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A UTILITY-BASED APPROACH TO U.S. NAVAL HUMANITARIAN ASSISTANCE AND DISASTER RELIEF (HADR) TASKING

by

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March 2018

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Due to naval vessels' unique sea and air capabilities, the United States government often calls on the Navy to provide immediate humanitarian assistance and disaster relief (HADR) to affected populations around the world. However, not all ships possess capabilities that can be adapted to the humanitarian mission, and they therefore should not be tasked with humanitarian missions. To respond quickly, it is not uncommon for combatant commanders to task the closest ships without considering if a more HADR-capable ship is available, if slightly farther away. This type of tasking can easily waste valuable U.S. resources (wartime assets, funding, manpower, and readiness) while providing a suboptimal HADR response package of ships to the affected population. In an environment of constrained resources, it is important that these resources are used as efficiently as possible when responding to disasters around the world. This study builds on prior U.S. Navy HADR research and provides decision makers with a utility-based optimization tool that accounts for and discusses the tradeoffs between vessel capability, proximity, and cost when selecting the optimal mix of sea assets for future HADR tasking.

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A UTILITY-BASED APPROACH TO U.S. NAVAL HUMANITARIAN ASSISTANCE AND DISASTER RELIEF (HADR) TASKING

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ABSTRACT

Due to naval vessels' unique sea and air capabilities, the United States government often calls on the Navy to provide immediate humanitarian assistance and disaster relief (HADR) to affected populations around the world. However, not all ships possess capabilities that can be adapted to the humanitarian mission, and they therefore should not be tasked with humanitarian missions. To respond quickly, it is not uncommon for combatant commanders to task the closest ships without considering if a more HADR-capable ship is available, if slightly farther away. This type of tasking can easily waste valuable U.S. resources (wartime assets, funding, manpower, and readiness) while providing a suboptimal HADR response package of ships to the affected population. In an environment of constrained resources, it is important that these resources are used as efficiently as possible when responding to disasters around the world. This study builds on prior U.S. Navy HADR research and provides decision makers with a utility-based optimization tool that accounts for and discusses the tradeoffs between vessel capability, proximity, and cost when selecting the optimal mix of sea assets for future HADR tasking.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFSB	Afloat forward staging base
APF	afloat pre-positioning force
AS	submarine tender
C2F	Commander, United States Fleet Forces Command
C3F	Commander, United States Third Fleet
C4F	Commander, United States Fourth Fleet
C5F	Commander, United States Fifth Fleet
C6F	Commander, United States Sixth Fleet
C7F	Commander, United States Seventh Fleet
CDRUSAFRICOM	Commander, United States Africa Command
CDRUSCENTCOM	Commander, United States Central Command
CDRUSEUCOM	Commander, United States European Command
CDRNORTHCOM	Commander, United States Northern Command
CDRUSPACOM	Commander, United States Pacific Command
CDRUSSOCOM	Commander, United States Special Operations Command
CDRUSSOUTHCOM	Commander, United States Southern Command
CDRUSSTRATCOM	Commander, United States Strategic Command
CDRUSTRANSCOM	Commander, United States Transportation Command
CG	guided missile cruiser
CVN	aircraft carrier, nuclear
CY	calendar year
DDG	guided missile destroyer
DoD	Department of Defense
DoN	Department of the Navy
DoS	Department of State
DoT	Department of Transportation

FAA of 1961	Foreign Assistance Act of 1961
FDR	foreign disaster relief
FFG	guided missile frigate
FSS	fast sealift ship
FY	fiscal year
HADR	humanitarian assistance and disaster relief
HST	high-speed transport
HSV	high-speed vessel
kt	knot (nautical miles per hour)
LCC	amphibious command ship
LCS	littoral combat ship
LHA	amphibious assault ship (general purpose)
LHD	amphibious assault ship (multipurpose)
LMSR	large, medium-speed roll-on/roll-off
LO/LO	lift-on/lift-off
LPD	amphibious transport dock
LSD	dock landing ship
M	million
MB	merchant dry cargo ship
MCM	mine countermeasures ship
MARAD	Maritime Administration
MARAD RRF	Maritime Administration Ready Reserve Force
MPF	maritime pre-positioning force
MPS	maritime pre-positioning ship
MPSRON	maritime pre-positioning ships squadron
MSC	Military Sealift Command
MV	merchant vessel
MT	merchant tanker

NAVSHIPSO	Naval Sea Systems Command Shipbuilding Support Office
nm	nautical mile
NGO	nongovernmental organization
NMS	National Military Strategy
NRF	Naval Reserve Force
NSS	National Security Strategy
O&S	operation and support
OFDA	Office of United States Foreign Disaster Assistance (USAID)
OHDACA	Overseas Humanitarian, Disaster, and Civic Aid (DSCA)
OPDS	offshore petroleum discharge system (USN)
PC	patrol craft
POL	petroleum, oils, and lubricants
RO/RO	roll-on/roll-off
RRF	Ready Reserve Force
Seabee	Navy construction engineer
SECNAV	Secretary of the Navy
SSBN	ballistic missile submarine (nuclear-powered)
SSGN	guided missile submarine (nuclear-powered)
SSN	submarine (nuclear-powered)
T-ACS	auxiliary crane ship
T-AE	ammunition ship
T-AFS	combat store ship
T-AG	offshore petroleum distribution ship
T-AGM	missile range instrumentation ship
T-AGOS	surveillance ship
T-AGS	surveying ship

T-AGSE	submarine escort ship (blocking vessel)
T-AH	hospital ship
T-AK	cargo ship
T-AKE	dry cargo and ammunition ship
T-AKR	fast logistics ship, vehicle cargo ship
T-AO	fleet replenishment oiler
T-AOE	fast combat support ship
T-AOT	transport oiler
T-ARC	cable repairing ship
T-ARS	salvage ship
T-ATF	fleet ocean tug
T-ATS	towing, salvage, and rescue ship
T-AVB	aviation logistics support ship
T-EPF	expeditionary fast transport
T-ESB	expeditionary sea base
T-ESD	expeditionary transfer dock
USAID	United States Agency for International Development
USEUCOM	United States European Command
USFF	United States Fleet Forces Command
USNORTHCOM	United States Northern Command
USPACOM	United States Pacific Command
USSOCOM	United States Special Operations Command
USSOUTHCOM	United States Southern Command
USSTRATCOM	United States Strategic Command
USTRANSCOM	United States Transportation Command
USN	United States Navy
USNS	United States Naval Ship
USS	United States Ship
VAMOSC	Visibility and Management of Operating Support Costs (Navy information system)
VTOL	vertical takeoff and landing

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First, I must acknowledge that I am merely a steward of the time, talent, abilities, and resources given to me by God. May this thesis bring glory to God and be a good use of His gifts.

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This thesis is dedicated to the affected populations around the world that have been, or will be, impacted by disasters large enough to require U.S. naval force involvement.

I. INTRODUCTION

U.S. Navy (USN) and Military Sealift Command (MSC) ships are often tasked to execute the humanitarian assistance and disaster relief (HADR) mission in accordance with U.S. government (USG) and National Security Strategy (NSS) goals (Department of the Navy [DoN], 2015). Inherently, ships can travel great distances on short notice and arrive on station, ready to serve affected populations for extended periods without burdening the damaged infrastructure. To varying degrees, U.S. combatant and non-combatant ships possess unique wartime capabilities that can be adapted to supply a response to emergent demands following a major disaster. These unique sea-based capabilities include, but are not limited to, vertical takeoff and landing (VTOL) aircraft (helicopters and MV-22 Osprey), search and rescue (SAR), amphibious ship to shore landing craft, cargo transportation (dry goods, refrigerated goods, freshwater, vehicles, fuel, people), medical aid, berthing capacity, personnel support, salvage and rescue, and sea-based towing operations. Of the HADR-adaptable ships, available inventory, proximity, and cost must be considered when determining the right mix of ships to send to the disaster location. Tasking the "right" mix of HADR response ships will ultimately maximize the USG aid provided to affected populations while minimizing waste and underutilization of precious U.S. assets and resources.

A. RESEARCH QUESTIONS

To accomplish effective and efficient tasking, this thesis sought to find answers to the following research objective and questions:

1. Primary Research Objective and Question

- (RO) Determine an HADR utility function that links ship HADR capability with reported operating and support (O&S) cost, and proximity.
- (RQ1) Of all available and active U.S. naval ships at disaster onset, what is the optimal mix of ships that maximizes the utility of HADR operations given platform capability, proximity, and cost?

2. Secondary Research Questions

- (SQ1) To what extent does asset capability play a role in maximizing the utility of HADR operations?
- (SQ2) To what extent does asset proximity play a role in maximizing the utility of HADR operations?
- (SQ3) To what extent does asset cost play a role in maximizing the utility of HADR operations?
- (SQ4) To what extent does asset total response duration play a role in maximizing the utility of HADR operations?

To answer these questions, this study links inventory ships from fiscal year (hence on referred to as FY) 2010 to 2017 with reported HADR capability scores, O&S costs, and proximity metrics to determine an HADR utility function that can be used by Combatant Commanders (CCDRs) and their staffs when selecting future HADR task forces.

B. MOTIVATION

This study builds on prior Naval Postgraduate School (NPS) research related to U.S. naval involvement in the HADR mission. These compartmentalized studies have been instrumental in advancing the knowledge base and execution of the U.S. naval HADR mission and are essential to this study. While prior research was based on generic ship type classifications (i.e., CVN, DDG, T-AK, T-AH, etc.), this study attempts to combine HADR capability, cost, and proximity into one model that includes all ships in the U.S. naval inventory from FY 2010 to 2017. Finally, this expanded data is used to derive a utility function that can be used by CCDRs and their staff when deciding which vessels to send in response to the next natural disaster.

The goal of combining ship HADR capability, O&S costs, and proximity is to maximize the benefit of USG HADR efforts while minimizing waste associated with tasking ineffective HADR platforms by providing decision makers a single utility-based tool for future HADR tasking. The closest ships may not always be the best ships to send

in a humanitarian crisis or disaster. This model will help determine if the utility of waiting for the "right" ship exceeds that of sending the closest or immediately available assets.

C. OVERVIEW

The thesis is arranged in the following way. Chapter II provides background information that discusses why and how the U.S. military is tasked by the USG to provide foreign HADR missions. Additionally, I provide a treetop look at the U.S. military combatant and naval command structures. Chapter III is titled Literature Review where I provide a brief literature review summarizing the articles relevant to this research, such as U.S. Navy vessel HADR capabilities and operating costs. In Chapter IV, I provide a detailed description of the data and my plan for analysis moving forward. Based on the gathered data, I assign ship class capabilities, average O&S costs, and proximity metrics for inclusion in the model. In Chapter V, I report my findings. This study ends with my conclusions and recommendations in Chapter VI.

No disaster scenario is the same, each requiring the fulfillment of different needs. Chapter V provides two methods that quickly aid decision makers in selecting the right mix of available ships during future, real-world HADR scenarios. In the first method, I provide a quick reference utility tool that allows mission planners to simply look up the utility score of each available ship, rank them from highest to lowest utility score, and then select only those ships with the best utility scores.

Commanders are intimately familiar with present force requirements, limitations, priorities, world events, and requested needs. This study simply aids in sending the "right" mix of HADR ships based on the existing pool of available ships and the needs of the affected population. Finally, to fully maximize the utility of an HADR response and minimize wasted resources, the available ship HADR utility scores should be cross-referenced with the reported response O&S costs for ships that possess similar HADR utility scores.

All findings are tempered with the understanding that the number of available ships, current tasking, proximity, and costs vary by day. Additionally, I acknowledge that force postures and standard operating procedures may result in CCDRs tasking ships that would

appear to have a low HADR utility rating but have a high value to Navy force protection measures that are beyond the scope of this study.

II. BACKGROUND: HADR MISSIONS IN THE U.S. MILITARY

It is important to establish why a wartime force, like the Navy, gets involved in the HADR mission in the first place. Foreign assistance has been a staple of the U.S. National Security Strategy (NSS) since 1948 when President Truman authorized the Marshall Plan to reconstruct war-torn Europe, promote democracy, and increase U.S. security (USAID, 2018). For over 30 years, humanitarian assistance has been mentioned in the NSS and is a testament to the significant role that the mission plays in the security of the nation (Office of the Secretary of Defense Historical Office [OSDHO], n.d.). Each subsequent National Military Strategy (NMS) has supported the NSS by directing military involvement in HADR type missions in a supporting role (OSDHO, n.d.).

A. DEPARTMENT OF STATE (DOS)

Congress passed the Foreign Assistance Act of 1961 (FAA of 1961) after witnessing the success and utility of developmental programs. Simultaneously, Congress consolidated existing USG outreach programs into one, newly created agency called the United States Agency for International Development (USAID) (USAID, 2018). USAID is a branch of the U.S. Department of State (DoS) and serves as the leading U.S. agency during USG foreign HADR missions (USAID, 2005).

Most often, the U.S. military serves in a supporting role to USAID when the unique capabilities of the military are requested. Overseas USG HADR responses are coordinated through the USAID branch called the Office of U.S. Foreign Disaster Assistance (OFDA). Specifically, OFDA works with the military through a Military Liaison Team (MLT) to enhance civil-military relations and understanding (OFDA/MLT, 2015). By U.S. law, three metrics must be met before USAID/OFDA can respond to an international disaster: "[1] the magnitude of the disaster exceeds the affected country's capacity to respond, [2] the affected country has requested or will accept USG assistance, and [3] it is in the interest of the USG to provide assistance" (USAID, 2005, p. xix).

USAID/OFDA involvement in HADR operations has risen since their establishment in 1961 as the rate, number, and intensity of disasters around the world have

increased (Guha-Sapir, 2018). Figure 1 depicts worldwide disaster occurrence data from the Université Catholique de Louvain's Emergency Events Database (EM-DAT) from 1900 to 2017. The most affected areas are observed to be located near the sea, with Asia holding the highest recorded number of natural disasters.

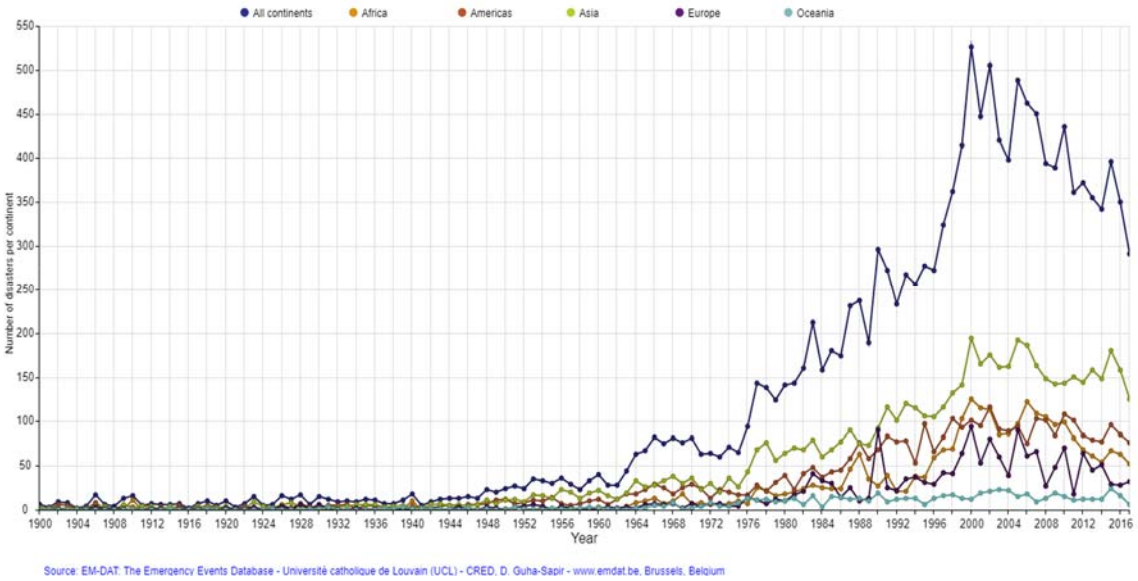

Figure 1. World Natural Disaster Trends (1900–2017). Source: Guha-Sapir (2018).

B. DEPARTMENT OF DEFENSE (DOD)

Supporting the FAA of 1961, DoD Directive 5100.46 mandates that the "DoD shall respond to foreign disasters (FDR) in support of USAID" (DoD, 2017). Joint Publication 3-29, titled *Foreign Humanitarian Assistance*, further stipulates that military responses should be "limited in scope and duration; designed to supplement or complement the efforts of the host nation (HN) that has the primary responsibility for providing the assistance; and may support the USG departments or agencies" (Joint Chiefs of Staff [JCS], 2014, p. I-1). DoD 5100.46 and JP 3-29 authorize nearby U.S. military commanders to conduct immediate life and limb HADR operations, without outside approval for up to 72 hours after disaster impact (JCS, 2014 p. I-5). Military HADR operations greater than 72 hours require authorization from the Secretary of Defense (SECDEF) (JCS, 2014 p. I-5). Figure 2

depicts JCS (2014) generalized scenarios that warrant a U.S. military HADR response and the type of aid that the DoD is authorized to provide affected populations around the world.

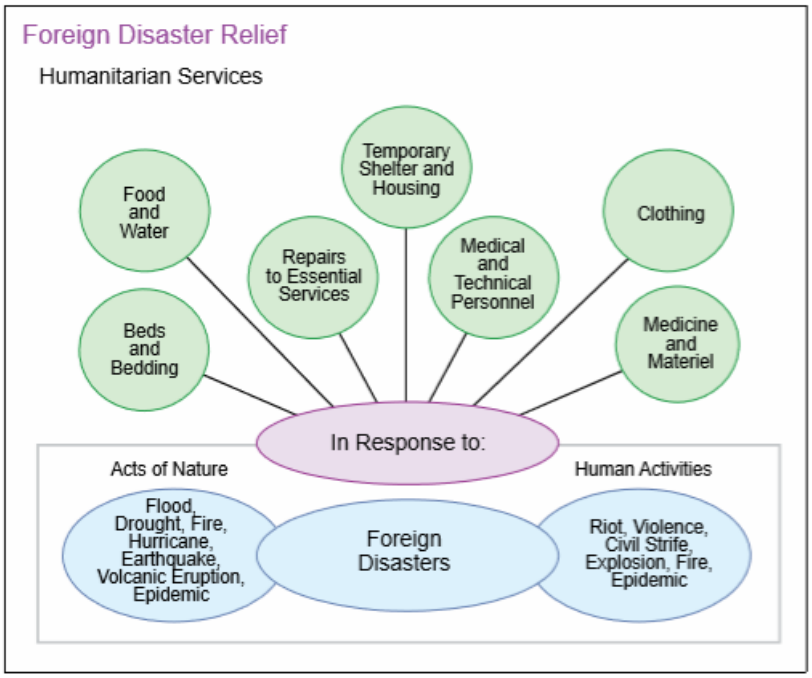

Figure 2. U.S. Military HADR Response Services Provided.
Source: JCS (2014, p. I-6).

OFDA requests military support from the SECDEF when unique military capabilities are needed during USAID responses. The SECDEF analyzes the situation and then tasks the applicable CCDR to respond. DoD divides the world into six regional combatant commands (COCOMs) led by a CCDR; U.S. Africa Command (USAFRICOM), U.S. Central Command (USCENTCOM), U.S. European Command (USEUCOM), U.S. Northern Command (USNORTHCOM), U.S. Pacific Command (USPACOM), and U.S. Southern Command (USSOUTHCOM). There are three additional combatant commands that operate world-wide with the regional combatant commands; U.S. Special Operations Command (USSOCOM), U.S. Strategic Command (USSTRATCOM), and the U.S. Transportation Command (USTRANSCOM) (DoD, n.d.). More germane to the HADR mission, USTRANSCOM oversees all land, air, and sea assets designed to transport DoD goods and personnel. Each CCDR has an OFDA Humanitarian

Assistance Advisor on staff to further facilitate civil-military coordination (OFDA/MLT, 2015, pp. 47–48). Figure 3 provides a visual depiction of each regional CCDR's Area of Responsibility (AOR).

Figure 3. Combatant Command AORs. Source: DoD (n.d.).

When disaster strikes near the sea, the applicable CCDR must quickly determine which vessels are available and task specific ships to provide an HADR response based on mission requests. To aid in this decision, JP 3-29 provides joint force general planning and execution guidelines which are further delineated by each U.S. military service. The Navy uses the unclassified tactical memorandum (TACMEMO) *Humanitarian Assistance/Disaster Relief (HA/DR) Operations Planning* guide known as TACMEMO 3-07.6-05 (DoN, 2005). Specific plans do not exist for every HADR scenario due to the complexity and unpredictable nature of disasters that require a humanitarian response. Vessel capability and utilitarian decision matrices are missing from these publications that could aid CCDRs in selecting the optimal mix.

C. DEPARTMENT OF THE NAVY (DON)

DoN ships are assigned to one of four custodians dependent on ship category, classification, status, type, and resource sponsor. The four custodians include the USN, MSC, Naval Reserve Force (NRF), and the Ready Reserve Force (RRF). Each COCOM has operational control over a designated portion of the USN and MSC inventories at any one time. Additionally, USTRANSCOM has operational control over portions of the MSC and RRF inventories at any one time (MSC, 2016).

As of March 7, 2017, the U.S. Navy reported 282 deployable battle force ships. Of the 282 deployable ships, 96 were deployed across the six AORs and 28 additional ships were underway for local training operations (U.S. Navy, 2018, March 7). These numbers do not include non-battle force MSC and RRF ships. Current battle force data can be found at www.navy.mil/navydata/nav_legacy.asp?id=146.

1. United States Navy (USN)

USN ships are titled as a United States Ship (USS) followed by the ship name, i.e. USS *Abraham Lincoln,* and are divided among six numbered fleets with AORs that do not always coincide with the geographic lines delineated by the COCOMs. Ships from each fleet can be assigned under the operational control of any CCDR if the ship is deployed to their AOR or tasked by higher authorities. U.S. Fleet Forces (USFF/C2F) is headquartered in Norfolk, VA and is responsible for homeland defense and the North Atlantic Ocean. U.S. Third Fleet (C3F) is headquartered in San Diego, CA and is responsible for the East Pacific. U.S. Fourth Fleet (C4F) is headquartered at Mayport, FL and is responsible for the South Atlantic. U.S. Fifth Fleet (C5F) is headquartered at Manama, Bahrain and is responsible for sea-based operations in the Middle East. U.S. Sixth Fleet (C6F) is headquartered in Naples, Italy and is responsible for sea-based operations in Europe. U.S. Seventh Fleet (C7F) is headquartered in Yokosuka, Japan and is responsible for the West Pacific. Reported USN fleet locations and descriptions can be found at http://www.navy.mil/CommandDirectory.asp.

Table 1 depicts a summary of FY 2017 U.S. Navy battle force vessels by classification and type, as defined in the Secretary of the Navy Instruction (SECNAVINST) 5030.8C. Table 2 depicts the homeport locations of all active USN ships, as of October 27, 2017, and illustrates how the total number of ships in a class can be misleading if location is not accounted for. Tables 1 and 2 are derived from my analysis of raw data obtained from the Navy Visibility and Management of Operating and Support Costs (VAMOSC) and Naval Vessel Register (NVR) databases used to conduct this study and will be defined further in Chapter IV. USN ships deploy from the listed homeports to the various numbered fleets, further reducing force concentrations during routine operations.

Table 1. USN Ship Allocation by Classification and Type, FY 2017

Ship Type[1]	Abbreviation	Count
Aircraft Carrier		11
Multi-Purpose Aircraft Carrier (Nuclear-Powered)	CVN	11
Amphibious Warfare		31
Amphibious Assault Ship (General Purpose)	LHA	1
Amphibious Assault Ship (Multi-Purpose)	LHD	8
Amphibious Transport Dock	LPD	10
Dock Landing Ship	LSD	12
Mine Warfare		11
Mine Countermeasures Ship	MCM	11
Patrol Combatant		13
Patrol Coastal	PC	13
Service Support		1
Command Ship	LCC	1
Submarine		70
Ballistic Missile Submarine (Nuclear-Powered)	SSBN	14
Guided Missile Submarine (Nuclear-Powered)	SSGN	4
Submarine (Nuclear-Powered)	SSN	52
Surface Combatant		96
Guided Missile Cruiser	CG	22
Guided Missile Destroyer	DDG	65
Littoral Combat Ship	LCS	9

[1] Ship Type names derived from reported NVR standard nomenclature values per SECNAVINST 5030.8C.

Raw data obtained from the NVR database, October 27, 2017.

Table 2. USN Ship Allocation by Homeport and Type, FY 2017

	Type Class														
Homeport	CG	CVN	DDG	LCC	LCS	LHA	LHD	LPD	LSD	MCM	PC	SSBN	SSGN	SSN	Total
BANGOR, WA												8	2	1	11
BREMERTON, WA		2												4	6
EVERETT, WA			5												5
GROTON, CT														12	12
KINGS BAY, GA												5	2		7
MANAMA, BAHRAIN										4	10				14
MAYPORT, FL	4		4		2		1	1	1		3				16
NAVAL BASE, GUAM														4	4
NEWPORT NEWS, VA		1												1	2
NORFOLK, VA	6	5	20				3	3						6	43
LITTLE CREEK, VA									5						5
PEARL HARBOR, HI	1		9											16	26
PORTSMOUTH, NH														3	3
PORTSMOUTH, VA												1		1	2
ROTA, SPAIN			4												4
SAN DIEGO, CA	8	2	15		7	1	3	5	4	3				4	52
SASEBO, JAPAN							1	1	2	4					8
YOKOSUKA, JAPAN	3	1	8	1											13
Total	22	11	65	1	9	1	8	10	12	11	13	14	4	52	233

Raw data obtained from the NVR database, October 27, 2017.

2. Naval Reserve Fleet (NRF)

The NRF is comprised of decommissioned, inactive USN combatant ships that are in mothball status if the nation needs them during a large-scale war. These ships are excluded from this study due to the limited probability of activation to conduct an HADR operation.

3. Military Sealift Command (MSC)

MSC ships are typically titled as a United States Naval Ship (USNS) followed by the ship name, i.e., USNS *Mercy*. For contract MSC ships, it is standard for them to have type names that begin with merchant dry cargo ship (MB), merchant vessel (MV) or merchant tanker (MT) followed by the name. Unlike USN ships, most MSC ships do not have an assigned homeport in the NVR database. The MSC is broken into six world-wide commands, depicted in Figure 4, that ultimately report to one of three upper-echelon commands; USTRANSCOM, USFF, or in select cases, the Assistant Secretary of the Navy for Research, Development and Acquisition (MSC, 2016, p. 8).

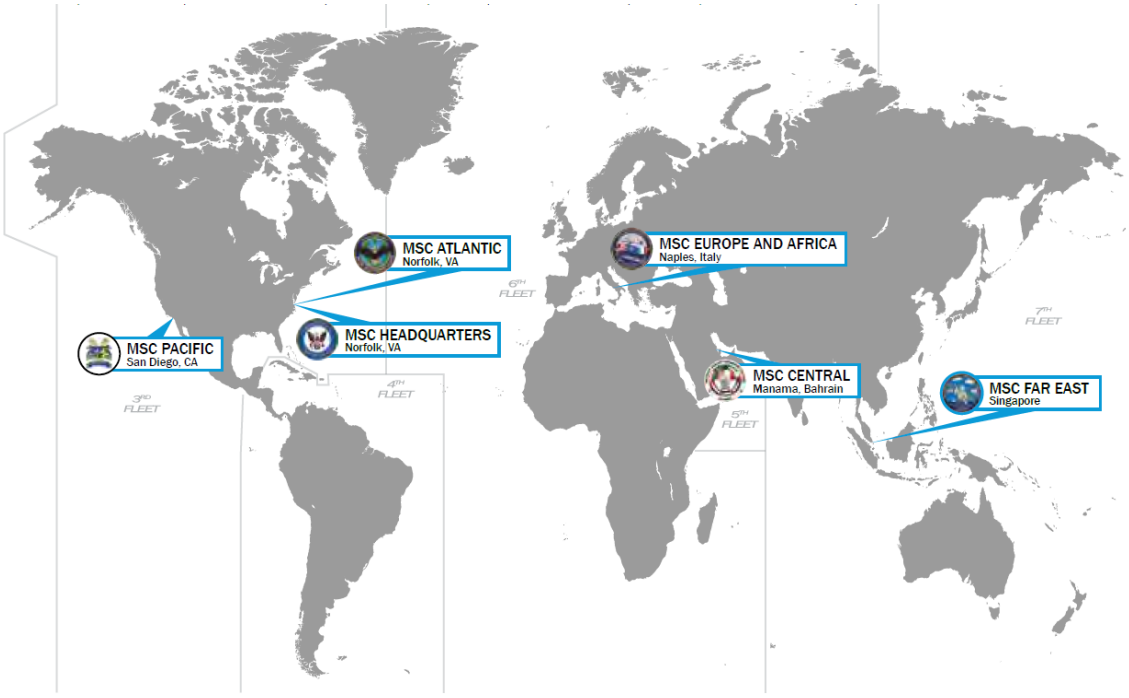

Figure 4. MSC Global Area Commands. Source: MSC (2017, p. 6).

Cargo capacity, medical-support capabilities, and the relatively low O&S costs of MSC ships make them valuable assets during HADR missions. The MSC is broken into five programs that determine what each MSC inventory ship is used for (MSC, 2016). Figure 5 is a screenshot from the 2016 MSC Handbook detailing each program. Of note, the MSC combat logistics and prepositioning force ships account for the remaining portion of the previously reported 282 battle force ships by the U.S. Navy.

Combat Logistics Force (PM1) (PM6) manages ships that provide underway replenishment, commercial helicopter services and other direct fleet support to Navy ships worldwide. These ships include fleet replenishment oilers, fleet ordnance and dry cargo ships, and fast combat support ships.

Service and Command Support (PM4) (PM7) (PM8) provides the Navy with towing, rescue and salvage, submarine support, and cable laying and repair services, as well as a command and control platform, floating medical facilities and the Navy's first Expeditionary Mobile Base. Also included are Expeditionary Fast Transports (EPF) which provide rapid, intra-theater transport of troops and military equipment.

Special Mission (PM2) supports specialized scientific and technical missions for DOD sponsors. Missions include ocean surveillance, oceanographic survey, cable laying, missile telemetry collection, submarine support and navigation test support.

Prepositioning (PM3) provides ships loaded with military stores for forward, at-sea staging around the world. Prepositioning ships carry cargo owned by the U.S. Army, Air Force, Navy, and Marine Corps.

Sealift (PM3) provides marine transportation to satisfy DOD sealift requirements. For dry cargo validated by USTRANSCOM and assigned to MSC, Sealift provides breakbulk, container and roll-on/roll-off (RORO), as well as other specialty ships (heavy lift/FLOFLO) from both government and commercial sources. Sealift also provides commercial tankers for movements of Defense Logistics Agency-Energy petroleum requirements.

Figure 5. MSC Ship Program Description. Source: MSC (2016).

Table 3 depicts a derived summary of the FY 2017 MSC ship inventory and respective program allocations based on VAMOSC data used in this study and verified with the 2016 MSC Handbook.

Table 3. MSC Ship Allocation by Program and Type, FY 2017.
Adapted from MSC (2016).

Ship Type	Abbreviation	Count
Combat Logistics Force		29
Dry Cargo/Ammunition	T-AKE	12
Fleet Replenishment Oilers	T-AO	15
Fast Combat Support Ship	T-AOE	2
Prepo: Army Prepositioned Stock-3 (APS-3)		7
Container Ship	T-AK	2
Large Medium Speed Roll-on/Roll-off (LMSR)	T-AKR	5
Prepo: Maritime Prepositioning Force (MPF)		14
Container Ships	T-AK	6
Dry Cargo/Ammunition	T-AKE	2
Large Medium Speed Roll-on/Roll-off (LMSR)	T-AKR	4
Expeditionary Transfer Dock	T-ESD	2
Prepo: Navy, Defense Logistics Agency and Air Force (NDAF)		5
High Speed Vessel	HSV	1
Offshore Petroleum Distribution System (OPDS)	T-AG	1
Container Ships	T-AK	2
High Speed Vessel	T-HST	1
Sealift		27
Dry Cargo Ship (Merchant)	MB	1
Roll-on/Roll-off (RO/RO) Container	T-AK	5
Dry Cargo Ship	T-AK	3
Large Medium Speed Roll-on/Roll-off (LMSR)	T-AKR	10
Tanker	T-AOT	7
High Speed Vessel	T-HST	1
Service Support		24
Afloat Forward Staging Base	AFSB	1
Submarine Tender	AS	2
Command Ship	LCC	1
Hospital Ship	T-AH	2
Cable Laying/Repair Ship	T-ARC	1
Rescue and Salvage	T-ARS	4
Fleet Ocean Tug	T-ATF	4
Expeditionary Fast Transport	T-EPF	8
Expeditionary Mobile Base	T-ESB	1
Special Mission		19
Submarine/Special Warfare Support	T-AGER	1
Missile Range Instrumentation Ship	T-AGM	2
Ocean Surveillance Ship	T-AGOS	5
Oceanographic Survey	T-AGS	6
Navigation Test Support	T-AGS	1
Submarine/Special Warfare Support	T-AGSE	4

Raw data obtained from the VAMOSC database, January 29, 2018.

4. Ready Reserve Force (RRF)

The RRF is the inactive component of the MSC, with similar classification and program assignments to MSC ships based on class. The 56 ships that compose the RRF are officially assigned to the U.S. Maritime Administration (MARAD) and are berthed at 18 coastal locations around the United States. This study does not include the ten depicted RRF special mission ships due to the low probability that these ships would be tasked during an HADR mission.

The primary difference between RRF ships and the MSC is that RRF ships are manned at minimal levels on a full-time basis. RRF ships are maintained in a ready status by small full-time crews, which enable RRF ships to be activated within predetermined activation windows. Unlike NRF ships, most RRF ships can be fully activated within 5 days of notification, with the longest activation period equaling 10 days (Department of Transportation [DoT], 2016). Figure 6 depicts the RRF force composition as of January 20, 2018. Figure 7 depicts the MARAD provided RRF ship berth locations and associated activation times, as of December 22, 2017 (DoT, 2017).

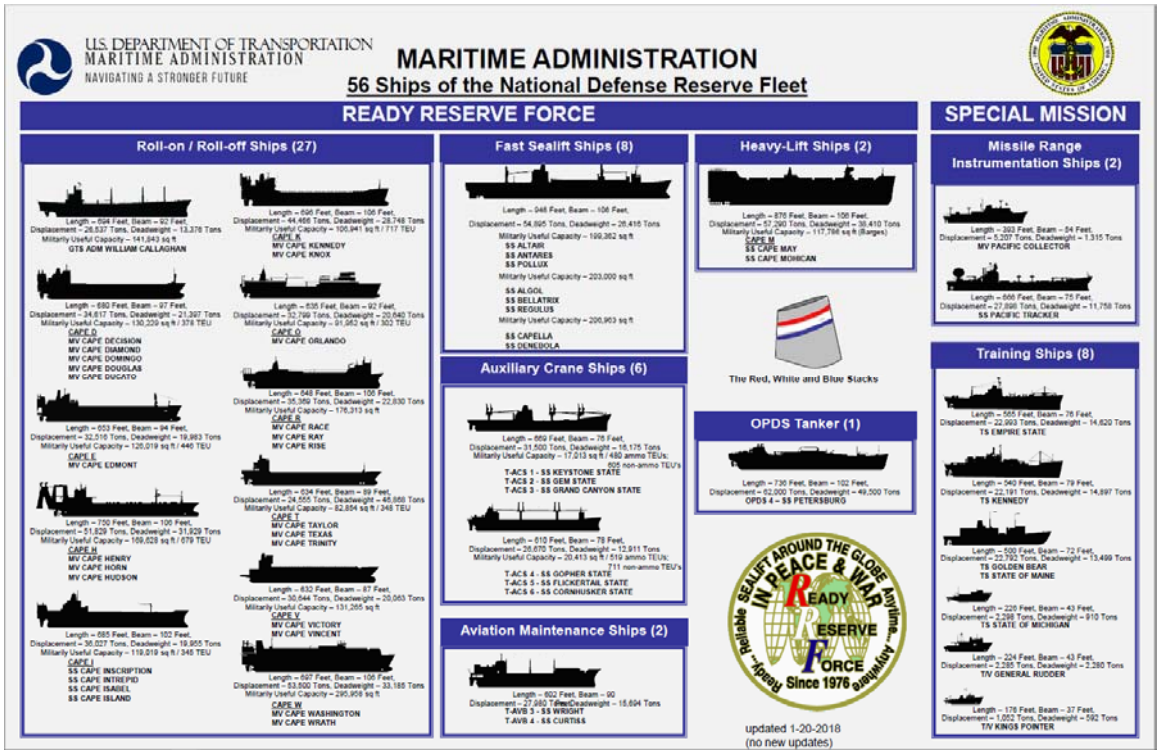

Figure 6. Maritime Administration Ship Composition (20 Jan 2018). Source: DoT (2018).

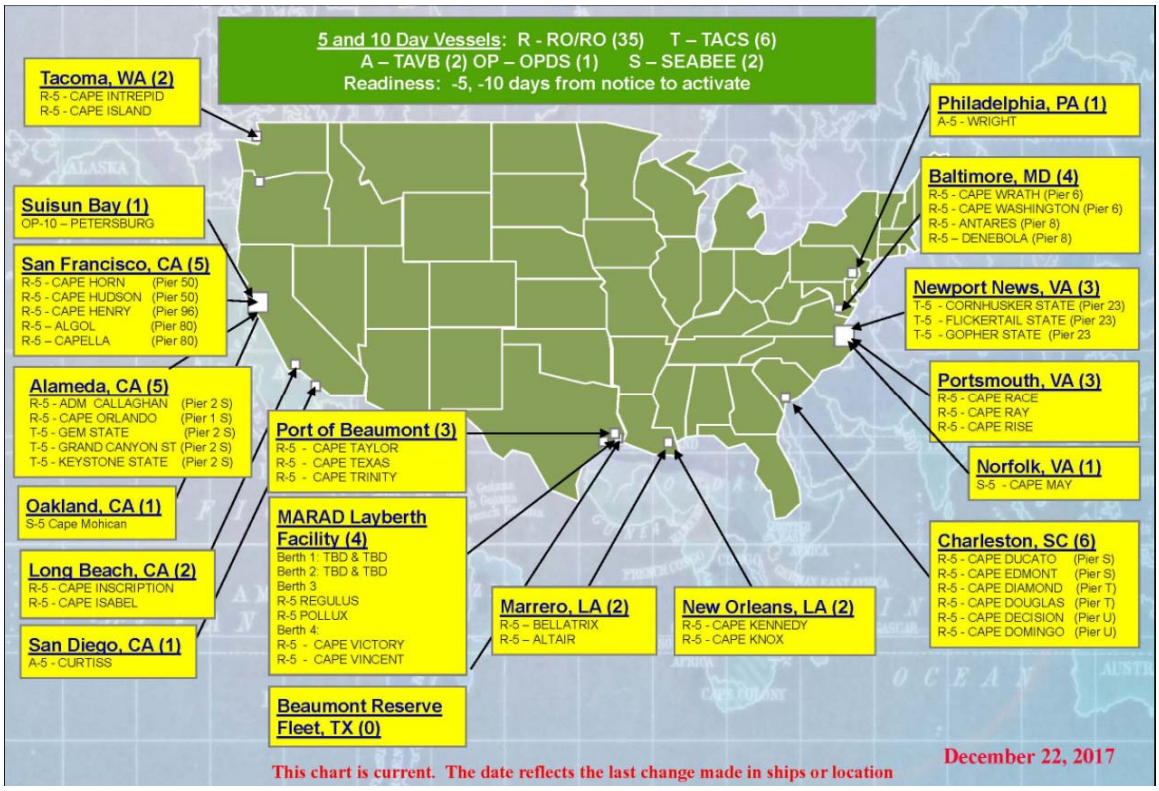

Figure 7. RRF Ship Locations and Activation Days. Source: DoT (2017).

D. SUMMARY

Tasking the "right" HADR ships in response to an emergent disaster is clearly a complicated business given the layered command structures and the world-wide distribution of limited ship inventories of each class. To respond quickly, it is not uncommon for combatant commanders to task the closest ships, without the luxury of time to fully consider how capable each ship is at conducting the HADR mission or whether waiting for a more distant but more capable ship would be better. This type of tasking can easily lend itself to wasting valuable U.S. resources (wartime assets, funding, manpower, and readiness) while providing a suboptimal HADR response to the affected population. In an environment of constrained resources, it is important that these resources be used as efficiently and effectively as possible when responding to disasters around the world.

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III. LITERATURE REVIEW

To begin the analysis of U.S. naval HADR tasking, I first provide a brief literature review of the studies that inspired and motivated this research. First, I provide a summary of the types of natural disasters for which the USN, MSC, and RRF are often tasked to provide a response. Once the types of disasters are established, I review the capability studies that serve as the foundation of the capability portion of this study. Next, I provide an overview of the existing HADR cost research, which includes analysis of O&S and reported incremental costs associated with naval HADR responses. The last pieces of literature pertain to some of the econometric methods used in this study. I will conclude the literature review by identifying gaps in the existing literature.

A. LITERATURE ABOUT THE PROBLEM

There have not been extensive studies in the field of HADR conducted by USN. Apte (2009) researched natural disaster characteristics and summarized the needs of affected populations and categorized disasters in terms of how quickly and localized disasters are that hit affected populations. Rapid onset disasters, spread across dispersed areas are the most difficult for responders, see Figure 8.

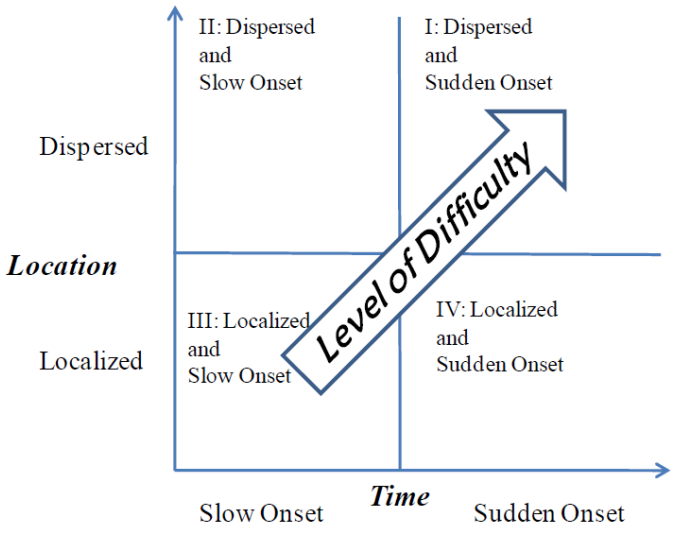

Figure 8. Classification of Disasters. Source: Apte (2009, p. 14).

Greenfield and Ingram (2011) paired the affected population needs with mission requests for aid and found eighteen different HADR capability metrics that naval ships could provide during an HADR response (Greenfield & Ingram, 2011). Greenfield and Ingram linked these HADR capability metrics with inherent U.S. naval ship capabilities and determined which Navy ships were adaptable to the HADR mission by ship type (i.e., DDG, LPD, T-AH, T-AK). Greenfield and Ingram (2011) established baseline metrics for Navy ship capabilities based on HN/OFDA requested needs and Navy-provided capabilities in response to three disasters; the Indian Ocean Tsunami of 2004, Hurricane Katrina in 2005, and the Haiti earthquake of 2010. The requested HADR capabilities are depicted as the column titles in Figures 9 and 10 (Greenfield & Ingram, 2011).

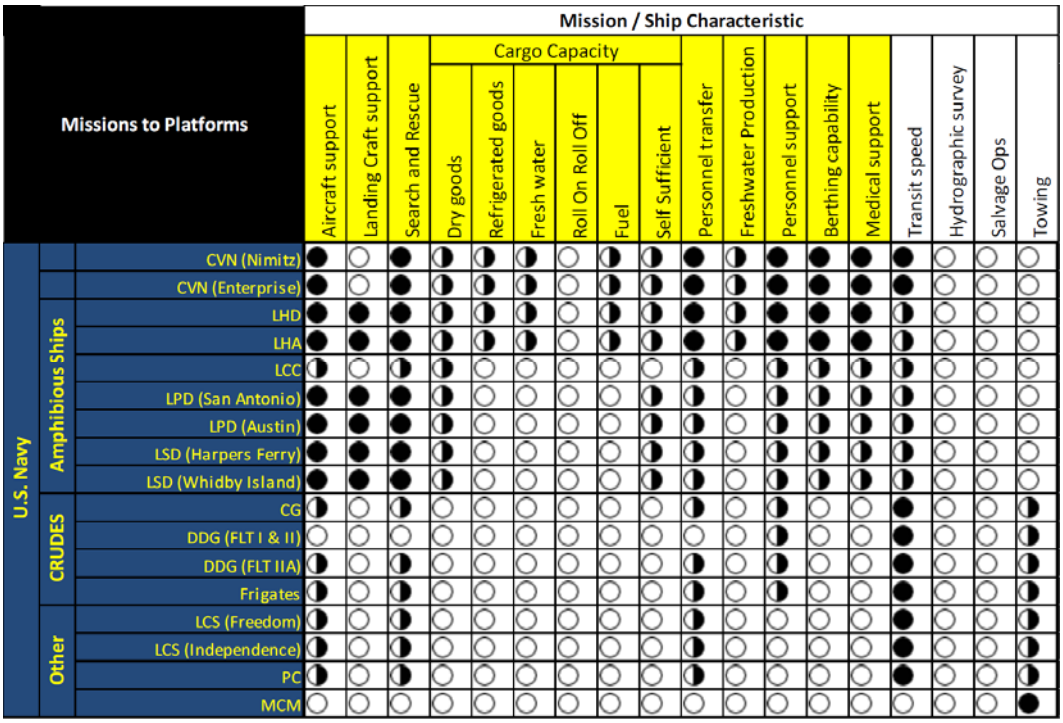

Figure 9. USN Ship Type HADR Capability Ratings. Source: Greenfield and Ingram (2011, p. 57).

Greenfield and Ingram (2011) assigned ordinal values (0, 1, or 2) to specific ship types for each of the 18 naval HADR capabilities, based on unclassified capabilities found in Navy Fact Files and Jane's Fighting Ships. Their assigned values can be observed in the

rows of Figures 9 and 10. An empty circle (0) means the vessel has no capability to perform the required HADR task, a half circle (1) means that the vessel is marginally capable, and a completely filled in circle (2) means that the vessel is highly capable of performing the requested HADR task (Greenfield & Ingram, 2011).

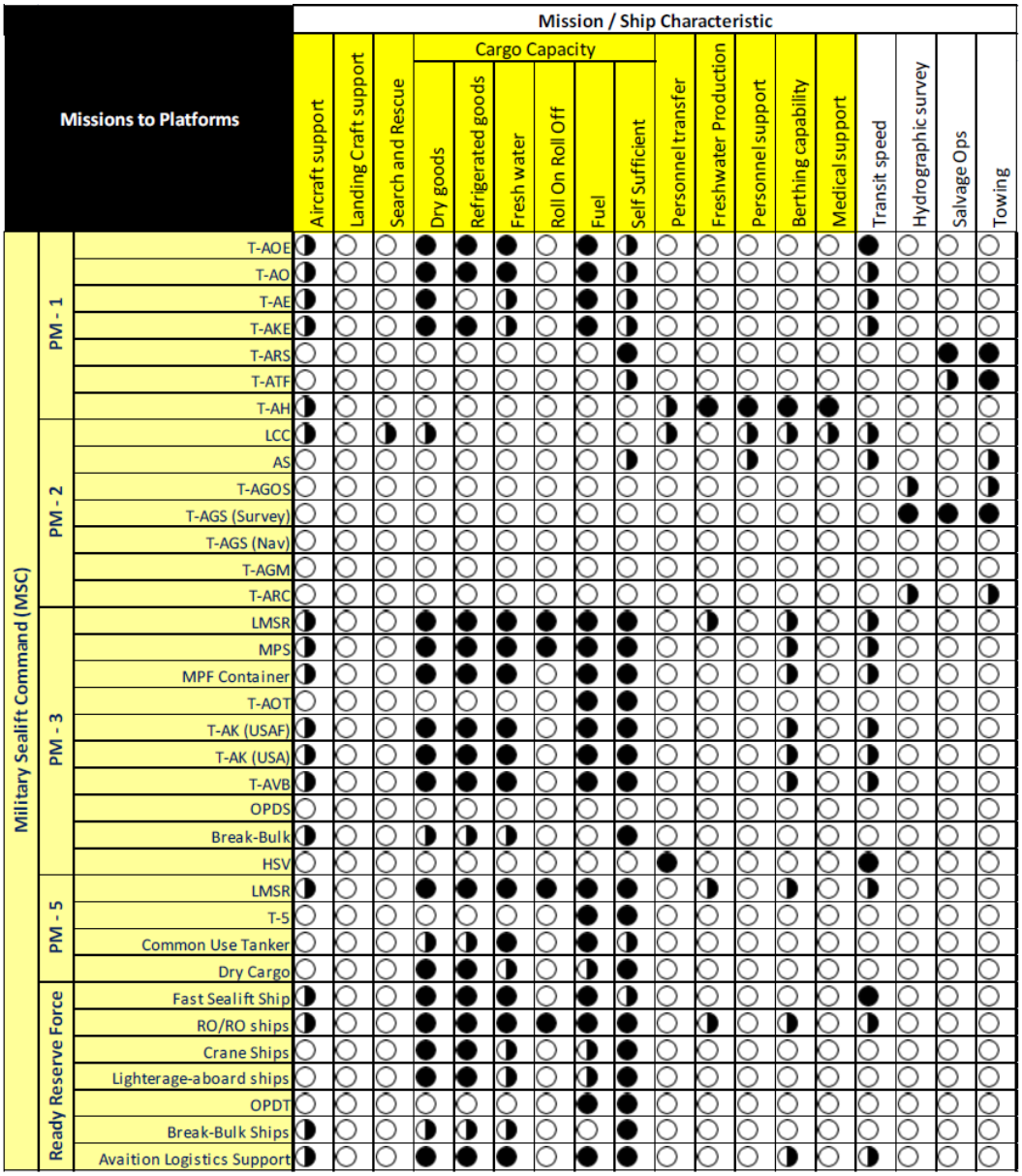

Figure 10. MSC and RRF Ship Type HADR Capability Ratings. Source: Greenfield and Ingram (2011, p. 58).

Greenfield and Ingram (2011) found that ships with VTOL capability were the most desirable ships along with those with the ability to provide heavy cargo sealift and medical support. Based on these responses and the reported capabilities, they determined that ships, such as destroyers without a helicopter onboard, are not suited for HADR missions and should not be sent (Greenfield & Ingram, 2011). I use Greenfield and Ingram (2011) reported 2010 Haiti earthquake HADR response ship names, number of days' transit, and number of days on station as metrics that I insert into the utility function to partially answer the secondary research questions. Specific values used will be reported in Chapters IV and V.

The first naval HADR cost study reported that the DoD does not have funding set aside to conduct the HADR mission and instead relies on Defense Security Cooperation Agency (DSCA) funds to reimburse each responding unit (Ures, 2011 p. 3). Ures (2011) went on to detail the funding process of providing an HADR response and reported incremental operating costs incurred during the 2004 Indian Ocean tsunami, 2010 Haiti earthquake, and 2010 floods in Pakistan. The author breaks the incremental operations costs into response categories and finds that helicopter operations result in the highest operational costs but also provide the greatest value to the HADR mission (Ures, 2011, p. 39). Similarly, Ures (2011) reports that hospital ships are costly and require remaining on station for longer periods of time to make them worth the investment.

Moffat (2014) investigated the associated costs differently than Ures by calculating the average daily O&S costs for individual ships that responded during the 2005 Indian Ocean tsunami, 2010 Haiti earthquake, and the 2011 Tohoku earthquake and tsunami. Moffat (2014) then averaged each type of ship based on these costs with hopes of providing a quick reference of daily operating costs by ship type. Moffat (2014) reports that he used annual fuel and operating costs from the Visibility and Management of Operating and Support Costs (VAMSOC) database. However, analysis of the reported cost figures indicates that manpower and other cost categories were included. The analysis combines cost findings with the capability findings of Greenfield and Ingram (2011) to determine a cost per unit of capability, where LHD ships have the lowest cost per capability and DDGs without a helicopter have the highest costs per unit of capability (Moffat, 2014, p. 16).

Apte and Yoho (2017) approached the cost problem differently by calculating the incremental costs associated with providing an HADR response. Specifically, they used values requested by the DoN for reimbursement from the Overseas Humanitarian, Disaster, and Civic Aid (OHDACA) fund run by the DoS and then paired the incremental costs with the daily operating costs reported by Moffat (2014) to determine the true daily cost of each ship that provided an HADR response (Apte & Yoho, 2017). Apte and Yoho (2017) summarized the HADR cost findings of Ures (2011), Herbert, Prosser, and Wharton (2012) and Moffat (2014) depicted in Figure 11.

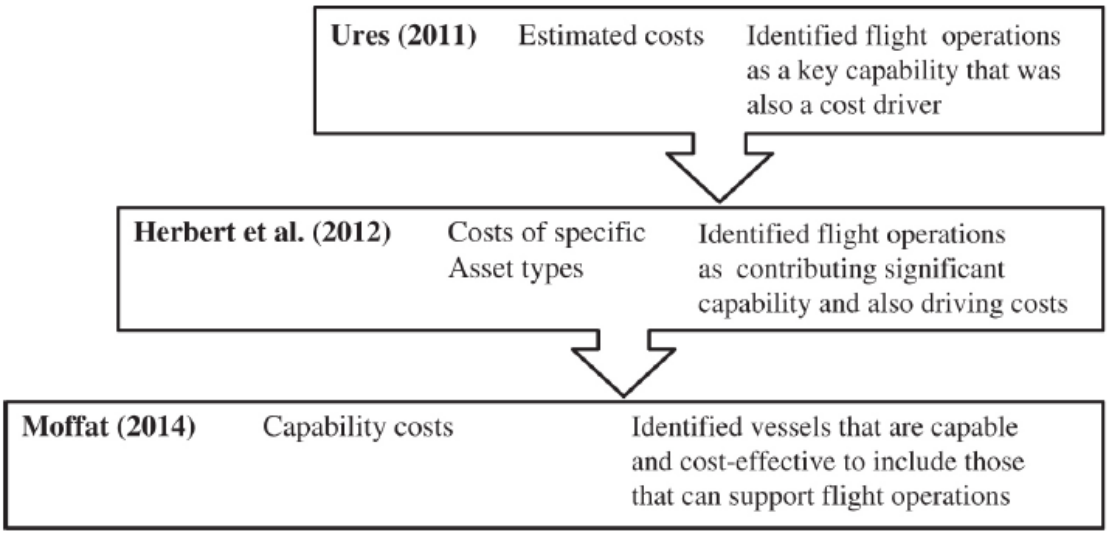

Figure 11. Summary of Existing USN HADR Cost Literature.
Source: Apte and Yoho (2017).

B. GAPS IN THE LITERATURE REQUIRING FURTHER STUDY

To date, the capabilities and O&S costs have not been paired with proximity and response duration to provide a holistic response picture. Each of the studies contained in the literature review recommend that follow-on research pair cost and capability with proximity and availability.

Additionally, existing capability studies have only reported findings at the ship type level vice the individual or ship class level. I find significant variance between ships within

a reported class, which merit further analysis in this study. Previous HADR cost studies have been limited to reporting cost values for individual response ships that have been ascribed to a ship type and have not included all ships of a given class. Individual response ships may have higher or lower O&S costs than the Fleet average and may falsely represent average ship type or class expenses. My analysis of the VAMOSC database reveals large variances in the O&S costs reported by individual ships within a given class. This study seeks to conduct further analysis at the class level to avoid biasing decisions based on a handful of ships vice an entire class average.

This study will build upon the existing HADR research to report HADR capabilities and O&S costs for all naval inventory ships from FY 2010 to 2017.

C. METHODOLOGY

This study relies on econometric tools to analyze ship inventories, O&S costs, capabilities, and proximity to determine an HADR utility function that aids decision makers in tasking the right mix of ships for future HADR responses. It is important to take a moment to define a couple of key econometric terms related to this study.

1. Utility

The notion of utility in economic theory can be defined as "a measure of happiness or satisfaction that a person receives from his [or her] circumstances" (Mankiw, 2015, p. 421). These circumstances include income, preferences, and the idea that people will maximize their happiness by spending their available money (or time) in ways that maximize the goods that they prefer. In each case, individuals will be willing to substitute their preferred goods for other goods when their circumstances change but, in all cases, individuals will find the pairing that gives them the most utility, or happiness, within a given budget (Mankiw, 2015). Utility functions can be as simple as summing two things together or based on much more complicated preference calculations.

This same notion can be applied to HADR scenarios, only now, the individual seeking happiness is the affected population seeking assistance while U.S. naval ships are the goods that fill capabilities needing maximization. As it is with commodities, certain

pairings of ships with a given budget and proximity will ultimately yield a higher satisfaction of need than sending another ship or pairing of ships.

2. Factor Analysis

This study uses STATA, a commercially available statistics and analysis software package, to conduct econometric regressions and factor analysis. In Chapter 13 of their book titled *Methods of Multivariate Analysis, Third Edition*, Rencher and Christensen (2012) describe factor analysis as an alternative to linear and multivariate regression if the data contains variables with characteristics that are hard to observe or that are collinear. Rencher and Christensen state that the "goal of factor analysis is to reduce redundancy among the variables by using a smaller number of factors" (2012, p. 435). These factors are supposed to represent the variables in chunks instead of individual variables. According to Rencher and Christensen (2012), the number of factors to use can be subjective. However, they provide steps to minimize the subjectivity.

Rencher and Christensen provide four steps that aid in selecting the right number of factors (*m)* to retain; (1) define the percentage of the variance in the data that needs to be accounted for (they propose 80% as an example), (2) "choose *m* equal to the number of eigenvalues greater than the average eigenvalue" (p. 453), (3) "use the scree test based on a plot of the eigenvalues" (p. 453), and (4) "test the hypothesis that m is the correct number of factors" (Rencher & Christensen, 2012, pp. 453-454). The steps provided by Rencher and Christensen are the foundation of the factor analysis used in this study, but I select 90% as the threshold for variance explained vice 80%.

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IV. DATA AND METHODOLOGY

This study uses data from multiple sources to determine USN, MSC, and RRF ship inventories, O&S costs, unclassified performance metrics, and HADR response metrics at the individual ship level from FY 2010 to 2017. First, I find data sources that report vessel name, hull number, class, type, status, O&S costs, and key milestone dates at the individual ship level. Next, I find HADR capability and performance metrics at the ship class level that I append to the individual ship data. Finally, I incorporate actual U.S. naval HADR response data for two historic natural disasters and establish a baseline for statistical analysis. Once all data sources are merged, I clean and code the data for analysis and reporting.

A. DATA SOURCES

Finding comprehensive data from FY 2010 to 2017 proved to be more difficult than expected. This study relies on five primary data sources; VAMOSC, NVR, official fact files (from USN, MSC, and MARAD), Jane's by Markit Fighting Ships, and relevant HADR data previously collected and reported by students and faculty at NPS. For inclusion, each data source must contain at least one of the following identifiers; ship name, hull number, class, or easily identifiable ship type.

1. Navy Visibility and Management of Operating and Support Costs (VAMOSC)

VAMOSC is an official Navy database that contains detailed, categorical cost and non-cost data for over 1,700 individual U.S. naval ships from FY 1984 and FY 1993 to present for USN/NRF and MSC/RRF designated ships, respectively (VAMOSC, n.d.-a). The VAMOSC-reported cost values represent end of FY totals for each cost category in Then-Year (TY) or user selected Constant-Year (CY) U.S. dollars (USD). VAMOSC-reported non-cost values represent end of FY count totals for each categorized item.

This study queries the VAMOSC Ship Data universe for USN/NRF ships and the Military Sealift Command Data universe for MSC/RRF vessels. As a registered user, I download Excel versions of the database that contain all available VAMOSC inventory,

cost and non-cost elements for USN, NRF, MSC, and RRF ships from the VAMOSC website (https://www.vamosc.navy.mil/) for FY 2010 to 2017. The Excel files, like the website, are broken into multiple tabs that allow the user to view the data in a formatted, summary view of all requested FYs or in an unformatted, simple table version that can be imported into statistical software packages. Figure 12 is a screenshot of the formatted, FY summary view of VAMOSC reported cost and non-cost data for the USS *Nimitz* (CVN 68) on the VAMOSC website. Figure 13 is a screenshot of similar data for the USS *Dewey* (DDG 105) as viewed in the unformatted, simple table (flat file) format on the VAMOSC website.

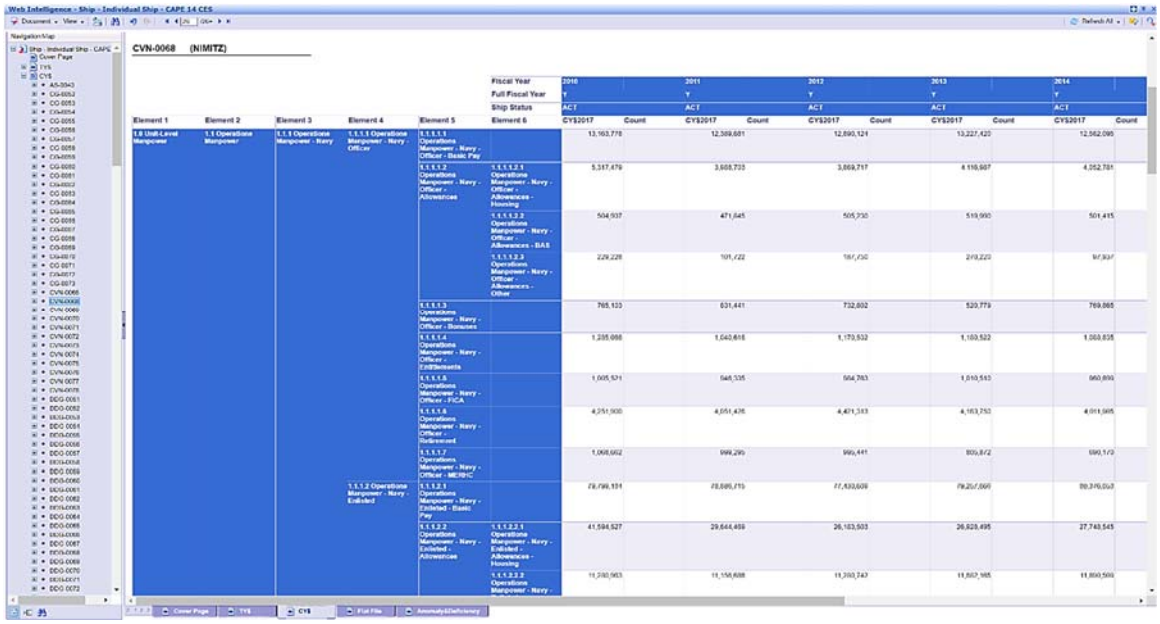

Figure 12. Screenshot of VAMOSC Individual Ship Data, Formatted View. Source: VAMOSC (n.d.-b).

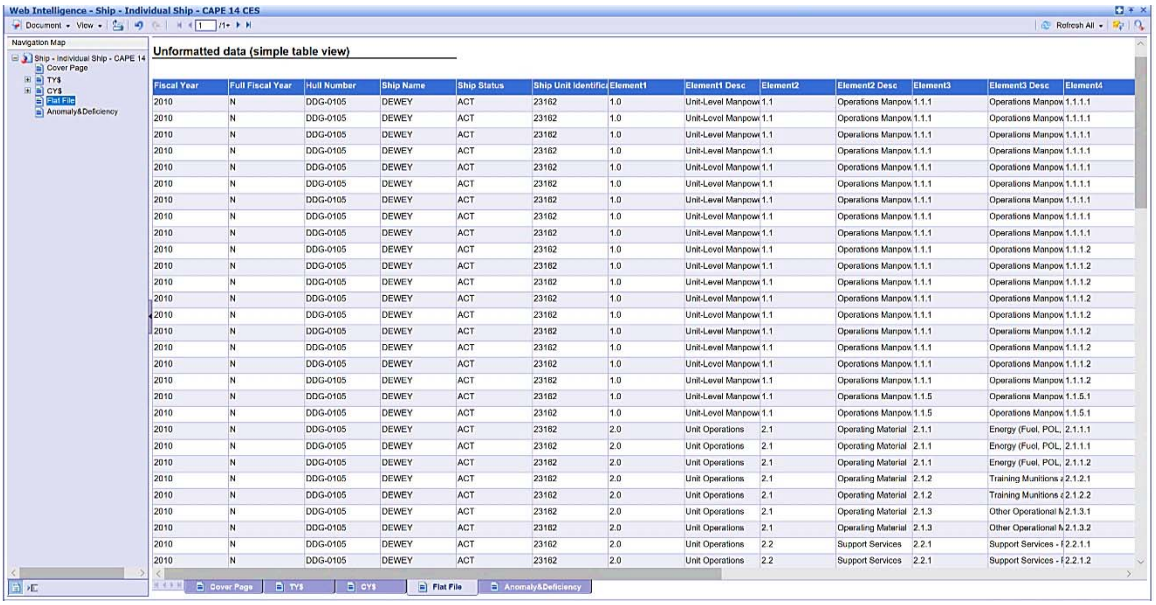

Figure 13. Screenshot of VAMOSC Individual Ship Data, Unformatted View. Source: VAMOSC (n.d.-b).

Queries of each respective VAMOSC universe "Individual Ship (CAPE CES)" database yield a total of 339,814 observations that represent line-itemized cost and non-cost entries for 588 ships in two excel files. Broken down, the USN/NRF Individual Ship (CAPE CES) query yields 158,285 observations that represent 283 ships and six multilayered element data fields. The MSC/RRF Individual Ship (CAPE CES) query yields 181,529 observations that represent 305 ships and five multilayered element data fields.

2. Naval Vessel Register (NVR)

The NVR is the official inventory of U.S. naval ships (NVR, n.d.). The database contains a single observation for all ships titled, built, authorized for construction or acquired by the USN or MSC from 1794 to present. The NVR contains unique ship identifier data fields that report vessel name, hull number, standard nomenclature, class, UIC, status, weights and measures, propulsion type, and applicable commissioning, decommissioning, activation, inactivation, in service, out of service, stricken, sunk, and disposal dates. Additionally, the NVR reports homeport, berth, custodian, shipyard, and other data fields for current USN, NRF, MSC, and RRF inventory ships. Naval Sea Systems Command Shipbuilding Support Office (NAVSHIPSO) actively maintains the

database in accordance with Congressional and SECNAV directives to ensure that the reported NVR ship status reflects real time information and not historic, time series data (SECNAV, 2016). Attempts to determine ship status, homeport, berth, custodian, etc., for a given ship at a specific date are beyond the intended scope of the NVR since these fields are overwritten with new data or erased entirely when the ship is no longer in the active inventory.

Public access to the current NVR database is available via the official NVR website at http://www.nvr.navy.mil/. For this study, the NAVSHIPSO graciously provided an Excel export of the complete NVR database, containing 2,659 observations that represent 2,659 ships from 1794 (former USS *Constitution*) to 27 October 2017, when the export was generated.

3. HADR Research at Naval Postgraduate School

This study is a continuation of NPS research related to the study of U.S. naval involvement in the HADR mission. Specifically, I rely on the ship type HADR capability matrix and disaster response data reported by Greenfield and Ingram (2010) and their summary of the ships tasked to provide an HADR response following the 2010 Haiti earthquake. From Moffat (2014), I append 2011 Japan earthquake and tsunami HADR response data and build upon his method of reporting average daily O&S costs.

4. Fact File Data Sources

I use official USN fact files, MSC handbook, and the MARAD ship characteristic pamphlet to verify, update or append unclassified ship class performance and HADR capability metrics reported by Greenfield and Ingram (2010) and Moffat (2014). USN fact files can be accessed at http://www.navy.mil/navydata/fact.asp. The MSC handbook and fact files can be accessed at www.msc.navy.mil/publications/. The MARAD handbook can be accessed at https://www.marad.dot.gov/search/RRF/.

5. Jane's Fighting Ships

For this study, I use the online version of Jane's by IHS Markit Fighting Ships (Jane's) provided by the Dudley Knox Library to verify, modify, or append performance and capability data fields that are not covered by the official USN, MSC, and MARAD files. Jane's is a for-profit, internationally recognized defense information clearing house that reports worldwide military composition, inventory, equipment status, on-board systems, performance metrics, and photographs. Among other categories, Jane's chronologically reports unclassified, qualitative and quantitative ship characteristics, and performance data for over 4,700 ships in 165 worldwide navies (Jane's by IHS Markit, 2018-a). Jane's data can be viewed via annually published, encyclopedic hard-copy books or with an online, paid subscription at https://janes.ihs.com.

B. DATA METHODOLOGY

This study uses STATA, a commercially available data analysis and statistical software program, to import, clean, and merge the data obtained from the various sources. During the cleaning process, I use coding to create STATA friendly variables that summarize the data or fix discrepancies that could prevent statistical analysis.

Of all the data sources used in this study, I find the VAMOSC database to be the most comprehensive source for ship inventory, cost, and non-cost data. Because of this, I chose the VAMOSC database to serve as the primary data source on which all other databases are merged. I first import the flat file versions of the VAMOSC data into STATA for further analysis. Next, I will describe my methodology for the inventory, cost, capability, proximity, utility, and disaster response parameters used in this study.

1. Inventory Parameters

The VAMOSC database reports FY cost and non-cost data at the individual ship level *if* the ship was in the U.S. naval inventory for *any* portion of the reporting FY. Ships are excluded from the reported FY data if they are absent from the inventory for the entire FY. Based on this knowledge, I use STATA to determine USN, MSC, and RRF inventory by FY as reported in the VAMOSC database.

To ensure that the same vessel is not listed under multiple names, I first scrub all vessel names, hull numbers, and ship classes to match those values reported by the official NVR database. For MSC contracted ships not contained in the NVR database, I use VAMOSC reported vessel names and hull numbers. Additionally, I manually assign missing ship classes based on fact file and Jane's Fighting Ships database information. For ships that are not contained in the fact files or Jane's database, I assign ship class values equal to the individual ship hull number.

I drop ships from the database with ship status values equal to NRF due to the low probability that NRF vessels will be reactivated to conduct the HADR mission. Additionally, NRF ships do not have designated crews nor a specified number of days to activate. I drop chartered ships from the database with Program values equal to 'Charter' since contract terms are not specified in the data, and it is unclear whether these ships can be re-tasked to conduct the HADR mission. Finally, I drop VAMOSC vessels named *Sea-Based X-Band Radar*, *Gem Stone State OSV*, and *Silver Star OSV* due to their special mission focus. Finally, I drop "vessels" named *COMPSRON One*, *COMPSRON Two*, and *COMPSRON Three* since they are the reporting senior for multiple ships vice individual ships.

The remaining VAMOSC database is then collapsed in STATA by sorting on vessel name and FY to reduce the data into one observation per ship, per applicable FY vice the multiple line entries previously depicted in Figure 13. During this process, I retain or generate desired cost and non-cost variables that represent FY totals for each ship/FY pairing, to be defined later in Table 6. This process condenses the VAMOSC database into 3,183 single line per ship/FY paired observations from the original 339,814-line item observations.

Once the initial scrub is complete, I add unique ship identification data, such as milestone dates, weights and measures, standard nomenclature, status, assignment, etc., by merging the VAMOSC database with the NVR database on matching vessel name. Thirteen VAMOSC reported ships (49 observations) do not have an NVR match. It is worth noting that merge results are inconsistent if the initial merge is executed by hull number vice vessel name due to different numbering conventions across databases. For example,

the NVR and Jane's report the hull number of the USS *Nimitz* as "CVN 68" while VAMOSC reports "CVN-0068." The USNS *Mercy* provides an example of this subtle difference for active MSC ships where the NVR reports "AH 19" and VAMOSC reports "T-AH-0019."

Next, I drop NVR imported observations (67) that do not have a VAMOSC match as indicated by missing FY values and no O&S cost data. The resulting panel database contains 3,183 observations that represent 469 unique ships across 100 ship classes, from FY 2010 to 2017.

Of the 3,183 remaining observations, 59.5% (1,895) are USN, 29.6% (942) MSC, and 10.9% (346) RRF. The total ratio of USN, MSC, and RRF ships remains consistent at the FY level, excluding FY 2013, when the reported RRF fleet spuriously dropped from 48 to 20 ships and returned to 46 ships in FY 2014. Table 4 depicts the ship inventory variable names used in this study and their associated definitions. Table 5, Inventory Summary Statistics, provides a cursory look at ship inventory levels by status and FY to identify general trends prior to deeper analysis.

Table 4. Inventory Variables and Definitions

Variable		Values
FY10	=	1 if VAMOSC *_FiscalYear* = 2010, =0 otherwise
FY11	=	1 if VAMOSC *_FiscalYear* = 2011, =0 otherwise
FY12	=	1 if VAMOSC *_FiscalYear* = 2012, =0 otherwise
FY13	=	1 if VAMOSC *_FiscalYear* = 2013, =0 otherwise
FY14	=	1 if VAMOSC *_FiscalYear* = 2014, =0 otherwise
FY15	=	1 if VAMOSC *_FiscalYear* = 2015, =0 otherwise
FY16	=	1 if VAMOSC *_FiscalYear* = 2016, =0 otherwise
FY17	=	1 if VAMOSC *_FiscalYear* = 2017, =0 otherwise
_ShipStaus	=	VAMOSC reported ship status (ACT, MSC, RRF)
StatusUSN	=	1 if ship assigned to USN, =0 otherwise
StatusMSC	=	1 if ship assigned to MSC, =0 otherwise
StatusRRF	=	1 if ship assigned to RRF, =0 otherwise
Status_USN_FY10	=	1 if ship assigned to USN in FY10, =0 otherwise
Status_USN_FY11	=	1 if ship assigned to USN in FY11, =0 otherwise
Status_USN_FY12	=	1 if ship assigned to USN in FY12, =0 otherwise
Status_USN_FY13	=	1 if ship assigned to USN in FY13, =0 otherwise
Status_USN_FY14	=	1 if ship assigned to USN in FY14, =0 otherwise
Status_USN_FY15	=	1 if ship assigned to USN in FY15, =0 otherwise
Status_USN_FY16	=	1 if ship assigned to USN in FY16, =0 otherwise
Status_USN_FY17	=	1 if ship assigned to USN in FY17, =0 otherwise
Status_MSC_FY10	=	1 if ship assigned to MSC in FY10, =0 otherwise
Status_MSC_FY11	=	1 if ship assigned to MSC in FY11, =0 otherwise
Status_MSC_FY12	=	1 if ship assigned to MSC in FY12, =0 otherwise
Status_MSC_FY13	=	1 if ship assigned to MSC in FY13, =0 otherwise
Status_MSC_FY14	=	1 if ship assigned to MSC in FY14, =0 otherwise
Status_MSC_FY15	=	1 if ship assigned to MSC in FY15, =0 otherwise
Status_MSC_FY16	=	1 if ship assigned to MSC in FY16, =0 otherwise
Status_MSC_FY17	=	1 if ship assigned to MSC in FY17, =0 otherwise
Status_RRF_FY10	=	1 if ship assigned to RRF in FY10, =0 otherwise
Status_RRF_FY11	=	1 if ship assigned to RRF in FY11, =0 otherwise
Status_RRF_FY12	=	1 if ship assigned to RRF in FY12, =0 otherwise
Status_RRF_FY13	=	1 if ship assigned to RRF in FY13, =0 otherwise
Status_RRF_FY14	=	1 if ship assigned to RRF in FY14, =0 otherwise
Status_RRF_FY15	=	1 if ship assigned to RRF in FY15, =0 otherwise
Status_RRF_FY16	=	1 if ship assigned to RRF in FY16, =0 otherwise
Status_RRF_FY17	=	1 if ship assigned to RRF in FY17, =0 otherwise
_NVR_StandardNomenclature	=	Encoded NVR ship standard nomenclature in accordance with SECNAVINST 5030.8C
_Class	=	Encoded NVR or generated ship class
Hull	=	NVR reported ship hull number
HullNumber	=	Encoded VAMOSC reported ship hull number
VesselName	=	NVR reported vessel name
UIC	=	Ship Unit Identification Code
_Assignment	=	Encoded NVR reported fleet assignment (Pacific or Atlantic), select ships
_Homeport	=	Encoded NVR reported homeport locations , all USN and select MSC ships
_Berth	=	Encoded NVR reported berth locations of select MARAD/RRF ships
_date_StatusChg	=	NVR reported date of the latest ship status change
_date_Comm	=	NVR reported ship commissioning date
_date_Inactive	=	NVR reported ship inactivation date
_date_Decomm	=	NVR reported ship decommissioning date
_date_InServe	=	NVR reported ship in service date
_date_OutServe	=	NVR reported ship out of service date
_OverallLength	=	NVR reported ship length (ft)
_ExtremeBeam	=	NVR reported ship beam width (ft) at the widest point
_MaxNavigationalDraft	=	NVR reported ship maximum navigational draft (ft)

* *Italicized* values are pre-defined variables that the specified variable is based on.
** NVR reported values are for active USN and MSC ships as of 27 OCT 2017.

