (vessels *Three Forty Three* and *Firefighter II* from the Fire Department of New York), and one of which used an off-the-shelf approach with an established design (the Port of San Diego Harbor Police's *Firestorm* vessels). In addition, the anchors were used to evaluate the U.S. Navy's attempt to modify the littoral combat ship platform to fulfill the new frigate requirement—essentially a large-scale example of an off-the-shelf adaptation. With both off-the-shelf adaptations, the users found it challenging to address mission needs given the actual performance of the platform. This strengthens the argument that design-build platforms, or at least better planning for off-the-shelf systems, is needed.[5]

Each year the Department of Homeland Security awards a limited amount of funding for all Port Security Grant Program requests. The requests cover all items, not just vessels, and agencies must compete for the limited funds. This creates a timeline issue for agencies whose vessels need to be replaced, but who are not awarded a grant. Additionally, the current level of grant funding is not guaranteed in future years. Agencies will need to start looking for other sources to fund their vessel fleets.

To establish guidelines for public safety vessel systems management, two actions are paramount. First, the five best-practice anchors recommended in this thesis (or a similar system) must be used as an established practice; these standards must be accepted as principles in vessel systems management to guide the decision-makers who are responsible for these systems. Along with this, and perhaps more significantly, the purchase and replacement schedules so common in vehicle fleets need to become bedrock principles that agencies must hold to.[6] These practices will create a foundation for the planning of vessel

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[5] Michelle Mackin, *Littoral Combat Ship and Frigate: Delaying Planned Frigate Acquisition Would Enable Better Informed Decisions* (Washington, DC: Government Accountability Office, April 2017), 9, https://www.gao.gov/assets/690/684151.pdf.

[6] Mike Scott, "Replacement Mileage Creeping Up for Public Safety Agencies," *Government Fleet*, March 2007, http://www.government-fleet.com/article/story/2007/03/replacement-mileage-creeping-up-for-public-safety-agencies.aspx.

systems over time, both for design and funding, and the anchors can be adapted to suit individual agencies' needs.

Second, and possibly more importantly, the paradigm for public safety vessels must shift. Agencies must stop looking at vessels as assets that have a linear lifespan—a beginning, an operational period, and an end. Instead, agencies must begin to look at their maritime capability as a circular cycle that must be maintained as long as their maritime mission exists. The vessel systems themselves are just a means to an end, and their management is a cycle of planning, purchasing, operating, planning for the next vessel, purchasing the next vessel, and finally retiring or disposing of the obsolete vessel. Understanding and heeding this cycle will create another foundational system for planning.

Vessel systems need to be seen as the realization of their maritime capacity, and they must be maintained through a planning cycle. If public safety agencies implement the changes recommended here in their vessel enterprise, their planning processes will be more efficient, and their vessels will be better suited for their jobs. Funding streams will likely change over time; if agencies are able to plan for their vessel systems, they will be better able to predict when the vessels will need to be replaced, and how to fund the replacements.

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I. THE PUBLIC SAFETY VESSEL PROBLEM

In 2009, the Port of San Diego Harbor Police had a problem. The agency possessed an aging vessel fleet composed of front-line police and fire vessels, many of them operating after thirty years of continuous use. These police and fire boats had been adapted from pleasure-craft hull designs, vessels that were not designed for decades of hard duty. Maintenance costs had mounted over the years after repeated fixes for cracks in the fiberglass and termite damage to the hulls' wood frames. All of these vessels ran with engines that failed to meet contemporary environmental standards; however, installing new engines would have involved major reengineering of the engine mounting design, a significant expense that was beyond the agency's resources. The department's solution to this legacy vessel problem was to purchase five new aluminum-hull firefighting vessels using funds from California's Port Security Program grants. However, the grants' eighteen-month performance period forced the agency to rush through a selection and purchase process.

The consequences of these rushed purchases became apparent when the newly deployed vessels experienced numerous engine and component failures. In 2014, the lieutenant who was put in charge of the vessel assets of the San Diego Harbor Police soon discovered that the agency had purchased a fleet that was ill-suited for a saltwater environment. Vessels had to be pulled out of service for significant failures such as blown turbochargers, damaged engine blocks from the engine overheating, or damaged jet drives from fouling. The department also learned that the vessels' jet propulsion systems were easily blocked in kelp beds, forcing operators to limp back or require towing back to the dock. The agency had to make major adaptations to the vessels, such as placing heat sensors in new locations to more effectively warn of vessel overheating and placing "claws"—or rakes—at the jet intake to clear kelp. Moreover, the vessels were poorly suited for firefighting in their environment because their system took one engine offline to operate the fire pump, allowing only one jet drive for operation, which made maneuverability more difficult in tight spaces. When the vessels responded to fires inside or in close proximity to a marina, they had to be moored to be effective and to avoid potential collisions in the tight

quarters of the slips. The vessels also struggled in open water due to their flat-bottomed hull design.

Had the agency conducted a more thorough study of the specifics of its mission and incorporated its findings into planning for the new vessels before they were procured, these challenges, including any post-purchase modifications, could have been avoided.

A. PROBLEM STATEMENT

Public safety and homeland security functions are deeply intertwined in the government sphere. Vessels used for public safety or homeland security purposes are tied to duties such as fire response, police patrol, life-saving/rescue response, homeland-security-related patrols and deterrence, and any function in support of those duties. Moreover, in most cases, local agencies are the first to respond to and address homeland security threats or incidents. Modern vessels used to support public safety and homeland security should be purpose-built to address these missions and to operate successfully in extreme and hazardous conditions, taking into account the operating environment.

Many state and local agencies maintain vessel fleets, also known as maritime assets, to fulfill an established mission set. These mission sets are a core part of the agency's responsibilities in such areas as fire and police response. The public safety vessel is the physical realization of the mission or capability. Municipal agencies, such as the Port of San Diego, the Port of Los Angeles, and the Port of New York, routinely respond with vessels to homeland security calls, such as those for suspicious persons near official maritime facilities or for security breach incidents. Many agencies, such as the Port of San Diego, perform a dual fire-police mission.[1] Their law enforcement and homeland security missions include counter-smuggling, police response, and port infrastructure protection, and they may be responsible for firefighting operations—and all these missions must rely on the same vessel. The public safety marine sector is a significant part of the whole homeland security enterprise and maintains constant coverage of America's critical port infrastructure.

[1] "Harbor Police Functions," Port of San Diego, accessed November 9, 2019, https://www.portofsandiego.org/public-safety/harbor-police/harbor-police-functions.

Based on the author's review of news media and articles describing public safety vessels and their procurement from domestic ports—including the Ports of Houston, Texas; Palmetto, Florida; Sandwich, Massachusetts; and San Diego, California—and various other public safety maritime agencies, it appears that agencies use an ad hoc or case-by-case approach for the planning and management of their fleets.[2] This means that they may adapt vessels to fit a public safety mission, or they may opt to not use a vessel at all. This conclusion is supported by requests for information that were sent to various maritime agencies as part of this thesis. There is little to no literature for public safety vessel professionals that focuses on strategic management of fleets over the vessels' life cycles.

In addition to lacking an overall strategy, agencies also lack a standardized platform, causing them to buy multiple systems of replacement parts, potentially multiple mechanic certifications for different platforms, and different operational procedures—all of which increase costs and decreases efficiencies. Because of the decreased initial cost of a predesigned system, some agencies choose to purchase off-the-shelf vessel systems that may not fully or properly meet their needs. Sometimes agencies will purchase a vessel system that was built for a different maritime environment and which must be modified. These modifications cost more money and, if they are not planned for, will cause the procurement to exceed its budget. Agencies that do not plan properly will also be unprepared for maintenance costs, causing more or unanticipated maintenance—

[2] "Port Welcomes New Fireboats," *Bay Area Houston Magazine*, March 2, 2014, http://www.bayareahoustonmag.com/port-welcomes-new-fireboats/; Shelly Earnst, "Emergency Response Boats: What to Know before You Buy," *Government Fleet*, November 16, 2017, http://www.government-fleet.com/channel/procurement/article/story/2017/11/a-shopper-s-guide-to-emergency-response-boats.aspx; Alan M. Petrillo, "Equipping Fire and Rescue Boats for Service," *Fire Apparatus & Emergency Equipment* 22, no. 7 (July 2017), https://www.fireapparatusmagazine.com/articles/print/volume-22/issue-7/features/equipping-fire-and-rescue-boats-for-service.html; Debbi Baker, "Harbor Police Show off New $1 Million Boats," *San Diego Union Tribune*, November 21, 2010, http://www.sandiegouniontribune.com/sdut-harbor-police-show-new-1-million-boats-2010nov21-story.html; Stephanie Rice, "New Fire Boat Coming to the Rescue?," *Columbian*, December 2, 2012, https://www.columbian.com/news/2012/dec/02/new-fire-boat-to-the-rescue/; Sean Flynn, "Newport Fire and Rescue Boat Is on its Way," *Newport Daily News*, April 19, 2018, https://www.newportri.com/7a4c62c2-3c18-575a-9e67-302c14809f4e.html; "Palmetto Request Highlights County's Limited Marine Resources," *Bredenton Times*, June 3, 2018, http://thebradentontimes.com/palmetto-request-highlights-countys-limited-marine-resources-p19887-158.htm; "Sandwich Fire Boat Again Ready for Service," *Cape Cod Times*, June 8, 2016, https://www.capecodtimes.com/article/20160608/NEWS/160609579; Carl Nolte, "SF Welcomes New Fireboat to Fleet on Anniversary of Loma Prieta," SFGate, October 18, 2016, https://www.sfgate.com/bayarea/article/SF-welcomes-new-fireboat-to-fleet-on-anniversary-9979107.php.

potentially more than the agency can provide. These inefficiencies show a lack of overall strategic planning; when agencies plan strategically, they look at the vessel fleet holistically to build standardized systems that will decrease costs.

When it comes to public safety vessels, agencies' procurement and management planning tends to surround the vessel asset as a singular item. It is about the vessel itself, not the overall mission of maritime capabilities the agency needs to fill. This is a linear approach: plan, purchase, maintain, and then dispose.[3] This approach does not incorporate a replacement plan, and it does not incorporate a plan for financing a new vessel once the older one is retired. The case-by-case approach to managing vessel systems addresses incidents in a reactionary fashion; it does not incorporate a model or system that perpetuates maritime operational capacity overall.[4] In essence, the agency manages crisis after crisis without an overarching strategy.

Furthermore, agencies that rely on grants are bound to the grant's performance timelines, which can cause the agency to rush through its study of vessel requirements and planning. If the agency has not prepared for the purchase of the vessel before it receives grant funds, it may have insufficient time to research what is needed for its specific mission; thus the requirements for the craft have not been identified or articulated, leading to a rush to buy something or to implement a quick fix. This poor preparation facilitates a system that responds to repeated crises without a long-term strategy. The operation of the vessel becomes an ongoing system of crisis management instead of operational strategy. Additionally, a lack of requirements prevents a full view of the life cycle of the vessel for planning purposes. Moreover, because vessels can operate for as long as twenty to thirty years, this process happens infrequently, inhibiting the creation of a working standard for planning. For some agencies, off-the-shelf systems have been good enough, so they do not

[3] "Life Cycle of a Ship," Shippipedia, accessed November 29, 2019, http://www.shippipedia.com/life-cycle-of-a-ship/.

[4] Diaswati Mardiasmo et al., "Asset Management and Governance: Analysing Vehicle Fleets in Asset-Intensive Organisations," *Contemporary Issues in Public Management: The Twelfth Annual Conference of the International Research Society for Public Management* (2008): 21.

see the need for a more comprehensive process.[5] Some federal and state agencies offer procurement models from which maritime agencies like the Port of San Diego Harbor Police can glean best practices. Such parallel processes can be used as guides for public safety vessel managers.

There are many challenges when adapting vessels to fit public safety missions, and the public safety vessel industry continues to make new developments to meet mission needs. New, purpose-built public safety vessels are highly adapted to the public safety and homeland security missions that municipal agencies now undertake on a regular basis. Key components of the public safety vessel system include planning—or procurement—which must be done on the front end, and a strategic approach to managing these vessel systems as assets over their lifespans.

B. RESEARCH QUESTIONS

1. If public safety agencies adopt a process for strategic requirement determinations for maritime vessels, and a strategic management system for maritime assets, how can they positively affect costs, production times, and life cycle maintenance?

2. How can agencies with public safety and homeland security missions adopt strategic management processes for maritime assets?

C. LITERATURE REVIEW

While there is little to no literature that speaks directly to vessel systems management at the municipal level, the U.S. military, as well as the commercial maritime industry, offer an abundance of life cycle data that can guide strategic asset management, and this data has applicability to the study of municipal vessel fleets. The Navy and the commercial ship-building sector have promoted best practices in ship life cycles and selection criteria. Municipal agencies that acquire and maintain ground vehicle fleets, such

[5] "Management of the Cape Class Patrol Boat Program," Australian National Audit Office, December 16, 2014, https://www.anao.gov.au/work/performance-audit/management-cape-class-patrol-boat-program.

as fire apparatuses or police vehicles, conduct vehicle fleet maintenance and have well-established guidelines that might be appropriate for maritime craft.

1. Navy, Coast Guard, and Commercial Shipping Models

The most significant source of vessel strategy is the U.S. Navy, which employs an elaborate and detailed planning process for procuring and maintaining ships. One example is the life cycle view of the dock landing ship (LSD) and its replacement, the LSD-X. In her 2012 master's thesis, Allison Hills uses the life-cycle cost estimate (LCCE) method to compare the new LSD(X) design to the competing LSD(XB) design. The analysis shows a LCCE of $20.360 billion for the LSD(X) design versus $23.419 billion for the LSD(XB).[6] This illustrates the usefulness of life cycle costing in evaluating designs for large projects, such as naval ship systems. Additionally, the Navy has illustrated its strategic approach in other projects, such as its initial development of the littoral combat ship.[7] This vessel was purpose-driven, created for a specific environment and mission. The Navy also has a detailed system for asset acquisition that can be used as a reference; however, its granularity would be unwieldy for most municipal-level vessel projects.[8] Naval acquisition involves several years of planning for vessels that are equivalent in size to small cities and cost the government many millions—or even billions—of dollars.

The U.S. Navy offers some guidance for strategic management over a vessel's lifespan. The vessels' designs are based on their mission or purpose, and the vessels' complexity make them extremely expensive to build.[9] The process is also competitive, and cost is not the only factor. For instance, four teams are competing to design the new U.S. Navy fast frigate (FFG(X)); the winner will be decided based not only on cost but also on

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[6] The U.S. Navy classifies this vessel as a "landing ship, dock," hence "LSD." Allison Hills, "Life Cycle Cost Estimate LSD(X)" (master's thesis, Naval Postgraduate School, June 2012), 41.

[7] Ronald O'Rourke, *Navy Littoral Combat Ship (LCS) Program: Background, Issues, and Options for Congress* (Washington, DC: Congressional Research Office, 2010), 16–17.

[8] "Milestone Overview," AcqNotes, accessed October 16, 2018, http://acqnotes.com/acqnote/acquisitions/milestone-overview.

[9] Mark V. Arena et al., *Why Has the Cost of Navy Ships Risen? A Macroscopic Examination of the Trends in U.S. Naval Ship Costs over the Past Several Decades* (Santa Monica, CA: RAND, 2006), 4–5, https://www.rand.org/pubs/monographs/MG484.html.

production timelines and vessel suitability.[10] The Navy plans for and manages the entire lifespan of a vessel, from the time its keel is laid until it is retired and recycled. According to a 2018 Government Accountability Office (GAO) report, however, the Navy is struggling to complete this scheduled maintenance, to the detriment of combat readiness.[11] In addition, U.S. Navy sources provide some guidance and benchmarks on managing marine-related events or hazards, such as corrosion. However, the Navy's vessels are far larger and more complex than the vessels that public safety agencies need; while the Navy's models may be too unwieldy for municipal agencies, they offer overarching principles that can be adapted for municipal use.

Published by the National Oceanic and Atmospheric Association (NOAA), the *Small Boat Standards and Procedures Manual* offers a partial model, if not a framework, for the management of vessels. This guide, which is specific to NOAA's fleet, touches mainly on vessel operational issues such as operator training, but it also details vessel construction, stability standards, and areas of operation. Additionally, it sets forth guidelines for selecting, maintaining, and disposing of vessels. The manual even addresses considerations for custom design (design-build) vessels and existing (off-the-shelf) platforms. In addition, the manual specifies how boats must be equipped and gives guidelines for modification.[12] Although the NOAA manual closely addresses the questions raised by the thesis, it is merely a policy framework that illustrates the need for this type of strategic planning. It does not go into the details that are needed for vessel practitioners in the public safety field; the guidelines are discussed only broadly, referencing further policies in the NOAA procedural guidelines.

The U.S. Coast Guard has publications, as well, that govern exactly how procurement professionals must conduct asset acquisition and planning. The

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[10] Ronald O'Rourke, *Navy Frigate (FFG[X]) Program: Background and Issues for Congress* (Washington, DC: Congressional Research Service, 2018), 9.

[11] John H. Pendelton, *Navy and Marine Corps Rebuilding Ship, Submarine, and Aviation Readiness Will Require Time and Sustained Management Attention* (Washington, DC: Government Accountability Office, 2018), 6, https://www.gao.gov/assets/700/695911.pdf.

[12] National Oceanic and Atmospheric Association, *The NOAA Small Boat Standards and Procedures Manual*, 4th ed. (Silver Spring, MD: U.S. Department of Commerce, 2017), 31–39, 57–59, 76, 77.

Non-Major Acquisition Process Manual, designed for smaller projects, can be used as a peripheral guide for overarching principles.[13] This manual addresses managing these acquisitions in three phases: the analysis or selection phase, the "obtain" phase, and the deployment/support phase. It also addresses off-the-shelf acquisitions as well as a life cycle system analysis. This process covers the entire lifespan of the system, with specific parameters for the selection and oversight of the item. While this manual is highly specific to the Coast Guard's organizational architecture, it gives some parameters that can be used as models for the overall process of planning a vessel's acquisition and operational lifespan. Included in this is planning for support systems to manage the entire platform that is purchased.

