A Framework for Global Natural Disasters Response: The Example of the United States Navy

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Contents

A Framework for Global Natural Disasters Response: The Example of the United States Navy

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ABSTRACT

Climate change is affecting the entire earth and due to increases in temperatures and greenhouse gases, we are starting to observe events that would not have existed several decades ago. The United Nations (UN) projects that the number of natural disasters will reach 560 a year by 2030. The UN report also says that "the scale and intensity of disasters are increasing, with more people killed or affected, in the last five years, than in the previous five." The result of this is that those least able to protect themselves or to move out of the path of danger – particularly in developing countries – will be most at risk and will suffer disproportionately. All this leads to our motivation for a framework that will help these nations respond more effectively to natural disasters. The United States Navy (USN) is one organization capable of providing Humanitarian Assistance and Disaster Relief (HADR) on a global scale and its effectiveness has been illustrated in some of the largest natural disasters in

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the last twenty years. However, in the future, the demand for disaster response will likely outgrow the ability of the USN to respond effectively everywhere there is need. Therefore, it is useful for nations to learn about what has made the USN effective in responding to past disasters as well as what gaps remain in disaster response need.

This monograph introduces frameworks for humanitarian operations to respond to natural disasters worldwide in ways that are effective and efficient. We will illustrate the frameworks using the case of the United States Navy (USN). We will suggest ways in which Non-Government Organizations (NGO) can apply the lessons learned from previous disaster responses that consider capabilities, cost, and proximity of resources to the disaster location. However, we will point out that dependance on the USN for HADR may not be the best solution for countries in the Asia Pacific region. Given that the USN is moving towards retiring large deck ships and moving onto Next Generation Logistics Ships (NGLS), especially for the logistics support in contested environments, the humanitarian aid may not be easily available in the future. With this perspective in mind, we make some recommendations for what Southeast Asian countries can do to become self-sufficient in the domain of disaster response. We also propose addressing disaster response as a design problem and identifying the fundamental components for developing a design to more effectively confront disaster response challenges in the future.

1

Introduction

In this monograph we introduce cases and frameworks that address global humanitarian logistics and disaster response conducted by the United States Navy (USN). The purpose of introducing these cases and frameworks is to identify those capabilities that enable efficient and effective responses to a humanitarian crisis or disaster. We do not consider each case illustrative of a perfect disaster response but instead we identify operational improvements that are readily implementable for the USN and that could be replicated by other nations either through their military or non-military institutions. We will also argue that dependance on the USN for humanitarian assistance and disaster response may not be the best or the most sustainable solution for countries in the Asia Pacific region. The main reason for our argument is that the USN is planning on the retirement of many large deck ships which are so useful in supporting disaster response and replacing them with Next Generation Logistics Ships (NGLS) to support combat operations in contested environments. The People's Liberation Army Navy (PLAN) believes that logistical support in the contested area of the South China Sea is the "Achilles heel" for the USN and has developed plans and concepts that make sustainment of operations difficult during a conflict.

Given increasing tensions and shifting priorities by the USN, immediate provision of humanitarian aid to other nations may not be readily available in the future due to both priorities and equipment capabilities. With this perspective in mind, we make some recommendations for what countries in the Asia Pacific region can do to become more self-sufficient in the domain of disaster response operations.

Our approach to this study will follow four steps. First, we provide a motivation for the attention given to humanitarian assistance and disaster response by addressing climate change and the impact of natural disasters in the Asia Pacific region, which is the most heavily populated region on earth. Second, we identify metrics for determining operational readiness to respond to a disaster event with a framework introduced by Apte *et al.* (2020). Third, we identify capabilities and competencies that have proven most effective among all those available to the USN during a disaster response and draw upon several cases to illustrate the points empirically (Apte *et al.*, 2013, 2020; Apte and Yoho, 2017, 2018). Though the USN is arguably one of the most technologically and organizationally capable organizations in the world to respond to a disaster, not all of its responses to disasters have been perfect from a technical or sociotechnical perspective. However, identifying those specific capabilities and competencies that have proven most useful is a good starting point for making recommendations to other nations and NGOs with regard to where they can allocate their resources most efficiently to build an effective disaster response capability. Finally, we introduce a design perspective for considering the future of disaster response and focus on four design elements for building an effective disaster response: technology, organization, information, and policy.