Table 5. Inventory Summary Statistics

Variable	N	mean	sd	min	max	n
ALL SHIPS (FY 2010–17)						
Status_USN	3,183	0.5954	0.4909	0	1	1,895
Status_MSC	3,183	0.2959	0.4565	0	1	942
Status_RRF	3,183	0.1087	0.3113	0	1	346
FY10 = 1						
Status_USN	401	0.6035	0.4898	0	1	242
Status_MSC	401	0.2843	0.4516	0	1	114
Status_RRF	401	0.1122	0.3160	0	1	45
FY11 = 1						
Status_USN	400	0.6050	0.4895	0	1	242
Status_MSC	400	0.2725	0.4458	0	1	109
Status_RRF	400	0.1225	0.3283	0	1	49
FY12 = 1						
Status_USN	402	0.5995	0.4906	0	1	241
Status_MSC	402	0.2811	0.4501	0	1	113
Status_RRF	402	0.1194	0.3247	0	1	48
FY13 = 1						
Status_USN	379	0.6359	0.4818	0	1	241
Status_MSC	379	0.3113	0.4637	0	1	118
Status_RRF	379	0.0528	0.2239	0	1	20
FY14 = 1						
Status_USN	403	0.5881	0.4928	0	1	237
Status_MSC	403	0.2978	0.4578	0	1	120
Status_RRF	403	0.1141	0.3184	0	1	46
FY15 = 1						
Status_USN	398	0.5804	0.4941	0	1	231
Status_MSC	398	0.3040	0.4606	0	1	121
Status_RRF	398	0.1156	0.3201	0	1	46
FY16 = 1						
Status_USN	396	0.5758	0.4949	0	1	228
Status_MSC	396	0.3081	0.4623	0	1	122
Status_RRF	396	0.1162	0.3208	0	1	46
FY17 = 1						
Status_USN	404	0.5767	0.4947	0	1	233
Status_MSC	404	0.3094	0.4628	0	1	125
Status_RRF	404	0.1139	0.3180	0	1	46

MSC and RRF raw data obtained from VAMOSC database, January 29, 2018.

USN raw data obtained from VAMOSC database, February 2, 2018.

2. Cost Parameters

The cost parameters reported in this study are based on the VAMOSC calculated CY 2017 dollars and not TY dollar amounts. USN/NRF ships can report up to 232 cost and 55 non-cost VAMOSC categories FY while MSC/RRF ships can only report up to 94 cost categories and 14 non-cost categories. Not all categories are reported by each ship, nor are

they required. A complete description of VAMOSC cost categories can be found in Appendix F of the VAMOSC Ships User Manual (VAMOSC, 2018) or pages 38–40 and Appendix E of the Military Sealift Command User Manual (VAMOSC, 2017). Both VAMOSC user manuals can be found under the 'Documentation' link on the VAMOSC website.

Using STATA, I generate a variable to calculate FY total ship cost by summing all reported CY2017 category total cost values for each vessel by FY prior to collapsing the data. Additionally, I create variables that calculate binned, VAMOSC reported FY cost totals for manpower, operations, maintenance, sustainment support, continued system improvement, and indirect support costs. Vessel FY total cost values were independently checked by comparing the total FY cost with the sum of the generated manpower, operations, maintenance, sustainment support, continued system improvement, and indirect support cost variables as depicted in the C_{TOT} formula:

$$C_{TOT_{i,t}} = C_{P_{i,t}} + C_{O_{i,t}} + C_{M_{i,t}} + C_{S_{i,t}} + C_{C_{i,t}} + C_{I_{i,t}}$$

where

- i represents an individual ship
- t represents FY
- C_{TOT} represents generated variable *CostYearTotal_CY2017* value
- C_P represents sum of VAMOSC reported FY manpower costs
- C_O represents sum of VAMOSC reported FY operations costs
- C_M represents sum of VAMOSC reported FY maintenance costs
- C_S represents sum of VAMOSC reported FY sustainment support costs
- C_C represents sum of VAMOSC reported FY continued system improvement costs
- C_I represents sum of VAMOSC reported FY indirect support costs.

Cost variable names and the specific VAMOSC cost element fields used to derive the variables are depicted in Table 6. Table 7 depicts cost variables further derived from the original VAMOSC cost elements.

Table 6. VAMOSC-Derived Cost and Non-cost Variable Definitions

Variable	Sym		STATA command: collapse bysort: *VesselName* and *_FiscalYear*	Column	Ship Universe Element	Ship Universe Field	MSC Ship Universe Element	MSC Ship Universe Field
CostYearTotal_CY17	C_{TOT}	=	Sum of ALL reported costs	CY2017	All		All	
_Cost_Manpower_CY17	C_P	=	Sum of reported 'Manpower' costs	CY2017	1	1.0	1	1.0
_Cost_Operations_CY17	C_O	=	Sum of reported 'Operations' costs	CY2017	1	2.0	1	2.0
_Cost_Maintenance_CY17	C_M	=	Sum of reported 'Maintenance' costs	CY2017	1	3.0	1	3.0
_Cost_SustSupport_CY17	C_S	=	Sum of reported 'Sustainment Support' costs	CY2017	1	4.0	1	4.0
_Cost_ContSysImpr_CY17	C_C	=	Sum of reported 'Continuing System Impr.'	CY2017	1	5.0	1	5.0
_Cost_IndirectSup_CY17	C_I	=	Sum of reported 'Indirect Support' costs	CY2017	1	6.0	1	6.0
_Cost_Fuel_CY17		=	Sum of reported 'Ship Petroleum, Oil & Lub.'	CY2017	3	2.1.1	3	2.1.1
Retained VAMOSC Non-Cost Variables								
_Pers_Tot		=	Reported 'Number of personnel - Total Assigned'	Count	1	C.0	1	B.0
_Pers_TotNavy		=	Reported 'Number of personnel - Navy'	Count	2	C.1		
_Pers_NavyOff		=	Reported 'Number of Officer personnel - Navy'	Count	3	C.1.1	2	B.1
_Pers_NavyEnl		=	Reported 'Number of Enlisted personnel - Navy'	Count	3	C.1.2	2	B.2
_PersTotMarine		=	Reported 'Number of personnel - Marine'	Count	2	C.2		
_Pers_MarineOff		=	Reported 'Number of Officer personnel - Marine'	Count	3	C.2.1		
_Pers_MarineEnl		=	Reported 'Number of Enlisted personnel - Marine'	Count	3	C.2.2		
_Pers_CivMariner		=	Reported 'Number of civilian mariner personnel'	Count			2	B.3
_Pers_ContractMar		=	Reported 'Number of contract mariner personnel'	Count			2	B.4
_SteamHrsTotal		=	Reported 'Hours - Steaming Total'	Count	1	E.0	1	C.0
_Steam HrsUnderway		=	Reported 'Hours - Steaming Underway'	Count	2	E.1	2	C.1
_SteamHrsNotUnderway		=	Reported 'Hours - Steaming Not Underway'	Count	2	E.2	2	C.2
_SteamHrsColdIron		=	Reported 'Hours - Cold Iron'	Count	2	E.3	2	C.3
_SteamDaysTotal		=	Reported 'Days - Steaming Underway'	Count	1	L.0		
_DaysAvail		=	Reported 'Days Available'	Count	1	N.0		
_MoOPCON		=	Reported 'Months assigned to OPCON'	Count	2	P.0		
_MoC2F		=	Reported 'Months assigned to C2F'	Count	2	P.1		
_MoC3F		=	Reported 'Months assigned to C3F'	Count	2	P.2		
_MoC4F		=	Reported 'Months assigned to C4F'	Count	2	P.3		
_MoC5F		=	Reported 'Months assigned to C5F'	Count	2	P.4		
_MoC6F		=	Reported 'Months assigned to C6F'	Count	2	P.5		
_MoC7F		=	Reported 'Months assigned to C7F'	Count	2	P.6		
_MoCNO		=	Reported 'Months in CNO Availability'	Count	2	P.7		
_MoMjrFlt		=	Reported 'Months in Major Fleet Availability'	Count	2	P.8		

Raw Ship Universe element and field entries obtained from VAMOSC (2018). Raw MSC Ship Universe element and field entries obtained from VAMOSC (2017).

Table 7. Generated Cost Variable Definitions

Variable		Values
log_CostYearTotal	=	Natural log of *CostYearTotal_CY17*
log_Cost_Manpower	=	Natural log of *Cost_Manpower_CY17*
log_Cost_Operations	=	Natural log of *_Cost_Operations_CY17*
log_Cost_Maintenance	=	Natural log of *_Cost_Maintenance_CY17*
log_Cost_SustSupport	=	Natural log of *_Cost_SustSupport_CY17*
log_Cost_ContSysImpr	=	Natural log of *_CostContSysImpr_CY17,*
log_Cost_IndirectSup	=	Natural log of *_CostIndirectSup_CY17*
_AvgYrCost_Class	=	Weighted average of class *CostYearTotal_CY17,* by: *_FiscalYear, _Class* & *_Status*
_AvgYrCost_ShortClass	=	Weighted average of type *CostYearTotal_CY17,* by: *_FY, _ShortClass* & *_ShipStatus*
_AvgDlyCost_Class	=	*_AvgYrCost_Class* / 365
_AvgDlyCost_ShortClass	=	*_AvgYrCost_ShortClass* / 365
_AvgYrCost_Ship_FY10_17	=	Average ship *CostYearTotal_CY17,* by *VesselName*
_AvgYrCost_Class_FY10_17	=	Weighted average of *_Class CostYearTotal_CY17,* by *_Class _ShipStatus*
_AvgYrCost_ShortClass_FY10_17	=	Weighted average of type *CostYearTotal_CY17,* by *_ShortClass _ShipStatus*
_AvgDlyCost_Ship_FY10_17	=	*_AvgYrCost_Ship_FY10_17* / 365
_AvgDlyCost_Class_FY10_17	=	*_AvgYrCost_Class_FY10_17* / 365
_AvgDlyCost_ShortClass_FY10_17	=	*_AvgYrCost_ShortClass_FY10_17* / 365
* *Italicized* values are pre-defined variables that the generated variable is based on.		

Table 8 depicts cost summary statistics by ship status from FY 2010 to 2017. Analysis of the reported cost summary statistics reveal that there are significant differences in reported *CostYearTotal_CY17* values based on ship status, where USN ships report a mean of $78.6 million (M) per year, MSC ships report a mean of $28.3 M per year and RRF ships report a mean of $.346 M per year. This disparity indicates that future cost regressions will require controls for ship class. Furthermore, the range of cost values in all categories indicates that there is significant variance at the individual ship and class levels.

Table 8. Cost Summary Statistics by Ship Status, FY 2010 to 2017.

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
CostYearTotal_CY17	3,183	55,203,509	82,076,561	-1,318,644	1,270,000,000
_Cost_Manpower_CY17	3,077	21,231,805	37,253,112	-33,426	263,127,632
_Cost_Operations_CY17	3,154	7,552,033	10,638,262	-1,093,258	217,977,664
_Cost_Maintenance_CY17	3,123	18,571,737	45,799,556	-993,961	1,050,000,000
_Cost_SustSupport_CY17	3,054	1,852,622	3,234,190	-78,618	57,342,260
_Cost_ContSysImpr_CY17	3,045	5,889,853	11,841,516	-339,792	137,621,264
_Cost_IndirectSup_CY17	1,239	4,012,388	5,276,364	-4,550,814	30,017,284
Status_USN = 1					
CostYearTotal_CY17	1,895	78,594,293	98,118,550	1,130,275	1,270,000,000
_Cost_Manpower_CY17	1,861	32,120,313	43,911,939	7,831	263,127,632
_Cost_Operations_CY17	1,888	7,460,705	12,409,396	-295,875	217,977,664
_Cost_Maintenance_CY17	1,895	27,331,734	56,868,735	-993,961	1,050,000,000
_Cost_SustSupport_CY17	1,895	2,935,642	3,706,465	78,499	57,342,260
_Cost_ContSysImpr_CY17	1,895	9,349,759	13,870,538	38,994	137,621,264
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_MSC = 1					
CostYearTotal_CY17	942	28,298,017	21,655,359	-63,695	182,452,512
_Cost_Manpower_CY17	916	6,063,629	11,243,674	-33,426	110,126,480
_Cost_Operations_CY17	942	10,207,055	6,710,113	-188,264	72,042,264
_Cost_Maintenance_CY17	927	6,695,188	6,845,843	-792,529	58,102,640
_Cost_SustSupport_CY17	859	110,485	253,579	-78,618	3,344,649
_Cost_ContSysImpr_CY17	850	255,070	1,668,640	-339,792	33,597,628
_Cost_IndirectSup_CY17	936	5,309,024	5,474,443	-4,550,814	30,017,284
Status_RRF = 1					
CostYearTotal_CY17	346	346,399	1,198,465	-1,318,644	15,819,286
_Cost_Manpower_CY17	300	255	4,412	0	76,426
_Cost_Operations_CY17	324	364,987	1,228,333	-1,093,258	15,819,286
_Cost_Maintenance_CY17	301	-1,794	17,382	-271,297	32,527
_Cost_SustSupport_CY17	300	-133	868	-10,184	0
_Cost_ContSysImpr_CY17	300	0	0	0	0
_Cost_IndirectSup_CY17	303	6,937	177,795	-1,043,000	2,507,842

MSC and RRF raw data obtained from VAMOSC database, January 29, 2018.

USN raw data obtained from VAMOSC database, February 2, 2018.

Next, ship status and FY were interacted to determine if trends exist that cannot be observed collectively from FY 2010 to 2017. USN ships do not exhibit significant total mean cost variance by FY, as depicted in Table 9, while maintenance costs appear to vary significantly by FY. Upon further investigation, the large USN maintenance cost averages can be attributed to two ships, USS *Theodore Roosevelt* (CVN 71) and USS *Abraham Lincoln* (CVN 72), undergoing expected 5-year nuclear power plant refueling and ship overhaul. These outliers were not removed from data as they are ongoing life cycle costs of aging aircraft carriers, with the USS *George Washington* (CVN 73) being removed from service this year to undergo its' own nuclear power plant refueling and overhaul process. Although the outlier costs were not removed, they support my prediction that costs need to

be analyzed at the ship or ship class level, over all reported FYs and not at the individual FY level to avoid biasing the results.

When controlling for ship status of MSC and individual FY, it is apparent that MSC ships routinely generate revenue from transporting goods unlike the combatant, USN ships. This phenomenon is observed in Table 10, where many of the minimum reported cost values are negative values. Like USN ships, the *CostYearTotal_CY17* averages remain relatively constant over the eight-year period, indicating that FY will not have a significant impact during future cost analysis regressions. The significantly lower MSC averages than USN ships support my hypothesis that ship status will be statistically significant in future analysis and will need to be controlled for in the cost models.

Finally, RRF ships are observed to be more susceptible to cost variations by year than USN and MSC ships. This result is expected due to the unpredictable occurrence of events that warrant the activation of RRF ships and the smaller sample size. Of the eight years contained in the data, the highest observed mean RRF *CostYearTotal_CY17* occurred in FY14 with a mean of $645,108 and the lowest occurred in FY17 with a mean of $105,091. The lower annual *CostYearTotal_CY17* values are indicative of the RRF ships accruing minimal manpower, operations, and maintenance costs while sitting inactive in an up-keep status for long periods of time. It is expected that actual O&S costs are comparable to like ship class MSC ships when recalled from inactive RRF service to active RRF service. Table 11 depicts the complete cost summary statistics for RRF ships by FY.

Table 9. Cost Summary Statistics by Status and Fiscal Year, USN Ships

Variable	N	mean	sd	min	max
Status_USN_FY10 = 1					
CostYearTotal_CY17	242	75,539,491	102,887,975	1,147,328	1,140,000,000
_Cost_Manpower_CY17	232	33,210,452	46,166,859	6,925,608	256,648,512
_Cost_Operations_CY17	241	7,527,824	14,367,027	26,283	200,829,904
_Cost_Maintenance_CY17	242	25,795,584	62,556,992	685,489	906,349,888
_Cost_SustSupport_CY17	242	2,524,674	2,658,232	78,499	18,985,046
_Cost_ContSysImpr_CY17	242	7,884,397	12,103,790	38,994	112,143,680
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY11 = 1					
CostYearTotal_CY17	242	77,486,488	107,786,145	1,787,391	1,230,000,000
_Cost_Manpower_CY17	232	33,086,995	45,644,608	2,498,422	253,550,480
_Cost_Operations_CY17	242	7,278,163	9,250,830	306	99,152,568
_Cost_Maintenance_CY17	242	27,841,407	68,720,327	648,362	987,468,928
_Cost_SustSupport_CY17	242	2,544,773	2,618,450	325,840	23,545,924
_Cost_ContSysImpr_CY17	242	8,102,382	13,544,857	233,651	113,959,120
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY12 = 1					
CostYearTotal_CY17	241	75,632,344	99,698,911	1,130,275	856,306,432
_Cost_Manpower_CY17	228	32,686,779	44,446,687	1,828,323	263,127,632
_Cost_Operations_CY17	241	7,452,309	13,883,518	-192,100	193,321,280
_Cost_Maintenance_CY17	241	28,366,227	55,275,980	582,296	646,963,328
_Cost_SustSupport_CY17	241	2,405,626	2,606,708	158,426	24,483,762
_Cost_ContSysImpr_CY17	241	6,484,590	11,009,912	59,091	87,642,048
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY13 = 1					
CostYearTotal_CY17	241	74,032,649	91,676,105	1,271,908	813,659,776
_Cost_Manpower_CY17	240	30,511,821	42,224,342	7,831	262,769,424
_Cost_Operations_CY17	241	7,076,698	15,332,827	-62,087	217,977,664
_Cost_Maintenance_CY17	241	26,369,794	51,134,522	387,952	606,928,832
_Cost_SustSupport_CY17	241	2,685,854	2,971,131	266,476	34,403,964
_Cost_ContSysImpr_CY17	241	7,515,086	12,570,930	151,083	118,542,008
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY14 = 1					
CostYearTotal_CY17	237	79,588,999	110,758,847	2,158,227	1,270,000,000
_Cost_Manpower_CY17	237	31,012,015	42,457,986	572,932	262,985,648
_Cost_Operations_CY17	237	7,720,728	14,007,418	645	173,158,912
_Cost_Maintenance_CY17	237	28,810,893	72,847,853	389,323	1,050,000,000
_Cost_SustSupport_CY17	237	2,887,325	4,431,620	298,219	57,342,260
_Cost_ContSysImpr_CY17	237	9,158,038	16,201,896	249,620	130,224,984
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY15 = 1					
CostYearTotal_CY17	231	84,934,763	100,040,390	8,294,252	1,020,000,000
_Cost_Manpower_CY17	231	32,500,627	43,803,708	2,528,152	242,581,136
_Cost_Operations_CY17	231	7,503,851	7,379,287	-295,875	55,807,000
_Cost_Maintenance_CY17	231	29,201,517	57,939,961	-993,961	786,568,704
_Cost_SustSupport_CY17	231	3,732,697	4,883,638	270,638	48,132,136
_Cost_ContSysImpr_CY17	231	11,996,071	16,232,997	474,398	137,621,264
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY16 = 1					
CostYearTotal_CY17	228	84,982,266	93,332,370	6,176,561	744,205,056
_Cost_Manpower_CY17	228	32,520,579	44,176,978	2,695,497	247,638,464
_Cost_Operations_CY17	227	8,292,530	10,601,118	16,724	99,352,640
_Cost_Maintenance_CY17	228	29,420,496	44,768,628	909,204	485,110,656
_Cost_SustSupport_CY17	228	3,420,263	4,100,536	218,481	36,306,508
_Cost_ContSysImpr_CY17	228	11,364,769	14,698,282	565,557	101,303,920
_Cost_IndirectSup_CY17	0	0	0	0	0
Status_USN_FY17 = 1					
CostYearTotal_CY17	233	77,150,878	74,187,466	6,052,224	452,775,936
_Cost_Manpower_CY17	233	31,533,427	42,901,076	2,629,771	238,088,112
_Cost_Operations_CY17	228	6,856,109	12,095,226	0	165,638,256
_Cost_Maintenance_CY17	233	22,920,592	29,047,873	1,032,486	189,974,048
_Cost_SustSupport_CY17	233	3,359,739	4,440,347	292,874	47,362,512
_Cost_ContSysImpr_CY17	233	12,628,138	12,715,151	396,652	77,159,632
_Cost_IndirectSup_CY17	0	0	0	0	0

Raw data obtained from the VAMOSC database, February 2, 2018.

Table 10. Cost Summary Statistics by Status and Fiscal Year, MSC Ships

Variable	N	mean	sd	min	max
Status_MSC_FY10 = 1					
CostYearTotal_CY17	114	28,906,521	23,287,965	2,454,368	182,452,512
_Cost_Manpower_CY17	114	5,340,508	11,562,927	-33,426	106,842,864
_Cost_Operations_CY17	114	10,709,804	7,954,549	608,584	65,437,456
_Cost_Maintenance_CY17	114	6,586,544	7,862,473	-792,529	49,887,336
_Cost_SustSupport_CY17	114	220,653	261,149	0	1,478,303
_Cost_ContSysImpr_CY17	114	237,821	834,785	-43,178	6,437,892
_Cost_IndirectSup_CY17	114	5,811,191	6,259,395	0	28,223,048
Status_MSC_FY11 = 1					
CostYearTotal_CY17	109	30,107,088	22,200,894	0	162,596,848
_Cost_Manpower_CY17	109	5,794,183	11,461,633	-2	104,212,496
_Cost_Operations_CY17	109	11,124,066	6,739,410	0	39,378,036
_Cost_Maintenance_CY17	109	6,458,121	5,806,514	0	33,030,680
_Cost_SustSupport_CY17	109	143,495	381,569	-32,253	3,344,649
_Cost_ContSysImpr_CY17	109	303,746	1,213,853	0	11,207,860
_Cost_IndirectSup_CY17	109	6,283,477	7,100,621	-526,205	30,017,284
Status_MSC_FY12 = 1					
CostYearTotal_CY17	113	30,517,933	23,007,241	580,941	171,880,480
_Cost_Manpower_CY17	113	5,773,728	10,936,147	0	99,979,336
_Cost_Operations_CY17	113	11,412,383	8,356,058	494,392	72,042,264
_Cost_Maintenance_CY17	113	6,744,375	6,819,129	0	39,358,788
_Cost_SustSupport_CY17	113	105,267	241,036	-18,326	1,392,883
_Cost_ContSysImpr_CY17	113	331,546	2,621,038	-134,022	27,770,302
_Cost_IndirectSup_CY17	113	6,150,636	6,164,678	-888,854	21,118,236
Status_MSC_FY13 = 1					
CostYearTotal_CY17	118	26,631,935	19,967,070	1,079,453	140,224,240
_Cost_Manpower_CY17	118	5,421,573	10,537,165	-6,202	99,134,704
_Cost_Operations_CY17	118	9,777,548	5,731,727	773,722	26,900,646
_Cost_Maintenance_CY17	118	5,631,526	5,694,405	-163,665	23,582,072
_Cost_SustSupport_CY17	118	90,788	244,492	-11,823	1,468,705
_Cost_ContSysImpr_CY17	118	194,200	601,352	-51,982	4,221,259
_Cost_IndirectSup_CY17	118	5,516,300	5,697,054	-7,500	19,877,208
Status_MSC_FY14 = 1					
CostYearTotal_CY17	120	25,981,236	20,430,385	1,621,182	150,418,208
_Cost_Manpower_CY17	120	5,493,091	10,949,470	-24,520	102,878,576
_Cost_Operations_CY17	120	9,615,982	5,772,238	269,529	27,359,236
_Cost_Maintenance_CY17	120	5,549,911	5,226,080	0	22,647,084
_Cost_SustSupport_CY17	120	70,280	194,352	-43,100	1,206,539
_Cost_ContSysImpr_CY17	120	466,752	3,102,645	-22,496	33,597,628
_Cost_IndirectSup_CY17	120	4,785,220	4,800,195	-60,228	17,030,320
Status_MSC_FY15 = 1					
CostYearTotal_CY17	121	28,334,617	22,303,678	112,883	146,241,392
_Cost_Manpower_CY17	121	6,436,337	11,880,911	0	110,126,480
_Cost_Operations_CY17	121	9,895,367	6,084,948	123,953	29,070,098
_Cost_Maintenance_CY17	121	7,317,797	7,456,326	-13,347	30,970,756
_Cost_SustSupport_CY17	121	68,946	182,327	-4,499	1,120,106
_Cost_ContSysImpr_CY17	121	191,874	1,048,076	-19,501	11,163,909
_Cost_IndirectSup_CY17	121	4,424,296	4,494,243	-529,952	16,372,933
Status_MSC_FY16 = 1					
CostYearTotal_CY17	122	28,328,225	20,858,278	1,050,002	143,026,016
_Cost_Manpower_CY17	122	6,584,864	11,288,083	-1	91,951,560
_Cost_Operations_CY17	122	10,246,432	6,684,338	925,394	51,835,048
_Cost_Maintenance_CY17	122	6,666,946	6,066,868	0	26,774,628
_Cost_SustSupport_CY17	122	56,503	172,103	-36,230	1,172,713
_Cost_ContSysImpr_CY17	122	117,419	450,198	-290,410	3,400,647
_Cost_IndirectSup_CY17	122	4,656,060	4,132,238	-252,965	14,838,118
Status_MSC_FY17 = 1					
CostYearTotal_CY17	125	27,890,726	21,418,243	-63,695	155,936,032
_Cost_Manpower_CY17	99	7,882,851	11,440,413	132,501	74,070,040
_Cost_Operations_CY17	125	9,095,467	5,902,795	-188,264	37,099,788
_Cost_Maintenance_CY17	110	8,729,035	8,878,786	-5,275	58,102,640
_Cost_SustSupport_CY17	42	186,506	297,108	-78,618	1,198,135
_Cost_ContSysImpr_CY17	33	80,511	241,107	-339,792	790,709
_Cost_IndirectSup_CY17	119	5,027,909	4,562,985	-4,550,814	17,672,000

Raw data obtained from the VAMOSC database, January 29, 2018.

Table 11. Cost Summary Statistics by Status and Fiscal Year, RRF Ships

Variable	N	mean	sd	min	max
Status_RRF_FY10 = 1					
CostYearTotal_CY17	45	596,502	1,122,230	-1,318,644	5,267,927
_Cost_Manpower_CY17	45	0	0	0	0
_Cost_Operations_CY17	45	563,420	1,110,715	-1,093,258	5,267,927
_Cost_Maintenance_CY17	45	-5,591	18,227	-88,703	32,527
_Cost_SustSupport_CY17	45	-663	1,561	-4,288	0
_Cost_ContSysImpr_CY17	45	0	0	0	0
_Cost_IndirectSup_CY17	45	39,336	385,416	-484,364	2,507,842
Status_RRF_ FY11 = 1					
CostYearTotal_CY17	49	185,558	452,440	-107,273	2,500,270
_Cost_Manpower_CY17	49	0	0	0	0
_Cost_Operations_CY17	49	183,269	449,864	-98,332	2,500,270
_Cost_Maintenance_CY17	49	-745	5,180	-34,859	5,287
_Cost_SustSupport_CY17	49	-208	1,455	-10,184	0
_Cost_ContSysImpr_CY17	49	0	0	0	0
_Cost_IndirectSup_CY17	49	3,241	21,435	-559	150,040
Status_RRF_FY12 = 1					
_CostYearTotal_CY17	48	352,007	676,629	-804,235	2,607,865
_Cost_Manpower_CY17	48	0	0	0	0
_Cost_Operations_CY17	48	352,266	676,448	-804,235	2,607,865
_Cost_Maintenance_CY17	48	-256	1,680	-11,646	0
_Cost_SustSupport_CY17	48	0	0	0	0
_Cost_ContSysImpr_CY17	48	0	0	0	0
_Cost_IndirectSup_CY17	48	-3	13	-66	16
Status_RRF_FY13 = 1					
CostYearTotal_CY17	20	301,014	530,998	-608,679	1,476,422
_Cost_Manpower_CY17	20	0	0	0	0
_Cost_Operations_CY17	20	318,574	540,357	-608,679	1,476,422
_Cost_Maintenance_CY17	20	-13,565	60,664	-271,297	0
_Cost_SustSupport_CY17	20	0	0	0	0
_Cost_ContSysImpr_CY17	20	0	0	0	0
_Cost_IndirectSup_CY17	20	-3,995	16,453	-73,781	0
Status_RRF_FY14 = 1					
CostYearTotal_CY17	46	645,108	2,636,460	-1,138,559	15,819,286
_Cost_Manpower_CY17	46	0	0	0	0
_Cost_Operations_CY17	46	667,521	2,625,308	-495,918	15,819,286
_Cost_Maintenance_CY17	46	261	1,772	0	12,020
_Cost_SustSupport_CY17	46	0	0	0	0
_Cost_ContSysImpr_CY17	46	0	0	0	0
_Cost_IndirectSup_CY17	46	-22,674	153,782	-1,043,000	0
Status_RRF_FY15 = 1					
CostYearTotal_CY17	46	324,407	1,000,445	-511,218	5,025,244
_Cost_Manpower_CY17	46	0	0	0	0
_Cost_Operations_CY17	46	312,128	995,706	-511,218	5,025,244
_Cost_Maintenance_CY17	46	0	0	0	0
_Cost_SustSupport_CY17	46	0	0	0	0
_Cost_ContSysImpr_CY17	46	0	0	0	0
_Cost_IndirectSup_CY17	46	12,279	58,920	0	325,057
Status_RRF_FY16 = 1					
CostYearTotal_CY17	46	251,535	791,460	-1,154,516	3,649,200
_Cost_Manpower_CY17	46	1,661	11,268	0	76,426
_Cost_Operations_CY17	46	266,602	768,458	-785,459	3,649,200
_Cost_Maintenance_CY17	46	427	2,893	0	19,620
_Cost_SustSupport_CY17	46	0	0	0	0
_Cost_ContSysImpr_CY17	46	0	0	0	0
_Cost_IndirectSup_CY17	46	-17,155	77,369	-369,057	85,497
Status_RRF_FY17 = 1					
CostYearTotal_CY17	46	105,091	366,713	-1,060,659	1,547,732
_Cost_Manpower_CY17	0	0	0	0	0
_Cost_Operations_CY17	24	138,078	488,682	-1,060,659	1,547,732
_Cost_Maintenance_CY17	1	18	.	18	18
_Cost_SustSupport_CY17	0	0	0	0	0
_Cost_ContSysImpr_CY17	0	0	0	0	0
_Cost_IndirectSup_CY17	3	506,771	558,162	2	1,105,023

Raw data obtained from the VAMOSC database, January 29, 2018.

Given that the range and mean of O&S costs vary significantly between USN, MSC, and RRF status ships and that costs within status groups vary significantly based on class of ship, I elect to calculate weighted average costs by class and type *(_AvgYrCost_Class* and *_AvgYrCost_ShortClass*) across all reported FYs vice individual FYs. Like Moffat (2014), I calculate average costs at the individual ship level, but these costs are not reliable measures to report cost values for a given class or type of ship as evidenced by the large maintenance costs for two aircraft carriers and much lower maintenance costs for the other nine database aircraft carriers. I then convert the generated average year cost variables into average O&S costs per day by dividing the *_AvgYrCost_* values by 365. Class average O&S cost per year (*_AvgYrCost_Class)* and per day values (*_AvgDlyCost_Class)* are reported in Chapter V and are used for the utility tool cost calculations in this study. Individual ship average annual O&S cost by FY and over the entire eight-year period are reported in Appendix A (USN), B (MSC), and C (RRF).

3. Capability Parameters

The underlying capability matrix for this study is based on the ship type capability findings of Greenfield and Ingram (2011). Like cost, I find enough variation in ship class HADR capabilities to warrant the expansion of the capability matrix to include all classes vice the previously reported ship type (i.e., CVN, DDG, T-AK, etc.) capability ratings. Based on the VAMOSC data, I find 100 unique ship classes in the U.S. naval inventory from FY 2010 to 2017. Of the 100 ship classes, 25 are USN, 56 MSC, and 18 RRF. The Mt Whitney class (LCC 19) appears in both the USN and MSC data with equal capability ratings, but different O&S cost values across USN and MSC status lines.

This study retains the ordinal rating system used by Greenfield and Ingram (2011) to assign ship type capability scores to all ship classes, depicted in Table 12.

Table 12. Ordinal Rating System. Adapted from Greenfield and Ingram (2011).

Symbol				Label Classification
Empty Circle	○	=	0	The vessel has no capability to conduct the specified mission
Half Filled Circle	◑	=	1	The vessel has some capability to conduct the specified mission
Filled Circle	●	=	2	The vessel is very capable in conducting the specified mission

I generate and assign ship class HADR capability variables in accordance with the capability definitions depicted in Table 13. Ship type capability ratings reported by Greenfield and Ingram (2011) and Moffat (2014) are used as the default ship class values. However, ship type abbreviations made it difficult to simply link capabilities to some MSC ship classes, requiring that I reference the official Navy fact files, MSC handbook, MARAD ship characteristics, and the Jane's Fighting Ships database.

Table 13. Capability Variable Names and Definitions. Adapted from Greenfield and Ingram (2011).

	Sym	Variable		Variable Definitions	
	V1	NumberVerticalLiftAircraft		=	Maximum number of vertical lift aircraft that ship can have on deck at one time
	V2	Cap_AviationFacilities*		0	Unable to support helicopter operations - No flight deck and no hangar
				1	Some ability to conduct vertical lift operations - Has a flight deck but no hangar
				2	Able to conduct sustained vertical lift operations - Has a flight deck and hangar
Critical Mission Capabilities	S1	Cap_VerticalLiftScore		=	V1 times V2
	S2	Cap_LandingCraft		0	No ability to support landing craft
				1	Some ability to support landing craft
				2	Landing craft embarked, able to load / off-load cargo and store amphibious vehicles
	S3	Cap_Searchand Rescue		0	No embarked helo, unable to efficiently conduct SAR missions
				1	Single embarked helo with communication equipment and night vision
				2	Multiple helos embarked with communication equipment and night vision
	S4	Cap_DryGoods	Cargo Capacity	0	No ability to store supplies beyond current ship use
	S5	Cap_RefrigeratedGoods			
	S6	Cap_Freshwater		1	Ability to store some supplies beyond ship's use
	S7	Cap_RollOnRollOff			
	S8	Cap_FuelStorageDispens		2	Ability to store and transfer mass amount of supplies
	S9	Cap_SelfSufficient			
	S10	Cap_PersonnelTransfer		0	No ability to support personnel transfer, slow speed vessel with deep draft
				1	Ability to support personnel transfer for 15-29 personnel
				2	High speed, shallow draft vessel with ability to transport 30+ personnel per voyage
	S11	Cap_FreshwaterProduction		0	No ability to produce freshwater beyond shipboard usage
				1	Ability to produce and transfer 2,000-5,000 gallons per day (gpd) beyond ship usage
				2	Able to produce and transfer > 5,000 gpd beyond shipboard usage
	S12	Cap_PersonnelSupport		0	Low crew number to support HADR mission (< 50 personnel)
				1	Medium size crew which can support HADR mission (51 - 200 personnel)
				2	Large crew with ability to support HADR mission (> 200 personnel)
	S13	Cap_BerthingCapacity		0	Little to no excess berthing or facilities (< 30 racks)
				1	Some excess berthing and facilities (31-50 racks)
				2	Large number of excess berthing and facilities (> 50)
	S14	Cap_MedicalSupport		0	No ability to conduct impatient medical treatments, no Medical officer embarked
				1	Some medical support onboard, ability to support minor medical procedures
				2	Medical officer embarked, ability to perform surgeries and hold several patients
Non-Dritical Mission capabilities	S15	Cap_TransitSpeed		0	0-18 knots max speed
				1	19-24 knots max speed
				2	25 + knots max speed
	S16	Cap_HydrographicSurvey		0	No ability to conduct hydrographic surveys
				1	Some ability to conduct hydrographic surveys, soundings and chart building
				2	Able to conduct hydrographic surveying, soundings and chart development
	S17	Cap_SalvageOps		0	No ability to conduct salvage operations
				1	Some ability for lift and salvage operations in shallow waters
				2	Heavy lift and deep water salvage operations capabilities
	S18	Cap_Towing		0	No ability to conduct towing operations
				1	Ability to conduct emergency towing operations
				2	Designed to conduct push, pull, or alongside towing operations

* Aircraft Support definitions modified from original meanings established by Greenfield et al. (2011).

I review, verify, update, and append capabilities for all classes based on the USN and MSC fact files, MSC and MARAD handbooks, and Jane's Fighting Ships. As noted in the literature review, the VTOL capability is one of the most versatile and universally requested U.S. naval capabilities during HADR operations. VTOL aircraft enable damage

assessments SAR operations, movement of personnel, cargo transport, and clean-up in areas with damaged infrastructure and obstructed roads. To account for the importance of helicopters, Moffat (2014) determined that the vertical lift capability required a higher weight rating than (0), (1), or (2). Moffat (2014) added a variable to account for the number of helicopter assigned to a ship type based on ship operating manuals and then multiplied the number of helicopters assigned by 20 points each, as depicted in Figure 14.

	Helicopters Aboard	Helo Point Score
CVN	8	160
LHD	23	460
LHA	17	340
LCC	2	40
LPD	6	120
LSD		0
CG	2	40
DDG (FLT I and II)	0	0
DDG (FLT IIA)	2	40
Frigate	2	40
SSN	0	0
T-ACS		0
T-AFS	2	40
T-AGS		0
T-AK		0
T-AH	0	0
T-AKE	2	40
T-AO	0	0
T-AOE	2	40
T-ARS		0
T-AKR		0
TUG		0
HSV		0

Figure 14. Moffat Helicopter Points by Ship Type. Source: Moffat (2014, p. 15).

There is merit to Moffat's (2014) assessment that the vertical lift capability requires special scoring treatment, however I disagree with the implementation. For this study, I modify the process used by Moffat (2014) to calculate ship class vertical lift capability scores by first expanding the scope of total aircraft counted to represent the maximum number of vertical lift aircraft that can physically be onboard each class of ship at any one moment in time vice just those assigned to the ship. Second, I find that the flat 20 points

per aircraft (Moffat, 2014) lacks a direct linkage to a ship's ability to conduct HADR aircraft operations. Therefore, I elect to multiply the maximum number of vertical lift aircraft onboard by a modified helicopter support variable that I call "Aviation Facilities." I assign "Aviation Facilities" scores equal to (0) for ships without a flight deck or a hangar, (1) to ships with a flight deck but no hangar, and (2) to ships with both a flight deck and a hangar.

Table 14 describes a complete breakdown of the maximum possible scores used in this study to calculate the reported ship class variable *CapabilityCompositeScore*.

Table 14. Maximum Capability Composite Score Calculation Matrix

	Vessel Capability		Ship Capability Score	Min Possible Score	Max Possible Score	Weight of Max Possible
1.	Maximum number, vertical lift aircraft simultaneously onboard:	=	_____	0	23	
2.	Aviation Facilities (0=None, 1=Flight Deck, 2=Flight Deck & Hangar)	=	_____	0	2	
3.	Vertical lift Score (product of line 1 times line 2) _____ x _____	=	_____	0	46	57.5%
4.	Landing craft support	=	_____	0	2	2.5%
5.	Search and rescue support	=	_____	0	2	2.5%
6.	Dry goods	=	_____	0	2	2.5%
7.	Refrigerated goods	=	_____	0	2	2.5%
8.	Fresh water	=	_____	0	2	2.5%
9.	Roll on/roll off	=	_____	0	2	2.5%
10.	Fuel storage and dispensation	=	_____	0	2	2.5%
11.	Self-sufficiency	=	_____	0	2	2.5%
12.	Personnel transfer	=	_____	0	2	2.5%
13.	Freshwater production	=	_____	0	2	2.5%
14.	Personnel support	=	_____	0	2	2.5%
15.	Berthing capacity	=	_____	0	2	2.5%
16.	Medical support	=	_____	0	2	2.5%
17.	Transit speed	=	_____	0	2	2.5%
18.	Hydrographic survey	=	_____	0	2	2.5%
19.	Salvage operations	=	_____	0	2	2.5%
20.	Towing	=	_____	0	2	2.5%
21.	Capability Composite Score (sum of lines 3 through 20)	=		0	80	100.0%

Table 15 provides the summary statistics for the capability variables of all observed ships from FY 2010 to 2017. The reported mean represents the average ship score for that

variable or capability composite score across all reported ships. The maximum observed composite score is 65 and the minimum is 0.

Table 15. Capability Summary Statistics—All Ships, FY 2010 to 2017

Variable	Observations (N)	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
Cap_NumberVerticalLift	3,183	1.6230	3.5851	0	23
Cap_AviationFacilities	3,183	0.8486	0.8388	0	2
Cap_VerticalLiftScore	3,183	2.9268	7.2216	0	46
Cap_LandingCraft	3,183	0.1844	0.5608	0	2
Cap_SearchandRescue	3,183	0.4304	0.6761	0	2
Cap_DryGoods	3,183	0.7031	0.8772	0	2
Cap_RefrigeratedGoods	3,183	0.6340	0.8875	0	2
Cap_Freshwater	3,183	0.5759	0.8382	0	2
Cap_RollOnRollOff	3,183	0.3073	0.7213	0	2
Cap_FuelStorageDispens	3,183	0.6305	0.8909	0	2
Cap_SelfSufficient	3,183	0.6695	0.8101	0	2
Cap_PersonnelTransfer	3,183	0.4885	0.6175	0	2
Cap_FreshwaterProduction	3,183	0.1731	0.3915	0	2
Cap_PersonnelSupport	3,183	0.4298	0.5980	0	2
Cap_BerthingCapacity	3,183	0.3421	0.5811	0	2
Cap_MedicalSupport	3,183	0.1800	0.5101	0	2
Cap_TransitSpeed	3,183	1.3208	0.7726	0	2
Cap_HydrographicSurvey	3,183	0.0584	0.2930	0	2
Cap_SalvageOperations	3,183	0.0616	0.3297	0	2
Cap_Towing	3,183	0.4326	0.6180	0	2
CapabilityCompositeScore	3,183	10.5489	10.5553	0	65

Tables 16, 17, and 18 break the database into ship status groups and report separate capability summary statistics for USN, MSC, and RRF ships from FY 2010 to 2017. USN is observed to report the highest capability composite score of 65 with a mean of 10.2 points. MSC reports the next highest composite score of 30 points and a mean of 10.6 points. RRF reports the lowest maximum composite score of 15 points and a mean of 12.5 points. This variation indicates that ship status, and likely ship class, will be correlated with utility calculations. Based on previous analysis indicating that ship force ratios remain consistent across FYs, I do not conduct capability summary statistics by FY but report 2017 capability scores in Chapter V.

Table 16. Capability Summary Statistics—All USN Ships, FY 2010 to 2017

Variable	N	mean	sd	min	max
Status_USN = 1					
Cap_NumberVerticalLift	1,895	2.2691	4.4867	0	23
Cap_AviationFacilities	1,895	1.0058	0.9096	0	2
Cap_VerticalLiftScore	1,895	4.3103	9.0292	0	46
Cap_LandingCraft	1,895	0.2565	0.6689	0	2
Cap_SearchandRescue	1,895	0.6960	0.7470	0	2
Cap_DryGoods	1,895	0.1773	0.3820	0	1
Cap_RefrigeratedGoods	1,895	0.0844	0.2781	0	1
Cap_Freshwater	1,895	0.0844	0.2781	0	1
Cap_RollOnRollOff	1,895	0.0000	0.0000	0	0
Cap_FuelStorageDispens	1,895	0.0844	0.2781	0	1
Cap_SelfSufficient	1,895	0.1731	0.3784	0	1
Cap_PersonnelTransfer	1,895	0.7256	0.6068	0	2
Cap_FreshwaterProduction	1,895	0.0844	0.2781	0	1
Cap_PersonnelSupport	1,895	0.6559	0.6283	0	2
Cap_BerthingCapacity	1,895	0.2617	0.6019	0	2
Cap_MedicalSupport	1,895	0.2617	0.6019	0	2
Cap_TransitSpeed	1,895	1.7303	0.5520	0	2
Cap_HydrographicSurvey	1,895	0.0000	0.0000	0	0
Cap_SalvageOperations	1,895	0.0000	0.0000	0	0
Cap_Towing	1,895	0.5715	0.5939	0	2
CapabilityCompositeScore	1,895	10.1578	13.1310	1	65

Table 17. Capability Summary Statistics—All MSC Ships, FY 2010 to 2017

Variable	N	mean	sd	min	max
Status_MSC = 1					
Cap_NumberVerticalLift	942	0.8195	0.8243	0	6
Cap_AviationFacilities	942	0.7611	0.6707	0	2
Cap_VerticalLiftScore	942	1.1189	1.5595	0	12
Cap_LandingCraft	942	0.1072	0.3662	0	2
Cap_SearchandRescue	942	0.0541	0.2653	0	2
Cap_DryGoods	942	1.3036	0.8863	0	2
Cap_RefrigeratedGoods	942	1.2569	0.9173	0	2
Cap_Freshwater	942	1.1136	0.9027	0	2
Cap_RollOnRollOff	942	0.6242	0.9272	0	2
Cap_FuelStorageDispens	942	1.3153	0.9422	0	2
Cap_SelfSufficient	942	1.2749	0.7375	0	2
Cap_PersonnelTransfer	942	0.1911	0.5088	0	2
Cap_FreshwaterProduction	942	0.2081	0.4460	0	2
Cap_PersonnelSupport	942	0.1327	0.3945	0	2
Cap_BerthingCapacity	942	0.3896	0.5277	0	2
Cap_MedicalSupport	942	0.0817	0.3399	0	2
Cap_TransitSpeed	942	0.7176	0.6072	0	2
Cap_HydrographicSurvey	942	0.1975	0.5126	0	2
Cap_SalvageOperations	942	0.2081	0.5806	0	2
Cap_Towing	942	0.3121	0.6777	0	2
CapabilityCompositeScore	942	10.6072	5.0055	0	30

Table 18. Capability Summary Statistics—All RRF Ships, FY 2010 to 2017

Variable	N	mean	sd	min	max
Status_RRF = 1					
Cap_NumberVerticalLift	346	0.2717	0.5396	0	2
Cap_AviationFacilities	346	0.2254	0.4185	0	1
Cap_VerticalLiftScore	346	0.2717	0.5396	0	2
Cap_LandingCraft	346	0.0000	0.0000	0	0
Cap_SearchandRescue	346	0.0000	0.0000	0	0
Cap_DryGoods	346	1.9480	0.3096	0	2
Cap_RefrigeratedGoods	346	1.9480	0.3096	0	2
Cap_Freshwater	346	1.8035	0.4525	0	2
Cap_RollOnRollOff	346	1.1272	0.9933	0	2
Cap_FuelStorageDispens	346	1.7572	0.5319	0	2
Cap_SelfSufficient	346	1.7399	0.5291	0	2
Cap_PersonnelTransfer	346	0.0000	0.0000	0	0
Cap_FreshwaterProduction	346	0.5636	0.4967	0	1
Cap_PersonnelSupport	346	0.0000	0.0000	0	0
Cap_BerthingCapacity	346	0.6532	0.4766	0	1
Cap_MedicalSupport	346	0.0000	0.0000	0	0
Cap_TransitSpeed	346	0.7197	0.7417	0	2
Cap_HydrographicSurvey	346	0.0000	0.0000	0	0
Cap_SalvageOperations	346	0.0000	0.0000	0	0
Cap_Towing	346	0.0000	0.0000	0	0
CapabilityCompositeScore	346	12.5318	2.8090	4	15

a. Capability Category Selection

I conduct factor analysis of the capability variables to determine which ship capabilities should be included in the *CapabilityCompositeScore* calculations that will later be used in the utility function. First, I conduct factor analysis for all inventory ships from FY 2010 to 2017. During the initial factor analysis, I find that 91.7% of the variation in the capability data can be explained by retaining five factors. I exclude reported values equal to less than 0.4 and find that all capability variables should be included in future models in accordance with Rencher and Christensen (2012) established factor analysis methods. This same process is repeated for each status type of ship (USN, MSC, RRF) and I find similar results except where a given class does not have any ships with a specific capability. The five factors can be broken into the following categories: (1) cargo capability, self-sufficiency, roll-on/roll-off (RO/RO), and berthing capacity, (2) VTOL, landing craft and SAR, (3) hydrographic survey and salvage, (4) sea-based towing and aircraft support, and

(5) water production. Table 19 reports the associated eigenvalues and proportions of capability variance during the factor analysis.

Table 19. Eigenvalue and Proportion of Variance of Capability Factor Analysis

Variable	Eigenvalue	Difference	Proportion	Cumulative
ALL SHIPS (FY 2010–17)				
Factor1	6.3511	0.3419	0.3626	0.3626
Factor2	6.0092	4.1928	0.3431	0.7056
Factor3	1.8164	0.8017	0.1037	0.8093
Factor4	1.0148	0.1421	0.0579	0.8673
Factor5	0.8726	0.2321	0.0498	0.9171
USN SHIPS (FY 2010–17)				
Factor1	10.9992	8.9080	0.6599	0.6599
Factor2	2.0912	0.2976	0.1255	0.7853
Factor3	1.7936	0.7564	0.1076	0.893
Factor4	1.0372	0.5332	0.0622	0.9552
Factor5	0.5040	0.3620	0.0302	0.9854
MSC SHIPS (FY 2010–17)				
Factor1	7.1271	3.3856	0.4003	0.4003
Factor2	3.7415	1.4454	0.2101	0.6104
Factor3	2.2961	0.9186	0.1290	0.7393
Factor4	1.3775	0.3920	0.0774	0.8167
Factor5	0.9855	0.1185	0.0553	0.8721
RRF SHIPS (FY 2010–17)				
Factor1	5.2622	2.0466	0.4504	0.4504
Factor2	3.2155	1.4307	0.2752	0.7256
Factor3	1.7849	0.9690	0.1528	0.8783
Factor4	0.8158	0.2606	0.0698	0.9482
Factor5	0.5553	0.5050	0.0475	0.9957

To validate the retained number of factors, I generate scree plots for each of the four factor analyses. In all but one case, there is an apparent flattening of the plot at the third or fourth factor followed by another downward bend after the fifth factor. Based on this finding, I retain five factors in accordance with Rencher and Christensen (2012). The mean is overlaid on top of the scree plot for easier interpretation. Figure 15 depicts the generated capability factor analysis scree plots for all inventory ships from FY 2010 to 2017 and for USN, MSC, and RRF ships during the same period.

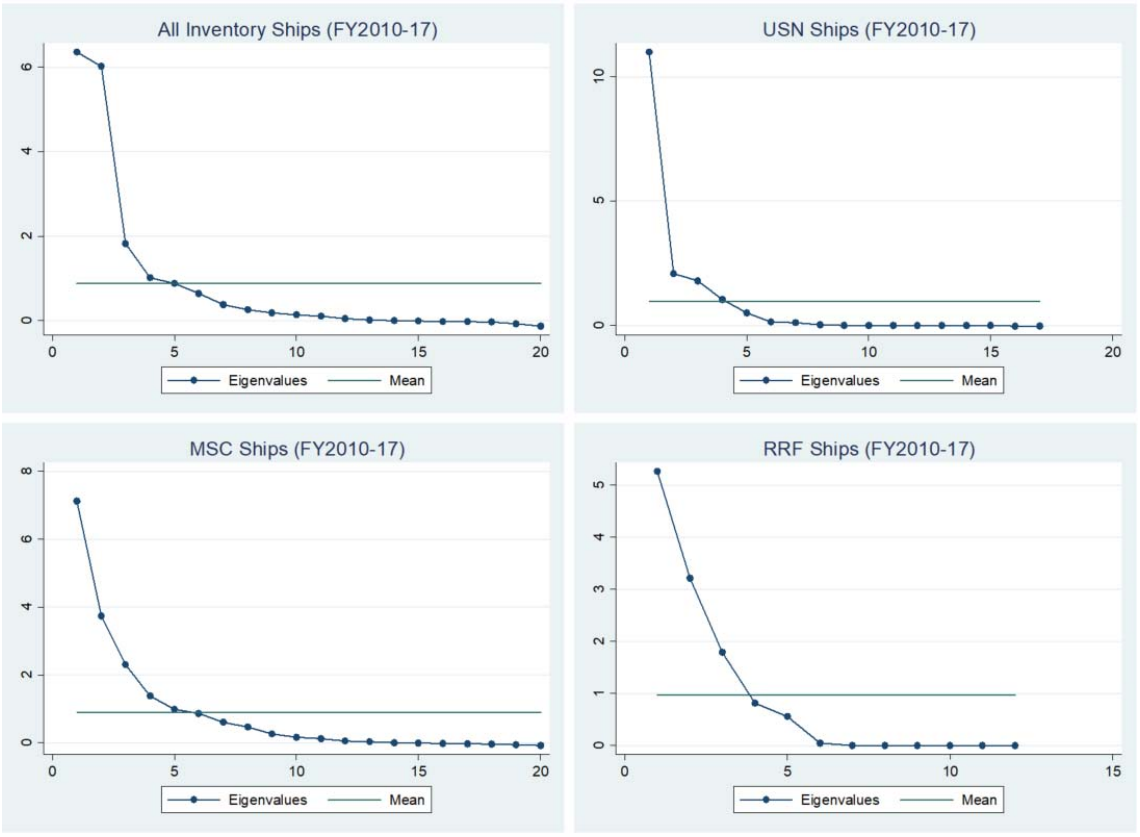

Figure 15. Scree Plot of Inventory Capability by Status

4. Proximity Parameters

Despite the ability to respond on short notice, the slower ship speeds may have a significant impact on the number of days a ship will spend transiting to the disaster location relative to the number of days on station. To account for this potential, I generate proximity variables that rely on algebraic calculations to determine the number of transit days required for a ship to reach a disaster location at a specified distance from current location to the disaster location. As such, I append class performance parameters to the capability matrix that include ship class maximum speed, maximum range, and maximum range speed as obtained from the USN, MSC, and RRF fact files, handbooks, and Jane's Fighting Ships data files. The resulting variables are depicted in Table 20.

Table 20. Proximity Variables and Definitions

Variable		Values
Prox_MaxSpeedKts	=	Appended ship/class maximum speed (kts)
Prox_MaxRangeSpeedKts	=	Appended ship/class maximum range speed (kts)
Prox_MaxRangeNM	=	Appended ship/class maximum range speed (kts)
Prox_DaysActivation	=	Appended ship/class minimum number of days required to activate
DaysTransit_'x'nm	=	Ship/class transit days required to travel 'x' nm, where 'x' starts a 0 and increases to 11,000 nm in increments of 250 nm. (45 variables total)

The proximity summary statistics are depicted in Table 21. The mean observed maximum range speed is 19.9 kts, with a minimum reported maximum range speed of six kts and a maximum of 35 kts. The observed mean maximum range is 10,583 nm. While most observations do not require any activation time, the ship class with the longest activation time requires 10 days. The observed mean activation time is 0.588 days.

Table 21. Proximity Summary Statistics—All Ships, FY 2010 to 2017

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
Prox_MaxSpeedKts	3,183	24.5338	6.7882	6	50
Prox_MaxRangeSpeedKts	3,183	19.8860	4.9644	6	35
Prox_MaxRangeNM	2,720	10583.2300	6749.2400	1200	21000
Prox_DaysActivation	3,183	0.5875	1.6772	0	10

Based on my experience as an aviator, I lean toward using maximum range speeds for the proximity calculations to provide the best chance of traveling longer distances given ship's maximum fuel loads and mission loadout. To verify this assumption, I conduct factor analysis on the proximity variables to determine whether maximum speed or maximum range speed should be used.

Due to missing maximum range distances for 463 observations, the factor analysis is limited to 2,720 observations. The results confirm that maximum range speed should be used since nearly 72% of the variation in the proximity data can be explained in factor one by maximum range speed alone, followed by maximum range. Overall maximum speed is the only item in the second factor greater than 0.4 and has less weight than maximum range

speed. For this reason, I elect to run all transit calculations and utility calculations using maximum range speed over maximum speed. Maximum range is excluded from calculations for this study but would be accounted for in real-world scenarios by mission planners and qualified ship crews. Should there be future iterations of this study, I recommend including maximum range rules in utility calculations if all data is available.

Next, I define the proximity equation that I use to calculate the number of days it would take an individual ship to travel from a given location to a disaster location:

$$T_{i,d} = \left(\frac{d_i}{s_i}\right) \Big/ 24\ hours$$

where

- *T* is the number of transit days required to arrive on-scene at the disaster location
- *i* represents one ship of a given class
- *d* represents ship distance from present position to disaster location (nm, nautical miles)
- *s* represents ship maximum range speed in knots.

I use this equation to generate transit day variables, starting at zero nm out to 11,000 nm, in 250 nm increments. The summary statistics for the transit days at maximum range speed are depicted in Table 22. For example, the mean number of days required to transit 6000nm is 13.5 days, with a minimum observed number of transit days equaling 7.1 days and a maximum observed of 41.7 days. Clearly, this indicates that ship speed and proximity will play a significant role in the utility of tasking individual ships. The extent to which proximity will impact utility will be determined in the utility calculations.

Table 22. Transit Days at Maximum Range Speed Summary Statistics

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
DaysTransit_0nm	3,183	0.0000	0.0000	0	0
DaysTransit_250nm	3,183	0.5629	0.1680	0.29762	1.73611
DaysTransit_500nm	3,183	1.1259	0.3361	0.59524	3.47222
DaysTransit_750nm	3,183	1.6888	0.5041	0.89286	5.20833
DaysTransit_1000nm	3,183	2.2518	0.6722	1.19048	6.94445
DaysTransit_1250nm	3,183	2.8147	0.8402	1.4881	8.68056
DaysTransit_1500nm	3,183	3.3776	1.0082	1.78571	10.4167
DaysTransit_1750nm	3,183	3.9406	1.1763	2.08333	12.1528
DaysTransit_2000nm	3,183	4.5035	1.3443	2.38095	13.8889
DaysTransit_2250nm	3,183	5.0664	1.5124	2.67857	15.625
DaysTransit_2500nm	3,183	5.6294	1.6804	2.97619	17.3611
DaysTransit_2750nm	3,183	6.1923	1.8484	3.27381	19.0972
DaysTransit_3000nm	3,183	6.7553	2.0165	3.57143	20.8333
DaysTransit_3250nm	3,183	7.3182	2.1845	3.86905	22.5694
DaysTransit_3500nm	3,183	7.8811	2.3525	4.16667	24.3056
DaysTransit_3750nm	3,183	8.4441	2.5206	4.46429	26.0417
DaysTransit_4000nm	3,183	9.0070	2.6886	4.76191	27.7778
DaysTransit_4250nm	3,183	9.5700	2.8567	5.05952	29.5139
DaysTransit_4500nm	3,183	10.1329	3.0247	5.35714	31.25
DaysTransit_4750nm	3,183	10.6958	3.1927	5.65476	32.9861
DaysTransit_5000nm	3,183	11.2588	3.3608	5.95238	34.7222
DaysTransit_5250nm	3,183	11.8217	3.5288	6.25	36.4583
DaysTransit_5500nm	3,183	12.3847	3.6969	6.54762	38.1944
DaysTransit_5750nm	3,183	12.9476	3.8649	6.84524	39.9306
DaysTransit_6000nm	3,183	13.5105	4.0329	7.14286	41.6667
DaysTransit_6250nm	3,183	14.0735	4.2010	7.44048	43.4028
DaysTransit_6500nm	3,183	14.6364	4.3690	7.7381	45.1389
DaysTransit_6750nm	3,183	15.1993	4.5371	8.03571	46.875
DaysTransit_7000nm	3,183	15.7623	4.7051	8.33333	48.6111
DaysTransit_7250nm	3,183	16.3252	4.8731	8.63095	50.3472
DaysTransit_7500nm	3,183	16.8882	5.0412	8.92857	52.0833
DaysTransit_7750nm	3,183	17.4511	5.2092	9.22619	53.8194
DaysTransit_8000nm	3,183	18.0140	5.3772	9.52381	55.5556
DaysTransit_8250nm	3,183	18.5770	5.5453	9.82143	57.2917
DaysTransit_8500nm	3,183	19.1399	5.7133	10.1191	59.0278
DaysTransit_8750nm	3,183	19.7029	5.8814	10.4167	60.7639
DaysTransit_9000nm	3,183	20.2658	6.0494	10.7143	62.5
DaysTransit_9250nm	3,183	20.8287	6.2174	11.0119	64.2361
DaysTransit_9500nm	3,183	21.3917	6.3855	11.3095	65.9722
DaysTransit_9750nm	3,183	21.9546	6.5535	11.6071	67.7083
DaysTransit_10000nm	3,183	22.5175	6.7216	11.9048	69.4444
DaysTransit_10250nm	3,183	23.0805	6.8896	12.2024	71.1806
DaysTransit_10500nm	3,183	23.6434	7.0576	12.5	72.9167
DaysTransit_10750nm	3,183	24.2064	7.2257	12.7976	74.6528
DaysTransit_11000nm	3,183	24.7693	7.3937	13.0952	76.3888

5. Utility Parameters

The final set of parameters generated for this study is used to calculate stylized utility values for each ship class. The goal of incorporating inventory, cost, capability, and proximity into the database is to maximize the combined utility of ships tasked to respond during a U.S. naval HADR operation. I use the following function to calculate ship utility for this study:

$$[U_{i,d,R},\ C_{i,R}] = (S_i * R_i) - (S_i * (T_i + A_i))$$

where

- *U* is the calculated HADR utility of a given ship or ship class
- *i* represents one ship of a given class
- *d* represents ship distance from present location to the disaster (nm)
- *S* is the ship/class *CapabilityCompositeScore* or specific capability metric score
- *R* is the expected number of HADR response days from 'Day + 0' to the final expected day of HADR operations
- *T* is the number of transit days from present position to disaster location
- *A* is the number of activation/preparation days required prior to departure
- *C* is vessel reported *_AvgDlyCost_Class_FY2010_17* in CY 2017 USD.

For analysis purposes, I generate 180 total utility variables that report ship class utility for distances starting at zero nm, extending out to 11,000 nm in 250 nm increments. This process is executed four times to report 10, 30, 60, and 90-day HADR responses from "Day +0" of disaster onset to the completion of the HADR response. Table 23 depicts the generated utility variable definitions.

Table 23. Utility Variables and Definitions

Variable		Values
Util_10dy_'x'nm	=	Ship/class utility score for a 10-Day HADR response, transiting 'x' nm to disaster location, where 'x' starts a 0 and increases to 11,000 nm in increments of 250 nm. (45 total variables)
Util_30dy_'x'nm	=	Ship/class utility score for a 30-Day HADR response, transiting 'x' nm to disaster location, where 'x' starts a 0 and increases to 11,000 nm in increments of 250 nm. (45 total variables)
Util_60dy_'x'nm	=	Ship/class utility score for a 60-Day HADR response, transiting 'x' nm to disaster location, where 'x' starts a 0 and increases to 11,000 nm in increments of 250 nm. (45 total variables)
Util_90dy_'x'nm	=	Ship/class utility score for a 90-Day HADR response, transiting 'x' nm to disaster location, where 'x' starts a 0 and increases to 11,000 nm in increments of 250 nm. (45 total variables)
ResponseCost_10days	=	Ship/class O&S cost to provide 10-day HADR response *_AvgDlyCost_Class_FY10_17* x 10 days
ResponseCost_30days	=	Ship/class O&S cost to provide 30-day HADR response *_AvgDlyCost_Class_FY10_17* x 30 days
ResponseCost_60days	=	Ship/class O&S cost to provide 60-day HADR response *_AvgDlyCost_Class_FY10_17* x 60 days
ResponseCost_90days	=	Ship/class O&S cost to provide 90-day HADR response *_AvgDlyCost_Class_FY10_17* x 90 days
* *Italicized* values are pre-defined variables that the generated variable is based on.		

Tables 24, 25, 26, and 27 depict utility summary statistics for 10, 30, 60, and 90-Day HADR responses, respectively. 'Min' column values of zero indicate that there are ships with zero HADR utility or that the distance traveled exactly cancels out the utility of an otherwise HADR-capable ship. Negative utility values in the 'min' column of the summary statistics indicate that the number of transit and activation days required to arrive on-scene for at least one ship in the data are greater than the allotted disaster response days. For example, in Table 24, we find that zero vessels provide any utility during a 10-day HADR response at distances of 8,500 nm and beyond. In Table 25, we find that all vessels can at least reach the disaster location within the 30-day response window out to 4,250 nm. Beyond 4,250 miles, we find negative reported minimum utility values, indicating that there are ships in the data that will not reach the disaster location within the 30-day response window at distances greater than 4,250 nm. Further analysis is required to determine which ships fall into this category and will be reported in the results. The same phenomena are observed in the 60-day utility summary statistics beyond 8,500 nm. There are no negative values in the 90-day response summary statistics, indicating that all ships can arrive on

scene within the given response window and provide positive HADR utility to the affected population.

Differences in the utility summary statistics behave similarly to the capability summary statistics when reported by individual status (USN, MSC, RRF). For simplicity, I have not reported them here and will let the results contained in Chapter V tell the rest of the story by specific class.

Table 24. Utility Summary Statistics by Proximity—
10-Day HADR Response

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010-17)					
Utility_10Day_0nm	3,183	98.2846	105.9065	0	650
Utility_10Day_250nm	3,183	92.7013	100.9935	-4.9342	616.146
Utility_10Day_500nm	3,183	87.1180	96.1161	-9.8684	582.292
Utility_10Day_750nm	3,183	81.5347	91.2799	-14.803	548.438
Utility_10Day_1000nm	3,183	75.9515	86.4918	-19.737	514.583
Utility_10Day_1250nm	3,183	70.3682	81.7604	-24.671	480.729
Utility_10Day_1500nm	3,183	64.7849	77.0961	-29.605	446.875
Utility_10Day_1750nm	3,183	59.2016	72.5117	-34.539	413.021
Utility_10Day_2000nm	3,183	53.6183	68.0235	-39.474	379.167
Utility_10Day_2250nm	3,183	48.0350	63.6518	-44.408	345.313
Utility_10Day_2500nm	3,183	42.4517	59.4224	-49.342	311.458
Utility_10Day_2750nm	3,183	36.8684	55.3678	-54.276	277.604
Utility_10Day_3000nm	3,183	31.2851	51.5293	-59.211	243.75
Utility_10Day_3250nm	3,183	25.7018	47.9588	-64.145	209.896
Utility_10Day_3500nm	3,183	20.1185	44.7207	-69.079	189.748
Utility_10Day_3750nm	3,183	14.5352	41.8919	-75.833	179.015
Utility_10Day_4000nm	3,183	8.9519	39.5605	-85.556	168.283
Utility_10Day_4250nm	3,183	3.3686	37.8185	-95.278	157.551
Utility_10Day_4500nm	3,183	-2.2147	36.7499	-105	146.818
Utility_10Day_4750nm	3,183	-7.7980	36.4140	-114.72	136.086
Utility_10Day_5000nm	3,183	-13.3813	36.8307	-124.44	125.354
Utility_10Day_5250nm	3,183	-18.9646	37.9755	-137.5	114.621
Utility_10Day_5500nm	3,183	-24.5479	39.7854	-158.33	103.889
Utility_10Day_5750nm	3,183	-30.1312	42.1749	-179.17	93.1566
Utility_10Day_6000nm	3,183	-35.7145	45.0519	-200	82.4243
Utility_10Day_6250nm	3,183	-41.2978	48.3295	-220.83	71.6919
Utility_10Day_6500nm	3,183	-46.8811	51.9317	-241.67	60.9596
Utility_10Day_6750nm	3,183	-52.4644	55.7958	-264.06	50.2273
Utility_10Day_7000nm	3,183	-58.0477	59.8711	-297.92	39.495
Utility_10Day_7250nm	3,183	-63.6310	64.1174	-331.77	28.7626
Utility_10Day_7500nm	3,183	-69.2143	68.5028	-365.63	18.0303
Utility_10Day_7750nm	3,183	-74.7976	73.0022	-399.48	12.381
Utility_10Day_8000nm	3,183	-80.3809	77.5959	-433.33	7.61905
Utility_10Day_8250nm	3,183	-85.9642	82.2681	-467.19	2.85715
Utility_10Day_8500nm	3,183	-91.5475	87.0061	-501.04	0
Utility_10Day_8750nm	3,183	-97.1308	91.7997	-534.9	0
Utility_10Day_9000nm	3,183	-102.7141	96.6406	-568.75	0
Utility_10Day_9250nm	3,183	-108.2974	101.5222	-602.6	0
Utility_10Day_9500nm	3,183	-113.8807	106.4387	-636.46	0
Utility_10Day_9750nm	3,183	-119.4640	111.3856	-670.31	0
Utility_10Day_10000nm	3,183	-125.0473	116.3589	-704.17	0
Utility_10Day_10250nm	3,183	-130.6306	121.3555	-738.02	0
Utility_10Day_10500nm	3,183	-136.2139	126.3726	-771.88	0
Utility_10Day_10750nm	3,183	-141.7972	131.4078	-805.73	0
Utility_10Day_11000nm	3,183	-147.3805	136.4591	-839.58	0

Table 25. Utility Summary Statistics by Proximity—
30-Day HADR Response

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
Utility_30Day_0nm	3,183	309.2617	315.6677	0	1950
Utility_30Day_250nm	3,183	303.6784	310.6210	0	1916.15
Utility_30Day_500nm	3,183	298.0951	305.5811	0	1882.29
Utility_30Day_750nm	3,183	292.5118	300.5484	0	1848.44
Utility_30Day_1000nm	3,183	286.9285	295.5232	0	1814.58
Utility_30Day_1250nm	3,183	281.3452	290.5060	0	1780.73
Utility_30Day_1500nm	3,183	275.7619	285.4971	0	1746.88
Utility_30Day_1750nm	3,183	270.1786	280.4969	0	1713.02
Utility_30Day_2000nm	3,183	264.5953	275.5060	0	1679.17
Utility_30Day_2250nm	3,183	259.0120	270.5250	0	1645.31
Utility_30Day_2500nm	3,183	253.4287	265.5542	0	1611.46
Utility_30Day_2750nm	3,183	247.8454	260.5943	0	1577.6
Utility_30Day_3000nm	3,183	242.2621	255.6460	0	1543.75
Utility_30Day_3250nm	3,183	236.6788	250.7100	0	1509.9
Utility_30Day_3500nm	3,183	231.0955	245.7869	0	1476.04
Utility_30Day_3750nm	3,183	225.5122	240.8775	0	1442.19
Utility_30Day_4000nm	3,183	219.9289	235.9828	0	1408.33
Utility_30Day_4250nm	3,183	214.3456	231.1037	0	1374.48
Utility_30Day_4500nm	3,183	208.7623	226.2411	-5	1340.63
Utility_30Day_4750nm	3,183	203.1790	221.3962	-11.944	1306.77
Utility_30Day_5000nm	3,183	197.5957	216.5701	-18.889	1272.92
Utility_30Day_5250nm	3,183	192.0124	211.7642	-25.833	1239.06
Utility_30Day_5500nm	3,183	186.4292	206.9797	-32.778	1205.21
Utility_30Day_5750nm	3,183	180.8459	202.2184	-39.722	1171.35
Utility_30Day_6000nm	3,183	175.2626	197.4817	-46.667	1137.5
Utility_30Day_6250nm	3,183	169.6793	192.7716	-53.611	1103.65
Utility_30Day_6500nm	3,183	164.0960	188.0901	-60.556	1069.79
Utility_30Day_6750nm	3,183	158.5127	183.4392	-67.5	1035.94
Utility_30Day_7000nm	3,183	152.9294	178.8216	-74.444	1002.08
Utility_30Day_7250nm	3,183	147.3461	174.2396	-81.389	968.229
Utility_30Day_7500nm	3,183	141.7628	169.6963	-88.333	934.375
Utility_30Day_7750nm	3,183	136.1795	165.1949	-95.278	900.521
Utility_30Day_8000nm	3,183	130.5962	160.7388	-102.22	866.667
Utility_30Day_8250nm	3,183	125.0129	156.3320	-109.17	832.813
Utility_30Day_8500nm	3,183	119.4296	151.9787	-116.11	798.958
Utility_30Day_8750nm	3,183	113.8463	147.6836	-123.06	765.104
Utility_30Day_9000nm	3,183	108.2630	143.4521	-130	731.25
Utility_30Day_9250nm	3,183	102.6797	139.2898	-136.94	697.396
Utility_30Day_9500nm	3,183	97.0964	135.2032	-143.89	663.542
Utility_30Day_9750nm	3,183	91.5131	131.1993	-150.83	629.688
Utility_30Day_10000nm	3,183	85.9298	127.2860	-157.78	595.833
Utility_30Day_10250nm	3,183	80.3465	123.4718	-164.72	579.975
Utility_30Day_10500nm	3,183	74.7632	119.7663	-171.67	569.242
Utility_30Day_10750nm	3,183	69.1799	116.1798	-178.61	558.51
Utility_30Day_11000nm	3,183	63.5966	112.7238	-185.56	547.778

Table 26. Utility Summary Statistics by Proximity—
60-Day HADR Response

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
Utility_60Day_0nm	3,183	625.7273	631.9907	0	3900
Utility_60Day_250nm	3,183	620.1440	626.9253	0	3866.15
Utility_60Day_500nm	3,183	614.5607	621.8629	0	3832.29
Utility_60Day_750nm	3,183	608.9774	616.8036	0	3798.44
Utility_60Day_1000nm	3,183	603.3941	611.7475	0	3764.58
Utility_60Day_1250nm	3,183	597.8108	606.6948	0	3730.73
Utility_60Day_1500nm	3,183	592.2275	601.6453	0	3696.88
Utility_60Day_1750nm	3,183	586.6442	596.5993	0	3663.02
Utility_60Day_2000nm	3,183	581.0609	591.5569	0	3629.17
Utility_60Day_2250nm	3,183	575.4776	586.5180	0	3595.31
Utility_60Day_2500nm	3,183	569.8943	581.4829	0	3561.46
Utility_60Day_2750nm	3,183	564.3110	576.4517	0	3527.6
Utility_60Day_3000nm	3,183	558.7277	571.4243	0	3493.75
Utility_60Day_3250nm	3,183	553.1444	566.4009	0	3459.9
Utility_60Day_3500nm	3,183	547.5611	561.3817	0	3426.04
Utility_60Day_3750nm	3,183	541.9778	556.3667	0	3392.19
Utility_60Day_4000nm	3,183	536.3945	551.3561	0	3358.33
Utility_60Day_4250nm	3,183	530.8112	546.3500	0	3324.48
Utility_60Day_4500nm	3,183	525.2279	541.3485	0	3290.63
Utility_60Day_4750nm	3,183	519.6446	536.3516	0	3256.77
Utility_60Day_5000nm	3,183	514.0613	531.3597	0	3222.92
Utility_60Day_5250nm	3,183	508.4780	526.3728	0	3189.06
Utility_60Day_5500nm	3,183	502.8947	521.3910	0	3155.21
Utility_60Day_5750nm	3,183	497.3115	516.4145	0	3121.35
Utility_60Day_6000nm	3,183	491.7282	511.4435	0	3087.5
Utility_60Day_6250nm	3,183	486.1449	506.4780	0	3053.65
Utility_60Day_6500nm	3,183	480.5616	501.5184	0	3019.79
Utility_60Day_6750nm	3,183	474.9783	496.5647	0	2985.94
Utility_60Day_7000nm	3,183	469.3950	491.6171	0	2952.08
Utility_60Day_7250nm	3,183	463.8117	486.6759	0	2918.23
Utility_60Day_7500nm	3,183	458.2284	481.7412	0	2884.38
Utility_60Day_7750nm	3,183	452.6451	476.8131	0	2850.52
Utility_60Day_8000nm	3,183	447.0618	471.8921	0	2816.67
Utility_60Day_8250nm	3,183	441.4785	466.9781	0	2782.81
Utility_60Day_8500nm	3,183	435.8952	462.0715	0	2748.96
Utility_60Day_8750nm	3,183	430.3119	457.1726	-3.0556	2715.1
Utility_60Day_9000nm	3,183	424.7286	452.2814	-10	2681.25
Utility_60Day_9250nm	3,183	419.1453	447.3984	-16.944	2647.4
Utility_60Day_9500nm	3,183	413.5620	442.5238	-23.889	2613.54
Utility_60Day_9750nm	3,183	407.9787	437.6579	-30.833	2579.69
Utility_60Day_10000nm	3,183	402.3954	432.8008	-37.778	2545.83
Utility_60Day_10250nm	3,183	396.8121	427.9531	-44.722	2511.98
Utility_60Day_10500nm	3,183	391.2288	423.1150	-51.667	2478.13
Utility_60Day_10750nm	3,183	385.6455	418.2867	-58.611	2444.27
Utility_60Day_11000nm	3,183	380.0622	413.4687	-65.556	2410.42

Table 27. Utility Summary Statistics by Proximity—
90-Day HADR Response

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010–17)					
Utility_90Day_0nm	3,183	942.1929	948.5379	0	5850
Utility_90Day_250nm	3,183	936.6096	943.4675	0	5816.15
Utility_90Day_500nm	3,183	931.0263	938.3990	0	5782.29
Utility_90Day_750nm	3,183	925.4430	933.3326	0	5748.44
Utility_90Day_1000nm	3,183	919.8597	928.2682	0	5714.58
Utility_90Day_1250nm	3,183	914.2764	923.2058	0	5680.73
Utility_90Day_1500nm	3,183	908.6931	918.1456	0	5646.88
Utility_90Day_1750nm	3,183	903.1098	913.0874	0	5613.02
Utility_90Day_2000nm	3,183	897.5265	908.0315	0	5579.17
Utility_90Day_2250nm	3,183	891.9432	902.9777	0	5545.31
Utility_90Day_2500nm	3,183	886.3599	897.9262	0	5511.46
Utility_90Day_2750nm	3,183	880.7766	892.8769	0	5477.6
Utility_90Day_3000nm	3,183	875.1933	887.8300	0	5443.75
Utility_90Day_3250nm	3,183	869.6100	882.7855	0	5409.9
Utility_90Day_3500nm	3,183	864.0267	877.7433	0	5376.04
Utility_90Day_3750nm	3,183	858.4434	872.7036	0	5342.19
Utility_90Day_4000nm	3,183	852.8601	867.6664	0	5308.33
Utility_90Day_4250nm	3,183	847.2768	862.6316	0	5274.48
Utility_90Day_4500nm	3,183	841.6935	857.5995	0	5240.63
Utility_90Day_4750nm	3,183	836.1102	852.5700	0	5206.77
Utility_90Day_5000nm	3,183	830.5269	847.5431	0	5172.92
Utility_90Day_5250nm	3,183	824.9436	842.5190	0	5139.06
Utility_90Day_5500nm	3,183	819.3604	837.4976	0	5105.21
Utility_90Day_5750nm	3,183	813.7770	832.4790	0	5071.35
Utility_90Day_6000nm	3,183	808.1938	827.4633	0	5037.5
Utility_90Day_6250nm	3,183	802.6105	822.4505	0	5003.65
Utility_90Day_6500nm	3,183	797.0272	817.4406	0	4969.79
Utility_90Day_6750nm	3,183	791.4439	812.4338	0	4935.94
Utility_90Day_7000nm	3,183	785.8606	807.4301	0	4902.08
Utility_90Day_7250nm	3,183	780.2773	802.4295	0	4868.23
Utility_90Day_7500nm	3,183	774.6940	797.4321	0	4834.38
Utility_90Day_7750nm	3,183	769.1107	792.4379	0	4800.52
Utility_90Day_8000nm	3,183	763.5274	787.4471	0	4766.67
Utility_90Day_8250nm	3,183	757.9441	782.4596	0	4732.81
Utility_90Day_8500nm	3,183	752.3608	777.4756	0	4698.96
Utility_90Day_8750nm	3,183	746.7775	772.4951	0	4665.1
Utility_90Day_9000nm	3,183	741.1942	767.5182	0	4631.25
Utility_90Day_9250nm	3,183	735.6109	762.5449	0	4597.4
Utility_90Day_9500nm	3,183	730.0276	757.5753	0	4563.54
Utility_90Day_9750nm	3,183	724.4443	752.6096	0	4529.69
Utility_90Day_10000nm	3,183	718.8610	747.6477	0	4495.83
Utility_90Day_10250nm	3,183	713.2777	742.6898	0	4461.98
Utility_90Day_10500nm	3,183	707.6944	737.7359	0	4428.13
Utility_90Day_10750nm	3,183	702.1111	732.7861	0	4394.27
Utility_90Day_11000nm	3,183	696.5278	727.8405	0	4360.42

Table 28 depicts the O&S cost summary statistics to provide a 10, 30, 60, and 90-day HADR response by class. As a reminder, the response period begins at Day + 0 and totals the number of response days indicated by the variable name. The mean class cost to provide a 10-day response is $1.5 M, with $12.4 M equaling the maximum observed. The mean class cost to provide a 90-day response is $13.6 M, with $111.7 M equaling the maximum observed.