The commercial boating industry, too, has established models for the life cycle of vessels, which municipal homeland security vessel programs can use as a baseline for their own models.[14] Commercial models show, on a large scale, how commercial ships are maintained and managed through their life cycles—from the beginning (or planning), to acquisition, to acceptance by the buyer, to deployment and eventual retirement. Managing a commercial ship is a large-scale industry in and of itself, and third-party companies often conduct this function for the vessel owner.[15] While commercial models do not perfectly translate to the smaller scale of municipal public safety vessels, there are some applicable components, such as articles that discuss the use of technology to assist with life cycle management or that help build efficiencies and a transparent view of the vessel's condition. Such systems monitor hull condition, hazardous materials present as part of the vessel's construction, ship operating systems, and damage.[16]

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[13] United States Coast Guard Acquisition Directorate, *Non-major Acquisition Process (NMAP) Manual*, COMDTINST M5000.11A (Washington, DC: Department of Homeland Security, April 2011), 3–4, https://www.dcms.uscg.mil/Portals/10/CG-9/Acquisition%20PDFs/Manuals%20and%20Briefs/CIM5000.pdf?ver=2017-04-18-150246-970&timestamp=1508520579130.

[14] Shippipedia, "Life Cycle of a Ship."

[15] "Ship Managers," Maritime Industry Knowledge Centre, accessed November 9, 2019, https://www.maritimeinfo.org/en/Maritime-Directory/ship-managers.

[16] Klaus-Dieter Thoben and Nils Homburg, "Maritime Life Cycle Management during Ship Operation," *International Conference on Product Life Cycle Management* (July 2009): 358–68, https://www.researchgate.net/publication/276290493_Maritime_Life_Cycle_Management_during_ship_operation.

In a 2015 article for BMT Defense Services in the United Kingdom, author N.A. Tomlinson reviews the strategic maintenance of vessels for both commercial and government entities.[17] Tomlinson proposes that ships, as major assets for a nation or corporation, are now better managed through asset management strategies to cover items such as maintenance. The use of a strategic system increases efficiencies and extends the operational life of the ship. The purpose of the vessel is simple: to make a profit for its owner. The goal of strategic maintenance is to optimize that profit; when the vessel is not in service, it is not earning a profit. Maintenance methods are seen as preventative, predictive, and reactive.[18] Each model shows different perspectives for addressing maintenance, and each has a place in vessel operations.

Using life cycle management, per Hills, and Tomlinson's article as a model to address municipal vessels can help agencies build the overarching strategies they need to maintain and procure vessels over their life cycles. Though these concepts are designed for commercial vessels and large projects, they can be scaled to create a model for public safety vessels. The educational website shippepedia discusses this life cycle in basic terms, and can also help agencies understand the life cycle of a municipal public safety vessel.[19] Finally, the maintenance models described by Tomlinson can be used to evaluate an agency's model and provide momentum to move away from a reactionary maintenance process, toward a process that builds efficiencies and prolongs vessels' lifespans.

2. Municipal Fleet Management and Trade Publications

Municipal agencies, such as fire departments, have some well-established systems to manage higher-end assets or systems equivalent in value to most vessel systems. For example, the town of the Blue Mountains in Ontario, Canada, has published a plan for its fire vehicle life cycle. The document first outlines the benefits of the asset planning

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[17] N.A. Tomlinson, "What Is the Ideal Maintenance Strategy? A Look at Both MoD and Commercial Shipping Best Practice," BMT Defense Services, accessed November 29, 2019, 13, http://bmt-defence.com/media/6371458/BMTDSL%20What%20is%20the%20Ideal%20Maintenance%20Strategy%20%20INEC%202016.pdf.

[18] Tomlinson, 4.

[19] Shippipedia, "Live Cycle of a Ship."

process, specifically the benefits of being able to better plan for how the department will use its resources. It proposes age-based apparatus assignments and retirement ages for the apparatus. The document also allows the town to plan for when assets are needed and what kind of assets should be purchased. The document ends with a strategic plan to meet the city's needs and to keep the fire services financially sustainable.[20] An internal memo from the Fairfax County Fire Department in Virginia documents a similar strategy.[21] The department's systems manage fire engine lifespans, deployment roles, and the age at which they are retired. Municipal vehicle fleet maintenance strategies provide benchmarks for the management of vehicles—for example, the department has maintenance schedules, along with mileage and age requirements for replacement. The very existence of these strategies indicates that a model to facilitate planning for the future is an established strategy for handling municipal assets.[22]

Trade publications such as *Government Fleet* provide some build-to-suit ideas for vehicle fleet management. Many municipalities set a life cycle limit on items like police cars and fire trucks that indicate replacement timelines, but nothing similar exists for the life cycle of maritime vessels, suggesting that such vessels are used until failure or unserviceability. Trade publications, however, are showing emerging conversations about public safety vessel procurement. For instance, Shelly Earnst's 2018 *Government Fleet* article shows growth in the realm of research or planning when it comes to buying new vessels. The article acknowledges that the needs of a public safety agency are not the same as those of consumers who purchase pleasure vessels: public safety uses put ten to fifteen times more hours on the vessels' systems over their operational lifetime.[23] The design of public safety vessels should therefore be based on performance and space needs for their

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[20] Darcy Chapman, Ron Doherty, and A.J. Lake, "Fleet Management Best Practices Fire Services and Emergency Management" (guidance document, Town of the Blue Mountains, Ontario, March 12, 2012), 2–4.

[21] Fairfax County Fire Department, "Fairfax County Fire and Rescue Apparatus Assistance Replacement Program" (unofficial memorandum, emailed to author April 10, 2018).

[22] Sharon Rollins, "Fleet Management Tips for Municipal Decision Makers" (report, University of Tennessee Municipal Technical Advisory Service, 2012), https://trace.tennessee.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1157&context=utk_mtaspubs.

[23] Earnst, "Emergency Response Boats."

mission. The goal should be a design build (or an established, purpose-driven design) that meets the mission's needs; the goal should not be to adapt a recreational boat. Earnst also cites the recommendation of Miami Dade Fire Department's Nicholas DiGiacomo to seek out a vessel based on the mission or needs of the department. For context, DiGiacomo works with a fleet of twenty-seven fire response vessels for Miami Dade.[24]

Trade publications provide foundational ideas that can contribute to the creation of a best-practice model for vessel systems operation in public safety. *Firehouse* magazine is one such source of information on fire-related vessels and vehicle fleet systems. This publication's articles can show the criteria for parallel best practices as well as examples of vessel procurement.[25] Municipal fleet maintenance strategies and manufacturer guidelines can also provide a reference point for the smaller units seen in municipal systems. These strategies and guidelines can certainly inform those who are developing requirements for a multirole vessel, or evaluating the likely long-term costs associated with any vessel procurement, whether for a single craft or a fleet. Such concepts as manufacturer estimates for engine lifespans, maintenance intervals, hull lifespans, replacement schedules, and funding timelines to support these systems can be proposed using these systems as models. Some municipal agencies, such as the city of New York, have a specific set of guidelines for vehicle replacement.[26] Others, such as the 2011 Florida Fleet Consolidation Committee report, indicate that guidelines are only a portion of this process, as they identify end-of-life considerations for vehicles and do not address the risk of inconsistent funding sources for necessary replacements.[27]

A review of media and news reports illustrates that fire departments are not the only agencies that are having problems with vessel systems and their management. A series of

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[24] Earnst.

[25] Lisa J. Huriash, "Fort Lauderdale Upgrades its Water Response with Fireboat 49," *South Florida Sun Sentinel*, December 3, 2017, http://www.sun-sentinel.com/local/broward/fort-lauderdale/fl-sb-lauderdale-fire-rescue-boat-20171130-story.html.

[26] Lisette Camillo, "Fleet Management Manual, City of New York" (New York: City of New York, May 2016), 17, 24.

[27] Brett Norton, "Vehicle/Fleet Management/Logistics" (committee report, Law Enforcement Fleet Consolidation Committee, November 10, 2011), 1–2, https://www.flhsmv.gov/LECTaskForce/FleetTeamReport.pdf.

articles from local media outlets shows that the Palmetto Police Department in Florida has no marine assets to patrol its nine miles of shoreline along the Manatee River.[28] These articles show that the area struggles with funding for the police department's maritime needs; instead of funding Palmetto's specific vessel needs, county governing boards chose to fund the ongoing operations of the county sheriff's marine unit, which also patrols the county waterways.[29] This case highlights the struggle of marine units that consistently compete for funding—not only for vessels but also for ongoing operational costs. The local county government has repeatedly turned down grant-funded vessels based on its current model, which requires the police to ask for the help of neighboring agencies or civilian vessels when responding to public safety calls.[30]

News media also illustrate the challenges faced by municipal agencies, which often adapt a vessel to do a public safety jobs. In an article for the *Columbian*, Stephanie Rice identifies the Vancouver Fire Department, which used a surplus U.S. Coast Guard vessel that had no ability to fight fires until it was replaced by a new fire boat, paid for by grants.[31] An article for the *South Florida Sun Sentinel* similarly describes the Fort Lauderdale Fire Department, which used to operate a fishing vessel that had been rigged with a fire pump; this is like throwing a fire pump onto a Ford pickup truck and calling it a fire engine. In 2017 the department received a more suitable replacement—a MetalCraft Marine vessel, purchased through grants.[32] These articles illustrate the need for strategic planning in boat procurement; ad hoc, case-by-case solutions are not appropriate. These supportive publications show the current state of public safety vessel procurement, and document some efforts in strategic management.

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[28] *Bredenton Times* "Palmetto Request."

[29] "Manatee County Commission Regular Meeting Minutes," Manatee County Government, May 22, 2018, https://www.mymanatee.org/published/May%2022,%202018%20-%20Regular%20Meeting%20on%20Tuesday,%20May%2022,%202018/1D02BD6A-7577-4291-B111-52DB094BF19C-F3D5A2A8-76B0-4876-8150-BFAC7B0F631E.htm.

[30] "Palmetto Police Department—Palmetto, Florida," PoliceOne, accessed November 9, 2019, https://www.policeone.com/Police-Departments/Palmetto-Police-Dept-Palmetto-FL/.

[31] Rice, "New Fire Boat."

[32] Huriash, "Fort Lauderdale Upgrades Water Response."

This issue is not completely isolated to maritime vessels. A lack of planning and, more crucially, a lack of funding when forecasting vehicle fleet needs was identified in a 2011 report by the Florida Department of Fish and Wildlife. The agencies called out in the report had identified future equipment losses but did not procure the necessary funding to address future needs. The Florida report shows that even when an agency has a planned threshold for retiring an asset—such as mileage or age—there are still risks. If there is no plan to fund the new replacement, older vehicles will continue to be used well past their lifespan. This lends to increased maintenance costs for older vehicles.[33]

The U.S. General Services Administration (GSA), whose missions is to "establish GSA as the premier provider of efficient and effective acquisition solutions across the federal government," is also be a source of information.[34] It establishes practices for government procurement as part of its mission, and provides a useful introduction to life cycle costing.[35] Agencies can use life cycle costing as a metric to evaluate timelines for a vessel's useful end of life.

A review of past agency models illustrates the failures of early efforts to adapt non-public-safety vessel platforms to public safety missions. Fire departments in New York, Florida, and Washington adapted pleasure, Coast Guard surplus, or fishing vessels for use in fire missions. As these fleets modernized, all three were later replaced with more purpose-built vessels, which were purchased using Department of Homeland Security or Port Security Grant Program funding.[36] The current era of new vessels, especially those funded by homeland security grants, appears to be designed based on more purpose-driven processes.

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[33] Norton, "Vehicle/Fleet Management/Logistics," 2.

[34] "Mission and Strategic Goals," General Services Administration, February 16, 2018, https://www.gsa.gov/about-us/background-history/mission-and-strategic-goals.

[35] "Life Cycle Costing," General Services Administration, August 13, 2017, https://www.gsa.gov/node/81412.

[36] Sean Maloney, "Maloney Announces Over $248K for Fire Rescue Vessel for Newburgh Fire Department," July 30, 2015, https://seanmaloney.house.gov/media-center/press-releases/maloney-announces-over-248k-for-fire-rescue-vessel-for-newburgh-fire.

3. Conclusion

The academic and professional literature that examines municipal ground vehicle fleet management is well-established, as is the literature on U.S. Navy and commercial vessel best practices for requirements development, procurement, and maintenance. What is lacking from the literature on vessel development and fleet management is a body of research and analysis that applies these same concepts to the smaller scope of municipal agency maritime vessels for public safety or homeland security; this thesis makes that contribution to the literature.

D. RESEARCH DESIGN

An initial review of literature and trade publications helped to identify relevant guidelines and practices for the strategic management of marine assets; this research supported the development of a thesis framework for understanding the difficulties that come with acquiring and managing public safety vessels. This framework was expanded based on research conducted on the concepts of life cycle costing and vessel lifespan timelines in order to identify additional best practices. Based on these fleet management best practices, the thesis developed five distinct "anchors," which were applied to three case studies for analysis, and used to develop recommendations for public safety agencies. These anchors are: mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations.

The anchors were then used to compare the effectiveness of off-the-shelf and design-build approaches to vessel acquisition. The planning process that the Fire Department of New York (FDNY) uses for its vessels, the *Three Forty Three* and the *Firefighter II*, is an example of a purpose- or mission-driven acquisition: these vessels were planned with specific mission needs in mind and were built to fulfill those needs. The Port of San Diego Harbor Police Department's acquisition of five fire/police vessels stands in stark contrast as an example of off-the-shelf design development, which resulted in additional costs. Although the Port of San Diego vessels were designed by the manufacturer for a specific mission and scope of use, their characteristics were not fully aligned with the actual missions for which the vessels were purchased. The San Diego

example, illustrative of a failure of commercial-off-the-shelf acquisition, is compared with the example of the U.S. Navy's littoral combat ship design, which was converted to a fast frigate, to illustrate how off-the-shelf systems can be adapted at a larger scale. This is also an example, however, of how modifying an off-the-shelf item for a mission can be problematic on a larger scale.

To answer the core research questions, a request for information (RFI) was created in compliance with Institutional Review Board guidelines and sent to public safety agencies that conduct vessel or maritime operations. The purpose of this survey effort was to understand how these agencies manage their vessel fleets, and to glean information about different agencies' design and planning processes. This RFI was designed to identify current trends in mission-driven planning, determination of life cycles, and the use of collaboration in planning.

This thesis includes an evaluation of the survey responses, which assess practices that are common across public safety agencies and identify exceptions or processes that are unique to specific organizations. The RFI instrument was written to generate data that can be used to understand the current state of vessel management, and support the study of efficiencies or improvements that have value in connection with best-practices models for vessel planning. One of the goals of the RFI effort was to identify practices that are working now, and practices that can be improved. The thesis evaluates the five best-practice anchors for public safety vessels and describes risks identified by the RFI respondents. These risks, specifically with respect to the dependence on grants to fund vessels, are addressed and solutions proposed.

E. CHAPTER OUTLINE

Chapter II introduces the concept of the vessel life cycle, and describes the concept of life cycle costing and how it applies to public safety agencies operating small maritime vessels. These concepts are foundational to the overall planning of and best practices for any vessel system, and are significant challenges for resource-limited agencies that are looking to acquire or maintain marine capabilities. Chapter III examines three case studies involving two types of procurement processes, design builds and off-the-shelf purchases.

These three cases are evaluated using the five best-practice anchors articulated in Chapter II. Chapter IV analyzes the responses from the RFI, and considers how this data can be employed to better understand the current state of the public safety vessel industry, and that industry's relationship with public safety and homeland security agencies. The RFI responses offer insights into how different agencies apply such concepts as design builds and off-the-shelf procurements; use collaborative planning at the front end of the life cycle; and use strategic planning practices to maintain marine assets. Chapter V proposes industry standards—based on use of life cycle costing and the five best-practice anchors—for public safety vessels. The final chapter also proposes a new cyclical paradigm for maritime operational capacity in public safety vessel management to replace the linear view of a vessel as a singular asset.

II. LIFE CYCLE COSTING AND BEST PRACTICES

Everything has a lifespan. Human beings are born, they grow up, live a life, and then eventually pass away. Equipment systems are similar: they have a beginning, a middle—or operational cycle—and an end. This life cycle is used as a model to view any item's life over time, as well as its costs. It allows the owner or manager of the asset to look at more than just the initial cost of a system, which is only part of its cost over time. For instance, it may be initially inexpensive to buy a used car, but if the car is prone to break down and gets only five miles to the gallon, it may cost more over time than a new, more efficient car. The cost of an object over its lifespan is called life cycle costing. This chapter introduces several principles, or milestones, as well as five best-practice anchors gleaned from trade and professional literature that can be used to analyze vessel systems.

A. THE LIFE CYCLE

The life cycle of any object starts with planning, then moves to procurement, to the operational life of the system, and eventually to the object's replacement and disposal. Then another life cycle begins. This is true of any asset, be it a dishwasher, a lawnmower, or a vehicle. Based on data from shipbuilders, industry experts estimate the acceptable lifespan of a ship to be approximately twenty to thirty years.[37] The RAND Corporation conducted a study of Australian naval vessels and listed eight steps in naval vessel life cycles: solution analysis, concept design, preliminary design, contract design, detailed design and construction, test and trials, operations and support, and retirement/disposal.[38] Naval vessels, however, are bigger and more complex than public safety vessels. Commercial shipbuilding models, on the other hand, are less complex than naval ships and can be easier to parallel with public safety vessels. Shippipedia, a reference website for commercial vessels, proposes a five-step cycle: initial planning, ordering, building,

[37] Dinu and Ilie, "Maritime Vessel Obsolescence," 2.

[38] John F. Schank et al., *Keeping Major Naval Ship Acquisitions on Course: Key Considerations for Managing Australia's SEA 5000 Future Frigate Program* (Santa Monica, CA: RAND, 2014), xvii–xviii, https://www.rand.org/content/dam/rand/pubs/research_reports/RR700/RR767/RAND_RR767.

operation, and recycling.[39] While life cycle processes for municipal public safety vessels are similar, they are generally far simpler than those for larger commercial vessels. This thesis focuses on a four-step process: planning, ordering/building, operation, and recycling.

1. Initial Planning

Initial planning outlines the requirements of the vessel based on the mission, environment, and other needs. During this stage, naval architects look at previous ship designs and devise new technological improvements.[40] Ship buyers look to specify the role of the vessel, as well as basic needs such as cargo type and capacity, the ballast, engines, fuel capacity, onboard quarters for crew or passengers, and hull design.[41] These plans affect the entire vessel's lifespan. They should also consider life cycle costing aspects such as recycling costs, and if potentially hazardous materials are to be used that will require remediation later. This will be discussed in the section on recycling.