Appendices

Appendix A

- **Amphibious Assault Ship:** The amphibious assault ship resembles a small aircraft carrier and is capable of launching and recovering vertical and short take-off and landing as well as rotary wing aircraft. These ships contain a well deck to support use of air cushioned landing craft (LCACs) as well as other watercraft. The primary attribute that an amphibious assault ship brings to the humanitarian assistance and disaster response mission is its ability to conduct and support vertical lift (helicopter) operations from the littoral for long periods of time (Figure A.1). The ship is also useful for conveying personnel and supplies from the sea to land and vice versa.
- **PM-2:** Special Mission Program ships provide operating platforms and services for a wide variety of U.S. military and other U.S. Government missions. Most special mission ships are Government-owned and operated by civilian mariners who work for private companies under contract to Military Sealift Command (MSC). Maritime support vessels – or MSVs – are a type of special mission program ship (Figure A.2).
- **PM-3:** Military Sealift Command's prepositioning ships are able to discharge cargo pier-side or while anchored offshore by using

shallow-draft barges. These ships support the movement of cargo to be ferried to ports on shore (Figure A.3).

- **Ready Reserve Force:** The Ready Reserve Force (RRF) provide prompt sealift support in the event they are needed for the rapid deployment of military forces. The RRF includes roll-on/roll-off (RO/RO) cargo ships, breakbulk ships, barge carriers, Auxiliary Crane Ships (ACSs), tankers, and two troop ships for surge sealift requirement which are capable of handling bulky, oversized military equipment (Figure A.4).
- **Nuclear carriers:** An aircraft carrier is a warship with a full-length flight deck and facilities for carrying, arming, deploying, and recovering aircraft, that serves as a seagoing airbase. A nuclear carrier is powered by nuclear power (Figure A.5).
- **CRUDES:** Navy cruisers and destroyers (CRUDES) protect carriers, cargo ships, oil tankers, and any other vessel that is part of its mission. These ships are multi-mission air, undersea, and surface warfare combatants that may also have ballistic missile defense capability. Further, these vessels may operate as part of a group or independently (Figure A.6 and A.7).
- **LCS**: Littoral combat ships are small surface vessels designed for near-shore operations (Figure A.8).

Figure A.1: The amphibious assault ship USS *America*.

Figure A.2: The maritime support vessel MV *C-Champion* (*Source*: Clark *et al.*, 2010).

Figure A.3: USNS *Gordon*.

Figure A.4: SS *Cape Medoncino.*

Figure A.5: USS *Theodore Roosevelt.*

Figure A.6: U.S. navy destroyer USS *Stockdale.*

Figure A.7: U.S. navy cruiser USS *Bunker Hill*.

Figure A.8: USS *Freedom*.

Appendix B: The Model

We use the following notation:

I = set of resources (ships), for $i \in I$; J = set of capabilities, for $j \in J$

D_j = demand for capability; $\{\eta_{ij}\}_{IxJ}$ = capability of ship;

c_{ij} = cost of functional capability $j \in J$ of ship $i \in I$

$$\eta_{ij} = \begin{cases} 2 & \text{if } i \text{ is capable for } j \\ 1 & \text{if } i \text{ is somewhat capable for } j \\ 0 & \text{if } i \text{ is not capable for } j \end{cases}$$

The Optimization Model

$$\text{minimize} \quad \sum_{i \in I} \sum_{j \in J} c_{ij} Y_i \tag{B.1}$$

$$\text{subject to} \quad \sum_{i \in I} \eta_{ij} Y_i \geq D_j \quad \forall j \in J \tag{B.2}$$

$$Y_i \text{ integer} \quad \forall i \in I \tag{B.3}$$

- Objective function (B.1) minimizes the cost of a ship i across all the capabilities summed over all ships, thus yielding the total cost
- Constraints (B.2) ensure that demand for capability is met by the flotilla of the ships that are deployed and/or diverted to the Affected Host Country

- Constraints (B.3) guarantee that fractional ships are not deployed or diverted
- The accessible data only gave the functional cost for all the ships together, the cost of functional capability of ship had to be assumed to be the same across the ships
- Single perspective—namely, which ships will be used if all costs were the same by focusing on capabilities alone as opposed to the cost of the capabilities
- Not all ships cost the same when deployed or diverted. The costs depend on many factors such as the ships' size, whether they are built to commercial standards, and whether they travel with support or sail alone.