Table 28. Summary Statistics for Stylized Response Cost by Duration

Variable	N	mean	sd	min	max
ALL SHIPS (FY 2010-17)					
ResponseCost_10days	3,183	1,512,425	1,999,486	(3,015)	12,412,615
ResponseCost_30days	3,183	4,537,275	5,998,458	(9,046)	37,237,844
ResponseCost_60days	3,183	9,074,549	11,996,917	(18,093)	74,475,688
ResponseCost_90days	3,183	13,611,824	17,995,376	(27,139)	111,713,536

6. Disaster Response Parameters

Finally, I append historic HADR response data for the 2010 Haiti earthquake, as gathered by Greenfield and Ingram (2011), and the 2011 Tohoku earthquake, as gathered by Moffat (2014). I use this data to test the newly established utility function and to provide a baseline for regression analysis to help determine the extent that proximity plays in utility and cost calculations, and that capability plays in utility and cost calculations. Table 29 depicts the HADR response variable names and definitions.

Table 29. HADR Response Variables and Definitions

Variable		Values
HADR_TaskedHaiti	=	1 if ship provided an HADR support to Haiti (*FY10 = 1*); =0 otherwise
HADR_TaskedJapan	=	1 if ship provided an HADR support to Japan (*FY11 = 1*); =0 otherwise
HADR_Transit	=	Ship number of transit and activation days to provide HADR response
HADR_OnStation	=	Ship number of days on station during HADR response
HADR_TotalDays	=	Ship number of total response day for HADR response
HADR_EstNM	=	Ship *HADR_Enroute* x *Prox_MaxRangeSpeedKts* x 24 hrs
HADR_Cost	=	Respective ship FY (*CostYearTotal_CY /* 365 days) x *HADR_TotalDays*, if *HADR_TaskedHaiti = 1 or HADR_TaskedJapan = 1.*
HADR_log_Cost	=	ln(*HADR_Cost)*
HADR_Utility	=	Ship *CapabilityCompositeScore* x *HADR_OnStation*
HADR_log_Utility	=	ln(*HADR_Utility)*
* *Italicized* values are pre-defined variables that the generated variable is based on.		

Of the 401 ships in the FY 2010 USN, MSC, and RRF inventories, 24 ships (6%) were tasked to execute the HADR mission following the 2010 Haiti earthquake. Of the 24 ships tasked, the mean number of transit days was 4.3 days. The minimum number of transit days was zero and the maximum was 14 days. The mean number of days on station was 25.6 days, with a minimum of 4 days and a maximum of 61 days. Based on reverse calculations, the mean utility provided by Haiti HADR response ships was 440.3 points, with a minimum of 54 and a maximum of 3,233 points. Associated O&S costs are based on actual ship VAMOSC-reported FY values. The mean ship O&S costs to provide HADR support to Haiti was $4.7 M (CY 2017 USD) with a minimum ship HADR cost of $.248 M and a maximum of $25.7 M.

Of the 400 ships in the FY 2011 USN, MSC, and RRF inventories, 23 ships (5.8%) were tasked to execute the HADR mission following the 2011 Tohoku earthquake and subsequent tsunami. Of the 23 ships tasked, the mean number of transit days was 2.4 days. The minimum number of transit days was zero and the maximum was 10 days. The mean number of days on station was 19.9 days, with a minimum of 6 and maximum of 25 days. Based on reverse calculations, the mean utility provided Tohoku HADR response ships was 277.5 points, with a minimum of 78 and a maximum of 1430 points. Associated O&S costs are based on actual ship VAMOSC-reported FY values. The mean ship O&S costs to provide HADR support to Japan was $5.2 M (CY 2017 USD) with a minimum ship HADR

cost of $0.432 M and a maximum of $23.6 M. Table 30 depicts a complete breakdown of the sample HADR response summary statistics.

Table 30. HADR Response Summary Statistics

Variable	N	mean	sd	min	max
TASKABLE INVENTORY SHIPS IF *FY10* = 1					
HADR_TaskedHaiti	401	0.0599	0.2375	0	1
HADR_TaskedHaiti = 1					
HADR_Transit (Haiti)	24	4.3333	3.5468	0	14
HADR_OnStation (Haiti)	24	25.6250	15.4942	4	61
HADR_TotalDays (Haiti)	24	29.9583	15.7990	11	66
HADR_EstNM (Haiti)	24	1876.0000	1602.8390	0	6720
HADR_Cost (Haiti)	24	4,745,247	5,497,692	247,652	25,681,862
HADR_log_Cost (Haiti)	24	14.8533	1.1332	12.4198	17.0613
HADR_Utility (Haiti)	24	440.2917	633.3172	54	3233
HADR_log_Utility (Haiti)	24	5.6451	0.8639	3.98898	8.081165
TASKABLE INVENTORY SHIPS IF *FY11* = 1					
HADR_TaskedJapan	400	0.0575	0.2331	0	1
HADR_TaskedJapan = 1					
HADR_Transit (Japan)	23	2.4348	2.6939	0	10
HADR_OnStation (Japan)	23	19.8696	4.9388	6	25
HADR_TotalDays (Japan)	23	22.3044	5.8187	6	29
HADR_EstNM (Japan)	23	1052.8700	980.6765	0	2880
HADR_Cost (Japan)	23	5,216,974	5,079,302	423,189	23,581,838
HADR_log_Cost (Japan)	23	15.1062	0.9037	12.9556	16.97599
HADR_Utility (Japan)	23	277.5217	283.8561	78	1430
HADR_log_Utility (Japan)	23	5.3766	0.6394	4.35671	7.265429

Haiti raw data obtained from Greenfield and Ingram (2011) database. Japan raw data obtained from Moffat (2014) database.

C. DATA SUMMARY

In conclusion, I determine U.S. naval ship inventory from FY 2010 to 2017, using the VAMOSC database. I retain cost and non-cost data at the individual ship level by FY, using VAMOSC calculated CY 2017 USD values. Due to significant variance in O&S costs across status and class categories, I calculate average annual costs by class from FY 2010 to 2017. I convert average annual amounts into average daily costs by class that will be used in utility rule of thumb calculations. For cost analysis, I decide to control for individual ship and year by using panel data regression analysis.

After verification, I assign capability parameters to each ship in the inventory by appending capability parameters by class. The *CapabilityCompositeScore* will play a key role in future utility function calculations, however individual capabilities can be inserted into the utility function if a specific capability is desired. I use factor analysis and find that all capability variables are needed in utility calculations.

Using an algebraic time, speed, distance equation, I generate a quick reference transit table that reports the required number of days to travel 0 to 11,000 nm, in 250 nm increments based on ship maximum range speed (Appendix D, Tables 57 and 58). The number of travel days and activation days serve as a penalty in the utility function, in that the capability that could be provided to the affected population is not available and is then deducted from the total possible utility of each ship while transiting. Additionally, I generate quick reference utility tables that report the maximum utility of USN, MSC and RRF ships for 10, 30, 60, and 90-day responses based on ship class maximum range speeds for distances of 0 nm to 11,000 nm, in 250 nm increments. All quick reference tables can be found in Appendix D.

Finally, I append historic disaster response data that I use to establish a baseline for regression analysis and to answer the secondary research questions. The regressions are based on existing FY inventory at disaster onset, reported ship FY O&S costs and the appended class capability data. I use Greenfield and Ingram (2011) and Moffat (2014) reported days in transit data to reverse calculate approximated transit distances. Additionally, I calculate utility values of each responding ship by inserting Greenfield and Ingram (2011) and Moffat (2014) reported days on station days plus the transit days to find the total number of response days that are then plugged into the utility function. I convert utility and O&S cost amounts into natural log values that can be easily interpreted during regression analysis.

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V. RESULTS AND ANALYSIS

I analyze the data to answer the primary and secondary research questions. The results are broken into two parts. In the first part, I report findings that support the primary research objective and question. The second part reports findings that support the secondary research questions. All results must be tempered with the caveat that many USN, MSC, and RRF ships are low density, high value assets that cannot be everywhere at one time. Furthermore, these results are not intended to detract from standard naval force protection constructs, nor are they intended to negate established mission tasking priorities. I simply report the HADR utility of FY 2010 to 2017 inventory ships based on Chapter IV ship class HADR capability metrics, VAMOSC reported O&S costs, stylized proximity, and response metrics.

A. PRIMARY RESEARCH OBJECTIVE AND QUESTION RESULTS

To recap, I use inventory, class O&S costs, capability metrics, and proximity metrics to solve the following primary research objective and question:

- (RO) Determine an HADR utility function that links ship HADR capability with reported O&S cost, and proximity.
- (RQ1) Of all available and active U.S. naval ships at disaster onset, what is the optimal mix of ships that maximizes the utility of HADR operations given platform capability, proximity, and cost?

Next, I report my findings for each required portion of the utility function.

1. Inventory Findings

First, I report USN, MSC, and RRF ship inventory levels by class and FY, from 2010 to 2017. Figure 16 is a graphical depiction of USN ship inventory by class. Most USN ship classes are observed to maintain a constant count across the eight-year period. For those classes observed to decrease in number, there are disproportionate increases in other classes designed to replace the decommissioned ships. For example, Oliver Hazard Perry class frigates (FFG 7) are observed to have 21 ships in 2010 and steadily decrease to zero

in 2016. Conversely, LCS 1 and LCS 2 ship counts are observed to increase during the same period as replacements to the FFG 7 class ships.

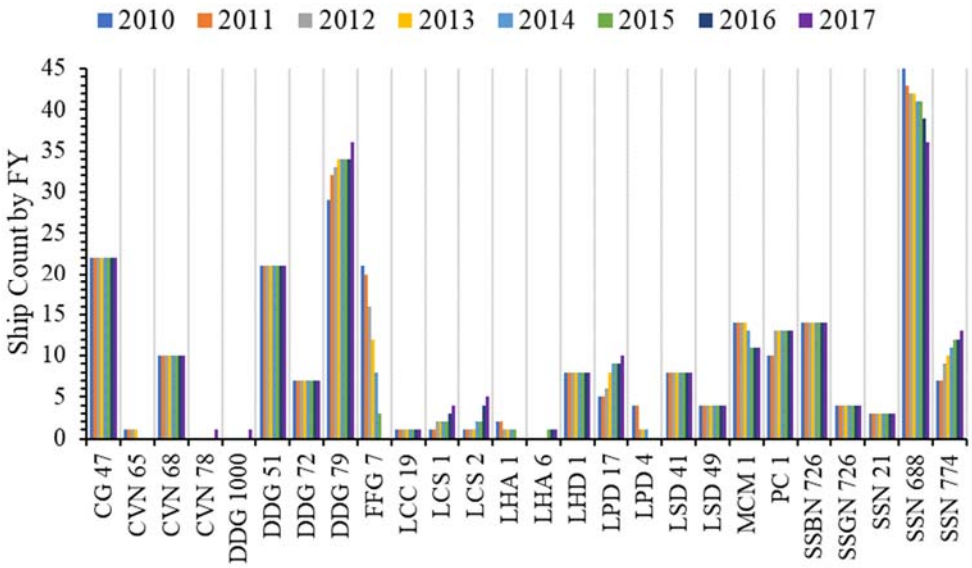

Figure 16. USN Ship Inventory by Fiscal Year and Class, FY 2010 to 2017

The highest total USN inventory count is observed in 2010 (242 ships) with the lowest count occurring in 2016 (228 ships). Table 31 contains a numerical depiction of USN ship count by class and FY. Grey boxes indicate that zero ships of a given class are reported in that year. The column labeled “Total Observed” represents the total number of times ships of a given class appear in the data. For example, this study contains costing data for 21 DDG 51 class ships each year from 2010 to 2017, resulting in a total of 168 DDG 51 class observations. This study uses the FY class count and total observed values to appropriately weight and calculate class average O&S costs.

Table 31. USN Ship Inventory by Class, FY 2010 to 2017.

Ship Type	Ship Class	Fiscal Year (Count) 2010	2011	2012	2013	2014	2015	2016	2017	Total Observed
CG	CG 47	22	22	22	22	22	22	22	22	176
CVN	CVN 65	1	1	1	1	0	0	0	0	4
CVN	CVN 68	10	10	10	10	10	10	10	10	80
CVN	CVN 78	0	0	0	0	0	0	0	1	1
DDG	DDG 1000	0	0	0	0	0	0	0	1	1
DDG	DDG 51	21	21	21	21	21	21	21	21	168
DDG	DDG 72	7	7	7	7	7	7	7	7	56
DDG	DDG 79	29	32	33	34	34	34	34	36	266
FFG	FFG 7	21	20	16	12	8	3	0	0	80
LCC	LCC 19	1	1	1	1	1	1	1	1	8
LCS	LCS 1	1	1	2	2	2	2	3	4	17
LCS	LCS 2	1	1	1	1	2	2	4	5	17
LHA	LHA 1	2	2	1	1	1	1	0	0	8
LHA	LHA 6	0	0	0	0	0	1	1	1	3
LHD	LHD 1	8	8	8	8	8	8	8	8	64
LPD	LPD 17	5	5	6	8	9	9	9	10	61
LPD	LPD 4	4	4	1	1	1	0	0	0	11
LSD	LSD 41	8	8	8	8	8	8	8	8	64
LSD	LSD 49	4	4	4	4	4	4	4	4	32
MCM	MCM 1	14	14	14	14	13	11	11	11	102
PC	PC 1	10	10	13	13	13	13	13	13	98
SSBN	SSBN 726	14	14	14	14	14	14	14	14	112
SSGN	SSGN 726	4	4	4	4	4	4	4	4	32
SSN	SSN 21	3	3	3	3	3	3	3	3	24
SSN	SSN 688	45	43	42	42	41	41	39	36	329
SSN	SSN 774	7	7	9	10	11	12	12	13	81
	Total	242	242	241	241	237	231	228	233	1895

Raw data obtained from the VAMOSC database, February 2, 2018.

Appendix A provides a complete listing of each USN ship reported in this study by class, vessel name, and hull number.

Unlike USN inventory, the reported total number of MSC ships has consistently risen from 2010 (114 ships) to 2017 (125 ships). RRF ship inventory count is consistent from FY 2010 to 2017, except for a spurious drop from 48 ships to 20 ships in 2013. The unexplained drop in 2013 is most likely related to an issue in one of the systems that feed into the VAMOSC database, since the missing ships were reported in 2012 and reappear in 2014. Tables 32 and 33 report MSC and RRF ship inventory count by class and FY. I do not include a graphical depiction of MSC and RRF inventories since many classes report only one ship, often for short durations. USN ship classes are designed for specific combat missions, while non-combat related MSC and RRF ships are often based on civilian merchant vessel designs. Additionally, this study includes long-term contracted, civilian merchant ships that conduct MSC and RRF transportation missions.

Table 32. MSC Ship Inventory by Class, FY 2010 to 2017

Type	Ship Class	Fiscal Year (Count) 2010	2011	2012	2013	2014	2015	2016	2017	Total Observed
T-AE	AE 26	4	1	1	1	1	0	0	0	8
T-AFS	AFS 1	1	0	0	0	0	0	0	0	1
AFSB	AFSB (I) 15	0	0	1	1	1	1	1	1	6
T-AG	AG 5001	1	1	1	1	1	1	1	1	8
T-AGER	AGER 111	1	1	1	1	1	1	1	1	8
T-AGM	AGM 23	1	1	1	1	1	0	0	0	5
T-AGM	AGM 24	1	1	1	1	1	1	1	1	8
T-AGM	AGM 25	0	0	1	1	1	1	1	1	6
T-AGOS	AGOS 19	4	4	4	4	4	4	4	4	32
T-AGOS	AGOS 23	1	1	1	1	1	1	1	1	8
T-AGS	AGS 45	1	1	1	1	1	1	1	1	8
T-AGS	AGS 60	6	6	6	6	6	7	6	6	49
T-AGSE	AGSE 1	4	4	4	4	4	4	4	4	32
T-AH	AH 19	2	2	2	2	2	2	2	2	16
T-AK	AK 0323	1	1	1	1	1	0	0	0	5
T-AK	AK 3005	3	3	3	3	3	3	3	3	24
T-AK	AK 3008	5	5	5	5	5	5	5	5	40
T-AK	AK 3015	3	3	3	3	3	3	3	3	24
T-AK	AK 4296	1	1	1	1	0	0	0	0	4
T-AK	AK 4396	1	0	0	1	1	1	1	1	6
T-AK	AK 4496	2	2	2	2	2	2	2	2	16
T-AK	AK 451	1	0	0	0	0	0	0	0	1
T-AK	AK 4729	1	0	0	0	0	0	0	0	1
T-AK	AK 5158	1	1	1	1	1	1	1	1	8
T-AK	AK 5272	0	0	1	1	1	1	1	1	6
T-AK	AK 5307	0	0	0	0	0	0	0	1	1
T-AK	AK 5362	0	0	0	0	0	1	1	1	3
T-AK	AK 9205	0	1	0	0	0	0	0	0	1
T-AKE	AKE 1	10	12	13	14	14	14	14	14	105
T-AKR	AKR 295	4	4	4	4	4	4	4	4	32
T-AKR	AKR 300	7	7	7	7	7	7	7	7	56
T-AKR	AKR 310	8	8	8	8	8	8	8	8	64
T-AO	AO 187	15	15	15	15	15	15	15	15	120
T-AOE	AOE 6	4	4	4	4	4	4	3	2	29
T-AOT	AOT 1121	4	1	1	1	1	1	1	1	11
T-AOT	AOT 4995	1	1	0	0	0	0	0	0	2
T-AOT	AOT 5205	0	1	1	1	1	1	1	1	7
T-AOT	AOT 5246	0	0	1	1	1	1	1	1	6
T-AOT	AOT 5356	0	0	0	0	1	1	1	1	4
T-AOT	AOT 5406	0	0	0	0	0	0	0	1	1
T-AOT	AOT 5419	0	0	0	0	0	0	1	1	2
T-AOT	AP 1000	0	1	1	1	1	1	1	1	7
T-ARC	ARC 7	1	1	1	1	1	1	1	1	8
T-ARS	ARS 50	4	4	4	4	4	4	4	4	32
AS	AS 39	2	2	2	2	2	2	2	2	16
T-ATF	ATF 166	4	4	4	4	4	4	4	4	32
T-ATF	ATF 4247	1	1	0	0	0	0	0	0	2
T-EPF	EPF 1	0	0	0	2	4	5	6	8	25
T-ESB	ESB 3	0	0	0	0	0	1	1	1	3
T-ESD	ESD 1	0	0	0	1	2	2	2	2	9
T-HST	HST 1	0	0	1	1	1	1	1	1	6
T-HST	HST 2	0	0	1	1	1	1	1	1	6
HSV	HSV 1	1	1	1	1	0	0	0	0	4
HSV	HSV 4676	1	1	1	1	1	1	1	1	8
LCC	LCC 19	1	1	1	1	1	1	1	1	8
MB	MB 1219	0	0	0	0	0	0	1	1	2
Total:	56	114	109	113	118	120	121	122	125	942

Raw data obtained from the VAMOSC database, January 29, 2018.

Table 33. RRF Ship Inventory by Class, FY 2010 to 2017

Type	Ship Class	Fiscal Year (Count) 2010	2011	2012	2013	2014	2015	2016	2017	Total Observed
T-ACS	ACS 1	1	3	3	2	3	3	3	3	21
T-ACS	ACS 4	3	3	3	2	3	3	3	3	23
T-AK	AK 575	1	1	0	0	0	0	0	0	2
T-AK	AK 882	2	2	2	1	2	2	2	2	15
T-AK	AK 981	2	2	2	0	0	0	0	0	6
T-AKR	AKR 10	4	4	4	3	4	4	4	4	31
T-AKR	AKR 1001	1	1	1	0	1	1	1	1	7
T-AKR	AKR 112	3	3	3	1	3	3	3	3	22
T-AKR	AKR 2044	0	1	1	0	1	1	1	1	6
T-AKR	AKR 287	8	8	8	4	8	8	8	8	60
T-AKR	AKR 5051	5	5	5	3	5	5	5	5	38
T-AKR	AKR 5066	2	3	3	0	3	3	3	3	20
T-AKR	AKR 5069	1	1	1	0	1	1	1	1	7
T-AKR	AKR 5082	2	2	2	1	2	2	2	2	15
T-AKR	AKR 9666	2	2	2	0	2	2	2	2	14
T-AKR	AKR 9678	2	3	3	0	3	3	3	3	20
T-AKR	AKR 9961	2	2	2	1	2	2	2	2	15
T-AOT	AOT 181	2	1	1	0	1	1	1	1	8
T-AVB	AVB 3	2	2	2	2	2	2	2	2	16
Total:	19	45	49	48	20	46	46	46	46	346

Raw data obtained from the VAMOSC database, January 29, 2018.

Appendix B provides a complete listing of MSC ships reported in this study by class, vessel name, and hull number. Appendix C provides a complete listing of reported RRF ships.

2. Cost Findings

I conduct regression analysis of reported ship O&S costs to determine the appropriate method of assigning utility function cost values to USN, MSC, and RRF ships. Based on previously reported Chapter IV cost summary statistics, I hypothesize that the effect of cost changes by fiscal year will not be statistically significant unless ship status is accounted for. To appropriately control for each ship and fiscal year, I conduct generalized least squares (GLS) panel data regressions using random effects, based on Hausman test results, to break the 3,183 observations into 469 clusters. Each cluster represents one database ship and automatically controls for each year that the ship appears in the data from 2010 to 2017. Within each group, the minimum observations per group is one, the maximum is eight, and the average is 6.8. StataCorp calls this a “GLS estimator (producing

a matrix-weighted average of the between and within results)" (StataCorp, 2014, p. 1). In addition, I estimate robust standard errors to correct for the likely presence of heteroskedasticity in these data.

The dependent variable for cost regressions in this study is *log_CostYearTotal* and I omit *FY*17 and *StatusUSN* as standardized control variables. The first GLS regression model, titled "Basic Cost Model (A)", depicted in Table 34, is very basic in that I simply control for FY and ship status (USN, MSC, and RRF). As expected, changes in FY are not observed to be statistically significant even at $p<0.1$. Ship status coefficients, however, are observed to be highly correlated with changes in total annual cost, at a 99 percent confidence level, as indicated by *** next to the coefficients. For example, the Basic Cost Model (A) coefficient for *StatusMSC* indicates that holding everything else constant, ships with a status of MSC are 96.2 percent less expensive than ships with a status of USN, on average. Basic Cost Model (A) only accounts for 73.1 percent of the variance in the overall reported *log_CostYearTotal* amounts.

To improve the basic model, I include five of the six contributing cost functions (i.e., *log_Cost_Manpower*, *log_Cost_Operations*, etc.) and omit *log_Cost_Maintenance* to avoid collinearity. With the addition of the cost function variables, all Basic Cost Model (B) coefficients, excluding *log_Cost_SustSupport*, are observed to be statistically significant at the 5 percent level of error or better. For example, the Basic Cost Model (B) coefficient for operations cost indicates that holding everything else constant, a one percent increase in operations costs is associated with a 0.713 percent increase in total cost. This indicates that the combination of status and cost functions are significantly correlated with changes in total annual cost by FY, however the basic models do not differentiate between USN, MSC, and RRF functional costs by year. Basic Cost Model (B) accounts for 91.5 percent of the variance in the overall reported *log_CostYearTotal* amounts. See Table 34 for a complete listing of Basic Model (A) and (B) coefficients.

Table 34. Basic Cost Regression Model Summary

Independent Variables	Basic Cost Model (A)		Basic Cost Model (B)	
FY10	0.4827***	[0.1508]	-0.1738**	[0.0855]
FY11	0.212	[0.1506]	-0.2474***	[0.0834]
FY12	0.1861	[0.1501]	-0.2415***	[0.0828]
FY13	0.1455	[0.1525]	-0.2596***	[0.0838]
FY14	0.0266	[0.1497]	-0.3003***	[0.0823]
FY15	0.111	[0.1500]	-0.2502***	[0.0825]
FY16	0.1818	[0.1500]	-0.2737***	[0.0825]
FY17	[omitted – reference]		[omitted – reference]	
StatusUSN	[omitted – reference]		[omitted – reference]	
StatusMSC	-0.9620***	[0.1315]	-2.0687***	[0.2030]
StatusRRF	-12.3091***	[0.1928]	-4.4396***	[0.2222]
log_Cost_Manpower			0.0377***	[0.0074]
log_Cost_Operations			0.7131***	[0.0085]
log_Cost_Maintenance			[omitted – reference]	
log_Cost_SustSupport			-0.0113	[0.0084]
log_Cost_ContSysImpr			0.0411***	[0.0089]
log_Cost_IndirectSupport			0.0800***	[0.0101]
Constant	17.5974***	[0.1252]	6.2731***	[0.2226]
*** p<0.01, ** p<0.05, * p<0.1 | [Robust Standard errors]				
Observations	3,183		3,183	
Number of ShipID	469		469	
Wald chi2	1357.66		21349.59	
Prob > chi2	0.0000		0.0000	
Overall R-sq	0.7305		0.9152	

Next, I increase cost model complexity to differentiate between USN, MSC, and RRF functional costs per year by interacting *FY10–FY17* variables with ship status. I run two GLS models per status group, titled USN (A), USN (B), MSC (A), and so forth. Basic Cost Model (B) is the baseline model for (A) variant status regressions. The (B) variant of each status model controls for individual ship classes that are related to the given status group.

USN (A) and (B) model FY coefficients report a different story than those reported in Basic Cost Model (B). USN FY10–FY16 annual cost coefficients are observed to decrease each year since 2010. For example, the USN (A) coefficient for *Status_USN_FY10* indicates that holding everything else constant, total annual costs in 2010 were, on average, 19.01 percent higher than those reported in 2017, at a 99 percent level of confidence. USN (A) cost function coefficients retain a positive correlation with total annual cost, with *log_Cost_SustSupport* indicating the largest elasticity of cost, where

a one percent increase in sustainment support cost is associated with a 0.4818 percent increase in total cost, at 99 percent level of confidence. USN (A) has an overall R-squared of 0.8193.

I omit LHD 1 class ships from the USN (B) regressions since it has the highest capability score of USN ships. USN (B) reports similar FY and functional cost findings to USN (A), only with smaller coefficient values. For example, the coefficient for *Status_USN_FY10* indicates that holding everything else constant, total annual costs in 2010 were on average, 12.5 percent higher than those reported in 2017, at a 99 percent level of confidence. All but the aircraft carriers report annual costs that are consistently lower than LHD 1 class ships, at a 99 percent level of confidence. For example, the coefficient for DDG 79 class ships indicates that holding everything else constant, DDG 79 class ships report lower total annual O&S costs by 75.1 percent than LHD 1 class ships, on average. USN (B) reports an overall R-squared of 0.8923. See Table 35 for a complete listing of USN status coefficients.

For the most part, MSC (A) and (B) status models do not indicate that FY has any significant correlation with reported MSC total annual cost. Like the USN status models, MSC (A) and (B) both indicate that functional cost categories are highly correlated with the total annual cost. Unlike the USN models, reported operations costs have the largest elasticity, holding everything else constant. I omit ESB 3 class from the MSC (B) regressions since it has the highest capability score of MSC ships. Strikingly, many MSC ships that possess lower HADR capability scores report O&S costs that are more expensive than ESB 3 class ships, while others consistently report lower costs. See Table 36 for a complete listing of MSC (A) and (B) cost coefficients.

RRF (A) and (B) status models follow the same trends that are reported in MSC (A) and (B) models. RRF status models do not indicate that FY has any significant correlation with reported RRF annual cost, and operations costs appear to have the largest elasticity. I omit AKR 10 class ships from the RRF (A) and (B) regressions since it has the highest capability composite score of RRF ships. Other RRF class ships report O&S costs that are both above and below those reported for AKR 10 class ships. See Table 37 for a complete listing of RRF (A) and (B) cost coefficients.

Table 35. USN Cost Regression by FY and Class, FY 2010 to 2017

Independent Variables	USN (A)		USN (B)	
Status_USN_FY10	0.1901***	[0.0280]	0.1247***	[0.0285]
Status_USN_FY11	0.1723***	[0.0279]	0.1221***	[0.0298]
Status_USN_FY12	0.2768***	[0.0283]	0.1980***	[0.0328]
Status_USN_FY13	0.1332***	[0.0276]	0.0908***	[0.0300]
Status_USN_FY14	0.1573***	[0.0277]	0.1230***	[0.0275]
Status_USN_FY15	0.0303	[0.0275]	0.0622**	[0.0243]
Status_USN_FY16	0.0544**	[0.0275]	0.0673***	[0.0211]
Status_USN_FY17	[omitted - reference]		[omitted - reference]	
log_Cost_Manpower	0.0444***	[0.0043]	0.0342***	[0.0088]
log_Cost_Operations	0.0409***	[0.0047]	0.0358***	[0.0077]
log_Cost_Maintenance	[omitted - reference]		[omitted - reference]	
log_Cost_SustSupport	0.4818***	[0.0194]	0.2163***	[0.0363]
log_Cost_ContSysImpr	0.2911***	[0.0096]	0.2833***	[0.0136]
log_Cost_IndirectSupport	[omitted - empty]		[omitted - empty]	
_Class (value)				
CG 47			-0.5730***	[0.0478]
CVN 65			0.8557***	[0.0542]
CVN 68			0.4549***	[0.1225]
CVN 78			-0.1653***	[0.0507]
DDG 1000			-0.8356***	[0.0868]
DDG 51			-0.7178***	[0.0491]
DDG 72			-0.6840***	[0.0493]
DDG 79			-0.7511***	[0.0476]
FFG 7			-0.8618***	[0.0704]
LCC 19			-0.4827***	[0.0440]
LCS 1			-0.4052***	[0.1568]
LCS 2			-0.7156***	[0.1621]
LHA 1			0.1557	[0.1552]
LHA 6			-0.3130***	[0.0464]
LHD 1			[omitted - reference]	
LPD 17			-0.4556***	[0.0587]
LPD 4			-0.3032***	[0.0913]
LSD 41			-0.5294***	[0.0631]
LSD 49			-0.4571***	[0.0600]
MCM 1			-1.0855***	[0.0821]
PC 1			-1.5938***	[0.1321]
SSBN 726			-0.2917***	[0.0752]
SSGN 726			-0.6399***	[0.0895]
SSN 21			-0.3499***	[0.1028]
SSN 688			-0.8717***	[0.0638]
SSN 774			-0.9791***	[0.0850]
Constant			9.7540***	[0.6699]
*** p<0.01, ** p<0.05, * p<0.1 | [Robust Standard errors]				
Observations	1,895		1,895	
Number of *ShipID*	274		274	
Overall R-sq	0.8193		0.8923	

Table 36. MSC Cost Regression by FY and Class, FY 2010 to 2017

Independent Variables	MSC (A)		MSC (B)	
Status_MSC_FY10	0.0033	[0.0799]	-0.0636	[0.0553]
Status_MSC_FY11	-0.06	[0.0717]	-0.0243	[0.0485]
Status_MSC_FY12	-0.0387	[0.0690]	-0.0238	[0.0457]
Status_MSC_FY13	-0.1316*	[0.0676]	-0.1302***	[0.0435]
Status_MSC_FY14	-0.1087	[0.0676]	-0.1195***	[0.0444]
Status_MSC_FY15	-0.0583	[0.0671]	-0.0581	[0.0487]
Status_MSC_FY16	-0.1004	[0.0667]	-0.0615*	[0.0348]
Status_MSC_FY17	[omitted - control]		[omitted - control]	
log_Cost_Manpower	0.0496***	[0.0049]	0.0300**	[0.0147]
log_Cost_Operations	0.5031***	[0.0161]	0.4037**	[0.1848]
log_Cost_Maintenance	[omitted - control]		[omitted - control]	
log_Cost_SustSupport	-0.0054	[0.0048]	0.0049	[0.0032]
log_Cost_ContSysImpr	0.0097**	[0.0045]	0.0157***	[0.0030]
log_Cost_IndirectSupport	0.0424***	[0.0054]	0.0349***	[0.0090]
_Class (value)				
AE 26			0.1023	[0.0812]
AFS 1			-0.2829	[0.2032]
AFSB (I) 15			0.6542***	[0.2138]
AG 5001			-0.2256	[0.2724]
AGER 111			-0.6724***	[0.2479]
AGM 23			-0.3307*	[0.1766]
AGM 24			-0.8012***	[0.0386]
AGM 25			-0.1515***	[0.0493]
AGOS 19			-0.6606***	[0.0505]
AGOS 23			-0.5312***	[0.0472]
AGS 45			-0.4906***	[0.1075]
AGS 60			-0.5880***	[0.1062]
AGSE 1			-0.1683	[0.3731]
AH 19			0.1693	[0.1243]
AK 0323			-0.2949	[0.3219]
AK 3005			-0.4247*	[0.2352]
AK 3008			-0.2942	[0.1868]
AK 3015			-0.4452**	[0.1751]
AK 4296			-0.5233*	[0.2712]
AK 4396			-0.2748	[0.3321]
AK 4496			-0.1492	[0.3570]
AK 451			-0.0916	[0.4036]
AK 4729			-0.0845	[0.3689]
AK 5158			0.0019	[0.2148]
AK 5272			-0.3587	[0.3387]
AK 5307			-1.5770***	[0.3430]
AK 5362			-0.2936	[0.3460]
AK 9205			-9.7124***	[2.6364]
AKE 1			0.3663***	[0.1058]
AKR 295			-0.234	[0.1836]
AKR 300			-0.3222**	[0.1585]
AKR 310			-0.3597**	[0.1724]
AO 187			0.3202***	[0.0705]
AOE 6			0.3829***	[0.1151]
AOT 1121			-0.2706	[0.2666]

Independent Variables	MSC (A)		MSC (B)	
AOT 4995			-0.6705***	[0.2325]
AOT 5205			0.8544***	[0.1703]
AOT 5246			-0.1227	[0.4122]
AOT 5356			-0.3746	[0.3405]
AOT 5406			0.4431	[0.5773]
AOT 5419			-0.1208	[0.4336]
AP 1000			0.2432	[0.5003]
ARC 7			0.1719*	[0.0887]
ARS 50			-0.0911	[0.2296]
AS 39			0.9557***	[0.2070]
ATF 166			-0.2841	[0.2958]
ATF 4247			-1.2271***	[0.1459]
EPF 1			0.0831	[0.1019]
ESB 3			[omitted - reference]	
ESD 1			-0.2229	[0.2255]
HST 1			0.2853	[0.1772]
HST 2			-2.6658***	[0.5023]
HSV 1			-0.2595	[0.2775]
HSV 4676			0.2314	[0.5025]
LCC 19			0.6167***	[0.1729]
MB 1219			-1.2031***	[0.1647]
Constant	7.7830***	[0.2503]	9.7366***	[2.6102]
*** p<0.01, ** p<0.05, * p<0.1 | [Robust Standard errors]				
Observations	942		942	
Number of *ShipID*	145		145	
Overall R-sq	0.6915		0.8577	

Table 37. RRF Cost Regression by FY and Class, FY 2010 to 2017

Independent Variables	RRF (A)		RRF (B)	
Status_RRF_FY10	-0.6273**	[0.2529]	-0.6327	[0.4308]
Status_RRF_FY11	-0.3287	[0.2433]	-0.3475	[0.2999]
Status_RRF_FY12	-0.298	[0.2451]	-0.2885	[0.2290]
Status_RRF_FY13	-0.2651	[0.3183]	-0.2919	[0.2259]
Status_RRF_FY14	-0.2756	[0.2468]	-0.2579	[0.2283]
Status_RRF_FY15	-0.4952**	[0.2461]	-0.491	[0.3222]
Status_RRF_FY16	-0.3971	[0.2479]	-0.3858	[0.2990]
Status_RRF_FY17	[omitted - reference]		[omitted - reference]	
log_Cost_Manpower	0.0394	[0.1065]	0.0482**	[0.0192]
log_Cost_Operations	0.9694***	[0.0103]	0.9659***	[0.0125]
log_Cost_Maintenance	[omitted – reference]		[omitted - reference]	
log_Cost_SustSupport	-	0	-	0
log_Cost_ContSysImpr	-	0	-	0
log_Cost_IndirectSupport	0.3825***	[0.0291]	0.4068***	[0.1189]
_Class (value)				
ACS 1			0.0008	[0.0449]
ACS 4			-0.0008	[0.0367]
AK 575			0.3000**	[0.1346]
AK 882			0.0343	[0.0497]
AK 981			0.1798**	[0.0848]
AKR 1001			-0.1898***	[0.0715]
AKR 112			0.0059	[0.0402]
AKR 10			[omitted - reference]	
AKR 2044			-0.1637**	[0.0656]
AKR 287			0.0425	[0.1757]
AKR 5051			-0.1474	[0.1146]
AKR 5066			-0.3225	[0.3476]
AKR 5069			-0.6005***	[0.1954]
AKR 5082			-0.7172***	[0.2175]
AKR 9666			-0.1898***	[0.0715]
AKR 9678			0.03	[0.0402]
AKR 9961			0.4378	[0.3096]
AOT 181			-0.9101***	[0.3169]
AVB 3			-0.1495	[0.1142]
Constant	0.4421**	[0.1783]	0.5331**	[0.2675]
*** p<0.01, ** p<0.05, * p<0.1 | [Robust Standard errors]				
Observations	346		346	
Number of *ShipID*	50		50	
Overall R-sq	.9668		.9683	

Based on my analysis of the cost regression results, I find it appropriate to report weighted average O&S costs by status and class over the entire eight-year period, from 2010 to 2017. Tables 38, 39, and 40 report average class O&S costs for USN, MSC, and RRF classes, respectively, by year in the middle columns, and the weighted average annual O&S costs by class in the far-right column. Later in this report, I convert the weighted average annual costs into daily costs by dividing each annual class value by 365. The calculated weighted average daily O&S costs are used in subsequent utility function calculations and reported tables.

Table 38. USN Weighted Average Cost by Class, FY 2010 to 2017

		Fiscal Year (Millions, CY2017 USD)								Weighted Avg
Type	Ship Class	2010	2011	2012	2013	2014	2015	2016	2017	Annual Cost
CG	CG 47	$ 72.7	$ 79.6	$ 74.0	$ 71.6	$ 76.0	$ 91.8	$ 75.5	$ 68.0	$ 76,144,880
CVN	CVN 65	503.7	320.2	284.1	205.4					328,362,368
CVN	CVN 68	446.5	487.3	477.9	440.3	480.6	472.0	458.6	361.2	453,060,448
CVN	CVN 78								119.2	119,167,440
DDG	DDG 1000								28.9	28,922,260
DDG	DDG 51	66.9	72.8	73.3	80.7	80.9	92.2	89.7	76.2	79,096,880
DDG	DDG 72	56.5	54.5	57.1	62.7	76.5	85.8	87.7	77.4	69,760,208
DDG	DDG 79	51.0	56.5	54.8	51.8	63.6	67.2	72.0	69.5	61,097,776
FFG	FFG 7	35.6	34.8	33.4	27.4	20.3	17.1			31,493,174
LCC	LCC 19	97.5	105.4	118.1	110.4	110.4	80.3	71.9	95.9	106,261,680
LCS	LCS 1	40.0	25.2	22.5	33.6	24.7	55.5	31.5	32.0	32,965,414
LCS	LCS 2	18.3	20.0	25.6	41.5	32.9	51.6	31.1	20.8	29,587,286
LHA	LHA 1	153.0	113.1	149.7	170.7	128.0	61.3			130,234,496
LHA	LHA 6						191.7	139.4	142.5	157,882,480
LHD	LHD 1	169.5	150.1	165.2	152.3	179.9	173.8	190.9	181.7	170,418,848
LPD	LPD 17	55.7	66.2	59.6	60.6	61.0	69.3	77.2	73.7	66,522,276
LPD	LPD 4	66.0	52.1	70.5	68.5	43.0				59,495,692
LSD	LSD 41	96.0	84.9	80.0	57.6	52.5	63.7	78.7	65.3	72,326,272
LSD	LSD 49	66.0	94.2	85.7	85.0	143.0	88.8	71.2	72.6	88,318,272
MCM	MCM 1	17.3	21.3	18.3	17.1	18.5	19.3	20.0	17.3	18,621,562
PC	PC 1	5.5	3.9	9.6	7.4	8.3	11.5	8.3	8.0	7,988,418
SSBN	SSBN 726	93.3	89.3	96.5	105.7	101.4	91.5	103.2	103.6	98,071,032
SSGN	SSGN 726	64.6	65.4	62.1	63.8	68.8	74.5	82.4	69.6	68,915,856
SSN	SSN 21	85.4	74.6	69.3	92.9	72.8	71.1	66.0	67.4	74,943,464
SSN	SSN 688	42.9	42.6	40.0	42.7	45.7	47.2	45.4	47.2	44,119,028
SSN	SSN 774	34.5	45.3	35.3	32.9	28.2	36.0	44.1	53.6	39,178,688

Raw data obtained from the VAMOSC database, February 2, 2018.

Table 39. MSC Weighted Average Ship Cost by Class, FY 2010 to 2017

		Fiscal Year (Millions, CY2017 USD)								Weighted Avg
Type	Ship Class	2010	2011	2012	2013	2014	2015	2016	2017	Annual Cost
T-AE	AE 26	30.7	32.8	32.2	24.3	3.6				$ 26,983,036
T-AFS	AFS 1	12.2								12,232,572
AFSB	AFSB (I) 15			64.4	47.6	43.8	46.4	46.5	53.5	50,386,244
T-AG	AG 5001	28.5	32.1	77.9	16.9	15.6	15.8	16.3	16.6	27,475,830
T-AGER	AGER 111	3.7	4.4	4.4	4.2	4.3	5.0	5.1	5.7	4,594,172
T-AGM	AGM 23	32.4	29.5	32.4	30.0	12.1				27,302,776
T-AGM	AGM 24	9.9	8.2	11.1	7.9	9.7	11.7	10.2	9.3	9,745,249
T-AGM	AGM 25			8.0	9.0	33.3	18.9	26.3	19.0	19,071,454
T-AGOS	AGOS 19	12.9	13.2	14.2	13.5	13.8	14.2	14.7	14.2	13,840,715
T-AGOS	AGOS 23	13.3	13.5	16.9	14.0	13.2	20.0	15.7	17.8	15,548,156
T-AGS	AGS 45	22.3	17.3	14.8	23.3	15.7	22.6	18.0	17.1	18,881,296
T-AGS	AGS 60	16.9	17.8	17.3	17.7	15.5	12.6	18.4	19.2	16,845,262
T-AGSE	AGSE 1	14.2	14.4	10.8	11.2	10.4	10.4	8.8	11.5	11,487,137
T-AH	AH 19	44.7	35.3	41.7	31.9	35.6	64.9	52.9	44.4	43,919,332
T-AK	AK 0323	14.9	15.6	16.0	14.2	10.2				14,193,536
T-AK	AK 3005	45.4	30.1	31.5	5.2	5.7	20.1	15.2	10.8	20,499,032
T-AK	AK 3008	31.8	30.1	21.4	33.0	30.5	23.6	26.4	30.8	28,470,034
T-AK	AK 3015	29.8	25.1	33.0	12.9	12.7	17.5	18.5	18.4	20,979,348
T-AK	AK 4296	15.4	15.4	13.5	2.8					11,770,027
T-AK	AK 4396	18.9			15.1	14.4	15.4	13.6	12.2	14,931,352
T-AK	AK 4496	20.1	25.4	17.1	16.7	18.4	15.3	20.8	21.6	19,414,082
T-AK	AK 451	21.9								21,934,258
T-AK	AK 4729	20.2								20,152,524
T-AK	AK 5158	9.9	10.2	10.9	9.3	9.0	7.4	6.9	1.1	8,086,183
T-AK	AK 5272			6.9	17.2	17.6	9.7	10.6	3.6	10,920,719
T-AK	AK 5307								2.0	1,971,438
T-AK	AK 5362						14.0	17.3	13.3	14,839,953
T-AK	AK 9205		-							-
T-AKE	AKE 1	47.7	48.3	50.1	47.3	45.6	52.4	50.0	48.0	48,704,312
T-AKR	AKR 295	7.2	15.4	10.1	6.8	8.3	9.3	14.6	15.2	10,881,764
T-AKR	AKR 300	15.9	13.4	14.6	16.8	17.9	16.4	16.4	20.1	16,453,320
T-AKR	AKR 310	19.8	29.3	29.5	28.7	25.9	25.6	26.4	30.2	26,919,102
T-AO	AO 187	38.1	38.3	39.5	36.2	37.9	42.2	41.2	38.7	39,003,804
T-AOE	AOE 6	59.6	71.9	68.4	48.5	52.9	53.4	58.7	66.8	59,597,668
T-AOT	AOT 1121	16.7	20.9	16.3	14.6	19.3	14.1	21.5	14.2	17,076,862
T-AOT	AOT 4995	8.3	7.0							7,655,851
T-AOT	AOT 5205		24.8	31.9	30.1	30.9	25.1	6.5	10.2	22,784,852
T-AOT	AOT 5246			23.2	22.5	20.6	26.5	26.0	7.6	21,036,164
T-AOT	AOT 5356					9.9	11.7	9.1	11.0	10,413,943
T-AOT	AOT 5406								26.0	25,959,490
T-AOT	AOT 5419							17.1	20.0	18,556,240
T-AOT	AP 1000		42.8	30.4	31.2	30.5	29.6	56.9	48.4	38,555,636
T-ARC	ARC 7	24.7	29.6	23.4	44.6	25.8	39.6	30.6	25.5	30,465,706
T-ARS	ARS 50	18.5	18.5	15.5	14.1	12.6	13.1	11.0	8.2	13,912,957
AS	AS 39	144.3	122.7	123.2	110.8	110.9	118.8	119.4	127.3	122,162,248
T-ATF	ATF 166	10.1	10.3	9.7	9.5	8.3	9.0	8.4	6.5	8,991,900
T-ATF	ATF 4247	2.5	2.8							2,614,522
T-EPF	EPF 1				6.2	11.1	16.9	21.9	20.6	17,523,320
T-ESB	ESB 3						7.7	20.0	44.1	23,949,086
T-ESD	ESD 1				9.2	19.6	24.5	26.3	24.8	22,165,712
T-HST	HST 1			8.9	5.9	3.0	4.0	14.9	35.8	12,097,424
T-HST	HST 2			0.5809	1.1	2.1	1.8	1.1	(0.0637)	1,096,013
HSV	HSV 1	35.2	33.2	35.7	24.4					32,121,192
HSV	HSV 4676	20.7	19.3	25.5	25.6	23.4	27.2	28.2	25.9	24,474,514
LCC	LCC 19	97.5	105.4	118.1	110.4	110.4	80.3	71.9	95.9	77,927,224
MB	MB 1219							2.1	1.9	2,012,326

Raw data obtained from the VAMOSC database, January 29, 2018.

Table 40. RRF Weighted Average Ship Cost by Class, FY 2010 to 2017

Type	Ship Class	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Weighted Avg Annual Cost
T-ACS	ACS 1	0.0454	0.0123	0.5246	(0.0388)	0.3872	0.0219	(0.0004)	0.4280	$ 194,704
T-ACS	ACS 4	1.3	0.0953	(0.2697)	(0.4150)	0.3491	0.1195	0.0854	0.5158	251,261
T-AK	AK 575	1.4	0.0004							677,965
T-AKR	AK 882	2.6	0.0948	1.9	0.3583	0.0540	0.0101	(0.0088)	(0.0470)	637,772
T-AK	AK 981	1.9	0.3560	-						757,098
T-AKR	AKR 10	0.4671	0.0069	0.1873	0.7196	(0.1582)	0.0714	0.3630	-	190,594
T-AKR	AKR 1001	(0.0253)	-	-		-	-	-	-	(3,608)
T-AKR	AKR 112	(0.3257)	1.0	0.9274	0.9378	(0.1713)	(0.0314)	0.2690	(0.0228)	269,192
T-AKR	AKR 2044		-	0.4782		(1.1386)	-	-	-	(110,065)
T-AKR	AKR 287	0.1544	0.1790	0.5900	0.3921	0.3661	0.0340	(0.0578)	0.2323	225,883
T-AKR	AKR 5051	0.8853	0.0330	0.1795	0.1569	0.0793	(0.0266)	0.0801	(0.0253)	170,963
T-AKR	AKR 5066	0.2864	0.0016	(0.0155)		-	0.1618	0.1331	0.2742	111,906
T-AKR	AKR 5069	0.3876	0.5278	(0.2514)		(0.0639)	0.3204	0.0166	-	133,873
T-AKR	AKR 5082	(0.4171)	0.2430	0.2404	(0.0179)	(0.1198)	0.5717	(0.3440)	0.2715	58,231
T-AKR	AKR 9666	(0.6601)	-	-		-	-	-	-	(94,304)
T-AKR	AKR 9678	0.3666	-	0.1563		8.1	2.0	1.2	(0.3123)	1,710,635
T-AKR	AKR 9961	0.5753	0.0245	(0.1488)	(0.0251)	0.2726	2.5	0.2552	0.0048	464,486
T-AOT	AOT 181	0.8213	(0.0146)	(0.0115)		-	-	0.0261	-	205,322
T-AVB	AVB 3	1.8	1.1	1.2	0.7383	0.9097	0.5729	2.6	(0.0024)	1,110,972

Raw data obtained from the VAMOSC database, January 29, 2018.

3. Capability Findings

The capabilities findings are divided into two segments. In the first segment, I report the capability factor analysis loadings alluded to in Chapter IV. In the second segment, I report capability variable values and capability composite scores used in this study by status and class.

a. Factor Analysis

To recap, I elect to retain all capability variables based on the depicted factor loadings to calculate class C*apabilityCompositeScore*. The left half of Table 41 reports capability factor analysis results for all USN, MSC, and RRF inventory ships, from 2010 to 2017. For comparison, I limit the second factor analysis to only look at 2017 inventory ships. The 2017 results are depicted in the right half of Table 41. Strikingly, the groupings and factor weights are consistent between the two tests. In both cases, the factors can be grouped into five general ship capabilities: (1) cargo capability, self-sufficiency, RO/RO, and berthing capacity, (2) VTOL, landing craft, and SAR, (3) hydrographic survey and salvage, (4) sea-based towing and aircraft support, and (5) fresh water production.

Table 41. Capability Factor Analysis Results

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
	ALL SHIPS (FY 2010-17)						ALL SHIPS FY 2017					
Cap_NumberVerticalLift		0.8768				0.1426		0.8548				0.1291
Cap_AviationFacilities		0.6467		0.4946		0.2142		0.6492		0.4332		0.2423
Cap_VerticalLiftScore		0.8664				0.1695		0.8447				0.1543
Cap_LandingCraft		0.622		-0.4124		0.2915		0.5987		-0.4492		0.3201
Cap_SearchandRescue		0.8755				0.2185		0.8833				0.2177
Cap_DryGoods	0.9293					0.0616	0.9207					0.0763
Cap_RefrigeratedGoods	0.9183					0.0434	0.9037					0.0355
Cap_Freshwater	0.929					0.0608	0.9145					0.062
Cap_RollOnRollOff	0.6985				0.4215	0.2792	0.6676				-0.4343	0.2762
Cap_FuelStorageDispens.	0.8963					0.0955	0.8671					0.1091
Cap_SelfSufficient	0.8802					0.197	0.8657					0.2104
Cap_PersonnelTransfer		0.8363				0.1727		0.8326				0.1827
Cap_FreshwaterProduction	0.657				0.4831	0.2349	0.6784					0.315
Cap_PersonnelSupport		0.881				0.1269		0.8818				0.1561
Cap_BerthingCapacity	0.6755	0.5975				0.0543	0.7197	0.5491				0.0529
Cap_MedicalSupport		0.8638				0.1198		0.8455				0.1267
Cap_TransitSpeed	-0.4363		-0.6395			0.3287	-0.4258		-0.6276			0.3209
Cap_HydrographicSurvey			0.6501			0.5109			0.6537			0.5087
Cap_SalvageOperations			0.7493			0.3354			0.7546			0.3299
Cap_Towing	-0.5884			0.4729		0.2785	-0.5998			0.4717		0.2735
Proportion of Variance	0.3626	0.3431	0.1037	0.0579	0.0498		0.3615	0.3401	0.1023	0.0566	0.0514	
Cumulative Variance	0.3626	0.7056	0.8093	0.8673	0.9171		0.3615	0.7017	0.8039	0.8606	0.912	
	Blanks represent absolute value loadings < .4						Blanks represent absolute value loadings < .4					

b. Assigned Class Capability Values and Capability Composite Scores

As described in Chapter IV, I use Greenfield and Ingram (2011) and Moffat (2014) capability ratings to establish the underlying capability matrices used in this study. These values are verified, updated, and appended with current official Navy fact files, MSC handbook data (MSC, 2016), MARAD ship characteristics (DoT, 2016), and Jane's by IHS Markit data (2018-b). As a last resort, I apply like class capability ratings to ship classes that are not reported in the official sources or in Jane's.

USN status ships report the highest *CapabilityCompositeScore* of 65 points for LPD 1 class ships. MSC reports the next highest composite score of 30 points for ESB 3 class ships. RRF status ships report the lowest maximum composite score of 15 points, assigned to AKR 10 class ships. Tables 42 (USN), 43 (MSC), and 44 (RRF) break the database into ship status groupings that report determined class HADR capability values and the resultant *CapabilityCompositeScore*. The tables are sorted in descending order, so that ship classes with the highest *CapabilityCompositeScores* are at the top and the least

HADR capable ship classes are at the bottom. The reported *CapabilityCompositeScores* are included in utility function calculations.

Submarines, patrol coastal craft, and Flight I and II Arleigh Burke class destroyers are observed to have the lowest USN HADR capability composite scores. Tankers and special mission MSC ships like ocean surveillance ships, missile instrumentation ships, cable laying ships, and ocean tugs are observed to have the lowest MSC and RRF HADR capability composite scores. Despite low composite scores, most ship classes possess at least one unique HADR capability and should not be excluded from future HADR response considerations in the absence of other, more capable ships.

Table 42. USN HADR Capability Ratings by Class, FY 2010 to 2017. Adapted from Greenfield and Ingram (2011) and Moffat (2014).

Ship Type	Class	Number of Vertical Lift Aircraft	Aviation Facilities	Vertical Lift Score (V1 x V2)	Landing Craft Support	Search and Rescue	Cargo Capacity						Personnel Transfer	Freshwater Production	Personnel Support	Berthing Capacity	Medical Support	Transit Speed	Hydrographic Survey	Salvage Ops	Towing	Composite Capability Score
							Dry Goods	Refrigerated goods	Fresh Water	Roll On Roll Off	Fuel Storage and Dispensation	Self Sufficient										
		V1	V2	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	∑Si
Amphibious Assault Ship	LHD 1	23	2	46	2	2	1	1	1		1	1	2	1	2	2	2	1				**65**
Amphibious Assault Ship	LHA 1	17	2	34	2	2	1	1	1		1	1	2	1	2	2	2	1				**53**
Aircraft Carrier	LHA 6	17	2	34	2	2	1	1	1		1	1	2	1	2	2	2	1				**53**
Aircraft Carrier	CVN 65	8	2	16		2	1	1	1		1	1	2	1	2	2	2	2				**34**
Aircraft Carrier	CVN 68	8	2	16		2	1	1	1		1	1	2	1	2	2	2	2				**34**
Aircraft Carrier	CVN 78	8	2	16		2	1	1	1		1	1	2	1	2	2	2	2				**34**
Amphibious Transport Dock	LPD 17	6	2	12	2	2	1					1	1		1	1	1	1				**23**
Amphibious Transport Dock	LPD 4	6	2	12	2	2	1					1	1		1	1	1	1				**23**
Dock Landing Ship	LSD 41	2	1	2	2	2	1					1	1		1	1	1	1				**13**
Dock Landing Ship	LSD 49	2	1	2	2	2	1					1	1		1	1	1	1				**13**
Guided Missile Cruiser	CG 47	2	2	4		1							1		1			2			1	**10**
Guided Missile Destroyer	DDG 1000	2	2	4		1							1		1			2			1	**10**
Guided Missile Destroyer	DDG 79	2	2	4		1							1		1			2			1	**10**
Guided Missile Frigate	FFG 7	2	2	4		1							1		1			2			1	**10**
Command Ship	LCC 19	2	1	2		1	1						1		1	1	1	1				**9**
Littoral Combat Ship	LCS 2	2	2	4		1							1					2			1	**9**
Littoral Combat Ship	LCS 1	1	2	2		1							1					2			1	**7**
Guided Missile Destroyer	DDG 51	1	1	1									1		1			2			1	**6**
Guided Missile Destroyer	DDG 72	1	1	1									1		1			2			1	**6**
Patrol Coastal	PC 1					1							1					2			1	**5**
Mine Countermeasures Ship	MCM 1																				2	**2**
Ballistic Missile Submarine	SSBN 726																	2				**2**
Submarine	SSN 688																	2				**2**
Submarine	SSN 774																	2				**2**
Guided Missile Submarine	SSGN 726																	1				**1**
Submarine	SSN 21																	1				**1**

Reported capability metrics verified and updated via USN fact files and Jane's Fighting Ships.

Table 43. MSC HADR Capability Ratings by Class, FY 2010 to 2017. Adapted from Greenfield and Ingram (2011) and Moffat (2014).

Ship Type	Class	Number of Vertical Lift Aircraft	Aviation Facilities	Vertical Lift Score (V1 x V2)	Landing Craft Support	Search and Rescue	Cargo Capacity						Personnel Transfer	Freshwater Production	Personnel Support	Berthing Capacity	Medical Support	Transit Speed	Hydrographic Survey	Salvage Ops	Towing	Composite Capability Score
							Dry Goods	Refrigerated goods	Fresh Water	Roll On Roll Off	Fuel Storage and Dispensation	Self Sufficient										
		V1	V2	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	∑Si
Expeditionary Mobile Base	ESB 3	4	2	8	2	2	2	2	2		2	2	1	1	2	2	2					30
Afloat Forward Staging Base	AFSB (I) 15	6	2	12	2	2	1					1	1		1	1	1	1				23
Ro-Ro Container	AK 3005	1	1	1	1		2	2	2	2	2	2				1		1				16
Large Medium Speed Ro-Ro	AKR 295	1	1	1			2	2	2	2	2	2		1		1		1				16
Large Medium Speed Ro-Ro	AKR 300	1	1	1			2	2	2	2	2	2		1		1		1				16
Large Medium Speed Ro-Ro	AKR 310	1	1	1			2	2	2	2	2	2		1		1		1				16
Expeditionary Fast Transport	EPF 1	1	1	1		1	1	1	1	2		2	2		1	1	1	2				16
High Speed Vessel	HSV 1	2	2	4			1	1	1	2	1	2	2					2				16
Ro-Ro Container	AK 3008	1	1	1	1		2	2	2	2	2	2				1						15
Ro-Ro Container	AK 3015	1	1	1			2	2	2	2	2	2				1		1				15
Ro-Ro Container	AK 0323						2	2	2	2	2	2				1		1				14
Dry Cargo Ship	AK 9205				1		2	2	2		2	2				1		1				13
Dry Cargo/Ammunition	AKE 1	2	2	4			2	2	1		2	1						1				13
Expeditionary Transfer Dock	ESD 1	1	1	1	2		1	1	1		2	2	1	1		1						13
USAF (Container Ships)	AK 4396						2	2	2		2	2				1		1				12
Container Ship	AK 4496						2	2	2		2	2				1		1				12
Dry Cargo Ship	AK 5272						2	2	2		2	2				1		1				12
USAF (Container Ships)	AK 5362						2	2	2		2	2				1		1				12
Fast Combat Support Ship	AOE 6	1	1	1			2	2	2		2	1						2				12
High Speed Vessel	HSV 4676						1	1	1	2	1	2	2					2				12
Dry Cargo/Ammunition Ship	AE 26	2	2	4			2		1		2	1						1				11
Hospital Ship	AH 19	2	1	2									1	2	2	2	2					11
USAF (Container Ships)	AK 4296						2	2	2		2	2				1						11
Dry Cargo Ship	AK 5158						2	2	2		2	2						1				11
Fleet Replenishment Oilers	AO 187	1	1	1			2	2	2		2	1						1				11
Combat Stores Ship	AFS 1	2	1	2			1	1	2		2	1						1				10
Dry Cargo Ship	AK 4729						2	2	2		2	2										10
Command Ship	LCC 19	2	1	2		1	1						1		1	1	1	1				9
Dry Cargo Ship	AK 5307						2	2	1		1	2										8
High Speed Vessel	HST 1						1			2			2					2				7
High Speed Vessel	HST 2						1			2			2					2				7
Oceanographic Survey	AGS 60																		2	2	2	6
Submarine/Special Warfare	AGSE 1						1	1				1	1		1				1			6
USN (Break-Bulk Ship)	AK 451	1	1	1			1	1	1			2										6
Rescue And Salvage	ARS 50											2								2	2	6
Submarine/Special Warfare	AGER 111						1	1				1	1						1			5
Submarine Tender	AS 39	1	1	1								1			1			1			1	5
OPDS Tanker	AG 5001										2	2										4
Tanker	AOT 1121										2	2										4
Tanker	AOT 4995										2	2										4
Tanker	AOT 5205										2	2										4
Tanker	AOT 5246										2	2										4
Tanker	AOT 5356										2	2										4
Tanker	AOT 5406										2	2										4
Tanker	AOT 5419										2	2										4
Tanker	AP 1000										2	2										4
Fleet Ocean Tug	ATF 166											1								1	2	4
Fleet Ocean Tug	ATF 4247											1								1	2	4
Ocean Surveillance Ship	AGOS 19																		1		1	2
Ocean Surveillance Ship	AGOS 23																		1		1	2
Cable Laying/Repair Ship	ARC 7																		1		1	2
Dry Cargo	MB 1219						1		1													2
Missile Range Instr. Ship	AGM 23																	1				1
Missile Range Instr. Ship	AGM 25																	1				1
Missile Range Instr. Ship	AGM 24																					
Navigation Test Support	AGS 45																					

Reported capability metrics verified and updated via MSC (2016) and Jane's Fighting Ships.

Table 44. RRF HADR Capability Ratings by Class, FY 2010 to 2017. Adapted from Greenfield and Ingram (2011) and Moffat (2014).

Ship Type	Class	Number of Vertical Lift Aircraft	Aviation Facilities	Vertical Lift Score (V_1 x V_2)	Landing Craft Support	Search and Rescue	Cargo Capacity						Personnel Transfer	Freshwater Production	Personnel Support	Berthing Capacity	Medical Support	Transit Speed	Hydrographic Survey	Salvage Ops	Towing	Composite Capability Score
							Dry Goods	Refrigerated goods	Fresh Water	Roll On Roll Off	Fuel Storage and Dispensation	Self Sufficient										
		V1	V2	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	∑Si
Large Medium Speed Ro-Ro	AKR 10						2	2	2	2	2	2		1		1		1				**15**
Large Medium Speed Ro-Ro	AKR 1001						2	2	2	2	2	2		1		1		1				**15**
Large Medium Speed Ro-Ro	AKR 2044						2	2	2	2	2	2		1		1		1				**15**
Large Medium Speed Ro-Ro	AKR 5066						2	2	2	2	2	2		1		1		1				**15**
Large Medium Speed Ro-Ro	AKR 9678						2	2	2	2	2	2		1		1		1				**15**
Large Medium Speed Ro-Ro	AKR 112						2	2	2	2	2	2		1		1						**14**
Large Medium Speed Ro-Ro	AKR 5051						2	2	2	2	2	2		1		1						**14**
Large Medium Speed Ro-Ro	AKR 5069						2	2	2	2	2	2		1		1						**14**
Large Medium Speed Ro-Ro	AKR 5082						2	2	2	2	2	2		1		1						**14**
Large Medium Speed Ro-Ro	AKR 9666						2	2	2	2	2	2		1		1						**14**
Large Medium Speed Ro-Ro	AKR 9961						2	2	2	2	2	2		1		1						**14**
Aviation Logistics Support Ship	AVB 3	2	1	2			2	2	2		2	2				1		1				**14**
Fast Sealift Ship	AKR 287	1	1	1			2	2	2		2	1						2				**12**
Auxiliary Crane Ship	ACS 4						2	2	1		1	2						1				**9**
Dry Cargo Ship	AK 981						2	2	1		1	2						1				**9**
Auxiliary Crane Ship	ACS 1						2	2	1		1	2										**8**
Seabee Heavy-Lift Ship	AK 882						2	2	2							1						**7**
Dry Cargo Ship	AK 575	1	1	1			1	1	1			2										**6**
OPDS Tanker	AOT 181										2	2										**4**

Reported RRF capability metrics verified and updated via DoT (2016) and Jane's Fighting Ships.

4. Proximity Findings

Next, I report the unclassified, open source maximum speeds and maximum range speeds used in this study for USN, MSC, and RRF classes in Tables 45, 46, and 47, respectively. To recap, I use official Navy fact files as the primary source for USN ship speeds, located at http://www.navy.mil/navydata/fact.asp. I use the 2016 MSC Handbook (MSC, 2016) to determine MSC ship speeds and the MARAD ship characteristics pamphlet (DoT, 2016) for RRF ship speeds. I reference the Jane's by IHS Markit database (Jane's, 2018-b) for class speeds that are not reported in the official U.S. naval sources. As a last resort, I apply like class speed to ship classes that are not reported in the official sources or in Jane's. In real world scenarios, I expect that mission planners will use actual speeds that are appropriate for a given ship or class to determine the number of required transit days. The open source speeds reported in this study may vary significantly from actual ship performance data and are only provided as a point of reference.

Table 45. USN Maximum Speed and Maximum Range Speed by Class, FY 2010 to 2017

Ship Type	Class Name	Class	Class (Hulls)	Max Speed (Kts)	Max Range Speed (Kts)	ActivationDays
				Sm	Sr	Ai
Guided Missile Cruiser	TICONDEROGA CLASS	CG 47	CG (52-73)	30	20	
Aircraft Carrier	ENTERPRISE CLASS	CVN 65	CVN (65)	33	33	
Aircraft Carrier	NIMITZ CLASS	CVN 68	CVN (68-77)	33	30	
Aircraft Carrier	GERALD R FORD CLASS	CVN 78	CVN (78)	30	30	
Guided Missile Destroyer	ZUMWALT CLASS	DDG 1000	DDG (1000)	30	20	
Guided Missile Destroyer	ARLEIGH BURKE CLASS (FLT I)	DDG 51	DDG (51-71)	32	20	
Guided Missile Destroyer	ARLEIGH BURKE CLASS (FLT II)	DDG 72	DDG (72-78)	32	20	
Guided Missile Destroyer	ARLEIGH BURKE CLASS (FLT IIA)	DDG 79	DDG (79-124)	31	20	
Guided Missile Frigate	OLIVER HAZARD PERRY CLASS	FFG 7	FFG (8,28-61)	29	23	
Command Ship	BLUE RIDGE CLASS	LCC 19	LCC (19-20)	23	16	
Littoral Combat Ship	FREEDOM CLASS	LCS 1	LCS (ODD #)	40	14	
Littoral Combat Ship	INDEPENDENCE CLASS	LCS 2	LCS (EVEN #)	50	14	
Amphibious Assault Ship	TARAWA CLASS	LHA 1	LHA (4-5)	24	20	
Aircraft Carrier	AMERICA CLASS	LHA 6	LHA (6)	22	20	
Amphibious Assault Ship	WASP CLASS	LHD 1	LHD (1-8)	22	20	
Amphibious Transport Dock	SAN ANTONIO CLASS	LPD 17	LPD (17-26)	22	18	
Amphibious Transport Dock	AUSTIN CLASS	LPD 4	LPD (4-16)	21	20	
Dock Landing Ship	WHIDBEY ISLAND CLASS	LSD 41	LSD (41-48)	22	18	
Dock Landing Ship	HARPERS FERRY CLASS	LSD 49	LSD (49-52)	22	18	
Mine Countermeasures Ship	AVENGER CLASS	MCM 1	MCM (3-14)	14	10	
Patrol Coastal	CYCLONE CLASS	PC 1	PC (2-14)	35	12	
Ballistic Missile Submarine	OHIO CLASS (BALLISTIC)	SSBN 726	SSBN (730-743)	25	25	
Guided Missile Submarine	OHIO CLASS (GUIDED)	SSGN 726	SSGN (726-729)	20	20	
Submarine	SEAWOLF CLASS	SSN 21	SSN (21-23)	20	20	
Submarine	LOS ANGELES CLASS	SSN 688	SSN (688-725,750-773)	25	25	
Submarine	VIRGINIA CLASS	SSN 774	SSN (774-786)	25	25	

Reported speeds are compiled from USN fact files and Jane's Fighting Ships data.

Table 46. MSC Maximum Speed and Maximum Range Speed by Class, FY 2010 to 2017

Ship Type	Class Name	Class	Class (Hulls)	Max Speed (Kts)	Max Range Speed (Kts)	ActivationDays
				Sm	Sr	Ai
Dry Cargo/Ammunition Ship	KILAUEA CLASS	AE 26	T-AE (32-35)	20	18	
Combat Stores Ship	MARS CLASS	AFS 1	T-AFS (7)	20	20	
Afloat Forward Staging Base	AUSTIN CLASS	AFSB (I) 15	T-AFSB (I) (15)	21	20	
OPDS Tanker	VADM K R WHEELER CLASS	AG 5001	T-AG (5001)	15	13	
Submarine/Special Warfare	UNKNOWN	AGER 111	T-AGER (111)	15	13	
Missile Range Instr. Ship	OBSERVATION ISLAND CLASS	AGM 23	T-AGM (23)	20	15	
Missile Range Instr. Ship	STALWART CLASS	AGM 24	T-AGM (24)	11	11	
Missile Range Instr. Ship	LORENZEN CLASS	AGM 25	T-AGM (25)	20	15	
Ocean Surveillance Ship	VICTORIOUS CLASS	AGOS 19	T-AGOS (19-22)	10	10	
Ocean Surveillance Ship	IMPECCABLE CLASS	AGOS 23	T-AGOS (23)	12	12	
Navigation Test Support	WATERS CLASS	AGS 45	T-AGS (45)	13	12	
Oceanographic Survey	PATHFINDER CLASS	AGS 60	T-AGS (60-66)	16	12	
Submarine/Special Warfare	IMPECCABLE CLASS	AGSE 1	T-AGSE (1-4)	15	14	
Hospital Ship	MERCY CLASS	AH 19	T-AH (19-20)	17	17	5
Ro-Ro Container	BUFFALO SOLDIER CLASS	AK 0323	T-AK (323)	16	16	
Ro-Ro Container	KOCAK CLASS	AK 3005	T-AK (3005-3007)	20	20	
Ro-Ro Container	BOBO CLASS	AK 3008	T-AK (3008-3012)	18	18	
Ro-Ro Container	MARTIN CLASS	AK 3015	T-AK (3015-3017)	22	17	
USAF (Container Ships)	STEVEN BENNETT CLASS	AK 4296	T-AK (4296)	16	16	
USAF (Container Ships)	BERNARD FISHER CLASS	AK 4396	T-AK (4396)	19	16	
Container Ship	JOHN U D PAGE CLASS	AK 4496	T-AK (4543-4544)	21	18	
USN (Break-Bulk Ship)	CAPE JACOB CLASS	AK 451	T-AK (5029)	17	17	
Dry Cargo Ship	AMERICAN TERN CLASS	AK 4729	T-AK (4729)	16	16	
Dry Cargo Ship	MOHEGAN CLASS	AK 5158	T-AK (5158)	20	16	
Dry Cargo Ship	MV BBC SEATTLE CLASS	AK 5272	T-AK (5272)	20	16	
Dry Cargo Ship	OCEAN CRESCENT CLASS	AK 5307	T-AK 5307	14	13	
USAF (Container Ships)	DAVID LYON CLASS	AK 5362	T-AK (5362)	19	16	
Dry Cargo Ship	VIRGINIAN CLASS	AK 9205	T-AK (9205)	20	16	
Dry Cargo/Ammunition	LEWIS AND CLARK CLASS	AKE 1	T-AKE (1-14)	20	20	
Large Medium Speed Ro-Ro	SHUGHART CLASS	AKR 295	T-AKR (295-298)	24	24	
Large Medium Speed Ro-Ro	BOB HOPE CLASS	AKR 300	T-AKR (300-306)	24	24	
Large Medium Speed Ro-Ro	WATSON CLASS	AKR 310	T-AKR (310-317)	24	24	
Fleet Replenishment Oilers	HENRY J KAISER CLASS	AO 187	T-AO (187-204)	20	20	
Fast Combat Support Ship	SUPPLY CLASS	AOE 6	T-AOE (6-8, 10)	30	22	
Tanker	CHAMPION CLASS	AOT 1121	T-AOT (1122-1125)	16	16	
Tanker	MT CLASS	AOT 4995	T-AOT (4995)	15	15	
Tanker	EVERGREEN STATE CLASS	AOT 5205	T-AOT (5205)	15	15	
Tanker	MAERSK PEARY CLASS	AOT 5246	T-AOT (5246)	15	15	
Tanker	SLNC PAX CLASS	AOT 5356	T-AOT (5356)	14	14	
Tanker	GALVESTON/PETROCHEM CLASS	AOT 5406	T-AOT (5406)	15	15	
Tanker	SLNC GOODWILL CLASS	AOT 5419	T-AOT (5419)	15	15	
Tanker	EMPIRE STATE CLASS	AP 1000	T-AOT (5193, 5246)	15	15	
Cable Laying/Repair Ship	ZEUS CLASS	ARC 7	T-ARC (7)	16	14	
Rescue And Salvage	SAFEGUARD CLASS	ARS 50	T-ARS (50-53)	14	12	
Submarine Tender	EMORY S LAND CLASS	AS 39	AS (39-40)	20	12	
Fleet Ocean Tug	POWHATAN CLASS	ATF 166	T-ATF (168-172)	15	13	
Fleet Ocean Tug	BEYEL CLASS	ATF 4247	T-ATF (4247)	6	6	
Expeditionary Fast Transport	SPEARHEAD CLASS	EPF 1	T-EPF (1-8)	43	35	
Expeditionary Mobile Base	LEWIS B PULLER CLASS	ESB 3	T-ESB (3)	15	15	
Expeditionary Transfer Dock	MONTFORD POINT CLASS	ESD 1	T-ESD (1-2)	18	15	
High Speed Vessel	GUAM CLASS	HST 1	T-HST (1)	40	33	
High Speed Vessel	PUERTO RICO CLASS	HST 2	T-HST (2)	40	33	
High Speed Vessel	JOINT VENTURE CLASS	HSV 1	T-HSV (2)	42	35	
High Speed Vessel	WESTPAC EXPRESS CLASS	HSV 4676	HSV (4676)	40	35	
Command Ship	BLUE RIDGE CLASS	LCC 19	LCC (19-20)	23	16	
Dry Cargo	SEA EAGLE CLASS	MB 1219	MB 1219	15	8	

Reported speeds are compiled from the MSC handbook and Jane's Fighting Ships data.