Planning for ship construction involves anticipating a highly complex construction process involving multiple systems, even for a small number of ships. In theory, planning for vessels involves a highly complex system of plans that address the large-scale processes of ship construction, from design to delivery. These plans are generally human-managed and cover the design, production schedules, and material acquisition for the building of the vessel. Humans—rather than systems—continue to be the planners, as human experience is often the best way to predict variables such as material availability.[42] However, due to these variables, production plans can change significantly during the actual construction of the vessel; such changes have ripple effects on the line of production, and can cause delays and cost overruns. In an article for *Aerospace Daily & Defense Report*, Michael Bruno notes that many of these delays or cost overruns are due to design modifications, material

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[39] Shippipedia, "Life Cycle of a Ship."

[40] Shippipedia.

[41] J.F.C. Conn and Cuthbert Coulson Pounder, "Ship Construction," *Encyclopedia Britannica*, last modified June 22, 2018, https://www.britannica.com/technology/ship-construction.

[42] Jinsong Bao et al., "Data-Driven Process Planning for Shipbuilding," *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* 32, no. 1 (February 2018): 122, http://dx.doi.org/10.1017/S089006041600055X.

changes, or personnel costs during production. Bruno also notes that some technologies are still in development when production begins for hi-tech naval projects, causing overruns as the technology matures and the design must be modified.[43] Sometimes, such as for defense vessels, politics can also impact the speed of a project.[44] A 2009 GAO report notes delays during development for lead ships (vessels that are first in their class) for the U.S. Navy totaling ninety-seven months over new classes.[45]

The planning phase is, ideally, when an established design is created or chosen for the vessel that will allow it to function properly during missions, minimizing the need for adaptations or alterations. Such a process should be collaborative and should bring in as many stakeholders as needed. Commercial shipbuilders attempt to minimize changes and delays by keeping industry experts at hand during key points in the planning process. While planning timelines are not clearly defined in the literature, the previously mentioned GAO report indicates that overall development and construction timelines range from twenty-two months (for an oil tanker) to thirty-six months (for a more complex cruise ship). These timelines can be reduced if technologies and designs are tested beforehand using computer simulation, and if stakeholders choose mature technologies; this leaves less to chance and establishes a collaborative planning process with the ship buyer/owner.[46] For vehicle fleets, which are similar to vessel fleets, experts suggest that the planning stage should include life cycle costing, which will help lay out the vehicle's timelines and overall cost estimates of ownership.[47]

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[43] Michael Bruno, "GAO Shipbuilding Practices Lead to 'Unrealistic' Funding," *Aerospace Daily & Defense Report* 213, no. 48 (March 14, 2005): 4.

[44] David Peer, "Realistic Timeframes for Designing and Building Ships," *Canadian Naval Review* 9, no. 1 (2013): 4–9.

[45] Government Accountability Office, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding* (Washington, DC: Government Accountability Office, May 2009), 2, https://www.gao.gov/assets/290/289531.pdf.

[46] Government Accountability Office, 14, 17.

[47] Roger Smith, "Best Practices in Fleet Management," *Public Sector Digest*, January 2011; Mike Scott, "Replacement Mileage Creeping Up for Public Safety Agencies," *Government Fleet*, March 2007, http://www.government-fleet.com/article/story/2007/03/replacement-mileage-creeping-up-for-public-safety-agencies.aspx; Rollins, "Fleet Management Tips for Municipal Decision Makers."

2. Ordering/Building

The ordering/building stage includes the initial contact, and creation of a contract between the ship owner and the builder. (The owner does not actually accept the delivery of or title for the ship until it has completed sea trials.) The ship contract outlines how the ship will be designed and built, covers timelines for construction and delivery of the vessel, and describes the rights and duties of the two parties. Milestones laid out in the contract can include contract signing, initial fabrication dates, keel laying, launching, and delivery.[48] In commercial shipbuilding, this stage is also when the ship owner puts together funding for the actual building of the ship.[49] Government ships tend to be far more complex and more heavily planned for than commercial vessels.[50] While ordering takes less time for small government vessels, there is still an intricate process in which the municipality or agency must select a manufacturer to build its vessel.

In addition, politics and government regulations can play a role in the ordering/ building stage. The process for commercial shipbuilders differs notably in one area with the U.S. Navy's shipbuilding process: the Navy must use exclusively U.S. shipbuilders to support its workforce, while commercial shipbuilders—who are governed by profit—have moved offshore to countries like Korea and China.[51] For example, liquefied natural gas (or LNG) carriers are manufactured outside of the United States due to less restrictive regulations overseas.[52] For the Navy, politics create a chaotic operational field for shipbuilders; shipyard assignments and budget approvals (and the shipyard's payment) can become entangled in congressional debate.[53] Additionally, special interest groups, as well

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[48] John L. Birkler et al., *Differences between Military and Commercial Shipbuilding: Applications for the United Kingdom's Ministry of Defence* (Santa Monica, CA: RAND, 2005), 33.

[49] Shippipedia, "Life Cycle of a Ship."

[50] Birkler et al., *Differences between Military and Commercial Shipbuilding*, 27–28

[51] Government Accountability Office, *Best Practices: Commercial Shipbuilding*, 53–54.

[52] Loren Thompson, "Trump Industrial Policy Likely to Target U.S. Commercial Shipbuilding & Merchant Fleet For Revival," *Forbes*, June 5, 2018, https://www.forbes.com/sites/lorenthompson/2018/06/05/trump-industrial-policy-likely-to-target-u-s-commercial-shipbuilding-merchant-fleet-for-revival/.

[53] Loren Thompson, "Five Problems That Could Torpedo America's Naval Shipbuilding Capability," *Forbes*, July 17, 2019, https://www.forbes.com/sites/lorenthompson/2019/07/19/five-problems-that-could-torpedo-americas-naval-shipbuilding-capability/.

as politicians working to address needs in their own districts, can influence contracts.[54] In municipal sales, agencies also have issues with the competitive bid process. In government awards, competitive bidding is a standard process for selection and procurement, which means government agencies must sometimes contend with lawsuits that contest the awards. For an example at the federal level, Elon Musk's company SpaceX contested the U.S. Air Force's decision to award contracts to several rocket manufacturers.[55]

There are two primary approaches that can be used for ordering and building vessels: a design-build approach, or the acquisition of an off-the-shelf system. In a design-build approach, vessels are designed from the keel up based on mission needs. Alternatively, an off-the-shelf vessel may be appropriate for a generally established mission; for example, manufacturers already have an established design that can work for police patrol vessels. Even off-the-shelf vessels can be adapted to mission-specific needs, within reason. During the ordering phase, purchasers can outline the desired criteria for a design build, or can outline modifications needed for an off-the-shelf design. Once the specifications are finalized, the order is usually memorialized in a contract.

Even while construction is underway, buyers can submit change orders or modifications to the vessel design when new needs arise. Building a ship can take months, or even years. For instance, designing a commercial ship such as a tanker could take up to six months, and building it could take as long as nine months. The construction and design time for large military vessels can be far longer due to the vessels' complexity.[56] For smaller municipal vessels, the process of fabricating a boat may also take many months. For example, the Charlestown Fire Department in Maryland secured funding for a new fire vessel in 2015, but did not receive the vessel until late 2017; and a fire vessel

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[54] Caroline Flammer, "Competing for Government Procurement Contracts: The Role of Corporate Social Responsibility," *Strategic Management Journal* 39, no. 5 (May 2018): 1300, https://doi.org/10.1002/smj.2767.

[55] Joey Roulette, "SpaceX Is Suing the U.S. Air Force, Accusing it of Awarding $2.3 Billion Worth of Contracts to Firms with 'Unbuilt, Unflown' Rocket Systems," *Business Insider* (May 23, 2019): 37–38, 40, https://www.businessinsider.com/elon-musk-spacex-sues-us-air-force-over-rocket-contracts-2019-5.

[56] Birkler et al., *Differences between Military and Commercial Shipbuilding*, 35–40

for Tarrytown, New York, was ordered in late 2017 but not delivered until October 2018.[57] While predesigned municipal public safety vessels may be less complicated than military vessels, considerable time may still elapse between when the vessels are order and when they are received.

Vessel planning is heavily influenced by the mission. For example, law enforcement boats will be operated for patrol duties, call response, and even potentially rescue operations. During these times they may operate in extreme conditions, such as inclement weather or rough seas. The mission of the vessel will dictate the design specifications, such as hull shape, engine type, and speed requirements. Environmental conditions are used, as well, to shape the design or outfitting of the vessel. Saltwater vessels have specific countermeasures installed and require maintenance measures such as freshwater flushing systems to address the corrosion of saltwater. If the environment involves heavy seas, the design must allow for a hull that is stable in such an environment.

3. Operation

Once the vessel is accepted by the purchaser, the operational period of the vessel begins; this stage covers the bulk of the vessel's lifespan and can last for decades. Even smaller municipal vessels have relatively long lifespans; for example, MetalCraft Marine, a producer of municipal fire and work vessels from Canada, states that its vessels have a twenty-five-year service life.[58] During this time, the vessel is underway, shipping cargo or passengers, conducting patrols, or otherwise fulfilling its mission. During this time, the vessel also may be out of service for extended periods for maintenance or repairs. This is true for both military and municipal vessels; however, the scale of the maintenance may be smaller for municipal vessels because they are generally smaller in size.

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[57] Matt Spillane, "Tarrytown Will Get a New Fireboat with $325K from State," lohud, September 21, 2017, https://www.lohud.com/story/news/local/westchester/2017/09/21/tarrytown-new-fireboat/688129001/; "MetalCraft Delivers Multimission Boat to New York," WorkBoat, October 16, 2018, https://www.workboat.com/news/shipbuilding/metalcraft-marine-us-delivers-fire-search-rescue-boat-to-n-y/.

[58] "MetalCraft Marine Workboats Brochure," MetalCraft Marine, accessed February 8, 2019, http://metalcraftmarine.com/pdf/PatrolBoatBrochure.pdf.

When a public safety vessel is deployed as a firefighting asset, it may be underway for short periods of time to respond to marine fires, or it might conduct rescue operations—for example, in 2009 FDNY vessels assisted with the passenger rescue of U.S. Airways Flight 1549, which ditched into the Hudson River.[59] Fire vessels also spend time being docked while they are maintained by their crew or maintenance staff, and are then activated again when responding to calls.

The lifespan of a vessel can be predicted based on past experience and with the use of some new tools. Often a ship's operational life is determined by the hull material, which has been studied significantly. Web-based tools such as the Structural Life Assessment of Ship Hulls (SLASH) methodology can now better predict hull failures due to corrosion, metal fatigue, reinforcing structure fatigue, and eventual hull failure. These systems use computer modeling and simulations to look at individual portions of the ship's construction, such as hull material, reinforced panels, and hull girders, to determine how they react with their environment on over time. The systems also seek to predict the number of times a system can be stressed before failure.[60] By looking at the frequency of these specific stresses over time, planners can use such models to predict when the components of the system will fail. This information can be used to predict maintenance and eventual hull failure and, as a result, lifespan.

The end of a vessel's service life can sometimes come before the physical service life or initially projected service life ends. This can be caused by environmental impacts such as physical fatigue. A vessel that may otherwise be capable of continuing to fill its role may also become obsolete based on its technical specifications, which can happen if the ship has been operating below a desired standard.[61] The owner of the vessel, whether it be a company or a municipality, will have to decide if the cost of the vessel's technical

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[59] "Special Report: Rescue Response to Flight 1549 in the Hudson River," *Law Officer* (blog), January 16, 2009, http://lawofficer.com/archive/special-report-rescue-response-to-flight-1549-in-the-hudson-river/.

[60] Bilal M. Ayyub et al., "Structural Life Expectancy of Marine Vessels: Ultimate Strength, Corrosion, Fatigue, Fracture, and Systems," *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part B: Mechanical Engineering* 1, no. 1 (February 27, 2015): 2, https://doi.org/10.1115/1.4026396.

[61] Dinu and Ilie, "Maritime Vessel Obsolescence," 4.

obsolescence and inefficiency is enough of an economic incentive to replace it with a more modern or efficient vessel.

4. Recycling

At the end of the operational life, a vessel is retired and recycled. Systems may be removed from the ship for reuse, and raw materials, such as steel, are harvested and recycled for other projects. According to the International Maritime Organization, everything is recycled; steel is recycled to become other building materials, and batteries and generators are reused on the land.[62] Sea2Cradle, a ship recycling company, states that it uses a green recycling program that creates minimal pollution by avoiding practices such as beaching, which is when ships are run aground on beaches and are then dismantled by local laborers.[63] In the United States, there are only eight certified locations for ship recycling, also called ship-breaking, five of which are in the Brownsville, Texas, area. These facilities break apart U.S. naval ships, as the United States prohibits the breaking down of military ships outside the country.[64] These ship-breaking locations are regulated by the Department of Transportation's Maritime Administration (MARAD) and are guided by Environmental Protection Agency guidelines. The Basel Action Network is a nongovernmental organization that works to prevent what it calls "toxic trade" in the disposal of hazardous waste around the world, and that has created guidelines with the United Nations for environmentally responsible ship recycling.[65]

For smaller vessels, the environmental problem is more complicated. Many older vessels use fiberglass hulls that are not cost-efficient to recycle. As a result, many of them

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[62] "Ship Recycling," United Nations Organization, accessed November 10, 2019, http://www.imo.org/en/OurWork/Environment/ShipRecycling/Pages/Default.aspx.

[63] "Ship Recycling," Sea2Cradle, accessed November 10, 2019, http://www.sea2cradle.com/ship-recycling/.

[64] Emily Badger, "How This Texas Town Owns the U.S. Naval Ship-Recycling Industry," Fast Company, October 24, 2012, https://www.fastcompany.com/3002137/how-texas-town-owns-us-naval-ship-recycling-industry.

[65] "About Us," Basel Action Network, accessed November 10, 2019, http://www.ban.org/about-us/.

are disposed via landfill.[66] Other hull materials, such as steel and aluminum, have more value in recycling and can be more readily disposed of. Often, the vessel can be sold at auction as surplus, which recoups some funds for the agency.[67] However, before a vessel can be auctioned off, agencies must pay to ensure all hazardous substances on the vessel have been removed, as required by the General Services Administration. This is a common practice in the disposal of government vehicles. Agencies may even invest a small amount of money for minor repairs to reclaim more money at auction.[68] Some vessels are retired and placed in reserve, and others are sold off to become historical vessels, such as the FDNY's retired fireboat *John D. McKean*, which was sold to two restauranteurs who wanted to preserve it for its history.[69]

As mentioned, the cost of recycling or the resale value to be recouped is a necessary part of life cycle costing. And life cycle costing is necessary to properly—and as accurately as possible—estimate the total cost of a vessel. The cost of disposal or recycling is a factor in estimating the next vessel's recycling costs as well. Due to Basel Action Network guidelines, these recycling issues must be considered in the early design stage due to the restrictions on hazardous materials and the records necessary for future disposal.[70]

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[66] Craig Ritchie, "Aging, Recycling Hulls a Looming Crisis," Boating Industry, January 12, 2017, https://boatingindustry.com/top-stories/2017/01/12/aging-recycling-hulls-a-looming-crisis/; Jim Flannery, "The Dead-Boat Disposal Crunch," Trade Only Today, January 25, 2016, https://www.tradeonlytoday.com/dealers/the-dead-boat-disposal-crunch.

[67] "Fire Boat," GovDeals, accessed November 10, 2019, https://www.govdeals.com/index.cfm?fa=Main.Item&itemid=77&acctid=8443; "2006 Metalcraft Marine FireStorm 30' Aluminum Fireboat," GovDeals, accessed February 9, 2019, https://www.govdeals.com/index.cfm?fa=Main.Item&itemid=10644&acctid=3934.

[68] Scott, "Replacement Mileage Creeping Up for Public Safety Agencies."

[69] Noah Remnick, "A Workhorse on the Hudson River, Now Retired from Fighting Fires, Chugs Toward a Second Act," *New York Times*, December 21, 2017, https://www.nytimes.com/2016/04/04/nyregion/a-workhorse-on-the-hudson-river-now-retired-from-fighting-fires-chugs-toward-a-second-act.html.

[70] Claudio Favi et al., "A Life Cycle Model to Assess Costs and Environmental Impacts of Different Maritime Vessel Typologies," *Proceedings of the International Design Engineering Technical Conference & Computers and Information Engineering* (2017): 1, https://doi.org/10.1115/DETC2017-68052.

5. Repeating the Cycle

The life of a vessel, as described above, appears to be linear: it has a beginning, a middle, and an end. However, life cycles should be seen as just that—circular cycles that are constantly repeating. Under normal operations, vessel operators have already begun planning and purchasing replacements before their current ships are retired. For example: Maersk, a major shipping company that ships products around the world, cannot wait the twelve to eighteen months it takes to replace a retired shipping vessel, or it risks losing income and losing customers to its competitors. In 2016, Maersk ordered twenty-seven new ships, which were delivered in 2017; while some of these ships were ordered to increase Maersk's shipping capacity, some were ordered to replace older or less efficient vessels.[71]

If a municipality relies upon vessels to fulfill a maritime mission and does not plan for the future replacement of aging systems, it runs the risk of not having the capacity to fulfill that mission—particularly if its vessels suffer a catastrophic failure that was predictable due to a vessel's age. Moreover, the agency will not have the time to study its mission needs in respect to vessel selection, much less wait for a new vessel to be ordered and built. Planning begins during the operational stage for each vessel, and allows agencies to prepare for the upcoming obsolescence and retirement of an aging fleet. For instance, in 2001, when its vessel was only eleven years old, the town of Charlestown, Maryland, began planning for a new vessel; the town continued to use the older vessel for more than fifteen years as stakeholders worked to secure funding for the new vessel.[72]

As a whole, vessel operations and systems should be viewed as an ongoing cycle (see Figure 1) that revolves around maritime capacity—not as a linear path that ends when the vessel's lifespan is over. Note that the planning portion for a new vessel should begin before the operational period ends for the current vessel. Once a new vessel is procured

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[71] Federica Ragonese, "Maersk Deploys First of 27 New Vessels Ordered," Container Management, May 3, 2017, https://container-mag.com/2017/05/03/maersk-deploys-first-new-vessels-ordered/.

[72] Meg Walburn Viviano, "Charlestown Fire Company's New Fire Boat 15 Years in the Making," *Chesapeake Bay Magazine*, August 15, 2017, https://www.chesapeakebaymagazine.com/baybulletin/2017/8/15/charlestown-fire-companys-new-fire-boat-15-years-in-the-making.

and accepted, the old one is recycled. This transition from a linear to a cyclical paradigm can help agencies maintain mission capability; after all, the mission of a maritime agency never ends, even if the equipment needed to complete that mission changes.