Appendix C

Calculate ship proximity as

$$T\_(i, d) = ((d\_i/s\_i))/(24 \text{ hours}) \tag{C.1}$$

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

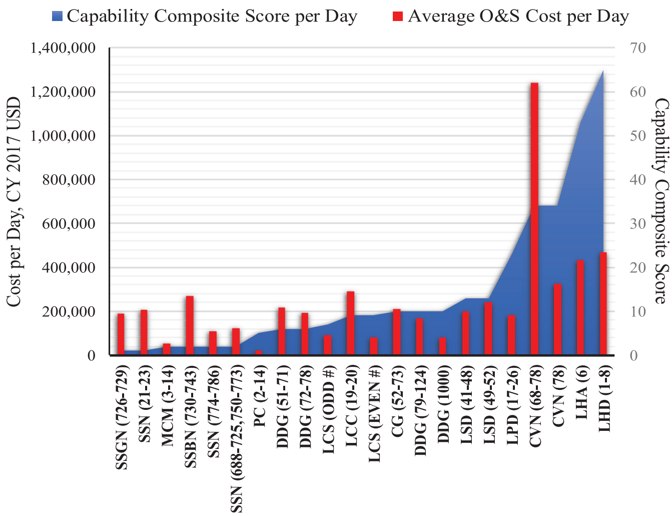

Figure C.1: USN capability vs. average O&S cost per day, by FY 2017 class (hull numbers).

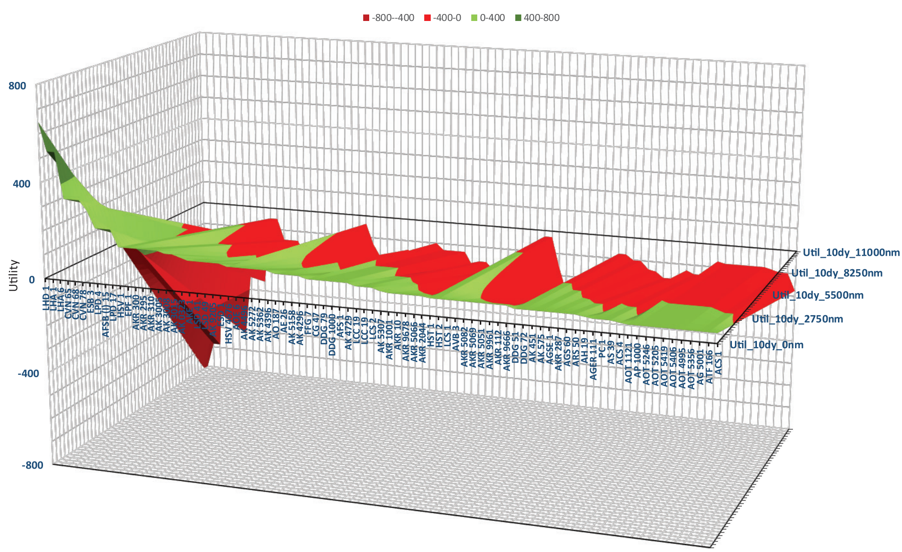

Figure C.2: Utility of 10-day HADR response by class.

Table C.1: 2010 Haiti earthquake HADR response ship utility and cost

Type	Ship Class	Hull Number	Days Transit	Days On Station	Total Days	HADR Utility Provided	HADR Response Cost (CY2017 USD)
CG	CG 47	CG 60	1	22	23	220	4,296,613
CG	CG 47	CG 52	1	20	21	200	3,392,109
DDG	DDG 72	DDG 76	6	15	21	90	3,442,237
FFG	FFG 7	FFG 36	0	35	35	350	3,096,840
LHA	LHA 1	LHA 4	5	61	66	**3233**	25,681,862
LHD	LHD 1	LHD 5	2	12	14	780	6,098,680
LHD	LHD 1	LHD 3	14	14	28	910	13,751,710
LPD	LPD 17	LPD 19	11	4	15	92	2,287,987
LSD	LSD 41	LSD 44	0	11	**11**	143	1,803,997
LSD	LSD 41	LSD 48	2	17	19	221	3,806,629
LSD	LSD 41	LSD 43	5	17	22	221	11,202,770
LSD	LSD 49	LSD 50	5	17	22	221	3,815,142
T-AGS	AGS 60	T-AGS 63	7	49	56	294	2,413,972
T-AH	AH 19	T-AH 20	4	51	55	561	5,492,085
T-AK	AK 3008	T-AK 3009	1	38	39	570	2,927,142
T-AK	AK 3008	T-AK 3011	5	18	23	270	2,569,926
T-AKE	AKE 1	T-AKE 1	4	44	48	572	7,553,157
T-AKE	AKE 1	T-AKE 2	0	15	15	195	2,417,308
T-AO	AO 187	T-AO 198	4	27	31	297	3,698,783
T-AO	AO 187	T-AO 195	6	18	24	198	2,628,176
T-ARS	ARS 50	T-ARS 51	3	9	12	**54**	584,808
T-ACS	ACS 4	T-ACS 4	10	42	52	378	247,652
T-ACS	ACS 4	T-ACS 6	3	42	45	378	358,824
T-AKR	AK 882	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).