Table 47. RRF Maximum Speed and Maximum Range Speed by Class, FY 2010 to 2017

Ship Type	Class_Name	Class	Class (Hulls)	Max Speed (Kts)	Max Range Speed (Kts)	ActivationDays
				Sm	Sr	Ai
Auxiliary Crane Ship	KEYSTONE STATE CLASS	ACS 1	T-ACS (1-3)	18	17	5
Auxiliary Crane Ship	GOPHER STATE CLASS	ACS 4	T-ACS (4-6)	19	17	5
Dry Cargo Ship	C5-S-75A CLASS	AK 575	T-AK (5051)	17	17	
Seabee Heavy-Lift Ship	CAPE M CLASS	AK 882	T-AKR (5063, 5065)	18	17	5
Dry Cargo Ship	CAPE FLATTERY CLASS	AK 981	T-AK (5070, 5073)	19	19	10
Large Medium Speed Ro-Ro	CAPE I CLASS	AKR 10	T-AKR (10-11, 5062, 5076)	21	19	5
Large Medium Speed Ro-Ro	ADM CALLAGHAN CLASS	AKR 1001	T-AKR (1001)	23	21	5
Large Medium Speed Ro-Ro	CAPE T CLASS	AKR 112	T-AKR (112, 113, 9711)	17	15	5
Large Medium Speed Ro-Ro	CAPE O CLASS	AKR 2044	T-AKR (2044)	19	17	5
Fast Sealift Ship	ALGOL CLASS	AKR 287	T-AKR (287-294)	30	27	5
Large Medium Speed Ro-Ro	CAPE D CLASS	AKR 5051	T-AKR (2024,5051-5055,5062)	17	16	5
Large Medium Speed Ro-Ro	CAPE H CLASS	AKR 5066	T-AKR (5066-5068)	19	17	5
Large Medium Speed Ro-Ro	CAPE E CLASS	AKR 5069	T-AKR (5069)	17	16	5
Large Medium Speed Ro-Ro	CAPE K CLASS	AKR 5082	T-AKR (5082-5083)	18	17	5
Large Medium Speed Ro-Ro	CAPE V CLASS	AKR 9666	T-AKR (9666, 9701)	16	15	5
Large Medium Speed Ro-Ro	CAPE R CLASS	AKR 9678	T-AKR (9678,9679,9960)	19	18	5
Large Medium Speed Ro-Ro	CAPE W CLASS	AKR 9961	T-AKR (9961-9962)	17	16	5
OPDS Tanker	OPDS CLASS	AOT 181	T-AOT (5084, 9101)	14	14	10
Aviation Logistics Support Ship	WRIGHT CLASS	AVB 3	T-AVB (3, 4)	20	19	5

Reported speeds and activation days are compiled from MARAD (DoT, 2016).

The reported speeds and activation days in Tables 44, 45, and 46 are included to provide two options for determining the number of transit days required for a potential HADR ship to reach a disaster location. The first option is to directly insert the applicable class maximum speed or maximum range speed of a potential HADR ship into the utility function to algebraically calculate the required number of transit days. The second, easier option is to lookup the number of required transit days via the pre-calculated quick reference tables provided in Appendix D, Table 57 for distances of 250 to 6,000 nm and Table 58 for distances of 6,250 to 12,000 nm.

5. Combined Capability and Average Daily O&S Cost Findings

I combine class capability composite score and average daily O&S costs, to provide a graphical depiction of the relationship between class HADR capability and cost. Figures 17 (USN), 18 (MSC), and 19 (RRF) depict capability composite score on the right

vertical axis and average daily O&S costs on the left axis. The classes are sorted by capability composite score, such that classes with the highest capability composite score are on the right side of the horizontal axis and the least capable are on the left side. Depicted red bars only represent class average daily O&S costs and should not be construed to depict breakeven or cross over points with respect to the blue capability field. The cost values are simply overlaid to provide a visual depiction of capability and cost of one ship class relative to other ship classes. It is important to note that CVN-78 was commissioned in July 2017, resulting in lower than normal reported FY O&S costs. Future reported FY O&S costs are expected to be in line with current Nimitz class carriers (CVN 68).

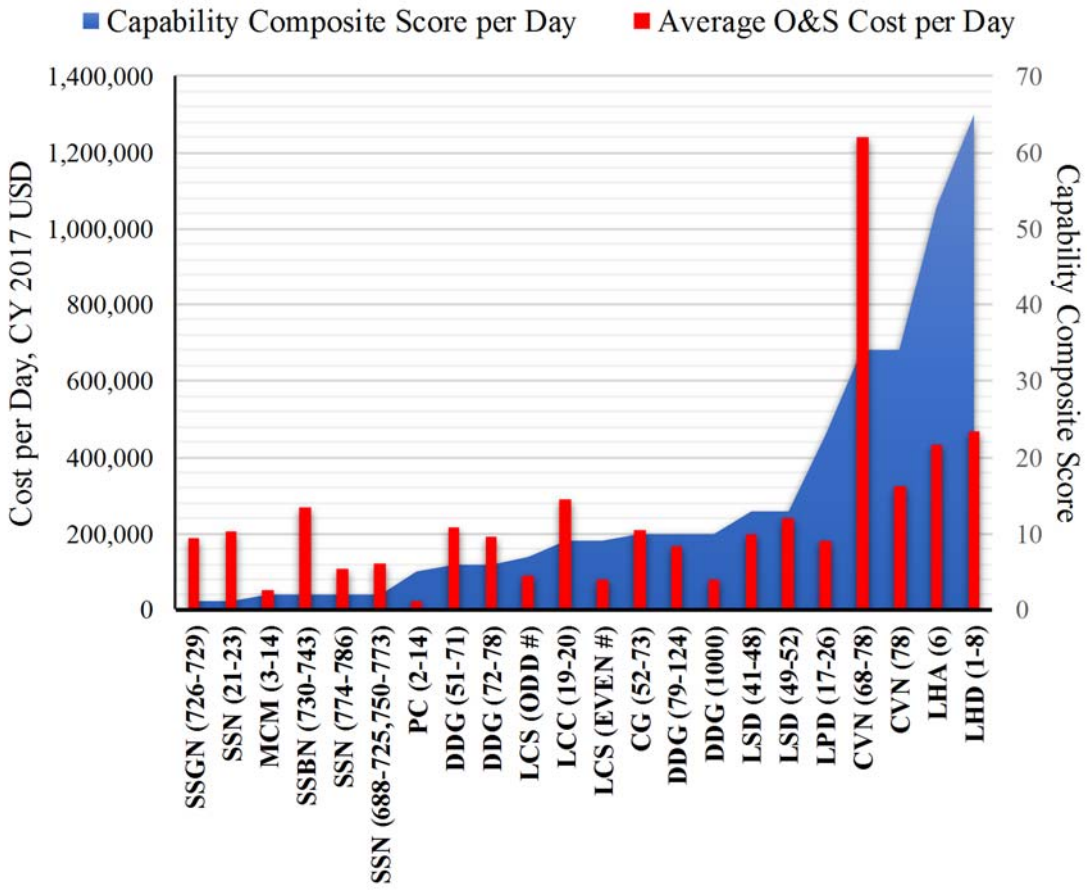

Figure 17. USN Capability versus Average O&S Cost per Day, by FY 2017 Class (Hull Numbers)

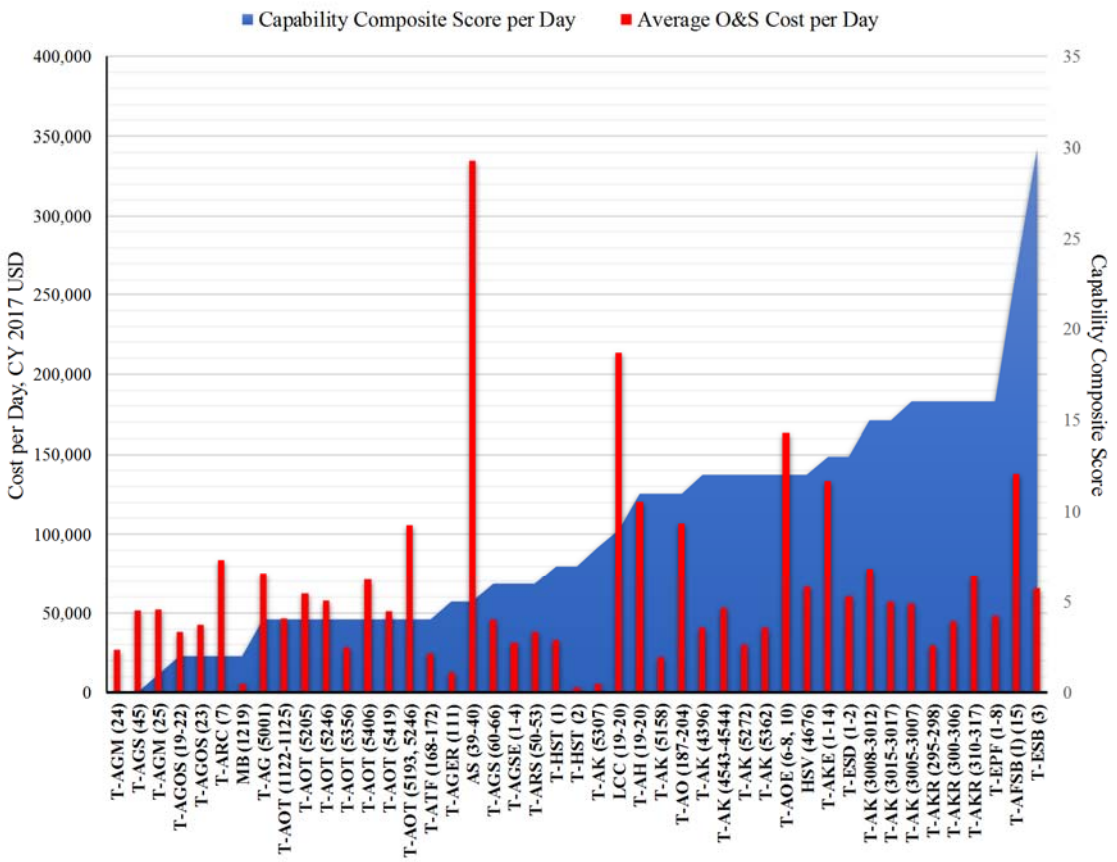

Figure 18. FY 2017 MSC Ship Capability versus Average O&S Cost per Day by Class (Hull Numbers)

Due to large periods of RRF ship inactivation, it is with great reluctance that I report similar findings for RRF ship classes. As an alternative quick reference, MSC average O&S cost per day can be used for RRF ships if the classes are similar in type. In cases where the MSC does not operate a similar class, an examination of the RRF class maximum annual reported costs is likely a better metric to determine average daily cost for RRF ships. With this limitation noted, I report RRF Capability vs. Average O&S Cost per Day in Figure 19. The relative reported O&S costs between RRF ship classes is valid when determining which RRF ships to task in HADR operations as compared to other RRF ships. Classes listed without depicted cost per day have reported more revenue than expense, on average, from FY 2010 to 2017 and I have excluded the negative values from the graph.

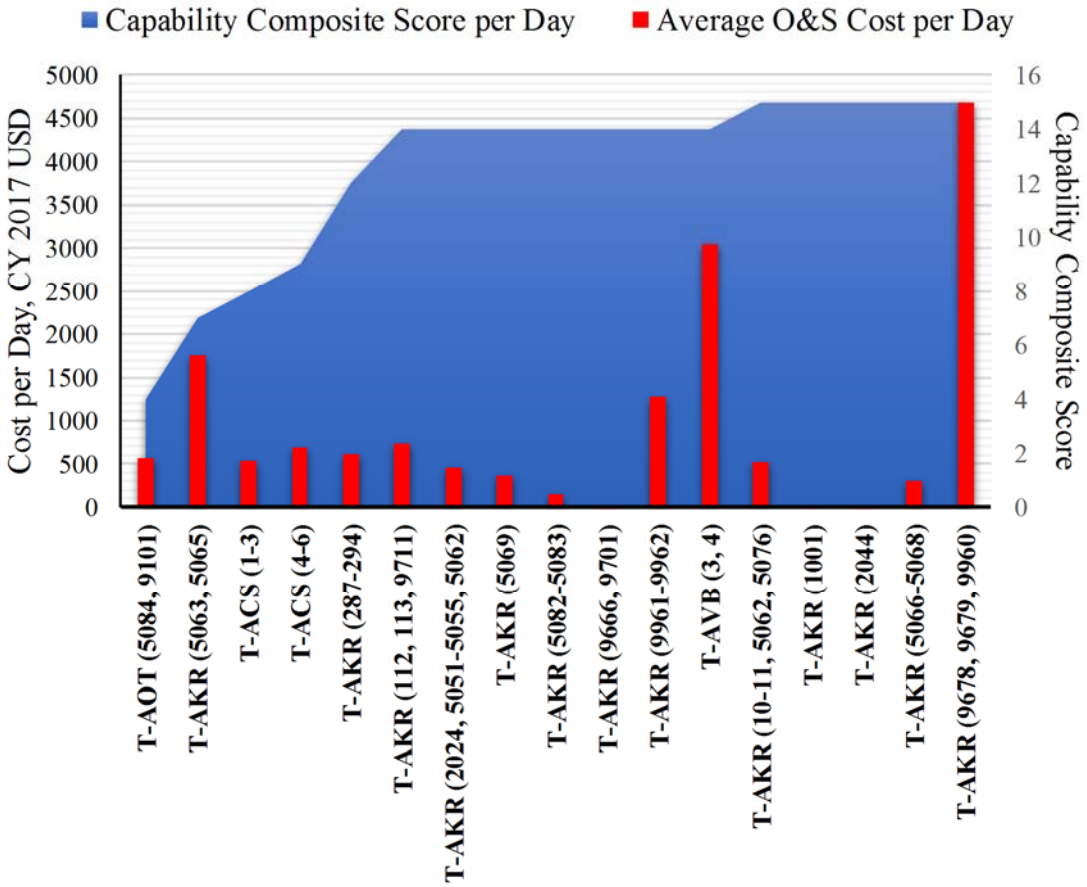

Figure 19. FY 2017 RRF Ship Capability versus Average O&S Cost per Day by Class (Hull Numbers)

6. Utility Findings

Finally, I insert ship class capability, maximum range speed, proximity, and average daily O&S cost findings into the utility function for notional 10, 30, 60, and 90-day HADR responses, with transit distances of 0 nm to 11,000 nm in 250 nm increments. Calculated class utility scores and response O&S costs are reported in Appendix D, Tables 59 to 82, by status, anticipated response duration, and distance.

It is important to note that the reported class utility scores will change if the desired transit speed is anything other than the class maximum range speed reported in this study. For example, the impact of speed on utility can be observed in Appendix D, Table 59 which provides USN class utility scores for a 10-day HADR response. As previously reported,

LHD 1 ships have the highest-class utility score for HADR responses that have 0 nm to transit. LHD 1 class ships have a calculated utility score of 650 points for a 10-day response that originates at 0 nm. A 10-day response from any location results in the expenditure of $4.67 M O&S funds for LHD 1 class ships. The second highest utility score under the same circumstances is 340 points, held by CVN 65, 68, and 78 class ships, with a reported expenditure of $12.4 M of O&S funds. As distance increases, the rankings change. For simplicity, I use the same transit distances for both LHD 1 and CVN 68 class ships. During a 10-day response, the ranking crossover occurs at 3,750 nm, where the reported utility score for CVN 68 class ships [162.9 points, $12.41 M] first exceeds the reported score for LHD 1 class ships [142.2 points, $4.67 M]. CVN 68 class ship utility scores continue to diverge and remain above LHD 1 ships as the required distance increases because of the slower LHD 1 class transit speed relative to CVN 68 class transit speeds. To minimize wasting limited USG resources, cost comparisons should be considered in situations where the utility scores of two ships are similar while seeking to maximize the provided HADR utility.

Figures 20, 21, and 22 provide a three-dimensional depiction of the calculated ship class utility scores during a 10, 30, 60, and 90-day HADR response from distances of 0 nm to 11,000 nm. An unexpected, but logical, finding from the utility graphs is that the response duration matters for utility score calculations. For example, during a 10-day response, most ships are observed to possess zero utility beyond 5,500 nm while all ships are observed to provide positive utility during HADR responses longer than 60 days out to 11,000 nm away. Green shading indicates greater than zero utility points at the given distance. Red shading indicates that the vessel provides no utility during an HADR response at the specified distance and response duration. Ship classes with the highest utility at 0 nm are sorted to the left side while the lowest are on the right.

I acknowledge that it is not normal for utility functions to depict negative values. Technically, the negative values equal zero. I have allowed the negative numbers to remain to depict lost capability (waste) to other priority tasking resulting from inappropriate HADR tasking. Additionally, utility functions typically require a maximum budget. As reported by Ures (2011), no budget exists for HADR responses.

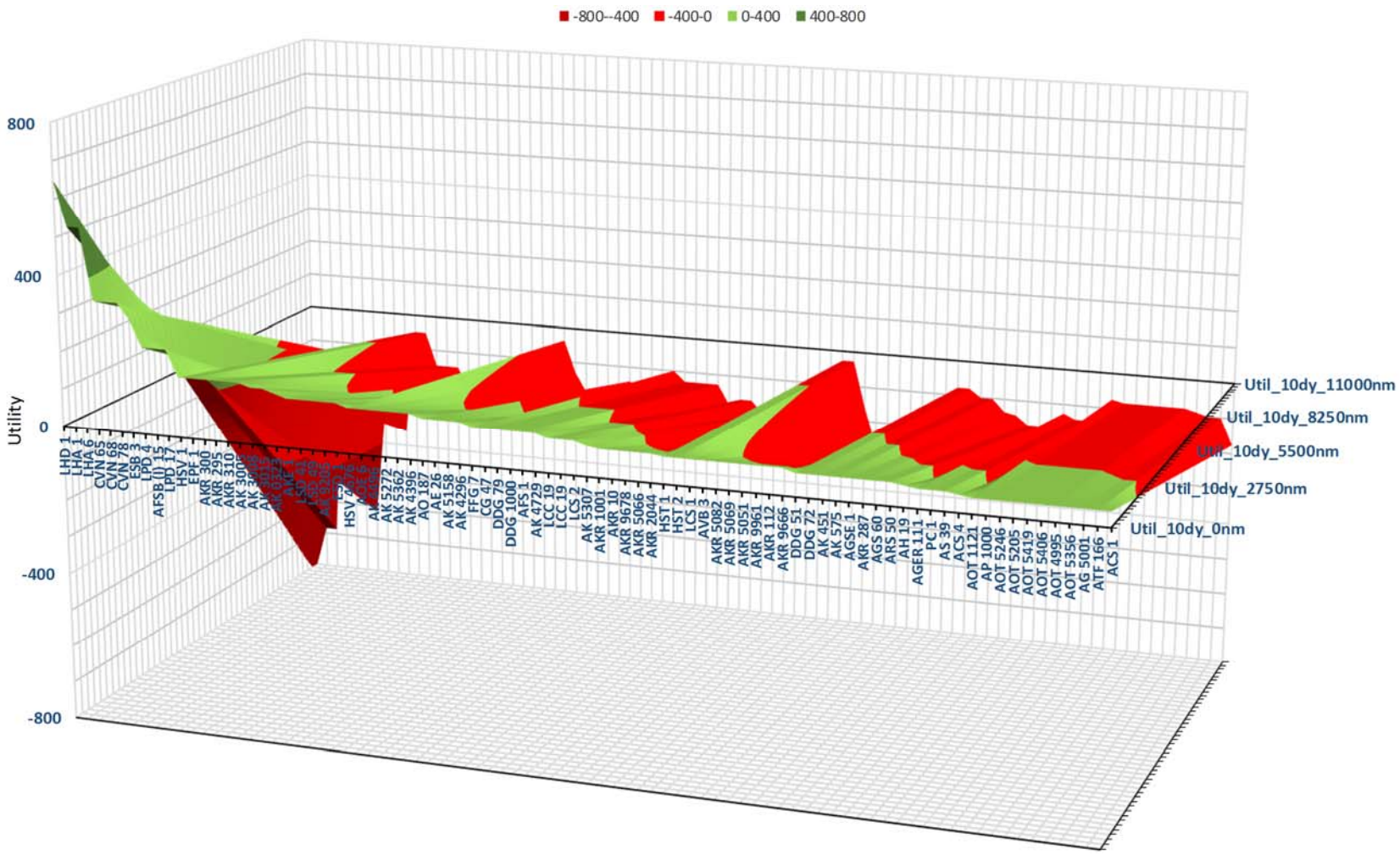

Figure 20. Utility of 10-Day HADR Response by Class

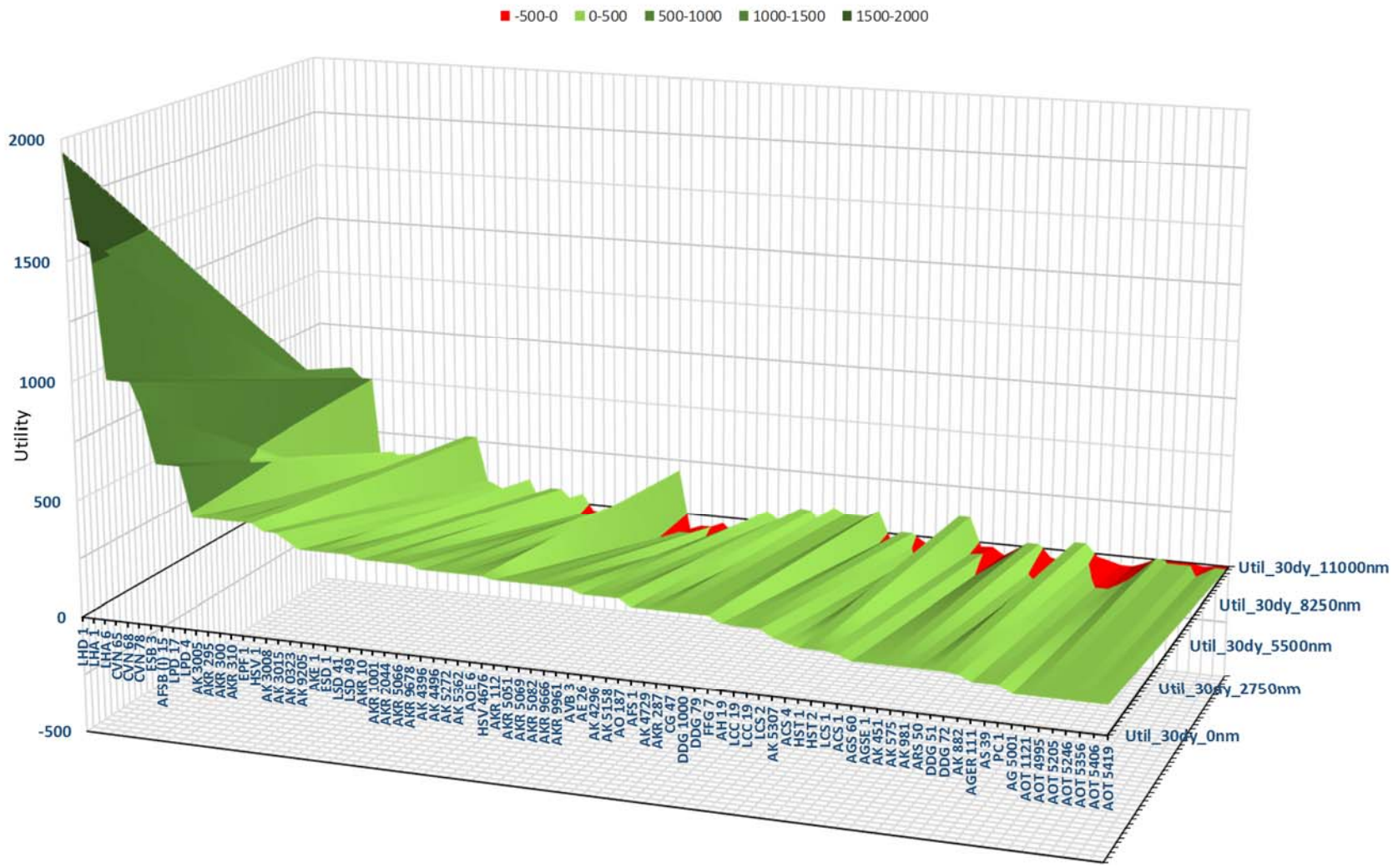

Figure 21. Utility of 30-Day HADR Response by Class

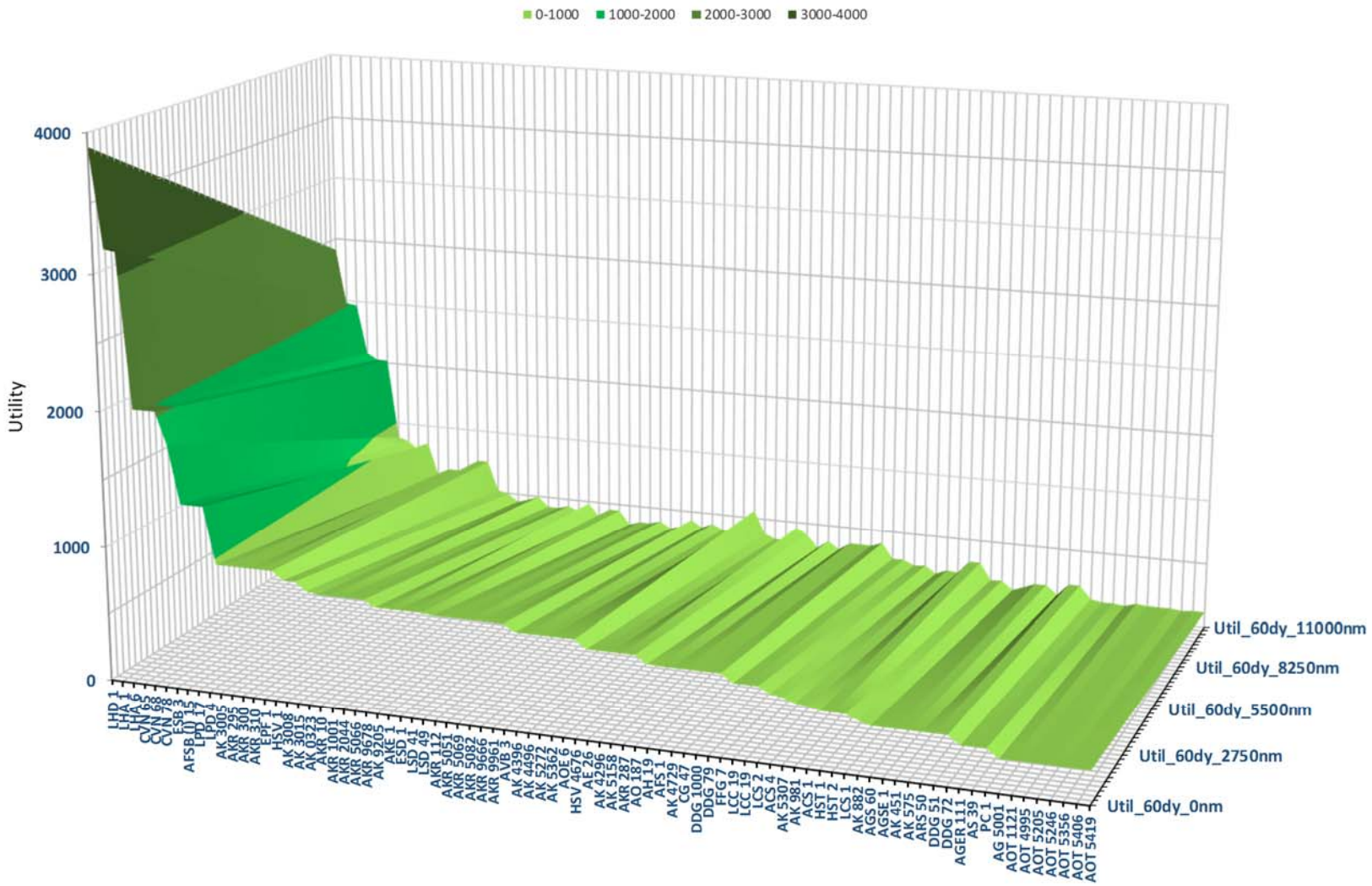

Figure 22. Utility of 60-Day HADR Response by Class

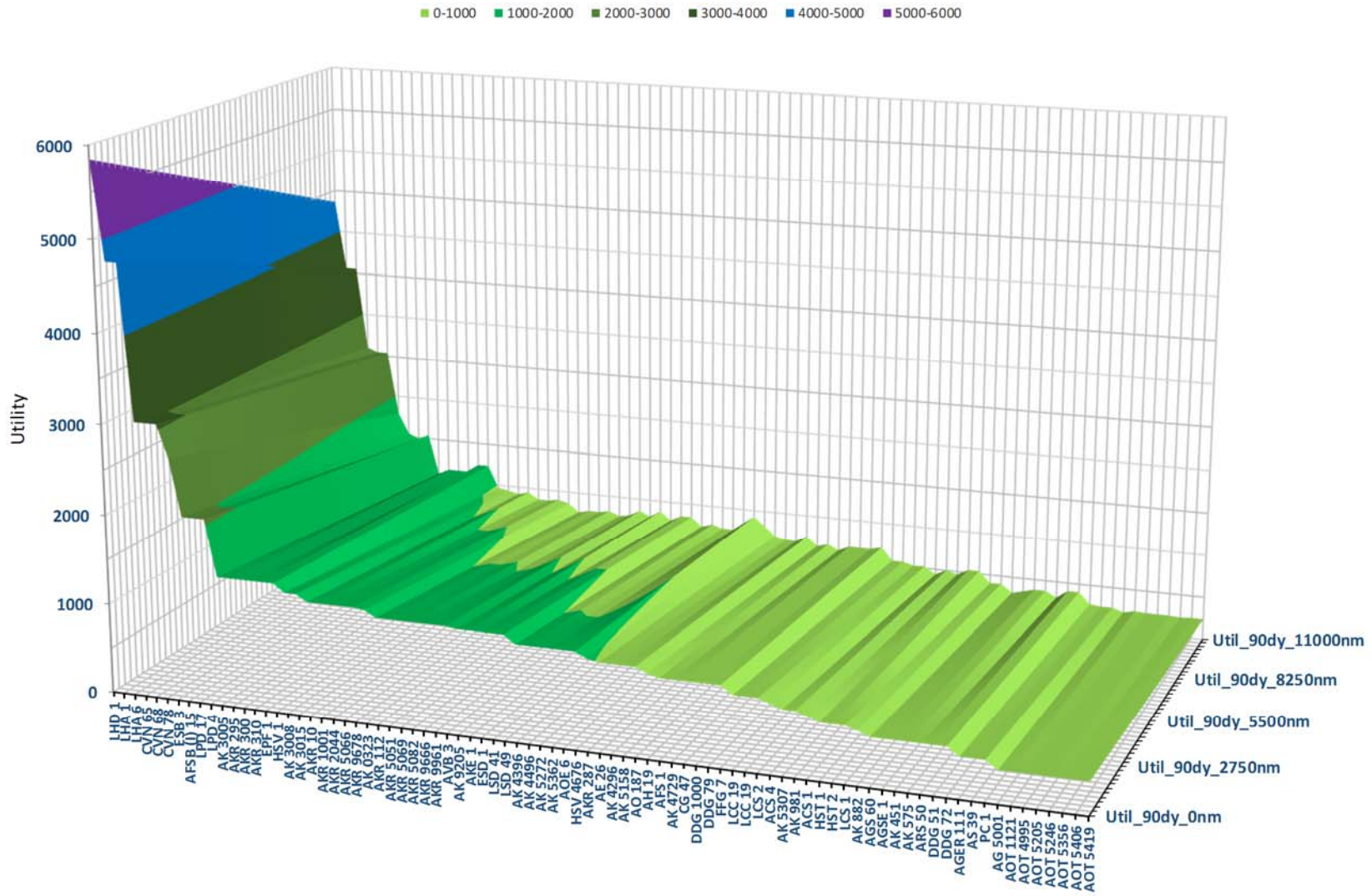

Figure 23. Utility of 90-Day HADR Response by Class

B. SECONDARY RESEARCH QUESTION RESULTS

To recap, I use two previously reported U.S. naval HADR responses to provide solutions to the following secondary research questions:

- (SQ1) To what extent does asset capability play a role in maximizing the utility of HADR operations?
- (SQ2) To what extent does asset proximity play a role in maximizing the utility of HADR operations?
- (SQ3) To what extent does asset cost play a role in maximizing the utility of HADR operations?
- (SQ4) To what extent does asset total response duration play in maximizing the utility of HADR operations?

Disaster Response Findings

Next, I report findings that help answer the secondary research questions. The 2010 Haiti earthquake response vessel names, number of transit days, and the number of days on station were previously reported by Greenfield and Ingram (2011). Equivalent response variables were reported for Japan by Moffat (2014). I sum the transit days and the number of days on station to create a variable called *HADR_TotalDays*. I calculate the values reported for "HADR Utility Provided" by inserting the number of ship transit days and total response days into the HADR utility function created by this study. I calculate the reported "HADR Response Cost (CY 2017 USD)" values by multiplying the ship total response days by actual, daily ship O&S costs for the respective response year.

Based on these calculations, LHA 4 provided the most utility to Haiti during its 66-day HADR response, at an estimated O&S cost of $25.7 M in CY 2017 USD [3,233 utility points, $25.7 M]. The calculated LHA 4 utility provided exceeds those provided by LHD 3 and 5 despite their higher *CapabilityCompositeScore* due to LHA 4's longer response duration. LSD 44 provided the shortest Haiti response, yielding a utility pairing of [143 utility points, $1.8 M]. The lowest calculated utility pairing for the Haiti response was provided by T-ARS 51 during its 12-day response, yielding an HADR utility of [54 utility

points, $0.584 M]. I would be remiss if I did not highlight that T-ARS 51 is one of the few U.S. naval inventory ships that can provide sea-based towing and conduct salvage and rescue operations during HADR missions. T-ARS 51 serves as a reminder that overall capability is not always the best metric when considering which ships to task during HADR missions. Unique capabilities matter.

Table 48 contains actual HADR response data for each ship tasked with providing an HADR response following the 2010 Haiti earthquake. Table 49 contains actual HADR response data for each ship tasked with providing an HADR response following the 2011 Tohoku earthquake and tsunami in Japan.

Table 48. 2010 Haiti Earthquake HADR Response Ship Utility and Cost

Type	Ship Class	Vessel Name	Hull Number	Days Transit	Days On Station	Total Days	HADR Utility Provided	HADR Response Cost (CY2017 USD)
CG	CG 47	NORMANDY	CG 60	1	22	23	220	4,296,613
CG	CG 47	BUNKER HILL	CG 52	1	20	21	200	3,392,109
DDG	DDG 72	HIGGINS	DDG 76	6	15	21	90	3,442,237
FFG	FFG 7	UNDERWOOD	FFG 36	0	35	35	350	3,096,840
LHA	LHA 1	NASSAU	LHA 4	5	61	66	3233	25,681,862
LHD	LHD 1	BATAAN	LHD 5	2	12	14	780	6,098,680
LHD	LHD 1	KEARSARGE	LHD 3	14	14	28	910	13,751,710
LPD	LPD 17	MESA VERDE	LPD 19	11	4	15	92	2,287,987
LSD	LSD 41	GUNSTON HALL	LSD 44	0	11	11	143	1,803,997
LSD	LSD 41	ASHLAND	LSD 48	2	17	19	221	3,806,629
LSD	LSD 41	FORT MCHENRY	LSD 43	5	17	22	221	11,202,770
LSD	LSD 49	CARTER HALL	LSD 50	5	17	22	221	3,815,142
T-AGS	AGS 60	HENSON	T-AGS 63	7	49	56	294	2,413,972
T-AH	AH 19	COMFORT	T-AH 20	4	51	55	561	5,492,085
T-AK	AK 3008	PFC DEWAYNE T WILLIAMS	T-AK 3009	1	38	39	570	2,927,142
T-AK	AK 3008	1ST LT JACK LUMMUS	T-AK 3011	5	18	23	270	2,569,926
T-AKE	AKE 1	LEWIS AND CLARK	T-AKE 1	4	44	48	572	7,553,157
T-AKE	AKE 1	SACAGAWEA	T-AKE 2	0	15	15	195	2,417,308
T-AO	AO 187	BIG HORN	T-AO 198	4	27	31	297	3,698,783
T-AO	AO 187	LEROY GRUMMAN	T-AO 195	6	18	24	198	2,628,176
T-ARS	ARS 50	GRASP	T-ARS 51	3	9	12	54	584,808
T-ACS	ACS 4	GOPHER STATE	T-ACS 4	10	42	52	378	247,652
T-ACS	ACS 4	CORNHUSKER STATE	T-ACS 6	3	42	45	378	358,824
T-AKR	AK 882	CAPE MAY	T-AKR 5063	5	17	22	119	317,519

Source data for response ships, number of days in transit, and days on station adapted from Greenfield & Ingram (2011).

Based on the reverse utility calculations, LHD 2 provided the most utility to Japan during its 28-day HADR response, at an estimated O&S cost of $12.1 M in CY 2017 USD [1,430 utility points, $12.1M]. T-AKE 4 provided the shortest Japan response, yielding a

utility pairing of [78 utility points, $0.781 M]. The lowest calculated utility pairing for the Japan response was provided by T-AKE 4. I observe that the Haiti HADR response was longer than the Japan response. The longer Haiti response duration is likely due to Haiti's limited ability to handle disaster relief efforts independently.

Table 49. 2011 Tohoku Earthquake HADR Response Ship Utility and Cost

Type	Ship Class	Vessel Name	Hull Number	Days Transit	Days On Station	Total Days	HADR Utility Provided	HADR Response Cost (CY2017 USD)
CG	CG 47	CHANCELLORSVILLE	CG 62	1	22	23	220	4,546,665
CG	CG 47	COWPENS	CG 63	2	21	23	210	4,845,260
CG	CG 47	SHILOH	CG 67	2	21	23	210	5,255,677
CVN	CVN 68	RONALD REAGAN	CVN 76	1	22	23	748	23,581,838
DDG	DDG 51	JOHN S MCCAIN	DDG 56	1	22	23	132	3,592,239
DDG	DDG 51	FITZGERALD	DDG 62	1	22	23	132	4,388,412
DDG	DDG 79	PREBLE	DDG 88	1	22	23	220	5,430,944
DDG	DDG 51	CURTIS WILBUR	DDG 54	1	23	24	138	3,636,537
DDG	DDG 79	MCCAMPBELL	DDG 85	0	24	24	240	4,715,649
DDG	DDG 79	MUSTIN	DDG 89	2	21	23	210	3,764,518
LCC	LCC 19	BLUE RIDGE	LCC 19	7	22	29	198	8,377,612
LHD	LHD 1	ESSEX	LHD 2	6	22	28	1430	12,110,066
LSD	LSD 41	GERMANTOWN	LSD 42	6	22	28	286	3,819,775
LSD	LSD 41	TORTUGA	LSD 46	3	25	28	325	4,336,003
LSD	LSD 49	HARPERS FERRY	LSD 49	6	22	28	286	12,950,246
HSV	HSV 4676	WESTPAC EXPRESS	HSV 4676	1	7	8	84	423,189
T-AKE	AKE 1	CARL BRASHEAR	T-AKE 7	1	14	15	182	2,020,978
T-AKE	AKE 1	RICHARD E BYRD	T-AKE 4	0	6	6	78	781,763
T-AKE	AKE 1	MATTHEW PERRY	T-AKE 9	3	20	23	260	2,645,257
T-AO	AO 187	PECOS	T-AO 197	0	17	17	187	1,449,992
T-AO	AO 187	RAPPAHANNOCK	T-AO 204	0	23	23	253	2,255,366
T-AOE	AOE 6	BRIDGE	T-AOE 10	1	22	23	264	4,046,646
T-ARS	ARS 50	SAFEGUARD	T-ARS 50	10	15	25	90	1,015,765

Source data for response ships, number of days in transit, and number of days on station adapted from Moffat (2014).

Next, I conduct regression analysis of the HADR response metrics to determine to what extent asset capability, cost, and proximity play in maximizing the utility of HADR operations. I conduct two ordinary least squares linear (OLS) regressions of the combined Haiti and Japan HADR response. The models are titled HADR (A) and HADR (B) with a sample size of 47 ships.

The dependent variable for the HADR utility regressions is a log linearized version of the calculated "HADR Utility Provided" variable named *log_HADR_Utility*. The first OLS model, HADR (A), controls for ship log linearized response cost (*HADR_log_Cost*),

number of transit days (*HADR_Enroute*), number of total response days (*HADR_TotalDays*), and *CapabilityCompositeScore*. I omit the variable *HADR_OnStation* in both models to avoid collinearity.

The HADR (A) coefficient for *HADR_log_Cost* indicates that holding everything else constant, a one percent increase in response O&S costs is associated with a 0.1249 percent increase in total utility provided, at a 99 percent confidence level. The HADR (A) coefficient for the number of transit days (*HADR_Enroute*) indicates that on average, a one day increase in HADR transit days is associated with a 5.79 percent decrease in the total utility provided by response ships, at a 99 percent confidence level. Furthermore, the coefficient for the total number of response days (*HADR_TotalDays*) indicates that on average, a one day increase in the total number of response days is correlated with a 3.87 percent increase in the total utility provided by response ships, also at a 99 percent level of confidence. Finally, the HADR (A) coefficient for ship capability composite score (*CapabilityCompositeScore*) indicates that a one-point increase in capability composite score is correlated with a 3.26 percent increase in the total utility provided by response ships at a 99 percent level of confidence. HADR (A) reports an R-squared of 92.1 percent with robust standard errors.

HADR (B) replaces capability composite score with response ship class to determine what impact, if any, individual classes have on the coefficients. The capability composite score is omitted to avoid collinearity. Like the cost regressions, I omit LHD 1 class ships as the class reference since both responses included LHD 1 class ships and it has the highest calculated *CapabilityCompositeScore*.

The HADR (B) coefficient for *HADR_log_Cost* indicates that holding everything else constant, a one percent increase in response O&S costs is not statistically significant under robust standard errors. Under non-robust standard errors, a one percent increase in response O&S costs is associated with a 0.1127 percent increase in total utility provided, at a 90 percent level of confidence. The HADR (B) coefficient for the number of transit days (*HADR_Enroute*) indicates that on average, a one day increase in HADR transit days is associated with a 3.8 percent decrease in the total utility provided by response ships, at a 99 percent confidence level. Furthermore, the HADR (B) coefficient for the total number

of response days (*HADR_TotalDays*) indicates that on average, a one-day increase in the total number of response days is correlated with a 4.19 percent increase in the total utility provided by response ships, also at a 99 percent level of confidence. As expected, the HADR (B) coefficients for class utility relative to LHD 1 class ships all indicate decreases in total utility relative to LHD 1 class ships, at a 99 percent level of confidence. HADR (B) reports an R-squared of 99.1 with robust standard errors. See Table 50 for a complete listing of HADR (A) and (B) model coefficients.

Table 50. U.S. Naval Haiti and Tohoku HADR Response Regressions

Independent Variables	HADR (A)		HADR (B)	
HADR_log_Cost	0.1249***	[0.0394]	0.1127	[0.0939]
HADR_Enroute	-0.0579***	[0.0113]	-0.0380***	[0.0087]
HADR_OnStation	[omitted - reference]		[omitted - reference]	
HADR_TotalDays	0.0387***	[0.0038]	0.0419***	[0.0040]
Capability				
CapabilityCompositeScore	0.0326***	[0.0023]		
_Class (value)				
ACS 4			-1.6671***	[0.3964]
AGS 60			-2.4473***	[0.2652]
AH 19			-1.9679***	[0.2247]
AK 3008			-1.2801***	[0.1552]
AK 882			-1.7771***	[0.3196]
AKE 1			-1.5385***	[0.1481]
AO 187			-1.5146***	[0.1393]
AOE 6			-1.4609***	[0.0946]
ARS 50			-2.2082***	[0.2545]
CG 47			-1.6589***	[0.0879]
CVN 68			-0.6181***	[0.1225]
DDG 51			-2.1478***	[0.0993]
DDG 72			-2.2451***	[0.1078]
DDG 79			-1.6578***	[0.0890]
FFG 7			-1.6894***	[0.1662]
HSV 4676			-1.7234***	[0.2663]
LCC 19			-1.8539***	[0.0702]
LHA 1			-0.8130***	[0.2620]
LHD 1			[omitted - reference]	
LPD 17			-1.7358***	[0.1674]
LSD 41			-1.4585***	[0.1065]
LSD 49			-1.4848***	[0.0812]
Constant	2.3149***	[0.5500]	4.3973**	[1.4604]
*** p<0.01, ** p<0.05, * p<0.1 | [Robust Standard errors]				
Observations	47		47	
Prob > F	0.0000		0.0000	
R-squared	0.9205		0.9913	

Out of curiosity, I conduct three comparative capability factor analyses related to the two reported HADR responses. For the first set of tests, I limit the USN, MSC, and RRF inventories to only include inventory ships during the given HADR response year. During the second set of tests, I conduct factor analyses limited to those ships tasked to provide an HADR response for each reported disaster. The final set of factor analyses included both FY 2010 and 2011 inventory ships compared to all ships tasked with providing an HADR response in either reported disaster. The results of all three iterations consistently indicate that there is a mismatch between overall USN, MSC, and RRF inventory HADR capability and what is sent to provide an HADR response.

Factor analysis loading results based on overall USN, MSC, and RRF FY ship inventory indicate that cargo capabilities are the primary need that USN, MSC, and RRF ships can fill, followed by VTOL, landing craft, and SAR. The factor analysis results for those ships sent to Haiti and Japan indicate that the priorities were reversed. See Tables 51, 52, and 53 for a complete listing of the described HADR response capability factor analysis results.

Table 51. Capability Factor Analysis of 2010 Haiti Earthquake Response

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
	ALL SHIPS FY 2010						2010 HAITI EARTHQUAKE RESPONSE SHIPS					
Cap_NumberVerticalLift		0.9064				0.145	0.7852					0.0346
Cap_AviationFacilities		0.6226		0.467		0.1914	0.5827		-0.4966			0.2357
Cap_VerticalLiftScore		0.8922				0.1709	0.7637					0.0426
Cap_LandingCraft		0.6596		-0.4511		0.2515	0.7005			-0.5514		0.0352
Cap_SearchandRescue		0.8248				0.2064	0.8368			-0.4208		0.0504
Cap_DryGoods	0.9172					0.06	-0.4364	0.8359				0.0918
Cap_RefrigeratedGoods	0.9253					0.0745	-0.5239	0.7822				0.0398
Cap_Freshwater	0.937					0.0605	-0.42	0.7986				0.1123
Cap_RollOnRollOff	0.7592					0.25		0.4604				0.5786
Cap_FuelStorageDispens.	0.9106					0.1065		0.7759				0.0936
Cap_SelfSufficient	0.8741					0.1951		0.5772		-0.4144		0.2605
Cap_PersonnelTransfer	-0.4276	0.7835				0.1256	0.9792					0.0257
Cap_FreshwaterProduction	0.5664	0.4629			-0.5266	0.1544	0.6413			0.4094	-0.439	0.0594
Cap_PersonnelSupport	-0.4023	0.8136				0.1066	0.9728					0.0208
Cap_BerthingCapacity	0.5025	0.7484				0.0605	0.7559	0.414	0.4102			0.0293
Cap_MedicalSupport		0.8938				0.108	0.9					0.0312
Cap_TransitSpeed	-0.4783		-0.6357			0.3358			-0.8501			0.0595
Cap_HydrographicSurvey			0.6386			0.5212		-0.4777	0.5469			0.3278
Cap_SalvageOperations			0.7415			0.3367		-0.57	0.6622			0.0563
Cap_Towing	-0.5595			0.4767		0.2846		-0.8328				0.0736
Proportion of Variance	0.3585	0.3451	0.1024	0.0588	0.0497		0.3821	0.2517	0.1191	0.0758	0.0584	
Cumulative Variance	0.3585	0.7036	0.8059	0.8647	0.9144		0.3821	0.6338	0.7529	0.8286	0.8871	
	Blanks represent absolute value loadings < .4						Blanks represent absolute value loadings < .4					

Table 52. Capability Factor Analysis of 2011 Tohoku Earthquake Response

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
	ALL SHIPS FY 2011						2011 TOHOKU EARTHQUAKE RESPONSE SHIPS					
Cap_NumberVerticalLift		0.9018				0.1449	0.7671	0.4252				0.088
Cap_AviationFacilities		0.6013		0.4659		0.1845			-0.7499			0.187
Cap_VerticalLiftScore		0.8861				0.1706	0.7446	0.414				0.0852
Cap_LandingCraft		0.6557		-0.4536		0.2511	0.5991		0.425		-0.4849	0.1618
Cap_SearchandRescue		0.7919				0.206	0.8655					0.1079
Cap_DryGoods	0.911					0.046		0.9081				0.0071
Cap_RefrigeratedGoods	0.9287					0.0438	-0.4355	0.8501				0.0039
Cap_Freshwater	0.9308					0.0593		0.8338				0.102
Cap_RollOnRollOff	0.7677					0.2414				0.9019		0.0706
Cap_FuelStorageDispens.	0.9127					0.0887	-0.4355	0.8501				0.0039
Cap_SelfSufficient	0.8689					0.1828		0.6521	0.64			0.0684
Cap_PersonnelTransfer	-0.4993	0.7406				0.1266	0.7874			0.5644		0.0023
Cap_FreshwaterProduction	0.5422	0.4962			-0.5258	0.1494	0.753	0.4408			0.4319	0.0452
Cap_PersonnelSupport	-0.4763	0.7731				0.1066	0.9369					0.0255
Cap_BerthingCapacity	0.4506	0.782				0.0584	0.857	0.4007				0.0565
Cap_MedicalSupport		0.8901				0.1087	0.857	0.4007				0.0565
Cap_TransitSpeed	-0.4886		-0.6378			0.3333		-0.4625	-0.6419	0.4594		0.1372
Cap_HydrographicSurvey			0.6386			0.5191						
Cap_SalvageOperations			0.7417			0.3328			0.7499		0.4719	0.0234
Cap_Towing	-0.5485			0.4734		0.2823		-0.8184			0.4631	0.0174
Proportion of Variance	0.3651	0.3409	0.1022	0.0582	0.0495		0.3504	0.2824	0.134	0.0934	0.0783	
Cumulative Variance	0.3651	0.706	0.8083	0.8664	0.916		0.3504	0.6328	0.7668	0.8602	0.9385	
	Blanks represent absolute value loadings < .4						Blanks represent absolute value loadings < .4					

Table 53. Capability Factor Analysis of Combined 2010 Haiti and 2011 Tohoku Earthquake Responses

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
	ALL SHIPS FY 2010 & 2011						TASKED COMBINED RESPONSE SHIPS					
Cap_NumberVerticalLift		0.9043				0.1447	0.7709	0.4039				0.1058
Cap_AviationFacilities		0.6101		0.4665		0.1885	0.4687		-0.6308			0.2984
Cap_VerticalLiftScore		0.8891				0.1705	0.7494					0.1186
Cap_LandingCraft		0.6578		-0.4515		0.2526	0.6446			-0.4649		0.1463
Cap_SearchandRescue		0.8046				0.2067	0.842					0.1224
Cap_DryGoods	0.9124					0.0536		0.8678				0.016
Cap_RefrigeratedGoods	0.9264					0.0598	-0.4926	0.8097				0.0191
Cap_Freshwater	0.9332					0.06		0.8149				0.1139
Cap_RollOnRollOff	0.7641					0.2456					0.7755	0.1231
Cap_FuelStorageDispens.	0.9116					0.0977	-0.4194	0.7914				0.0786
Cap_SelfSufficient	0.8704					0.189		0.6274	0.4184			0.2446
Cap_PersonnelTransfer	-0.473	0.7573				0.1261	0.8902					0.0723
Cap_FreshwaterProduction	0.5489	0.4862			-0.5262	0.152	0.6653			0.4053		0.2469
Cap_PersonnelSupport	-0.4493	0.7889				0.1065	0.9646					0.0358
Cap_BerthingCapacity	0.4677	0.7713				0.0594	0.7772	0.458				0.086
Cap_MedicalSupport		0.8923				0.1082	0.8721					0.0542
Cap_TransitSpeed	-0.4849		-0.6365			0.335		-0.424	-0.7603			0.1744
Cap_HydrographicSurvey			0.6385			0.5204			0.5349			0.4615
Cap_SalvageOperations			0.7415			0.335			0.7858			0.1065
Cap_Towing	-0.552			0.475		0.2835		-0.8318				0.0855
Proportion of Variance	0.362	0.3432	0.1023	0.0585	0.0496		0.3532	0.2586	0.1261	0.0784	0.0516	
Cumulative Variance	0.362	0.7052	0.8076	0.866	0.9156		0.3532	0.6118	0.7379	0.8163	0.8679	
	Blanks represent absolute value loadings < .4						Blanks represent absolute value loadings < .4					

Although there is an apparent mismatch between inventory ships and those sent to respond, it is impossible to claim with certainty that other ships should have been sent without knowing the USAID/OFDA requested capabilities paired with instantaneous fleet readiness, current tasking, and proximity of available ships to the disaster locations.

C. SUMMARY OF FINDINGS

1. Primary Research Objective and Question

a. (RO) Define a utility function for tasking HADR response ships

As detailed in Chapter IV, I use the following function to calculate ship utility:

$$[U_{i,d,R},\ C_{i,R}] = (S_i * R_i) - (S_i * (T_i + A_i))$$

where

- *U* is the calculated HADR utility of a given ship or ship class
- *i* represents one ship of a given class
- *d* represents ship distance from present location to the disaster (nm)
- *S* is the ship/class *CapabilityCompositeScore* or specific capability metric score
- *R* is the expected number of HADR response days from 'Day + 0' to the final expected day of HADR operations
- *T* is the number of transit days from present position to disaster location, calculated by dividing distance by ship speed (kts) and 24 hours
- *A* is the number of activation/preparation days required prior to departure
- *C* is vessel reported *_AvgDlyCost_Class_FY2010_17* in CY2017 USD.

Next, I provide three tables that contain a condensed version of the previously reported utility variables. These values are provided for direct insertion into the utility function if a mission planner would rather calculate the utility scores rather than look it up in provided quick reference tables in Appendix D. See Tables 54 (USN), 55 (MSC), and 56 (RRF) ship class values.

Table 54. Summary of USN Utility Function Variable Findings by Class

Type Description	Type	Ship Class	Class Hull Numbers	Capability Composite Score	Maximum Speed	Maximum Range Speed	Number of Activation Days	Average Daily O&S Cost (CY 2017 USD)
				Si	Sm	Sr	Ai	Ci
Guided Missile Cruiser	CG	CG 47	CG (52-73)	10	30	20		208,616
Multi-Purpose Aircraft Carrier (Nuclear-Powered)	CVN	CVN 65	CVN (65)	34	33	33		899,623
Multi-Purpose Aircraft Carrier (Nuclear-Powered)	CVN	CVN 68	CVN (68-78)	34	33	30		1,241,262
Multi-Purpose Aircraft Carrier (Nuclear-Powered)	CVN	CVN 78	CVN (78)	34	30	30		326,486
Guided Missile Destroyer	DDG	DDG 1000	DDG (1000)	10	30	20		79,239
Guided Missile Destroyer	DDG	DDG 51	DDG (51-71)	6	32	20		216,704
Guided Missile Destroyer	DDG	DDG 72	DDG (72-78)	6	32	20		191,124
Guided Missile Destroyer	DDG	DDG 79	DDG (79-124)	10	31	20		167,391
Guided Missile Frigate	FFG	FFG 7	FFG (8, 28-61)	10	29	23		86,283
Command Ship	LCC	LCC 19	(LCC 19-20)	9	23	16		291,128
Littoral Combat Ship	LCS	LCS 1	LCS (ODD #)	7	40	14		90,316
Littoral Combat Ship	LCS	LCS 2	LCS (EVEN #)	9	50	14		81,061
Amphibious Assault Ship (General Purpose)	LHA	LHA 1	LHA (4-5)	53	24	20		356,807
Amphibious Assault Ship (General Purpose)	LHA	LHA 6	LHA (6)	53	22	20		432,555
Amphibious Assault Ship (Multi-Purpose)	LHD	LHD 1	LHD (1-8)	65	22	20		466,901
Amphibious Transport Dock	LPD	LPD 17	LPD (17-26)	23	22	18		182,253
Amphibious Transport Dock	LPD	LPD 4	LPD (4-16)	23	21	20		163,002
Dock Landing Ship	LSD	LSD 41	LSD (41-48)	13	22	18		198,154
Dock Landing Ship	LSD	LSD 49	LSD (49-52)	13	22	18		241,968
Mine Countermeasures Ship	MCM	MCM 1	MCM (3-14)	2	14	10		51,018
Patrol Coastal	PC	PC 1	PC (2-14)	5	35	12		21,886
Ballistic Missile Submarine (Nuclear-Powered)	SSBN	SSBN 726	SSBN (730-743)	2	25	25		268,688
Guided Missile Submarine (Nuclear-Powered)	SSGN	SSGN 726	SSGN (726-729)	1	20	20		188,811
Submarine (Nuclear-Powered)	SSN	SSN 21	SSN (21-23)	1	20	20		205,325
Submarine (Nuclear-Powered)	SSN	SSN 688	SSN (688-725,750-773)	2	25	25		120,874
Submarine (Nuclear-Powered)	SSN	SSN 774	SSN (774-786)	2	25	25		107,339

Table 55. Summary of MSC Utility Function Variable Findings by Class

Type Description	Type	Ship Class	Class Hull Numbers	Capability Composite Score	Maximum Speed	Maximum Range Speed	Number of Activation Days	Average Daily O&S Cost (CY 2017 USD)
				Si	Sm	Sr	Ai	Ci
Ammunition Ship	T-AE	AE 26	T-AE (32-35)	11	20	18		73,926
Combat Stores Ship	T-AFS	AFS 1	T-AFS (7)	10	20	20		33,514
Afloat Forward Staging Base	AFSB	AFSB (I) 15	T-AFSB (I) (15)	23	21	20		138,045
Defense Logistics Agency (OPDS)	T-AG	AG 5001	T-AG (5001)	4	15	13		75,276
Submarine/Special Warfare Support	T-AGER	AGER 111	T-AGER (111)	5	15	13		12,587
Missile Range Instrumentation Ship	T-AGM	AGM 23	T-AGM (23)	1	20	15		74,802
Missile Range Instrumentation Ship	T-AGM	AGM 24	T-AGM (24)		11	11		26,699
Missile Range Instrumentation Ship	T-AGM	AGM 25	T-AGM (25)	1	20	15		52,251
Ocean Surveillance Ship	T-AGOS	AGOS 19	T-AGOS (19-22)	2	10	10		37,920
Ocean Surveillance Ship	T-AGOS	AGOS 23	T-AGOS (23)	2	12	12		42,598
Navigation Test Support	T-AGS	AGS 45	T-AGS (45)		13	12		51,730
Oceanographic Survey	T-AGS	AGS 60	T-AGS (60-66)	6	16	12		46,151
Submarine/Special Warfare Support	T-AGSE	AGSE 1	T-AGSE (1-4)	6	15	14		31,472
Hospital Ship	T-AH	AH 19	T-AH (19-20)	11	17	17	5	120,327
NDAF (Container Ships)	T-AK	AK 0323	T-AK (323)	14	16	16		38,886
Ro-Ro Container	T-AK	AK 3005	T-AK (3005-3007)	16	20	20		56,162
Ro-Ro Container	T-AK	AK 3008	T-AK (3008-3012)	15	18	18		78,000
Ro-Ro Container	T-AK	AK 3015	T-AK (3015-3017)	15	22	17		57,478
NDAF (Container Ships)	T-AK	AK 4296	T-AK (4296)	11	16	16		32,247
NDAF (Container Ships)	T-AK	AK 4396	T-AK (4396)	12	19	16		40,908
Container Ship	T-AK	AK 4496	T-AK (4543-4544)	12	21	18		53,189
U.S. Navy (Break-Bulk Ship)	T-AK	AK 451	T-AK (5029)	6	17	17		60,094
Dry Cargo Ship	T-AK	AK 4729	T-AK (4729)	10	16	16		55,212
Dry Cargo Ship	T-AK	AK 5158	T-AK (5158)	11	20	16		22,154
Dry Cargo Ship	T-AK	AK 5272	T-AK (5272)	12	20	16		29,920
Dry Cargo Ship	T-AK	AK 5307	T-AK 5307	8	14	13		5,401
NDAF (Container Ships)	T-AK	AK 5362	T-AK (5362)	12	19	16		40,657
Dry Cargo Ship	T-AK	AK 9205	T-AK (9205)	13	20	16		
Dry Cargo/Ammunition Ship	T-AKE	AKE 1	T-AKE (1-14)	13	20	20		133,436
Large Medium Speed Ro-Ro	T-AKR	AKR 295	T-AKR (295-298)	16	24	24		29,813
Large Medium Speed Ro-Ro	T-AKR	AKR 300	T-AKR (300-306)	16	24	24		45,078
Large Medium Speed Ro-Ro	T-AKR	AKR 310	T-AKR (310-317)	16	24	24		73,751
Fleet Replenishment Oilers	T-AO	AO 187	T-AO (187-204)	11	20	20		106,860
Fast Combat Support Ship	T-AOE	AOE 6	T-AOE (6-8, 10)	12	30	22		163,281
Tanker	T-AOT	AOT 1121	T-AOT (1122-1125)	4	16	16		46,786
Tanker	T-AOT	AOT 4995	T-AOT (4995)	4	15	15		20,975
Tanker	T-AOT	AOT 5205	T-AOT (5205)	4	15	15		62,424
Tanker	T-AOT	AOT 5246	T-AOT (5246)	4	15	15		57,633
Tanker	T-AOT	AOT 5356	T-AOT (5356)	4	14	14		28,531
Tanker	T-AOT	AOT 5406	T-AOT (5406)	4	15	15		71,122
Tanker	T-AOT	AOT 5419	T-AOT (5419)	4	15	15		50,839
Tanker	T-AOT	AP 1000	T-AOT (5193, 5246)	4	15	15		105,632
Cable Laying/Repair Ship	T-ARC	ARC 7	T-ARC (7)	2	16	14		83,468
Rescue And Salvage	T-ARS	ARS 50	T-ARS (50-53)	6	14	12		38,118
Submarine Tender	AS	AS 39	AS (39-40)	5	20	12		334,691
Fleet Ocean Tug	T-ATF	ATF 166	T-ATF (168-172)	4	15	13		24,635
Dry Cargo Ship	T-ATF	ATF 4247	T-ATF (4247)	4	6	6		7,163
Expeditionary Fast Transport	T-EPF	EPF 1	T-EPF (1-8)	16	43	35		48,009
Expeditionary Mobile Base	T-ESB	ESB 3	T-ESB (3)	30	15	15		65,614
Expeditionary Transfer Dock	T-ESD	ESD 1	T-ESD (1-2)	13	18	15		60,728
High Speed Vessel	T-HST	HST 1	T-HST (1)	7	40	33		33,144
High Speed Vessel	T-HST	HST 2	T-HST (2)	7	40	33		3,003
High Speed Vessel	HSV	HSV 1	T-HSV (2)	16	42	35		88,003
High Speed Vessel	HSV	HSV 4676	HSV (4676)	12	40	35		67,053
Command Ship	LCC	LCC 19	LCC (19-20)	9	23	16		213,499
Dry Cargo Ship	MB	MB 1219	MB (1219)	2	15	8		5,513

Table 56. Summary of RRF Utility Function Variable Findings by Class

Type Description	Type	Ship Class	Class Hull Numbers	Capability Composite Score	Maximum Speed	Maximum Range Speed	Number of Activation Days	Average Daily O&S Cost (CY 2017 USD)
				Si	Sm	Sr	Ai	Ci
Auxiliary Crane Ship	T-ACS	ACS 1	T-ACS (1-3)	8	18	17	5	533
Auxiliary Crane Ship	T-ACS	ACS 4	T-ACS (4-6)	9	19	17	5	688
Dry Cargo Ship	T-AK	AK 575	T-AK (5051)	6	17	17		1,857
Heavy-Lift Ship	T-AKR	AK 882	T-AKR (5063, 5065)	7	18	17	5	1,747
Dry Cargo Ship	T-AK	AK 981	T-AK (5070, 5073)	9	19	19	10	2,074
Large Medium Speed Ro-Ro	T-AKR	AKR 10	AKR (10-11, 5062, 5076)	15	21	19	5	522
Large Medium Speed Ro-Ro	T-AKR	AKR 1001	T-AKR (1001)	15	23	21	5	-10
Large Medium Speed Ro-Ro	T-AKR	AKR 112	T-AKR (112, 113, 9711)	14	17	15	5	738
Large Medium Speed Ro-Ro	T-AKR	AKR 2044	T-AKR (2044)	15	19	17	5	-302
Fast Sealift Ship	T-AKR	AKR 287	T-AKR (287-294)	12	30	27	5	619
Large Medium Speed Ro-Ro	T-AKR	AKR 5051	R (2024,5051-5055,5062)	14	17	16	5	468
Large Medium Speed Ro-Ro	T-AKR	AKR 5066	T-AKR (5066-5068)	15	19	17	5	307
Large Medium Speed Ro-Ro	T-AKR	AKR 5069	T-AKR (5069)	14	17	16	5	367
Large Medium Speed Ro-Ro	T-AKR	AKR 5082	T-AKR (5082-5083)	14	18	17	5	160
Large Medium Speed Ro-Ro	T-AKR	AKR 9666	T-AKR (9666, 9701)	14	16	15	5	-258
Large Medium Speed Ro-Ro	T-AKR	AKR 9678	AKR (9678, 9679, 9960)	15	19	18	5	4,687
Large Medium Speed Ro-Ro	T-AKR	AKR 9961	T-AKR (9961-9962)	14	17	16	5	1,273
OPDS Tanker	T-AOT	AOT 181	T-AOT (5084, 9101)	4	14	14	10	563
Aviation Logistics Support Ship	T-AVB	AVB 3	T-AVB (3, 4)	14	20	19	5	3,044

b. (RQ1) Find the optimal mix of ships to task during an HADR response

Time is of the essence when disaster strikes. Appendix D, Tables 59 to 82, are designed to provide decision makers with a quick reference tool to aid in selecting the right mix of HADR response ships, based on anticipated response duration, available ships, and their respective distance to the disaster location. Each disaster scenario is unique, as are the number, type, and location of ships that are available for HADR tasking. These unique features prevent a one-size fits all answer to the question of providing a pre-planned, optimal mix of ships that should be sent during an HADR response.

Since no disaster scenario is the same, this study provides a method of selecting the right mix of ships during future, real-world HADR scenarios. The quick reference utility tool allows mission planners to quickly look up the utility score of each available ship, rank them from highest to lowest utility score, and then select only those ships with the highest

utility scores above the threshold USAID/OFDA requested and/or CCDR authorized number of HADR response ships.

Commanders are intimately familiar with present force requirements and priorities. This study simply aids in sending the "right" mix of HADR ships based on a given pool of available ships and unpredictable real-world conditions that must be accounted for. Finally, to fully maximize the utility of an HADR response and minimize wasted resources, the available ship HADR utility scores should be cross-referenced with the reported response O&S costs for ships that possess similar HADR utility scores.

2. Secondary Research Questions

Admittedly, the sample size is small for answering the secondary research questions. However, the findings are statistically significant. I report HADR model (A) results in response to the secondary research questions to specifically answer SQ1. HADR model (B) is observed to explain a slightly higher percentage of the variance in the utility data. HADR (B) however does not speak to the extent that asset capability plays in maximizing the utility of HADR operations. Future studies can expand the scope of reported disasters to determine if the reported secondary question findings can be refined.

a. (SQ1) To what extent does asset capability play a role in maximizing the utility of HADR operations?

Based on the coefficient results provided in HADR model (A), I find that on average, while holding everything else constant, a one point increase in ship capability composite score is correlated with a 3.26 percent increase in the total utility provided by response ships, at a 99 percent level of confidence.

b. (SQ2) To what extent does asset proximity play a role in maximizing the utility of HADR operations?

Based on the coefficient results provided in HADR model (A), I find that on average, while holding everything else constant, a one day increase in HADR transit days is associated with a 5.79 percent decrease in the total utility provided by response ships, at a 99 percent level of confidence.

c. (SQ3) To what extent does asset cost play a role in maximizing the utility of HADR operations?

Based on the coefficient results provided in HADR model (A), I find that on average, while holding everything else constant, a one percent increase in response O&S costs is associated with a 0.1249 percent increase in total utility provided, at 99 percent confidence level.

d. (SQ4) To what extent does asset total response duration play in maximizing the utility of HADR operations?

Based on the coefficient results provided in HADR model (A), I find that on average, while holding everything else constant, a one day increase in the total number of response days is correlated with a 3.87 percent increase in the total utility provided by response ships, at a 99 percent level of confidence.

This concludes the results and analysis chapter of this study. Next, I provide conclusions, recommendations, and opportunities for further HADR research in Chapter VI.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This study demonstrates that without forethought, selecting the right mix of HADR response ships can be complicated, time consuming, and often detrimental to mission success if not done properly. There are many endogenous and exogenous factors that impact ship HADR utility and CCDR tasking decisions. Within the sphere of U.S. naval control are force structure allocations, inventory, ship type, service required capabilities, HADR policy, and to a lesser extent, O&S cost. Exogenous factors include disaster type, timing, location, world events, USG budget, HN need, and USAID/OFDA requested capabilities.

Due to the complex and unpredictable nature of disasters, specific plans do not exist for every HADR scenario. Each disaster response is different, requiring varying levels of U.S. naval HADR support to USAID, the HN, and the affected populations. Furthermore, CCDRs are intimately familiar with present force requirements and priorities that may limit the ships that can be sent during an HADR mission. This study simply aids in sending the "right" mix of HADR ships based on the utility of a given pool of available ships and not the unpredictable, real-world conditions that CCDRs are also burdened with balancing.

These complexities make it unrealistic to establish a one-size fits all package of ships that should be sent during an HADR response. The more efficient and effective method of providing the optimal mix of HADR response is to allow CCDRs and their staffs to rapidly make informed HADR tasking decisions based on the tools provided in this study. The utility function and quick reference tools maximize the utility of available ships that can be tasked for an HADR response while minimizing wasted USG resources that could be used for other priority tasking. Appendix D allows mission planners to quickly look up the utility score of each available ship, rank them from highest to lowest utility score, and then select only those ships with the highest utility scores above the threshold USAID/OFDA requested and/or CCDR authorized number of HADR response ships.

This study demonstrates that inventory, cost, capability, proximity, and response duration play significant roles in HADR utility calculations. In cases where low density capabilities (towing, hydrographic survey, etc.) are not required, the most efficient tasking of HADR vessels occurs when vessels with the highest capability composite score are sent in lieu of multiple, lesser capable ships. In Chapter V, I provide Tables 54 (USN), 55 (MSC), and 56 (RRF) that break the database into ship status groupings ranked by overall class HADR capability rating, from highest to lowest capability composite scores. USN status ships report the highest capability composite score of 65 points for LPD 1 class ships. MSC reports the next highest composite score of 30 points for ESB 3 class ships. RRF status ships report the lowest maximum composite score of 15 points, assigned to AKR 10 class ships. Submarines, patrol coastal craft, and Flight I and II Arleigh Burke-class destroyers are observed to have the lowest USN HADR capability composite scores. Tankers and special mission MSC ships like ocean surveillance ships, missile instrumentation ships, cable laying ships, and ocean tugs are observed to have the lowest MSC and RRF HADR capability composite scores. Despite low composite scores, most ship classes possess at least one unique HADR capability and should not be excluded from future HADR response considerations in the absence of other, more capable ships.

I have shown that overall ship capability composite scores are not the only factor to consider as unique capabilities matter. Sometimes individual and unique capabilities matter even more, as evidenced by the inclusion of T-ARS 51 during the 2010 Haiti earthquake response. T-ARS 51 serves as a reminder that overall capability score is not always the best metric when considering which ships to task during HADR missions since very few inventory ships are able to conduct the sea-based towing mission or the salvage and rescue mission. In Chapter V, I provide the breakdown of ship class capability ratings to detail which ships have unique capabilities in Tables 42 (USN), 43 (MSC), and 44 (RRF). The utility function allows mission planners to insert the unique capability values into the utility function for comparison instead of the composite score in cases where specific, unique, low density ships are requested.

To truly maximize utility, mission planners must consider O&S and incremental costs during the HADR tasking process, especially in cases where two ships, or a combination of ships, have similar utility ratings but significantly different O&S costs. In most cases, this study enables decision makers to pick the cheapest option while providing a high level of utility, selected from the available pool of ships. Lower costs, paired with high capability ratings minimize wasted resources and maximize vessel contributions to the affected population.

In pursuit of answering the secondary research questions, I demonstrated that the duration of an HADR response matters. Naturally, longer duration responses are highly correlated with increased utility and allow slower ships to respond within the given timeline. However, longer duration responses are correlated with increased cost. To mitigate the impact of these increased costs, mission planners must select the cheapest of the most highly rated utility ships to minimize the required response duration while simultaneously reducing the cost per unit of utility provided.

Proximity matters. Any increase in the number of transit days detracts from the utility provided to the affected population, especially for short response durations. This is not to say that the closest ships should be sent. The utility graphs and tables clearly demonstrate that some ships should never be sent in response to an HADR disaster. Conversely, the same graphs and tables show that it is better to wait on certain, more highly HADR utility rated ships. Every scenario requires careful analysis of the available ships and I expect that mission planners will use actual speeds that are appropriate for a given ship or class to determine the number of required transit days. These values may not be the open source speeds reported in this study, which may vary significantly from actual ship performance.

B. RECOMMENDATIONS

This HADR research project had one true goal - provide decisions makers with a comprehensive HADR utility tool that incorporates U.S. naval inventory, ship cost, capability, proximity, and response duration to maximize the combined utility of ships tasked to respond during a U.S. naval HADR operation. To this end, I recommend that

CCDRs assess the merit of this work and incorporate Appendix D, or similar, quick reference tables into HADR mission planning documents and action plans. Time is of the essence when disaster strikes and there are too many variables to account for on the spot.

Appendix D, Tables 59 to 82, are designed to provide decision makers with a quick reference tool to aid in selecting a highly HADR-capable mix of response ships, based on anticipated response duration, available ships, and their respective distance to the disaster location. Each disaster scenario is unique, as are the number, type, and location of ships that are available for HADR tasking. These unique features prevent a one-size fits all answer to the question of providing a pre-planned, optimal mix of ships that should be sent during an HADR response.

Current versions of the USAID Field Operators Guide, JP-29, and U.S Navy HADR manuals are missing ship HADR capability and utility decision matrices that could aid CCDRs in selecting the optimal mix of available HADR package vessel. Existing documentation describes cargo door and hold dimensions for aircraft but does not specifically call out naval ship capabilities, capacities, etc. I recommend adding two HADR U.S. naval ship planning options to these publications. The first option is to include the reported utility function along with the USN, MSC, and RRF capability and O&S summary tables provided in this study. The second, easier method, is to include the HADR quick reference utility and proximity tables generated for this study using class maximum range speeds. These two options provide decision makers with researched and pre-calculated HADR utility metrics for varying distances and response durations without the added pressure and time crunch induced by a recent disaster.