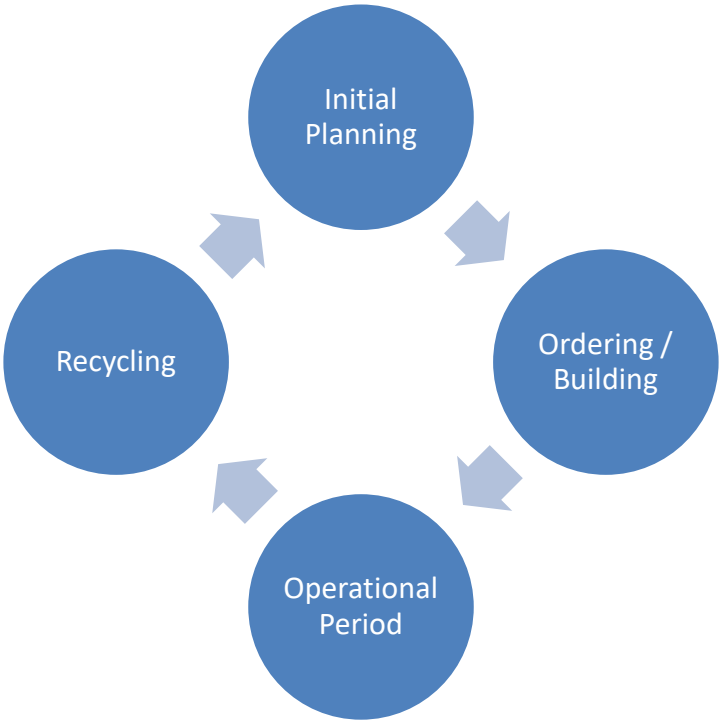

Figure 1. Life Cycle Costing Paradigm for Vessels

B. LIFE-CYCLE COSTING MODEL

The life cycle costing model—which is one potential model for establishing the cost for a vessel over its lifespan—was established by the Department of Defense in the 1960s and has been used by the General Services Administration. It views assets in a twenty-year cost cycle and compares the initial cost of acquisition to the costs of maintenance, training, repairs, and replacement.[73] Life cycle costing guides planners to replace an item before costs begin to climb due to aging systems or inefficiencies. In addition, stages used in life cycle costing parallel the stages of life for a vessel or ship.

[73] General Services Administration, "Life Cycle Costing."

In the article "Maritime Vessel Obsolescence, Life Cycle Cost and Design Service Life," O. Dinu and A. M. Ilie describe the life cycle costing method using the following formula:

$C_t = CO + CM + CF + CD$ (1)

where

C_t—total life cycle cost

C_O—initial cost

C_M—maintenance cost (this could include inspection, repair, layup, conversion, and modification and resale costs)

C_F—failure cost

C_D—disposal cost (this could include resale costs)[74]

To adapt this formula to determine the total cost of a municipal vessel, C_t is the total cost of the vessel over its lifetime. Initial cost of the vessel—including planning, development, and construction—is C_O. Maintenance, or C_M, is the normal preventative and estimated corrective maintenance cost of the vessel, including predicted engine replacement or yard work. Failure cost, or C_F, represents costs associated with injuries, fatalities, routine damage, shipyard damage, and environmental damage. Finally, C_D is the disposal cost of the boat, including resale or recycling costs (if there is a resale value, this is a negative value that reduces the overall cost of the vessel). The product of this formula is an estimate only; future costs cannot be fully predicted.[75] Overall, the goal should be to determine the optimal time to replace the asset or vehicle.[76] An agency or company that is buying a ship can use this formula to help determine when large-scale expenses will occur, to determine the appropriate lifespan of the vessel. When costs increase and it becomes inefficient to maintain a vessel, this can trigger plans for a replacement.

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[74] Dinu and Ilie, "Maritime Vessel Obsolescence," 3.

[75] Dinu and Ilie, 4.

[76] Bibona, "How to Calculate Optimal Replacement Cycles."

C. BEST PRACTICES AS ANCHORS FOR EVALUATING VESSELS

In 2018, a task force from the state of Missouri released a report that reviewed fleet management strategies, revealing that common standards for fleet management are needed to optimize efficiency. More importantly, however, the task force found that local agencies must go beyond *adopting* common practices: agencies are best positioned to *adapt* best practices to create their own strategies based on their specific needs.[77] Municipalities manage large numbers of vehicles—such as cars, buses, or trucks—as part of the business of government. Over time, some best practices have emerged for vehicle fleet management among cities and federal agencies, particularly from the city of New York and other municipalities, the U.S. Department of Health and Human Services, and industry literature such as *Government Fleet* magazine.[78] This section uses those best practices to create five anchors for evaluating vessel asset management: mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations.

1. Mission-Driven Planning

Defining a vessel's mission, or purpose, is a foundational planning principle for fleet management. A vessel's mission drives its capabilities, as well as the specifications that go into its design. Included in those specifications are environmental concerns for the vessel's area of operations. For example: Will the vessel be operating in salt water or fresh water? Will it need to operate in hazardous conditions—such as at shallow depths, or in storms, ice, or kelp? Without a clear understanding of the vessel's mission, it can be difficult to choose the right vessel or evaluate a vessel's performance. In a 2011 article for *Public Sector Digest*, Roger Smith emphasizes the importance of this planning, calling it "mission critical"; the state of Mississippi's university system echoes this finding in a

[77] Hawthorn Foundation, "Task Force on Fleet Management Final Report" (report, Hawthorn Foundation, January 10, 2018), 10, https://static1.squarespace.com/static/54fe01fde4b068b128045b78/t/5a5641b7e4966b8ca3e5ee52/1515602359720/20180110+COO+Task+Force+on+Fleet+Management_FINAL.pdf.

[78] "Bright Ideas: Fleet Management Policies," *Government Fleet*, July 13, 2009, http://www.government-fleet.com/146280/bright-ideas-fleet-management-policies.

report about policy guidelines for vehicle use.[79] While Smith's article also discusses vehicles, his considerations translate easily to vessels. He reviews, for instance, challenges such as road grades, gross vehicle weight ratings, and cargo against the vessel's mission, environment, and capacity. Smith believes this information can be used to create specifications for the selection of an appropriate vehicle (or vessel).[80]

Sticking with the vehicle comparison, industry publications in vehicle fleet management suggest that when selecting a vehicle (car, truck, or bus), fleet managers should avoid looking at the "bottom line" of cost, and should instead evaluate the vehicle's capabilities.[81] Like for vessels, government vehicle fleets are often managed through their entire lifespan, from planning to procurement, maintenance, replacement, and finally disposal. And vehicle assignment is typically based on mission: What will be the scope of the vehicle's duties? How must it be equipped for the mission? For buses, is the bus set up to operate in certain conditions? How many people should it carry?[82] The city of Mount Lebanon, Pennsylvania, provides a good example: the city categorizes its equipment in a four-year fleet management plan, where it delineates the types of vehicles needed and provides a rationale based on the mission of each vehicle.[83] At the federal level, the U.S. Department of Health and Human Services has an overarching strategic plan that addresses vehicle fleet management and procurement, due to the number of vehicles it fields for its staff.[84] The department's strategy covers the vehicle's purpose, the scope of its use, and strategies to determine which type of car to assign to which class of employee. It also

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[79] Smith, "Best Practices in Fleet Management," 2; Mississippi Board of Trustees of State and Institutions of Higher Learning, "Motor Vehicle and Fleet Management Best Practice Guidelines," Guide (Mississippi Board of Trustees of State Institutions of Higher Learning, Office of Risk Management), accessed February 15, 2019, http://www.mississippi.edu/rm/downloads/emergency_plans_best_practices_guidelines/motor_vehicle_fleet_mgt_best_practices.pdf. pg. 5

[80] Smith, "Best Practices in Fleet Management," 2.

[81] Chris Shellenbach, "6 Steps to Better Fleet Vehicle Selection," Union Leasing, March 3, 2015, http://insights.unionleasing.com/6-steps-to-better-fleet-vehicle-selection.

[82] Smith, "Best Practices in Fleet Management," 2.

[83] Municipality of Mt. Lebanon, "Proposed Fleet Replacement Schedules 2013–2017" (fleet management document, Municipality of Mt. Lebanon, October 2, 2012), 6–10, https://www.mtlebanon.org/DocumentCenter/View/9081/FLEET-MANAGEMENT-2013-2017?bidId=.

[84] James H. Kerr, "U.S. Department of Health and Human Services 2015 Fleet Management Plan" (planning document, U.S. Department of Health and Human Services, July 23, 2015).

addresses the direct and indirect costs of the vehicle; indirect costs can include maintenance and support staff.

Those who manage vehicle fleets must also plan for future technological or regulatory changes, such as those that might affect fuel economy, when creating an overall strategy. In the case of the Health and Human Services Department, fuel efficiency was a guiding principle for the purchase of new cars and SUVs.[85] Most importantly, this shows that the department used an overarching principle to guide vehicle replacement. The department's fleet management plan document also forecasts the types of vehicles it will need in the future based on its overarching goals and mission.

When it comes specifically to maritime vessels, the FDNY's "Marine Operations Strategy" includes a detailed approach to planning for the acquisition and construction of its vessels.[86] It considers how the vessel's mission fits into the agency's tiered response for emergency calls. For instance, the smaller, faster vessels respond to an incident first, then the larger (tier 1) vessels are deployed if needed. Vessels are purchased or designed based upon their mission within the tier system.

2. Procurement and Replacement Schedules: Planning for the Future

Replacement practices are fairly well documented for cars, trucks, buses, and other special municipal vehicles such as firetrucks. Rather than waiting for a vehicle to fail, a city can plan to replace a vehicle based on its age or mileage, and can begin budgeting or seeking funding for the replacement in advance. There are few specifics in the literature, however, when it comes to replacement for vessels. A key component for replacement planning is determining the vessel's lifespan, and the requests for information sent for this thesis (discussed in more detail in Chapter IV) show that the vessel's hull material is most often used in this determination. Life cycle costing can also be used to estimate when the cost of the vessel's ongoing maintenance will become too high.

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[85] Kerr, 15.

[86] Fire Department of New York, "Marine Operations Strategy" (strategy document, Fire Department of New York, December 1, 2010), 2–4.

For cars and other municipal public safety vehicles, a best practice is to establish lifespans using maintenance costs, operating expenses, depreciation, and the amount of time the vehicles are out of service.[87] For instance, many police departments use a specific schedule for disposing of police patrol vehicles at auction, such as when the vehicle reaches 100,000 miles.[88] Some municipalities, such as the city of Mt. Lebanon, Pennsylvania, replace vehicles based on their age.[89]

The city of New York takes a different approach: it defines the conditions under which the vehicle can be replaced. The 2016 "New York City Fleet Management Manual" dictates several considerations that go into such a decision. For example, planners seek to determine if the vehicle is fulfilling the city's mission, and the job it was purchased for. They also evaluate repair, damage, or maintenance history against the cost of replacement, with consideration for city safety and emissions standards, the availability of replacement parts, and whether or not the vehicle's technology is outdated. When the age of a vehicle—but only when combined with factors such as mileage, engine hours, and the overall vehicle condition, including mechanical and body condition—means it is more economical to simply replace the car, the city can opt to do so; the vehicle's age alone is not enough to warrant a replacement.[90] It is important to note that these criteria apply to vehicles only; the fleet management plan does not address vessels, so any application of this protocol toward vessels is purely theoretical. The plan does show, however, a more complex matrix to evaluate vehicles for replacement—based on more than just the vehicle's age—and it can potentially be used as a model for vessels.

Moreover, if an agency depends heavily on its physical assets, such as vessels or vehicles, the management and planning of those assets become increasingly important. A lost vehicle or vessel means lost mission capabilities. In a 2008 article, Diaswati Mardiasmo and coauthors, most of whom are business professors from the Queensland

[87] Scott, "Replacement Mileage Creeping Up for Public Safety Agencies."

[88] Scott.

[89] Municipality of Mt. Lebanon, "Proposed Fleet Replacement Schedules," 11–15.

[90] Camillo, "Fleet Management Manual," 17.

University of Technology, state that the organizations that are heavily asset-reliant will be strongly impacted by asset performance. Some of the sectors they identify are transportation, mining, and utilities.[91] This risk also applies to municipal public safety fleets such as fire or police agencies.

For the purposes of this thesis, the following description of asset management is most relevant:

> Asset management generally starts as early as identifying the need for a new asset. This is followed by writing asset specifications, forecasting financials related to the asset, predicting its life cycle, acquirement of asset, maintenance of assets, reporting of assets, and disposal system for assets.[92]

This description highlights the importance of planning for new assets as part of managing a fleet. It recognizes that a new asset, or vessel, is needed as part of this process, pointing to the need for creating a replacement schedule ahead of time rather than reactively replacing a failed system. When an agency continues to use a vessel that is operating beyond its estimated lifespan, the vessel may suddenly fail; and without a replacement schedule, there will be no replacement on hand. Agencies cannot effectively plan for a new vessel when they are in crisis mode due to a vessel failure, yet they must still maintain their maritime capacity. Agencies cannot continue forward on borrowed time and hope for the best.

3. Funding

Asset managers must evaluate the financial costs for operating their vessels beyond the initial purchase, and account for these costs in their fleet budget. Forecasting and maintaining the budget in a manner that eliminates waste is also part of this process, especially in the municipal setting. This is often done in a yearly budget cycle, but could be expanded to cover multiyear forecasting.[93] Preventative maintenance is necessary in fleet management to maintain efficiency and extend vessels' service life, and repairs will

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[91] Mardiasmo et al., "Asset Management and Governance," 3.

[92] Mardiasmo et al., 5.

[93] John Moore, "How to Develop and Control a Fleet Budget," *Automotive Fleet*, March 1, 2000, http://www.automotive-fleet.com/144892/how-to-develop-and-control-a-fleet-budget.

also be needed to address unexpected damage or breakage that occurs while vessels are in service.[94] Fleet managers therefore need a projected budget for ongoing maintenance, parts to be kept on hand, and fuel, as well as for the creation of a preventative maintenance schedule (usually this schedule can be determined by the manufacturer). The budget for maintenance should be estimated using the life cycle costing method. This will generally translate into yearly budgets and schedules for these items.

The aforementioned article by Smith describes maintenance costs as either preventative or reactive. Reactive maintenance responds to a failure that has taken the asset out of service—for example, a flat tire or engine failure on a bus. The asset cannot go on until it is repaired. Preventative maintenance, on the other hand, is completed to avoid catastrophic failures, or to maintain the performance and efficiency of the asset. Preventative maintenance can be predicted and even budgeted for to maximize the amount of time a vehicle is in service. Smith proposes that planners should budget fifty cents for reactive maintenance funds for every dollar budgeted for preventative maintenance funds, a model that allows vehicles to have 98 percent in-service time, or "uptime."[95]

Fuel costs, just like maintenance costs, must also be forecast and included in the budget for a vessel's life cycle. A 2008 article noted that fuel costs are overtaking depreciation costs in government fleets.[96]

4. Personnel

The number of staff members needed to operate a fire truck is an important consideration for an agency that is purchasing a fire apparatus—and the same consideration is important for maritime vessels. How many staff members are needed to operate the vessel for its tour of duty? Does the agency have a minimum staffing level? What types of training and skill sets are needed for the staff members who operate and maintain the vessel? These staffing considerations—and the pay, burden, and overhead that come with

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[94] Smith, "Best Practices in Fleet Management," 2.

[95] Smith, 2.

[96] Chad Simon, "Fleets Share Fuel Management Best Practices," *Government Fleet*, September 1, 2008, http://www.government-fleet.com/146063/fleets-share-fuel-management-best-practices.

them—need to be built into personnel budgets. Staffing considerations must also heed the number of personnel needed for reactionary and preventative maintenance; this should be a significant part of the maintenance plan for a vessel as well.

5. Disposal

As previously discussed, there are environmental concerns when it comes to disposing of a maritime vessel. Asset managers must therefore make plans for a vessel's safe disposal, such as selling the vessel at an auction or sending it to a scrap yard for recycling. Money recovered at an auction decreases the vessel's overall life cycle cost. And if there are costs for environmental mitigation of hazardous waste from the vessel, this will increase the overall life cycle cost. There are advantages to buying government-owned vehicles at auction, as consumers know they are generally well cared for.[97] This could translate to vessels as well. The disposal of a vessel can also potentially lower its overall life cycle cost if its parts can be recycled.

The process for disposing of a retired vessel can be planned. Smith also addresses disposal indirectly in his article, touching on the importance of finding the optimal age for disposal of assets to minimize life cycle cost.[98] However, vessels have much longer lifespans than the vehicles Smith discusses. Municipal vessels or vehicles can be held in reserve, sold via municipal processes to recoup public funds, or destroyed. The town of Blue Mountains in Canada, for example, has set timeframes for when a fire apparatus is considered part of the front line (years one through fifteen), when it is moved to second-line status (years sixteen through twenty), and when it is transitioned to reserve status (years twenty through twenty-five); these timelines may differ based on the size of the city and fire insurance ratings for the area.[99]

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[97] Scott, "Replacement Mileage Creeping Up for Public Safety Agencies."

[98] Scott.

[99] Chapman, Doherty, and Lake, "Asset Management Plan," 8.

D. CONCLUSION

Ships, like all other assets, have a life cycle. Life cycle costing can use information about the vessel to estimate the overall cost it will incur over its planning period, operational life, and eventual retirement or recycling. With this knowledge, municipalities can make plans to replace their maritime vessels. Municipalities can also use the best-practice anchors of municipal vehicle fleet management to plan effectively for vessel replacement; the anchors represent a process that seems widely accepted in the field, though it is undocumented in the literature.

III. AGENCY EXPERIENCES IN VESSEL PLANNING AND ACQUISITIONS

In 1989, the San Francisco Fire Department was preparing to retire its lone, aging fire vessel, the *Phoenix*. Many in government saw it as an obsolete firefighting system that was never used. Then, on October 17, the Loma Prieta earthquake struck the area, and the fireboat was pressed into action. Ever since, the fire department has maintained a fleet of three fire vessels.[100] Throughout the United States, other municipalities use vessels for public safety and homeland security functions as well, such as port security and police and fire response.

Many municipalities purchase off-the-shelf vessels; such vessels are often easier to purchase than custom-built solutions because they are based on established systems that are already in use. They are also often quick to procure because little time is needed for research and design, though they can still be lightly customized or adapted by the manufacturer with proper planning and ordering, as discussed in Chapter II. Alternatively, vessels can be designed from the keel up based on mission needs, which is known as a design-build strategy. In larger agencies, such as the U.S. military, planners use an established, complex system to plan for vessel acquisition; however, the U.S. military is not immune to the temptation of off-the-shelf solutions. Such solutions may not fulfill the requirements the military seeks in a design, but their ease and cost make them attractive.