Table C.2: 2011 Tohoku earthquake HADR response ship utility and cost

Type	Ship Class	Hull Number	Days Tran	Days On S	Total Days	HADR Util	ist (CY2017 USD)
CG	CG 47	CG 62	1	22	23	220	4,546,665
CG	CG 47	CG 63	2	21	23	210	4,845,260
CG	CG 47	CG 67	2	21	23	210	5,255,677
CVN	CVN 68	CVN 76	1	22	23	748	23,581,838
DDG	DDG 51	DDG 56	1	22	23	132	3,592,239
DDG	DDG 51	DDG 62	1	22	23	132	4,388,412
DDG	DDG 79	DDG 88	1	22	23	220	5,430,944
DDG	DDG 51	DDG 54	1	23	24	138	3,636,537
DDG	DDG 79	DDG 85	0	24	24	240	4,715,649
DDG	DDG 79	DDG 89	2	21	23	210	3,764,518
LCC	LCC 19	LCC 19	7	22	29	198	8,377,612
LHD	LHD 1	LHD 2	6	22	28	**1430**	12,110,066
LSD	LSD 41	LSD 42	6	22	28	286	3,819,775
LSD	LSD 41	LSD 46	3	25	28	325	4,336,003
LSD	LSD 49	LSD 49	6	22	28	286	12,950,246
HSV	HSV 4676	HSV 4676	1	7	8	84	423,189
T-AKE	AKE 1	T-AKE 7	1	14	15	182	2,020,978
T-AKE	AKE 1	T-AKE 4	0	**6**	6	**78**	781,763
T-AKE	AKE 1	T-AKE 9	3	20	23	260	2,645,257
T-AO	AO 187	T-AO 197	0	17	17	187	1,449,992
T-AO	AO 187	T-AO 204	0	23	23	253	2,255,366
T-AOE	AOE 6	T-AOE 10	1	22	23	264	4,046,646
T-ARS	ARS 50	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).

Appendix D

Optimization Model

For post analysis we developed the optimization model VL to minimize the cost of vertical lift operations while meeting the demand.

Indices and Index Set

I = *Aircraft*, $i \in I$, {i = *Type of Aircraft; 1: CH-53E; 2: MH-60S; 3: MH-60R; 4: V-22 short range; 5: V-22 long range 6: UH-1*}

Input Data

Ci = *cost of sortie($US)/sortie for aircraft type* i

Vi = *number of aircraft that are available for aircraft type* i

Ti = *sorties that are available for aircraft type* i

σi = *Search and rescue (SAR) capability score for aircraft type* i

λi = *maximum usable free lift capacity (lbs) for aircraft type* i

μi = *aircraft limit capacity (lbs) for aircraft type* i

φi = *maximum aircraft fuel capacity (lbs) for aircraft type* i

τi = *cost ($US)/flight hour for aircraft type* i

πi = *hours per sortie (hours/sortie) for aircraft type* i

χi = *maximum sorties per day (sorties/day) for aircraft type* i

ρi = *Range capability score for aircraft type* i

D = *Total capacity demand, in lbs.*

Calculated Parameter Data

$$\lambda_i = \mu_i - \varphi_i$$
$$C_i = (\tau_i)(\pi_i)$$
$$T_i = (V_i)(\chi_i)$$