Tasking the “right” HADR ships in response to an emergent disaster is clearly a complicated business given the layered command structures and the world-wide distribution of limited ship inventories of each class. To respond quickly, it is not uncommon for combatant commanders to task the closest ships, without the luxury of time to fully consider how capable each ship is at conducting the HADR mission or whether waiting for a more distant but more capable ship would be better. This type of tasking can easily lend itself to wasting valuable U.S. resources (wartime assets, funding, manpower, and readiness) while providing a suboptimal HADR response to the affected population.

In an environment of constrained resources, it is important that these resources be used as efficiently and effectively as possible when responding to disasters around the world.

C. FUTURE RESEARCH OPPORTUNITIES

The study of U.S. naval involvement in the HADR mission has been fascinating. I was surprised to learn how much is still unknown about a mission that has been going on so long. There is much work yet to be done.

First, I must highlight that this study does not answer the question of what ships were available for tasking during the 2010 Haiti earthquake and 2011 Tohoku earthquake. It is impossible to claim with certainty that the secondary question solutions are complete without knowing what ships were available at disaster onset. Other ships may have been available with higher HADR utility ratings that were not tasked. These ships could have an impact on future results. As of 2013, the number of months that a USN ship is assigned to each CCDR is reported in the VAMOSC. This piece of information may be helpful to future researchers if the study only includes disasters after 2013. I must note that similar data is not reported for MSC or RRF ships.

Admittedly, this study only includes two U.S. Navy HADR responses to sudden, unexpected earthquake scenarios. Clearly, there is room to expand the scope of this study to incorporate a more diverse set of U.S. naval disaster responses into the model, particularly for the secondary research questions. I recommend the inclusion of slow and rapid onset disasters with localized and dispersed intensities per Apte (2009). Should there be future iterations of this study, I recommend including maximum range rules in utility calculations if all data is available.

Finally, future studies can combine the utility function with performance metric feedback which includes itemized HN HADR requests, OFDA requests, and equivalent Navy provided support. This information will help refine and validate the utility function.

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APPENDIX A. USN DATABASE SHIPS

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
CG	CG 47	BUNKER HILL	CG-0052	59.0	69.7	89.6	66.0	68.1	109.8	73.1	78.4	613,657,472
CG	CG 47	MOBILE BAY	CG-0053	71.9	66.8	71.7	87.7	69.8	74.3	75.8	86.2	604,205,056
CG	CG 47	ANTIETAM	CG-0054	96.5	76.2	73.4	78.9	79.6	80.9	76.1	58.0	619,581,888
CG	CG 47	LEYTE GULF	CG-0055	62.9	64.6	118.8	52.7	72.0	67.1	103.6	73.8	615,303,744
CG	CG 47	SAN JACINTO	CG-0056	69.8	117.0	76.1	74.5	81.9	106.2	85.5	69.2	680,139,200
CG	CG 47	LAKE CHAMPLAIN	CG-0057	62.1	82.7	73.2	61.9	66.9	105.4	73.4	75.8	601,432,384
CG	CG 47	PHILIPPINE SEA	CG-0058	80.0	67.4	69.0	55.3	72.2	81.8	71.9	74.3	571,919,232
CG	CG 47	PRINCETON	CG-0059	74.0	71.1	64.8	110.6	72.8	75.5	75.8	69.3	613,857,408
CG	CG 47	NORMANDY	CG-0060	68.2	59.3	70.7	136.7	74.0	79.4	80.0	73.7	641,949,248
CG	CG 47	MONTEREY	CG-0061	100.6	78.9	65.0	63.2	107.4	109.5	83.8	71.2	679,611,072
CG	CG 47	CHANCELLORSVILLE	CG-0062	64.1	72.2	80.7	63.9	78.0	79.0	91.5	75.0	604,275,776
CG	CG 47	COWPENS	CG-0063	76.1	76.9	73.0	67.9	77.2	124.8	25.1	39.2	560,257,088
CG	CG 47	GETTYSBURG	CG-0064	63.1	68.3	58.2	63.3	68.1	128.1	89.6	61.3	599,903,872
CG	CG 47	CHOSIN	CG-0065	77.0	173.3	99.6	66.6	65.9	74.3	57.2	28.8	642,687,360
CG	CG 47	HUE CITY	CG-0066	73.9	91.2	64.9	65.6	65.8	71.6	70.2	69.8	572,883,456
CG	CG 47	SHILOH	CG-0067	79.6	83.4	82.0	71.8	75.7	81.0	73.3	67.0	613,782,656
CG	CG 47	ANZIO	CG-0068	66.9	63.8	51.2	46.7	58.7	72.4	77.7	71.3	508,606,976
CG	CG 47	VICKSBURG	CG-0069	68.5	57.4	67.6	58.0	66.4	84.0	52.9	74.4	529,206,912
CG	CG 47	LAKE ERIE	CG-0070	70.6	71.0	71.9	67.6	124.2	88.8	90.9	76.2	661,239,552
CG	CG 47	CAPE ST GEORGE	CG-0071	58.9	71.1	84.0	60.2	69.5	143.4	66.5	53.9	607,521,728
CG	CG 47	VELLA GULF	CG-0072	72.2	65.1	63.6	95.1	88.5	100.3	91.9	69.9	646,645,824
CG	CG 47	PORT ROYAL	CG-0073	84.3	103.8	58.7	61.2	69.7	81.5	74.7	78.9	612,831,360
CVN	CVN 65	ENTERPRISE	CVN-0065	503.7	320.2	284.1	205.4					1,313,449,472
CVN	CVN 68	NIMITZ	CVN-0068	359.3	557.9	330.5	315.7	330.2	503.9	425.0	324.6	3,146,934,272
CVN	CVN 68	DWIGHT D EISENHOWER	CVN-0069	346.6	387.2	329.8	407.9	597.1	401.1	323.4	380.7	3,173,848,576
CVN	CVN 68	CARL VINSON	CVN-0070	391.1	436.6	585.2	492.1	310.8	464.2	421.0	336.8	3,437,839,872
CVN	CVN 68	THEODORE ROOSEVELT	CVN-0071	1138.3	1225.3	856.3	548.0	305.4	315.3	518.1	349.2	5,255,952,384
CVN	CVN 68	ABRAHAM LINCOLN	CVN-0072	339.2	409.4	543.2	813.7	1265.0	1018.2	744.2	254.7	5,387,588,096
CVN	CVN 68	GEORGE WASHINGTON	CVN-0073	485.4	474.4	500.0	507.4	476.0	484.6	451.3	343.5	3,722,579,712
CVN	CVN 68	JOHN C STENNIS	CVN-0074	380.8	287.5	318.3	410.0	416.4	301.3	345.8	433.3	2,893,551,104
CVN	CVN 68	HARRY S TRUMAN	CVN-0075	328.5	426.6	383.3	288.6	344.9	347.3	433.2	452.8	3,005,178,880
CVN	CVN 68	RONALD REAGAN	CVN-0076	407.9	374.2	591.9	330.4	456.0	435.8	453.2	430.8	3,480,259,584
CVN	CVN 68	GEORGE H W BUSH	CVN-0077	288.0	293.7	340.6	289.5	304.2	448.3	471.0	305.8	2,741,103,616
CVN	CVN 78	GERALD R FORD	CVN-0078								119.2	119,167,440

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
DDG	DDG 51	ARLEIGH BURKE	DDG-0051	59.9	100.5	66.3	78.3	155.9	102.9	121.8	62.5	748,045,952
DDG	DDG 51	BARRY	DDG-0052	54.5	138.5	125.7	85.7	91.6	79.1	62.9	60.0	698,065,280
DDG	DDG 51	JOHN PAUL JONES	DDG-0053	176.1	86.3	99.7	75.1	68.3	89.1	88.7	95.4	778,529,856
DDG	DDG 51	CURTIS WILBUR	DDG-0054	64.1	55.3	89.6	74.7	116.0	68.3	68.3	82.9	619,225,728
DDG	DDG 51	STOUT	DDG-0055	53.3	66.3	101.0	57.4	79.7	71.7	66.2	60.9	556,501,824
DDG	DDG 51	JOHN S MCCAIN	DDG-0056	59.2	57.0	66.6	96.5	88.8	141.6	115.4	69.0	694,135,296
DDG	DDG 51	MITSCHER	DDG-0057	50.1	70.0	58.0	182.8	74.0	159.2	96.8	66.5	757,375,808
DDG	DDG 51	LABOON	DDG-0058	47.5	71.6	59.1	77.2	86.4	81.9	71.5	65.5	560,774,400
DDG	DDG 51	RUSSELL	DDG-0059	60.8	74.7	69.4	96.4	81.4	75.5	112.6	71.8	642,577,856
DDG	DDG 51	PAUL HAMILTON	DDG-0060	99.3	59.2	58.7	56.7	65.9	91.3	108.9	60.4	600,632,512
DDG	DDG 51	RAMAGE	DDG-0061	72.6	62.2	91.7	78.7	60.5	96.5	132.9	86.5	681,594,816
DDG	DDG 51	FITZGERALD	DDG-0062	64.1	69.6	64.4	64.9	74.1	70.8	71.7	62.7	542,393,920
DDG	DDG 51	STETHEM	DDG-0063	67.2	65.6	63.5	62.6	64.4	74.2	88.2	70.3	555,933,568
DDG	DDG 51	CARNEY	DDG-0064	55.4	59.0	78.6	63.7	62.2	75.2	77.0	82.5	553,783,232
DDG	DDG 51	BENFOLD	DDG-0065	70.3	155.7	64.8	80.6	55.2	71.5	75.7	84.8	658,516,608
DDG	DDG 51	GONZALEZ	DDG-0066	47.8	49.9	45.8	53.6	69.2	81.6	128.6	104.7	581,169,408
DDG	DDG 51	COLE	DDG-0067	60.8	52.6	51.2	52.0	52.0	71.7	73.4	67.6	481,273,024
DDG	DDG 51	THE SULLIVANS	DDG-0068	57.2	51.9	73.0	71.2	140.1	86.4	76.9	83.3	640,074,688
DDG	DDG 51	MILIUS	DDG-0069	75.8	67.1	86.2	155.3	82.7	212.6	65.1	77.3	822,158,848
DDG	DDG 51	HOPPER	DDG-0070	62.9	64.7	71.0	59.3	64.0	59.4	94.8	93.4	569,311,296
DDG	DDG 51	ROSS	DDG-0071	46.9	51.7	54.0	72.7	67.0	75.4	86.4	92.0	546,201,536
DDG	DDG 72	MAHAN	DDG-0072	54.6	56.9	54.0	64.8	48.5	108.7	61.3	57.4	506,245,216
DDG	DDG 72	DECATUR	DDG-0073	51.1	61.8	51.1	60.0	103.0	67.3	74.1	95.4	563,844,800
DDG	DDG 72	MCFAUL	DDG-0074	57.5	50.6	53.2	47.4	73.3	85.8	144.4	96.2	608,467,072
DDG	DDG 72	DONALD COOK	DDG-0075	47.8	49.3	71.7	72.5	71.0	67.3	75.9	63.9	519,344,608
DDG	DDG 72	HIGGINS	DDG-0076	59.8	56.8	48.9	65.0	62.4	70.9	105.2	70.7	539,682,752
DDG	DDG 72	O'KANE	DDG-0077	72.3	56.4	63.0	63.3	69.7	112.9	66.6	65.2	569,436,160
DDG	DDG 72	PORTER	DDG-0078	52.2	49.9	57.9	65.6	107.4	87.6	86.2	92.7	599,550,848
DDG	DDG 79	OSCAR AUSTIN	DDG-0079	46.2	56.6	49.9	53.8	53.6	68.6	84.4	63.4	476,536,256
DDG	DDG 79	ROOSEVELT	DDG-0080	71.5	59.3	53.2	51.7	66.3	70.0	107.5	130.6	610,155,456
DDG	DDG 79	WINSTON S CHURCHILL	DDG-0081	57.1	74.6	52.6	48.5	55.2	68.0	68.7	58.3	482,936,128
DDG	DDG 79	LASSEN	DDG-0082	63.1	66.1	67.2	59.5	62.6	66.0	58.0	71.6	514,030,720
DDG	DDG 79	HOWARD	DDG-0083	50.7	54.8	73.0	48.2	74.6	59.2	71.6	62.7	494,875,616
DDG	DDG 79	BULKELEY	DDG-0084	44.3	58.6	72.8	51.8	60.1	64.7	70.7	81.8	504,702,304
DDG	DDG 79	MCCAMPBELL	DDG-0085	62.5	71.7	73.1	61.4	107.6	61.2	70.7	85.1	593,341,376
DDG	DDG 79	SHOUP	DDG-0086	46.4	78.1	44.6	55.4	71.7	55.2	65.3	59.1	475,809,120
DDG	DDG 79	MASON	DDG-0087	60.0	73.8	70.8	54.4	68.3	70.8	72.7	78.1	548,895,424
DDG	DDG 79	PREBLE	DDG-0088	47.2	86.2	51.0	54.4	57.1	67.3	67.2	68.9	499,325,216
DDG	DDG 79	MUSTIN	DDG-0089	61.2	59.7	74.4	64.5	66.7	69.1	71.2	60.6	527,410,752

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
DDG	DDG 79	CHAFEE	DDG-0090	55.7	55.7	58.8	63.3	69.8	78.0	76.1	70.3	527,627,712
DDG	DDG 79	PINCKNEY	DDG-0091	54.6	51.5	59.3	47.2	96.3	71.5	66.4	68.0	514,927,104
DDG	DDG 79	MOMSEN	DDG-0092	46.7	53.9	50.9	49.1	110.3	47.5	67.8	78.3	504,586,304
DDG	DDG 79	CHUNG-HOON	DDG-0093	58.3	58.0	57.0	57.3	91.8	64.4	72.4	79.2	538,478,912
DDG	DDG 79	NITZE	DDG-0094	46.2	43.2	51.7	45.7	70.6	90.8	73.8	68.3	490,309,632
DDG	DDG 79	JAMES E WILLIAMS	DDG-0095	51.0	55.2	59.0	53.8	57.7	63.3	88.5	64.8	493,157,568
DDG	DDG 79	BAINBRIDGE	DDG-0096	45.5	60.9	56.1	51.2	56.1	62.8	68.9	67.9	469,323,744
DDG	DDG 79	HALSEY	DDG-0097	47.0	57.0	52.7	46.8	70.0	81.1	69.1	71.6	495,281,760
DDG	DDG 79	FORREST SHERMAN	DDG-0098	48.0	53.3	46.0	43.2	50.7	60.4	90.0	62.7	454,394,016
DDG	DDG 79	FARRAGUT	DDG-0099	54.2	45.6	51.4	57.7	54.8	68.2	76.1	77.1	485,088,928
DDG	DDG 79	KIDD	DDG-0100	52.8	53.6	61.7	46.6	59.9	102.4	62.6	62.9	502,496,512
DDG	DDG 79	GRIDLEY	DDG-0101	52.3	54.0	48.5	50.3	52.7	67.6	95.6	111.8	532,646,528
DDG	DDG 79	SAMPSON	DDG-0102	54.6	45.8	50.4	48.1	52.9	73.0	60.5	61.7	447,082,592
DDG	DDG 79	TRUXTUN	DDG-0103	37.8	49.4	45.4	57.1	54.7	55.3	58.9	60.6	419,149,824
DDG	DDG 79	STERETT	DDG-0104	42.5	55.2	53.9	45.6	52.4	75.1	57.5	61.0	443,136,352
DDG	DDG 79	DEWEY	DDG-0105	41.4	47.2	52.3	44.4	51.9	71.5	60.3	62.4	431,407,840
DDG	DDG 79	STOCKDALE	DDG-0106	45.2	53.6	46.2	56.5	52.9	63.5	100.4	54.5	472,789,056
DDG	DDG 79	GRAVELY	DDG-0107		44.9	40.4	51.3	44.7	56.8	69.3	68.3	375,687,928
DDG	DDG 79	WAYNE E MEYER	DDG-0108	36.3	50.1	52.7	43.6	54.0	61.1	59.8	62.1	419,819,680
DDG	DDG 79	JASON DUNHAM	DDG-0109		46.4	44.1	45.3	48.6	66.0	63.1	57.2	370,593,804
DDG	DDG 79	WILLIAM P LAWRENCE	DDG-0110		33.0	43.5	56.8	51.7	58.9	68.2	75.0	387,049,320
DDG	DDG 79	SPRUANCE	DDG-0111			43.7	47.3	57.4	56.9	69.3	83.4	358,095,336
DDG	DDG 79	MICHAEL MURPHY	DDG-0112				48.5	57.5	69.9	64.0	66.0	305,839,760
DDG	DDG 79	JOHN FINN	DDG-0113								46.0	46,049,252
DDG	DDG 79	RAFAEL PERALTA	DDG-0115								39.0	38,970,404
DDG	DDG 1000	ZUMWALT	DDG-1000								28.9	28,922,260
FFG	FFG 7	MCINERNEY	FFG-0008	23.2								23,244,542
FFG	FFG 7	JOHN L HALL	FFG-0032	31.4	29.2	8.1						68,747,922
FFG	FFG 7	JARRETT	FFG-0033	32.6	18.0							50,613,232
FFG	FFG 7	UNDERWOOD	FFG-0036	32.3	28.6	30.6	9.3					100,864,768
FFG	FFG 7	HALYBURTON	FFG-0040	32.0	42.6	37.4	33.4	24.6				169,937,600
FFG	FFG 7	THACH	FFG-0043	42.1	37.1	30.8	29.2	4.4				143,558,930
FFG	FFG 7	DE WERT	FFG-0045	33.1	45.2							78,223,936
FFG	FFG 7	RENTZ	FFG-0046	38.1	34.7	34.9	32.0	19.4				159,103,660
FFG	FFG 7	NICHOLAS	FFG-0047	39.3	38.9	29.9	29.4	12.1				149,599,520
FFG	FFG 7	VANDEGRIFT	FFG-0048	30.9	36.6	38.9	38.3	37.4	16.5			198,559,188
FFG	FFG 7	ROBERT G BRADLEY	FFG-0049	40.2	42.3							82,512,392
FFG	FFG 7	TAYLOR	FFG-0050	42.7	33.7	38.0	38.6	32.6	20.1			205,666,920
FFG	FFG 7	GARY	FFG-0051	38.6	35.8	32.2						106,699,872

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
FFG	FFG 7	CARR	FFG-0052	31.8	41.9	27.6	11.2					112,495,336
FFG	FFG 7	HAWES	FFG-0053	23.1	5.4							28,455,824
FFG	FFG 7	FORD	FFG-0054	29.0	35.3	27.4	21.9	2.2				115,695,020
FFG	FFG 7	ELROD	FFG-0055	37.2	32.5	32.5						102,256,680
FFG	FFG 7	REUBEN JAMES	FFG-0057	42.0	34.7	41.4	25.7					143,791,392
FFG	FFG 7	SAMUEL B ROBERTS	FFG-0058	40.4	47.5	48.0						135,819,672
FFG	FFG 7	KAUFFMAN	FFG-0059	36.9	39.3	42.5	33.3					152,088,032
FFG	FFG 7	RODNEY M DAVIS	FFG-0060					30.1	14.5			44,633,184
FFG	FFG 7	INGRAHAM	FFG-0061	49.9	36.0	34.3	26.7					146,886,320
LCC	LCC 19	BLUE RIDGE	LCC-0019	97.5	105.4	118.1	110.4	110.4	139.2	89.8	79.3	850,093,440
LCS	LCS 1	FREEDOM	LCS-0001	40.0	25.2	33.2	42.9	23.5	66.3	39.7	33.6	304,436,032
LCS	LCS 2	INDEPENDENCE	LCS-0002	18.3	20.0	25.6	41.5	27.9	69.4	54.4	25.9	282,928,512
LCS	LCS 1	FORT WORTH	LCS-0003			11.7	24.4	25.9	44.7	39.5	55.5	201,666,072
LCS	LCS 2	CORONADO	LCS-0004					38.0	33.7	34.3	19.6	125,650,496
LCS	LCS 1	MILWAUKEE	LCS-0005							15.4	18.6	34,083,512
LCS	LCS 2	JACKSON	LCS-0006							21.6	25.0	46,598,888
LCS	LCS 1	DETROIT	LCS-0007								20.2	20,226,428
LCS	LCS 2	MONTGOMERY	LCS-0008							14.3	19.4	33,700,560
LCS	LCS 2	GABRIELLE GIFFORDS	LCS-0010								14.1	14,105,418
LHA	LHA 1	NASSAU	LHA-0004	142.0	54.5							196,514,544
LHA	LHA 1	PELELIU	LHA-0005	163.9	171.7	149.7	170.7	128.0	61.3			845,361,408
LHA	LHA 6	AMERICA	LHA-0006						191.7	139.4	142.5	473,647,440
LHD	LHD 1	WASP	LHD-0001	134.4	144.0	130.7	149.3	329.9	186.3	193.7	232.7	1,501,041,792
LHD	LHD 1	ESSEX	LHD-0002	180.7	157.9	304.5	172.7	167.0	182.1	322.7	159.7	1,647,323,904
LHD	LHD 1	KEARSARGE	LHD-0003	179.3	147.5	159.1	167.9	160.5	143.6	155.1	169.9	1,282,929,152
LHD	LHD 1	BOXER	LHD-0004	239.5	163.1	164.0	143.2	201.6	173.2	166.6	258.6	1,509,848,576
LHD	LHD 1	BATAAN	LHD-0005	159.0	139.3	143.7	129.1	131.8	208.9	195.4	151.4	1,258,679,168
LHD	LHD 1	BONHOMME RICHARD	LHD-0006	213.5	209.3	144.0	157.9	141.6	150.3	151.8	144.6	1,312,935,168
LHD	LHD 1	IWO JIMA	LHD-0007	135.4	114.4	124.4	176.9	158.5	157.5	183.3	139.0	1,189,341,184
LHD	LHD 1	MAKIN ISLAND	LHD-0008	114.2	125.1	151.0	121.5	147.9	188.9	158.5	197.7	1,204,707,200
LPD	LPD 4	CLEVELAND	LPD-0007	73.4	55.0							128,385,792
LPD	LPD 4	DUBUQUE	LPD-0008	60.8	32.3							93,089,232
LPD	LPD 4	DENVER	LPD-0009	65.8	71.6	70.5	68.5	43.0				319,363,600
LPD	LPD 4	PONCE	LPD-0015	64.0	49.6							113,613,984
LPD	LPD 17	SAN ANTONIO	LPD-0017	86.5	68.1	47.8	59.9	69.9	69.5	67.8	144.7	614,158,336
LPD	LPD 17	NEW ORLEANS	LPD-0018	54.0	70.9	90.6	64.2	89.3	69.8	69.7	83.1	591,468,800
LPD	LPD 17	MESA VERDE	LPD-0019	55.7	69.1	67.0	60.4	61.9	78.6	89.3	64.1	546,143,296
LPD	LPD 17	GREEN BAY	LPD-0020	44.3	82.0	62.4	99.2	66.8	67.9	72.9	60.5	555,975,872
LPD	LPD 17	NEW YORK	LPD-0021	38.0	40.9	50.7	64.4	62.5	65.6	101.5	66.0	489,594,336

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
LPD	LPD 17	SAN DIEGO	LPD-0022			39.2	50.5	59.5	87.6	65.6	61.5	363,879,744
LPD	LPD 17	ANCHORAGE	LPD-0023				46.7	53.6	71.2	99.8	56.6	327,889,780
LPD	LPD 17	ARLINGTON	LPD-0024				39.8	42.9	56.3	63.3	69.0	271,296,160
LPD	LPD 17	SOMERSET	LPD-0025					43.0	57.6	65.3	83.2	249,187,024
LPD	LPD 17	JOHN P MURTHA	LPD-0026								48.3	48,265,364
LSD	LSD 41	WHIDBEY ISLAND	LSD-0041	113.5	59.8	48.4	46.9	49.2	64.2	62.5	44.2	488,791,968
LSD	LSD 41	GERMANTOWN	LSD-0042	81.9	49.8	60.0	53.0	53.1	62.3	64.7	59.6	484,304,032
LSD	LSD 41	FORT MCHENRY	LSD-0043	185.9	122.1	66.0	57.1	50.1	57.2	56.2	78.2	672,837,888
LSD	LSD 41	GUNSTON HALL	LSD-0044	59.9	46.6	47.4	49.7	53.5	61.8	133.4	48.6	500,900,960
LSD	LSD 41	COMSTOCK	LSD-0045	61.1	79.3	181.3	81.4	55.3	100.1	69.1	106.5	734,069,824
LSD	LSD 41	TORTUGA	LSD-0046	53.1	56.5	51.9	49.2	55.9	50.5	78.3	71.2	466,542,656
LSD	LSD 41	RUSHMORE	LSD-0047	139.4	70.4	48.7	57.9	53.0	61.5	110.5	60.2	601,648,640
LSD	LSD 41	ASHLAND	LSD-0048	73.1	194.5	136.5	65.1	49.7	51.9	54.9	54.0	679,785,280
LSD	LSD 49	HARPERS FERRY	LSD-0049	70.4	168.8	70.9	60.4	67.8	75.3	61.7	102.2	677,535,872
LSD	LSD 49	CARTER HALL	LSD-0050	63.3	57.6	70.2	63.4	211.6	141.8	91.4	58.0	757,285,120
LSD	LSD 49	OAK HILL	LSD-0051	70.4	71.3	141.7	153.4	62.2	52.4	58.3	71.8	681,509,248
LSD	LSD 49	PEARL HARBOR	LSD-0052	59.9	79.2	60.2	62.6	230.3	85.8	73.4	58.5	709,854,464
MCM	MCM 1	AVENGER	MCM-0001	21.7	28.7	23.7	16.2	10.8				101,055,960
MCM	MCM 1	DEFENDER	MCM-0002	18.1	22.6	16.7	17.5	10.2				85,023,560
MCM	MCM 1	SENTRY	MCM-0003	16.1	22.1	15.9	15.8	22.7	19.9	20.8	17.0	150,381,792
MCM	MCM 1	CHAMPION	MCM-0004	19.6	18.7	19.7	16.9	16.4	19.0	17.0	17.2	144,424,544
MCM	MCM 1	GUARDIAN	MCM-0005	21.2	18.5	18.9	7.2					65,764,084
MCM	MCM 1	DEVASTATOR	MCM-0006	16.9	25.8	14.6	19.0	19.7	18.8	19.1	15.0	148,800,608
MCM	MCM 1	PATRIOT	MCM-0007	16.5	22.5	17.4	23.6	18.9	15.9	20.2	17.3	152,371,776
MCM	MCM 1	SCOUT	MCM-0008	17.2	20.6	16.1	15.8	23.6	20.9	20.2	16.6	151,127,008
MCM	MCM 1	PIONEER	MCM-0009	15.0	22.5	21.9	22.0	18.5	19.6	18.8	18.7	157,055,632
MCM	MCM 1	WARRIOR	MCM-0010	15.4	20.8	15.6	20.8	25.0	19.1	19.7	20.3	156,698,224
MCM	MCM 1	GLADIATOR	MCM-0011	14.6	16.5	19.6	15.4	18.8	17.5	18.1	15.3	135,745,488
MCM	MCM 1	ARDENT	MCM-0012	17.2	19.7	16.9	15.8	22.9	21.5	29.2	20.3	163,354,048
MCM	MCM 1	DEXTROUS	MCM-0013	16.1	20.4	19.4	16.7	14.4	18.2	18.4	16.5	140,082,416
MCM	MCM 1	CHIEF	MCM-0014	17.3	19.2	19.7	15.9	18.8	21.8	18.4	16.4	147,514,144
PC	PC 1	TEMPEST	PC-0002	1.9	3.8	38.2	10.9	8.8	11.6	6.9	6.5	88,580,104
PC	PC 1	HURRICANE	PC-0003	3.6	3.3	3.5	11.7	11.9	9.5	9.0	6.6	59,160,172
PC	PC 1	MONSOON	PC-0004	1.1	1.8	2.4	13.1	12.0	9.4	7.5	7.2	54,614,196
PC	PC 1	TYPHOON	PC-0005	8.2	7.1	3.2	7.9	8.2	8.5	7.6	7.8	58,494,384
PC	PC 1	SIROCCO	PC-0006	10.5	4.5	3.3	8.8	8.4	9.5	10.7	8.3	64,051,548
PC	PC 1	SQUALL	PC-0007	1.6	5.4	29.7	9.2	6.4	12.5	6.2	7.4	78,332,352
PC	PC 1	ZEPHYR	PC-0008			1.4	1.3	6.2	19.0	9.5	6.9	44,176,719
PC	PC 1	CHINOOK	PC-0009	8.9	2.2	4.4	7.3	5.0	8.3	8.8	6.7	51,537,280

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
PC	PC 1	FIREBOLT	PC-0010	8.8	3.4	5.5	5.2	6.3	9.3	10.0	7.1	55,580,116
PC	PC 1	WHIRLWIND	PC-0011	8.2	2.5	5.9	4.5	7.1	8.8	6.4	6.4	49,806,044
PC	PC 1	THUNDERBOLT	PC-0012	2.1	4.5	25.2	11.3	4.8	8.7	7.7	6.1	70,309,896
PC	PC 1	SHAMAL	PC-0013			1.2	3.3	18.8	9.7	6.5	9.6	49,151,937
PC	PC 1	TORNADO	PC-0014			1.1	2.0	4.1	24.5	10.6	16.8	59,070,138
SSBN	SSBN 726	HENRY M JACKSON	SSBN-0730	59.0	56.1	59.4	57.1	57.6	65.2	67.3	111.3	533,110,464
SSBN	SSBN 726	ALABAMA	SSBN-0731	59.9	59.4	60.2	55.9	60.4	61.5	63.4	63.7	484,450,976
SSBN	SSBN 726	ALASKA	SSBN-0732	107.8	56.7	59.9	62.2	59.4	63.1	62.2	60.4	531,534,176
SSBN	SSBN 726	NEVADA	SSBN-0733	78.4	52.3	56.8	65.3	59.8	58.0	69.0	61.7	501,240,992
SSBN	SSBN 726	TENNESSEE	SSBN-0734	119.7	137.1	103.8	274.4	65.3	63.4	76.7	63.2	903,614,400
SSBN	SSBN 726	PENNSYLVANIA	SSBN-0735	162.9	170.2	105.0	115.5	57.6	119.0	65.4	54.2	849,751,872
SSBN	SSBN 726	WEST VIRGINIA	SSBN-0736	76.4	155.4	161.3	138.1	168.4	62.2	159.4	67.6	988,836,800
SSBN	SSBN 726	KENTUCKY	SSBN-0737	67.0	91.0	171.9	175.4	123.3	80.8	120.7	220.3	1,050,282,752
SSBN	SSBN 726	MARYLAND	SSBN-0738	261.7	59.4	277.6	193.8	181.7	146.4	138.2	66.1	1,324,825,600
SSBN	SSBN 726	NEBRASKA	SSBN-0739	57.5	158.6	64.2	86.7	156.6	197.9	151.2	84.0	956,536,576
SSBN	SSBN 726	RHODE ISLAND	SSBN-0740	58.6	60.6	55.5	65.2	81.0	89.4	225.3	189.2	824,864,768
SSBN	SSBN 726	MAINE	SSBN-0741	60.5	54.8	60.0	60.8	62.6	105.9	118.4	265.7	788,495,232
SSBN	SSBN 726	WYOMING	SSBN-0742	77.3	56.7	58.1	73.8	57.2	64.6	60.7	85.9	534,364,736
SSBN	SSBN 726	LOUISIANA	SSBN-0743	59.4	82.2	57.2	55.7	228.9	103.7	67.2	57.7	712,046,528
SSGN	SSGN 726	OHIO	SSGN-0726	77.9	62.8	82.9	53.9	106.5	90.6	60.4	120.1	655,060,992
SSGN	SSGN 726	MICHIGAN	SSGN-0727	75.2	87.4	57.2	82.3	57.6	96.3	153.8	56.1	665,873,536
SSGN	SSGN 726	FLORIDA	SSGN-0728	48.5	64.8	49.7	71.1	55.8	45.7	68.2	54.4	458,148,032
SSGN	SSGN 726	GEORGIA	SSGN-0729	56.7	46.8	58.9	47.9	55.4	65.5	47.1	47.9	426,224,704
SSN	SSN 21	SEAWOLF	SSN-0021	106.4	99.8	57.8	39.3	50.6	62.4	89.7	99.8	605,831,232
SSN	SSN 21	CONNECTICUT	SSN-0022	43.8	66.3	102.8	130.8	94.7	95.0	63.3	51.6	648,296,128
SSN	SSN 21	JIMMY CARTER	SSN-0023	106.0	57.7	47.3	108.8	73.2	55.7	45.0	50.8	544,515,840
SSN	SSN 688	LOS ANGELES	SSN-0688	15.5								15,478,460
SSN	SSN 688	PHILADELPHIA	SSN-0690	16.1								16,062,027
SSN	SSN 688	MEMPHIS	SSN-0691	19.6	15.9							35,474,096
SSN	SSN 688	BREMERTON	SSN-0698	60.5	29.7	30.3	29.1	66.3	39.0	31.2	36.6	322,578,784
SSN	SSN 688	JACKSONVILLE	SSN-0699	33.2	64.2	29.7	35.4	33.4	27.9	36.6	28.3	288,693,056
SSN	SSN 688	DALLAS	SSN-0700	43.8	22.2	22.9	22.1	28.0	54.8	24.9	21.5	240,253,056
SSN	SSN 688	LA JOLLA	SSN-0701	39.7	27.1	27.9	26.5	29.3	24.1			174,578,184
SSN	SSN 688	CITY OF CORPUS CHRISTI	SSN-0705	42.9	54.3	65.3	30.4	28.8	36.7	22.5		280,848,428
SSN	SSN 688	ALBUQUERQUE	SSN-0706	45.6	31.5	32.8	38.8	65.4	29.8	17.3		261,035,068
SSN	SSN 688	SAN FRANCISCO	SSN-0711	35.5	60.7	35.1	25.5	30.3	39.1	30.2	30.6	286,806,464
SSN	SSN 688	HOUSTON	SSN-0713	35.8	33.6	58.4	27.8	30.3	35.3	25.6		246,678,320
SSN	SSN 688	NORFOLK	SSN-0714	28.0	61.1	21.0	32.0	26.4	15.6			184,092,612
SSN	SSN 688	BUFFALO	SSN-0715	33.0	30.4	30.0	82.5	53.1	39.8	31.4	35.7	335,965,280

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
SSN	SSN 688	OLYMPIA	SSN-0717	32.0	65.6	26.8	27.9	35.2	69.0	48.2	40.9	345,597,152
SSN	SSN 688	PROVIDENCE	SSN-0719	34.0	28.5	23.7	23.4	34.1	39.0	93.4	50.9	326,906,304
SSN	SSN 688	PITTSBURGH	SSN-0720	25.1	40.6	58.8	68.2	23.7	26.5	25.6	23.1	291,674,144
SSN	SSN 688	CHICAGO	SSN-0721	119.9	64.8	28.4	26.6	30.4	28.6	32.3	40.2	371,071,648
SSN	SSN 688	KEY WEST	SSN-0722	77.2	102.6	64.3	29.0	29.9	28.9	30.1	37.5	399,552,704
SSN	SSN 688	OKLAHOMA CITY	SSN-0723	69.5	30.8	28.1	38.3	41.4	33.6	82.1	36.0	359,730,272
SSN	SSN 688	LOUISVILLE	SSN-0724	30.6	34.6	32.8	82.3	31.3	43.9	39.8	27.7	323,060,608
SSN	SSN 688	HELENA	SSN-0725	133.2	61.4	22.8	23.0	32.3	37.2	32.9	21.2	363,974,688
SSN	SSN 688	NEWPORT NEWS	SSN-0750	40.2	73.1	92.9	110.1	53.9	31.9	28.8	34.6	465,695,392
SSN	SSN 688	SAN JUAN	SSN-0751	98.5	93.0	40.8	29.2	23.5	32.5	26.2	32.7	376,422,112
SSN	SSN 688	PASADENA	SSN-0752	42.7	54.1	121.6	79.1	29.2	30.4	42.0	30.0	429,121,696
SSN	SSN 688	ALBANY	SSN-0753	25.0	57.0	39.7	58.1	137.3	119.1	109.6	89.0	634,753,536
SSN	SSN 688	TOPEKA	SSN-0754	65.4	29.1	45.6	112.7	79.1	36.2	34.4	36.4	438,676,608
SSN	SSN 688	MIAMI	SSN-0755	43.7	45.1	93.8	70.7					253,277,472
SSN	SSN 688	SCRANTON	SSN-0756	31.4	26.1	26.8	44.5	86.1	120.2	79.8	36.3	451,217,056
SSN	SSN 688	ALEXANDRIA	SSN-0757	28.0	39.5	32.6	41.7	113.0	74.9	43.4	40.0	412,951,008
SSN	SSN 688	ASHEVILLE	SSN-0758	29.2	37.8	32.4	42.7	120.4	105.0	67.5	68.2	503,243,616
SSN	SSN 688	JEFFERSON CITY	SSN-0759	29.1	32.2	36.7	31.3	35.8	79.1	88.1	82.7	415,026,976
SSN	SSN 688	ANNAPOLIS	SSN-0760	26.9	27.1	27.6	40.4	34.5	92.3	108.3	70.3	427,271,968
SSN	SSN 688	SPRINGFIELD	SSN-0761	29.9	26.5	24.6	22.7	47.1	50.6	40.5	125.4	367,287,680
SSN	SSN 688	COLUMBUS	SSN-0762	61.4	55.4	24.4	30.3	26.6	33.6	55.7	36.4	323,912,608
SSN	SSN 688	SANTA FE	SSN-0763	32.1	32.5	64.6	29.7	31.8	39.4	34.8	32.9	297,791,328
SSN	SSN 688	BOISE	SSN-0764	26.3	24.8	21.3	29.8	34.0	48.2	56.0	22.8	263,236,080
SSN	SSN 688	MONTPELIER	SSN-0765	70.6	24.2	23.9	58.2	25.1	37.1	44.3	156.8	440,145,152
SSN	SSN 688	CHARLOTTE	SSN-0766	34.4	51.4	49.8	26.7	35.1	36.8	41.6	43.8	319,615,456
SSN	SSN 688	HAMPTON	SSN-0767	38.3	29.1	49.4	29.9	34.6	44.8	80.4	111.4	417,916,672
SSN	SSN 688	HARTFORD	SSN-0768	33.6	46.3	22.7	35.9	30.1	28.7	26.5	23.0	246,640,384
SSN	SSN 688	TOLEDO	SSN-0769	32.9	40.0	22.0	40.9	32.8	41.2	25.6	27.9	263,362,656
SSN	SSN 688	TUCSON	SSN-0770	32.5	33.5	30.8	34.4	84.2	46.6	29.3	35.6	327,006,528
SSN	SSN 688	COLUMBIA	SSN-0771	32.3	33.0	55.6	41.9	31.1	50.4	35.7	44.2	324,174,848
SSN	SSN 688	GREENEVILLE	SSN-0772	33.9	30.5	27.9	32.0	36.2	71.8	31.7	60.5	324,511,360
SSN	SSN 688	CHEYENNE	SSN-0773	43.1	30.5	31.7	53.2	63.4	35.7	36.0	28.2	321,791,168
SSN	SSN 774	VIRGINIA	SSN-0774	59.0	135.2	54.1	29.5	26.1	28.6	26.5	46.1	405,217,536
SSN	SSN 774	TEXAS	SSN-0775	37.4	49.0	99.5	103.5	56.1	43.5	37.3	34.3	460,574,912
SSN	SSN 774	HAWAII	SSN-0776	40.8	33.1	26.5	27.7	42.6	102.7	119.4	65.8	458,576,256
SSN	SSN 774	NORTH CAROLINA	SSN-0777	33.6	32.6	27.6	29.1	27.8	39.9	74.7	118.6	383,784,512
SSN	SSN 774	NEW HAMPSHIRE	SSN-0778	26.3	25.0	22.9	31.4	23.9	34.4	54.2	130.3	348,550,720
SSN	SSN 774	NEW MEXICO	SSN-0779	23.2	21.7	24.6	22.5	23.8	22.8	43.1	70.3	252,033,792
SSN	SSN 774	MISSOURI	SSN-0780	21.0	20.2	20.6	21.2	23.1	27.1	35.4	36.5	205,085,792

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
SSN	SSN 774	CALIFORNIA	SSN-0781			23.3	25.3	25.7	32.6	32.9	35.6	175,426,092
SSN	SSN 774	MISSISSIPPI	SSN-0782			18.8	20.1	22.6	39.2	29.4	34.3	164,464,380
SSN	SSN 774	MINNESOTA	SSN-0783				18.4	20.3	20.9	28.4	34.6	122,560,100
SSN	SSN 774	NORTH DAKOTA	SSN-0784					18.1	22.9	21.9	32.7	95,669,912
SSN	SSN 774	JOHN WARNER	SSN-0785						17.8	26.3	26.6	70,768,554
SSN	SSN 774	ILLINOIS	SSN-0786								30.8	30,761,204

Raw data obtained from the VAMOSC database, February 2, 2018.

APPENDIX B. MSC DATABASE SHIPS

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD)								Average Annual Cost
				2010	2011	2012	2013	2014	2015	2016	2017	
AFSB	AFSB (I) 15	PONCE (AFSB)	AFSB(I)-0015			64.4	47.6	43.8	46.4	46.5	53.5	302,317,464
AS	AS 39	EMORY S LAND	AS-0039	106.2	82.8	74.4	81.4	71.3	91.3	95.7	98.6	701,820,288
AS	AS 39	FRANK CABLE	AS-0040	182.5	162.6	171.9	140.2	150.4	146.2	143.0	155.9	1,252,775,680
HSV	HSV 1	SWIFT	HSV-0002	35.2	33.2	35.7	24.4					128,484,768
HSV	HSV 4676	WESTPAC EXPRESS	HSV-4676	20.7	19.3	25.5	25.6	23.4	27.2	28.2	25.9	195,796,112
LCC	LCC 19	MOUNT WHITNEY	LCC-0020	77.3	75.6	78.9	73.1	70.4	80.3	71.9	95.9	623,417,792
MB	MB 1219	SEA EAGLE	MB-1219							2.1	1.9	4,024,652
T-AE	AE 26	FLINT	T-AE-0032	35.5	32.8	32.2	24.3	3.6				128,345,080
T-AE	AE 26	SHASTA	T-AE-0033	36.3								36,287,420
T-AE	AE 26	MOUNT BAKER	T-AE-0034	17.4								17,356,500
T-AE	AE 26	KISKA	T-AE-0035	33.9								33,875,276
T-AFS	AFS 1	SAN JOSE	T-AFS-0007	12.2								12,232,572
T-AG	AG 5001	VADM K R WHEELER	T-AG-5001	28.5	32.1	77.9	16.9	15.6	15.8	16.3	16.6	219,806,640
T-AGER	AGER 111	DOLORES CHOUEST	T-AGER-0111	3.7	4.4	4.4	4.2	4.3	5.0	5.1	5.7	36,753,376
T-AGM	AGM 23	OBSERVATION ISLAND	T-AGM-0023	32.4	29.5	32.4	30.0	12.1				136,513,880
T-AGM	AGM 24	INVINCIBLE	T-AGM-0024	9.9	8.2	11.1	7.9	9.7	11.7	10.2	9.3	77,961,992
T-AGM	AGM 25	HOWARD O LORENZEN	T-AGM-0025			8.0	9.0	33.3	18.9	26.3	19.0	114,428,724
T-AGOS	AGOS 19	VICTORIOUS	T-AGOS-0019	11.7	12.3	17.1	11.7	16.1	13.7	17.3	14.6	114,514,064
T-AGOS	AGOS 19	ABLE	T-AGOS-0020	11.7	16.5	16.9	13.4	13.6	15.1	14.3	16.3	117,741,048
T-AGOS	AGOS 19	EFFECTIVE	T-AGOS-0021	18.3	11.2	12.2	15.9	14.2	15.9	13.2	13.9	114,867,800
T-AGOS	AGOS 19	LOYAL	T-AGOS-0022	10.0	12.7	10.9	13.1	11.3	12.1	13.9	11.8	95,779,960
T-AGOS	AGOS 23	IMPECCABLE	T-AGOS-0023	13.3	13.5	16.9	14.0	13.2	20.0	15.7	17.8	124,385,248
T-AGS	AGS 45	WATERS	T-AGS-0045	22.3	17.3	14.8	23.3	15.7	22.6	18.0	17.1	151,050,368
T-AGS	AGS 60	PATHFINDER	T-AGS-0060	14.8	15.5	20.7	16.6	16.6	15.5	17.8	18.9	136,396,400
T-AGS	AGS 60	SUMNER	T-AGS-0061	18.3	16.5	15.9	19.9	8.8	0.11			79,478,754
T-AGS	AGS 60	BOWDITCH	T-AGS-0062	17.7	22.6	15.5	16.4	17.7	17.2	20.0	17.3	144,490,944
T-AGS	AGS 60	HENSON	T-AGS-0063	15.7	20.8	14.9	17.7	16.6	17.2	22.5	18.7	144,042,816
T-AGS	AGS 60	BRUCE C HEEZEN	T-AGS-0064	20.1	15.3	17.1	18.2	16.5	16.3	19.3	18.2	140,938,384
T-AGS	AGS 60	MARY SEARS	T-AGS-0065	15.0	16.3	19.5	17.7	16.6	20.0	18.3	22.6	145,878,336
T-AGS	AGS 60	MAURY	T-AGS-0066						2.1	12.4	19.6	34,192,167
T-AGSE	AGSE 1	BLACK POWDER	T-AGSE-0001	14.9	14.5	10.8	11.5	10.3	13.1	10.1	10.8	96,190,712
T-AGSE	AGSE 1	WESTWIND	T-AGSE-0002	15.3	14.8	10.6	11.7	10.4	10.1	7.9	11.5	92,377,064
T-AGSE	AGSE 1	EAGLEVIEW	T-AGSE-0003	15.3	13.8	10.6	11.4	10.3	9.2	8.9	12.1	91,676,224
T-AGSE	AGSE 1	ARROWHEAD	T-AGSE-0004	11.3	14.6	11.3	10.3	10.6	9.3	8.2	11.7	87,344,384

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
T-AH	AH 19	MERCY	T-AH-0019	52.9	26.5	46.1	32.5	44.8	75.5	74.3	35.9	388,534,240
T-AH	AH 19	COMFORT	T-AH-0020	36.4	44.0	37.3	31.2	26.5	54.3	31.5	52.8	314,175,104
T-AK	AK 0323	TSGT JOHN A CHAPMAN	T-AK-0323	14.9	15.6	16.0	14.2	10.2				70,967,680
T-AK	AK 3005	SGT MATEJ KOCAK	T-AK-3005	28.6	28.7	40.6	5.5	5.4	33.0	6.2	13.3	161,285,376
T-AK	AK 3005	PFC EUGENE A OBREGON	T-AK-3006	74.1	34.1	16.1	5.0	6.2	19.7	17.1	5.9	178,135,424
T-AK	AK 3005	MAJ STEPHEN W PLESS	T-AK-3007	33.6	27.6	37.7	5.1	5.5	7.6	22.2	13.3	152,555,952
T-AK	AK 3008	2ND LT JOHN P BOBO	T-AK-3008	36.3	24.9	22.8	38.1	26.4	23.9	21.6	38.0	231,902,752
T-AK	AK 3008	PFC DEWAYNE T WILLIAMS	T-AK-3009	27.4	23.7	20.7	43.9	25.9	23.6	21.6	37.4	224,122,976
T-AK	AK 3008	1ST LT BALDOMERO LOPEZ	T-AK-3010	27.9	37.5	20.4	24.7	40.3	20.5	23.2	34.6	229,125,584
T-AK	AK 3008	1ST LT JACK LUMMUS	T-AK-3011	40.8	25.4	21.6	32.8	35.2	28.7	29.3	24.2	238,004,064
T-AK	AK 3008	SGT WILLIAM R BUTTON	T-AK-3012	26.8	39.0	21.7	25.7	24.9	21.1	36.6	19.9	215,646,000
T-AK	AK 3015	1ST LT HARRY L MARTIN	T-AK-3015	33.2	24.6	27.5	6.0	6.0	15.2	6.3	10.4	129,113,672
T-AK	AK 3015	LCPL ROY M WHEAT	T-AK-3016	31.0	26.2	29.1	5.1	5.1	11.9	4.9	12.3	125,611,080
T-AK	AK 3015	GYSGT FRED W. STOCKHAM	T-AK-3017	25.2	24.5	42.3	27.7	26.9	25.3	44.4	32.5	248,779,600
T-AK	AK 4296	CAPT STEVEN L BENNETT	T-AK-4296	15.4	15.4	13.5	2.8					47,080,108
T-AK	AK 4396	MAJ BERNARD F FISHER	T-AK-4396	18.9			15.1	14.4	15.4	13.6	12.2	89,588,112
T-AK	AK 4496	LTC JOHN U D PAGE	T-AK-4543	21.2	25.7	17.2	17.5	17.9	13.2	24.6	21.9	159,202,192
T-AK	AK 4496	SSG EDWARD A CARTER, JR	T-AK-4544	19.1	25.1	17.1	15.9	18.8	17.4	16.9	21.2	151,423,120
T-AK	AK 4729	AMERICAN TERN	T-AK-4729	20.2								20,152,524
T-AK	AK 451	CAPE JACOB	T-AK-5029	21.9								21,934,258
T-AK	AK 5158	MOHEGAN	T-AK-5158	9.9	10.2	10.9	9.3	9.0	7.4	6.9	1.1	64,689,464
T-AK	AK 5272	BBC SEATTLE	T-AK-5272			6.9	17.2	17.6	9.7	10.6	3.6	65,524,314
T-AK	AK 5307	OCEAN CRESCENT	T-AK-5307								2.0	1,971,438
T-AK	AK 5362	CAPT DAVID I LYON	T-AK-5362						14.0	17.3	13.3	44,519,859
T-AK	AK 9205	VIRGINIAN	T-AK-9205		0.0							0
T-AKE	AKE 1	LEWIS AND CLARK	T-AKE-0001	57.4	73.5	43.7	31.2	28.4	53.9	42.8	31.1	362,090,176
T-AKE	AKE 1	SACAGAWEA	T-AKE-0002	58.8	62.3	61.7	37.6	31.2	44.8	39.5	50.3	386,279,072
T-AKE	AKE 1	ALAN SHEPARD	T-AKE-0003	49.8	48.5	67.8	50.1	40.1	53.9	48.2	58.8	417,255,904
T-AKE	AKE 1	RICHARD E BYRD	T-AKE-0004	52.1	47.6	52.1	64.3	47.1	54.3	49.0	43.4	409,931,392
T-AKE	AKE 1	ROBERT E PEARY	T-AKE-0005	57.4	59.0	48.1	50.1	45.4	54.9	41.2	36.7	392,854,752
T-AKE	AKE 1	AMELIA EARHART	T-AKE-0006	43.8	49.5	56.3	46.5	62.9	52.7	62.8	48.7	423,029,472
T-AKE	AKE 1	CARL BRASHEAR	T-AKE-0007	43.9	49.2	51.3	60.0	43.2	54.7	50.6	57.9	410,729,504
T-AKE	AKE 1	WALLY SCHIRRA	T-AKE-0008	64.6	58.5	59.6	50.3	61.9	48.5	49.2	52.1	444,613,344
T-AKE	AKE 1	MATTHEW PERRY	T-AKE-0009	39.6	42.0	51.9	52.8	46.6	65.9	48.1	53.3	400,332,448
T-AKE	AKE 1	CHARLES DREW	T-AKE-0010	9.7	50.3	55.2	59.4	50.7	70.0	48.2	44.6	388,112,032
T-AKE	AKE 1	WASHINGTON CHAMBERS	T-AKE-0011		32.5	49.6	53.7	45.8	50.5	61.5	48.1	341,771,276
T-AKE	AKE 1	WILLIAM MC LEAN	T-AKE-0012		7.0	34.5	30.1	47.3	32.2	54.3	38.9	244,299,608
T-AKE	AKE 1	MEDGAR EVERS	T-AKE-0013			19.6	37.7	45.8	41.7	46.2	53.4	244,475,232
T-AKE	AKE 1	CESAR CHAVEZ	T-AKE-0014				38.2	41.9	55.3	57.7	55.1	248,178,380

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
T-AKR	AKR 295	SHUGHART	T-AKR-0295	7.2	16.1	8.5	8.3	6.3	7.6	17.5	10.0	81,471,912
T-AKR	AKR 295	GORDON	T-AKR-0296	7.9	9.6	15.1	7.7	10.9	10.5	14.7	14.3	90,690,640
T-AKR	AKR 295	YANO	T-AKR-0297	7.1	17.2	8.2	4.9	7.5	9.5	18.5	13.4	86,322,352
T-AKR	AKR 295	GILLILAND	T-AKR-0298	6.7	18.9	8.7	6.4	8.7	9.8	7.6	22.9	89,731,544
T-AKR	AKR 300	BOB HOPE	T-AKR-0300	8.5	8.9	7.2	8.7	18.5	9.1	10.5	12.3	83,695,648
T-AKR	AKR 300	FISHER	T-AKR-0301	16.8	10.2	8.1	8.4	16.6	10.2	9.1	18.2	97,602,128
T-AKR	AKR 300	SEAY	T-AKR-0302	41.9	30.0	25.5	29.0	35.1	29.7	24.4	25.8	241,474,896
T-AKR	AKR 300	MENDONCA	T-AKR-0303	17.0	9.1	7.1	6.6	8.3	22.2	8.1	15.4	93,928,152
T-AKR	AKR 300	PILILAAU	T-AKR-0304	10.3	21.8	31.8	41.3	31.7	29.7	45.2	29.7	241,418,624
T-AKR	AKR 300	BRITTIN	T-AKR-0305	10.6	7.2	15.9	6.5	7.4	7.0	8.2	29.0	91,766,960
T-AKR	AKR 300	BENAVIDEZ	T-AKR-0306	6.4	6.9	6.8	17.0	7.6	7.0	9.6	10.1	71,499,488
T-AKR	AKR 310	WATSON	T-AKR-0310	18.7	25.9	43.1	21.1	17.8	13.5	14.9	21.5	176,436,752
T-AKR	AKR 310	SISLER	T-AKR-0311	28.6	47.6	29.6	27.1	27.8	44.0	25.0	27.7	257,447,488
T-AKR	AKR 310	DAHL	T-AKR-0312	37.9	26.0	27.1	48.2	31.0	32.6	26.2	31.1	260,189,120
T-AKR	AKR 310	RED CLOUD	T-AKR-0313	4.0	12.7	36.9	24.2	21.2	23.2	40.8	24.5	187,417,664
T-AKR	AKR 310	CHARLTON	T-AKR-0314	23.0	24.8	26.7	33.6	23.8	21.9	30.2	52.7	236,699,872
T-AKR	AKR 310	WATKINS	T-AKR-0315	8.9	31.8	24.3	17.7	30.2	23.0	23.2	22.3	181,302,976
T-AKR	AKR 310	POMEROY	T-AKR-0316	14.2	31.6	20.9	18.5	33.5	22.5	23.1	22.0	186,399,904
T-AKR	AKR 310	SODERMAN	T-AKR-0317	22.9	34.1	27.3	39.1	22.3	24.1	27.8	39.4	236,928,768
T-AO	AO 187	HENRY J KAISER	T-AO-0187	42.7	45.2	40.5	29.9	30.0	37.8	40.8	38.7	305,511,552
T-AO	AO 187	JOSHUA HUMPHREYS	T-AO-0188	36.6	35.3	34.6	29.1	26.9	31.0	36.7	37.3	267,568,928
T-AO	AO 187	JOHN LENTHALL	T-AO-0189	43.6	39.2	41.3	30.9	37.1	47.3	41.6	42.2	323,092,576
T-AO	AO 187	WALTER S DIEHL	T-AO-0193	32.8	36.2	38.9	39.0	36.7	41.8	43.5	39.1	308,077,184
T-AO	AO 187	JOHN ERICSSON	T-AO-0194	31.5	35.2	40.7	40.4	39.5	44.8	46.5	40.2	318,819,488
T-AO	AO 187	LEROY GRUMMAN	T-AO-0195	40.0	42.9	36.0	34.6	42.6	39.5	46.5	35.6	317,565,248
T-AO	AO 187	KANAWHA	T-AO-0196	41.6	44.2	40.6	36.2	34.9	42.2	37.6	34.0	311,232,576
T-AO	AO 187	PECOS	T-AO-0197	40.3	31.1	39.1	35.8	36.9	41.4	38.4	37.8	300,794,720
T-AO	AO 187	BIG HORN	T-AO-0198	43.6	44.6	43.1	32.8	37.3	45.6	44.1	45.4	336,573,504
T-AO	AO 187	TIPPECANOE	T-AO-0199	34.2	32.8	42.4	42.4	42.4	40.3	38.9	33.9	307,362,144
T-AO	AO 187	GUADALUPE	T-AO-0200	29.3	29.4	44.4	34.0	36.8	37.3	32.2	38.6	282,082,688
T-AO	AO 187	PATUXENT	T-AO-0201	48.9	42.6	38.2	47.7	41.3	59.9	38.8	45.0	362,337,600
T-AO	AO 187	YUKON	T-AO-0202	31.0	30.5	34.0	34.2	40.2	40.5	35.4	37.5	283,230,464
T-AO	AO 187	LARAMIE	T-AO-0203	42.9	49.0	37.1	37.8	48.4	44.4	47.2	35.2	341,990,528
T-AO	AO 187	RAPPAHANNOCK	T-AO-0204	32.2	35.8	40.7	38.5	37.7	39.2	49.9	40.2	314,217,312
T-AOE	AOE 6	SUPPLY	T-AOE-0006	72.8	81.3	63.0	38.8	70.6	77.2	56.4	70.2	530,355,552
T-AOE	AOE 6	RAINIER	T-AOE-0007	52.9	58.5	66.1	62.5	64.3	64.6	58.8		427,765,604
T-AOE	AOE 6	ARCTIC	T-AOE-0008	62.5	83.3	78.1	40.9	69.5	67.1	60.9	63.4	525,761,088
T-AOE	AOE 6	BRIDGE	T-AOE-0010	50.2	64.2	66.2	51.9	7.3	4.7			244,450,128
T-AOT	AOT 1121	PAUL BUCK	T-AOT-1122	13.1								13,078,380

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Average Annual Cost
T-AOT	AOT 1121	SAMUEL L COBB	T-AOT-1123	15.7								15,666,783
T-AOT	AOT 1121	RICHARD G MATTHIESEN	T-AOT-1124	17.9								17,932,468
T-AOT	AOT 1121	LAWRENCE H GIANELLA	T-AOT-1125	20.2	20.9	16.3	14.6	19.3	14.1	21.5	14.2	141,167,856
T-AOT	AOT 4995	TRANSPACIFIC	T-AOT-4995	8.3	7.0							15,311,702
T-AOT	AP 1000	EMPIRE STATE	T-AOT-5193		42.8	30.4	31.2	30.5	29.6	56.9	48.4	269,889,452
T-AOT	AOT 5205	EVERGREEN STATE	T-AOT-5205		24.8	31.9	30.1	30.9	25.1	6.5	10.2	159,493,964
T-AOT	AOT 5246	MAERSK PEARY	T-AOT-5246			23.2	22.5	20.6	26.5	26.0	7.6	126,216,984
T-AOT	AOT 5356	SLNC PAX	T-AOT-5356					9.9	11.7	9.1	11.0	41,655,772
T-AOT	AOT 5406	GALVESTON/PETROCHEM PRODUCER	T-AOT-5406								26.0	25,959,490
T-AOT	AOT 5419	SLNC GOODWILL	T-AOT-5419							17.1	20.0	37,112,480
T-ARC	ARC 7	ZEUS	T-ARC-0007	24.7	29.6	23.4	44.6	25.8	39.6	30.6	25.5	243,725,648
T-ARS	ARS 50	SAFEGUARD	T-ARS-0050	19.4	14.8	16.8	18.9	13.3	18.0	9.7	0.8	111,743,136
T-ARS	ARS 50	GRASP	T-ARS-0051	17.8	19.4	19.3	10.5	12.4	12.1	11.1	14.7	117,297,552
T-ARS	ARS 50	SALVOR	T-ARS-0052	17.5	17.7	13.4	9.7	15.6	11.9	15.1	15.0	115,900,520
T-ARS	ARS 50	GRAPPLE	T-ARS-0053	19.3	21.8	12.4	17.3	9.0	10.3	7.9	2.2	100,273,424
T-ATF	ATF 166	CATAWBA	T-ATF-0168	12.9	8.9	7.8	9.6	6.4	8.4	5.8	7.6	67,432,360
T-ATF	ATF 166	NAVAJO	T-ATF-0169	9.1	9.5	14.5	8.6	10.5	11.8	6.3	0.9	71,233,552
T-ATF	ATF 166	SIOUX	T-ATF-0171	9.5	13.2	9.2	8.0	10.5	8.6	13.1	9.3	81,331,920
T-ATF	ATF 166	APACHE	T-ATF-0172	9.1	9.7	7.3	11.8	6.0	7.1	8.5	8.3	67,742,960
T-ATF	ATF 4247	MEGAN BEYEL	T-ATF-4247	2.5	2.8							5,229,044
T-EPF	EPF 1	SPEARHEAD	T-EPF-0001				8.1	20.6	18.9	28.8	23.6	99,913,730
T-EPF	EPF 1	CHOCTAW COUNTY	T-EPF-0002				4.3	13.0	16.2	21.6	20.6	75,860,005
T-EPF	EPF 1	MILLINOCKET	T-EPF-0003					9.3	25.0	26.9	22.2	83,363,128
T-EPF	EPF 1	FALL RIVER	T-EPF-0004					1.6	18.5	18.4	19.2	57,806,928
T-EPF	EPF 1	TRENTON	T-EPF-0005						5.9	23.1	24.2	53,258,028
T-EPF	EPF 1	BRUNSWICK	T-EPF-0006							12.7	21.5	34,130,904
T-EPF	EPF 1	CARSON CITY	T-EPF-0007								22.9	22,914,396
T-EPF	EPF 1	YUMA	T-EPF-0008								10.8	10,835,891
T-ESB	ESB 3	LEWIS B PULLER	T-ESB-0003						7.7	20.0	44.1	71,847,258
T-ESD	ESD 1	MONTFORD POINT	T-ESD-0001				9.2	22.6	28.3	27.4	25.7	113,178,170
T-ESD	ESD 1	JOHN GLENN	T-ESD-0002					16.5	20.7	25.2	23.9	86,313,248
T-HST	HST 1	GUAM	T-HST-0001			8.9	5.9	3.0	4.0	14.9	35.8	72,584,544
T-HST	HST 2	PUERTO RICO	T-HST-0002			0.6	1.1	2.1	1.8	1.1	-0.1	6,576,079

Raw data obtained from the VAMOSC database, January 29, 2018.

APPENDIX C. RRF DATABASE SHIPS

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD)								Weighted Avg Annual Cost
				2010	2011	2012	2013	2014	2015	2016	2017	
T-ACS	ACS 1	KEYSTONE STATE	T-ACS-0001		0.0000	0.5532		0.5536	-0.0080	0.0000	0.4256	1,524,446
T-ACS	ACS 1	GEM STATE	T-ACS-0002		0.0368	0.5355	-0.0520	-0.0021	0.0000	0.0000	0.5561	1,074,319
T-ACS	ACS 1	GRAND CANYON STATE	T-ACS-0003	0.0454	0.0000	0.4850	-0.0257	0.6103	0.0737	-0.0011	0.3024	1,490,027
T-ACS	ACS 4	GOPHER STATE	T-ACS-0004	1.7383	0.0970	-0.0049	-0.2212	0.4740	0.0000	-0.3302	0.0000	1,753,034
T-ACS	ACS 4	FLICKERTAIL STATE	T-ACS-0005	-0.7260	-0.0036	-0.8042		0.0000	0.0000	0.5253	1.5477	539,191
T-ACS	ACS 4	CORNHUSKER STATE	T-ACS-0006	2.9105	0.1925	0.0000	-0.6087	0.5732	0.3586	0.0612	-0.0005	3,486,769
T-AK	AK 575	CAPE GIBSON	T-AK-5051	1.3555	0.0004							1,355,930
T-AK	AK 981	CAPE FLATTERY	T-AK-5070	1.8159	0.7065	0.0000						2,522,497
T-AK	AK 981	CAPE FAREWELL	T-AK-5073	2.0146	0.0055	0.0000						2,020,090
T-AKR	AKR 10	CAPE ISLAND	T-AKR-0010	0.7621	0.0000	0.7491		-0.0162	0.0000	0.4528	0.0000	1,947,716
T-AKR	AKR 10	CAPE INTREPID	T-AKR-0011	0.2671	0.0162	0.0000	0.7009	-0.2443	0.5240	0.0000	0.0000	1,263,899
T-AKR	AKR 112	CAPE TEXAS	T-AKR-0112	-0.0165	0.5480	0.7220		-0.4061	0.1062	0.3590	0.0000	1,312,590
T-AKR	AKR 112	CAPE TAYLOR	T-AKR-0113	-0.0094	0.0000	0.6146		-0.0094	0.0020	0.0000	0.0000	597,821
T-AKR	AKR 287	ALGOL	T-AKR-0287	1.4639	-0.1073	1.2203	-0.0143	-0.4959	0.2721	0.0314	0.0000	2,370,118
T-AKR	AKR 287	BELLATRIX	T-AKR-0288	-0.0885	0.0017	0.9614	-0.0978	1.0511	0.0000	0.0000	0.3233	2,151,233
T-AKR	AKR 287	DENEBOLA	T-AKR-0289	-0.1436	-0.0349	1.2691		0.8005	0.0000	-0.4938	0.0527	1,450,071
T-AKR	AKR 287	POLLUX	T-AKR-0290	-0.1669	0.7424	0.0000	0.4210	0.0000	0.0000	0.0000	0.3374	1,333,887
T-AKR	AKR 287	ALTAIR	T-AKR-0291	-0.0638	-0.0001	0.0000		1.0511	0.0000	0.0000	0.1418	1,129,086
T-AKR	AKR 287	REGULUS	T-AKR-0292	-0.0696	0.0000	0.0000	1.2597	0.5910	0.0000	0.0000	-0.3572	1,423,883
T-AKR	AKR 287	CAPELLA	T-AKR-0293	0.3453	0.8295	0.0003		0.0000	0.0000	0.0000	0.8411	2,016,298
T-AKR	AKR 287	ANTARES	T-AKR-0294	-0.0414	0.0005	1.2691		-0.0688	0.0000	0.0000	0.5190	1,678,419
T-AKR	AKR 1001	ADMIRAL W M CALLAGHAN	T-AKR-1001	-0.0253	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	-25,259
T-AKR	AKR 2044	CAPE ORLANDO	T-AKR-2044		0.0000	0.4782		-1.1386	0.0000	0.0000	0.0000	-660,389
T-AKR	AKR 5051	CAPE DUCATO	T-AKR-5051	0.4884	0.0829	0.0000		0.0000	0.0000	0.0000	0.0000	571,365
T-AKR	AKR 5051	CAPE DOUGLAS	T-AKR-5052	1.6864	0.0018	0.4620	0.4712	-0.0060	-0.1331	0.4004	0.0000	2,882,581
T-AKR	AKR 5051	CAPE DOMINGO	T-AKR-5053	0.5631	0.0088	0.0000		0.4024	0.0000	0.0000	-0.1267	847,643
T-AKR	AKR 5051	CAPE DECISION	T-AKR-5054	1.0752	0.0405	0.4357	0.0033	0.0000	0.0000	0.0000	0.0000	1,554,701
T-AKR	AKR 5051	CAPE DIAMOND	T-AKR-5055	0.6133	0.0308	0.0000	-0.0038	0.0000	0.0000	0.0000	0.0000	640,316
T-AKR	AKR 10	CAPE ISABEL	T-AKR-5062	0.6631	0.0115	0.0000	0.7922	-0.1204	-0.2386	0.4995	0.0000	1,607,356
T-AKR	AK 882	CAPE MAY	T-AKR-5063	5.2679	0.1833	2.5752	0.3583	0.3554	0.0000	0.0000	-0.0939	8,646,228
T-AKR	AK 882	CAPE MOHICAN	T-AKR-5065	-0.0048	0.0063	1.1636		-0.2473	0.0203	-0.0175	-0.0001	920,355
T-AKR	AKR 5066	CAPE HUDSON	T-AKR-5066	0.6193	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	619,307
T-AKR	AKR 5066	CAPE HENRY	T-AKR-5067	-0.0466	0.0000	-0.0499		0.0000	0.4855	0.3993	0.8226	1,610,787

Type	Ship Class	Ship Name	Hull Number	Fiscal Year (Millions, CY2017 USD) 2010	2011	2012	2013	2014	2015	2016	2017	Weighted Avg Annual Cost
T-AKR	AKR 5066	CAPE HORN	T-AKR-5068		0.0047	0.0034		0.0000	0.0000	0.0000	0.0000	8,032
T-AKR	AKR 5069	CAPE EDMONT	T-AKR-5069	0.3876	0.5278	-0.2514		-0.0639	0.3204	0.0166	0.0000	937,113
T-AKR	AKR 10	CAPE INSCRIPTION	T-AKR-5076	0.1761	0.0000	0.0000	0.6658	-0.2519	0.0000	0.4995	0.0000	1,089,437
T-AKR	AKR 5082	CAPE KNOX	T-AKR-5082	0.0186	0.4859	0.8975	-0.0179	-0.2396	0.0428	0.4664	0.0000	1,653,719
T-AKR	AKR 5082	CAPE KENNEDY	T-AKR-5083	-0.8528	0.0000	-0.4167		0.0000	1.1006	-1.1545	0.5431	-780,258
T-AKR	AKR 9666	CAPE VINCENT	T-AKR-9666	-1.3186	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	-1,318,644
T-AKR	AKR 9678	CAPE RISE	T-AKR-9678	0.1874	0.0000	0.4689		-0.0144	3.0370	0.0142	0.0000	3,693,226
T-AKR	AKR 9678	CAPE RAY	T-AKR-9679	0.5458	0.0000	0.0000		15.8193	-0.5112	0.0000	-1.0607	14,793,231
T-AKR	AKR 9666	CAPE VICTORY	T-AKR-9701	-0.0016	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	-1,617
T-AKR	AKR 112	CAPE TRINITY	T-AKR-9711	-0.9511	2.5003	1.4457	0.9378	-0.0983	-0.2024	0.4481	-0.0683	4,011,803
T-AKR	AKR 9678	CAPE RACE	T-AKR-9960		0.0000	0.0000		8.4517	3.5015	3.6492	0.1238	15,726,236
T-AKR	AKR 9961	CAPE WASHINGTON	T-AKR-9961	0.5559	0.0000	-0.2976		0.0000	0.0000	0.5103	0.2227	991,247
T-AKR	AKR 9961	CAPE WRATH	T-AKR-9962	0.5948	0.0490	0.0000	-0.0251	0.5451	5.0252	0.0000	-0.2130	5,976,045
T-AOT	AOT 181	CHESAPEAKE	T-AOT-5084	-0.0001								-64
T-AOT	AOT 181	PETERSBURG	T-AOT-9101	1.6426	-0.0146	-0.0115		0.0000	0.0000	0.0261	0.0000	1,642,641
T-AVB	AVB 3	WRIGHT	T-AVB-0003	2.0259	1.4629	2.6079	0.0002	1.8038	0.7520	2.1465	0.0047	10,803,798
T-AVB	AVB 3	CURTISS	T-AVB-0004	1.5391	0.6791	-0.1847	1.4764	0.0155	0.3939	3.0619	-0.0094	6,971,745

Raw data obtained from the VAMOSC database, January 29, 2018.

APPENDIX D. QUICK REFERENCE TABLES

This section provides mission planners with quick reference tables that contain pre-calculated transit days and ship class utility scores for 10, 30, 60, and 90-day HADR responses, at a given range.

A. TRANSIT DAYS REQUIRED

Table 57 provides the pre-calculated number of transit days required to travel distances of 250 nm to 6,000 nm at a given ship speed. Table 58 provides the pre-calculated number of transit days required to travel distances of 6,250 nm to 12,000 nm at a given ship speed.

B. CLASS UTILITY SCORES

Tables 59 to 82 provide pre-calculated utility scores for ships of a given status and class during 10, 30, 60, and 90-day HADR responses, respectively. Utility scores are based on the ship class capability composite score, maximum range speed, and required number of activation days values that are reported in Chapter V. The last column of the table provides the total O&S costs for a desired response duration as calculated in the *ResponseCost_xDays* variable equal to *_AvgDlyCost_Class_FY10_17* multiplied by the number of response days.

Depicted utility values will change if a different transit speed is intended. Use the utility function and the provided variable values in Chapter V if a different transit speed is desired or required for a given class.