This chapter evaluates three municipal vessel cases: the FDNY's *Three Forty Three* and *Fire Fighter II*, the San Diego Harbor Police Department's vessel acquisition from MetalCraft Marine, and the U.S. Navy's attempt to use the littoral combat ship design for a new frigate system. The five anchors established in Chapter II—mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations—are used to evaluate each system.

[100] Cheryl Jennings, "Lessons Learned from Loma Prieta Earthquake," ABC7 San Francisco, October 14, 2014, https://abc7news.com/349748/.

A. FDNY'S DESIGN BUILD FOR TWO NEW FIREBOATS

The FDNY operates a large marine division that uses multiple vessels, from thirty-foot rapid-response vessels to its two newest 140-foot Tier 1 response vessels, the *Three Forty Three* and *Fire Fighter II*. The Marine Division is manned by 120 members of the FDNY and is responsible for fire, rescue, and medical response for over 560 miles of coastline.[101]

The *Three Forty Three* and *Fire Fighter II* replaced fireboats that were over fifty years old (they began their service in 1938 and 1956) and that were incurring increasing maintenance costs.[102] The older vessels had been adapted to a changing list of needs as firefighting evolved over time. For example, the vessels began service before foam was used in firefighting. As a result, these older vessels stored foam on deck in fifty-five-gallon drums, where it froze in cold weather; modern vessels store foam in an onboard tank. The older vessels also required the use of Jacob's ladders, which are ladders used to board vessels whose decks are a different height than the waterline (see Figure 2). These ladders can be difficult for firefighters to maneuver in full gear. The literature does not indicate that the older vessels had any chemical, biological, radiological, nuclear, or explosive (CBRNE) capability.

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[101] Donald J. Mihalek, "The FDNY Marine Unit," *Tactical Life*, July 20, 2012, https://www.tactical-life.com/exclusives/the-fdny-marine-unit/.

[102] Jane Jerrard, "FDNY's New Fireboat, the Three Forty Three," *Fire Rescue Magazine* 5, no. 9 (September 2010), https://www.firerescuemagazine.com/articles/print/volume-5/issue-9/vehicle-operation-apparatus/fdny-s-new-fireboat-the-three-forty-three.html; Alan M. Petrillo, "Special Delivery: Two New Fireboats for FDNY," *Fire Apparatus & Emergency Equipment* 5, no. 16 (May 2011), https://www.fireapparatusmagazine.com/articles/print/volume-16/issue-5/features/special-delivery-two-new-fireboats-for-fdny.html.

Figure 2. Jacob's Ladder Used to Board Vessels.[103]

1. Mission-Driven Planning

The FDNY has documented its maritime mission in a document simply titled "Marine Operations Strategy," which outlines what it refers to as a "tiered response" to maritime threats. In this model, each vessel in the tier has specific capabilities, and each tier aligns with strategies outlined by the Department of Homeland Security to address an all-hazards approach.[104] The response size (or tier) is based on the needs for addressing the particular fire or threat. Smaller, faster, and more agile tier 2 vessels respond first, and tier 1 vessels are dispatched to larger incidents. This allows for flexibility to address additional threats as they arise. FDNY uses the catchphrase "fast, powerful, and agile" for its Marine Division; this vision and the tired response strategy have driven the department to retired old vessels in pursuit of new technology.[105]

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[103] Source: "Petty Officer Second Class Clint Foster clings to the Jacob's ladder," Department of Defense, accessed November 16, 2019, https://archive.defense.gov/Photos/newsphoto.aspx?newsphotoid=1229.

[104] FDNY, "Marine Operations Strategy," 3–4, 6.

[105] Remnick, "Workhorse on the Hudson River."

The "Marine Operations Strategy" also outlines the department's overall processes for managing threats to water-side locations. Its overarching mission is as follows:

> To protect lives and property within the Port of New York and New Jersey and surrounding regions by responding to fires, water rescues, hazardous material incidents, medical emergencies and maritime disasters. In collaboration with port security partners, Marine Operations advances public safety through incident prevention, harbor protection and safety education. The robust and timely response of FDNY's Marine Operations protects the Port of New York and New Jersey and strengthens homeland security efforts.[106]

The department must work to address all the threats inherent in any given mission (an all-hazards approach), and all the elements of the mission directly impact the design of the department's fireboats. The department, and its vessels, must protect the harbor, which is significant when considering the size and nature of shipping and infrastructure in New York Harbor. Finally, the strategy notes a robust response, which dictates the amount of resources the agency can leverage in conjunction with its Port Authority neighbors.

The FDNY's strategic outlook led the design of the new *Three Forty Three* and the *Fire Fighter II*, which were delivered in 2010. Both vessels were designed for an all-hazards approach, utilizing a command-and-control system. Speed, pumping capacity, and firefighter boarding access to other vessels were capability requirements. In addition, the vessels' cabins are pressurized above atmospheric pressure to keep the crew safe from CBRNE threats, for an all-hazards or counterterrorism design approach. The design of the vessels was collaborative: FDNY staff met with U.S. Navy engineers from the Joint Program Executive Office for Chemical and Biological Defense and Naval Sea Systems Command.[107] Staff from the FDNY also visited fire agencies in Seattle and Los Angeles that had recently purchased vessels from the vendor Robert Allan Ltd., for additional insight.[108] These vessels were planned for under the overarching principles of the department's operations strategy and were purpose-built.

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[106] FDNY, "Marine Operations Strategy," 2.

[107] "Ahoy? FDNY Launches New Fireboat," *View Point FDNY Newsletter* (October 2009): 3.

[108] Petrillo, "Special Delivery."

2. Procurement and Replacement Schedules

Although the FDNY does not have a vessel-specific replacement plan, the city of New York has documented criteria for vehicle replacement, as noted in the previous chapter. It is reasonable to assume that these same criteria can be used in the replacement of vessel systems. The previous vessels had become obsolete and no longer met the mission standards. The vessels also lacked capabilities needed for firefighting and other threats, such as CBRNE, that had emerged since their design and purchase. Even if the vessels were mechanically sound and could pump great amounts of water in support of firefighting operations, the vessels could not address the emerging threats seen in the homeland security realm. This made the vessels ineffective for their role in the FDNY, and technically obsolete.

3. Funding

Both the *Three Forty Three* and *Fire Fighter II* were purchased using $54 million in federal Port Security grants, with the remainder of the money coming from the city.[109] This is indicative of that fact that grants fund most, if not all, public safety vessel purchases.

There is no specific line item in the FDNY budget that addresses the marine units or their support. The FDNY Marine Division does not appear anywhere in the department's budget, so it is impossible to evaluate its funding for day-to-day operations. Of the overall budget, $1.4 billion goes to responding to and extinguishing fires, which covers marine units along with all other fire response. Contract services for motor vehicle equipment, which would theoretically cover vessels as well, is listed as $2.2 million in the department's fiscal year 2019 budget.[110]

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[109] Jerrard, "FDNY's New Fireboat."

[110] Latonia McKinney et al., "The Council of the City of New York Report of the Finance Division on the Fiscal 2019 Preliminary Budget and the Fiscal 2018 Preliminary Mayor's Management Report for the Fire Department of New York" (report, City of New York, March 8, 2018), 30.

4. Personnel

The FDNY staffs three marine companies which comprise 120 specially trained marine firefighters. The FDNY staff stationed with the Marine Division conducts daily maintenance and checks.[111] The staff members have highly specialized roles—including marine pilots, marine engineers, and wipers—each of which conducts specific tasks. Pilots operate and navigate the FDNY's fireboats, and must have a U.S. Coast Guard Merchant Mariners 100 Ton Master License.[112] Marine engineers operate and even repair the engines and pumps of the vessel, conducting maintenance operations both above and below; they must hold a U.S. Coast Guard Merchant Marine engineer license before they apply for a position with the FDNY.[113] Wipers are firefighters who help marine engineers maintain the vessel's engines, pumps, and other equipment. The wipers must also acquire a Merchant Marine license through the U.S. Coast Guard before they can be promoted. These are promotional positions, not rotational assignments. Civilian divers for the city's marine repair shops receive advanced SCUBA training—not for water rescue but to perform under-hull inspections of the FDNY fireboats, or even to clear damage from debris below the waterline.[114]

5. Disposal

The *John D. McKean* and the *Fire Fighter I* were the last two FDNY fire vessels that were retired. Both were removed from active service around 2010, and disposal was difficult. One vessel was auctioned, and the other was donated as a historical artifact to the city of New York. Because of their connection to the city, the vessels were revered for their

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[111] Amy Freeze and Jon Sprei, "EXCLUSIVE: Amy Freeze Tours FDNY Marine Unit's Life-Saving Vessels," ABC7 New York, May 21, 2018, https://abc7ny.com/3502491/.

[112] Edna Wells Handy, "Notice of Examination—Promotion to Marine Pilot, FDMY Exam #3528," (notice, City of New York, January 2013), http://www.nyc.gov/html/dcas/downloads/pdf/noes/201303528000.pdf.

[113] Edna Wells Handy, "Notice of Examination—Promotion to Marine Engineer (Uniformed—Fire Department)" (notice, City of New York, Department of Citywide Administrative Services Application Unit, January 30, 2002).

[114] "Maintaining the Fleet—The Marine Maintenance Diver Program," FDNY, accessed February 4, 2019, http://www.fdnypro.org/maintaining-the-fleet-the-marine-maintenance-diver-program/.

service and their place in history.[115] The *John D. McKean* (see Figure 3), which cost over $1.4 million in 1954, was sold at auction for $57,400 in 2010 to two restauranteurs who wanted to create a historic legacy for the vessel by turning it into a museum near their restaurants.[116] Later, the restauranteurs met resistance from local residents about the placement of the vessel on the waterfront, which impacted their view.[117] The vessel is operated as a museum and maintained by a nonprofit organization, the Fireboat McKean Preservation Project.[118] In 2017, the *Fire Fighter* was placed in nearby Greenport as a historical attraction.[119]

Figure 3. The FDNY Fireboat *John D. McKean.*[120]

[115] "About the Fireboat Fire Fighter Museum," America's Fireboat, accessed November 27, 2019, https://americasfireboat.org/about/.

[116]"There is no indication within the FDNY budget of income from auctioned equipment. It is unknown which fund this money actually goes to.

[117] Edgar Sandoval and Thomas Tracy, "Sleepy Hollow Residents Complain FDNY Relic Blocks Their Riverfront Views," *New York Daily News*, February 1, 2018, https://www.nydailynews.com/new-york/sleepy-hollow-residents-fdny-relic-blocks-views-article-1.3793959.

[118] NYC Fireboat John D. McKean Preservation Project," accessed March 17, 2019, https://www.fireboatmckean.org/.

[119] Remnick, "Workhorse on the Hudson River."

[120] Source: Image gallery, Fireboat John D. McKean Preservation Project, accessed November 16, 2019, https://www.fireboatmckean.org/gallery-1/mhoejzwycyln5zt04ov1aamalrhocv.

At a cost of 12.5 percent of the funds, the city of New York uses the website PropertyRoom.com to auction off all surplus or retired equipment, from police cars to fire engines.[121] It can be reasonably assumed that fire vessels, once retired, also fall into this category. These recovered funds from auction are not specifically identified in the overall city budget and cannot be found in the FDNY budget. The FDNY should better identify these funds as income in the city budget, and should factor them into life cycle costing calculations. These funds could be directed to the vessel program to potentially defray operating costs. Other potential programs that could use these funds include planning, vessel acquisition, and training. Keeping the funds within the program would illustrate the advantages of recycling vessels as assets.

B. SAN DIEGO HARBOR POLICE'S STRUGGLING OFF-THE-SHELF SOLUTION

The Port of San Diego Harbor Police Department was established by the Port District Act of 1962 in the California Legislature.[122] This public safety agency has a combined police and marine firefighting mission. The Harbor Police Department is responsible for the San Diego Bay, its surrounding tidelands, and contract law enforcement for the San Diego International Airport. The agency's specific duties in the maritime area of San Diego Bay include security and police services for Maritime Transportation Security Act facilities (two cruise ship terminals and two cargo terminals), police response to waterborne incidents, and maritime firefighting. The Port of San Diego is considered a strategic port by the Department of Defense and the Department of Transportation's Maritime Administration. This means the port is considered a significant location for military loading or support in times of national emergency.[123] The Harbor Police Department has a 140-member force and there are ten vessels assigned to the

[121] Shane Dixon Kavanaugh, "Shift to Online Car Auctions Yields 6-Acre Bonus," Crain's New York Business, May 12, 2012, http://www.crainsnewyork.com/article/20120515/REAL_ESTATE/120519932.

[122] California Legislature Acts of 1962, Ch. 67 § 1 (1962), http://www.slc.ca.gov/programs/Granted_Lands/G10_San_Diego/G10-08_San_Diego_Unified_Port_District/S1962_Ch67.pdf.

[123] Joan M. Bondareff and Katherine V. Scontras, "Strategic Seaports," Blank Rome LLP, December 2012, https://www.blankrome.com/publications/strategic-seaports.

department.[124] Of those, there are currently five police/fire vessels from MetalCraft Marine, four SAFE Boats International law enforcement vessels, and one small rigid-hull vessel for dive operations. Officers of the department are cross-trained in marine firefighting.[125]

In 2009, the Harbor Police vessel fleet was facing some specific challenges. The fleet included four thirty-two-foot Livesay-hull, custom-built vessels, and the agency had just retired a 1960s-era Bertram fishing vessel that had been adapted for policing/ firefighting. These vessels had a fiberglass, wood-framed hull, and were an average age of twenty-four years old. The boats had significant maintenance issues such as broken engine mounts, diesel engines that were operating at double the expected lifespan, and $2.5 million in anticipated repair costs in the coming years.[126] In addition, the vessels' power plants had been converted from diesel to gasoline in the 1990s, only to be converted back to diesel in the 2000s. These older vessels' diesel engines were out of environmental compliance under new air pollution standards in the district, making them no longer usable as police vessels.[127] The department studied new designs and selected the MetalCraft Marine Firestorm 36 vessel, shown in Figure 4, to replace the obsolete fleet of vessels.

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[124] Port of San Diego, "Harbor Police Functions."

[125] Matt Hoffman, "San Diego Harbor Police Officers Double as Maritime Firefighters," KPBS, October 3, 2018, https://www.kpbs.org/news/2018/oct/03/port-san-diego-harbor-police-officers-double-marin/.

[126] Office of the District Clerk, "Port of San Diego, 09-01-09 Board of Port Commissioners Action Agenda—Regular Closed Session—Agenda Item 29" (agenda, San Diego Unified Port District, September 11, 2009)

[127] Office of the District Clerk, 3.

Figure 4. Off-the-Shelf MetalCraft Marine Vessels Purchased by the Port of San Diego Harbor Police[128]

1. Mission-Driven Planning

A committee evaluated and outlined vessel requirements with a strong emphasis on firefighting, an all-hazards approach, and an off-the-shelf solution. The agency eventually selected the MetalCraft Marine Firestorm 36 based on the criteria and a compressed timeline caused by the grant performance period. Representatives from the Harbor Police Department submitted a request to the San Diego Unified Port District Board of Directors in September 2009 to use State of California Port Security Grants to purchase the initial two of five vessels. The vessels are aluminum, flat-bottom hull designs and use twin Cummins 5.9L diesel engines that fall within Tier 2 environmental regulations. The vessels use jet propulsion for greater speed and maneuverability.[129] The Firestorm 36 is a multi-mission platform for both police and fire response. The vessel is designed to operate at a speed of approximately 45 knots with the new jet drives and has a shallower draft than the earlier fireboats, making the vessel capable in shallow water.

[128] Source: Port of San Diego Harbor Police, accessed November 16, 2019, https://www.portofsandiego.org/public-safety/harbor-police

[129] Bob Duemmel, "San Diego Harbor Police Provides Fire, Rescue Protection on Water," Firehouse, March 12, 2013, www.firehouse.com/rescue/technical-rescue/confined-space/article/10891911/san-diego-harbor-police-provides-fire-rescue-protection-on-water.

The major mission-driven impetus for the department purchasing the off-the-shelf vessels was firefighting. Initial studies showed that the MetalCraft Marine vessels were an ideal solution for three main reasons. First, they met National Fire Protection Association (NFPA) standards for marine firefighting. Second, the vessels were an all-hazards platform that met Port Security Grant guidelines. Finally, MetalCraft Marine could build the vessels and deliver them within the grant performance period.[130] The initial acceptance in 2010 went without incident. By 2014, however, numerous issues began to emerge. First, engines were consistently overheating, causing turbocharger failure as well as complete engine failures, necessitating engine replacements. The department adapted the vessels by changing the heat sensor locations to alert operators in advance of overheating, by changing vessel operation procedures, and by changing the piping for coolant water coming into the water exchange system.

It became evident over time, also, that the vessel is not well-suited to operations in kelp beds, which clog the jet water intakes. These kelp beds surround the area of Point Loma to the west and south, and the entrance to San Diego Bay directly outside the Port of San Diego's jurisdiction.[131] The kelp regularly enters the bay as well. Adaptations were made by purchasing "claw" mechanisms to clear kelp from the intakes.

The vessels are also difficult to operate in high winds due to the flat hull design. This is because the higher profile of the cabin area and flat hull make the vessel vulnerable to wind gusts when it is operating at slow speeds. Moreover, on the open ocean, the flat hull does not provide adequate stability with swells. The vessel also has to dedicate one engine to the pump system when conducing firefighting operations, making the fireboat difficult to maneuver for most vessel operators. Firefighters must dock the vessel in proximity to firefighting operations to keep the vessel stable while still supplying firefighting water.

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[130] Office of the District Clerk, "BPC Board Minutes," 1–2.

[131] "Point Loma Kelp Beds Fishing Map," Mexfish, accessed March 15, 2019, https://www.mexfish.com/enad/enad/plkelpmp/plkelpmp.htm.

Additionally, once the vessels were in use, the cooling water intake hardware began to break because the parts were constructed of dissimilar metals (aluminum and stainless steel), causing galvanic corrosion.[132] This led to the aluminum portion of the joint breaking and water filling the bilge, which put the vessel at risk of sinking. Firefighting pipes became pitted due to aluminum corrosion at joints, which means the aluminum piping had to be replaced with stainless steel piping.