Decision Variables

Xi = Number of aircraft sorties for aircraft type i

Objective *(minimize): Total cost of vertical lift sortie operations*

$$z = \sum_{i \in I} C_i X_i$$

Constraints

$$\sum_{i \in I} \lambda_i X_i \geq D \tag{D.1}$$

$$\sum_{i \in I} \sigma_i X_i \leq 0 \tag{D.2}$$

$$\sum_{i \in I} \rho_i X_i \leq 0 \tag{D.3}$$

$$X_i \leq T_i, \quad i \in I \tag{D.4}$$

$$X_i \geq 0 \tag{D.5}$$

Constraint (D.1) represents the demand in terms of capacity of the aircraft to be satisfied. Constraint (D.2) account for the Search and Rescue (SAR) capability requirements. We require that at least 25% of the aircraft be SAR-capable. MH60R, MH60S and UH1 are the only assets that are SAR capable. Constraints (D.2) are therefore derived based on the capability σi, SAR capability score. Based on the subject matter expert's recommendation we require that at least 10% of the optimal mix possess long range capabilities. Constraint (D.3) accounts for the proportionality of range capability score, ρi for each aircraft. Constraint (D.4) limits the total number of available aircraft sorties to Ti, based on available aircraft within United States Pacific Fleet (USPACFLT), Vi, and χi. The group that has the aircrafts available for humanitarian aid within the fleet is the ESG. Hence, we looked at the aircrafts available based on the current configuration of ESG.

Table D.1: Minimum daily average cost-survival

	S	C	U	V(S)	R	V(L)			
	H60S	CH53	UH-1	V-22	H-60S	V-22	Sum Products		
Number of Sorties	**1**	**0**	**70**	**0**	**0**	**8**			
Number of Sorties/Day	3.16	2.9	3.2	4.94	3.01	2.06			
Number of Aircraft	1	0	22	0	0	4		27	
Daily Cost (Cost/Flight Hr)	$ 417.55	$ 1,335.56	$ 368.20	$ 1,391.02	$ 432.90	$ 1,391.02			
Hours/Sortie	1.49	1.58	1.47	1.02	1.54	1.98			
Daily Cost (Cost/Sortie)	$ 622.15	$ 2,110.18	$ 541.25	$ 1,418.84	$ 666.67	$ 2,754.22	$60,543.69	MIN	
Constraints:									
Total Daily Capacity	3100	8357	2861.6	6150	1500	6150	252,612.0	>=	250,000.00
SAR Capability	0.75	-0.25	0.75	-0.25	0.75	-0.25	51.3	>=	0.00
10% Long Range (>120NM)	-0.1	-0.1	-0.1	-0.1	-0.1	0.9	0.1	>=	0.00
Max MH60S	1						1.0	<=	237.00
Max CH53E		1					0.0	<=	174.00
Max UH-1			1				70.0	<=	192.00
Max MV-22				1		1	8.0	<=	553.28
Max MH-60R					1		0.0	<=	252.84
	$ 0.20	$ 0.25	$ 0.19	$ 0.23	$ 0.44	$ 0.45			

Constraint (D.5) requires the optimization model to produce a non-negative solution. In VL, we minimize cost of the vertical lift operations in response to the sudden on-set disaster.

Appendix E

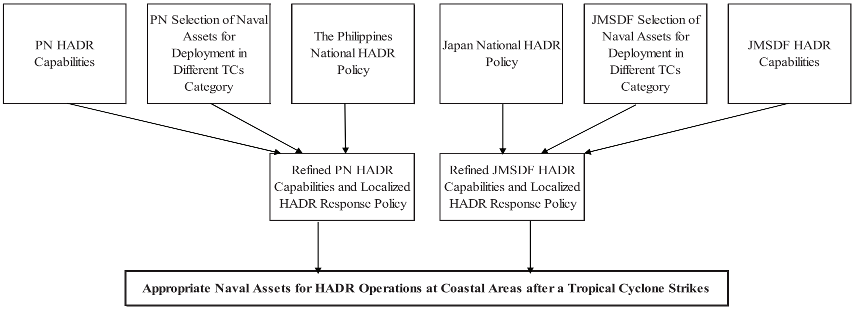

Figure E.1: Framework for the determination of naval assets for HADR operations. Adapted from Greenfield and Ingram (2011); Apte *et al.* (2013); Gastrock and Iturriaga (2013); Moffat (2014); Gangcuangco *et al.* (2020). This figure shows the thinking process of decision making in disaster relief, and also shows the framework of analysis in this research.

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