Table 57. Number of Days Required to Transit (250 to 6,000 nm)

Speed (kts)	Transit Days	Distance (nm)																						
		250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000
	5	2.08	4.17	6.25	8.33	10.42	12.50	14.58	16.67	18.75	20.83	22.92	25.00	27.08	29.17	31.25	33.33	35.42	37.50	39.58	41.67	43.75	45.83	47.92	50.00
	6	1.74	3.47	5.21	6.94	8.68	10.42	12.15	13.89	15.63	17.36	19.10	20.83	22.57	24.31	26.04	27.78	29.51	31.25	32.99	34.72	36.46	38.19	39.93	41.67
	7	1.49	2.98	4.46	5.95	7.44	8.93	10.42	11.90	13.39	14.88	16.37	17.86	19.35	20.83	22.32	23.81	25.30	26.79	28.27	29.76	31.25	32.74	34.23	35.71
	8	1.30	2.60	3.91	5.21	6.51	7.81	9.11	10.42	11.72	13.02	14.32	15.63	16.93	18.23	19.53	20.83	22.14	23.44	24.74	26.04	27.34	28.65	29.95	31.25
	9	1.16	2.31	3.47	4.63	5.79	6.94	8.10	9.26	10.42	11.57	12.73	13.89	15.05	16.20	17.36	18.52	19.68	20.83	21.99	23.15	24.31	25.46	26.62	27.78
	10	1.04	2.08	3.13	4.17	5.21	6.25	7.29	8.33	9.38	10.42	11.46	12.50	13.54	14.58	15.63	16.67	17.71	18.75	19.79	20.83	21.88	22.92	23.96	25.00
	11	0.95	1.89	2.84	3.79	4.73	5.68	6.63	7.58	8.52	9.47	10.42	11.36	12.31	13.26	14.20	15.15	16.10	17.05	17.99	18.94	19.89	20.83	21.78	22.73
	12	0.87	1.74	2.60	3.47	4.34	5.21	6.08	6.94	7.81	8.68	9.55	10.42	11.28	12.15	13.02	13.89	14.76	15.63	16.49	17.36	18.23	19.10	19.97	20.83
	13	0.80	1.60	2.40	3.21	4.01	4.81	5.61	6.41	7.21	8.01	8.81	9.62	10.42	11.22	12.02	12.82	13.62	14.42	15.22	16.03	16.83	17.63	18.43	19.23
	14	0.74	1.49	2.23	2.98	3.72	4.46	5.21	5.95	6.70	7.44	8.18	8.93	9.67	10.42	11.16	11.90	12.65	13.39	14.14	14.88	15.63	16.37	17.11	17.86
	15	0.69	1.39	2.08	2.78	3.47	4.17	4.86	5.56	6.25	6.94	7.64	8.33	9.03	9.72	10.42	11.11	11.81	12.50	13.19	13.89	14.58	15.28	15.97	16.67
	16	0.65	1.30	1.95	2.60	3.26	3.91	4.56	5.21	5.86	6.51	7.16	7.81	8.46	9.11	9.77	10.42	11.07	11.72	12.37	13.02	13.67	14.32	14.97	15.63
	17	0.61	1.23	1.84	2.45	3.06	3.68	4.29	4.90	5.51	6.13	6.74	7.35	7.97	8.58	9.19	9.80	10.42	11.03	11.64	12.25	12.87	13.48	14.09	14.71
	18	0.58	1.16	1.74	2.31	2.89	3.47	4.05	4.63	5.21	5.79	6.37	6.94	7.52	8.10	8.68	9.26	9.84	10.42	11.00	11.57	12.15	12.73	13.31	13.89
	19	0.55	1.10	1.64	2.19	2.74	3.29	3.84	4.39	4.93	5.48	6.03	6.58	7.13	7.68	8.22	8.77	9.32	9.87	10.42	10.96	11.51	12.06	12.61	13.16
	20	0.52	1.04	1.56	2.08	2.60	3.13	3.65	4.17	4.69	5.21	5.73	6.25	6.77	7.29	7.81	8.33	8.85	9.38	9.90	10.42	10.94	11.46	11.98	12.50
	21	0.50	0.99	1.49	1.98	2.48	2.98	3.47	3.97	4.46	4.96	5.46	5.95	6.45	6.94	7.44	7.94	8.43	8.93	9.42	9.92	10.42	10.91	11.41	11.90
	22	0.47	0.95	1.42	1.89	2.37	2.84	3.31	3.79	4.26	4.73	5.21	5.68	6.16	6.63	7.10	7.58	8.05	8.52	9.00	9.47	9.94	10.42	10.89	11.36
	23	0.45	0.91	1.36	1.81	2.26	2.72	3.17	3.62	4.08	4.53	4.98	5.43	5.89	6.34	6.79	7.25	7.70	8.15	8.61	9.06	9.51	9.96	10.42	10.87
	24	0.43	0.87	1.30	1.74	2.17	2.60	3.04	3.47	3.91	4.34	4.77	5.21	5.64	6.08	6.51	6.94	7.38	7.81	8.25	8.68	9.11	9.55	9.98	10.42
	25	0.42	0.83	1.25	1.67	2.08	2.50	2.92	3.33	3.75	4.17	4.58	5.00	5.42	5.83	6.25	6.67	7.08	7.50	7.92	8.33	8.75	9.17	9.58	10.00
	26	0.40	0.80	1.20	1.60	2.00	2.40	2.80	3.21	3.61	4.01	4.41	4.81	5.21	5.61	6.01	6.41	6.81	7.21	7.61	8.01	8.41	8.81	9.21	9.62
	27	0.39	0.77	1.16	1.54	1.93	2.31	2.70	3.09	3.47	3.86	4.24	4.63	5.02	5.40	5.79	6.17	6.56	6.94	7.33	7.72	8.10	8.49	8.87	9.26
	28	0.37	0.74	1.12	1.49	1.86	2.23	2.60	2.98	3.35	3.72	4.09	4.46	4.84	5.21	5.58	5.95	6.32	6.70	7.07	7.44	7.81	8.18	8.56	8.93
	29	0.36	0.72	1.08	1.44	1.80	2.16	2.51	2.87	3.23	3.59	3.95	4.31	4.67	5.03	5.39	5.75	6.11	6.47	6.82	7.18	7.54	7.90	8.26	8.62
	30	0.35	0.69	1.04	1.39	1.74	2.08	2.43	2.78	3.13	3.47	3.82	4.17	4.51	4.86	5.21	5.56	5.90	6.25	6.60	6.94	7.29	7.64	7.99	8.33
	31	0.34	0.67	1.01	1.34	1.68	2.02	2.35	2.69	3.02	3.36	3.70	4.03	4.37	4.70	5.04	5.38	5.71	6.05	6.38	6.72	7.06	7.39	7.73	8.06
	32	0.33	0.65	0.98	1.30	1.63	1.95	2.28	2.60	2.93	3.26	3.58	3.91	4.23	4.56	4.88	5.21	5.53	5.86	6.18	6.51	6.84	7.16	7.49	7.81
	33	0.32	0.63	0.95	1.26	1.58	1.89	2.21	2.53	2.84	3.16	3.47	3.79	4.10	4.42	4.73	5.05	5.37	5.68	6.00	6.31	6.63	6.94	7.26	7.58
	34	0.31	0.61	0.92	1.23	1.53	1.84	2.14	2.45	2.76	3.06	3.37	3.68	3.98	4.29	4.60	4.90	5.21	5.51	5.82	6.13	6.43	6.74	7.05	7.35
	35	0.30	0.60	0.89	1.19	1.49	1.79	2.08	2.38	2.68	2.98	3.27	3.57	3.87	4.17	4.46	4.76	5.06	5.36	5.65	5.95	6.25	6.55	6.85	7.14
	36	0.29	0.58	0.87	1.16	1.45	1.74	2.03	2.31	2.60	2.89	3.18	3.47	3.76	4.05	4.34	4.63	4.92	5.21	5.50	5.79	6.08	6.37	6.66	6.94
	37	0.28	0.56	0.84	1.13	1.41	1.69	1.97	2.25	2.53	2.82	3.10	3.38	3.66	3.94	4.22	4.50	4.79	5.07	5.35	5.63	5.91	6.19	6.48	6.76
	38	0.27	0.55	0.82	1.10	1.37	1.64	1.92	2.19	2.47	2.74	3.02	3.29	3.56	3.84	4.11	4.39	4.66	4.93	5.21	5.48	5.76	6.03	6.30	6.58
	39	0.27	0.53	0.80	1.07	1.34	1.60	1.87	2.14	2.40	2.67	2.94	3.21	3.47	3.74	4.01	4.27	4.54	4.81	5.07	5.34	5.61	5.88	6.14	6.41
	40	0.26	0.52	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60	2.86	3.13	3.39	3.65	3.91	4.17	4.43	4.69	4.95	5.21	5.47	5.73	5.99	6.25
	41	0.25	0.51	0.76	1.02	1.27	1.52	1.78	2.03	2.29	2.54	2.79	3.05	3.30	3.56	3.81	4.07	4.32	4.57	4.83	5.08	5.34	5.59	5.84	6.10
	42	0.25	0.50	0.74	0.99	1.24	1.49	1.74	1.98	2.23	2.48	2.73	2.98	3.22	3.47	3.72	3.97	4.22	4.46	4.71	4.96	5.21	5.46	5.70	5.95
	43	0.24	0.48	0.73	0.97	1.21	1.45	1.70	1.94	2.18	2.42	2.66	2.91	3.15	3.39	3.63	3.88	4.12	4.36	4.60	4.84	5.09	5.33	5.57	5.81
	44	0.24	0.47	0.71	0.95	1.18	1.42	1.66	1.89	2.13	2.37	2.60	2.84	3.08	3.31	3.55	3.79	4.02	4.26	4.50	4.73	4.97	5.21	5.45	5.68
	45	0.23	0.46	0.69	0.93	1.16	1.39	1.62	1.85	2.08	2.31	2.55	2.78	3.01	3.24	3.47	3.70	3.94	4.17	4.40	4.63	4.86	5.09	5.32	5.56
	46	0.23	0.45	0.68	0.91	1.13	1.36	1.59	1.81	2.04	2.26	2.49	2.72	2.94	3.17	3.40	3.62	3.85	4.08	4.30	4.53	4.76	4.98	5.21	5.43
	47	0.22	0.44	0.66	0.89	1.11	1.33	1.55	1.77	1.99	2.22	2.44	2.66	2.88	3.10	3.32	3.55	3.77	3.99	4.21	4.43	4.65	4.88	5.10	5.32
	48	0.22	0.43	0.65	0.87	1.09	1.30	1.52	1.74	1.95	2.17	2.39	2.60	2.82	3.04	3.26	3.47	3.69	3.91	4.12	4.34	4.56	4.77	4.99	5.21
	49	0.21	0.43	0.64	0.85	1.06	1.28	1.49	1.70	1.91	2.13	2.34	2.55	2.76	2.98	3.19	3.40	3.61	3.83	4.04	4.25	4.46	4.68	4.89	5.10
	50	0.21	0.42	0.63	0.83	1.04	1.25	1.46	1.67	1.88	2.08	2.29	2.50	2.71	2.92	3.13	3.33	3.54	3.75	3.96	4.17	4.38	4.58	4.79	5.00

Table 58. Number of Days Required to Transit (6,250 to 12,000 nm)

Transit Days	Distance (nm)																							
Speed (kts)	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	11250	11500	11750	12000
5	52.08	54.17	56.25	58.33	60.42	62.50	64.58	66.67	68.75	70.83	72.92	75.00	77.08	79.17	81.25	83.33	85.42	87.50	89.58	91.67	93.75	95.83	97.92	100.00
6	43.40	45.14	46.88	48.61	50.35	52.08	53.82	55.56	57.29	59.03	60.76	62.50	64.24	65.97	67.71	69.44	71.18	72.92	74.65	76.39	78.13	79.86	81.60	83.33
7	37.20	38.69	40.18	41.67	43.15	44.64	46.13	47.62	49.11	50.60	52.08	53.57	55.06	56.55	58.04	59.52	61.01	62.50	63.99	65.48	66.96	68.45	69.94	71.43
8	32.55	33.85	35.16	36.46	37.76	39.06	40.36	41.67	42.97	44.27	45.57	46.88	48.18	49.48	50.78	52.08	53.39	54.69	55.99	57.29	58.59	59.90	61.20	62.50
9	28.94	30.09	31.25	32.41	33.56	34.72	35.88	37.04	38.19	39.35	40.51	41.67	42.82	43.98	45.14	46.30	47.45	48.61	49.77	50.93	52.08	53.24	54.40	55.56
10	26.04	27.08	28.13	29.17	30.21	31.25	32.29	33.33	34.38	35.42	36.46	37.50	38.54	39.58	40.63	41.67	42.71	43.75	44.79	45.83	46.88	47.92	48.96	50.00
11	23.67	24.62	25.57	26.52	27.46	28.41	29.36	30.30	31.25	32.20	33.14	34.09	35.04	35.98	36.93	37.88	38.83	39.77	40.72	41.67	42.61	43.56	44.51	45.45
12	21.70	22.57	23.44	24.31	25.17	26.04	26.91	27.78	28.65	29.51	30.38	31.25	32.12	32.99	33.85	34.72	35.59	36.46	37.33	38.19	39.06	39.93	40.80	41.67
13	20.03	20.83	21.63	22.44	23.24	24.04	24.84	25.64	26.44	27.24	28.04	28.85	29.65	30.45	31.25	32.05	32.85	33.65	34.46	35.26	36.06	36.86	37.66	38.46
14	18.60	19.35	20.09	20.83	21.58	22.32	23.07	23.81	24.55	25.30	26.04	26.79	27.53	28.27	29.02	29.76	30.51	31.25	31.99	32.74	33.48	34.23	34.97	35.71
15	17.36	18.06	18.75	19.44	20.14	20.83	21.53	22.22	22.92	23.61	24.31	25.00	25.69	26.39	27.08	27.78	28.47	29.17	29.86	30.56	31.25	31.94	32.64	33.33
16	16.28	16.93	17.58	18.23	18.88	19.53	20.18	20.83	21.48	22.14	22.79	23.44	24.09	24.74	25.39	26.04	26.69	27.34	27.99	28.65	29.30	29.95	30.60	31.25
17	15.32	15.93	16.54	17.16	17.77	18.38	19.00	19.61	20.22	20.83	21.45	22.06	22.67	23.28	23.90	24.51	25.12	25.74	26.35	26.96	27.57	28.19	28.80	29.41
18	14.47	15.05	15.63	16.20	16.78	17.36	17.94	18.52	19.10	19.68	20.25	20.83	21.41	21.99	22.57	23.15	23.73	24.31	24.88	25.46	26.04	26.62	27.20	27.78
19	13.71	14.25	14.80	15.35	15.90	16.45	17.00	17.54	18.09	18.64	19.19	19.74	20.29	20.83	21.38	21.93	22.48	23.03	23.57	24.12	24.67	25.22	25.77	26.32
20	13.02	13.54	14.06	14.58	15.10	15.63	16.15	16.67	17.19	17.71	18.23	18.75	19.27	19.79	20.31	20.83	21.35	21.88	22.40	22.92	23.44	23.96	24.48	25.00
21	12.40	12.90	13.39	13.89	14.38	14.88	15.38	15.87	16.37	16.87	17.36	17.86	18.35	18.85	19.35	19.84	20.34	20.83	21.33	21.83	22.32	22.82	23.31	23.81
22	11.84	12.31	12.78	13.26	13.73	14.20	14.68	15.15	15.63	16.10	16.57	17.05	17.52	17.99	18.47	18.94	19.41	19.89	20.36	20.83	21.31	21.78	22.25	22.73
23	11.32	11.78	12.23	12.68	13.13	13.59	14.04	14.49	14.95	15.40	15.85	16.30	16.76	17.21	17.66	18.12	18.57	19.02	19.47	19.93	20.38	20.83	21.29	21.74
24	10.85	11.28	11.72	12.15	12.59	13.02	13.45	13.89	14.32	14.76	15.19	15.63	16.06	16.49	16.93	17.36	17.80	18.23	18.66	19.10	19.53	19.97	20.40	20.83
25	10.42	10.83	11.25	11.67	12.08	12.50	12.92	13.33	13.75	14.17	14.58	15.00	15.42	15.83	16.25	16.67	17.08	17.50	17.92	18.33	18.75	19.17	19.58	20.00
26	10.02	10.42	10.82	11.22	11.62	12.02	12.42	12.82	13.22	13.62	14.02	14.42	14.82	15.22	15.63	16.03	16.43	16.83	17.23	17.63	18.03	18.43	18.83	19.23
27	9.65	10.03	10.42	10.80	11.19	11.57	11.96	12.35	12.73	13.12	13.50	13.89	14.27	14.66	15.05	15.43	15.82	16.20	16.59	16.98	17.36	17.75	18.13	18.52
28	9.30	9.67	10.04	10.42	10.79	11.16	11.53	11.90	12.28	12.65	13.02	13.39	13.76	14.14	14.51	14.88	15.25	15.63	16.00	16.37	16.74	17.11	17.49	17.86
29	8.98	9.34	9.70	10.06	10.42	10.78	11.14	11.49	11.85	12.21	12.57	12.93	13.29	13.65	14.01	14.37	14.73	15.09	15.45	15.80	16.16	16.52	16.88	17.24
30	8.68	9.03	9.38	9.72	10.07	10.42	10.76	11.11	11.46	11.81	12.15	12.50	12.85	13.19	13.54	13.89	14.24	14.58	14.93	15.28	15.63	15.97	16.32	16.67
31	8.40	8.74	9.07	9.41	9.74	10.08	10.42	10.75	11.09	11.42	11.76	12.10	12.43	12.77	13.10	13.44	13.78	14.11	14.45	14.78	15.12	15.46	15.79	16.13
32	8.14	8.46	8.79	9.11	9.44	9.77	10.09	10.42	10.74	11.07	11.39	11.72	12.04	12.37	12.70	13.02	13.35	13.67	14.00	14.32	14.65	14.97	15.30	15.63
33	7.89	8.21	8.52	8.84	9.15	9.47	9.79	10.10	10.42	10.73	11.05	11.36	11.68	11.99	12.31	12.63	12.94	13.26	13.57	13.89	14.20	14.52	14.84	15.15
34	7.66	7.97	8.27	8.58	8.88	9.19	9.50	9.80	10.11	10.42	10.72	11.03	11.34	11.64	11.95	12.25	12.56	12.87	13.17	13.48	13.79	14.09	14.40	14.71
35	7.44	7.74	8.04	8.33	8.63	8.93	9.23	9.52	9.82	10.12	10.42	10.71	11.01	11.31	11.61	11.90	12.20	12.50	12.80	13.10	13.39	13.69	13.99	14.29
36	7.23	7.52	7.81	8.10	8.39	8.68	8.97	9.26	9.55	9.84	10.13	10.42	10.71	11.00	11.28	11.57	11.86	12.15	12.44	12.73	13.02	13.31	13.60	13.89
37	7.04	7.32	7.60	7.88	8.16	8.45	8.73	9.01	9.29	9.57	9.85	10.14	10.42	10.70	10.98	11.26	11.54	11.82	12.11	12.39	12.67	12.95	13.23	13.51
38	6.85	7.13	7.40	7.68	7.95	8.22	8.50	8.77	9.05	9.32	9.59	9.87	10.14	10.42	10.69	10.96	11.24	11.51	11.79	12.06	12.34	12.61	12.88	13.16
39	6.68	6.94	7.21	7.48	7.75	8.01	8.28	8.55	8.81	9.08	9.35	9.62	9.88	10.15	10.42	10.68	10.95	11.22	11.49	11.75	12.02	12.29	12.55	12.82
40	6.51	6.77	7.03	7.29	7.55	7.81	8.07	8.33	8.59	8.85	9.11	9.38	9.64	9.90	10.16	10.42	10.68	10.94	11.20	11.46	11.72	11.98	12.24	12.50
41	6.35	6.61	6.86	7.11	7.37	7.62	7.88	8.13	8.38	8.64	8.89	9.15	9.40	9.65	9.91	10.16	10.42	10.67	10.92	11.18	11.43	11.69	11.94	12.20
42	6.20	6.45	6.70	6.94	7.19	7.44	7.69	7.94	8.18	8.43	8.68	8.93	9.18	9.42	9.67	9.92	10.17	10.42	10.66	10.91	11.16	11.41	11.66	11.90
43	6.06	6.30	6.54	6.78	7.03	7.27	7.51	7.75	7.99	8.24	8.48	8.72	8.96	9.21	9.45	9.69	9.93	10.17	10.42	10.66	10.90	11.14	11.39	11.63
44	5.92	6.16	6.39	6.63	6.87	7.10	7.34	7.58	7.81	8.05	8.29	8.52	8.76	9.00	9.23	9.47	9.71	9.94	10.18	10.42	10.65	10.89	11.13	11.36
45	5.79	6.02	6.25	6.48	6.71	6.94	7.18	7.41	7.64	7.87	8.10	8.33	8.56	8.80	9.03	9.26	9.49	9.72	9.95	10.19	10.42	10.65	10.88	11.11
46	5.66	5.89	6.11	6.34	6.57	6.79	7.02	7.25	7.47	7.70	7.93	8.15	8.38	8.61	8.83	9.06	9.28	9.51	9.74	9.96	10.19	10.42	10.64	10.87
47	5.54	5.76	5.98	6.21	6.43	6.65	6.87	7.09	7.31	7.54	7.76	7.98	8.20	8.42	8.64	8.87	9.09	9.31	9.53	9.75	9.97	10.20	10.42	10.64
48	5.43	5.64	5.86	6.08	6.29	6.51	6.73	6.94	7.16	7.38	7.60	7.81	8.03	8.25	8.46	8.68	8.90	9.11	9.33	9.55	9.77	9.98	10.20	10.42
49	5.31	5.53	5.74	5.95	6.16	6.38	6.59	6.80	7.02	7.23	7.44	7.65	7.87	8.08	8.29	8.50	8.72	8.93	9.14	9.35	9.57	9.78	9.99	10.20
50	5.21	5.42	5.63	5.83	6.04	6.25	6.46	6.67	6.88	7.08	7.29	7.50	7.71	7.92	8.13	8.33	8.54	8.75	8.96	9.17	9.38	9.58	9.79	10.00

Table 59. USN Class Utility Score for 10-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(10 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
CG 47	100.0	94.8	89.6	84.4	79.2	74.0	68.8	63.5	58.3	53.1	47.9	42.7	37.5	32.3	27.1	21.9	16.7	11.5	6.3	1.0	-4.2	-9.4	-14.6	2,086,161
CVN 65	340.0	329.3	318.5	307.8	297.1	286.3	275.6	264.9	254.1	243.4	232.7	221.9	211.2	200.5	189.7	179.0	168.3	157.6	146.8	136.1	125.4	114.6	103.9	8,996,229
CVN 68	340.0	328.2	316.4	304.6	292.8	281.0	269.2	257.4	245.6	233.8	221.9	210.1	198.3	186.5	174.7	162.9	151.1	139.3	127.5	115.7	103.9	92.1	80.3	12,412,615
CVN 78	340.0	328.2	316.4	304.6	292.8	281.0	269.2	257.4	245.6	233.8	221.9	210.1	198.3	186.5	174.7	162.9	151.1	139.3	127.5	115.7	103.9	92.1	80.3	3,264,861
DDG 1000	100.0	94.8	89.6	84.4	79.2	74.0	68.8	63.5	58.3	53.1	47.9	42.7	37.5	32.3	27.1	21.9	16.7	11.5	6.3	1.0	-4.2	-9.4	-14.6	792,391
DDG 51	60.0	56.9	53.8	50.6	47.5	44.4	41.3	38.1	35.0	31.9	28.8	25.6	22.5	19.4	16.3	13.1	10.0	6.9	3.8	0.6	-2.5	-5.6	-8.7	2,167,038
DDG 72	60.0	56.9	53.8	50.6	47.5	44.4	41.3	38.1	35.0	31.9	28.8	25.6	22.5	19.4	16.3	13.1	10.0	6.9	3.8	0.6	-2.5	-5.6	-8.7	1,911,239
DDG 79	100.0	94.8	89.6	84.4	79.2	74.0	68.8	63.5	58.3	53.1	47.9	42.7	37.5	32.3	27.1	21.9	16.7	11.5	6.3	1.0	-4.2	-9.4	-14.6	1,673,912
FFG 7	100.0	95.5	90.9	86.4	81.9	77.4	72.8	68.3	63.8	59.2	54.7	50.2	45.7	41.1	36.6	32.1	27.5	23.0	18.5	13.9	9.4	4.9	0.4	862,827
LCC 19	90.0	84.1	78.3	72.4	66.6	60.7	54.8	49.0	43.1	37.3	31.4	25.5	19.7	13.8	8.0	2.1	-3.8	-9.6	-15.5	-21.3	-27.2	-33.0	-38.9	2,911,279
LCS 1	70.0	64.8	59.6	54.4	49.2	44.0	38.8	33.5	28.3	23.1	17.9	12.7	7.5	2.3	-2.9	-8.1	-13.3	-18.5	-23.8	-29.0	-34.2	-39.4	-44.6	903,162
LCS 2	90.0	83.3	76.6	69.9	63.2	56.5	49.8	43.1	36.4	29.7	23.0	16.3	9.6	2.9	-3.8	-10.4	-17.1	-23.8	-30.5	-37.2	-43.9	-50.6	-57.3	810,611
LHA 1	530.0	502.4	474.8	447.2	419.6	392.0	364.4	336.8	309.2	281.6	254.0	226.4	198.8	171.1	143.5	115.9	88.3	60.7	33.1	5.5	-22.1	-49.7	-77.3	3,568,069
LHA 6	530.0	502.4	474.8	447.2	419.6	392.0	364.4	336.8	309.2	281.6	254.0	226.4	198.8	171.1	143.5	115.9	88.3	60.7	33.1	5.5	-22.1	-49.7	-77.3	4,325,548
LHD 1	650.0	616.1	582.3	548.4	514.6	480.7	446.9	413.0	379.2	345.3	311.5	277.6	243.8	209.9	176.0	142.2	108.3	74.5	40.6	6.8	-27.1	-60.9	-94.8	4,669,010
LPD 17	230.0	216.7	203.4	190.1	176.8	163.4	150.1	136.8	123.5	110.2	96.9	83.6	70.3	57.0	43.7	30.3	17.0	3.7	-9.6	-22.9	-36.2	-49.5	-62.8	1,822,528
LPD 4	230.0	218.0	206.0	194.1	182.1	170.1	158.1	146.1	134.2	122.2	110.2	98.2	86.3	74.3	62.3	50.3	38.3	26.4	14.4	2.4	-9.6	-21.6	-33.5	1,630,019
LSD 41	130.0	122.5	115.0	107.4	99.9	92.4	84.9	77.3	69.8	62.3	54.8	47.2	39.7	32.2	24.7	17.2	9.6	2.1	-5.4	-12.9	-20.5	-28.0	-35.5	1,981,542
LSD 49	130.0	122.5	115.0	107.4	99.9	92.4	84.9	77.3	69.8	62.3	54.8	47.2	39.7	32.2	24.7	17.2	9.6	2.1	-5.4	-12.9	-20.5	-28.0	-35.5	2,419,679
MCM 1	20.0	17.9	15.8	13.8	11.7	9.6	7.5	5.4	3.3	1.3	-0.8	-2.9	-5.0	-7.1	-9.2	-11.3	-13.3	-15.4	-17.5	-19.6	-21.7	-23.8	-25.8	510,180
PC 1	50.0	45.7	41.3	37.0	32.6	28.3	24.0	19.6	15.3	10.9	6.6	2.3	-2.1	-6.4	-10.8	-15.1	-19.4	-23.8	-28.1	-32.5	-36.8	-41.1	-45.5	218,861
SSBN 726	20.0	19.2	18.3	17.5	16.7	15.8	15.0	14.2	13.3	12.5	11.7	10.8	10.0	9.2	8.3	7.5	6.7	5.8	5.0	4.2	3.3	2.5	1.7	2,686,878
SSGN 726	10.0	9.5	9.0	8.4	7.9	7.4	6.9	6.4	5.8	5.3	4.8	4.3	3.8	3.2	2.7	2.2	1.7	1.1	0.6	0.1	-0.4	-0.9	-1.5	1,888,106
SSN 21	10.0	9.5	9.0	8.4	7.9	7.4	6.9	6.4	5.8	5.3	4.8	4.3	3.8	3.2	2.7	2.2	1.7	1.1	0.6	0.1	-0.4	-0.9	-1.5	2,053,246
SSN 688	20.0	19.2	18.3	17.5	16.7	15.8	15.0	14.2	13.3	12.5	11.7	10.8	10.0	9.2	8.3	7.5	6.7	5.8	5.0	4.2	3.3	2.5	1.7	1,208,741
SSN 774	20.0	19.2	18.3	17.5	16.7	15.8	15.0	14.2	13.3	12.5	11.7	10.8	10.0	9.2	8.3	7.5	6.7	5.8	5.0	4.2	3.3	2.5	1.7	1,073,389

Table 60. USN Class Utility Score for 10-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(10 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
CG 47	-14.6	-19.8	-25.0	-30.2	-35.4	-40.6	-45.8	-51.0	-56.3	-61.5	-66.7	-71.9	-77.1	-82.3	-87.5	-92.7	-97.9	-103.1	-108.3	-113.5	-118.8	-124.0	-129.2	2,086,161
CVN 65	103.9	93.2	82.4	71.7	61.0	50.2	39.5	28.8	18.0	7.3	-3.4	-14.2	-24.9	-35.6	-46.4	-57.1	-67.8	-78.6	-89.3	-100.0	-110.8	-121.5	-132.2	8,996,229
CVN 68	80.3	68.5	56.7	44.9	33.1	21.3	9.4	-2.4	-14.2	-26.0	-37.8	-49.6	-61.4	-73.2	-85.0	-96.8	-108.6	-120.4	-132.2	-144.0	-155.8	-167.6	-179.4	12,412,615
CVN 78	80.3	68.5	56.7	44.9	33.1	21.3	9.4	-2.4	-14.2	-26.0	-37.8	-49.6	-61.4	-73.2	-85.0	-96.8	-108.6	-120.4	-132.2	-144.0	-155.8	-167.6	-179.4	3,264,861
DDG 1000	-14.6	-19.8	-25.0	-30.2	-35.4	-40.6	-45.8	-51.0	-56.3	-61.5	-66.7	-71.9	-77.1	-82.3	-87.5	-92.7	-97.9	-103.1	-108.3	-113.5	-118.8	-124.0	-129.2	792,391
DDG 51	-8.7	-11.9	-15.0	-18.1	-21.3	-24.4	-27.5	-30.6	-33.8	-36.9	-40.0	-43.1	-46.3	-49.4	-52.5	-55.6	-58.7	-61.9	-65.0	-68.1	-71.3	-74.4	-77.5	2,167,038
DDG 72	-8.7	-11.9	-15.0	-18.1	-21.3	-24.4	-27.5	-30.6	-33.8	-36.9	-40.0	-43.1	-46.3	-49.4	-52.5	-55.6	-58.7	-61.9	-65.0	-68.1	-71.3	-74.4	-77.5	1,911,239
DDG 79	-14.6	-19.8	-25.0	-30.2	-35.4	-40.6	-45.8	-51.0	-56.3	-61.5	-66.7	-71.9	-77.1	-82.3	-87.5	-92.7	-97.9	-103.1	-108.3	-113.5	-118.8	-124.0	-129.2	1,673,912
FFG 7	0.4	-4.2	-8.7	-13.2	-17.8	-22.3	-26.8	-31.3	-35.9	-40.4	-44.9	-49.5	-54.0	-58.5	-63.0	-67.6	-72.1	-76.6	-81.2	-85.7	-90.2	-94.7	-99.3	862,827
LCC 19	-38.9	-44.8	-50.6	-56.5	-62.3	-68.2	-74.1	-79.9	-85.8	-91.6	-97.5	-103.4	-109.2	-115.1	-120.9	-126.8	-132.7	-138.5	-144.4	-150.2	-156.1	-162.0	-167.8	2,911,279
LCS 1	-44.6	-49.8	-55.0	-60.2	-65.4	-70.6	-75.8	-81.0	-86.3	-91.5	-96.7	-101.9	-107.1	-112.3	-117.5	-122.7	-127.9	-133.1	-138.3	-143.5	-148.8	-154.0	-159.2	903,162
LCS 2	-57.3	-64.0	-70.7	-77.4	-84.1	-90.8	-97.5	-104.2	-110.9	-117.6	-124.3	-131.0	-137.7	-144.4	-151.1	-157.8	-164.5	-171.2	-177.9	-184.6	-191.3	-197.9	-204.6	810,611
LHA 1	-77.3	-104.9	-132.5	-160.1	-187.7	-215.3	-242.9	-270.5	-298.1	-325.7	-353.3	-380.9	-408.5	-436.1	-463.8	-491.4	-519.0	-546.6	-574.2	-601.8	-629.4	-657.0	-684.6	3,568,069
LHA 6	-77.3	-104.9	-132.5	-160.1	-187.7	-215.3	-242.9	-270.5	-298.1	-325.7	-353.3	-380.9	-408.5	-436.1	-463.8	-491.4	-519.0	-546.6	-574.2	-601.8	-629.4	-657.0	-684.6	4,325,548
LHD 1	-94.8	-128.6	-162.5	-196.4	-230.2	-264.1	-297.9	-331.8	-365.6	-399.5	-433.3	-467.2	-501.0	-534.9	-568.8	-602.6	-636.5	-670.3	-704.2	-738.0	-771.9	-805.7	-839.6	4,669,010
LPD 17	-62.8	-76.1	-89.4	-102.8	-116.1	-129.4	-142.7	-156.0	-169.3	-182.6	-195.9	-209.2	-222.5	-235.9	-249.2	-262.5	-275.8	-289.1	-302.4	-315.7	-329.0	-342.3	-355.6	1,822,528
LPD 4	-33.5	-45.5	-57.5	-69.5	-81.5	-93.4	-105.4	-117.4	-129.4	-141.4	-153.3	-165.3	-177.3	-189.3	-201.3	-213.2	-225.2	-237.2	-249.2	-261.1	-273.1	-285.1	-297.1	1,630,019
LSD 41	-35.5	-43.0	-50.6	-58.1	-65.6	-73.1	-80.6	-88.2	-95.7	-103.2	-110.7	-118.3	-125.8	-133.3	-140.8	-148.4	-155.9	-163.4	-170.9	-178.4	-186.0	-193.5	-201.0	1,981,542
LSD 49	-35.5	-43.0	-50.6	-58.1	-65.6	-73.1	-80.6	-88.2	-95.7	-103.2	-110.7	-118.3	-125.8	-133.3	-140.8	-148.4	-155.9	-163.4	-170.9	-178.4	-186.0	-193.5	-201.0	2,419,679
MCM 1	-25.8	-27.9	-30.0	-32.1	-34.2	-36.3	-38.3	-40.4	-42.5	-44.6	-46.7	-48.8	-50.8	-52.9	-55.0	-57.1	-59.2	-61.3	-63.3	-65.4	-67.5	-69.6	-71.7	510,180
PC 1	-45.5	-49.8	-54.2	-58.5	-62.8	-67.2	-71.5	-75.9	-80.2	-84.5	-88.9	-93.2	-97.6	-101.9	-106.3	-110.6	-114.9	-119.3	-123.6	-128.0	-132.3	-136.6	-141.0	218,861
SSBN 726	1.7	0.8	0.0	-0.8	-1.7	-2.5	-3.3	-4.2	-5.0	-5.8	-6.7	-7.5	-8.3	-9.2	-10.0	-10.8	-11.7	-12.5	-13.3	-14.2	-15.0	-15.8	-16.7	2,686,878
SSGN 726	-1.5	-2.0	-2.5	-3.0	-3.5	-4.1	-4.6	-5.1	-5.6	-6.1	-6.7	-7.2	-7.7	-8.2	-8.8	-9.3	-9.8	-10.3	-10.8	-11.4	-11.9	-12.4	-12.9	1,888,106
SSN 21	-1.5	-2.0	-2.5	-3.0	-3.5	-4.1	-4.6	-5.1	-5.6	-6.1	-6.7	-7.2	-7.7	-8.2	-8.8	-9.3	-9.8	-10.3	-10.8	-11.4	-11.9	-12.4	-12.9	2,053,246
SSN 688	1.7	0.8	0.0	-0.8	-1.7	-2.5	-3.3	-4.2	-5.0	-5.8	-6.7	-7.5	-8.3	-9.2	-10.0	-10.8	-11.7	-12.5	-13.3	-14.2	-15.0	-15.8	-16.7	1,208,741
SSN 774	1.7	0.8	0.0	-0.8	-1.7	-2.5	-3.3	-4.2	-5.0	-5.8	-6.7	-7.5	-8.3	-9.2	-10.0	-10.8	-11.7	-12.5	-13.3	-14.2	-15.0	-15.8	-16.7	1,073,389

Table 61. USN Class Utility Score for 30-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(30 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
CG 47	300.0	294.8	289.6	284.4	279.2	274.0	268.8	263.5	258.3	253.1	247.9	242.7	237.5	232.3	227.1	221.9	216.7	211.5	206.3	201.0	195.8	190.6	185.4	6,258,484
CVN 65	1020.0	1009.3	998.5	987.8	977.1	966.3	955.6	944.9	934.1	923.4	912.7	901.9	891.2	880.5	869.7	859.0	848.3	837.6	826.8	816.1	805.4	794.6	783.9	26,988,688
CVN 68	1020.0	1008.2	996.4	984.6	972.8	961.0	949.2	937.4	925.6	913.8	901.9	890.1	878.3	866.5	854.7	842.9	831.1	819.3	807.5	795.7	783.9	772.1	760.3	37,237,844
CVN 78	1020.0	1008.2	996.4	984.6	972.8	961.0	949.2	937.4	925.6	913.8	901.9	890.1	878.3	866.5	854.7	842.9	831.1	819.3	807.5	795.7	783.9	772.1	760.3	9,794,584
DDG 1000	300.0	294.8	289.6	284.4	279.2	274.0	268.8	263.5	258.3	253.1	247.9	242.7	237.5	232.3	227.1	221.9	216.7	211.5	206.3	201.0	195.8	190.6	185.4	2,377,172
DDG 51	180.0	176.9	173.8	170.6	167.5	164.4	161.3	158.1	155.0	151.9	148.8	145.6	142.5	139.4	136.3	133.1	130.0	126.9	123.8	120.6	117.5	114.4	111.3	6,501,114
DDG 72	180.0	176.9	173.8	170.6	167.5	164.4	161.3	158.1	155.0	151.9	148.8	145.6	142.5	139.4	136.3	133.1	130.0	126.9	123.8	120.6	117.5	114.4	111.3	5,733,716
DDG 79	300.0	294.8	289.6	284.4	279.2	274.0	268.8	263.5	258.3	253.1	247.9	242.7	237.5	232.3	227.1	221.9	216.7	211.5	206.3	201.0	195.8	190.6	185.4	5,021,735
FFG 7	300.0	295.5	290.9	286.4	281.9	277.4	272.8	268.3	263.8	259.2	254.7	250.2	245.7	241.1	236.6	232.1	227.5	223.0	218.5	213.9	209.4	204.9	200.4	2,588,480
LCC 19	270.0	264.1	258.3	252.4	246.6	240.7	234.8	229.0	223.1	217.3	211.4	205.5	199.7	193.8	188.0	182.1	176.3	170.4	164.5	158.7	152.8	147.0	141.1	8,733,836
LCS 1	210.0	204.8	199.6	194.4	189.2	184.0	178.8	173.5	168.3	163.1	157.9	152.7	147.5	142.3	137.1	131.9	126.7	121.5	116.3	111.0	105.8	100.6	95.4	2,709,486
LCS 2	270.0	263.3	256.6	249.9	243.2	236.5	229.8	223.1	216.4	209.7	203.0	196.3	189.6	182.9	176.3	169.6	162.9	156.2	149.5	142.8	136.1	129.4	122.7	2,431,832
LHA 1	1590.0	1562.4	1534.8	1507.2	1479.6	1452.0	1424.4	1396.8	1369.2	1341.6	1314.0	1286.4	1258.8	1231.1	1203.5	1175.9	1148.3	1120.7	1093.1	1065.5	1037.9	1010.3	982.7	10,704,205
LHA 6	1590.0	1562.4	1534.8	1507.2	1479.6	1452.0	1424.4	1396.8	1369.2	1341.6	1314.0	1286.4	1258.8	1231.1	1203.5	1175.9	1148.3	1120.7	1093.1	1065.5	1037.9	1010.3	982.7	12,976,642
LHD 1	1950.0	1916.1	1882.3	1848.4	1814.6	1780.7	1746.9	1713.0	1679.2	1645.3	1611.5	1577.6	1543.8	1509.9	1476.0	1442.2	1408.3	1374.5	1340.6	1306.8	1272.9	1239.1	1205.2	14,007,029
LPD 17	690.0	676.7	663.4	650.1	636.8	623.4	610.1	596.8	583.5	570.2	556.9	543.6	530.3	517.0	503.7	490.3	477.0	463.7	450.4	437.1	423.8	410.5	397.2	5,467,585
LPD 4	690.0	678.0	666.0	654.1	642.1	630.1	618.1	606.1	594.2	582.2	570.2	558.2	546.3	534.3	522.3	510.3	498.3	486.4	474.4	462.4	450.4	438.4	426.5	4,890,057
LSD 41	390.0	382.5	375.0	367.4	359.9	352.4	344.9	337.3	329.8	322.3	314.8	307.2	299.7	292.2	284.7	277.2	269.6	262.1	254.6	247.1	239.5	232.0	224.5	5,944,625
LSD 49	390.0	382.5	375.0	367.4	359.9	352.4	344.9	337.3	329.8	322.3	314.8	307.2	299.7	292.2	284.7	277.2	269.6	262.1	254.6	247.1	239.5	232.0	224.5	7,259,036
MCM 1	60.0	57.9	55.8	53.8	51.7	49.6	47.5	45.4	43.3	41.3	39.2	37.1	35.0	32.9	30.8	28.8	26.7	24.6	22.5	20.4	18.3	16.3	14.2	1,530,539
PC 1	150.0	145.7	141.3	137.0	132.6	128.3	124.0	119.6	115.3	110.9	106.6	102.3	97.9	93.6	89.2	84.9	80.6	76.2	71.9	67.5	63.2	58.9	54.5	656,582
SSBN 726	60.0	59.2	58.3	57.5	56.7	55.8	55.0	54.2	53.3	52.5	51.7	50.8	50.0	49.2	48.3	47.5	46.7	45.8	45.0	44.2	43.3	42.5	41.7	8,060,633
SSGN 726	30.0	29.5	29.0	28.4	27.9	27.4	26.9	26.4	25.8	25.3	24.8	24.3	23.8	23.2	22.7	22.2	21.7	21.1	20.6	20.1	19.6	19.1	18.5	5,664,317
SSN 21	30.0	29.5	29.0	28.4	27.9	27.4	26.9	26.4	25.8	25.3	24.8	24.3	23.8	23.2	22.7	22.2	21.7	21.1	20.6	20.1	19.6	19.1	18.5	6,159,737
SSN 688	60.0	59.2	58.3	57.5	56.7	55.8	55.0	54.2	53.3	52.5	51.7	50.8	50.0	49.2	48.3	47.5	46.7	45.8	45.0	44.2	43.3	42.5	41.7	3,626,222
SSN 774	60.0	59.2	58.3	57.5	56.7	55.8	55.0	54.2	53.3	52.5	51.7	50.8	50.0	49.2	48.3	47.5	46.7	45.8	45.0	44.2	43.3	42.5	41.7	3,220,166

Table 62. USN Class Utility Score for 30-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(30 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
CG 47	185.4	180.2	175.0	169.8	164.6	159.4	154.2	149.0	143.8	138.5	133.3	128.1	122.9	117.7	112.5	107.3	102.1	96.9	91.7	86.5	81.3	76.0	70.8	6,258,484
CVN 65	783.9	773.2	762.4	751.7	741.0	730.2	719.5	708.8	698.0	687.3	676.6	665.8	655.1	644.4	633.6	622.9	612.2	601.4	590.7	580.0	569.2	558.5	547.8	26,988,688
CVN 68	760.3	748.5	736.7	724.9	713.1	701.3	689.4	677.6	665.8	654.0	642.2	630.4	618.6	606.8	595.0	583.2	571.4	559.6	547.8	536.0	524.2	512.4	500.6	37,237,844
CVN 78	760.3	748.5	736.7	724.9	713.1	701.3	689.4	677.6	665.8	654.0	642.2	630.4	618.6	606.8	595.0	583.2	571.4	559.6	547.8	536.0	524.2	512.4	500.6	9,794,584
DDG 1000	185.4	180.2	175.0	169.8	164.6	159.4	154.2	149.0	143.8	138.5	133.3	128.1	122.9	117.7	112.5	107.3	102.1	96.9	91.7	86.5	81.3	76.0	70.8	2,377,172
DDG 51	111.3	108.1	105.0	101.9	98.8	95.6	92.5	89.4	86.3	83.1	80.0	76.9	73.8	70.6	67.5	64.4	61.3	58.1	55.0	51.9	48.8	45.6	42.5	6,501,114
DDG 72	111.3	108.1	105.0	101.9	98.8	95.6	92.5	89.4	86.3	83.1	80.0	76.9	73.8	70.6	67.5	64.4	61.3	58.1	55.0	51.9	48.8	45.6	42.5	5,733,716
DDG 79	185.4	180.2	175.0	169.8	164.6	159.4	154.2	149.0	143.8	138.5	133.3	128.1	122.9	117.7	112.5	107.3	102.1	96.9	91.7	86.5	81.3	76.0	70.8	5,021,735
FFG 7	200.4	195.8	191.3	186.8	182.2	177.7	173.2	168.7	164.1	159.6	155.1	150.5	146.0	141.5	137.0	132.4	127.9	123.4	118.8	114.3	109.8	105.3	100.7	2,588,480
LCC 19	141.1	135.2	129.4	123.5	117.7	111.8	105.9	100.1	94.2	88.4	82.5	76.6	70.8	64.9	59.1	53.2	47.3	41.5	35.6	29.8	23.9	18.0	12.2	8,733,836
LCS 1	95.4	90.2	85.0	79.8	74.6	69.4	64.2	59.0	53.8	48.5	43.3	38.1	32.9	27.7	22.5	17.3	12.1	6.9	1.7	-3.5	-8.8	-14.0	-19.2	2,709,486
LCS 2	122.7	116.0	109.3	102.6	95.9	89.2	82.5	75.8	69.1	62.4	55.7	49.0	42.3	35.6	28.9	22.2	15.5	8.8	2.1	-4.6	-11.3	-17.9	-24.6	2,431,832
LHA 1	982.7	955.1	927.5	899.9	872.3	844.7	817.1	789.5	761.9	734.3	706.7	679.1	651.5	623.9	596.3	568.6	541.0	513.4	485.8	458.2	430.6	403.0	375.4	10,704,205
LHA 6	982.7	955.1	927.5	899.9	872.3	844.7	817.1	789.5	761.9	734.3	706.7	679.1	651.5	623.9	596.3	568.6	541.0	513.4	485.8	458.2	430.6	403.0	375.4	12,976,642
LHD 1	1205.2	1171.4	1137.5	1103.6	1069.8	1035.9	1002.1	968.2	934.4	900.5	866.7	832.8	799.0	765.1	731.3	697.4	663.5	629.7	595.8	562.0	528.1	494.3	460.4	14,007,029
LPD 17	397.2	383.9	370.6	357.2	343.9	330.6	317.3	304.0	290.7	277.4	264.1	250.8	237.5	224.1	210.8	197.5	184.2	170.9	157.6	144.3	131.0	117.7	104.4	5,467,585
LPD 4	426.5	414.5	402.5	390.5	378.5	366.6	354.6	342.6	330.6	318.6	306.7	294.7	282.7	270.7	258.8	246.8	234.8	222.8	210.8	198.9	186.9	174.9	162.9	4,890,057
LSD 41	224.5	217.0	209.4	201.9	194.4	186.9	179.4	171.8	164.3	156.8	149.3	141.7	134.2	126.7	119.2	111.6	104.1	96.6	89.1	81.6	74.0	66.5	59.0	5,944,625
LSD 49	224.5	217.0	209.4	201.9	194.4	186.9	179.4	171.8	164.3	156.8	149.3	141.7	134.2	126.7	119.2	111.6	104.1	96.6	89.1	81.6	74.0	66.5	59.0	7,259,036
MCM 1	14.2	12.1	10.0	7.9	5.8	3.8	1.7	-0.4	-2.5	-4.6	-6.7	-8.8	-10.8	-12.9	-15.0	-17.1	-19.2	-21.3	-23.3	-25.4	-27.5	-29.6	-31.7	1,530,539
PC 1	54.5	50.2	45.8	41.5	37.2	32.8	28.5	24.1	19.8	15.5	11.1	6.8	2.4	-1.9	-6.3	-10.6	-14.9	-19.3	-23.6	-28.0	-32.3	-36.6	-41.0	656,582
SSBN 726	41.7	40.8	40.0	39.2	38.3	37.5	36.7	35.8	35.0	34.2	33.3	32.5	31.7	30.8	30.0	29.2	28.3	27.5	26.7	25.8	25.0	24.2	23.3	8,060,633
SSGN 726	18.5	18.0	17.5	17.0	16.5	15.9	15.4	14.9	14.4	13.9	13.3	12.8	12.3	11.8	11.3	10.7	10.2	9.7	9.2	8.6	8.1	7.6	7.1	5,664,317
SSN 21	18.5	18.0	17.5	17.0	16.5	15.9	15.4	14.9	14.4	13.9	13.3	12.8	12.3	11.8	11.3	10.7	10.2	9.7	9.2	8.6	8.1	7.6	7.1	6,159,737
SSN 688	41.7	40.8	40.0	39.2	38.3	37.5	36.7	35.8	35.0	34.2	33.3	32.5	31.7	30.8	30.0	29.2	28.3	27.5	26.7	25.8	25.0	24.2	23.3	3,626,222
SSN 774	41.7	40.8	40.0	39.2	38.3	37.5	36.7	35.8	35.0	34.2	33.3	32.5	31.7	30.8	30.0	29.2	28.3	27.5	26.7	25.8	25.0	24.2	23.3	3,220,166

Table 63. USN Class Utility Score for 60-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(60 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
CG 47	600.0	594.8	589.6	584.4	579.2	574.0	568.8	563.5	558.3	553.1	547.9	542.7	537.5	532.3	527.1	521.9	516.7	511.5	506.3	501.0	495.8	490.6	485.4	12,516,967
CVN 65	2040.0	2029.3	2018.5	2007.8	1997.1	1986.3	1975.6	1964.9	1954.1	1943.4	1932.7	1921.9	1911.2	1900.5	1889.7	1879.0	1868.3	1857.6	1846.8	1836.1	1825.4	1814.6	1803.9	53,977,376
CVN 68	2040.0	2028.2	2016.4	2004.6	1992.8	1981.0	1969.2	1957.4	1945.6	1933.8	1921.9	1910.1	1898.3	1886.5	1874.7	1862.9	1851.1	1839.3	1827.5	1815.7	1803.9	1792.1	1780.3	74,475,688
CVN 78	2040.0	2028.2	2016.4	2004.6	1992.8	1981.0	1969.2	1957.4	1945.6	1933.8	1921.9	1910.1	1898.3	1886.5	1874.7	1862.9	1851.1	1839.3	1827.5	1815.7	1803.9	1792.1	1780.3	19,589,168
DDG 1000	600.0	594.8	589.6	584.4	579.2	574.0	568.8	563.5	558.3	553.1	547.9	542.7	537.5	532.3	527.1	521.9	516.7	511.5	506.3	501.0	495.8	490.6	485.4	4,754,344
DDG 51	360.0	356.9	353.8	350.6	347.5	344.4	341.3	338.1	335.0	331.9	328.8	325.6	322.5	319.4	316.3	313.1	310.0	306.9	303.8	300.6	297.5	294.4	291.3	13,002,227
DDG 72	360.0	356.9	353.8	350.6	347.5	344.4	341.3	338.1	335.0	331.9	328.8	325.6	322.5	319.4	316.3	313.1	310.0	306.9	303.8	300.6	297.5	294.4	291.3	11,467,432
DDG 79	600.0	594.8	589.6	584.4	579.2	574.0	568.8	563.5	558.3	553.1	547.9	542.7	537.5	532.3	527.1	521.9	516.7	511.5	506.3	501.0	495.8	490.6	485.4	10,043,470
FFG 7	600.0	595.5	590.9	586.4	581.9	577.4	572.8	568.3	563.8	559.2	554.7	550.2	545.7	541.1	536.6	532.1	527.5	523.0	518.5	513.9	509.4	504.9	500.4	5,176,961
LCC 19	540.0	534.1	528.3	522.4	516.6	510.7	504.8	499.0	493.1	487.3	481.4	475.5	469.7	463.8	458.0	452.1	446.3	440.4	434.5	428.7	422.8	417.0	411.1	17,467,672
LCS 1	420.0	414.8	409.6	404.4	399.2	394.0	388.8	383.5	378.3	373.1	367.9	362.7	357.5	352.3	347.1	341.9	336.7	331.5	326.3	321.0	315.8	310.6	305.4	5,418,972
LCS 2	540.0	533.3	526.6	519.9	513.2	506.5	499.8	493.1	486.4	479.7	473.0	466.3	459.6	452.9	446.3	439.6	432.9	426.2	419.5	412.8	406.1	399.4	392.7	4,863,664
LHA 1	3180.0	3152.4	3124.8	3097.2	3069.6	3042.0	3014.4	2986.8	2959.2	2931.6	2904.0	2876.4	2848.8	2821.1	2793.5	2765.9	2738.3	2710.7	2683.1	2655.5	2627.9	2600.3	2572.7	21,408,410
LHA 6	3180.0	3152.4	3124.8	3097.2	3069.6	3042.0	3014.4	2986.8	2959.2	2931.6	2904.0	2876.4	2848.8	2821.1	2793.5	2765.9	2738.3	2710.7	2683.1	2655.5	2627.9	2600.3	2572.7	25,953,284
LHD 1	3900.0	3866.1	3832.3	3798.4	3764.6	3730.7	3696.9	3663.0	3629.2	3595.3	3561.5	3527.6	3493.8	3459.9	3426.0	3392.2	3358.3	3324.5	3290.6	3256.8	3222.9	3189.1	3155.2	28,014,058
LPD 17	1380.0	1366.7	1353.4	1340.1	1326.8	1313.4	1300.1	1286.8	1273.5	1260.2	1246.9	1233.6	1220.3	1207.0	1193.7	1180.3	1167.0	1153.7	1140.4	1127.1	1113.8	1100.5	1087.2	10,935,169
LPD 4	1380.0	1368.0	1356.0	1344.1	1332.1	1320.1	1308.1	1296.1	1284.2	1272.2	1260.2	1248.2	1236.3	1224.3	1212.3	1200.3	1188.3	1176.4	1164.4	1152.4	1140.4	1128.4	1116.5	9,780,113
LSD 41	780.0	772.5	765.0	757.4	749.9	742.4	734.9	727.3	719.8	712.3	704.8	697.2	689.7	682.2	674.7	667.2	659.6	652.1	644.6	637.1	629.5	622.0	614.5	11,889,250
LSD 49	780.0	772.5	765.0	757.4	749.9	742.4	734.9	727.3	719.8	712.3	704.8	697.2	689.7	682.2	674.7	667.2	659.6	652.1	644.6	637.1	629.5	622.0	614.5	14,518,072
MCM 1	120.0	117.9	115.8	113.8	111.7	109.6	107.5	105.4	103.3	101.3	99.2	97.1	95.0	92.9	90.8	88.8	86.7	84.6	82.5	80.4	78.3	76.3	74.2	3,061,079
PC 1	300.0	295.7	291.3	287.0	282.6	278.3	274.0	269.6	265.3	260.9	256.6	252.3	247.9	243.6	239.2	234.9	230.6	226.2	221.9	217.5	213.2	208.9	204.5	1,313,165
SSBN 726	120.0	119.2	118.3	117.5	116.7	115.8	115.0	114.2	113.3	112.5	111.7	110.8	110.0	109.2	108.3	107.5	106.7	105.8	105.0	104.2	103.3	102.5	101.7	16,121,265
SSGN 726	60.0	59.5	59.0	58.4	57.9	57.4	56.9	56.4	55.8	55.3	54.8	54.3	53.8	53.2	52.7	52.2	51.7	51.1	50.6	50.1	49.6	49.1	48.5	11,328,634
SSN 21	60.0	59.5	59.0	58.4	57.9	57.4	56.9	56.4	55.8	55.3	54.8	54.3	53.8	53.2	52.7	52.2	51.7	51.1	50.6	50.1	49.6	49.1	48.5	12,319,474
SSN 688	120.0	119.2	118.3	117.5	116.7	115.8	115.0	114.2	113.3	112.5	111.7	110.8	110.0	109.2	108.3	107.5	106.7	105.8	105.0	104.2	103.3	102.5	101.7	7,252,443
SSN 774	120.0	119.2	118.3	117.5	116.7	115.8	115.0	114.2	113.3	112.5	111.7	110.8	110.0	109.2	108.3	107.5	106.7	105.8	105.0	104.2	103.3	102.5	101.7	6,440,333

Table 64. USN Class Utility Score for 60-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(60 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
CG 47	485.4	480.2	475.0	469.8	464.6	459.4	454.2	449.0	443.8	438.5	433.3	428.1	422.9	417.7	412.5	407.3	402.1	396.9	391.7	386.5	381.3	376.0	370.8	12,516,967
CVN 65	1803.9	1793.2	1782.4	1771.7	1761.0	1750.2	1739.5	1728.8	1718.0	1707.3	1696.6	1685.8	1675.1	1664.4	1653.6	1642.9	1632.2	1621.4	1610.7	1600.0	1589.2	1578.5	1567.8	53,977,376
CVN 68	1780.3	1768.5	1756.7	1744.9	1733.1	1721.3	1709.4	1697.6	1685.8	1674.0	1662.2	1650.4	1638.6	1626.8	1615.0	1603.2	1591.4	1579.6	1567.8	1556.0	1544.2	1532.4	1520.6	74,475,688
CVN 78	1780.3	1768.5	1756.7	1744.9	1733.1	1721.3	1709.4	1697.6	1685.8	1674.0	1662.2	1650.4	1638.6	1626.8	1615.0	1603.2	1591.4	1579.6	1567.8	1556.0	1544.2	1532.4	1520.6	19,589,168
DDG 1000	485.4	480.2	475.0	469.8	464.6	459.4	454.2	449.0	443.8	438.5	433.3	428.1	422.9	417.7	412.5	407.3	402.1	396.9	391.7	386.5	381.3	376.0	370.8	4,754,344
DDG 51	291.3	288.1	285.0	281.9	278.8	275.6	272.5	269.4	266.3	263.1	260.0	256.9	253.8	250.6	247.5	244.4	241.3	238.1	235.0	231.9	228.8	225.6	222.5	13,002,227
DDG 72	291.3	288.1	285.0	281.9	278.8	275.6	272.5	269.4	266.3	263.1	260.0	256.9	253.8	250.6	247.5	244.4	241.3	238.1	235.0	231.9	228.8	225.6	222.5	11,467,432
DDG 79	485.4	480.2	475.0	469.8	464.6	459.4	454.2	449.0	443.8	438.5	433.3	428.1	422.9	417.7	412.5	407.3	402.1	396.9	391.7	386.5	381.3	376.0	370.8	10,043,470
FFG 7	500.4	495.8	491.3	486.8	482.2	477.7	473.2	468.7	464.1	459.6	455.1	450.5	446.0	441.5	437.0	432.4	427.9	423.4	418.8	414.3	409.8	405.3	400.7	5,176,961
LCC 19	411.1	405.2	399.4	393.5	387.7	381.8	375.9	370.1	364.2	358.4	352.5	346.6	340.8	334.9	329.1	323.2	317.3	311.5	305.6	299.8	293.9	288.0	282.2	17,467,672
LCS 1	305.4	300.2	295.0	289.8	284.6	279.4	274.2	269.0	263.8	258.5	253.3	248.1	242.9	237.7	232.5	227.3	222.1	216.9	211.7	206.5	201.3	196.0	190.8	5,418,972
LCS 2	392.7	386.0	379.3	372.6	365.9	359.2	352.5	345.8	339.1	332.4	325.7	319.0	312.3	305.6	298.9	292.2	285.5	278.8	272.1	265.4	258.8	252.1	245.4	4,863,664
LHA 1	2572.7	2545.1	2517.5	2489.9	2462.3	2434.7	2407.1	2379.5	2351.9	2324.3	2296.7	2269.1	2241.5	2213.9	2186.3	2158.6	2131.0	2103.4	2075.8	2048.2	2020.6	1993.0	1965.4	21,408,410
LHA 6	2572.7	2545.1	2517.5	2489.9	2462.3	2434.7	2407.1	2379.5	2351.9	2324.3	2296.7	2269.1	2241.5	2213.9	2186.3	2158.6	2131.0	2103.4	2075.8	2048.2	2020.6	1993.0	1965.4	25,953,284
LHD 1	3155.2	3121.4	3087.5	3053.6	3019.8	2985.9	2952.1	2918.2	2884.4	2850.5	2816.7	2782.8	2749.0	2715.1	2681.3	2647.4	2613.5	2579.7	2545.8	2512.0	2478.1	2444.3	2410.4	28,014,058
LPD 17	1087.2	1073.9	1060.6	1047.2	1033.9	1020.6	1007.3	994.0	980.7	967.4	954.1	940.8	927.5	914.1	900.8	887.5	874.2	860.9	847.6	834.3	821.0	807.7	794.4	10,935,169
LPD 4	1116.5	1104.5	1092.5	1080.5	1068.5	1056.6	1044.6	1032.6	1020.6	1008.6	996.7	984.7	972.7	960.7	948.8	936.8	924.8	912.8	900.8	888.9	876.9	864.9	852.9	9,780,113
LSD 41	614.5	607.0	599.4	591.9	584.4	576.9	569.4	561.8	554.3	546.8	539.3	531.7	524.2	516.7	509.2	501.6	494.1	486.6	479.1	471.6	464.0	456.5	449.0	11,889,250
LSD 49	614.5	607.0	599.4	591.9	584.4	576.9	569.4	561.8	554.3	546.8	539.3	531.7	524.2	516.7	509.2	501.6	494.1	486.6	479.1	471.6	464.0	456.5	449.0	14,518,072
MCM 1	74.2	72.1	70.0	67.9	65.8	63.8	61.7	59.6	57.5	55.4	53.3	51.3	49.2	47.1	45.0	42.9	40.8	38.8	36.7	34.6	32.5	30.4	28.3	3,061,079
PC 1	204.5	200.2	195.8	191.5	187.2	182.8	178.5	174.1	169.8	165.5	161.1	156.8	152.4	148.1	143.8	139.4	135.1	130.7	126.4	122.0	117.7	113.4	109.0	1,313,165
SSBN 726	101.7	100.8	100.0	99.2	98.3	97.5	96.7	95.8	95.0	94.2	93.3	92.5	91.7	90.8	90.0	89.2	88.3	87.5	86.7	85.8	85.0	84.2	83.3	16,121,265
SSGN 726	48.5	48.0	47.5	47.0	46.5	45.9	45.4	44.9	44.4	43.9	43.3	42.8	42.3	41.8	41.3	40.7	40.2	39.7	39.2	38.6	38.1	37.6	37.1	11,328,634
SSN 21	48.5	48.0	47.5	47.0	46.5	45.9	45.4	44.9	44.4	43.9	43.3	42.8	42.3	41.8	41.3	40.7	40.2	39.7	39.2	38.6	38.1	37.6	37.1	12,319,474
SSN 688	101.7	100.8	100.0	99.2	98.3	97.5	96.7	95.8	95.0	94.2	93.3	92.5	91.7	90.8	90.0	89.2	88.3	87.5	86.7	85.8	85.0	84.2	83.3	7,252,443
SSN 774	101.7	100.8	100.0	99.2	98.3	97.5	96.7	95.8	95.0	94.2	93.3	92.5	91.7	90.8	90.0	89.2	88.3	87.5	86.7	85.8	85.0	84.2	83.3	6,440,333

Table 65. USN Class Utility Score for 90-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(90 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
CG 47	900.0	894.8	889.6	884.4	879.2	874.0	868.8	863.5	858.3	853.1	847.9	842.7	837.5	832.3	827.1	821.9	816.7	811.5	806.3	801.0	795.8	790.6	785.4	18,775,450
CVN 65	3060.0	3049.3	3038.5	3027.8	3017.1	3006.3	2995.6	2984.9	2974.1	2963.4	2952.7	2941.9	2931.2	2920.5	2909.7	2899.0	2888.3	2877.6	2866.8	2856.1	2845.4	2834.6	2823.9	80,966,064
CVN 68	3060.0	3048.2	3036.4	3024.6	3012.8	3001.0	2989.2	2977.4	2965.6	2953.8	2941.9	2930.1	2918.3	2906.5	2894.7	2882.9	2871.1	2859.3	2847.5	2835.7	2823.9	2812.1	2800.3	111,713,536
CVN 78	3060.0	3048.2	3036.4	3024.6	3012.8	3001.0	2989.2	2977.4	2965.6	2953.8	2941.9	2930.1	2918.3	2906.5	2894.7	2882.9	2871.1	2859.3	2847.5	2835.7	2823.9	2812.1	2800.3	29,383,752
DDG 1000	900.0	894.8	889.6	884.4	879.2	874.0	868.8	863.5	858.3	853.1	847.9	842.7	837.5	832.3	827.1	821.9	816.7	811.5	806.3	801.0	795.8	790.6	785.4	7,131,517
DDG 51	540.0	536.9	533.8	530.6	527.5	524.4	521.3	518.1	515.0	511.9	508.8	505.6	502.5	499.4	496.3	493.1	490.0	486.9	483.8	480.6	477.5	474.4	471.3	19,503,340
DDG 72	540.0	536.9	533.8	530.6	527.5	524.4	521.3	518.1	515.0	511.9	508.8	505.6	502.5	499.4	496.3	493.1	490.0	486.9	483.8	480.6	477.5	474.4	471.3	17,201,148
DDG 79	900.0	894.8	889.6	884.4	879.2	874.0	868.8	863.5	858.3	853.1	847.9	842.7	837.5	832.3	827.1	821.9	816.7	811.5	806.3	801.0	795.8	790.6	785.4	15,065,205
FFG 7	900.0	895.5	890.9	886.4	881.9	877.4	872.8	868.3	863.8	859.2	854.7	850.2	845.7	841.1	836.6	832.1	827.5	823.0	818.5	813.9	809.4	804.9	800.4	7,765,441
LCC 19	810.0	804.1	798.3	792.4	786.6	780.7	774.8	769.0	763.1	757.3	751.4	745.5	739.7	733.8	728.0	722.1	716.3	710.4	704.5	698.7	692.8	687.0	681.1	26,201,508
LCS 1	630.0	624.8	619.6	614.4	609.2	604.0	598.8	593.5	588.3	583.1	577.9	572.7	567.5	562.3	557.1	551.9	546.7	541.5	536.3	531.0	525.8	520.6	515.4	8,128,459
LCS 2	810.0	803.3	796.6	789.9	783.2	776.5	769.8	763.1	756.4	749.7	743.0	736.3	729.6	722.9	716.3	709.6	702.9	696.2	689.5	682.8	676.1	669.4	662.7	7,295,495
LHA 1	4770.0	4742.4	4714.8	4687.2	4659.6	4632.0	4604.4	4576.8	4549.2	4521.6	4494.0	4466.4	4438.8	4411.1	4383.5	4355.9	4328.3	4300.7	4273.1	4245.5	4217.9	4190.3	4162.7	32,112,616
LHA 6	4770.0	4742.4	4714.8	4687.2	4659.6	4632.0	4604.4	4576.8	4549.2	4521.6	4494.0	4466.4	4438.8	4411.1	4383.5	4355.9	4328.3	4300.7	4273.1	4245.5	4217.9	4190.3	4162.7	38,929,928
LHD 1	5850.0	5816.1	5782.3	5748.4	5714.6	5680.7	5646.9	5613.0	5579.2	5545.3	5511.5	5477.6	5443.8	5409.9	5376.0	5342.2	5308.3	5274.5	5240.6	5206.8	5172.9	5139.1	5105.2	42,021,088
LPD 17	2070.0	2056.7	2043.4	2030.1	2016.8	2003.4	1990.1	1976.8	1963.5	1950.2	1936.9	1923.6	1910.3	1897.0	1883.7	1870.3	1857.0	1843.7	1830.4	1817.1	1803.8	1790.5	1777.2	16,402,753
LPD 4	2070.0	2058.0	2046.0	2034.1	2022.1	2010.1	1998.1	1986.1	1974.2	1962.2	1950.2	1938.2	1926.3	1914.3	1902.3	1890.3	1878.3	1866.4	1854.4	1842.4	1830.4	1818.4	1806.5	14,670,170
LSD 41	1170.0	1162.5	1155.0	1147.4	1139.9	1132.4	1124.9	1117.3	1109.8	1102.3	1094.8	1087.2	1079.7	1072.2	1064.7	1057.2	1049.6	1042.1	1034.6	1027.1	1019.5	1012.0	1004.5	17,833,876
LSD 49	1170.0	1162.5	1155.0	1147.4	1139.9	1132.4	1124.9	1117.3	1109.8	1102.3	1094.8	1087.2	1079.7	1072.2	1064.7	1057.2	1049.6	1042.1	1034.6	1027.1	1019.5	1012.0	1004.5	21,777,108
MCM 1	180.0	177.9	175.8	173.8	171.7	169.6	167.5	165.4	163.3	161.3	159.2	157.1	155.0	152.9	150.8	148.8	146.7	144.6	142.5	140.4	138.3	136.3	134.2	4,591,618
PC 1	450.0	445.7	441.3	437.0	432.6	428.3	424.0	419.6	415.3	410.9	406.6	402.3	397.9	393.6	389.2	384.9	380.6	376.2	371.9	367.5	363.2	358.9	354.5	1,969,747
SSBN 726	180.0	179.2	178.3	177.5	176.7	175.8	175.0	174.2	173.3	172.5	171.7	170.8	170.0	169.2	168.3	167.5	166.7	165.8	165.0	164.2	163.3	162.5	161.7	24,181,898
SSGN 726	90.0	89.5	89.0	88.4	87.9	87.4	86.9	86.4	85.8	85.3	84.8	84.3	83.8	83.2	82.7	82.2	81.7	81.1	80.6	80.1	79.6	79.1	78.5	16,992,950
SSN 21	90.0	89.5	89.0	88.4	87.9	87.4	86.9	86.4	85.8	85.3	84.8	84.3	83.8	83.2	82.7	82.2	81.7	81.1	80.6	80.1	79.6	79.1	78.5	18,479,210
SSN 688	180.0	179.2	178.3	177.5	176.7	175.8	175.0	174.2	173.3	172.5	171.7	170.8	170.0	169.2	168.3	167.5	166.7	165.8	165.0	164.2	163.3	162.5	161.7	10,878,664
SSN 774	180.0	179.2	178.3	177.5	176.7	175.8	175.0	174.2	173.3	172.5	171.7	170.8	170.0	169.2	168.3	167.5	166.7	165.8	165.0	164.2	163.3	162.5	161.7	9,660,499

Table 66. USN Class Utility Score for 90-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(90 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
CG 47	785.4	780.2	775.0	769.8	764.6	759.4	754.2	749.0	743.8	738.5	733.3	728.1	722.9	717.7	712.5	707.3	702.1	696.9	691.7	686.5	681.3	676.0	670.8	18,775,450
CVN 65	2823.9	2813.2	2802.4	2791.7	2781.0	2770.2	2759.5	2748.8	2738.0	2727.3	2716.6	2705.8	2695.1	2684.4	2673.6	2662.9	2652.2	2641.4	2630.7	2620.0	2609.2	2598.5	2587.8	80,966,064
CVN 68	2800.3	2788.5	2776.7	2764.9	2753.1	2741.3	2729.4	2717.6	2705.8	2694.0	2682.2	2670.4	2658.6	2646.8	2635.0	2623.2	2611.4	2599.6	2587.8	2576.0	2564.2	2552.4	2540.6	111,713,536
CVN 78	2800.3	2788.5	2776.7	2764.9	2753.1	2741.3	2729.4	2717.6	2705.8	2694.0	2682.2	2670.4	2658.6	2646.8	2635.0	2623.2	2611.4	2599.6	2587.8	2576.0	2564.2	2552.4	2540.6	29,383,752
DDG 1000	785.4	780.2	775.0	769.8	764.6	759.4	754.2	749.0	743.8	738.5	733.3	728.1	722.9	717.7	712.5	707.3	702.1	696.9	691.7	686.5	681.3	676.0	670.8	7,131,517
DDG 51	471.3	468.1	465.0	461.9	458.8	455.6	452.5	449.4	446.3	443.1	440.0	436.9	433.8	430.6	427.5	424.4	421.3	418.1	415.0	411.9	408.8	405.6	402.5	19,503,340
DDG 72	471.3	468.1	465.0	461.9	458.8	455.6	452.5	449.4	446.3	443.1	440.0	436.9	433.8	430.6	427.5	424.4	421.3	418.1	415.0	411.9	408.8	405.6	402.5	17,201,148
DDG 79	785.4	780.2	775.0	769.8	764.6	759.4	754.2	749.0	743.8	738.5	733.3	728.1	722.9	717.7	712.5	707.3	702.1	696.9	691.7	686.5	681.3	676.0	670.8	15,065,205
FFG 7	800.4	795.8	791.3	786.8	782.2	777.7	773.2	768.7	764.1	759.6	755.1	750.5	746.0	741.5	737.0	732.4	727.9	723.4	718.8	714.3	709.8	705.3	700.7	7,765,441
LCC 19	681.1	675.2	669.4	663.5	657.7	651.8	645.9	640.1	634.2	628.4	622.5	616.6	610.8	604.9	599.1	593.2	587.3	581.5	575.6	569.8	563.9	558.0	552.2	26,201,508
LCS 1	515.4	510.2	505.0	499.8	494.6	489.4	484.2	479.0	473.8	468.5	463.3	458.1	452.9	447.7	442.5	437.3	432.1	426.9	421.7	416.5	411.3	406.0	400.8	8,128,459
LCS 2	662.7	656.0	649.3	642.6	635.9	629.2	622.5	615.8	609.1	602.4	595.7	589.0	582.3	575.6	568.9	562.2	555.5	548.8	542.1	535.4	528.8	522.1	515.4	7,295,495
LHA 1	4162.7	4135.1	4107.5	4079.9	4052.3	4024.7	3997.1	3969.5	3941.9	3914.3	3886.7	3859.1	3831.5	3803.9	3776.3	3748.6	3721.0	3693.4	3665.8	3638.2	3610.6	3583.0	3555.4	32,112,616
LHA 6	4162.7	4135.1	4107.5	4079.9	4052.3	4024.7	3997.1	3969.5	3941.9	3914.3	3886.7	3859.1	3831.5	3803.9	3776.3	3748.6	3721.0	3693.4	3665.8	3638.2	3610.6	3583.0	3555.4	38,929,928
LHD 1	5105.2	5071.4	5037.5	5003.6	4969.8	4935.9	4902.1	4868.2	4834.4	4800.5	4766.7	4732.8	4699.0	4665.1	4631.3	4597.4	4563.5	4529.7	4495.8	4462.0	4428.1	4394.3	4360.4	42,021,088
LPD 17	1777.2	1763.9	1750.6	1737.2	1723.9	1710.6	1697.3	1684.0	1670.7	1657.4	1644.1	1630.8	1617.5	1604.1	1590.8	1577.5	1564.2	1550.9	1537.6	1524.3	1511.0	1497.7	1484.4	16,402,753
LPD 4	1806.5	1794.5	1782.5	1770.5	1758.5	1746.6	1734.6	1722.6	1710.6	1698.6	1686.7	1674.7	1662.7	1650.7	1638.8	1626.8	1614.8	1602.8	1590.8	1578.9	1566.9	1554.9	1542.9	14,670,170
LSD 41	1004.5	997.0	989.4	981.9	974.4	966.9	959.4	951.8	944.3	936.8	929.3	921.7	914.2	906.7	899.2	891.6	884.1	876.6	869.1	861.6	854.0	846.5	839.0	17,833,876
LSD 49	1004.5	997.0	989.4	981.9	974.4	966.9	959.4	951.8	944.3	936.8	929.3	921.7	914.2	906.7	899.2	891.6	884.1	876.6	869.1	861.6	854.0	846.5	839.0	21,777,108
MCM 1	134.2	132.1	130.0	127.9	125.8	123.8	121.7	119.6	117.5	115.4	113.3	111.3	109.2	107.1	105.0	102.9	100.8	98.8	96.7	94.6	92.5	90.4	88.3	4,591,618
PC 1	354.5	350.2	345.8	341.5	337.2	332.8	328.5	324.1	319.8	315.5	311.1	306.8	302.4	298.1	293.8	289.4	285.1	280.7	276.4	272.0	267.7	263.4	259.0	1,969,747
SSBN 726	161.7	160.8	160.0	159.2	158.3	157.5	156.7	155.8	155.0	154.2	153.3	152.5	151.7	150.8	150.0	149.2	148.3	147.5	146.7	145.8	145.0	144.2	143.3	24,181,898
SSGN 726	78.5	78.0	77.5	77.0	76.5	75.9	75.4	74.9	74.4	73.9	73.3	72.8	72.3	71.8	71.3	70.7	70.2	69.7	69.2	68.6	68.1	67.6	67.1	16,992,950
SSN 21	78.5	78.0	77.5	77.0	76.5	75.9	75.4	74.9	74.4	73.9	73.3	72.8	72.3	71.8	71.3	70.7	70.2	69.7	69.2	68.6	68.1	67.6	67.1	18,479,210
SSN 688	161.7	160.8	160.0	159.2	158.3	157.5	156.7	155.8	155.0	154.2	153.3	152.5	151.7	150.8	150.0	149.2	148.3	147.5	146.7	145.8	145.0	144.2	143.3	10,878,664
SSN 774	161.7	160.8	160.0	159.2	158.3	157.5	156.7	155.8	155.0	154.2	153.3	152.5	151.7	150.8	150.0	149.2	148.3	147.5	146.7	145.8	145.0	144.2	143.3	9,660,499

Table 67. MSC Class Utility Score for 10-Day HADR Response (0 to 5,500 nm)