The MetalCraft vessels were also operated more often than traditionally intended for police departments. The deployment model called for two vessels, each with two crew members, to be underway on patrol during a ten-hour shift, with three shifts per day. When the vessel was initially evaluated, it was beleived to meet the department's goals for this type of deployment.[133] However, when the department's maintenance staff queried the manufacturers, they discovered that such vessels are usually operated by fire departments, where the operational tempo differs significantly from police departments; fire agencies often store the vessels on lifts or at the dock and operate them only half as much as the Harbor Police, who conduct maritime police operations twenty-four hours per day.

2. Procurement and Replacement Schedules

There is currently no schedule for replacing vessels in the Port of San Diego Harbor Police's fleet. Previously, with the older Livesay hulls, vessels were used until they were unserviceable or became too expensive to maintain. This pattern of waiting for imminent failure before replacement continues with the current fleet, as evidenced by new major component replacements. In January 2019, a local boatyard in San Diego was awarded a bid to replace four engines that were in danger of failure on two of the Harbor Police vessels. Based on engine oil samples, it was determined that the engines had excessive wear, and that they would fail if they were not replaced. The older engine had a realized

[132] "Types of Marine Corrosion," Boat Owners Association of the United States, accessed November 16, 2019, https://www.boatus.com/boattech/articles/marine-corrosion.asp.

[133] Office of the District Clerk, "BPC Board Minutes," 2.

lifespan of six years or 6,000 hours, while the new engines have a projected nine-year, 9,000-hour lifespan.[134]

In 2020, the oldest of the Firestorm vessels will have been in service for ten years. The agency is now looking ahead to acquire new vessels with a more comprehensive view of the strategic selection process that incorporates lessons learned. While there is no current plan for funding new vessels, the Homeland Security Grant program is the most likely source. This lack of forecasting for budgeting or funding, and the reliance on grants, in part inspired this thesis's mission to find a better way to manage vessels as assets, to plan for the next generation of vessels for public safety, and to look for best practices.

3. Funding

The new Firestorm vessels were purchased using fiscal year 2007 and 2008 Proposition 1B California Maritime Port Security Grant Program funds. These funds had previously been frozen by the state due to the budget crisis, but were unfrozen in mid-2009.[135] These funds did not require any matching funds by the agency, but the grant did not allow for an extension of a June 2010 performance deadline. Due to these time constraints, and their tie to the sole source of funding for the vessels, the initial purchase bypassed a normally required competitive bid process.[136]

While numbers specific to the operation and support of the vessels do not appear in budget documents, the following general information was found in the district's 2018 financial report. The Harbor Police Department has a total operation budget of $23.9 million after accounting for contract expenses for law enforcement services at the San Diego Regional Airport. Total Port District support services, which include maintenance

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[134] Parimal M. Rohit, "Marine Group Boat Works to Repower San Diego Harbor Police Fireboats – The Log," *The Log*, January 30, 2019, https://www.thelog.com/local/marine-group-boat-works-to-repower-san-diego-harbor-police-fireboats/.

[135] Arnold Schwarzenegger, "State Budget 2008–2009" (report, Office of the Governor, State of California, September 23, 2009), 12, http://www.dof.ca.gov/Budget/Historical_Budget_Publications/2008-09/documents/State_Budget-Veto_Message_2008-09.pdf.

[136] Office of the District Clerk, "BPC Board Minutes," 1.

support for the Harbor Police vessel fleet, cost $37.7 million.[137] For an example of maintenance costs, the 2019 engine replacement mentioned above, which included one spare engine and transmission module for maintenance needs, cost $398,000. This was funded by the Port District budget.[138]

4. Personnel

The Port of San Diego employs three full-time marine mechanics who are specifically trained in vessel diesel engines, and outsources any work that is beyond their mandate. The port does not have a maintenance facility of its own to conduct vessel haul-outs or major maintenance.

The Port of San Diego has a mandated staffing level of 140 officers. Officers receive specialized in-house training in vessel operations and marine firefighting but are not formally certified as firefighters. The staffing model has two, two-officer vessel units on patrol at any given time. This covers three shifts every day. In the agency, all officers work vessel patrol, and officers are all cross-trained in maritime firefighting through a department-created and -presented course. Vessel operators are certified after a training period on the operation of the vessel through a formal process. This system allows for more flexibility with staffing but does not allow for specialization in firefighting operations.

5. Disposal

The current status of vessel disposal follows Port District rules that allow for surveying of the vessel and eventual auction. Three Livesay hull vessels, for example, were sold at auction to reclaim funds for the Port's General Fund. The converted Bertram fireboat was removed from service the previous year in a similar manner. One Livesay hull vessel was donated to a local entity for research. Due to the fiberglass hull design, these vessels were not good candidates for recycling. It is a reasonable assumption that the

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[137] Michael Arons et al., "Port of San Diego Comprehensive Annual Financial Report" (report, Port of San Diego, November 21, 2018), 30, https://pantheonstorage.blob.core.windows.net/administration/2018-cafr-final.pdf.

[138] Parimal M. Rohit, "Marine Group Boat Works to Repower San Diego Harbor Police Fireboats," The Log, January 30, 2019, https://www.thelog.com/local/marine-group-boat-works-to-repower-san-diego-harbor-police-fireboats/.

current vessels, when retired, will likely go through a similar process of auction. This is a standard process for all "surveyed" port assets (retired assets), whether it be cars, trucks, or office equipment. These recovered funds from auction are sent to the Port General Fund and not recouped specifically by the agency. If this is the case for the MetalCraft Marine vessels when they are retired, the metal from the vessels themselves (the hulls are made of aluminum) could be recycled following the appropriate hazardous materials mitigation.

C. U.S. NAVY AND THE FRIGATE/LITTORAL COMBAT SHIP DESIGN

In 2000, the U.S. Navy began submitting requests for a littoral combat ship (LCS) to replace an aging fleet of mine countermeasure vessels, mine hunter vessels, and Oliver Hazard Perry–class frigates.[139] The vessel's role was to patrol coastal (littoral) waters in an asymmetric war platform.[140] The Navy used a new procurement method, in the end selecting two designs to be purchased from Lockheed Martin and General Dynamics subcontractor Austal USA in ten ship block purchases, saving the federal government significant funds.[141] This new approach was an attempt to lower costs and decrease development and construction time for smaller vessels. The General Dynamics/Austal USA vessel, or Independence-class vessel, was a trimaran design, while the Lockheed Martin Freedom-class vessel was a more traditional, single-hull design. Vessels began active deployment in 2010 and 2011.

The initial LCS system faced several problems early on. Issues included cost overruns, major maintenance issues, and concerns regarding poor combat survivability. One vessel had such significant mechanical problems that it had to be towed into port one month after entering active service. According to a 2017 Government Accountability

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[139] "LCS: The USAs Littoral Combat Ships," Defense Industry Daily, December 13, 2018, http://www.defenseindustrydaily.com/the-usas-new-littoral-combat-ships-updated-01343/.

[140] "The Littoral Combat Ship (LCS)," Naval Technology, accessed November 16, 2019, https://www.naval-technology.com/projects/littoral/.

[141] "Littoral Combat Ship Class—LCS," United States Navy, last updated January 7, 2019, https://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=1650&ct=4.

Office (GAO) report, costs have doubled from the initial estimates for the vessels.[142] Additionally, there have been compatibility problems between the two LCS sea frames with the different mission-specific modules, or "mission packages."[143] Because of these challenges, the Navy stepped away from the LCS platform after its initial order was completed and instead chose a guided-missile fast frigate (FFG) platform for 2020.[144]

In pursuing the frigate, the Navy opted in July 2016 to look at a slightly modified LCS sea frame. This approach was similar to an agency purchasing a lightly modified off-the-shelf vessel and adapting it to meet mission-specific goals. The use of an established design might cut costs for research and design.

1. Mission-Driven Planning

The frigate was seen as a successor to the LCS design.[145] Again, much like its LCS counterpart, it was designed to be fast and maneuverable in its intended environment. The new vessels would require minimal crew and would feature switchable mission-specific packages (or modules) that can be changed for the mission.[146] Improvements were made for multi-mission capabilities and a longer range for over-the-horizon missile systems. Improvements to the LCS design concentrated on the ship's ability to survive attacks: the new design included increased armor and its combat effectiveness was improved with new anti-aircraft capability. Additionally, the new vessel would use a permanently mounted anti-submarine and anti-surface system, whereas the earlier LCS used a single modular,

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[142] Michelle Mackin, *Littoral Combat Ship and Frigate: Delaying Planned Frigate Acquisition Would Enable Better Informed Decisions* (Washington, DC: Government Accountability Office, April 2017), 1, https://www.gao.gov/assets/690/684151.pdf.

[143] Jared Keller, "The Navy Basically Just Admitted That the Littoral Combat Ship Is a Floating Garbage Pile," Task & Purpose, August 12, 2018, https://taskandpurpose.com/navy-littoral-combat-ship-problems.

[144] Mackin, *Littoral Combat Ship and Frigate*; Rourke, *Navy LCS Program*, 3–4.

[145] Mackin, *Littoral Combat Ship and Frigate*; David Larter, "The U.S. Navy Is Planning for its New Frigate to be a Workhorse," Defense News, January 30, 2019, https://www.defensenews.com/naval/2019/01/30/the-us-navy-is-planning-for-its-new-frigate-to-be-a-workhorse/.

[146] United States Navy, "Littoral Combat Ship Class—LCS."

multi-mission package.[147] The U.S. Navy hoped these improvements would suffice for the frigate program.

A 2017 GAO report, however, cautioned against efforts to accept the adapted LCS design without significant study; moreover, the new design did little to address the fundamental shortfalls of the original LCS design.[148] Some of these limitations were listed as space issues for an expanded crew (the LCS was specified for 98 crew members and the frigate for 130) and equipment or maintenance issues. According to the GAO, the new design also did not offer significantly greater capabilities.[149] Efforts continued into late 2018, when a subsequent GAO report stated that the Navy was still pursuing the frigate, though it would be adapted from a different vessel; there was insufficient time to develop a vessel from the ground up based on the Navy's timeline for the launch of the new frigate program in 2020.[150] In March 2019, five designs from different companies were being evaluated for the FFG program, still including one of the adapted LCS hulls.[151]

2. Procurement and Replacement Schedules

The research and development schedule was accelerated when the Navy moved to the development of a frigate design for 2020 under a block-buy program (purchasing a "block," or group, of vessels).[152] The 2017 GAO report raised concerns that this compressed timeline would cause the Navy to move forward without adequate information, including for cost estimates . While a block buy may save money on the initial purchase, it leads to the risk of future costs.[153]

Any proposed vessel replacement would be at the end of the new frigate's service life, which would likely be similar to the target lifespan of the LCS design—

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[147] Mackin, *Littoral Combat Ship and Frigate*, 7.

[148] Mackin.

[149] Mackin, 5–6.

[150] O'Rourke, *Navy Frigate (FFG[X]) Program*, 7–9.

[151] Larter, "Navy Is Planning for New Frigate to be a Workhorse."

[152] O'Rourke, *Navy Frigate (FFG[X]) Program*, 12.

[153] Mackin, *Littoral Combat Ship and Frigate*, 9.

twenty-five years.[154] This is similar to previous frigates, such as the Oliver Hazard Perry–class frigate (a 1970s design), which was the last fielded U.S. frigate and had a service life of approximately thirty years (the last of these, the USS *Simpson*, was retired in 2015 after thirty years of service).[155] However, these service lives can be extended. For instance, the Navy briefly considered reactivating eight of its Oliver Hazard Perry–class FFGs to bring up ship numbers and counter threats from China and Russia. The Navy eventually abandoned this idea when it realized the cost for reactivation did not produce a vessel with enough capabilities.[156]

3. Funding

While this option for the frigate design was considered the most economical, presumably due to the cost savings of adapting a current design, it was also considered the least capable. According to the 2017 GAO report, the initial estimate of the cost for the frigate block buy was $9 billion in 2017.[157] However, the report stated that the rush to purchase twelve frigates was preventing an accurate cost estimate. The block buy concept was supposed to prevent further cost increases, maintaining only a $100 million increase in cost from the LCS design to the frigate design. According to a 2019 article, the costs per unit stabilized at $800 million per vessel after development costs.[158]

4. Personnel

The new frigate will employ a larger crew of 130—as opposed to the LCS's 98—but the frigate will still struggle for crew space. To combat previous problems with vessel

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[154] "LCS Lifespan," *Navy Matters* (blog), August 18, 2013, https://navy-matters.blogspot.com/2013/08/lcs-lifespan.html.

[155] Tyler Rogoway, "U.S. to Offer Surplus Oliver Hazard Perry Class Frigates to Ukraine: Reports," The Drive, October 20, 2018, http://www.thedrive.com/the-war-zone/24342/u-s-to-offer-surplus-oliver-hazard-perry-frigates-to-ukraine-reports.

[156] Kyle Mizokami, "The U.S. Navy Won't Bring Back Mothballed Ships to Boost the Fleet," Popular Mechanics, February 21, 2019, https://www.popularmechanics.com/military/navy-ships/a26448230/navy-wont-bring-back-mothballed-ships/.

[157] Mackin, *Littoral Combat Ship and Frigate*, 9.

[158] David Larter, "The U.S. Navy's New, More Lethal Frigate Is Coming into Focus," Defense News, January 28, 2019, https://www.defensenews.com/naval/2019/01/28/the-navys-new-more-lethal-frigate-is-coming-into-focus/.

operations tied to training, the Navy announced it would consider using a blue-and-gold-team system for crews in 2019, similar to that used on submarines, minesweepers, and patrol vessels. The *on* crew will be out to sea deployed while the *off* crew will be on shore, training in FFG simulators. This will keep the vessel at sea longer (actually doubling its operation time), and indicates a different perspective for the manning of these vessels. In essence, this doubles the size of the crew to capitalize on operational time and training in an effort to address struggles the LCS faced with lack of training.[159]

5. Disposal

Prior to disposal, many of the frigates may be placed in reserve status, which means they could potentially be reactivated for a major conflict.[160] As U.S. naval vessels, they will have few options for disposal. In the past, the Navy used retired ships as targets for the training of active duty warships; these practices, however, ceased following environmental concerns from groups such as the Basel Action Network.[161] Other solutions are potential sales to an allied nation; previous FFG designs, such as Perry-class frigates, have been offered in foreign sales or aid to nations such as Ukraine.[162] Other solutions include scrapping at one of the certified U.S. shipbreaking locations. This is the case for vessels such as retired aircraft carriers.[163] These shipbreaking locations are generally along the Texas coast.

D. CONCLUSION

The examples in this chapter indicate the benefits of thoughtful and thorough collaboration when planning for and managing a vessel as an asset. Design builds and off-

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[159] Larter, "U.S. Navy Is Planning for New Frigate to Be a Workhorse."

[160] B. Turque, "`Rusty Tubs': The Navy's Ghost Fleet," *Newsweek* 115, no. 24 (June 11, 1990): 28.

[161] Jeremy Carroll, "U.S. Navy's Ship Disposal Policy Comes under Fire," *Waste & Recycling News* 17, no. 6 (July 25, 2011): 0003; Laura Zippel, "A Sinking Ship: EPA Regulation of the Navy Training Program SINKEX Under the Ocean Dumping Act and the Toxic Substances Control Act," *Washington Journal of Environmental Law and Policy* 3, no. 2 (2013): 267–95.

[162] Rogoway, "U.S. to Offer Surplus Frigates to Ukraine."

[163] Sam LaGrone, "Navy Pays Texas Ship Breaker a Penny to Dismantle Carrier Ranger," USNI News, December 22, 2014, https://news.usni.org/2014/12/22/navy-pays-texas-ship-breaker-penny-dismantle-carrier-ranger.

the-shelf acquisition both require comprehensive planning if they are to be successful. Moreover, when funding timelines are involved, agencies may not have sufficient time for planning, which can cause unexpected costs or maintenance issues, as was the case for the San Diego Harbor Police.

Mission-driven planning was involved in all three cases. However, in the FDNY case, the design-build strategy created a fully thought-out design based on the agency's tiered response plan and overall maritime strategy. The FDNY's *Three Forty Three* and *Fire Fighter II* were designed and built specifically to fulfill a role with mission-specific capabilities (e.g., ballast tanks to adjust deck height for safer boarding and CBRNE protections). The two off-the-shelf acquisitions (San Diego Harbor Police and U.S. Navy) show that time constraints can inhibit more exhaustive planning. The San Diego Harbor Police chose a relevant (firefighting) and capable platform, but did not fully consider the operational tempo and environment. The Navy looked for cost savings and timeliness but did not consider the limitations of the off-the-shelf design. It should also be noted that the Navy has an extremely complex and robust planning system through groups like Naval Sea Systems Command (NAVSEA) that is used for large projects like acquiring warships.[164] Municipalities—even larger ones, like New York City—lack such robust resources, and must plan on a smaller scale.

While there appear to be some general guidelines about when to replace vessels, neither the FDNY nor the Port of San Diego Harbor Police document the defined lifespans of their public safety vessels. This makes it difficult for the agencies to forecast for replacements, and may force them to replace failed vessels without sufficient planning. Vessels seem to be evaluated on a case-by-case basis to determine when they are too expensive to maintain, or have become obsolete. The Navy also has an idea of the lifespan of a vessel from its initial design, but the lifespan may not be adhered to strongly, as is suggested by the practice of keeping older vessels on reserve and then recalling them

[164] "Defense Acquisition Life Cycle Wall Chart," Defense Acquisition University, January 31, 2018, https://www.dau.mil/tools/t/Department-of-Defense-Acquisition-Life-Cycle-Chart.

(which was the case for the World War II–era battleship the USS *New Jersey*, which was commissioned in 1943 and then recommissioned in 1950, 1968, and 1982).[165]

Funding for both of the municipal vessel fleets (New York City and San Diego) came from grants. This pattern is consistent with all other municipal vessels for public safety or homeland security functions seen in the research. Port Security grants or Federal Emergency Management Agency (FEMA) grants have paid for all the vessels discussed in the requests for information as well as all vessels researched in the literature. The grant process does create a ceiling for the funding based upon the amount awarded. If the costs go over, the municipality will generally have to fill the gap, unless another grant is used. The U.S. Navy vessel was funded through the Department of Defense, which is not analogous to the municipal process as it is controlled by congressional appropriations.

Personnel considerations in both the municipal agencies are based on agency standards or staffing models. The FDNY has a specific set of roles for fire vessels, which appears to be more rigid than the adaptable positions of the San Diego Harbor Police, who train as both firefighters and police officers. If a vessel crewperson or operator is unable to staff the vessel, any other member with the same certification can fill in. For the Navy, staffing numbers increased for the vessel but space to house them on the FFG design did not. Adaptations to the personnel system were made for the frigate to have multiple crews to keep up with the operational tempo and training from lessons learned in the LCS program. Both municipal agencies maintain their own maintenance staff. The Navy has its own system for maintaining vessels through civilian shipyards.

All three agencies have a system for recycling retired vessels. The Navy has specific rules for recycling its vessels once they are decommissioned, while the municipal agencies have other options, such as resale at auction. If they cannot be auctioned, current vessels use materials that are more readily recycled (steel or aluminum). However, as can

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[165] "New Jersey II (BB-62)," Naval History and Heritage Command, August 13, 2015, http://public2.nhhcaws.local/research/histories/ship-histories/danfs/n/new-jersey-ii.html; Norman Polmar, "The U.S. Navy: The Battleships Are Back!" U.S. Naval Institute, August 1998, https://www.usni.org/magazines/proceedings/1998/august/us-navy-battleships-are-back; Edward G. Keating, *A Historical Survey of Ship Reactivations* (Washington, DC: Congressional Budget Office, May 2018), 1, https://www.cbo.gov/system/files?file=115th-congress-2017-2018/reports/53820-shipreactivation.pdf.

be seen in the case of FDNY vessels, the community sometimes has strong emotional ties to the vessels, lessening the chance of recycling.

To better explain how agencies view their maritime vessel programs, requests for information were sent out to numerous public safety agencies. The next chapter examines the responses and how public safety and homeland security agencies plan and manage their vessel systems. The next chapter also reviews literature that helps illustrate the state of the industry with regards to municipal public safety vessels.

IV. THE CURRENT STATE OF THE INDUSTRY

There is very little direct documentation about the current state of the industry in vessel systems planning and management for the municipal homeland security field. While some news articles and trade publications lend insight, a more direct approach is necessary to explore this topic in any meaningful way. To address the primary research questions of this thesis and attempt to formulate policy recommendations, this research sought to discover how local public safety agencies are currently researching, buying, planning for, and managing vessels to fulfill their homeland security mission. The researcher sent out surveys—or requests for information (RFIs)—in an attempt to make observations and draw conclusions about efficiency (or lack thereof) in this environment. The RFIs were sent to various public safety agencies that have maritime missions. This chapter describes the RFI responses, which lend insight into the current state of the public safety vessel industry.

A. REQUESTS FOR INFORMATION

RFIs were sent to twelve agencies with ties to maritime operations that potentially encompass public safety or homeland security missions. These included ports, fire departments, and police agencies. Eight agencies responded. The agencies were asked to provide the following information:

- Agency name
- Type of agency (fire, law enforcement, or public safety)
- Agency size
- Annual budget

And they were asked the following questions:

- How large is your agency's vessel fleet?
- Does your agency use a mission-driven planning process for selecting new vessels?

- Does your agency use this process for “design builds” or to purchase off-the-shelf systems?
- If your agency has used off-the-shelf vessel systems, have they resulted in additional costs for unanticipated adaptation? Please give a brief description, if applicable.
- Does your agency forecast maintenance as part of its overall strategy for vessel operations?
- Does your agency employ a collaborative process for vessel planning? If so, who is included in your collaborative planning?
- Does your agency have a determined “lifespan” for your vessel? If so, how is that lifespan calculated?
- Does your agency follow a best-practice model for vessel management?
- Does your agency confer with other agencies with vessel assets on how to select a new vessel?

1. Agency Info: Type, Size, and Budget

Respondents were either from fire departments (two), law enforcement agencies (five), or in the case of one port, a public safety agency (encompassing both fire and police). The agencies varied in size from a large metropolitan fire agency with 1,700 staff members (the agency did not indicate how many staff members are dedicated to its marine unit) to a smaller police marine unit with twenty-three staff members.

Budgets for maritime operations were difficult to determine from the responses. Reported budgets ranged from $272,000 for the harbor division of a large metropolitan police force to $380 million for the entire budget of a large metropolitan fire department. The budget for the harbor unit is not detailed specifically in most agencies’ published budgets. Vessel fleet size ranged from as few as two fire vessels for a smaller fire department to forty-two vessels for a large metropolitan police agency’s harbor unit.

2. Mission-Driven Planning

When the agencies were asked whether they use a mission-driven planning process for selecting new vessels, the responses were mixed. Four of eight respondents stated that they use mission-driven planning, while both fire agencies noted a "needs-based" approach. The remaining two agencies indicated that they do not use a mission-driven approach; one mentioned that the agency is moving to a strategic planning model. While there are still mixed directions on mission-driven or even needs-driven processes, agencies appear to be moving toward a strategic approach in the selection of new vessels. Overall, agencies seem to be thinking about the vessel's capabilities during the planning process.

3. Design Build or Off-the-Shelf Purchases

When the agencies were asked whether they use design builds or off-the-shelf systems, all indicated they use a design-build approach to some extent. All the fire agencies use design-built vessels, and one large fire agency noted that all fire vessels—with the exception of its personal watercraft (PWC) vessels, which are essentially off-the-shelf systems—are design builds due to mission needs and grant requirements. However, the other fire agency that responded uses an off-the-shelf system from MetalCraft Marine for its newest fireboat but keeps an adapted fishing vessel as a reserve.

Three of eight agencies noted that their law enforcement vessels were more likely to be off-the-shelf. One agency mentioned that this was due to a need for uniformity. One police agency's design-build processes involved buying a known platform but outfitting it with tailored engines or equipment. This version of a design build could also be seen as an off-the-shelf vessel with minor mission-specific adaptations.

4. Unanticipated Costs

For the off-the-shelf systems, two agencies described the modifications as preplanned and budgeted. A large fire agency reported the addition of fire department identification markings on personal watercraft and two police agencies stated that they placed radios and markings on police vessels. One agency makes extensive upgrades to electronics and incorporates forward-looking infrared (FLIR) and radiation detection for

its law enforcement mission. These tools for the maritime agency have become a more standard part of the homeland security mission, and as such can now be planned/budgeted for when building a new vessel.[166] One agency mentioned a design issue with the generator that had to be corrected on an off-the-shelf vessel. The responses show that most modifications to off-the-shelf systems were planned as part of the acquisition to adapt the vessel for its intended mission. This indicates effective planning prior to the purchase of off-the-shelf systems. Only one agency had to make unexpected modifications to adapt the vessel.

5. Forecasting Maintenance

When asked if the agency forecasts maintenance as part of the overall strategy for vessel operations, all eight responded affirmatively. Two respondents stated that their maintenance is based on hours in service, while others indicated annual or scheduled maintenance. Regarding maintenance, some of the agencies noted differing processes or strategies. One agency uses certified marine mechanics, two noted that their agencies conduct maintenance with internal mechanic staff, and one uses contracted maintenance staff. One large fire agency stated that its internal mechanic staff only maintains the agency's smaller vessels; maintenance for the larger vessels is planned by fireboat engineers, and the larger fireboats are hauled to dry docks and serviced every two to three years by contracted staff. One agency noted that vessel maintenance is part of its overall selection process.

These responses indicate that vessel maintenance is widely reported as part of the agency's overall planning strategy. Particularly, this forecasting or planning looks at preventative maintenance, as described in Chapter II. The specifics may differ (the preventative maintenance may be hours- or schedule-based), but it is, indeed, part of the planning process.

[166] Brian Patrick Hill, "Maritime Terrorism and the Small Boat Threat to the United States: A Proposed Response" (master's thesis, Naval Postgraduate School, 2009), https://www.hsdl.org/?view&did=232151.

6. Collaborative Planning

Seven of the eight respondents addressed the question about collaborative planning. Of those seven, five mentioned some level of collaborative planning. One stated that, in lieu of a collaborative planning process, the agency depends on input from port engineers for vessel planning. One large fire agency indicated that it does not use a collaborative plan; the stakeholders within the department do not meet strategically due to a lack of support from the department's administration. The agency representative noted that this lack of collaboration between departments hinders overall planning for the vessel.

Responses were mixed when it comes to who is included in the collaborative process. The most common groups included in the planning are members from within the agency and maintenance personnel. Two agencies collaborate with federal partners, and one smaller fire agency stated it uses a committee and peers to plan.

7. Determining a Lifespan

Five of the eight respondents stated that they have a determined lifespan for their vessels. Three of the eight agencies operate the vessels until failure. Several criteria for determining lifespan were discussed: hull material (two agencies), manufacturer (two agencies), and marine surveyor/mechanic input (two agencies). One agency stated it uses past experience to determine lifespan.

Some agencies indicated a more reactive look at vessel management. One major metropolitan fire department said that vessels are operated far longer than their expected lifespan. For this fire agency, lifespans are dictated by hull material, with an expectation of ten to twenty years for aluminum hulls, and thirty to fifty years for steel. It should be noted, however, that this was due to the agency's experience with past vessels; it was not determined by a strategic measure. Currently, two of the agency's three active, large fireboats are more than sixty-six years old (built in 1952).

8. Using Best-Practice Models

Of the eight agencies, four use a best-practice model for vessel management. One agency's representative merely stated that mechanics use established guidelines, and

another said they have not used a best-practice model, but have begun having certified personnel take over vessel maintenance and management. One agency said it created a successful strategic process for managing its vessels, and another said it does not use a best-practice model.

9. Conferring with Other Agencies

All eight respondents stated that they confer with other agencies about the acquisition of new vessels. Some contact similar agencies for input while others contact federal, state, and local partners. Two agencies do this through an informal process. Responses to this question showed universal use of collaborative planning, which conflicts with the responses to the previous question about collaborative planning practices. For instance, a respondent from a large agency stated that this process was informal, but was effective with regional partners from the initial point of grant writing for the new vessel.

10. Other Trends

Several trends regarding the design of the vessels emerged among the RFI responses. First, funding appears to influence design—for instance, a vessel must be able to achieve an all-hazards approach to be eligible for grants. As one large sheriff's agency stated, "Grant-funded purchases from the state funds require a build to specs." Another large fire agency stated, "Basically, all boats have been design built as a fed-grant-funded vessel." The vessels' designs are always driven by some planning- or needs-based approach determined by capability standards from the National Fire Protection Association.

Agencies are also moving toward increased strategic planning. A respondent from a small port noted that they hired a director of strategic planning to oversee the purchase of new vessels. And a respondent from a large metropolitan fire department noted a shift to some degree toward strategic management, mentioning the new practice of using their marine engineers to evaluate the current fireboat fleet and its maintenance. This same fire agency indicated, overall, a more reactive look at vessel management and maintenance based upon past practices.

Five of eight respondents mentioned a plan or process for the lifespan of the vessel. The criteria for replacement were vague for some, which makes planning for replacement vessels difficult. In some cases, agencies that have an estimated lifespan for a vessel still operate the vessel beyond established timeframes. This could potentially be due to the high cost of replacing a fireboat, which can vary from over $11 million (the cost of the San Francisco Fire Department's new fireboat, the *St. Francis*) to approximately $25 million (the cost of the Port of Long Beach's *Protector*) or $27 million (the cost—each—for the FDNY's two largest vessels).[167] Also, some agencies find it difficult to justify the purchase of large fireboats because, thanks to safer infrastructure, they are needed infrequently.[168]

B. CONCLUSION

The RFI responses show that acquisition and vessel management strategies vary widely across the United States. From the literature review, it is apparent that, in the past, agencies adapted already existing platforms such as fishing boats or pleasure craft into public safety vessels. The responses show a movement toward a more strategic view of planning for vessel systems and their management, a shift away from purchasing or procurement and toward a more collaborative acquisition approach that includes partnerships with industry during the design phase and efforts to manage life cycle costs.

Chapter V synthesizes the information from this chapter, along with the best practices described Chapters II and III, to identify standard parts of a vessel management system, and to look at how they can build efficiencies. This final chapter also evaluates current industry practices in vessel systems acquisition and management, and proposes best practices to push the public safety vessel industry to a more universally strategic approach.

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[167] Ken Hocke, "San Francisco's Hot New Fireboat," WorkBoat, November 5, 2016, https://www.workboat.com/news/government/san-franciscos-hot-new-fireboat/; Ron Almeida, "First Look: Port of Long Beach's Powerful New Fireboat," Fire Fighting Captain, August 29, 2013, https://gcaptain.com/powerful-fireboats-voith-propulsion/; Jerrard, "FDNY's New Fireboat."

[168] Joseph Ockerhausen, Hollis Stambaugh, and Seth Kelly, "Special Report: Fireboats, Then and Now" (report, U.S. Fire Administration, May 2003), 6–8, https://www.usfa.fema.gov/downloads/pdf/publications/tr-146.pdf.

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V. OBSERVATIONS AND CONCLUSIONS

This thesis examined best practices in vessel acquisitions and the life cycle costing of municipal vessel programs in the United States. Based on the parallel systems of vehicle fleet management, five best-practice anchors were proposed: mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations. The research also evaluated the responses from the requests for information based on these best-practice anchors, with a specific focus on design-build versus off-the-shelf solutions. This chapter proposes the value of these anchors and discusses how to use them as the basis for a best-practice model in vessel system management to build efficiencies in the planning process.

A. FINDINGS

1. Life Cycle Costing

Life cycle costing for the vessel's lifespan is an important tool for eliminating the reactive mindset to crisis. Life cycle costing can give an agency a realistic view of the overall cost of the vessel and estimate its lifespan—i.e., how much time can elapse before the vessel will need to be replaced. While these are only estimates, they can help planners understand the true cost of the vessel over time, which will allow the agency to plan more efficiently and prevent the agency from continuing to pay more for repairs as the vessel nears the end of its life.

An RFI respondent from a municipal fire agency noted that the agency's vessels are being operated beyond their lifespan: vessels with a lifespan of thirty to fifty years are being operated as front-line fire vessels at more than sixty-six years of age. Three of the eight agency respondents mentioned no specified lifespan to use as a planning tool, with one noting that the vessels continued working at fifteen to twenty years of age. Another agency has vague guidelines based upon multiple inputs, but does not have a specified lifespan. In all of these cases, the agency's ability to plan effectively is inhibited without a replacement schedule as a moving target.

Life cycle costing can be used to identify the time during a vessel's life cycle when the cost for operation and maintenance will exceed the cost of purchasing a new vessel, allowing agency planners to identify the optimum time to recycle or auction off their vessels as assets. The maintenance staff of the San Diego Harbor Police identified, for instance, that, as its vessels aged, the costs for maintenance became excessive: at fifteen years of age, maintenance and agreement costs (boat yard and contracted major vessel maintenance) rose to over half the initial cost of the vessel.[169] Similar cases are presented in the literature, and life cycle costing could prevent this. While the RFI responses indicated that agencies do engage in planning practices, there was no clear indication that life cycle costing, as a rule, is used for planning purposes.

2. The Five Best-Practice Anchors

Five best-practice anchors were identified based on fleet vehicle management practices: mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations. These five anchors can shape vessel system management.

a. Best-Practice Anchor 1—Mission-Driven Planning

In the past, agencies have adapted vessels—such as fishing vessels, pleasure craft, or military vessels—for use in a public safety role. From a historical perspective, many of these vessels were ill-equipped or unable to fulfill their missions prior to the implementation of homeland security/port security grants. The research indicates that there has been a move toward a more structured and strategic approach in vessel acquisition—largely based on the influence of grant funding.

In all three case studies, there was considerable thought about the mission of the vessel and its impact on the design. The FDNY planned its vessel procurement with an all-hazards approach, using pumping capacity benchmarks from lessons learned in the aftermath of 9/11. These vessels hold a specific place in the strategic operations plan for

[169] Aaron Brothers, "Firestorm Cost Estimates per Vessel" (internal document, Port of San Diego, October 26, 2018).

the FDNY and were built to meet those roles. The Port of San Diego Harbor Police used a similar approach for its new fire vessels. The agency's planning emphasized firefighting capabilities due to its firefighting mandate. Because its funds were unfrozen halfway through the usual three-year grant performance period, the agency only had eighteen months to plan, specify requirements, procure, and receive its new vessel. Due to these time constraints, the Port of San Diego chose the Firestorm 36 model from MetalCraft Marine. Had there been time for more planning, environmental issues might have been predicted and mitigated earlier in the planning/design phase, preventing later costs and adaptations. In the U.S. Navy's quest for a new frigate, the mission was clear, but the attempt to adapt the LCS sea frame to the FFG design produced a product that was listed as the least capable. In all three cases, the vessel's mission dictated the design; for the Port of San Diego and the Navy, however, the execution was flawed due to time constraints or the desire to save money during the design phase by using an off-the-shelf design.

Mission-driven specification should dictate design. Stakeholders need to plan collaboratively and have a holistic view of potential issues, such as those related to the mission or operational environment for the vessel. Such an approach limits the need for later adaptation by identifying threats or challenges early. It can also identify the support needs of the vessel. This first step lays the groundwork for the acquisition process and for determining the lifespan of the vessel. It is also the foundation for this vessel's design.

b. Best-Practice Anchor 2—Procurement and Replacement Schedules

A standardized, structured procurement and replacement schedule appears to be the largest missing piece in vessel systems management. Many of the agencies in the literature and those that responded to the RFIs use replacement-schedule-based criteria on such issues as overall vessel age and hull material. There is little evidence to suggest that agencies are following this process with any level of consistency. One agency stated that its vessels are sixteen or more years past their retirement age. Some responses indicated that agencies run their vessels until they fail while others indicated no designated lifespan for their vessels. This is evidence of a lack of schedules for procurement and replacement—or that, if an agency has a schedule, it is not being used; plans for purchasing another vessel

or for a mission-driven design are generally created only after a decision is made to purchase a vessel. If most agencies are not forecasting an end of life for their vessel fleets, they are left in a reactionary position—caught with vessels that have failed or are nearing failure, and that must be replaced to maintain the maritime mission.

If agencies maintain specific schedules for procurement and replacement, they will know at what age the vessel will be retired, and can therefore prepare funding in a more organized manner. An agency that plans for vessel retirement and replacement has the time to more efficiently and accurately design its replacement vessels. The life cycle costing method or a similar approach can be used to identify the optimal time to retire and resell/ recycle a vessel.

c. Best-Practice Anchor 3—Funding

Grants are now a significant factor in vessel acquisitions. In virtually all of the research literature, new public safety vessels were funded by federal or state grants. And these grants require an all-hazards approach to vessel design. This means vessels purchased with grant funding must address a range of natural threats, such as locally predictable natural disasters, as well as manmade threats such as CBRNE.[170] Agencies that accept Port Security Grant Program (PSGP) funds must also adopt the National Incident Management System (NIMS).[171]

In addition, grant timelines can cause issues for planning and the execution of a vessel purchase—as was the case for the San Diego Harbor Police Department. Generally, performance periods for the PSGP are three years long. For example, the fiscal year 2018 PSGP performance period began in September 2018 and ends on August 31, 2021.[172] This includes the time needed for typical government processes, such as requests for proposals/ quotes, competitive bid processes, responses from vendors, and construction. This thesis

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[170] Regen, "A Rundown of Key Federal Grants Programs," 14–17.