Utility Score (10 Days)	Distance (nm)																							Response Cost CY2017 USD
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	
AE 26	110.0	103.6	97.3	90.9	84.5	78.2	71.8	65.4	59.1	52.7	46.3	40.0	33.6	27.2	20.9	14.5	8.1	1.8	-4.6	-10.9	-17.3	-23.7	-30.0	739,261
AFS 1	100.0	94.8	89.6	84.4	79.2	74.0	68.8	63.5	58.3	53.1	47.9	42.7	37.5	32.3	27.1	21.9	16.7	11.5	6.3	1.0	-4.2	-9.4	-14.6	335,139
AFSB (I) 15	230.0	218.0	206.0	194.1	182.1	170.1	158.1	146.1	134.2	122.2	110.2	98.2	86.3	74.3	62.3	50.3	38.3	26.4	14.4	2.4	-9.6	-21.6	-33.5	1,380,445
AG 5001	40.0	36.8	33.6	30.4	27.2	24.0	20.8	17.6	14.4	11.2	7.9	4.7	1.5	-1.7	-4.9	-8.1	-11.3	-14.5	-17.7	-20.9	-24.1	-27.3	-30.5	752,763
AGER 111	50.0	46.0	42.0	38.0	34.0	30.0	26.0	22.0	17.9	13.9	9.9	5.9	1.9	-2.1	-6.1	-10.1	-14.1	-18.1	-22.1	-26.1	-30.1	-34.1	-38.1	125,868
AGM 23	10.0	9.3	8.6	7.9	7.2	6.5	5.8	5.1	4.4	3.8	3.1	2.4	1.7	1.0	0.3	-0.4	-1.1	-1.8	-2.5	-3.2	-3.9	-4.6	-5.3	748,021
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	266,993
AGM 25	10.0	9.3	8.6	7.9	7.2	6.5	5.8	5.1	4.4	3.8	3.1	2.4	1.7	1.0	0.3	-0.4	-1.1	-1.8	-2.5	-3.2	-3.9	-4.6	-5.3	522,506
AGOS 19	20.0	17.9	15.8	13.8	11.7	9.6	7.5	5.4	3.3	1.3	-0.8	-2.9	-5.0	-7.1	-9.2	-11.3	-13.3	-15.4	-17.5	-19.6	-21.7	-23.8	-25.8	379,198
AGOS 23	20.0	18.3	16.5	14.8	13.1	11.3	9.6	7.8	6.1	4.4	2.6	0.9	-0.8	-2.6	-4.3	-6.0	-7.8	-9.5	-11.3	-13.0	-14.7	-16.5	-18.2	425,977
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	517,296
AGS 60	60.0	54.8	49.6	44.4	39.2	34.0	28.8	23.5	18.3	13.1	7.9	2.7	-2.5	-7.7	-12.9	-18.1	-23.3	-28.5	-33.8	-39.0	-44.2	-49.4	-54.6	461,514
AGSE 1	60.0	55.5	51.1	46.6	42.1	37.7	33.2	28.8	24.3	19.8	15.4	10.9	6.4	2.0	-2.5	-7.0	-11.4	-15.9	-20.4	-24.8	-29.3	-33.8	-38.2	314,716
AH 19	55.0	48.3	41.5	34.8	28.0	21.3	14.6	7.8	1.1	-5.7	-12.4	-19.1	-25.9	-32.6	-39.4	-46.1	-52.8	-59.6	-66.3	-73.1	-79.8	-86.5	-93.3	1,203,269
AK 0323	140.0	130.9	121.8	112.7	103.5	94.4	85.3	76.2	67.1	58.0	48.9	39.7	30.6	21.5	12.4	3.3	-5.8	-14.9	-24.1	-33.2	-42.3	-51.4	-60.5	388,864
AK 3005	160.0	151.7	143.3	135.0	126.7	118.3	110.0	101.7	93.3	85.0	76.7	68.3	60.0	51.7	43.3	35.0	26.7	18.3	10.0	1.7	-6.7	-15.0	-23.3	561,617
AK 3008	150.0	141.3	132.6	124.0	115.3	106.6	97.9	89.2	80.6	71.9	63.2	54.5	45.8	37.2	28.5	19.8	11.1	2.4	-6.3	-14.9	-23.6	-32.3	-41.0	780,001
AK 3015	150.0	140.8	131.6	122.4	113.2	104.0	94.9	85.7	76.5	67.3	58.1	48.9	39.7	30.5	21.3	12.1	2.9	-6.3	-15.4	-24.6	-33.8	-43.0	-52.2	574,777
AK 4296	110.0	102.8	95.7	88.5	81.4	74.2	67.0	59.9	52.7	45.5	38.4	31.2	24.1	16.9	9.7	2.6	-4.6	-11.7	-18.9	-26.1	-33.2	-40.4	-47.6	322,467
AK 4396	120.0	112.2	104.4	96.6	88.8	80.9	73.1	65.3	57.5	49.7	41.9	34.1	26.3	18.4	10.6	2.8	-5.0	-12.8	-20.6	-28.4	-36.2	-44.1	-51.9	409,078
AK 4496	120.0	113.1	106.1	99.2	92.2	85.3	78.3	71.4	64.4	57.5	50.6	43.6	36.7	29.7	22.8	15.8	8.9	1.9	-5.0	-11.9	-18.9	-25.8	-32.8	531,893
AK 451	60.0	56.3	52.6	49.0	45.3	41.6	37.9	34.3	30.6	26.9	23.2	19.6	15.9	12.2	8.5	4.9	1.2	-2.5	-6.2	-9.9	-13.5	-17.2	-20.9	600,939
AK 4729	100.0	93.5	87.0	80.5	74.0	67.4	60.9	54.4	47.9	41.4	34.9	28.4	21.9	15.4	8.9	2.3	-4.2	-10.7	-17.2	-23.7	-30.2	-36.7	-43.2	552,124
AK 5158	110.0	102.8	95.7	88.5	81.4	74.2	67.0	59.9	52.7	45.5	38.4	31.2	24.1	16.9	9.7	2.6	-4.6	-11.7	-18.9	-26.1	-33.2	-40.4	-47.6	221,539
AK 5272	120.0	112.2	104.4	96.6	88.8	80.9	73.1	65.3	57.5	49.7	41.9	34.1	26.3	18.4	10.6	2.8	-5.0	-12.8	-20.6	-28.4	-36.2	-44.1	-51.9	299,198
AK 5307	80.0	73.6	67.2	60.8	54.4	47.9	41.5	35.1	28.7	22.3	15.9	9.5	3.1	-3.3	-9.7	-16.2	-22.6	-29.0	-35.4	-41.8	-48.2	-54.6	-61.0	54,012
AK 5362	120.0	112.2	104.4	96.6	88.8	80.9	73.1	65.3	57.5	49.7	41.9	34.1	26.3	18.4	10.6	2.8	-5.0	-12.8	-20.6	-28.4	-36.2	-44.1	-51.9	406,574
AK 9205	130.0	121.5	113.1	104.6	96.1	87.7	79.2	70.8	62.3	53.8	45.4	36.9	28.4	20.0	11.5	3.0	-5.4	-13.9	-22.3	-30.8	-39.3	-47.7	-56.2	-
AKE 1	130.0	123.2	116.5	109.7	102.9	96.1	89.4	82.6	75.8	69.1	62.3	55.5	48.8	42.0	35.2	28.4	21.7	14.9	8.1	1.4	-5.4	-12.2	-19.0	1,334,365
AKR 295	160.0	153.1	146.1	139.2	132.2	125.3	118.3	111.4	104.4	97.5	90.6	83.6	76.7	69.7	62.8	55.8	48.9	41.9	35.0	28.1	21.1	14.2	7.2	298,131
AKR 300	160.0	153.1	146.1	139.2	132.2	125.3	118.3	111.4	104.4	97.5	90.6	83.6	76.7	69.7	62.8	55.8	48.9	41.9	35.0	28.1	21.1	14.2	7.2	450,776
AKR 310	160.0	153.1	146.1	139.2	132.2	125.3	118.3	111.4	104.4	97.5	90.6	83.6	76.7	69.7	62.8	55.8	48.9	41.9	35.0	28.1	21.1	14.2	7.2	737,510
AO 187	110.0	104.3	98.5	92.8	87.1	81.4	75.6	69.9	64.2	58.4	52.7	47.0	41.3	35.5	29.8	24.1	18.3	12.6	6.9	1.1	-4.6	-10.3	-16.0	1,068,597
AOE 6	120.0	114.3	108.6	103.0	97.3	91.6	85.9	80.2	74.5	68.9	63.2	57.5	51.8	46.1	40.5	34.8	29.1	23.4	17.7	12.0	6.4	0.7	-5.0	1,632,813
AOT 1121	40.0	37.4	34.8	32.2	29.6	27.0	24.4	21.8	19.2	16.6	14.0	11.4	8.8	6.1	3.5	0.9	-1.7	-4.3	-6.9	-9.5	-12.1	-14.7	-17.3	467,859
AOT 4995	40.0	37.2	34.4	31.7	28.9	26.1	23.3	20.6	17.8	15.0	12.2	9.4	6.7	3.9	1.1	-1.7	-4.4	-7.2	-10.0	-12.8	-15.6	-18.3	-21.1	209,749
AOT 5205	40.0	37.2	34.4	31.7	28.9	26.1	23.3	20.6	17.8	15.0	12.2	9.4	6.7	3.9	1.1	-1.7	-4.4	-7.2	-10.0	-12.8	-15.6	-18.3	-21.1	624,243
AOT 5246	40.0	37.2	34.4	31.7	28.9	26.1	23.3	20.6	17.8	15.0	12.2	9.4	6.7	3.9	1.1	-1.7	-4.4	-7.2	-10.0	-12.8	-15.6	-18.3	-21.1	576,333
AOT 5356	40.0	37.0	34.0	31.1	28.1	25.1	22.1	19.2	16.2	13.2	10.2	7.3	4.3	1.3	-1.7	-4.6	-7.6	-10.6	-13.6	-16.5	-19.5	-22.5	-25.5	285,314
AOT 5406	40.0	37.2	34.4	31.7	28.9	26.1	23.3	20.6	17.8	15.0	12.2	9.4	6.7	3.9	1.1	-1.7	-4.4	-7.2	-10.0	-12.8	-15.6	-18.3	-21.1	711,219
AOT 5419	40.0	37.2	34.4	31.7	28.9	26.1	23.3	20.6	17.8	15.0	12.2	9.4	6.7	3.9	1.1	-1.7	-4.4	-7.2	-10.0	-12.8	-15.6	-18.3	-21.1	508,390
AP 1000	40.0	37.2	34.4	31.7	28.9	26.1	23.3	20.6	17.8	15.0	12.2	9.4	6.7	3.9	1.1	-1.7	-4.4	-7.2	-10.0	-12.8	-15.6	-18.3	-21.1	1,056,319
ARC 7	20.0	18.5	17.0	15.5	14.0	12.6	11.1	9.6	8.1	6.6	5.1	3.6	2.1	0.7	-0.8	-2.3	-3.8	-5.3	-6.8	-8.3	-9.8	-11.3	-12.7	834,677
ARS 50	60.0	54.8	49.6	44.4	39.2	34.0	28.8	23.5	18.3	13.1	7.9	2.7	-2.5	-7.7	-12.9	-18.1	-23.3	-28.5	-33.8	-39.0	-44.2	-49.4	-54.6	381,177
AS 39	50.0	45.7	41.3	37.0	32.6	28.3	24.0	19.6	15.3	10.9	6.6	2.3	-2.1	-6.4	-10.8	-15.1	-19.4	-23.8	-28.1	-32.5	-36.8	-41.1	-45.5	3,346,911
ATF 166	40.0	36.8	33.6	30.4	27.2	24.0	20.8	17.6	14.4	11.2	7.9	4.7	1.5	-1.7	-4.9	-8.1	-11.3	-14.5	-17.7	-20.9	-24.1	-27.3	-30.5	246,353
ATF 4247	40.0	33.1	26.1	19.2	12.2	5.3	-1.7	-8.6	-15.6	-22.5	-29.4	-36.4	-43.3	-50.3	-57.2	-64.2	-71.1	-78.1	-85.0	-91.9	-98.9	-105.8	-112.8	71,631
EPF 1	160.0	155.2	150.5	145.7	141.0	136.2	131.4	126.7	121.9	117.1	112.4	107.6	102.9	98.1	93.3	88.6	83.8	79.0	74.3	69.5	64.8	60.0	55.2	480,091
ESB 3	300.0	279.2	258.3	237.5	216.7	195.8	175.0	154.2	133.3	112.5	91.7	70.8	50.0	29.2	8.3	-12.5	-33.3	-54.2	-75.0	-95.8	-116.7	-137.5	-158.3	656,139
ESD 1	130.0	121.0	111.9	102.9	93.9	84.9	75.8	66.8	57.8	48.8	39.7	30.7	21.7	12.6	3.6	-5.4	-14.4	-23.5	-32.5	-41.5	-50.6	-59.6	-68.6	607,280
HST 1	70.0	67.8	65.6	63.4	61.2	59.0	56.7	54.5	52.3	50.1	47.9	45.7	43.5	41.3	39.1	36.9	34.6	32.4	30.2	28.0	25.8	23.6	21.4	331,436
HST 2	70.0	67.8	65.6	63.4	61.2	59.0	56.7	54.5	52.3	50.1	47.9	45.7	43.5	41.3	39.1	36.9	34.6	32.4	30.2	28.0	25.8	23.6	21.4	30,028
HSV 1	160.0	155.2	150.5	145.7	141.0	136.2	131.4	126.7	121.9	117.1	112.4	107.6	102.9	98.1	93.3	88.6	83.8	79.0	74.3	69.5	64.8	60.0	55.2	880,033
HSV 4676	120.0	116.4	112.9	109.3	105.7	102.1	98.6	95.0	91.4	87.9	84.3	80.7	77.1	73.6	70.0	66.4	62.9	59.3	55.7	52.1	48.6	45.0	41.4	670,535
LCC 19	90.0	84.1	78.3	72.4	66.6	60.7	54.8	49.0	43.1	37.3	31.4	25.5	19.7	13.8	8.0	2.1	-3.8	-9.6	-15.5	-21.3	-27.2	-33.0	-38.9	2,134,993
MB 1219	20.0	17.4	14.8	12.2	9.6	7.0	4.4	1.8	-0.8	-3.4	-6.0	-8.6	-11.3	-13.9	-16.5	-19.1	-21.7	-24.3	-26.9	-29.5	-32.1	-34.7	-37.3	55,132

Table 68. MSC Class Utility Score for 10-Day HADR Response (5,500 to 11,000 nm)

Utility Score (10 Days)	Distance (nm)																							Response Cost CY2017 USD
	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	
AE 26	-30.0	-36.4	-42.8	-49.1	-55.5	-61.9	-68.2	-74.6	-81.0	-87.3	-93.7	-100.1	-106.4	-112.8	-119.2	-125.5	-131.9	-138.3	-144.6	-151.0	-157.4	-163.7	-170.1	739,261
AFS 1	-14.6	-19.8	-25.0	-30.2	-35.4	-40.6	-45.8	-51.0	-56.3	-61.5	-66.7	-71.9	-77.1	-82.3	-87.5	-92.7	-97.9	-103.1	-108.3	-113.5	-118.8	-124.0	-129.2	335,139
AFSB (I) 15	-33.5	-45.5	-57.5	-69.5	-81.5	-93.4	-105.4	-117.4	-129.4	-141.4	-153.3	-165.3	-177.3	-189.3	-201.3	-213.2	-225.2	-237.2	-249.2	-261.1	-273.1	-285.1	-297.1	1,380,445
AG 5001	-30.5	-33.7	-36.9	-40.1	-43.3	-46.5	-49.7	-52.9	-56.2	-59.4	-62.6	-65.8	-69.0	-72.2	-75.4	-78.6	-81.8	-85.0	-88.2	-91.4	-94.6	-97.8	-101.0	752,763
AGER 111	-38.1	-42.1	-46.2	-50.2	-54.2	-58.2	-62.2	-66.2	-70.2	-74.2	-78.2	-82.2	-86.2	-90.2	-94.2	-98.2	-102.2	-106.3	-110.3	-114.3	-118.3	-122.3	-126.3	125,868
AGM 23	-5.3	-6.0	-6.7	-7.4	-8.1	-8.8	-9.4	-10.1	-10.8	-11.5	-12.2	-12.9	-13.6	-14.3	-15.0	-15.7	-16.4	-17.1	-17.8	-18.5	-19.2	-19.9	-20.6	748,021
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	266,993
AGM 25	-5.3	-6.0	-6.7	-7.4	-8.1	-8.8	-9.4	-10.1	-10.8	-11.5	-12.2	-12.9	-13.6	-14.3	-15.0	-15.7	-16.4	-17.1	-17.8	-18.5	-19.2	-19.9	-20.6	522,506
AGOS 19	-25.8	-27.9	-30.0	-32.1	-34.2	-36.3	-38.3	-40.4	-42.5	-44.6	-46.7	-48.8	-50.8	-52.9	-55.0	-57.1	-59.2	-61.3	-63.3	-65.4	-67.5	-69.6	-71.7	379,198
AGOS 23	-18.2	-19.9	-21.7	-23.4	-25.1	-26.9	-28.6	-30.3	-32.1	-33.8	-35.6	-37.3	-39.0	-40.8	-42.5	-44.2	-46.0	-47.7	-49.4	-51.2	-52.9	-54.7	-56.4	425,977
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	517,296
AGS 60	-54.6	-59.8	-65.0	-70.2	-75.4	-80.6	-85.8	-91.0	-96.3	-101.5	-106.7	-111.9	-117.1	-122.3	-127.5	-132.7	-137.9	-143.1	-148.3	-153.5	-158.8	-164.0	-169.2	461,514
AGSE 1	-38.2	-42.7	-47.1	-51.6	-56.1	-60.5	-65.0	-69.5	-73.9	-78.4	-82.9	-87.3	-91.8	-96.3	-100.7	-105.2	-109.6	-114.1	-118.6	-123.0	-127.5	-132.0	-136.4	314,716
AH 19	-93.3	-100.0	-106.8	-113.5	-120.2	-127.0	-133.7	-140.5	-147.2	-153.9	-160.7	-167.4	-174.2	-180.9	-187.6	-194.4	-201.1	-207.9	-214.6	-221.3	-228.1	-234.8	-241.6	1,203,269
AK 0323	-60.5	-69.6	-78.8	-87.9	-97.0	-106.1	-115.2	-124.3	-133.4	-142.6	-151.7	-160.8	-169.9	-179.0	-188.1	-197.2	-206.4	-215.5	-224.6	-233.7	-242.8	-251.9	-261.0	388,864
AK 3005	-23.3	-31.7	-40.0	-48.3	-56.7	-65.0	-73.3	-81.7	-90.0	-98.3	-106.7	-115.0	-123.3	-131.7	-140.0	-148.3	-156.7	-165.0	-173.3	-181.7	-190.0	-198.3	-206.7	561,617
AK 3008	-41.0	-49.7	-58.3	-67.0	-75.7	-84.4	-93.1	-101.7	-110.4	-119.1	-127.8	-136.5	-145.1	-153.8	-162.5	-171.2	-179.9	-188.5	-197.2	-205.9	-214.6	-223.3	-231.9	780,001
AK 3015	-52.2	-61.4	-70.6	-79.8	-89.0	-98.2	-107.4	-116.5	-125.7	-134.9	-144.1	-153.3	-162.5	-171.7	-180.9	-190.1	-199.3	-208.5	-217.6	-226.8	-236.0	-245.2	-254.4	574,777
AK 4296	-47.6	-54.7	-61.9	-69.0	-76.2	-83.4	-90.5	-97.7	-104.8	-112.0	-119.2	-126.3	-133.5	-140.7	-147.8	-155.0	-162.1	-169.3	-176.5	-183.6	-190.8	-197.9	-205.1	322,467
AK 4396	-51.9	-59.7	-67.5	-75.3	-83.1	-90.9	-98.7	-106.6	-114.4	-122.2	-130.0	-137.8	-145.6	-153.4	-161.3	-169.1	-176.9	-184.7	-192.5	-200.3	-208.1	-215.9	-223.8	409,078
AK 4496	-32.8	-39.7	-46.7	-53.6	-60.6	-67.5	-74.4	-81.4	-88.3	-95.3	-102.2	-109.2	-116.1	-123.1	-130.0	-136.9	-143.9	-150.8	-157.8	-164.7	-171.7	-178.6	-185.6	531,893
AK 451	-20.9	-24.6	-28.2	-31.9	-35.6	-39.3	-42.9	-46.6	-50.3	-54.0	-57.6	-61.3	-65.0	-68.7	-72.4	-76.0	-79.7	-83.4	-87.1	-90.7	-94.4	-98.1	-101.8	600,939
AK 4729	-43.2	-49.7	-56.3	-62.8	-69.3	-75.8	-82.3	-88.8	-95.3	-101.8	-108.3	-114.8	-121.4	-127.9	-134.4	-140.9	-147.4	-153.9	-160.4	-166.9	-173.4	-179.9	-186.5	552,124
AK 5158	-47.6	-54.7	-61.9	-69.0	-76.2	-83.4	-90.5	-97.7	-104.8	-112.0	-119.2	-126.3	-133.5	-140.7	-147.8	-155.0	-162.1	-169.3	-176.5	-183.6	-190.8	-197.9	-205.1	221,539
AK 5272	-51.9	-59.7	-67.5	-75.3	-83.1	-90.9	-98.7	-106.6	-114.4	-122.2	-130.0	-137.8	-145.6	-153.4	-161.3	-169.1	-176.9	-184.7	-192.5	-200.3	-208.1	-215.9	-223.8	299,198
AK 5307	-61.0	-67.4	-73.8	-80.3	-86.7	-93.1	-99.5	-105.9	-112.3	-118.7	-125.1	-131.5	-137.9	-144.4	-150.8	-157.2	-163.6	-170.0	-176.4	-182.8	-189.2	-195.6	-202.1	54,012
AK 5362	-51.9	-59.7	-67.5	-75.3	-83.1	-90.9	-98.7	-106.6	-114.4	-122.2	-130.0	-137.8	-145.6	-153.4	-161.3	-169.1	-176.9	-184.7	-192.5	-200.3	-208.1	-215.9	-223.8	406,574
AK 9205	-56.2	-64.7	-73.1	-81.6	-90.1	-98.5	-107.0	-115.4	-123.9	-132.4	-140.8	-149.3	-157.8	-166.2	-174.7	-183.2	-191.6	-200.1	-208.5	-217.0	-225.5	-233.9	-242.4	-
AKE 1	-19.0	-25.7	-32.5	-39.3	-46.0	-52.8	-59.6	-66.4	-73.1	-79.9	-86.7	-93.4	-100.2	-107.0	-113.8	-120.5	-127.3	-134.1	-140.8	-147.6	-154.4	-161.1	-167.9	1,334,365
AKR 295	7.2	0.3	-6.7	-13.6	-20.6	-27.5	-34.4	-41.4	-48.3	-55.3	-62.2	-69.2	-76.1	-83.1	-90.0	-96.9	-103.9	-110.8	-117.8	-124.7	-131.7	-138.6	-145.6	298,131
AKR 300	7.2	0.3	-6.7	-13.6	-20.6	-27.5	-34.4	-41.4	-48.3	-55.3	-62.2	-69.2	-76.1	-83.1	-90.0	-96.9	-103.9	-110.8	-117.8	-124.7	-131.7	-138.6	-145.6	450,776
AKR 310	7.2	0.3	-6.7	-13.6	-20.6	-27.5	-34.4	-41.4	-48.3	-55.3	-62.2	-69.2	-76.1	-83.1	-90.0	-96.9	-103.9	-110.8	-117.8	-124.7	-131.7	-138.6	-145.6	737,510
AO 187	-16.0	-21.8	-27.5	-33.2	-39.0	-44.7	-50.4	-56.1	-61.9	-67.6	-73.3	-79.1	-84.8	-90.5	-96.3	-102.0	-107.7	-113.4	-119.2	-124.9	-130.6	-136.4	-142.1	1,068,597
AOE 6	-5.0	-10.7	-16.4	-22.0	-27.7	-33.4	-39.1	-44.8	-50.5	-56.1	-61.8	-67.5	-73.2	-78.9	-84.5	-90.2	-95.9	-101.6	-107.3	-113.0	-118.6	-124.3	-130.0	1,632,813
AOT 1121	-17.3	-19.9	-22.5	-25.1	-27.7	-30.3	-32.9	-35.5	-38.1	-40.7	-43.3	-45.9	-48.5	-51.1	-53.8	-56.4	-59.0	-61.6	-64.2	-66.8	-69.4	-72.0	-74.6	467,859
AOT 4995	-21.1	-23.9	-26.7	-29.4	-32.2	-35.0	-37.8	-40.6	-43.3	-46.1	-48.9	-51.7	-54.4	-57.2	-60.0	-62.8	-65.6	-68.3	-71.1	-73.9	-76.7	-79.4	-82.2	209,749
AOT 5205	-21.1	-23.9	-26.7	-29.4	-32.2	-35.0	-37.8	-40.6	-43.3	-46.1	-48.9	-51.7	-54.4	-57.2	-60.0	-62.8	-65.6	-68.3	-71.1	-73.9	-76.7	-79.4	-82.2	624,243
AOT 5246	-21.1	-23.9	-26.7	-29.4	-32.2	-35.0	-37.8	-40.6	-43.3	-46.1	-48.9	-51.7	-54.4	-57.2	-60.0	-62.8	-65.6	-68.3	-71.1	-73.9	-76.7	-79.4	-82.2	576,333
AOT 5356	-25.5	-28.5	-31.4	-34.4	-37.4	-40.4	-43.3	-46.3	-49.3	-52.3	-55.2	-58.2	-61.2	-64.2	-67.1	-70.1	-73.1	-76.1	-79.0	-82.0	-85.0	-88.0	-91.0	285,314
AOT 5406	-21.1	-23.9	-26.7	-29.4	-32.2	-35.0	-37.8	-40.6	-43.3	-46.1	-48.9	-51.7	-54.4	-57.2	-60.0	-62.8	-65.6	-68.3	-71.1	-73.9	-76.7	-79.4	-82.2	711,219
AOT 5419	-21.1	-23.9	-26.7	-29.4	-32.2	-35.0	-37.8	-40.6	-43.3	-46.1	-48.9	-51.7	-54.4	-57.2	-60.0	-62.8	-65.6	-68.3	-71.1	-73.9	-76.7	-79.4	-82.2	508,390
AP 1000	-21.1	-23.9	-26.7	-29.4	-32.2	-35.0	-37.8	-40.6	-43.3	-46.1	-48.9	-51.7	-54.4	-57.2	-60.0	-62.8	-65.6	-68.3	-71.1	-73.9	-76.7	-79.4	-82.2	1,056,319
ARC 7	-12.7	-14.2	-15.7	-17.2	-18.7	-20.2	-21.7	-23.2	-24.6	-26.1	-27.6	-29.1	-30.6	-32.1	-33.6	-35.1	-36.5	-38.0	-39.5	-41.0	-42.5	-44.0	-45.5	834,677
ARS 50	-54.6	-59.8	-65.0	-70.2	-75.4	-80.6	-85.8	-91.0	-96.3	-101.5	-106.7	-111.9	-117.1	-122.3	-127.5	-132.7	-137.9	-143.1	-148.3	-153.5	-158.8	-164.0	-169.2	381,177
AS 39	-45.5	-49.8	-54.2	-58.5	-62.8	-67.2	-71.5	-75.9	-80.2	-84.5	-88.9	-93.2	-97.6	-101.9	-106.3	-110.6	-114.9	-119.3	-123.6	-128.0	-132.3	-136.6	-141.0	3,346,911
ATF 166	-30.5	-33.7	-36.9	-40.1	-43.3	-46.5	-49.7	-52.9	-56.2	-59.4	-62.6	-65.8	-69.0	-72.2	-75.4	-78.6	-81.8	-85.0	-88.2	-91.4	-94.6	-97.8	-101.0	246,353
ATF 4247	-112.8	-119.7	-126.7	-133.6	-140.6	-147.5	-154.4	-161.4	-168.3	-175.3	-182.2	-189.2	-196.1	-203.1	-210.0	-216.9	-223.9	-230.8	-237.8	-244.7	-251.7	-258.6	-265.6	71,631
EPF 1	55.2	50.5	45.7	41.0	36.2	31.4	26.7	21.9	17.1	12.4	7.6	2.9	-1.9	-6.7	-11.4	-16.2	-21.0	-25.7	-30.5	-35.2	-40.0	-44.8	-49.5	480,091
ESB 3	-158.3	-179.2	-200.0	-220.8	-241.7	-262.5	-283.3	-304.2	-325.0	-345.8	-366.7	-387.5	-408.3	-429.2	-450.0	-470.8	-491.7	-512.5	-533.3	-554.2	-575.0	-595.8	-616.7	656,139
ESD 1	-68.6	-77.6	-86.7	-95.7	-104.7	-113.8	-122.8	-131.8	-140.8	-149.9	-158.9	-167.9	-176.9	-186.0	-195.0	-204.0	-213.1	-222.1	-231.1	-240.1	-249.2	-258.2	-267.2	607,280
HST 1	21.4	19.2	17.0	14.8	12.6	10.3	8.1	5.9	3.7	1.5	-0.7	-2.9	-5.1	-7.3	-9.5	-11.8	-14.0	-16.2	-18.4	-20.6	-22.8	-25.0	-27.2	331,436
HST 2	21.4	19.2	17.0	14.8	12.6	10.3	8.1	5.9	3.7	1.5	-0.7	-2.9	-5.1	-7.3	-9.5	-11.8	-14.0	-16.2	-18.4	-20.6	-22.8	-25.0	-27.2	30,028
HSV 1	55.2	50.5	45.7	41.0	36.2	31.4	26.7	21.9	17.1	12.4	7.6	2.9	-1.9	-6.7	-11.4	-16.2	-21.0	-25.7	-30.5	-35.2	-40.0	-44.8	-49.5	880,033
HSV 4676	41.4	37.9	34.3	30.7	27.1	23.6	20.0	16.4	12.9	9.3	5.7	2.1	-1.4	-5.0	-8.6	-12.1	-15.7	-19.3	-22.9	-26.4	-30.0	-33.6	-37.1	670,535
LCC 19	-38.9	-44.8	-50.6	-56.5	-62.3	-68.2	-74.1	-79.9	-85.8	-91.6	-97.5	-103.4	-109.2	-115.1	-120.9	-126.8	-132.7	-138.5	-144.4	-150.2	-156.1	-162.0	-167.8	2,134,993
MB 1219	-37.3	-39.9	-42.5	-45.1	-47.7	-50.3	-52.9	-55.5	-58.1	-60.7	-63.3	-65.9	-68.5	-71.1	-73.8	-76.4	-79.0	-81.6	-84.2	-86.8	-89.4	-92.0	-94.6	55,132

Table 69. MSC Class Utility Score for 30-Day HADR Response (0 to 5,500 nm)

Utility Score (30 Days)	Distance (nm)																							Response Cost CY2017 USD
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	
AE 26	330.0	323.6	317.3	310.9	304.5	298.2	291.8	285.4	279.1	272.7	266.3	260.0	253.6	247.2	240.9	234.5	228.1	221.8	215.4	209.1	202.7	196.3	190.0	2,217,784
AFS 1	300.0	294.8	289.6	284.4	279.2	274.0	268.8	263.5	258.3	253.1	247.9	242.7	237.5	232.3	227.1	221.9	216.7	211.5	206.3	201.0	195.8	190.6	185.4	1,005,417
AFSB (I) 15	690.0	678.0	666.0	654.1	642.1	630.1	618.1	606.1	594.2	582.2	570.2	558.2	546.3	534.3	522.3	510.3	498.3	486.4	474.4	462.4	450.4	438.4	426.5	4,141,335
AG 5001	120.0	116.8	113.6	110.4	107.2	104.0	100.8	97.6	94.4	91.2	87.9	84.7	81.5	78.3	75.1	71.9	68.7	65.5	62.3	59.1	55.9	52.7	49.5	2,258,288
AGER 111	150.0	146.0	142.0	138.0	134.0	130.0	126.0	122.0	117.9	113.9	109.9	105.9	101.9	97.9	93.9	89.9	85.9	81.9	77.9	73.9	69.9	65.9	61.9	377,603
AGM 23	30.0	29.3	28.6	27.9	27.2	26.5	25.8	25.1	24.4	23.8	23.1	22.4	21.7	21.0	20.3	19.6	18.9	18.2	17.5	16.8	16.1	15.4	14.7	2,244,064
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	800,979
AGM 25	30.0	29.3	28.6	27.9	27.2	26.5	25.8	25.1	24.4	23.8	23.1	22.4	21.7	21.0	20.3	19.6	18.9	18.2	17.5	16.8	16.1	15.4	14.7	1,567,517
AGOS 19	60.0	57.9	55.8	53.8	51.7	49.6	47.5	45.4	43.3	41.3	39.2	37.1	35.0	32.9	30.8	28.8	26.7	24.6	22.5	20.4	18.3	16.3	14.2	1,137,593
AGOS 23	60.0	58.3	56.5	54.8	53.1	51.3	49.6	47.8	46.1	44.4	42.6	40.9	39.2	37.4	35.7	34.0	32.2	30.5	28.8	27.0	25.3	23.5	21.8	1,277,931
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,551,887
AGS 60	180.0	174.8	169.6	164.4	159.2	154.0	148.8	143.5	138.3	133.1	127.9	122.7	117.5	112.3	107.1	101.9	96.7	91.5	86.3	81.0	75.8	70.6	65.4	1,384,542
AGSE 1	180.0	175.5	171.1	166.6	162.1	157.7	153.2	148.8	144.3	139.8	135.4	130.9	126.4	122.0	117.5	113.0	108.6	104.1	99.6	95.2	90.7	86.3	81.8	944,148
AH 19	275.0	268.3	261.5	254.8	248.0	241.3	234.6	227.8	221.1	214.3	207.6	200.9	194.1	187.4	180.6	173.9	167.2	160.4	153.7	146.9	140.2	133.5	126.7	3,609,808
AK 0323	420.0	410.9	401.8	392.7	383.5	374.4	365.3	356.2	347.1	338.0	328.9	319.7	310.6	301.5	292.4	283.3	274.2	265.1	255.9	246.8	237.7	228.6	219.5	1,166,592
AK 3005	480.0	471.7	463.3	455.0	446.7	438.3	430.0	421.7	413.3	405.0	396.7	388.3	380.0	371.7	363.3	355.0	346.7	338.3	330.0	321.7	313.3	305.0	296.7	1,684,852
AK 3008	450.0	441.3	432.6	424.0	415.3	406.6	397.9	389.2	380.6	371.9	363.2	354.5	345.8	337.2	328.5	319.8	311.1	302.4	293.8	285.1	276.4	267.7	259.0	2,340,003
AK 3015	450.0	440.8	431.6	422.4	413.2	404.0	394.9	385.7	376.5	367.3	358.1	348.9	339.7	330.5	321.3	312.1	302.9	293.8	284.6	275.4	266.2	257.0	247.8	1,724,330
AK 4296	330.0	322.8	315.7	308.5	301.4	294.2	287.0	279.9	272.7	265.5	258.4	251.2	244.1	236.9	229.7	222.6	215.4	208.3	201.1	193.9	186.8	179.6	172.4	967,399
AK 4396	360.0	352.2	344.4	336.6	328.8	320.9	313.1	305.3	297.5	289.7	281.9	274.1	266.3	258.4	250.6	242.8	235.0	227.2	219.4	211.6	203.8	195.9	188.1	1,227,234
AK 4496	360.0	353.1	346.1	339.2	332.2	325.3	318.3	311.4	304.4	297.5	290.6	283.6	276.7	269.7	262.8	255.8	248.9	241.9	235.0	228.1	221.1	214.2	207.2	1,595,678
AK 451	180.0	176.3	172.6	169.0	165.3	161.6	157.9	154.3	150.6	146.9	143.2	139.6	135.9	132.2	128.5	124.9	121.2	117.5	113.8	110.1	106.5	102.8	99.1	1,802,816
AK 4729	300.0	293.5	287.0	280.5	274.0	267.4	260.9	254.4	247.9	241.4	234.9	228.4	221.9	215.4	208.9	202.3	195.8	189.3	182.8	176.3	169.8	163.3	156.8	1,656,372
AK 5158	330.0	322.8	315.7	308.5	301.4	294.2	287.0	279.9	272.7	265.5	258.4	251.2	244.1	236.9	229.7	222.6	215.4	208.3	201.1	193.9	186.8	179.6	172.4	664,618
AK 5272	360.0	352.2	344.4	336.6	328.8	320.9	313.1	305.3	297.5	289.7	281.9	274.1	266.3	258.4	250.6	242.8	235.0	227.2	219.4	211.6	203.8	195.9	188.1	897,593
AK 5307	240.0	233.6	227.2	220.8	214.4	207.9	201.5	195.1	188.7	182.3	175.9	169.5	163.1	156.7	150.3	143.8	137.4	131.0	124.6	118.2	111.8	105.4	99.0	162,036
AK 5362	360.0	352.2	344.4	336.6	328.8	320.9	313.1	305.3	297.5	289.7	281.9	274.1	266.3	258.4	250.6	242.8	235.0	227.2	219.4	211.6	203.8	195.9	188.1	1,219,722
AK 9205	390.0	381.5	373.1	364.6	356.1	347.7	339.2	330.8	322.3	313.8	305.4	296.9	288.4	280.0	271.5	263.0	254.6	246.1	237.7	229.2	220.7	212.3	203.8	-
AKE 1	390.0	383.2	376.5	369.7	362.9	356.1	349.4	342.6	335.8	329.1	322.3	315.5	308.8	302.0	295.2	288.4	281.7	274.9	268.1	261.4	254.6	247.8	241.0	4,003,094
AKR 295	480.0	473.1	466.1	459.2	452.2	445.3	438.3	431.4	424.4	417.5	410.6	403.6	396.7	389.7	382.8	375.8	368.9	361.9	355.0	348.1	341.1	334.2	327.2	894,392
AKR 300	480.0	473.1	466.1	459.2	452.2	445.3	438.3	431.4	424.4	417.5	410.6	403.6	396.7	389.7	382.8	375.8	368.9	361.9	355.0	348.1	341.1	334.2	327.2	1,352,328
AKR 310	480.0	473.1	466.1	459.2	452.2	445.3	438.3	431.4	424.4	417.5	410.6	403.6	396.7	389.7	382.8	375.8	368.9	361.9	355.0	348.1	341.1	334.2	327.2	2,212,529
AO 187	330.0	324.3	318.5	312.8	307.1	301.4	295.6	289.9	284.2	278.4	272.7	267.0	261.3	255.5	249.8	244.1	238.3	232.6	226.9	221.1	215.4	209.7	204.0	3,205,792
AOE 6	360.0	354.3	348.6	343.0	337.3	331.6	325.9	320.2	314.5	308.9	303.2	297.5	291.8	286.1	280.5	274.8	269.1	263.4	257.7	252.0	246.4	240.7	235.0	4,898,439
AOT 1121	120.0	117.4	114.8	112.2	109.6	107.0	104.4	101.8	99.2	96.6	94.0	91.4	88.8	86.1	83.5	80.9	78.3	75.7	73.1	70.5	67.9	65.3	62.7	1,403,578
AOT 4995	120.0	117.2	114.4	111.7	108.9	106.1	103.3	100.6	97.8	95.0	92.2	89.4	86.7	83.9	81.1	78.3	75.6	72.8	70.0	67.2	64.4	61.7	58.9	629,248
AOT 5205	120.0	117.2	114.4	111.7	108.9	106.1	103.3	100.6	97.8	95.0	92.2	89.4	86.7	83.9	81.1	78.3	75.6	72.8	70.0	67.2	64.4	61.7	58.9	1,872,728
AOT 5246	120.0	117.2	114.4	111.7	108.9	106.1	103.3	100.6	97.8	95.0	92.2	89.4	86.7	83.9	81.1	78.3	75.6	72.8	70.0	67.2	64.4	61.7	58.9	1,729,000
AOT 5356	120.0	117.0	114.0	111.1	108.1	105.1	102.1	99.2	96.2	93.2	90.2	87.3	84.3	81.3	78.3	75.4	72.4	69.4	66.4	63.5	60.5	57.5	54.5	855,941
AOT 5406	120.0	117.2	114.4	111.7	108.9	106.1	103.3	100.6	97.8	95.0	92.2	89.4	86.7	83.9	81.1	78.3	75.6	72.8	70.0	67.2	64.4	61.7	58.9	2,133,657
AOT 5419	120.0	117.2	114.4	111.7	108.9	106.1	103.3	100.6	97.8	95.0	92.2	89.4	86.7	83.9	81.1	78.3	75.6	72.8	70.0	67.2	64.4	61.7	58.9	1,525,171
AP 1000	120.0	117.2	114.4	111.7	108.9	106.1	103.3	100.6	97.8	95.0	92.2	89.4	86.7	83.9	81.1	78.3	75.6	72.8	70.0	67.2	64.4	61.7	58.9	3,168,957
ARC 7	60.0	58.5	57.0	55.5	54.0	52.6	51.1	49.6	48.1	46.6	45.1	43.6	42.1	40.7	39.2	37.7	36.2	34.7	33.2	31.7	30.2	28.8	27.3	2,504,031
ARS 50	180.0	174.8	169.6	164.4	159.2	154.0	148.8	143.5	138.3	133.1	127.9	122.7	117.5	112.3	107.1	101.9	96.7	91.5	86.3	81.0	75.8	70.6	65.4	1,143,531
AS 39	150.0	145.7	141.3	137.0	132.6	128.3	124.0	119.6	115.3	110.9	106.6	102.3	97.9	93.6	89.2	84.9	80.6	76.2	71.9	67.5	63.2	58.9	54.5	10,040,733
ATF 166	120.0	116.8	113.6	110.4	107.2	104.0	100.8	97.6	94.4	91.2	87.9	84.7	81.5	78.3	75.1	71.9	68.7	65.5	62.3	59.1	55.9	52.7	49.5	739,060
ATF 4247	120.0	113.1	106.1	99.2	92.2	85.3	78.3	71.4	64.4	57.5	50.6	43.6	36.7	29.7	22.8	15.8	8.9	1.9	-5.0	-11.9	-18.9	-25.8	-32.8	214,892
EPF 1	480.0	475.2	470.5	465.7	461.0	456.2	451.4	446.7	441.9	437.1	432.4	427.6	422.9	418.1	413.3	408.6	403.8	399.0	394.3	389.5	384.8	380.0	375.2	1,440,273
ESB 3	900.0	879.2	858.3	837.5	816.7	795.8	775.0	754.2	733.3	712.5	691.7	670.8	650.0	629.2	608.3	587.5	566.7	545.8	525.0	504.2	483.3	462.5	441.7	1,968,418
ESD 1	390.0	381.0	371.9	362.9	353.9	344.9	335.8	326.8	317.8	308.8	299.7	290.7	281.7	272.6	263.6	254.6	245.6	236.5	227.5	218.5	209.4	200.4	191.4	1,821,839
HST 1	210.0	207.8	205.6	203.4	201.2	199.0	196.7	194.5	192.3	190.1	187.9	185.7	183.5	181.3	179.1	176.9	174.6	172.4	170.2	168.0	165.8	163.6	161.4	994,309
HST 2	210.0	207.8	205.6	203.4	201.2	199.0	196.7	194.5	192.3	190.1	187.9	185.7	183.5	181.3	179.1	176.9	174.6	172.4	170.2	168.0	165.8	163.6	161.4	90,083
HSV 1	480.0	475.2	470.5	465.7	461.0	456.2	451.4	446.7	441.9	437.1	432.4	427.6	422.9	418.1	413.3	408.6	403.8	399.0	394.3	389.5	384.8	380.0	375.2	2,640,098
HSV 4676	360.0	356.4	352.9	349.3	345.7	342.1	338.6	335.0	331.4	327.9	324.3	320.7	317.1	313.6	310.0	306.4	302.9	299.3	295.7	292.1	288.6	285.0	281.4	2,011,604
LCC 19	270.0	264.1	258.3	252.4	246.6	240.7	234.8	229.0	223.1	217.3	211.4	205.5	199.7	193.8	188.0	182.1	176.3	170.4	164.5	158.7	152.8	147.0	141.1	6,404,978
MB 1219	60.0	57.4	54.8	52.2	49.6	47.0	44.4	41.8	39.2	36.6	34.0	31.4	28.8	26.1	23.5	20.9	18.3	15.7	13.1	10.5	7.9	5.3	2.7	165,397

Table 70. MSC Class Utility Score for 30-Day HADR Response (5,500 to 11,000 nm)

Utility Score (30 Days)	Distance (nm)																							Response Cost
	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
AE 26	190.0	183.6	177.2	170.9	164.5	158.1	151.8	145.4	139.0	132.7	126.3	119.9	113.6	107.2	100.8	94.5	88.1	81.7	75.4	69.0	62.6	56.3	49.9	2,217,784
AFS 1	185.4	180.2	175.0	169.8	164.6	159.4	154.2	149.0	143.8	138.5	133.3	128.1	122.9	117.7	112.5	107.3	102.1	96.9	91.7	86.5	81.3	76.0	70.8	1,005,417
AFSB (I) 15	426.5	414.5	402.5	390.5	378.5	366.6	354.6	342.6	330.6	318.6	306.7	294.7	282.7	270.7	258.8	246.8	234.8	222.8	210.8	198.9	186.9	174.9	162.9	4,141,335
AG 5001	49.5	46.3	43.1	39.9	36.7	33.5	30.3	27.1	23.8	20.6	17.4	14.2	11.0	7.8	4.6	1.4	-1.8	-5.0	-8.2	-11.4	-14.6	-17.8	-21.0	2,258,288
AGER 111	61.9	57.9	53.8	49.8	45.8	41.8	37.8	33.8	29.8	25.8	21.8	17.8	13.8	9.8	5.8	1.8	-2.2	-6.3	-10.3	-14.3	-18.3	-22.3	-26.3	377,603
AGM 23	14.7	14.0	13.3	12.6	11.9	11.3	10.6	9.9	9.2	8.5	7.8	7.1	6.4	5.7	5.0	4.3	3.6	2.9	2.2	1.5	0.8	0.1	-0.6	2,244,064
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	800,979
AGM 25	14.7	14.0	13.3	12.6	11.9	11.3	10.6	9.9	9.2	8.5	7.8	7.1	6.4	5.7	5.0	4.3	3.6	2.9	2.2	1.5	0.8	0.1	-0.6	1,567,517
AGOS 19	14.2	12.1	10.0	7.9	5.8	3.8	1.7	-0.4	-2.5	-4.6	-6.7	-8.8	-10.8	-12.9	-15.0	-17.1	-19.2	-21.3	-23.3	-25.4	-27.5	-29.6	-31.7	1,137,593
AGOS 23	21.8	20.1	18.3	16.6	14.9	13.1	11.4	9.7	7.9	6.2	4.4	2.7	1.0	-0.8	-2.5	-4.2	-6.0	-7.7	-9.4	-11.2	-12.9	-14.7	-16.4	1,277,931
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,551,887
AGS 60	65.4	60.2	55.0	49.8	44.6	39.4	34.2	29.0	23.8	18.5	13.3	8.1	2.9	-2.3	-7.5	-12.7	-17.9	-23.1	-28.3	-33.5	-38.7	-44.0	-49.2	1,384,542
AGSE 1	81.8	77.3	72.9	68.4	63.9	59.5	55.0	50.5	46.1	41.6	37.1	32.7	28.2	23.8	19.3	14.8	10.4	5.9	1.4	-3.0	-7.5	-12.0	-16.4	944,148
AH 19	126.7	120.0	113.2	106.5	99.8	93.0	86.3	79.5	72.8	66.1	59.3	52.6	45.8	39.1	32.4	25.6	18.9	12.1	5.4	-1.3	-8.1	-14.8	-21.6	3,609,808
AK 0323	219.5	210.4	201.3	192.1	183.0	173.9	164.8	155.7	146.6	137.4	128.3	119.2	110.1	101.0	91.9	82.8	73.6	64.5	55.4	46.3	37.2	28.1	19.0	1,166,592
AK 3005	296.7	288.3	280.0	271.7	263.3	255.0	246.7	238.3	230.0	221.7	213.3	205.0	196.7	188.3	180.0	171.7	163.3	155.0	146.7	138.3	130.0	121.7	113.3	1,684,852
AK 3008	259.0	250.3	241.7	233.0	224.3	215.6	206.9	198.3	189.6	180.9	172.2	163.5	154.9	146.2	137.5	128.8	120.1	111.5	102.8	94.1	85.4	76.7	68.1	2,340,003
AK 3015	247.8	238.6	229.4	220.2	211.0	201.8	192.6	183.5	174.3	165.1	155.9	146.7	137.5	128.3	119.1	109.9	100.7	91.5	82.4	73.2	64.0	54.8	45.6	1,724,330
AK 4296	172.4	165.3	158.1	151.0	143.8	136.6	129.5	122.3	115.2	108.0	100.8	93.7	86.5	79.3	72.2	65.0	57.9	50.7	43.5	36.4	29.2	22.1	14.9	967,399
AK 4396	188.1	180.3	172.5	164.7	156.9	149.1	141.3	133.4	125.6	117.8	110.0	102.2	94.4	86.6	78.8	70.9	63.1	55.3	47.5	39.7	31.9	24.1	16.2	1,227,234
AK 4496	207.2	200.3	193.3	186.4	179.4	172.5	165.6	158.6	151.7	144.7	137.8	130.8	123.9	116.9	110.0	103.1	96.1	89.2	82.2	75.3	68.3	61.4	54.4	1,595,678
AK 451	99.1	95.4	91.8	88.1	84.4	80.7	77.1	73.4	69.7	66.0	62.4	58.7	55.0	51.3	47.6	44.0	40.3	36.6	32.9	29.3	25.6	21.9	18.2	1,802,816
AK 4729	156.8	150.3	143.8	137.2	130.7	124.2	117.7	111.2	104.7	98.2	91.7	85.2	78.6	72.1	65.6	59.1	52.6	46.1	39.6	33.1	26.6	20.1	13.5	1,656,372
AK 5158	172.4	165.3	158.1	151.0	143.8	136.6	129.5	122.3	115.2	108.0	100.8	93.7	86.5	79.3	72.2	65.0	57.9	50.7	43.5	36.4	29.2	22.1	14.9	664,618
AK 5272	188.1	180.3	172.5	164.7	156.9	149.1	141.3	133.4	125.6	117.8	110.0	102.2	94.4	86.6	78.8	70.9	63.1	55.3	47.5	39.7	31.9	24.1	16.2	897,593
AK 5307	99.0	92.6	86.2	79.7	73.3	66.9	60.5	54.1	47.7	41.3	34.9	28.5	22.1	15.6	9.2	2.8	-3.6	-10.0	-16.4	-22.8	-29.2	-35.6	-42.1	162,036
AK 5362	188.1	180.3	172.5	164.7	156.9	149.1	141.3	133.4	125.6	117.8	110.0	102.2	94.4	86.6	78.8	70.9	63.1	55.3	47.5	39.7	31.9	24.1	16.2	1,219,722
AK 9205	203.8	195.3	186.9	178.4	169.9	161.5	153.0	144.6	136.1	127.6	119.2	110.7	102.2	93.8	85.3	76.8	68.4	59.9	51.5	43.0	34.5	26.1	17.6	-
AKE 1	241.0	234.3	227.5	220.7	214.0	207.2	200.4	193.6	186.9	180.1	173.3	166.6	159.8	153.0	146.3	139.5	132.7	125.9	119.2	112.4	105.6	98.9	92.1	4,003,094
AKR 295	327.2	320.3	313.3	306.4	299.4	292.5	285.6	278.6	271.7	264.7	257.8	250.8	243.9	236.9	230.0	223.1	216.1	209.2	202.2	195.3	188.3	181.4	174.4	894,392
AKR 300	327.2	320.3	313.3	306.4	299.4	292.5	285.6	278.6	271.7	264.7	257.8	250.8	243.9	236.9	230.0	223.1	216.1	209.2	202.2	195.3	188.3	181.4	174.4	1,352,328
AKR 310	327.2	320.3	313.3	306.4	299.4	292.5	285.6	278.6	271.7	264.7	257.8	250.8	243.9	236.9	230.0	223.1	216.1	209.2	202.2	195.3	188.3	181.4	174.4	2,212,529
AO 187	204.0	198.2	192.5	186.8	181.0	175.3	169.6	163.9	158.1	152.4	146.7	140.9	135.2	129.5	123.8	118.0	112.3	106.6	100.8	95.1	89.4	83.6	77.9	3,205,792
AOE 6	235.0	229.3	223.6	218.0	212.3	206.6	200.9	195.2	189.5	183.9	178.2	172.5	166.8	161.1	155.5	149.8	144.1	138.4	132.7	127.0	121.4	115.7	110.0	4,898,439
AOT 1121	62.7	60.1	57.5	54.9	52.3	49.7	47.1	44.5	41.9	39.3	36.7	34.1	31.5	28.9	26.3	23.6	21.0	18.4	15.8	13.2	10.6	8.0	5.4	1,403,578
AOT 4995	58.9	56.1	53.3	50.6	47.8	45.0	42.2	39.4	36.7	33.9	31.1	28.3	25.6	22.8	20.0	17.2	14.4	11.7	8.9	6.1	3.3	0.6	-2.2	629,248
AOT 5205	58.9	56.1	53.3	50.6	47.8	45.0	42.2	39.4	36.7	33.9	31.1	28.3	25.6	22.8	20.0	17.2	14.4	11.7	8.9	6.1	3.3	0.6	-2.2	1,872,728
AOT 5246	58.9	56.1	53.3	50.6	47.8	45.0	42.2	39.4	36.7	33.9	31.1	28.3	25.6	22.8	20.0	17.2	14.4	11.7	8.9	6.1	3.3	0.6	-2.2	1,729,000
AOT 5356	54.5	51.5	48.6	45.6	42.6	39.6	36.7	33.7	30.7	27.7	24.8	21.8	18.8	15.8	12.9	9.9	6.9	3.9	1.0	-2.0	-5.0	-8.0	-11.0	855,941
AOT 5406	58.9	56.1	53.3	50.6	47.8	45.0	42.2	39.4	36.7	33.9	31.1	28.3	25.6	22.8	20.0	17.2	14.4	11.7	8.9	6.1	3.3	0.6	-2.2	2,133,657
AOT 5419	58.9	56.1	53.3	50.6	47.8	45.0	42.2	39.4	36.7	33.9	31.1	28.3	25.6	22.8	20.0	17.2	14.4	11.7	8.9	6.1	3.3	0.6	-2.2	1,525,171
AP 1000	58.9	56.1	53.3	50.6	47.8	45.0	42.2	39.4	36.7	33.9	31.1	28.3	25.6	22.8	20.0	17.2	14.4	11.7	8.9	6.1	3.3	0.6	-2.2	3,168,957
ARC 7	27.3	25.8	24.3	22.8	21.3	19.8	18.3	16.8	15.4	13.9	12.4	10.9	9.4	7.9	6.4	4.9	3.5	2.0	0.5	-1.0	-2.5	-4.0	-5.5	2,504,031
ARS 50	65.4	60.2	55.0	49.8	44.6	39.4	34.2	29.0	23.8	18.5	13.3	8.1	2.9	-2.3	-7.5	-12.7	-17.9	-23.1	-28.3	-33.5	-38.7	-44.0	-49.2	1,143,531
AS 39	54.5	50.2	45.8	41.5	37.2	32.8	28.5	24.1	19.8	15.5	11.1	6.8	2.4	-1.9	-6.3	-10.6	-14.9	-19.3	-23.6	-28.0	-32.3	-36.6	-41.0	10,040,733
ATF 166	49.5	46.3	43.1	39.9	36.7	33.5	30.3	27.1	23.8	20.6	17.4	14.2	11.0	7.8	4.6	1.4	-1.8	-5.0	-8.2	-11.4	-14.6	-17.8	-21.0	739,060
ATF 4247	-32.8	-39.7	-46.7	-53.6	-60.6	-67.5	-74.4	-81.4	-88.3	-95.3	-102.2	-109.2	-116.1	-123.1	-130.0	-136.9	-143.9	-150.8	-157.8	-164.7	-171.7	-178.6	-185.6	214,892
EPF 1	375.2	370.5	365.7	361.0	356.2	351.4	346.7	341.9	337.1	332.4	327.6	322.9	318.1	313.3	308.6	303.8	299.0	294.3	289.5	284.8	280.0	275.2	270.5	1,440,273
ESB 3	441.7	420.8	400.0	379.2	358.3	337.5	316.7	295.8	275.0	254.2	233.3	212.5	191.7	170.8	150.0	129.2	108.3	87.5	66.7	45.8	25.0	4.2	-16.7	1,968,418
ESD 1	191.4	182.4	173.3	164.3	155.3	146.3	137.2	128.2	119.2	110.1	101.1	92.1	83.1	74.0	65.0	56.0	46.9	37.9	28.9	19.9	10.8	1.8	-7.2	1,821,839
HST 1	161.4	159.2	157.0	154.8	152.6	150.3	148.1	145.9	143.7	141.5	139.3	137.1	134.9	132.7	130.5	128.2	126.0	123.8	121.6	119.4	117.2	115.0	112.8	994,309
HST 2	161.4	159.2	157.0	154.8	152.6	150.3	148.1	145.9	143.7	141.5	139.3	137.1	134.9	132.7	130.5	128.2	126.0	123.8	121.6	119.4	117.2	115.0	112.8	90,083
HSV 1	375.2	370.5	365.7	361.0	356.2	351.4	346.7	341.9	337.1	332.4	327.6	322.9	318.1	313.3	308.6	303.8	299.0	294.3	289.5	284.8	280.0	275.2	270.5	2,640,098
HSV 4676	281.4	277.9	274.3	270.7	267.1	263.6	260.0	256.4	252.9	249.3	245.7	242.1	238.6	235.0	231.4	227.9	224.3	220.7	217.1	213.6	210.0	206.4	202.9	2,011,604
LCC 19	141.1	135.2	129.4	123.5	117.7	111.8	105.9	100.1	94.2	88.4	82.5	76.6	70.8	64.9	59.1	53.2	47.3	41.5	35.6	29.8	23.9	18.0	12.2	6,404,978
MB 1219	2.7	0.1	-2.5	-5.1	-7.7	-10.3	-12.9	-15.5	-18.1	-20.7	-23.3	-25.9	-28.5	-31.1	-33.8	-36.4	-39.0	-41.6	-44.2	-46.8	-49.4	-52.0	-54.6	165,397

Table 71. MSC Class Utility Score for 60-Day HADR Response (0 to 5,500 nm)

Utility Score (60 Days)	Distance (nm)																							Response Cost CY2017 USD
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	
AE 26	660.0	653.6	647.3	640.9	634.5	628.2	621.8	615.4	609.1	602.7	596.3	590.0	583.6	577.2	570.9	564.5	558.1	551.8	545.4	539.1	532.7	526.3	520.0	4,435,568
AFS 1	600.0	594.8	589.6	584.4	579.2	574.0	568.8	563.5	558.3	553.1	547.9	542.7	537.5	532.3	527.1	521.9	516.7	511.5	506.3	501.0	495.8	490.6	485.4	2,010,834
AFSB (I) 15	1380.0	1368.0	1356.0	1344.1	1332.1	1320.1	1308.1	1296.1	1284.2	1272.2	1260.2	1248.2	1236.3	1224.3	1212.3	1200.3	1188.3	1176.4	1164.4	1152.4	1140.4	1128.4	1116.5	8,282,670
AG 5001	240.0	236.8	233.6	230.4	227.2	224.0	220.8	217.6	214.4	211.2	207.9	204.7	201.5	198.3	195.1	191.9	188.7	185.5	182.3	179.1	175.9	172.7	169.5	4,516,575
AGER 111	300.0	296.0	292.0	288.0	284.0	280.0	276.0	272.0	267.9	263.9	259.9	255.9	251.9	247.9	243.9	239.9	235.9	231.9	227.9	223.9	219.9	215.9	211.9	755,206
AGM 23	60.0	59.3	58.6	57.9	57.2	56.5	55.8	55.1	54.4	53.8	53.1	52.4	51.7	51.0	50.3	49.6	48.9	48.2	47.5	46.8	46.1	45.4	44.7	4,488,128
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,601,959
AGM 25	60.0	59.3	58.6	57.9	57.2	56.5	55.8	55.1	54.4	53.8	53.1	52.4	51.7	51.0	50.3	49.6	48.9	48.2	47.5	46.8	46.1	45.4	44.7	3,135,034
AGOS 19	120.0	117.9	115.8	113.8	111.7	109.6	107.5	105.4	103.3	101.3	99.2	97.1	95.0	92.9	90.8	88.8	86.7	84.6	82.5	80.4	78.3	76.3	74.2	2,275,186
AGOS 23	120.0	118.3	116.5	114.8	113.1	111.3	109.6	107.8	106.1	104.4	102.6	100.9	99.2	97.4	95.7	94.0	92.2	90.5	88.8	87.0	85.3	83.5	81.8	2,555,861
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,103,775
AGS 60	360.0	354.8	349.6	344.4	339.2	334.0	328.8	323.5	318.3	313.1	307.9	302.7	297.5	292.3	287.1	281.9	276.7	271.5	266.3	261.0	255.8	250.6	245.4	2,769,084
AGSE 1	360.0	355.5	351.1	346.6	342.1	337.7	333.2	328.8	324.3	319.8	315.4	310.9	306.4	302.0	297.5	293.0	288.6	284.1	279.6	275.2	270.7	266.3	261.8	1,888,297
AH 19	605.0	598.3	591.5	584.8	578.0	571.3	564.6	557.8	551.1	544.3	537.6	530.9	524.1	517.4	510.6	503.9	497.2	490.4	483.7	476.9	470.2	463.5	456.7	7,219,616
AK 0323	840.0	830.9	821.8	812.7	803.5	794.4	785.3	776.2	767.1	758.0	748.9	739.7	730.6	721.5	712.4	703.3	694.2	685.1	675.9	666.8	657.7	648.6	639.5	2,333,184
AK 3005	960.0	951.7	943.3	935.0	926.7	918.3	910.0	901.7	893.3	885.0	876.7	868.3	860.0	851.7	843.3	835.0	826.7	818.3	810.0	801.7	793.3	785.0	776.7	3,369,704
AK 3008	900.0	891.3	882.6	874.0	865.3	856.6	847.9	839.2	830.6	821.9	813.2	804.5	795.8	787.2	778.5	769.8	761.1	752.4	743.8	735.1	726.4	717.7	709.0	4,680,006
AK 3015	900.0	890.8	881.6	872.4	863.2	854.0	844.9	835.7	826.5	817.3	808.1	798.9	789.7	780.5	771.3	762.1	752.9	743.8	734.6	725.4	716.2	707.0	697.8	3,448,660
AK 4296	660.0	652.8	645.7	638.5	631.4	624.2	617.0	609.9	602.7	595.5	588.4	581.2	574.1	566.9	559.7	552.6	545.4	538.3	531.1	523.9	516.8	509.6	502.4	1,934,799
AK 4396	720.0	712.2	704.4	696.6	688.8	680.9	673.1	665.3	657.5	649.7	641.9	634.1	626.3	618.4	610.6	602.8	595.0	587.2	579.4	571.6	563.8	555.9	548.1	2,454,469
AK 4496	720.0	713.1	706.1	699.2	692.2	685.3	678.3	671.4	664.4	657.5	650.6	643.6	636.7	629.7	622.8	615.8	608.9	601.9	595.0	588.1	581.1	574.2	567.2	3,191,356
AK 451	360.0	356.3	352.6	349.0	345.3	341.6	337.9	334.3	330.6	326.9	323.2	319.6	315.9	312.2	308.5	304.9	301.2	297.5	293.8	290.1	286.5	282.8	279.1	3,605,632
AK 4729	600.0	593.5	587.0	580.5	574.0	567.4	560.9	554.4	547.9	541.4	534.9	528.4	521.9	515.4	508.9	502.3	495.8	489.3	482.8	476.3	469.8	463.3	456.8	3,312,744
AK 5158	660.0	652.8	645.7	638.5	631.4	624.2	617.0	609.9	602.7	595.5	588.4	581.2	574.1	566.9	559.7	552.6	545.4	538.3	531.1	523.9	516.8	509.6	502.4	1,329,236
AK 5272	720.0	712.2	704.4	696.6	688.8	680.9	673.1	665.3	657.5	649.7	641.9	634.1	626.3	618.4	610.6	602.8	595.0	587.2	579.4	571.6	563.8	555.9	548.1	1,795,187
AK 5307	480.0	473.6	467.2	460.8	454.4	447.9	441.5	435.1	428.7	422.3	415.9	409.5	403.1	396.7	390.3	383.8	377.4	371.0	364.6	358.2	351.8	345.4	339.0	324,072
AK 5362	720.0	712.2	704.4	696.6	688.8	680.9	673.1	665.3	657.5	649.7	641.9	634.1	626.3	618.4	610.6	602.8	595.0	587.2	579.4	571.6	563.8	555.9	548.1	2,439,445
AK 9205	780.0	771.5	763.1	754.6	746.1	737.7	729.2	720.8	712.3	703.8	695.4	686.9	678.4	670.0	661.5	653.0	644.6	636.1	627.7	619.2	610.7	602.3	593.8	-
AKE 1	780.0	773.2	766.5	759.7	752.9	746.1	739.4	732.6	725.8	719.1	712.3	705.5	698.8	692.0	685.2	678.4	671.7	664.9	658.1	651.4	644.6	637.8	631.0	8,006,188
AKR 295	960.0	953.1	946.1	939.2	932.2	925.3	918.3	911.4	904.4	897.5	890.6	883.6	876.7	869.7	862.8	855.8	848.9	841.9	835.0	828.1	821.1	814.2	807.2	1,788,783
AKR 300	960.0	953.1	946.1	939.2	932.2	925.3	918.3	911.4	904.4	897.5	890.6	883.6	876.7	869.7	862.8	855.8	848.9	841.9	835.0	828.1	821.1	814.2	807.2	2,704,656
AKR 310	960.0	953.1	946.1	939.2	932.2	925.3	918.3	911.4	904.4	897.5	890.6	883.6	876.7	869.7	862.8	855.8	848.9	841.9	835.0	828.1	821.1	814.2	807.2	4,425,058
AO 187	660.0	654.3	648.5	642.8	637.1	631.4	625.6	619.9	614.2	608.4	602.7	597.0	591.3	585.5	579.8	574.1	568.3	562.6	556.9	551.1	545.4	539.7	534.0	6,411,584
AOE 6	720.0	714.3	708.6	703.0	697.3	691.6	685.9	680.2	674.5	668.9	663.2	657.5	651.8	646.1	640.5	634.8	629.1	623.4	617.7	612.0	606.4	600.7	595.0	9,796,877
AOT 1121	240.0	237.4	234.8	232.2	229.6	227.0	224.4	221.8	219.2	216.6	214.0	211.4	208.8	206.1	203.5	200.9	198.3	195.7	193.1	190.5	187.9	185.3	182.7	2,807,155
AOT 4995	240.0	237.2	234.4	231.7	228.9	226.1	223.3	220.6	217.8	215.0	212.2	209.4	206.7	203.9	201.1	198.3	195.6	192.8	190.0	187.2	184.4	181.7	178.9	1,258,496
AOT 5205	240.0	237.2	234.4	231.7	228.9	226.1	223.3	220.6	217.8	215.0	212.2	209.4	206.7	203.9	201.1	198.3	195.6	192.8	190.0	187.2	184.4	181.7	178.9	3,745,455
AOT 5246	240.0	237.2	234.4	231.7	228.9	226.1	223.3	220.6	217.8	215.0	212.2	209.4	206.7	203.9	201.1	198.3	195.6	192.8	190.0	187.2	184.4	181.7	178.9	3,458,000
AOT 5356	240.0	237.0	234.0	231.1	228.1	225.1	222.1	219.2	216.2	213.2	210.2	207.3	204.3	201.3	198.3	195.4	192.4	189.4	186.4	183.5	180.5	177.5	174.5	1,711,881
AOT 5406	240.0	237.2	234.4	231.7	228.9	226.1	223.3	220.6	217.8	215.0	212.2	209.4	206.7	203.9	201.1	198.3	195.6	192.8	190.0	187.2	184.4	181.7	178.9	4,267,314
AOT 5419	240.0	237.2	234.4	231.7	228.9	226.1	223.3	220.6	217.8	215.0	212.2	209.4	206.7	203.9	201.1	198.3	195.6	192.8	190.0	187.2	184.4	181.7	178.9	3,050,341
AP 1000	240.0	237.2	234.4	231.7	228.9	226.1	223.3	220.6	217.8	215.0	212.2	209.4	206.7	203.9	201.1	198.3	195.6	192.8	190.0	187.2	184.4	181.7	178.9	6,337,913
ARC 7	120.0	118.5	117.0	115.5	114.0	112.6	111.1	109.6	108.1	106.6	105.1	103.6	102.1	100.7	99.2	97.7	96.2	94.7	93.2	91.7	90.2	88.8	87.3	5,008,061
ARS 50	360.0	354.8	349.6	344.4	339.2	334.0	328.8	323.5	318.3	313.1	307.9	302.7	297.5	292.3	287.1	281.9	276.7	271.5	266.3	261.0	255.8	250.6	245.4	2,287,062
AS 39	300.0	295.7	291.3	287.0	282.6	278.3	274.0	269.6	265.3	260.9	256.6	252.3	247.9	243.6	239.2	234.9	230.6	226.2	221.9	217.5	213.2	208.9	204.5	20,081,466
ATF 166	240.0	236.8	233.6	230.4	227.2	224.0	220.8	217.6	214.4	211.2	207.9	204.7	201.5	198.3	195.1	191.9	188.7	185.5	182.3	179.1	175.9	172.7	169.5	1,478,121
ATF 4247	240.0	233.1	226.1	219.2	212.2	205.3	198.3	191.4	184.4	177.5	170.6	163.6	156.7	149.7	142.8	135.8	128.9	121.9	115.0	108.1	101.1	94.2	87.2	429,784
EPF 1	960.0	955.2	950.5	945.7	941.0	936.2	931.4	926.7	921.9	917.1	912.4	907.6	902.9	898.1	893.3	888.6	883.8	879.0	874.3	869.5	864.8	860.0	855.2	2,880,546
ESB 3	1800.0	1779.2	1758.3	1737.5	1716.7	1695.8	1675.0	1654.2	1633.3	1612.5	1591.7	1570.8	1550.0	1529.2	1508.3	1487.5	1466.7	1445.8	1425.0	1404.2	1383.3	1362.5	1341.7	3,936,836
ESD 1	780.0	771.0	761.9	752.9	743.9	734.9	725.8	716.8	707.8	698.8	689.7	680.7	671.7	662.6	653.6	644.6	635.6	626.5	617.5	608.5	599.4	590.4	581.4	3,643,679
HST 1	420.0	417.8	415.6	413.4	411.2	409.0	406.7	404.5	402.3	400.1	397.9	395.7	393.5	391.3	389.1	386.9	384.6	382.4	380.2	378.0	375.8	373.6	371.4	1,988,618
HST 2	420.0	417.8	415.6	413.4	411.2	409.0	406.7	404.5	402.3	400.1	397.9	395.7	393.5	391.3	389.1	386.9	384.6	382.4	380.2	378.0	375.8	373.6	371.4	180,167
HSV 1	960.0	955.2	950.5	945.7	941.0	936.2	931.4	926.7	921.9	917.1	912.4	907.6	902.9	898.1	893.3	888.6	883.8	879.0	874.3	869.5	864.8	860.0	855.2	5,280,196
HSV 4676	720.0	716.4	712.9	709.3	705.7	702.1	698.6	695.0	691.4	687.9	684.3	680.7	677.1	673.6	670.0	666.4	662.9	659.3	655.7	652.1	648.6	645.0	641.4	4,023,208
LCC 19	540.0	534.1	528.3	522.4	516.6	510.7	504.8	499.0	493.1	487.3	481.4	475.5	469.7	463.8	458.0	452.1	446.3	440.4	434.5	428.7	422.8	417.0	411.1	12,809,955
MB 1219	120.0	117.4	114.8	112.2	109.6	107.0	104.4	101.8	99.2	96.6	94.0	91.4	88.8	86.1	83.5	80.9	78.3	75.7	73.1	70.5	67.9	65.3	62.7	330,793

Table 72. MSC Class Utility Score for 60-Day HADR Response (5,500 to 11,000 nm)

Utility Score (60 Days)	Distance (nm)																							Response Cost CY2017 USD
	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	
AE 26	520.0	513.6	507.2	500.9	494.5	488.1	481.8	475.4	469.0	462.7	456.3	449.9	443.6	437.2	430.8	424.5	418.1	411.7	405.4	399.0	392.6	386.3	379.9	4,435,568
AFS 1	485.4	480.2	475.0	469.8	464.6	459.4	454.2	449.0	443.8	438.5	433.3	428.1	422.9	417.7	412.5	407.3	402.1	396.9	391.7	386.5	381.3	376.0	370.8	2,010,834
AFSB (I) 15	1116.5	1104.5	1092.5	1080.5	1068.5	1056.6	1044.6	1032.6	1020.6	1008.6	996.7	984.7	972.7	960.7	948.8	936.8	924.8	912.8	900.8	888.9	876.9	864.9	852.9	8,282,670
AG 5001	169.5	166.3	163.1	159.9	156.7	153.5	150.3	147.1	143.8	140.6	137.4	134.2	131.0	127.8	124.6	121.4	118.2	115.0	111.8	108.6	105.4	102.2	99.0	4,516,575
AGER 111	211.9	207.9	203.8	199.8	195.8	191.8	187.8	183.8	179.8	175.8	171.8	167.8	163.8	159.8	155.8	151.8	147.8	143.8	139.7	135.7	131.7	127.7	123.7	755,206
AGM 23	44.7	44.0	43.3	42.6	41.9	41.3	40.6	39.9	39.2	38.5	37.8	37.1	36.4	35.7	35.0	34.3	33.6	32.9	32.2	31.5	30.8	30.1	29.4	4,488,128
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,601,959
AGM 25	44.7	44.0	43.3	42.6	41.9	41.3	40.6	39.9	39.2	38.5	37.8	37.1	36.4	35.7	35.0	34.3	33.6	32.9	32.2	31.5	30.8	30.1	29.4	3,135,034
AGOS 19	74.2	72.1	70.0	67.9	65.8	63.8	61.7	59.6	57.5	55.4	53.3	51.3	49.2	47.1	45.0	42.9	40.8	38.8	36.7	34.6	32.5	30.4	28.3	2,275,186
AGOS 23	81.8	80.1	78.3	76.6	74.9	73.1	71.4	69.7	67.9	66.2	64.4	62.7	61.0	59.2	57.5	55.8	54.0	52.3	50.6	48.8	47.1	45.3	43.6	2,555,861
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,103,775
AGS 60	245.4	240.2	235.0	229.8	224.6	219.4	214.2	209.0	203.8	198.5	193.3	188.1	182.9	177.7	172.5	167.3	162.1	156.9	151.7	146.5	141.3	136.0	130.8	2,769,084
AGSE 1	261.8	257.3	252.9	248.4	243.9	239.5	235.0	230.5	226.1	221.6	217.1	212.7	208.2	203.8	199.3	194.8	190.4	185.9	181.4	177.0	172.5	168.0	163.6	1,888,297
AH 19	456.7	450.0	443.2	436.5	429.8	423.0	416.3	409.5	402.8	396.1	389.3	382.6	375.8	369.1	362.4	355.6	348.9	342.1	335.4	328.7	321.9	315.2	308.4	7,219,616
AK 0323	639.5	630.4	621.3	612.1	603.0	593.9	584.8	575.7	566.6	557.4	548.3	539.2	530.1	521.0	511.9	502.8	493.6	484.5	475.4	466.3	457.2	448.1	439.0	2,333,184
AK 3005	776.7	768.3	760.0	751.7	743.3	735.0	726.7	718.3	710.0	701.7	693.3	685.0	676.7	668.3	660.0	651.7	643.3	635.0	626.7	618.3	610.0	601.7	593.3	3,369,704
AK 3008	709.0	700.3	691.7	683.0	674.3	665.6	656.9	648.3	639.6	630.9	622.2	613.5	604.9	596.2	587.5	578.8	570.1	561.5	552.8	544.1	535.4	526.7	518.1	4,680,006
AK 3015	697.8	688.6	679.4	670.2	661.0	651.8	642.6	633.5	624.3	615.1	605.9	596.7	587.5	578.3	569.1	559.9	550.7	541.5	532.4	523.2	514.0	504.8	495.6	3,448,660
AK 4296	502.4	495.3	488.1	481.0	473.8	466.6	459.5	452.3	445.2	438.0	430.8	423.7	416.5	409.3	402.2	395.0	387.9	380.7	373.5	366.4	359.2	352.1	344.9	1,934,799
AK 4396	548.1	540.3	532.5	524.7	516.9	509.1	501.3	493.4	485.6	477.8	470.0	462.2	454.4	446.6	438.8	430.9	423.1	415.3	407.5	399.7	391.9	384.1	376.3	2,454,469
AK 4496	567.2	560.3	553.3	546.4	539.4	532.5	525.6	518.6	511.7	504.7	497.8	490.8	483.9	476.9	470.0	463.1	456.1	449.2	442.2	435.3	428.3	421.4	414.4	3,191,356
AK 451	279.1	275.4	271.8	268.1	264.4	260.7	257.1	253.4	249.7	246.0	242.4	238.7	235.0	231.3	227.6	224.0	220.3	216.6	212.9	209.3	205.6	201.9	198.2	3,605,632
AK 4729	456.8	450.3	443.8	437.2	430.7	424.2	417.7	411.2	404.7	398.2	391.7	385.2	378.6	372.1	365.6	359.1	352.6	346.1	339.6	333.1	326.6	320.1	313.5	3,312,744
AK 5158	502.4	495.3	488.1	481.0	473.8	466.6	459.5	452.3	445.2	438.0	430.8	423.7	416.5	409.3	402.2	395.0	387.9	380.7	373.5	366.4	359.2	352.1	344.9	1,329,236
AK 5272	548.1	540.3	532.5	524.7	516.9	509.1	501.3	493.4	485.6	477.8	470.0	462.2	454.4	446.6	438.8	430.9	423.1	415.3	407.5	399.7	391.9	384.1	376.3	1,795,187
AK 5307	339.0	332.6	326.2	319.7	313.3	306.9	300.5	294.1	287.7	281.3	274.9	268.5	262.1	255.6	249.2	242.8	236.4	230.0	223.6	217.2	210.8	204.4	197.9	324,072
AK 5362	548.1	540.3	532.5	524.7	516.9	509.1	501.3	493.4	485.6	477.8	470.0	462.2	454.4	446.6	438.8	430.9	423.1	415.3	407.5	399.7	391.9	384.1	376.3	2,439,445
AK 9205	593.8	585.3	576.9	568.4	559.9	551.5	543.0	534.6	526.1	517.6	509.2	500.7	492.2	483.8	475.3	466.8	458.4	449.9	441.5	433.0	424.5	416.1	407.6	-
AKE 1	631.0	624.3	617.5	610.7	604.0	597.2	590.4	583.6	576.9	570.1	563.3	556.6	549.8	543.0	536.3	529.5	522.7	515.9	509.2	502.4	495.6	488.9	482.1	8,006,188
AKR 295	807.2	800.3	793.3	786.4	779.4	772.5	765.6	758.6	751.7	744.7	737.8	730.8	723.9	716.9	710.0	703.1	696.1	689.2	682.2	675.3	668.3	661.4	654.4	1,788,783
AKR 300	807.2	800.3	793.3	786.4	779.4	772.5	765.6	758.6	751.7	744.7	737.8	730.8	723.9	716.9	710.0	703.1	696.1	689.2	682.2	675.3	668.3	661.4	654.4	2,704,656
AKR 310	807.2	800.3	793.3	786.4	779.4	772.5	765.6	758.6	751.7	744.7	737.8	730.8	723.9	716.9	710.0	703.1	696.1	689.2	682.2	675.3	668.3	661.4	654.4	4,425,058
AO 187	534.0	528.2	522.5	516.8	511.0	505.3	499.6	493.9	488.1	482.4	476.7	470.9	465.2	459.5	453.8	448.0	442.3	436.6	430.8	425.1	419.4	413.6	407.9	6,411,584
AOE 6	595.0	589.3	583.6	578.0	572.3	566.6	560.9	555.2	549.5	543.9	538.2	532.5	526.8	521.1	515.5	509.8	504.1	498.4	492.7	487.0	481.4	475.7	470.0	9,796,877
AOT 1121	182.7	180.1	177.5	174.9	172.3	169.7	167.1	164.5	161.9	159.3	156.7	154.1	151.5	148.9	146.3	143.6	141.0	138.4	135.8	133.2	130.6	128.0	125.4	2,807,155
AOT 4995	178.9	176.1	173.3	170.6	167.8	165.0	162.2	159.4	156.7	153.9	151.1	148.3	145.6	142.8	140.0	137.2	134.4	131.7	128.9	126.1	123.3	120.6	117.8	1,258,496
AOT 5205	178.9	176.1	173.3	170.6	167.8	165.0	162.2	159.4	156.7	153.9	151.1	148.3	145.6	142.8	140.0	137.2	134.4	131.7	128.9	126.1	123.3	120.6	117.8	3,745,455
AOT 5246	178.9	176.1	173.3	170.6	167.8	165.0	162.2	159.4	156.7	153.9	151.1	148.3	145.6	142.8	140.0	137.2	134.4	131.7	128.9	126.1	123.3	120.6	117.8	3,458,000
AOT 5356	174.5	171.5	168.6	165.6	162.6	159.6	156.7	153.7	150.7	147.7	144.8	141.8	138.8	135.8	132.9	129.9	126.9	123.9	121.0	118.0	115.0	112.0	109.0	1,711,881
AOT 5406	178.9	176.1	173.3	170.6	167.8	165.0	162.2	159.4	156.7	153.9	151.1	148.3	145.6	142.8	140.0	137.2	134.4	131.7	128.9	126.1	123.3	120.6	117.8	4,267,314
AOT 5419	178.9	176.1	173.3	170.6	167.8	165.0	162.2	159.4	156.7	153.9	151.1	148.3	145.6	142.8	140.0	137.2	134.4	131.7	128.9	126.1	123.3	120.6	117.8	3,050,341
AP 1000	178.9	176.1	173.3	170.6	167.8	165.0	162.2	159.4	156.7	153.9	151.1	148.3	145.6	142.8	140.0	137.2	134.4	131.7	128.9	126.1	123.3	120.6	117.8	6,337,913
ARC 7	87.3	85.8	84.3	82.8	81.3	79.8	78.3	76.8	75.4	73.9	72.4	70.9	69.4	67.9	66.4	64.9	63.5	62.0	60.5	59.0	57.5	56.0	54.5	5,008,061
ARS 50	245.4	240.2	235.0	229.8	224.6	219.4	214.2	209.0	203.8	198.5	193.3	188.1	182.9	177.7	172.5	167.3	162.1	156.9	151.7	146.5	141.3	136.0	130.8	2,287,062
AS 39	204.5	200.2	195.8	191.5	187.2	182.8	178.5	174.1	169.8	165.5	161.1	156.8	152.4	148.1	143.8	139.4	135.1	130.7	126.4	122.0	117.7	113.4	109.0	20,081,466
ATF 166	169.5	166.3	163.1	159.9	156.7	153.5	150.3	147.1	143.8	140.6	137.4	134.2	131.0	127.8	124.6	121.4	118.2	115.0	111.8	108.6	105.4	102.2	99.0	1,478,121
ATF 4247	87.2	80.3	73.3	66.4	59.4	52.5	45.6	38.6	31.7	24.7	17.8	10.8	3.9	-3.1	-10.0	-16.9	-23.9	-30.8	-37.8	-44.7	-51.7	-58.6	-65.6	429,784
EPF 1	855.2	850.5	845.7	841.0	836.2	831.4	826.7	821.9	817.1	812.4	807.6	802.9	798.1	793.3	788.6	783.8	779.0	774.3	769.5	764.8	760.0	755.2	750.5	2,880,546
ESB 3	1341.7	1320.8	1300.0	1279.2	1258.3	1237.5	1216.7	1195.8	1175.0	1154.2	1133.3	1112.5	1091.7	1070.8	1050.0	1029.2	1008.3	987.5	966.7	945.8	925.0	904.2	883.3	3,936,836
ESD 1	581.4	572.4	563.3	554.3	545.3	536.3	527.2	518.2	509.2	500.1	491.1	482.1	473.1	464.0	455.0	446.0	436.9	427.9	418.9	409.9	400.8	391.8	382.8	3,643,679
HST 1	371.4	369.2	367.0	364.8	362.6	360.3	358.1	355.9	353.7	351.5	349.3	347.1	344.9	342.7	340.5	338.2	336.0	333.8	331.6	329.4	327.2	325.0	322.8	1,988,618
HST 2	371.4	369.2	367.0	364.8	362.6	360.3	358.1	355.9	353.7	351.5	349.3	347.1	344.9	342.7	340.5	338.2	336.0	333.8	331.6	329.4	327.2	325.0	322.8	180,167
HSV 1	855.2	850.5	845.7	841.0	836.2	831.4	826.7	821.9	817.1	812.4	807.6	802.9	798.1	793.3	788.6	783.8	779.0	774.3	769.5	764.8	760.0	755.2	750.5	5,280,196
HSV 4676	641.4	637.9	634.3	630.7	627.1	623.6	620.0	616.4	612.9	609.3	605.7	602.1	598.6	595.0	591.4	587.9	584.3	580.7	577.1	573.6	570.0	566.4	562.9	4,023,208
LCC 19	411.1	405.2	399.4	393.5	387.7	381.8	375.9	370.1	364.2	358.4	352.5	346.6	340.8	334.9	329.1	323.2	317.3	311.5	305.6	299.8	293.9	288.0	282.2	12,809,955
MB 1219	62.7	60.1	57.5	54.9	52.3	49.7	47.1	44.5	41.9	39.3	36.7	34.1	31.5	28.9	26.3	23.6	21.0	18.4	15.8	13.2	10.6	8.0	5.4	330,793