[171] "The Department of Homeland Security Notice of Funding Opportunity Fiscal Year 2018 Port Security Grant Program (PSGP)," Federal Emergency Management Agency (FEMA), May 16, 2018, 5, https://www.fema.gov/media-library-data/1526580376486-24ccded583e0c379efedfb47505b51a6/ FY_2018_PSGP_5_16_18_FINAL_508.pdf.

[172] FEMA, 3.

proposes, based on the anecdotal evidence, that a plan for the replacement vessel should already be completed or in place before the grant is awarded.

This dependence on grant funding for municipal vessel fleets, however, comes with significant risks. Every municipal vessel purchased since 9/11 that was identified in the literature, in the case studies (except for the U.S. Navy LCS), and in the RFI responses was purchased with federal or state grants, most through the PSGP, which supports FEMA's aim to increase port resiliency and security measures. In fiscal year 2018, FEMA listed $100 million in funds to be distributed for a range of projects, including for vessels.[173] Agencies around the nation will compete for these grants, and an agency that has not planned will be gambling a grant opportunity; if the agency is in need of a new vessel, its maritime capability will be at risk. Agencies must therefore identify funding sources outside the grant process and be capable of funding their own fleets.

d. Best-Practice Anchor 4—Personnel Considerations

Most agencies represented in the literature and the RFIs have adequate personnel to operate and maintain their vessel systems. Some of the RFI agencies use outside contractors for vessel maintenance to support their maritime efforts. Other agencies, such as the FDNY, have highly specialized jobs within their vessel systems, while others still, such as the Port of San Diego Harbor Police, keep their skill sets generalized to allow for staffing flexibilities. In the case of the LCS/frigate system, the U.S. Navy showed ingenuity by adapting the submarine staffing system to have both operational and training staff for the same ship. This keeps the vessels operational while also addressing training concerns brought on by the earlier LCS design.

e. Best-Practice Anchor 5—Disposal Considerations

There is little documentation showing how municipal or homeland security vessels are disposed of or recycled. Some agencies struggle to recycle vessels due to their place in history, and others choose vessels that are not easily recycled due to their construction materials. There are opportunities to use this anchor as an area for growth. Some materials

[173] FEMA, 3.

are not suitable for recycling, such as fiberglass. By keeping recycling or disposal in mind, agencies can choose designs and hull material that facilitate this process. In turn, if a vessel has a higher resale or recycling value, this is an opportunity to decrease the life cycle cost.

3. Off-the-Shelf versus Design-Build Systems

By using a design-build approach and working collaboratively with stakeholders and the manufacturer, the FDNY acquired vessels that were comprehensively planned. Similarly, the larger fire vessels examined in the research were generally design-build systems. Other agencies use off-the-shelf systems, which require less planning and can be successful. Most of the grant-funded municipal vessels mentioned in the literature and RFIs (and one of the case studies) were off-the-shelf systems such as those from MetalCraft. These vessels can be adapted with adequate study and planning. Numerous RFI responses indicated that off-the-shelf systems were used successfully for their role—including law enforcement vessels and smaller fire vessels procured from manufacturers like MetalCraft Marine. In these cases, a thorough study of the vessel's mission, needs, and design must be conducted prior to selection to ensure the mission-driven planning anchor is considered. In some cases, unforeseen issues occur, such as the shortfalls in the design of the MetalCraft Marine vessels purchased by the San Diego Harbor Police, which could have been avoided with some additional study and design specifications prior to the grant award.

The U.S. Navy was not immune to the desire for an off-the-shelf solution when confronted by a compressed timeline. It attempted to adapt the LCS into a frigate to meet a 2020 deadline. A GAO report warned that the adapted frigate would not address the shortfalls of the LCS design.[174] These lessons again illustrate that the use of off-the-shelf systems in an attempt to save time and decrease acquisition costs comes with risks to performance and mission capability. Using the best-practice anchor of mission-driven design, an agency can better evaluate the viability of both off-the-shelf and design-build systems. However, cost savings from off-the-shelf systems should be balanced with the

[174] Mackin, *Littoral Combat Ship and Frigate*.

vessel's ability to accomplish its mission. Then, if an off-the-shelf system is selected, thorough planning to adapt the vessel to its mission and environment is necessary.

B. ANSWERING THE RESEARCH QUESTIONS

The first research question for this project was: If public safety agencies adopt a process for strategic requirement determinations for maritime vessels, and a strategic management system for maritime assets, how can they positively affect costs, production times, and life cycle maintenance? Tools such as life cycle costing and the best practices described in this thesis can increase efficiencies. They can facilitate better planning for the vessel's mission, optimal recycle or resale value, and proper resource management for its overall operation.

The second research question was: How can agencies with public safety and homeland security missions adopt strategic management processes for maritime assets? Incorporating this change into the industry will mean accepting the five best-practice anchors proposed in this thesis. The literature and RFIs show that there is already a movement in the United States toward more strategic planning for vessels. Public safety agencies are moving, too, toward an all-hazards approach for vessels thanks to the influence of grant funding. There is little documentation on best practices for strategically managing a vessel fleet for the public safety sector; however, life cycle costing and the best practices described in this thesis present a working model.

A general best-practice model should be formally established for vessel assets. This model could then be used to influence policymakers at the municipal level to address funding needs. The model may also illuminate the dependence on grant funding, which can encourage agencies to search for other funding methods. The five best-practice anchors proposed in this thesis—mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations—can be used as metrics to evaluate and guide agencies with management of their vessel fleets.

It is tempting to view the purchase and management of public safety vessels linearly: research it, procure it, maintain it, and retire it. Beginning, middle, end. A more resilient view, however, is a cyclical process that centers on public safety agencies

maintaining their maritime capacity as a function of citizen safety and homeland security. This mindset focuses on continued capacity—not just management of a vessel or fleet. This can then prevent the urgent need to replace a vessel that has failed, which impacts planning and funding.

C. RECOMMENDATIONS

(1) Anticipate that grants will not always be available.

Agencies must not rely on federal or state grants as a dependable source of funding for vessels. Since a vessel is a long-term asset lasting anywhere from ten to fifty years, depending on hull material estimates, planning for funding will be necessary ahead of time. Some solutions can be public-private partnerships or the use of a capital fund to put money into over time to pay for the asset in the future. Alternatives to grant funding must be sought out and planned for.

(2) Estimate the age at which the vessel will be too expensive to maintain.

Life cycle costing will allow planners to identify the point at which the cost of maintaining a vessel may exceed the cost of purchasing a new one. This can then be used as model to establish vessel lifespans, which can be plugged into the procurement/ replacement schedule of any vessel program. Life cycle costing will allow an agency to have a more complete idea of the overall cost of a vessel as an asset, better plan for major maintenance, and more effectively budget for that maintenance. This perspective will also help agencies plan for the recycling or disposal of their vessels, which can in turn influence the design of the vessel and potentially decrease its overall life cycle cost.

(3) Evaluate whether a design build or an off-the-shelf design is right for the particular agency or mission.

Design builds are preferable because they allow the vessel to be specifically designed and configured based on thorough planning. However, they can be more costly and time-consuming, and so a design build may not be attainable—or necessary—for many agencies. For agencies that are looking for a vessel with an established design or configuration, such as vessels fulfilling a singular law enforcement or firefighting mission,

effective off-the-shelf designs can be configured for the agency. This can also be a cost-saving model, as long as the agency follows a thorough planning process.

(4) Establish and use the best-practice anchors to build efficiencies in vessel systems and manage planning efforts.

The five best-practice anchors can help guide agencies in the management of vessels over their lifetime; mission-driven planning, procurement and replacement schedules, funding, personnel considerations, and disposal considerations can create a framework for a more efficient lifespan of the vessel. In theory, these anchors ensure that the agency has adequately planned for a vessel and has forecasted realistic costs. Funding and personnel resources will be understood before the vessel is acquired. Finally, with the knowledge that the vessel's overall cost can be mitigated through recycling, the vessel's material and hazardous material components can be planned for.

(5) Change the paradigm: View vessel systems not as a singular, linear asset but rather as a cycle of vessel management that will maintain maritime capabilities.

How can agencies with public safety and homeland security missions adopt strategic management processes for maritime assets? Approaching vessel management not as a linear task but rather as a cycle for continued capacity will help shift the mindset of planners to preserve that capacity.

D. THE RISKS OF GRANT RELIANCE

All the agencies queried in the RFIs—and almost all those examined in the literature—use federal or state grant funding to purchase new vessels. This shows a potential overdependence on grants. Some grants, such as California Port Security Grants, have transitioned away from the mission of port security and toward transportation. The federal program initially funded approximately $300 million in port security needs, but now funds only about $100 million. Agencies even use these funds, as in the case of the Port of San Diego Harbor Police, to fund ongoing maintenance needs. These funding sources may at some time disappear, leaving agencies with difficult choices about how to deal with vessel needs in the future.

E. FUTURE RESEARCH

Continued research should address the future of grants as a funding source for public safety vessels. If the dependence on grants continues to stand as the current practice, this funding source can be evaluated to better address vessel needs as a national system. In addition, the study of alternate funding sources to purchase vessel needs would provide valuable choices to agencies who cannot wait for grants. Other research could address more specific challenges such as better ways to attain multi-mission vessel platforms for both police and fire public safety missions to reflect agencies that do both. Most importantly, this thesis should serve as a springboard for more discussion about the topic of strategic management of public safety vessel systems.

F. CONCLUSION

The public safety maritime industry is struggling to manage vessel fleets using a strategic model. Vessel systems are often planned in ways that are not efficient and do not allow for or follow planning models. Municipalities and government agencies must plan better for their vessel fleets to be more efficient. Moreover, they must stick to these plans when it comes to funding, and retirement of older systems. The current model hopes for the best and will eventually lead to unplanned or unexpected failure of vessels, placing an agency's maritime capability at risk. The public will demand efficiency and value of the dollars spent on government equipment—in this case, vessels.

Figure 5 shows the established, linear approach to vessel management. The five best-practice anchors, however, facilitate the changes shown in Figure 6: the paradigm becomes a circular cycle, at the center of which is maintaining maritime capabilities. This is similar to and borrows from the circular life cycle costing paradigm mentioned in Chapter II (Figure 1). Also, the recycling of old assets (disposal) now happens after the acquisition of the new asset, to better reflect the realities of procurement schedules.

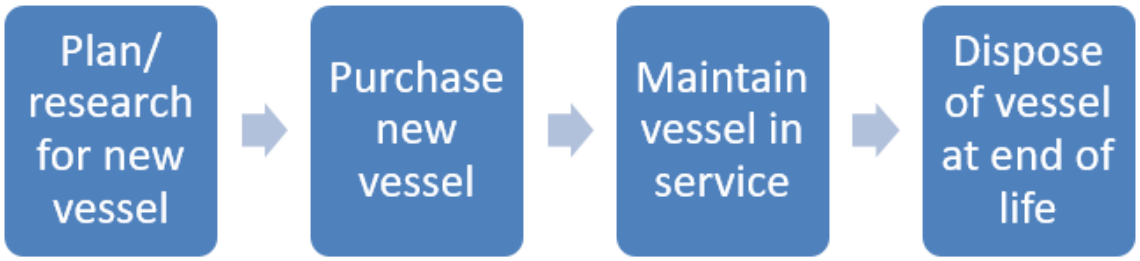

Figure 5. Linear Model of Vessel Lifespan

Figure 6. Improved Cyclical View around Capabilities Maintenance

Grants, while an effective tool, have become an industry crutch that municipalities use to avoid funding their vessels. While this is understandable due to the high cost of vessels, grants are not a guaranteed source of funding, particularly when it may urgently

be needed. The public will expect that agencies responsible for a maritime mission maintain this capacity as part of their public service. Costs can be somewhat deferred by the recycling of vessels. While the money reclaimed may be meager in comparison to the total cost of a vessel, it is a factor that lowers the overall life cycle cost.

These challenges can be avoided, and efficiencies increased. Mission capacity can be maintained and planning can be efficient through use of the practices listed above. Such practices should stand as potential best practices and an ongoing mindset for maintaining this capacity.

APPENDIX A. RFI QUESTIONS

Agency Name:_____

Fire:____ Law Enforcement:____ Public Safety:____

Agency Size: _____ Annual Budget:_____

1. How large is your agency's vessel fleet?
2. Does your agency use a mission-driven planning process for selecting new vessels?
3. Does your agency use this process for "design builds" or to purchase off-the-shelf systems?
4. If your agency has used off-the-shelf vessel systems, have they resulted in additional costs for unanticipated adaptation? Please give a brief description, if applicable.
5. Does your agency forecast maintenance as part of its overall strategy for vessel operations?
6. Does your agency employ a collaborative process for vessel planning? If so, who is included in your collaborative planning?
7. Does your agency have a determined "lifespan" for your vessel? If so, how is that lifespan calculated?
8. Does your agency follow a best-practice model for vessel management?
9. Does your agency confer with other agencies with vessel assets on how to select a new vessel?

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APPENDIX B. MASKED RFI RESPONSES

	Agency type*	Agency size/ budget	Vessel fleet size	Mission-driven planning of vessels?	Design build or off-the-shelf?	If off-the-shelf, resulted in unanticipated costs?
Agency 1	LE	177 staff $272K	42 vsls	Yes	Design build	N/A
Agency 2	LE	23 staff $2,204,500	15 vsls	Yes	Design build based on specifications	N/A
Agency 3	FD	1700 staff $380 million	7 total: 3 large fire vsls, 2 smaller vsls, 2 jet skis	No, but specific needs of vessel due to fire mission dictate	All design build due to grants	Only jet skis are off-the-shelf—minor modifications for markings
Agency 4	FD	484 staff $94 million	2 vsls	Needs-based	Design build	N/A
Agency 5	LE	41 staff Budget varies	3 patrol, 1 fire	No	Design build	N/A
Agency 6	LE	700 sworn staff	9 vsls, 2 PWCs	Yes: deep-water security, patrol, and rescue	Both. Most are design-built or modified for specific parameters. Grant-funded purchases from state funds require a build to specs. Off-the-shelf if applicable and possible. PWCs are only modified to for police equipment.	Modifications for police markings, lights, radios. Anticipated costs for outfilling.
Agency 7	LE	135 staff	30 total: 8 LE vsls, 4 PWCs, 4 dive team vsls, 14 MLETC vsls	Yes, emphasis on port security mission/rapid police response. No cross between police mission and fire response.	Both. Prior policy was off-the-shelf for uniformity in vessels; design build used recently for mission-specific vessel.	For patrol operations, heavily upgraded the off-the-shelf electronic package (FLIR or radiation detection)—resulted in additional costs
Agency 8	Public safety	25 staff $1.4mil for LE marine, $600K for firefighting	5 total: 3 LE, 1 FD, 1 fire barge	No, but formalizing new strategic planning	Transitioning to off-the-shelf LE vessels with modifications. FD will use design build.	Only for LE—safeboats had design issue with generator and needed modification

* LE = law enforcement; FD = fire department

	Forecast maintenance as part of overall strategy?	Employ collaborative planning? If so, who?	Determined lifespan for vessel? How is it calculated?	Follow a best-practice model for vessel management?	Confer with other agencies on how to select a new vessel?
Agency 1	Yes, planned days for maintenance.		Yes, based upon manufacturer and hull material	No	Yes
Agency 2	Yes, maintenance practice is PM every 100 hours of vessel usage, performed by marine mechanics (fluid changes, spark plugs when needed, and inspection for hull cracks, engine propeller checks, and ensure vessel components are operational).		Ten years (approx.) marine patrol vessel maintenance sergeant with input from marine mechanics, who determine when such repairs become cost-prohibitive.	Yes	
Agency 3	Large vessels rotate through dry dock very 2–3 years. Smaller vessels maintained through FD.	Collaboratively—the unit captain, lieutenant, marine maintenance sergeant, marine mechanics, and marine patrol officers provide input and they conduct an in-depth analysis concerning vessel research from state, local, and federal partners on existing vessels either in the field or available on the market for our intended purpose. Additionally, the unit conducts site visits on selected manufacturers to ensure the quality of their product is acceptable for police functions on the waterways. They also conduct a trial run on all vessels before purchase.	Large vessels (two or three or are more than 60 years old). Steel hulls forecast for 30 to 50 years; aluminum hulls for 10 to 20 years. [Author's note—does not appear to be followed]	No—has been reactionary. However, they are starting a new concept. Fireboat engineers (certified marine engineers from the maritime shipping/tug boat industries) are given responsibility to maintain rescue boat, mooseboat and jet skis. Previously, city shops/Agency Bureau of Equipment arranged for repairs—method was ineffective, tons of wasted time and poor communication between all parties.	Not formally, but good informal relations for collaborative input
Agency 4	Yes	Yes, committee and peers	No	Yes	Yes

	Forecast maintenance as part of overall strategy?	Employ collaborative planning? If so, who?	Determined lifespan for vessel? How is it calculated?	Follow a best-practice model for vessel management?	Confer with other agencies on how to select a new vessel?
Agency 5	Yes	No	No … run vessels until failure	Yes	Yes
Agency 6	Hours-based maintenance schedule by contract maintenance personnel	Need-based, then proposed and routed through chain of command	No—some have 15 to 20 years in service	Mechanic uses established guidelines	Informal discussion
Agency 7	Yes, also part of vessel selection process.	Yes, include maintenance personnel	Yes, based upon past experience. Has dramatically increased due to use of jet docks to lessen environmental impact to hulls.	Yes	Yes, local, state, and federal partners
Agency 8	Yes	Yes—director, strategic planning; director, port security; chief of police and security; Refinery Terminal Fire Company fire chief and asst chiefs; to a degree, industry reps and the port pilots	Manufacturer forecast, marine surveyor, and inspection reports.	Self-created model that works for the agency	Yes—Port of LA/ LB, Port of San Francisco, Port of NY/NJ, Port of Houston, Port of Miami, U.S. Coast Guard, U.S. Customs and Border Protection, Texas Parks & Wildlife, Florida Fish & Wildlife Conservation Commission, and various other port authorities and marine LE agencies.

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