Table 73. MSC Class Utility Score for 90-Day HADR Response (0 to 5,500 nm)

Utility Score (90 Days)	Distance (nm)																							Response Cost CY2017 USD
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	
AE 26	990.0	983.6	977.3	970.9	964.5	958.2	951.8	945.4	939.1	932.7	926.3	920.0	913.6	907.2	900.9	894.5	888.1	881.8	875.4	869.1	862.7	856.3	850.0	6,653,351
AFS 1	900.0	894.8	889.6	884.4	879.2	874.0	868.8	863.5	858.3	853.1	847.9	842.7	837.5	832.3	827.1	821.9	816.7	811.5	806.3	801.0	795.8	790.6	785.4	3,016,251
AFSB (I) 15	2070.0	2058.0	2046.0	2034.1	2022.1	2010.1	1998.1	1986.1	1974.2	1962.2	1950.2	1938.2	1926.3	1914.3	1902.3	1890.3	1878.3	1866.4	1854.4	1842.4	1830.4	1818.4	1806.5	12,424,005
AG 5001	360.0	356.8	353.6	350.4	347.2	344.0	340.8	337.6	334.4	331.2	327.9	324.7	321.5	318.3	315.1	311.9	308.7	305.5	302.3	299.1	295.9	292.7	289.5	6,774,863
AGER 111	450.0	446.0	442.0	438.0	434.0	430.0	426.0	422.0	417.9	413.9	409.9	405.9	401.9	397.9	393.9	389.9	385.9	381.9	377.9	373.9	369.9	365.9	361.9	1,132,810
AGM 23	90.0	89.3	88.6	87.9	87.2	86.5	85.8	85.1	84.4	83.8	83.1	82.4	81.7	81.0	80.3	79.6	78.9	78.2	77.5	76.8	76.1	75.4	74.7	6,732,191
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,402,938
AGM 25	90.0	89.3	88.6	87.9	87.2	86.5	85.8	85.1	84.4	83.8	83.1	82.4	81.7	81.0	80.3	79.6	78.9	78.2	77.5	76.8	76.1	75.4	74.7	4,702,551
AGOS 19	180.0	177.9	175.8	173.8	171.7	169.6	167.5	165.4	163.3	161.3	159.2	157.1	155.0	152.9	150.8	148.8	146.7	144.6	142.5	140.4	138.3	136.3	134.2	3,412,779
AGOS 23	180.0	178.3	176.5	174.8	173.1	171.3	169.6	167.8	166.1	164.4	162.6	160.9	159.2	157.4	155.7	154.0	152.2	150.5	148.8	147.0	145.3	143.5	141.8	3,833,792
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,655,662
AGS 60	540.0	534.8	529.6	524.4	519.2	514.0	508.8	503.5	498.3	493.1	487.9	482.7	477.5	472.3	467.1	461.9	456.7	451.5	446.3	441.0	435.8	430.6	425.4	4,153,626
AGSE 1	540.0	535.5	531.1	526.6	522.1	517.7	513.2	508.8	504.3	499.8	495.4	490.9	486.4	482.0	477.5	473.0	468.6	464.1	459.6	455.2	450.7	446.3	441.8	2,832,445
AH 19	935.0	928.3	921.5	914.8	908.0	901.3	894.6	887.8	881.1	874.3	867.6	860.9	854.1	847.4	840.6	833.9	827.2	820.4	813.7	806.9	800.2	793.5	786.7	10,829,424
AK 0323	1260.0	1250.9	1241.8	1232.7	1223.5	1214.4	1205.3	1196.2	1187.1	1178.0	1168.9	1159.7	1150.6	1141.5	1132.4	1123.3	1114.2	1105.1	1095.9	1086.8	1077.7	1068.6	1059.5	3,499,776
AK 3005	1440.0	1431.7	1423.3	1415.0	1406.7	1398.3	1390.0	1381.7	1373.3	1365.0	1356.7	1348.3	1340.0	1331.7	1323.3	1315.0	1306.7	1298.3	1290.0	1281.7	1273.3	1265.0	1256.7	5,054,556
AK 3008	1350.0	1341.3	1332.6	1324.0	1315.3	1306.6	1297.9	1289.2	1280.6	1271.9	1263.2	1254.5	1245.8	1237.2	1228.5	1219.8	1211.1	1202.4	1193.8	1185.1	1176.4	1167.7	1159.0	7,020,009
AK 3015	1350.0	1340.8	1331.6	1322.4	1313.2	1304.0	1294.9	1285.7	1276.5	1267.3	1258.1	1248.9	1239.7	1230.5	1221.3	1212.1	1202.9	1193.8	1184.6	1175.4	1166.2	1157.0	1147.8	5,172,990
AK 4296	990.0	982.8	975.7	968.5	961.4	954.2	947.0	939.9	932.7	925.5	918.4	911.2	904.1	896.9	889.7	882.6	875.4	868.3	861.1	853.9	846.8	839.6	832.4	2,902,198
AK 4396	1080.0	1072.2	1064.4	1056.6	1048.8	1040.9	1033.1	1025.3	1017.5	1009.7	1001.9	994.1	986.3	978.4	970.6	962.8	955.0	947.2	939.4	931.6	923.8	915.9	908.1	3,681,703
AK 4496	1080.0	1073.1	1066.1	1059.2	1052.2	1045.3	1038.3	1031.4	1024.4	1017.5	1010.6	1003.6	996.7	989.7	982.8	975.8	968.9	961.9	955.0	948.1	941.1	934.2	927.2	4,787,034
AK 451	540.0	536.3	532.6	529.0	525.3	521.6	517.9	514.3	510.6	506.9	503.2	499.6	495.9	492.2	488.5	484.9	481.2	477.5	473.8	470.1	466.5	462.8	459.1	5,408,448
AK 4729	900.0	893.5	887.0	880.5	874.0	867.4	860.9	854.4	847.9	841.4	834.9	828.4	821.9	815.4	808.9	802.3	795.8	789.3	782.8	776.3	769.8	763.3	756.8	4,969,116
AK 5158	990.0	982.8	975.7	968.5	961.4	954.2	947.0	939.9	932.7	925.5	918.4	911.2	904.1	896.9	889.7	882.6	875.4	868.3	861.1	853.9	846.8	839.6	832.4	1,993,853
AK 5272	1080.0	1072.2	1064.4	1056.6	1048.8	1040.9	1033.1	1025.3	1017.5	1009.7	1001.9	994.1	986.3	978.4	970.6	962.8	955.0	947.2	939.4	931.6	923.8	915.9	908.1	2,692,780
AK 5307	720.0	713.6	707.2	700.8	694.4	687.9	681.5	675.1	668.7	662.3	655.9	649.5	643.1	636.7	630.3	623.8	617.4	611.0	604.6	598.2	591.8	585.4	579.0	486,108
AK 5362	1080.0	1072.2	1064.4	1056.6	1048.8	1040.9	1033.1	1025.3	1017.5	1009.7	1001.9	994.1	986.3	978.4	970.6	962.8	955.0	947.2	939.4	931.6	923.8	915.9	908.1	3,659,167
AK 9205	1170.0	1161.5	1153.1	1144.6	1136.1	1127.7	1119.2	1110.8	1102.3	1093.8	1085.4	1076.9	1068.4	1060.0	1051.5	1043.0	1034.6	1026.1	1017.7	1009.2	1000.7	992.3	983.8	-
AKE 1	1170.0	1163.2	1156.5	1149.7	1142.9	1136.1	1129.4	1122.6	1115.8	1109.1	1102.3	1095.5	1088.8	1082.0	1075.2	1068.4	1061.7	1054.9	1048.1	1041.4	1034.6	1027.8	1021.0	12,009,282
AKR 295	1440.0	1433.1	1426.1	1419.2	1412.2	1405.3	1398.3	1391.4	1384.4	1377.5	1370.6	1363.6	1356.7	1349.7	1342.8	1335.8	1328.9	1321.9	1315.0	1308.1	1301.1	1294.2	1287.2	2,683,175
AKR 300	1440.0	1433.1	1426.1	1419.2	1412.2	1405.3	1398.3	1391.4	1384.4	1377.5	1370.6	1363.6	1356.7	1349.7	1342.8	1335.8	1328.9	1321.9	1315.0	1308.1	1301.1	1294.2	1287.2	4,056,983
AKR 310	1440.0	1433.1	1426.1	1419.2	1412.2	1405.3	1398.3	1391.4	1384.4	1377.5	1370.6	1363.6	1356.7	1349.7	1342.8	1335.8	1328.9	1321.9	1315.0	1308.1	1301.1	1294.2	1287.2	6,637,587
AO 187	990.0	984.3	978.5	972.8	967.1	961.4	955.6	949.9	944.2	938.4	932.7	927.0	921.3	915.5	909.8	904.1	898.3	892.6	886.9	881.1	875.4	869.7	864.0	9,617,376
AOE 6	1080.0	1074.3	1068.6	1063.0	1057.3	1051.6	1045.9	1040.2	1034.5	1028.9	1023.2	1017.5	1011.8	1006.1	1000.5	994.8	989.1	983.4	977.7	972.0	966.4	960.7	955.0	14,695,315
AOT 1121	360.0	357.4	354.8	352.2	349.6	347.0	344.4	341.8	339.2	336.6	334.0	331.4	328.8	326.1	323.5	320.9	318.3	315.7	313.1	310.5	307.9	305.3	302.7	4,210,733
AOT 4995	360.0	357.2	354.4	351.7	348.9	346.1	343.3	340.6	337.8	335.0	332.2	329.4	326.7	323.9	321.1	318.3	315.6	312.8	310.0	307.2	304.4	301.7	298.9	1,887,744
AOT 5205	360.0	357.2	354.4	351.7	348.9	346.1	343.3	340.6	337.8	335.0	332.2	329.4	326.7	323.9	321.1	318.3	315.6	312.8	310.0	307.2	304.4	301.7	298.9	5,618,183
AOT 5246	360.0	357.2	354.4	351.7	348.9	346.1	343.3	340.6	337.8	335.0	332.2	329.4	326.7	323.9	321.1	318.3	315.6	312.8	310.0	307.2	304.4	301.7	298.9	5,186,999
AOT 5356	360.0	357.0	354.0	351.1	348.1	345.1	342.1	339.2	336.2	333.2	330.2	327.3	324.3	321.3	318.3	315.4	312.4	309.4	306.4	303.5	300.5	297.5	294.5	2,567,822
AOT 5406	360.0	357.2	354.4	351.7	348.9	346.1	343.3	340.6	337.8	335.0	332.2	329.4	326.7	323.9	321.1	318.3	315.6	312.8	310.0	307.2	304.4	301.7	298.9	6,400,970
AOT 5419	360.0	357.2	354.4	351.7	348.9	346.1	343.3	340.6	337.8	335.0	332.2	329.4	326.7	323.9	321.1	318.3	315.6	312.8	310.0	307.2	304.4	301.7	298.9	4,575,512
AP 1000	360.0	357.2	354.4	351.7	348.9	346.1	343.3	340.6	337.8	335.0	332.2	329.4	326.7	323.9	321.1	318.3	315.6	312.8	310.0	307.2	304.4	301.7	298.9	9,506,869
ARC 7	180.0	178.5	177.0	175.5	174.0	172.6	171.1	169.6	168.1	166.6	165.1	163.6	162.1	160.7	159.2	157.7	156.2	154.7	153.2	151.7	150.2	148.8	147.3	7,512,092
ARS 50	540.0	534.8	529.6	524.4	519.2	514.0	508.8	503.5	498.3	493.1	487.9	482.7	477.5	472.3	467.1	461.9	456.7	451.5	446.3	441.0	435.8	430.6	425.4	3,430,592
AS 39	450.0	445.7	441.3	437.0	432.6	428.3	424.0	419.6	415.3	410.9	406.6	402.3	397.9	393.6	389.2	384.9	380.6	376.2	371.9	367.5	363.2	358.9	354.5	30,122,198
ATF 166	360.0	356.8	353.6	350.4	347.2	344.0	340.8	337.6	334.4	331.2	327.9	324.7	321.5	318.3	315.1	311.9	308.7	305.5	302.3	299.1	295.9	292.7	289.5	2,217,181
ATF 4247	360.0	353.1	346.1	339.2	332.2	325.3	318.3	311.4	304.4	297.5	290.6	283.6	276.7	269.7	262.8	255.8	248.9	241.9	235.0	228.1	221.1	214.2	207.2	644,677
EPF 1	1440.0	1435.2	1430.5	1425.7	1421.0	1416.2	1411.4	1406.7	1401.9	1397.1	1392.4	1387.6	1382.9	1378.1	1373.3	1368.6	1363.8	1359.0	1354.3	1349.5	1344.8	1340.0	1335.2	4,320,819
ESB 3	2700.0	2679.2	2658.3	2637.5	2616.7	2595.8	2575.0	2554.2	2533.3	2512.5	2491.7	2470.8	2450.0	2429.2	2408.3	2387.5	2366.7	2345.8	2325.0	2304.2	2283.3	2262.5	2241.7	5,905,255
ESD 1	1170.0	1161.0	1151.9	1142.9	1133.9	1124.9	1115.8	1106.8	1097.8	1088.8	1079.7	1070.7	1061.7	1052.6	1043.6	1034.6	1025.6	1016.5	1007.5	998.5	989.4	980.4	971.4	5,465,518
HST 1	630.0	627.8	625.6	623.4	621.2	619.0	616.7	614.5	612.3	610.1	607.9	605.7	603.5	601.3	599.1	596.9	594.6	592.4	590.2	588.0	585.8	583.6	581.4	2,982,927
HST 2	630.0	627.8	625.6	623.4	621.2	619.0	616.7	614.5	612.3	610.1	607.9	605.7	603.5	601.3	599.1	596.9	594.6	592.4	590.2	588.0	585.8	583.6	581.4	270,250
HSV 1	1440.0	1435.2	1430.5	1425.7	1421.0	1416.2	1411.4	1406.7	1401.9	1397.1	1392.4	1387.6	1382.9	1378.1	1373.3	1368.6	1363.8	1359.0	1354.3	1349.5	1344.8	1340.0	1335.2	7,920,294
HSV 4676	1080.0	1076.4	1072.9	1069.3	1065.7	1062.1	1058.6	1055.0	1051.4	1047.9	1044.3	1040.7	1037.1	1033.6	1030.0	1026.4	1022.9	1019.3	1015.7	1012.1	1008.6	1005.0	1001.4	6,034,812
LCC 19	810.0	804.1	798.3	792.4	786.6	780.7	774.8	769.0	763.1	757.3	751.4	745.5	739.7	733.8	728.0	722.1	716.3	710.4	704.5	698.7	692.8	687.0	681.1	19,214,932
MB 1219	180.0	177.4	174.8	172.2	169.6	167.0	164.4	161.8	159.2	156.6	154.0	151.4	148.8	146.1	143.5	140.9	138.3	135.7	133.1	130.5	127.9	125.3	122.7	496,190

Table 74. MSC Class Utility Score for 90-Day HADR Response (5,500 to 11,000 nm)

Utility Score (90 Days)	Distance (nm)																							Response Cost CY2017 USD
	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	
AE 26	850.0	843.6	837.2	830.9	824.5	818.1	811.8	805.4	799.0	792.7	786.3	779.9	773.6	767.2	760.8	754.5	748.1	741.7	735.4	729.0	722.6	716.3	709.9	6,653,351
AFS 1	785.4	780.2	775.0	769.8	764.6	759.4	754.2	749.0	743.8	738.5	733.3	728.1	722.9	717.7	712.5	707.3	702.1	696.9	691.7	686.5	681.3	676.0	670.8	3,016,251
AFSB (I) 15	1806.5	1794.5	1782.5	1770.5	1758.5	1746.6	1734.6	1722.6	1710.6	1698.6	1686.7	1674.7	1662.7	1650.7	1638.8	1626.8	1614.8	1602.8	1590.8	1578.9	1566.9	1554.9	1542.9	12,424,005
AG 5001	289.5	286.3	283.1	279.9	276.7	273.5	270.3	267.1	263.8	260.6	257.4	254.2	251.0	247.8	244.6	241.4	238.2	235.0	231.8	228.6	225.4	222.2	219.0	6,774,863
AGER 111	361.9	357.9	353.8	349.8	345.8	341.8	337.8	333.8	329.8	325.8	321.8	317.8	313.8	309.8	305.8	301.8	297.8	293.8	289.7	285.7	281.7	277.7	273.7	1,132,810
AGM 23	74.7	74.0	73.3	72.6	71.9	71.3	70.6	69.9	69.2	68.5	67.8	67.1	66.4	65.7	65.0	64.3	63.6	62.9	62.2	61.5	60.8	60.1	59.4	6,732,191
AGM 24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,402,938
AGM 25	74.7	74.0	73.3	72.6	71.9	71.3	70.6	69.9	69.2	68.5	67.8	67.1	66.4	65.7	65.0	64.3	63.6	62.9	62.2	61.5	60.8	60.1	59.4	4,702,551
AGOS 19	134.2	132.1	130.0	127.9	125.8	123.8	121.7	119.6	117.5	115.4	113.3	111.3	109.2	107.1	105.0	102.9	100.8	98.8	96.7	94.6	92.5	90.4	88.3	3,412,779
AGOS 23	141.8	140.1	138.3	136.6	134.9	133.1	131.4	129.7	127.9	126.2	124.4	122.7	121.0	119.2	117.5	115.8	114.0	112.3	110.6	108.8	107.1	105.3	103.6	3,833,792
AGS 45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,655,662
AGS 60	425.4	420.2	415.0	409.8	404.6	399.4	394.2	389.0	383.8	378.5	373.3	368.1	362.9	357.7	352.5	347.3	342.1	336.9	331.7	326.5	321.3	316.0	310.8	4,153,626
AGSE 1	441.8	437.3	432.9	428.4	423.9	419.5	415.0	410.5	406.1	401.6	397.1	392.7	388.2	383.8	379.3	374.8	370.4	365.9	361.4	357.0	352.5	348.0	343.6	2,832,445
AH 19	786.7	780.0	773.2	766.5	759.8	753.0	746.3	739.5	732.8	726.1	719.3	712.6	705.8	699.1	692.4	685.6	678.9	672.1	665.4	658.7	651.9	645.2	638.4	10,829,424
AK 0323	1059.5	1050.4	1041.3	1032.1	1023.0	1013.9	1004.8	995.7	986.6	977.4	968.3	959.2	950.1	941.0	931.9	922.8	913.6	904.5	895.4	886.3	877.2	868.1	859.0	3,499,776
AK 3005	1256.7	1248.3	1240.0	1231.7	1223.3	1215.0	1206.7	1198.3	1190.0	1181.7	1173.3	1165.0	1156.7	1148.3	1140.0	1131.7	1123.3	1115.0	1106.7	1098.3	1090.0	1081.7	1073.3	5,054,556
AK 3008	1159.0	1150.3	1141.7	1133.0	1124.3	1115.6	1106.9	1098.3	1089.6	1080.9	1072.2	1063.5	1054.9	1046.2	1037.5	1028.8	1020.1	1011.5	1002.8	994.1	985.4	976.7	968.1	7,020,009
AK 3015	1147.8	1138.6	1129.4	1120.2	1111.0	1101.8	1092.6	1083.5	1074.3	1065.1	1055.9	1046.7	1037.5	1028.3	1019.1	1009.9	1000.7	991.5	982.4	973.2	964.0	954.8	945.6	5,172,990
AK 4296	832.4	825.3	818.1	811.0	803.8	796.6	789.5	782.3	775.2	768.0	760.8	753.7	746.5	739.3	732.2	725.0	717.9	710.7	703.5	696.4	689.2	682.1	674.9	2,902,198
AK 4396	908.1	900.3	892.5	884.7	876.9	869.1	861.3	853.4	845.6	837.8	830.0	822.2	814.4	806.6	798.8	790.9	783.1	775.3	767.5	759.7	751.9	744.1	736.3	3,681,703
AK 4496	927.2	920.3	913.3	906.4	899.4	892.5	885.6	878.6	871.7	864.7	857.8	850.8	843.9	836.9	830.0	823.1	816.1	809.2	802.2	795.3	788.3	781.4	774.4	4,787,034
AK 451	459.1	455.4	451.8	448.1	444.4	440.7	437.1	433.4	429.7	426.0	422.4	418.7	415.0	411.3	407.6	404.0	400.3	396.6	392.9	389.3	385.6	381.9	378.2	5,408,448
AK 4729	756.8	750.3	743.8	737.2	730.7	724.2	717.7	711.2	704.7	698.2	691.7	685.2	678.6	672.1	665.6	659.1	652.6	646.1	639.6	633.1	626.6	620.1	613.5	4,969,116
AK 5158	832.4	825.3	818.1	811.0	803.8	796.6	789.5	782.3	775.2	768.0	760.8	753.7	746.5	739.3	732.2	725.0	717.9	710.7	703.5	696.4	689.2	682.1	674.9	1,993,853
AK 5272	908.1	900.3	892.5	884.7	876.9	869.1	861.3	853.4	845.6	837.8	830.0	822.2	814.4	806.6	798.8	790.9	783.1	775.3	767.5	759.7	751.9	744.1	736.3	2,692,780
AK 5307	579.0	572.6	566.2	559.7	553.3	546.9	540.5	534.1	527.7	521.3	514.9	508.5	502.1	495.6	489.2	482.8	476.4	470.0	463.6	457.2	450.8	444.4	437.9	486,108
AK 5362	908.1	900.3	892.5	884.7	876.9	869.1	861.3	853.4	845.6	837.8	830.0	822.2	814.4	806.6	798.8	790.9	783.1	775.3	767.5	759.7	751.9	744.1	736.3	3,659,167
AK 9205	983.8	975.3	966.9	958.4	949.9	941.5	933.0	924.6	916.1	907.6	899.2	890.7	882.2	873.8	865.3	856.8	848.4	839.9	831.5	823.0	814.5	806.1	797.6	-
AKE 1	1021.0	1014.3	1007.5	1000.7	994.0	987.2	980.4	973.6	966.9	960.1	953.3	946.6	939.8	933.0	926.3	919.5	912.7	905.9	899.2	892.4	885.6	878.9	872.1	12,009,282
AKR 295	1287.2	1280.3	1273.3	1266.4	1259.4	1252.5	1245.6	1238.6	1231.7	1224.7	1217.8	1210.8	1203.9	1196.9	1190.0	1183.1	1176.1	1169.2	1162.2	1155.3	1148.3	1141.4	1134.4	2,683,175
AKR 300	1287.2	1280.3	1273.3	1266.4	1259.4	1252.5	1245.6	1238.6	1231.7	1224.7	1217.8	1210.8	1203.9	1196.9	1190.0	1183.1	1176.1	1169.2	1162.2	1155.3	1148.3	1141.4	1134.4	4,056,983
AKR 310	1287.2	1280.3	1273.3	1266.4	1259.4	1252.5	1245.6	1238.6	1231.7	1224.7	1217.8	1210.8	1203.9	1196.9	1190.0	1183.1	1176.1	1169.2	1162.2	1155.3	1148.3	1141.4	1134.4	6,637,587
AO 187	864.0	858.2	852.5	846.8	841.0	835.3	829.6	823.9	818.1	812.4	806.7	800.9	795.2	789.5	783.8	778.0	772.3	766.6	760.8	755.1	749.4	743.6	737.9	9,617,376
AOE 6	955.0	949.3	943.6	938.0	932.3	926.6	920.9	915.2	909.5	903.9	898.2	892.5	886.8	881.1	875.5	869.8	864.1	858.4	852.7	847.0	841.4	835.7	830.0	14,695,315
AOT 1121	302.7	300.1	297.5	294.9	292.3	289.7	287.1	284.5	281.9	279.3	276.7	274.1	271.5	268.9	266.3	263.6	261.0	258.4	255.8	253.2	250.6	248.0	245.4	4,210,733
AOT 4995	298.9	296.1	293.3	290.6	287.8	285.0	282.2	279.4	276.7	273.9	271.1	268.3	265.6	262.8	260.0	257.2	254.4	251.7	248.9	246.1	243.3	240.6	237.8	1,887,744
AOT 5205	298.9	296.1	293.3	290.6	287.8	285.0	282.2	279.4	276.7	273.9	271.1	268.3	265.6	262.8	260.0	257.2	254.4	251.7	248.9	246.1	243.3	240.6	237.8	5,618,183
AOT 5246	298.9	296.1	293.3	290.6	287.8	285.0	282.2	279.4	276.7	273.9	271.1	268.3	265.6	262.8	260.0	257.2	254.4	251.7	248.9	246.1	243.3	240.6	237.8	5,186,999
AOT 5356	294.5	291.5	288.6	285.6	282.6	279.6	276.7	273.7	270.7	267.7	264.8	261.8	258.8	255.8	252.9	249.9	246.9	243.9	241.0	238.0	235.0	232.0	229.0	2,567,822
AOT 5406	298.9	296.1	293.3	290.6	287.8	285.0	282.2	279.4	276.7	273.9	271.1	268.3	265.6	262.8	260.0	257.2	254.4	251.7	248.9	246.1	243.3	240.6	237.8	6,400,970
AOT 5419	298.9	296.1	293.3	290.6	287.8	285.0	282.2	279.4	276.7	273.9	271.1	268.3	265.6	262.8	260.0	257.2	254.4	251.7	248.9	246.1	243.3	240.6	237.8	4,575,512
AP 1000	298.9	296.1	293.3	290.6	287.8	285.0	282.2	279.4	276.7	273.9	271.1	268.3	265.6	262.8	260.0	257.2	254.4	251.7	248.9	246.1	243.3	240.6	237.8	9,506,869
ARC 7	147.3	145.8	144.3	142.8	141.3	139.8	138.3	136.8	135.4	133.9	132.4	130.9	129.4	127.9	126.4	124.9	123.5	122.0	120.5	119.0	117.5	116.0	114.5	7,512,092
ARS 50	425.4	420.2	415.0	409.8	404.6	399.4	394.2	389.0	383.8	378.5	373.3	368.1	362.9	357.7	352.5	347.3	342.1	336.9	331.7	326.5	321.3	316.0	310.8	3,430,592
AS 39	354.5	350.2	345.8	341.5	337.2	332.8	328.5	324.1	319.8	315.5	311.1	306.8	302.4	298.1	293.8	289.4	285.1	280.7	276.4	272.0	267.7	263.4	259.0	30,122,198
ATF 166	289.5	286.3	283.1	279.9	276.7	273.5	270.3	267.1	263.8	260.6	257.4	254.2	251.0	247.8	244.6	241.4	238.2	235.0	231.8	228.6	225.4	222.2	219.0	2,217,181
ATF 4247	207.2	200.3	193.3	186.4	179.4	172.5	165.6	158.6	151.7	144.7	137.8	130.8	123.9	116.9	110.0	103.1	96.1	89.2	82.2	75.3	68.3	61.4	54.4	644,677
EPF 1	1335.2	1330.5	1325.7	1321.0	1316.2	1311.4	1306.7	1301.9	1297.1	1292.4	1287.6	1282.9	1278.1	1273.3	1268.6	1263.8	1259.0	1254.3	1249.5	1244.8	1240.0	1235.2	1230.5	4,320,819
ESB 3	2241.7	2220.8	2200.0	2179.2	2158.3	2137.5	2116.7	2095.8	2075.0	2054.2	2033.3	2012.5	1991.7	1970.8	1950.0	1929.2	1908.3	1887.5	1866.7	1845.8	1825.0	1804.2	1783.3	5,905,255
ESD 1	971.4	962.4	953.3	944.3	935.3	926.3	917.2	908.2	899.2	890.1	881.1	872.1	863.1	854.0	845.0	836.0	826.9	817.9	808.9	799.9	790.8	781.8	772.8	5,465,518
HST 1	581.4	579.2	577.0	574.8	572.6	570.3	568.1	565.9	563.7	561.5	559.3	557.1	554.9	552.7	550.5	548.2	546.0	543.8	541.6	539.4	537.2	535.0	532.8	2,982,927
HST 2	581.4	579.2	577.0	574.8	572.6	570.3	568.1	565.9	563.7	561.5	559.3	557.1	554.9	552.7	550.5	548.2	546.0	543.8	541.6	539.4	537.2	535.0	532.8	270,250
HSV 1	1335.2	1330.5	1325.7	1321.0	1316.2	1311.4	1306.7	1301.9	1297.1	1292.4	1287.6	1282.9	1278.1	1273.3	1268.6	1263.8	1259.0	1254.3	1249.5	1244.8	1240.0	1235.2	1230.5	7,920,294
HSV 4676	1001.4	997.9	994.3	990.7	987.1	983.6	980.0	976.4	972.9	969.3	965.7	962.1	958.6	955.0	951.4	947.9	944.3	940.7	937.1	933.6	930.0	926.4	922.9	6,034,812
LCC 19	681.1	675.2	669.4	663.5	657.7	651.8	645.9	640.1	634.2	628.4	622.5	616.6	610.8	604.9	599.1	593.2	587.3	581.5	575.6	569.8	563.9	558.0	552.2	19,214,932
MB 1219	122.7	120.1	117.5	114.9	112.3	109.7	107.1	104.5	101.9	99.3	96.7	94.1	91.5	88.9	86.3	83.6	81.0	78.4	75.8	73.2	70.6	68.0	65.4	496,190

Table 75. RRF Class Utility Score for 10-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(10 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
ACS 1	40.0	35.1	30.2	25.3	20.4	15.5	10.6	5.7	0.8	-4.1	-9.0	-13.9	-18.8	-23.7	-28.6	-33.5	-38.4	-43.3	-48.2	-53.1	-58.0	-62.9	-67.8	5,334
ACS 4	45.0	39.5	34.0	28.5	22.9	17.4	11.9	6.4	0.9	-4.6	-10.1	-15.7	-21.2	-26.7	-32.2	-37.7	-43.2	-48.8	-54.3	-59.8	-65.3	-70.8	-76.3	6,884
AK 575	60.0	56.3	52.6	49.0	45.3	41.6	37.9	34.3	30.6	26.9	23.2	19.6	15.9	12.2	8.5	4.9	1.2	-2.5	-6.2	-9.9	-13.5	-17.2	-20.9	18,574
AK 882	35.0	30.7	26.4	22.1	17.8	13.6	9.3	5.0	0.7	-3.6	-7.9	-12.2	-16.5	-20.8	-25.0	-29.3	-33.6	-37.9	-42.2	-46.5	-50.8	-55.1	-59.4	17,473
AK 981	0.0	-4.9	-9.9	-14.8	-19.7	-24.7	-29.6	-34.5	-39.5	-44.4	-49.3	-54.3	-59.2	-64.1	-69.1	-74.0	-78.9	-83.9	-88.8	-93.8	-98.7	-103.6	-108.6	20,742
AKR 10	75.0	66.8	58.6	50.3	42.1	33.9	25.7	17.4	9.2	1.0	-7.2	-15.5	-23.7	-31.9	-40.1	-48.4	-56.6	-64.8	-73.0	-81.3	-89.5	-97.7	-105.9	5,222
AKR 1001	75.0	67.6	60.1	52.7	45.2	37.8	30.4	22.9	15.5	8.0	0.6	-6.8	-14.3	-21.7	-29.2	-36.6	-44.0	-51.5	-58.9	-66.4	-73.8	-81.3	-88.7	(99)
AKR 112	70.0	60.3	50.6	40.8	31.1	21.4	11.7	1.9	-7.8	-17.5	-27.2	-36.9	-46.7	-56.4	-66.1	-75.8	-85.6	-95.3	-105.0	-114.7	-124.4	-134.2	-143.9	7,375
AKR 2044	75.0	65.8	56.6	47.4	38.2	29.0	19.9	10.7	1.5	-7.7	-16.9	-26.1	-35.3	-44.5	-53.7	-62.9	-72.1	-81.3	-90.4	-99.6	-108.8	-118.0	-127.2	(3,015)
AKR 287	60.0	55.4	50.7	46.1	41.5	36.9	32.2	27.6	23.0	18.3	13.7	9.1	4.4	-0.2	-4.8	-9.4	-14.1	-18.7	-23.3	-28.0	-32.6	-37.2	-41.9	6,189
AKR 5051	70.0	60.9	51.8	42.7	33.5	24.4	15.3	6.2	-2.9	-12.0	-21.1	-30.3	-39.4	-48.5	-57.6	-66.7	-75.8	-84.9	-94.1	-103.2	-112.3	-121.4	-130.5	4,684
AKR 5066	75.0	65.8	56.6	47.4	38.2	29.0	19.9	10.7	1.5	-7.7	-16.9	-26.1	-35.3	-44.5	-53.7	-62.9	-72.1	-81.3	-90.4	-99.6	-108.8	-118.0	-127.2	3,066
AKR 5069	70.0	60.9	51.8	42.7	33.5	24.4	15.3	6.2	-2.9	-12.0	-21.1	-30.3	-39.4	-48.5	-57.6	-66.7	-75.8	-84.9	-94.1	-103.2	-112.3	-121.4	-130.5	3,668
AKR 5082	70.0	61.4	52.8	44.3	35.7	27.1	18.5	10.0	1.4	-7.2	-15.8	-24.4	-32.9	-41.5	-50.1	-58.7	-67.3	-75.8	-84.4	-93.0	-101.6	-110.1	-118.7	1,595
AKR 9666	70.0	60.3	50.6	40.8	31.1	21.4	11.7	1.9	-7.8	-17.5	-27.2	-36.9	-46.7	-56.4	-66.1	-75.8	-85.6	-95.3	-105.0	-114.7	-124.4	-134.2	-143.9	(2,584)
AKR 9678	75.0	66.3	57.6	49.0	40.3	31.6	22.9	14.2	5.6	-3.1	-11.8	-20.5	-29.2	-37.8	-46.5	-55.2	-63.9	-72.6	-81.3	-89.9	-98.6	-107.3	-116.0	46,867
AKR 9961	70.0	60.9	51.8	42.7	33.5	24.4	15.3	6.2	-2.9	-12.0	-21.1	-30.3	-39.4	-48.5	-57.6	-66.7	-75.8	-84.9	-94.1	-103.2	-112.3	-121.4	-130.5	12,726
AOT 181	0.0	-3.0	-6.0	-8.9	-11.9	-14.9	-17.9	-20.8	-23.8	-26.8	-29.8	-32.7	-35.7	-38.7	-41.7	-44.6	-47.6	-50.6	-53.6	-56.5	-59.5	-62.5	-65.5	5,625
AVB 3	70.0	62.3	54.6	47.0	39.3	31.6	23.9	16.3	8.6	0.9	-6.8	-14.4	-22.1	-29.8	-37.5	-45.1	-52.8	-60.5	-68.2	-75.8	-83.5	-91.2	-98.9	30,438

Table 76. RRF Class Utility Score for 10-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(10 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
ACS 1	-67.8	-72.7	-77.6	-82.5	-87.5	-92.4	-97.3	-102.2	-107.1	-112.0	-116.9	-121.8	-126.7	-131.6	-136.5	-141.4	-146.3	-151.2	-156.1	-161.0	-165.9	-170.8	-175.7	5,334
ACS 4	-76.3	-81.8	-87.4	-92.9	-98.4	-103.9	-109.4	-114.9	-120.4	-126.0	-131.5	-137.0	-142.5	-148.0	-153.5	-159.0	-164.6	-170.1	-175.6	-181.1	-186.6	-192.1	-197.6	6,884
AK 575	-20.9	-24.6	-28.2	-31.9	-35.6	-39.3	-42.9	-46.6	-50.3	-54.0	-57.6	-61.3	-65.0	-68.7	-72.4	-76.0	-79.7	-83.4	-87.1	-90.7	-94.4	-98.1	-101.8	18,574
AK 882	-59.4	-63.7	-67.9	-72.2	-76.5	-80.8	-85.1	-89.4	-93.7	-98.0	-102.3	-106.5	-110.8	-115.1	-119.4	-123.7	-128.0	-132.3	-136.6	-140.9	-145.1	-149.4	-153.7	17,473
AK 981	-108.6	-113.5	-118.4	-123.4	-128.3	-133.2	-138.2	-143.1	-148.0	-153.0	-157.9	-162.8	-167.8	-172.7	-177.6	-182.6	-187.5	-192.4	-197.4	-202.3	-207.2	-212.2	-217.1	20,742
AKR 10	-105.9	-114.1	-122.4	-130.6	-138.8	-147.0	-155.3	-163.5	-171.7	-179.9	-188.2	-196.4	-204.6	-212.8	-221.1	-229.3	-237.5	-245.7	-253.9	-262.2	-270.4	-278.6	-286.8	5,222
AKR 1001	-88.7	-96.1	-103.6	-111.0	-118.5	-125.9	-133.3	-140.8	-148.2	-155.7	-163.1	-170.5	-178.0	-185.4	-192.9	-200.3	-207.7	-215.2	-222.6	-230.1	-237.5	-244.9	-252.4	(99)
AKR 112	-143.9	-153.6	-163.3	-173.1	-182.8	-192.5	-202.2	-211.9	-221.7	-231.4	-241.1	-250.8	-260.6	-270.3	-280.0	-289.7	-299.4	-309.2	-318.9	-328.6	-338.3	-348.1	-357.8	7,375
AKR 2044	-127.2	-136.4	-145.6	-154.8	-164.0	-173.2	-182.4	-191.5	-200.7	-209.9	-219.1	-228.3	-237.5	-246.7	-255.9	-265.1	-274.3	-283.5	-292.6	-301.8	-311.0	-320.2	-329.4	(3,015)
AKR 287	-41.9	-46.5	-51.1	-55.7	-60.4	-65.0	-69.6	-74.3	-78.9	-83.5	-88.1	-92.8	-97.4	-102.0	-106.7	-111.3	-115.9	-120.6	-125.2	-129.8	-134.4	-139.1	-143.7	6,189
AKR 5051	-130.5	-139.6	-148.8	-157.9	-167.0	-176.1	-185.2	-194.3	-203.4	-212.6	-221.7	-230.8	-239.9	-249.0	-258.1	-267.2	-276.4	-285.5	-294.6	-303.7	-312.8	-321.9	-331.0	4,684
AKR 5066	-127.2	-136.4	-145.6	-154.8	-164.0	-173.2	-182.4	-191.5	-200.7	-209.9	-219.1	-228.3	-237.5	-246.7	-255.9	-265.1	-274.3	-283.5	-292.6	-301.8	-311.0	-320.2	-329.4	3,066
AKR 5069	-130.5	-139.6	-148.8	-157.9	-167.0	-176.1	-185.2	-194.3	-203.4	-212.6	-221.7	-230.8	-239.9	-249.0	-258.1	-267.2	-276.4	-285.5	-294.6	-303.7	-312.8	-321.9	-331.0	3,668
AKR 5082	-118.7	-127.3	-135.9	-144.5	-153.0	-161.6	-170.2	-178.8	-187.4	-195.9	-204.5	-213.1	-221.7	-230.2	-238.8	-247.4	-256.0	-264.6	-273.1	-281.7	-290.3	-298.9	-307.5	1,595
AKR 9666	-143.9	-153.6	-163.3	-173.1	-182.8	-192.5	-202.2	-211.9	-221.7	-231.4	-241.1	-250.8	-260.6	-270.3	-280.0	-289.7	-299.4	-309.2	-318.9	-328.6	-338.3	-348.1	-357.8	(2,584)
AKR 9678	-116.0	-124.7	-133.3	-142.0	-150.7	-159.4	-168.1	-176.7	-185.4	-194.1	-202.8	-211.5	-220.1	-228.8	-237.5	-246.2	-254.9	-263.5	-272.2	-280.9	-289.6	-298.3	-306.9	46,867
AKR 9961	-130.5	-139.6	-148.8	-157.9	-167.0	-176.1	-185.2	-194.3	-203.4	-212.6	-221.7	-230.8	-239.9	-249.0	-258.1	-267.2	-276.4	-285.5	-294.6	-303.7	-312.8	-321.9	-331.0	12,726
AOT 181	-65.5	-68.5	-71.4	-74.4	-77.4	-80.4	-83.3	-86.3	-89.3	-92.3	-95.2	-98.2	-101.2	-104.2	-107.1	-110.1	-113.1	-116.1	-119.0	-122.0	-125.0	-128.0	-131.0	5,625
AVB 3	-98.9	-106.5	-114.2	-121.9	-129.6	-137.2	-144.9	-152.6	-160.3	-167.9	-175.6	-183.3	-191.0	-198.6	-206.3	-214.0	-221.7	-229.3	-237.0	-244.7	-252.4	-260.0	-267.7	30,438

Table 77. RRF Class Utility Score for 30-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(30 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
ACS 1	200.0	195.1	190.2	185.3	180.4	175.5	170.6	165.7	160.8	155.9	151.0	146.1	141.2	136.3	131.4	126.5	121.6	116.7	111.8	106.9	102.0	97.1	92.2	16,003
ACS 4	225.0	219.5	214.0	208.5	202.9	197.4	191.9	186.4	180.9	175.4	169.9	164.3	158.8	153.3	147.8	142.3	136.8	131.3	125.7	120.2	114.7	109.2	103.7	20,652
AK 575	180.0	176.3	172.6	169.0	165.3	161.6	157.9	154.3	150.6	146.9	143.2	139.6	135.9	132.2	128.5	124.9	121.2	117.5	113.8	110.1	106.5	102.8	99.1	55,723
AK 882	175.0	170.7	166.4	162.1	157.8	153.6	149.3	145.0	140.7	136.4	132.1	127.8	123.5	119.2	115.0	110.7	106.4	102.1	97.8	93.5	89.2	84.9	80.6	52,420
AK 981	180.0	175.1	170.1	165.2	160.3	155.3	150.4	145.5	140.5	135.6	130.7	125.7	120.8	115.9	110.9	106.0	101.1	96.1	91.2	86.3	81.3	76.4	71.4	62,227
AKR 10	375.0	366.8	358.6	350.3	342.1	333.9	325.7	317.4	309.2	301.0	292.8	284.5	276.3	268.1	259.9	251.6	243.4	235.2	227.0	218.8	210.5	202.3	194.1	15,665
AKR 1001	375.0	367.6	360.1	352.7	345.2	337.8	330.4	322.9	315.5	308.0	300.6	293.2	285.7	278.3	270.8	263.4	256.0	248.5	241.1	233.6	226.2	218.8	211.3	(297)
AKR 112	350.0	340.3	330.6	320.8	311.1	301.4	291.7	281.9	272.2	262.5	252.8	243.1	233.3	223.6	213.9	204.2	194.4	184.7	175.0	165.3	155.6	145.8	136.1	22,125
AKR 2044	375.0	365.8	356.6	347.4	338.2	329.0	319.9	310.7	301.5	292.3	283.1	273.9	264.7	255.5	246.3	237.1	227.9	218.8	209.6	200.4	191.2	182.0	172.8	(9,046)
AKR 287	300.0	295.4	290.7	286.1	281.5	276.9	272.2	267.6	263.0	258.3	253.7	249.1	244.4	239.8	235.2	230.6	225.9	221.3	216.7	212.0	207.4	202.8	198.1	18,566
AKR 5051	350.0	340.9	331.8	322.7	313.5	304.4	295.3	286.2	277.1	268.0	258.9	249.7	240.6	231.5	222.4	213.3	204.2	195.1	185.9	176.8	167.7	158.6	149.5	14,052
AKR 5066	375.0	365.8	356.6	347.4	338.2	329.0	319.9	310.7	301.5	292.3	283.1	273.9	264.7	255.5	246.3	237.1	227.9	218.8	209.6	200.4	191.2	182.0	172.8	9,198
AKR 5069	350.0	340.9	331.8	322.7	313.5	304.4	295.3	286.2	277.1	268.0	258.9	249.7	240.6	231.5	222.4	213.3	204.2	195.1	185.9	176.8	167.7	158.6	149.5	11,003
AKR 5082	350.0	341.4	332.8	324.3	315.7	307.1	298.5	290.0	281.4	272.8	264.2	255.6	247.1	238.5	229.9	221.3	212.7	204.2	195.6	187.0	178.4	169.9	161.3	4,786
AKR 9666	350.0	340.3	330.6	320.8	311.1	301.4	291.7	281.9	272.2	262.5	252.8	243.1	233.3	223.6	213.9	204.2	194.4	184.7	175.0	165.3	155.6	145.8	136.1	(7,751)
AKR 9678	375.0	366.3	357.6	349.0	340.3	331.6	322.9	314.2	305.6	296.9	288.2	279.5	270.8	262.2	253.5	244.8	236.1	227.4	218.8	210.1	201.4	192.7	184.0	140,600
AKR 9961	350.0	340.9	331.8	322.7	313.5	304.4	295.3	286.2	277.1	268.0	258.9	249.7	240.6	231.5	222.4	213.3	204.2	195.1	185.9	176.8	167.7	158.6	149.5	38,177
AOT 181	80.0	77.0	74.0	71.1	68.1	65.1	62.1	59.2	56.2	53.2	50.2	47.3	44.3	41.3	38.3	35.4	32.4	29.4	26.4	23.5	20.5	17.5	14.5	16,876
AVB 3	350.0	342.3	334.6	327.0	319.3	311.6	303.9	296.3	288.6	280.9	273.2	265.6	257.9	250.2	242.5	234.9	227.2	219.5	211.8	204.2	196.5	188.8	181.1	91,313

Table 78. RRF Class Utility Score for 30-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(30 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
ACS 1	92.2	87.3	82.4	77.5	72.5	67.6	62.7	57.8	52.9	48.0	43.1	38.2	33.3	28.4	23.5	18.6	13.7	8.8	3.9	-1.0	-5.9	-10.8	-15.7	16,003
ACS 4	103.7	98.2	92.6	87.1	81.6	76.1	70.6	65.1	59.6	54.0	48.5	43.0	37.5	32.0	26.5	21.0	15.4	9.9	4.4	-1.1	-6.6	-12.1	-17.6	20,652
AK 575	99.1	95.4	91.8	88.1	84.4	80.7	77.1	73.4	69.7	66.0	62.4	58.7	55.0	51.3	47.6	44.0	40.3	36.6	32.9	29.3	25.6	21.9	18.2	55,723
AK 882	80.6	76.3	72.1	67.8	63.5	59.2	54.9	50.6	46.3	42.0	37.7	33.5	29.2	24.9	20.6	16.3	12.0	7.7	3.4	-0.9	-5.1	-9.4	-13.7	52,420
AK 981	71.4	66.5	61.6	56.6	51.7	46.8	41.8	36.9	32.0	27.0	22.1	17.2	12.2	7.3	2.4	-2.6	-7.5	-12.4	-17.4	-22.3	-27.2	-32.2	-37.1	62,227
AKR 10	194.1	185.9	177.6	169.4	161.2	153.0	144.7	136.5	128.3	120.1	111.8	103.6	95.4	87.2	78.9	70.7	62.5	54.3	46.1	37.8	29.6	21.4	13.2	15,665
AKR 1001	211.3	203.9	196.4	189.0	181.5	174.1	166.7	159.2	151.8	144.3	136.9	129.5	122.0	114.6	107.1	99.7	92.3	84.8	77.4	69.9	62.5	55.1	47.6	(297)
AKR 112	136.1	126.4	116.7	106.9	97.2	87.5	77.8	68.1	58.3	48.6	38.9	29.2	19.4	9.7	0.0	-9.7	-19.4	-29.2	-38.9	-48.6	-58.3	-68.1	-77.8	22,125
AKR 2044	172.8	163.6	154.4	145.2	136.0	126.8	117.6	108.5	99.3	90.1	80.9	71.7	62.5	53.3	44.1	34.9	25.7	16.5	7.4	-1.8	-11.0	-20.2	-29.4	(9,046)
AKR 287	198.1	193.5	188.9	184.3	179.6	175.0	170.4	165.7	161.1	156.5	151.9	147.2	142.6	138.0	133.3	128.7	124.1	119.4	114.8	110.2	105.6	100.9	96.3	18,566
AKR 5051	149.5	140.4	131.3	122.1	113.0	103.9	94.8	85.7	76.6	67.4	58.3	49.2	40.1	31.0	21.9	12.8	3.6	-5.5	-14.6	-23.7	-32.8	-41.9	-51.0	14,052
AKR 5066	172.8	163.6	154.4	145.2	136.0	126.8	117.6	108.5	99.3	90.1	80.9	71.7	62.5	53.3	44.1	34.9	25.7	16.5	7.4	-1.8	-11.0	-20.2	-29.4	9,198
AKR 5069	149.5	140.4	131.3	122.1	113.0	103.9	94.8	85.7	76.6	67.4	58.3	49.2	40.1	31.0	21.9	12.8	3.6	-5.5	-14.6	-23.7	-32.8	-41.9	-51.0	11,003
AKR 5082	161.3	152.7	144.1	135.5	127.0	118.4	109.8	101.2	92.6	84.1	75.5	66.9	58.3	49.8	41.2	32.6	24.0	15.4	6.9	-1.7	-10.3	-18.9	-27.5	4,786
AKR 9666	136.1	126.4	116.7	106.9	97.2	87.5	77.8	68.1	58.3	48.6	38.9	29.2	19.4	9.7	0.0	-9.7	-19.4	-29.2	-38.9	-48.6	-58.3	-68.1	-77.8	(7,751)
AKR 9678	184.0	175.3	166.7	158.0	149.3	140.6	131.9	123.3	114.6	105.9	97.2	88.5	79.9	71.2	62.5	53.8	45.1	36.5	27.8	19.1	10.4	1.7	-6.9	140,600
AKR 9961	149.5	140.4	131.3	122.1	113.0	103.9	94.8	85.7	76.6	67.4	58.3	49.2	40.1	31.0	21.9	12.8	3.6	-5.5	-14.6	-23.7	-32.8	-41.9	-51.0	38,177
AOT 181	14.5	11.5	8.6	5.6	2.6	-0.4	-3.3	-6.3	-9.3	-12.3	-15.2	-18.2	-21.2	-24.2	-27.1	-30.1	-33.1	-36.1	-39.0	-42.0	-45.0	-48.0	-51.0	16,876
AVB 3	181.1	173.5	165.8	158.1	150.4	142.8	135.1	127.4	119.7	112.1	104.4	96.7	89.0	81.4	73.7	66.0	58.3	50.7	43.0	35.3	27.6	20.0	12.3	91,313

Table 79. RRF Class Utility Score for 60-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(60 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
ACS 1	440.0	435.1	430.2	425.3	420.4	415.5	410.6	405.7	400.8	395.9	391.0	386.1	381.2	376.3	371.4	366.5	361.6	356.7	351.8	346.9	342.0	337.1	332.2	32,006
ACS 4	495.0	489.5	484.0	478.5	472.9	467.4	461.9	456.4	450.9	445.4	439.9	434.3	428.8	423.3	417.8	412.3	406.8	401.3	395.7	390.2	384.7	379.2	373.7	41,303
AK 575	360.0	356.3	352.6	349.0	345.3	341.6	337.9	334.3	330.6	326.9	323.2	319.6	315.9	312.2	308.5	304.9	301.2	297.5	293.8	290.1	286.5	282.8	279.1	111,446
AK 882	385.0	380.7	376.4	372.1	367.8	363.6	359.3	355.0	350.7	346.4	342.1	337.8	333.5	329.2	325.0	320.7	316.4	312.1	307.8	303.5	299.2	294.9	290.6	104,839
AK 981	450.0	445.1	440.1	435.2	430.3	425.3	420.4	415.5	410.5	405.6	400.7	395.7	390.8	385.9	380.9	376.0	371.1	366.1	361.2	356.3	351.3	346.4	341.4	124,454
AKR 10	825.0	816.8	808.6	800.3	792.1	783.9	775.7	767.4	759.2	751.0	742.8	734.5	726.3	718.1	709.9	701.6	693.4	685.2	677.0	668.8	660.5	652.3	644.1	31,330
AKR 1001	825.0	817.6	810.1	802.7	795.2	787.8	780.4	772.9	765.5	758.0	750.6	743.2	735.7	728.3	720.8	713.4	706.0	698.5	691.1	683.6	676.2	668.8	661.3	(593)
AKR 112	770.0	760.3	750.6	740.8	731.1	721.4	711.7	701.9	692.2	682.5	672.8	663.1	653.3	643.6	633.9	624.2	614.4	604.7	595.0	585.3	575.6	565.8	556.1	44,251
AKR 2044	825.0	815.8	806.6	797.4	788.2	779.0	769.9	760.7	751.5	742.3	733.1	723.9	714.7	705.5	696.3	687.1	677.9	668.8	659.6	650.4	641.2	632.0	622.8	(18,093)
AKR 287	660.0	655.4	650.7	646.1	641.5	636.9	632.2	627.6	623.0	618.3	613.7	609.1	604.4	599.8	595.2	590.6	585.9	581.3	576.7	572.0	567.4	562.8	558.1	37,131
AKR 5051	770.0	760.9	751.8	742.7	733.5	724.4	715.3	706.2	697.1	688.0	678.9	669.7	660.6	651.5	642.4	633.3	624.2	615.1	605.9	596.8	587.7	578.6	569.5	28,104
AKR 5066	825.0	815.8	806.6	797.4	788.2	779.0	769.9	760.7	751.5	742.3	733.1	723.9	714.7	705.5	696.3	687.1	677.9	668.8	659.6	650.4	641.2	632.0	622.8	18,396
AKR 5069	770.0	760.9	751.8	742.7	733.5	724.4	715.3	706.2	697.1	688.0	678.9	669.7	660.6	651.5	642.4	633.3	624.2	615.1	605.9	596.8	587.7	578.6	569.5	22,007
AKR 5082	770.0	761.4	752.8	744.3	735.7	727.1	718.5	710.0	701.4	692.8	684.2	675.6	667.1	658.5	649.9	641.3	632.7	624.2	615.6	607.0	598.4	589.9	581.3	9,572
AKR 9666	770.0	760.3	750.6	740.8	731.1	721.4	711.7	701.9	692.2	682.5	672.8	663.1	653.3	643.6	633.9	624.2	614.4	604.7	595.0	585.3	575.6	565.8	556.1	(15,502)
AKR 9678	825.0	816.3	807.6	799.0	790.3	781.6	772.9	764.2	755.6	746.9	738.2	729.5	720.8	712.2	703.5	694.8	686.1	677.4	668.8	660.1	651.4	642.7	634.0	281,200
AKR 9961	770.0	760.9	751.8	742.7	733.5	724.4	715.3	706.2	697.1	688.0	678.9	669.7	660.6	651.5	642.4	633.3	624.2	615.1	605.9	596.8	587.7	578.6	569.5	76,354
AOT 181	200.0	197.0	194.0	191.1	188.1	185.1	182.1	179.2	176.2	173.2	170.2	167.3	164.3	161.3	158.3	155.4	152.4	149.4	146.4	143.5	140.5	137.5	134.5	33,752
AVB 3	770.0	762.3	754.6	747.0	739.3	731.6	723.9	716.3	708.6	700.9	693.2	685.6	677.9	670.2	662.5	654.9	647.2	639.5	631.8	624.2	616.5	608.8	601.1	182,625

Table 80. RRF Class Utility Score for 60-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(60 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
ACS 1	332.2	327.3	322.4	317.5	312.5	307.6	302.7	297.8	292.9	288.0	283.1	278.2	273.3	268.4	263.5	258.6	253.7	248.8	243.9	239.0	234.1	229.2	224.3	32,006
ACS 4	373.7	368.2	362.6	357.1	351.6	346.1	340.6	335.1	329.6	324.0	318.5	313.0	307.5	302.0	296.5	291.0	285.4	279.9	274.4	268.9	263.4	257.9	252.4	41,303
AK 575	279.1	275.4	271.8	268.1	264.4	260.7	257.1	253.4	249.7	246.0	242.4	238.7	235.0	231.3	227.6	224.0	220.3	216.6	212.9	209.3	205.6	201.9	198.2	111,446
AK 882	290.6	286.3	282.1	277.8	273.5	269.2	264.9	260.6	256.3	252.0	247.7	243.5	239.2	234.9	230.6	226.3	222.0	217.7	213.4	209.1	204.9	200.6	196.3	104,839
AK 981	341.4	336.5	331.6	326.6	321.7	316.8	311.8	306.9	302.0	297.0	292.1	287.2	282.2	277.3	272.4	267.4	262.5	257.6	252.6	247.7	242.8	237.8	232.9	124,454
AKR 10	644.1	635.9	627.6	619.4	611.2	603.0	594.7	586.5	578.3	570.1	561.8	553.6	545.4	537.2	528.9	520.7	512.5	504.3	496.1	487.8	479.6	471.4	463.2	31,330
AKR 1001	661.3	653.9	646.4	639.0	631.5	624.1	616.7	609.2	601.8	594.3	586.9	579.5	572.0	564.6	557.1	549.7	542.3	534.8	527.4	519.9	512.5	505.1	497.6	(593)
AKR 112	556.1	546.4	536.7	526.9	517.2	507.5	497.8	488.1	478.3	468.6	458.9	449.2	439.4	429.7	420.0	410.3	400.6	390.8	381.1	371.4	361.7	351.9	342.2	44,251
AKR 2044	622.8	613.6	604.4	595.2	586.0	576.8	567.6	558.5	549.3	540.1	530.9	521.7	512.5	503.3	494.1	484.9	475.7	466.5	457.4	448.2	439.0	429.8	420.6	(18,093)
AKR 287	558.1	553.5	548.9	544.3	539.6	535.0	530.4	525.7	521.1	516.5	511.9	507.2	502.6	498.0	493.3	488.7	484.1	479.4	474.8	470.2	465.6	460.9	456.3	37,131
AKR 5051	569.5	560.4	551.3	542.1	533.0	523.9	514.8	505.7	496.6	487.4	478.3	469.2	460.1	451.0	441.9	432.8	423.6	414.5	405.4	396.3	387.2	378.1	369.0	28,104
AKR 5066	622.8	613.6	604.4	595.2	586.0	576.8	567.6	558.5	549.3	540.1	530.9	521.7	512.5	503.3	494.1	484.9	475.7	466.5	457.4	448.2	439.0	429.8	420.6	18,396
AKR 5069	569.5	560.4	551.3	542.1	533.0	523.9	514.8	505.7	496.6	487.4	478.3	469.2	460.1	451.0	441.9	432.8	423.6	414.5	405.4	396.3	387.2	378.1	369.0	22,007
AKR 5082	581.3	572.7	564.1	555.5	547.0	538.4	529.8	521.2	512.6	504.1	495.5	486.9	478.3	469.8	461.2	452.6	444.0	435.4	426.9	418.3	409.7	401.1	392.5	9,572
AKR 9666	556.1	546.4	536.7	526.9	517.2	507.5	497.8	488.1	478.3	468.6	458.9	449.2	439.4	429.7	420.0	410.3	400.6	390.8	381.1	371.4	361.7	351.9	342.2	(15,502)
AKR 9678	634.0	625.3	616.7	608.0	599.3	590.6	581.9	573.3	564.6	555.9	547.2	538.5	529.9	521.2	512.5	503.8	495.1	486.5	477.8	469.1	460.4	451.7	443.1	281,200
AKR 9961	569.5	560.4	551.3	542.1	533.0	523.9	514.8	505.7	496.6	487.4	478.3	469.2	460.1	451.0	441.9	432.8	423.6	414.5	405.4	396.3	387.2	378.1	369.0	76,354
AOT 181	134.5	131.5	128.6	125.6	122.6	119.6	116.7	113.7	110.7	107.7	104.8	101.8	98.8	95.8	92.9	89.9	86.9	83.9	81.0	78.0	75.0	72.0	69.0	33,752
AVB 3	601.1	593.5	585.8	578.1	570.4	562.8	555.1	547.4	539.7	532.1	524.4	516.7	509.0	501.4	493.7	486.0	478.3	470.7	463.0	455.3	447.6	440.0	432.3	182,625

Table 81. RRF Class Utility Score for 90-Day HADR Response (0 to 5,500 nm)

Utility Score	Distance (nm)																							Response Cost
(90 Days)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	CY2017 USD
ACS 1	680.0	675.1	670.2	665.3	660.4	655.5	650.6	645.7	640.8	635.9	631.0	626.1	621.2	616.3	611.4	606.5	601.6	596.7	591.8	586.9	582.0	577.1	572.2	48,009
ACS 4	765.0	759.5	754.0	748.5	742.9	737.4	731.9	726.4	720.9	715.4	709.9	704.3	698.8	693.3	687.8	682.3	676.8	671.3	665.7	660.2	654.7	649.2	643.7	61,955
AK 575	540.0	536.3	532.6	529.0	525.3	521.6	517.9	514.3	510.6	506.9	503.2	499.6	495.9	492.2	488.5	484.9	481.2	477.5	473.8	470.1	466.5	462.8	459.1	167,169
AK 882	595.0	590.7	586.4	582.1	577.8	573.6	569.3	565.0	560.7	556.4	552.1	547.8	543.5	539.2	535.0	530.7	526.4	522.1	517.8	513.5	509.2	504.9	500.6	157,259
AK 981	720.0	715.1	710.1	705.2	700.3	695.3	690.4	685.5	680.5	675.6	670.7	665.7	660.8	655.9	650.9	646.0	641.1	636.1	631.2	626.3	621.3	616.4	611.4	186,682
AKR 10	1275.0	1266.8	1258.6	1250.3	1242.1	1233.9	1225.7	1217.4	1209.2	1201.0	1192.8	1184.5	1176.3	1168.1	1159.9	1151.6	1143.4	1135.2	1127.0	1118.8	1110.5	1102.3	1094.1	46,996
AKR 1001	1275.0	1267.6	1260.1	1252.7	1245.2	1237.8	1230.4	1222.9	1215.5	1208.0	1200.6	1193.2	1185.7	1178.3	1170.8	1163.4	1156.0	1148.5	1141.1	1133.6	1126.2	1118.8	1111.3	(890)
AKR 112	1190.0	1180.3	1170.6	1160.8	1151.1	1141.4	1131.7	1121.9	1112.2	1102.5	1092.8	1083.1	1073.3	1063.6	1053.9	1044.2	1034.4	1024.7	1015.0	1005.3	995.6	985.8	976.1	66,376
AKR 2044	1275.0	1265.8	1256.6	1247.4	1238.2	1229.0	1219.9	1210.7	1201.5	1192.3	1183.1	1173.9	1164.7	1155.5	1146.3	1137.1	1127.9	1118.8	1109.6	1100.4	1091.2	1082.0	1072.8	(27,139)
AKR 287	1020.0	1015.4	1010.7	1006.1	1001.5	996.9	992.2	987.6	983.0	978.3	973.7	969.1	964.4	959.8	955.2	950.6	945.9	941.3	936.7	932.0	927.4	922.8	918.1	55,697
AKR 5051	1190.0	1180.9	1171.8	1162.7	1153.5	1144.4	1135.3	1126.2	1117.1	1108.0	1098.9	1089.7	1080.6	1071.5	1062.4	1053.3	1044.2	1035.1	1025.9	1016.8	1007.7	998.6	989.5	42,155
AKR 5066	1275.0	1265.8	1256.6	1247.4	1238.2	1229.0	1219.9	1210.7	1201.5	1192.3	1183.1	1173.9	1164.7	1155.5	1146.3	1137.1	1127.9	1118.8	1109.6	1100.4	1091.2	1082.0	1072.8	27,593
AKR 5069	1190.0	1180.9	1171.8	1162.7	1153.5	1144.4	1135.3	1126.2	1117.1	1108.0	1098.9	1089.7	1080.6	1071.5	1062.4	1053.3	1044.2	1035.1	1025.9	1016.8	1007.7	998.6	989.5	33,010
AKR 5082	1190.0	1181.4	1172.8	1164.3	1155.7	1147.1	1138.5	1130.0	1121.4	1112.8	1104.2	1095.6	1087.1	1078.5	1069.9	1061.3	1052.7	1044.2	1035.6	1027.0	1018.4	1009.9	1001.3	14,358
AKR 9666	1190.0	1180.3	1170.6	1160.8	1151.1	1141.4	1131.7	1121.9	1112.2	1102.5	1092.8	1083.1	1073.3	1063.6	1053.9	1044.2	1034.4	1024.7	1015.0	1005.3	995.6	985.8	976.1	(23,253)
AKR 9678	1275.0	1266.3	1257.6	1249.0	1240.3	1231.6	1222.9	1214.2	1205.6	1196.9	1188.2	1179.5	1170.8	1162.2	1153.5	1144.8	1136.1	1127.4	1118.8	1110.1	1101.4	1092.7	1084.0	421,800
AKR 9961	1190.0	1180.9	1171.8	1162.7	1153.5	1144.4	1135.3	1126.2	1117.1	1108.0	1098.9	1089.7	1080.6	1071.5	1062.4	1053.3	1044.2	1035.1	1025.9	1016.8	1007.7	998.6	989.5	114,531
AOT 181	320.0	317.0	314.0	311.1	308.1	305.1	302.1	299.2	296.2	293.2	290.2	287.3	284.3	281.3	278.3	275.4	272.4	269.4	266.4	263.5	260.5	257.5	254.5	50,627
AVB 3	1190.0	1182.3	1174.6	1167.0	1159.3	1151.6	1143.9	1136.3	1128.6	1120.9	1113.2	1105.6	1097.9	1090.2	1082.5	1074.9	1067.2	1059.5	1051.8	1044.2	1036.5	1028.8	1021.1	273,938

Table 82. RRF Class Utility Score for 90-Day HADR Response (5,500 to 11,000 nm)

Utility Score	Distance (nm)																							Response Cost
(90 Days)	5500	5750	6000	6250	6500	6750	7000	7250	7500	7750	8000	8250	8500	8750	9000	9250	9500	9750	10000	10250	10500	10750	11000	CY2017 USD
ACS 1	572.2	567.3	562.4	557.5	552.5	547.6	542.7	537.8	532.9	528.0	523.1	518.2	513.3	508.4	503.5	498.6	493.7	488.8	483.9	479.0	474.1	469.2	464.3	48,009
ACS 4	643.7	638.2	632.6	627.1	621.6	616.1	610.6	605.1	599.6	594.0	588.5	583.0	577.5	572.0	566.5	561.0	555.4	549.9	544.4	538.9	533.4	527.9	522.4	61,955
AK 575	459.1	455.4	451.8	448.1	444.4	440.7	437.1	433.4	429.7	426.0	422.4	418.7	415.0	411.3	407.6	404.0	400.3	396.6	392.9	389.3	385.6	381.9	378.2	167,169
AK 882	500.6	496.3	492.1	487.8	483.5	479.2	474.9	470.6	466.3	462.0	457.7	453.5	449.2	444.9	440.6	436.3	432.0	427.7	423.4	419.1	414.9	410.6	406.3	157,259
AK 981	611.4	606.5	601.6	596.6	591.7	586.8	581.8	576.9	572.0	567.0	562.1	557.2	552.2	547.3	542.4	537.4	532.5	527.6	522.6	517.7	512.8	507.8	502.9	186,682
AKR 10	1094.1	1085.9	1077.6	1069.4	1061.2	1053.0	1044.7	1036.5	1028.3	1020.1	1011.8	1003.6	995.4	987.2	978.9	970.7	962.5	954.3	946.1	937.8	929.6	921.4	913.2	46,996
AKR 1001	1111.3	1103.9	1096.4	1089.0	1081.5	1074.1	1066.7	1059.2	1051.8	1044.3	1036.9	1029.5	1022.0	1014.6	1007.1	999.7	992.3	984.8	977.4	969.9	962.5	955.1	947.6	(890)
AKR 112	976.1	966.4	956.7	946.9	937.2	927.5	917.8	908.1	898.3	888.6	878.9	869.2	859.4	849.7	840.0	830.3	820.6	810.8	801.1	791.4	781.7	771.9	762.2	66,376
AKR 2044	1072.8	1063.6	1054.4	1045.2	1036.0	1026.8	1017.6	1008.5	999.3	990.1	980.9	971.7	962.5	953.3	944.1	934.9	925.7	916.5	907.4	898.2	889.0	879.8	870.6	(27,139)
AKR 287	918.1	913.5	908.9	904.3	899.6	895.0	890.4	885.7	881.1	876.5	871.9	867.2	862.6	858.0	853.3	848.7	844.1	839.4	834.8	830.2	825.6	820.9	816.3	55,697
AKR 5051	989.5	980.4	971.3	962.1	953.0	943.9	934.8	925.7	916.6	907.4	898.3	889.2	880.1	871.0	861.9	852.8	843.6	834.5	825.4	816.3	807.2	798.1	789.0	42,155
AKR 5066	1072.8	1063.6	1054.4	1045.2	1036.0	1026.8	1017.6	1008.5	999.3	990.1	980.9	971.7	962.5	953.3	944.1	934.9	925.7	916.5	907.4	898.2	889.0	879.8	870.6	27,593
AKR 5069	989.5	980.4	971.3	962.1	953.0	943.9	934.8	925.7	916.6	907.4	898.3	889.2	880.1	871.0	861.9	852.8	843.6	834.5	825.4	816.3	807.2	798.1	789.0	33,010
AKR 5082	1001.3	992.7	984.1	975.5	967.0	958.4	949.8	941.2	932.6	924.1	915.5	906.9	898.3	889.8	881.2	872.6	864.0	855.4	846.9	838.3	829.7	821.1	812.5	14,358
AKR 9666	976.1	966.4	956.7	946.9	937.2	927.5	917.8	908.1	898.3	888.6	878.9	869.2	859.4	849.7	840.0	830.3	820.6	810.8	801.1	791.4	781.7	771.9	762.2	(23,253)
AKR 9678	1084.0	1075.3	1066.7	1058.0	1049.3	1040.6	1031.9	1023.3	1014.6	1005.9	997.2	988.5	979.9	971.2	962.5	953.8	945.1	936.5	927.8	919.1	910.4	901.7	893.1	421,800
AKR 9961	989.5	980.4	971.3	962.1	953.0	943.9	934.8	925.7	916.6	907.4	898.3	889.2	880.1	871.0	861.9	852.8	843.6	834.5	825.4	816.3	807.2	798.1	789.0	114,531
AOT 181	254.5	251.5	248.6	245.6	242.6	239.6	236.7	233.7	230.7	227.7	224.8	221.8	218.8	215.8	212.9	209.9	206.9	203.9	201.0	198.0	195.0	192.0	189.0	50,627
AVB 3	1021.1	1013.5	1005.8	998.1	990.4	982.8	975.1	967.4	959.7	952.1	944.4	936.7	929.0	921.4	913.7	906.0	898.3	890.7	883.0	875.3	867.6	860.0	852.3	273,938

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