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**ANALYSIS OF DEPARTMENT OF DEFENSE (DOD)
SUPPORT IN DOMESTIC DISASTER RELIEF**

June 2018

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DISASTER RELIEF**

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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	accumulated cycle energy
CDT	Central Daylight Time
DHHS	Department of Health and Human Services
DHS	Department of Homeland Security
DoC	Department of Commerce
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoI	Department of Interior
DoT	Department of Transportation
DSC	dual-status commander
DSCA	Defense Support of Civil Authorities
EMAC	emergency management assistance compact
EPA	Environmental Protection Agency
ESF	emergency support function
FCO	federal coordinating officer
FEMA	Federal Emergency Management Agency
GAO	Government Accountability Office
GCC	Geographical Combatant Commander
HSPD	Homeland Security Presidential Directive
ISR	intelligence, surveillance, and reconnaissance
LFA	lead federal agency
MA	mission assignments
MHE	material handling equipment
NHC	National Hurricane Center
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NORTHCOM	U.S. Northern Command
NRCC	National Response Coordination Center
NRF	National Response Framework

MAA	Mutual Aid Agreements
MOU	Memorandum of Understanding
MPH	miles per hour
NGO	non-governmental
NRP	National Response Plan
PCA	Posse Comitatus Act
SecDef	Secretary of Defense
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USDJ	United States Department of Justice

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I. INTRODUCTION

A. OVERVIEW AND PURPOSE

The 2017 hurricane season presented local, state, and federal agencies with challenges never seen during past hurricane seasons. Hurricanes Harvey, Irma, and Maria required interagency coordination to save lives, reduce damage to property, and begin the recovery process within the affected communities. In most cases, local and state authorities are capable of handling disasters, but when state resources are limited or no longer available, the Department of Defense (DoD) provides critical capabilities in search and rescue, engineering, transportation, aviation, communications, and medical support. Along with the previously identified capabilities, the DoD brings unique and versatile leadership experiences in the most demanding and stressful situations. While performing Defense Support of Civil Authority (DSCA) operations they support the Department of Homeland Security (DHS)

Since 2008, there were 63 major disaster declarations due to direct impact from hurricanes, tropical storms, or flooding resulting from a hurricane. The disaster declaration affected 28 states, tribal, or territories with nineteen percent directly affecting Texas, Florida, and Puerto Rico (Disasters, 2018). Natural disasters such as Hurricanes Katrina (2005) and Sandy (2012) have identified challenges with response integration and the effective use of DoD personnel. Since the 9/11 terrorist attacks, regulations have favored the use of military assets in homeland security and domestic disaster relief. Hurricane Katrina affected more than half-million people and motivated Congress to pass the Post-Katrina Emergency Management Reform Act of 2006, which streamlined processes within DHS and lean forward in providing response and recovery efforts when reacting to a natural and man-made crisis and emergency planning (DSCA a vital resource, 2015). Lessons learned from Hurricanes Katrina and Sandy have developed DoD's role in the national response system stronger than any other time in our nation's history.

The purpose of this project is to analyze mission assignments (MA) from Federal Emergency Management Agency (FEMA) to supporting agencies and the capabilities

requisitioned for Hurricanes Harvey, Irma, and Maria from the DoD to Texas, Florida and Puerto Rico with respect to. Our research assessed the support provided to three aforementioned hurricanes and the role the DoD in domestic disaster response. Hurricanes Harvey, Irma, and Maria garnered the public attention and raised questions regarding DoD's involvement in domestic disaster relief in relation to other federal agencies. With an expected 75% of the global population moving to urban areas by 2050 and developing evidence of climate change, we can expect an increase in the number of people affected by flooding and storm disasters (IMEchE, 2013). Since the three hurricanes were within the last ten months from the date of this report, we accessed the information received for this project through public information with a cut-off on 25 April 2018.

B. PROJECT ORGANIZATION

This project is organized into five chapters. Chapter II provides background on legal and policy foundations, the federal lead of interagency efforts and the role of DoD, and finally, developments and impacts of hurricanes Harvey, Irma, and Maria. In Chapter III, we analyze the data and outline the methodology of gathering and analyzing the mission assignments used to task federal agencies. Chapter IV is an analysis and discussion of the results from chapter III. Finally, in Chapter V, we identify the contributions of the study and recommend future research.

II. BACKGROUND

A. OVERVIEW

This project focuses on the activities DoD performed in support of FEMA in disaster relief assistance during hurricane operations, also known as civil support. To achieve this objective, the background has five primary sections that explore conceptual thoughts of DoD involvement in domestic disaster relief operations. First, we studied policies and laws that provide the federal government authority to assist in disaster relief operations. Second, we analyze the federal directives and documents that contribute to the National Response Plan (NRP) and responsibilities of FEMA. Third, we analyze documents relating to the DoD's role while performing DSCA missions. Lastly, we examine the impacts to Texas, Florida, and Puerto Rico and impacts related to Hurricanes Harvey, Irma, and Maria, respectively. This project provides an increased understanding of the role of DoD and how we integrate ourselves in to DSCA missions.

There have been many scholarly articles, studies, books, and reports written on Homeland Security and Homeland Defense and we provide a brief overview of relevant information. The *Introduction to Homeland Defense and Defense Support to Civil Authorities*, *The U.S. Military's Role to Support and Defend*, written by Bert B. Tussing and Robert McCreight explaining of the role the DoD has in homeland security and defense. The lead agency for homeland security is DHS and is responsible for the "enterprise" of agencies consisting of government, non-government (NGO), and private sector organizations that support the national effort. The DoD has a supporting role in homeland security and will never be in charge of disaster relief operations. Unlike homeland security, the DoD is the lead agency for homeland defense and is responsible for the protection of the U.S. territories from any threat that is identified by the president. For the purpose of this project, we focused on the DoD role in homeland security and what the military refers to as DSCA operations.

B. LEGAL AND POLICY FOUNDATIONS

1. Posse Comitatus Act

Established in 1878 under Title 18, United States Code (USC), Posse Comitatus Act (PCA) restricts the use of Title 10 Army and Air Force, forces to perform any civilian law enforcement activities. The Coast Guard, covered by Title 14 of the USC is exempt from PCA due to their role in peacetime domestic law enforcement mission in securing our nations water passages and coastal borders. Department of Defense Instruction (DoDI) 3025.21, Defense Support of Civilian Law Enforcement Agencies, expands the limitation to Navy and Marine forces in the use of civilian law enforcement and prohibits the use of any Title 10 force, unless authorized by the president. Actions that are prohibited by federal DoD personnel are

- Interdiction of a vehicle, vessel, or aircraft
- A search or seizure
- An arrest; apprehension; stop and frisk
- Using force or physical violence, brandishing a weapon, discharging or using a weapon, or threatening to discharge or use a weapon
- Evidence collection
- Surveillance of individuals
- Testing or other forensic investigations (Department of Defense, 2013).

PCA does not limit Title 32 forces from operating under their respective state laws and therefore are exempt from PCA and are required to work under state restrictions and laws. When the National Guard is activated under Title 10 status, it will follow the same regulations as active and reserve components of the DoD.

2. Stafford Act

While most disasters are addressed within the limitations of a state, some disasters or emergencies overwhelm the local resources; in such times, the local government can request assistance from federal agencies through the exercise of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), or the Economy Act. Signed into law in 1988, the Stafford Act (2016a) defines a major disaster as "any natural catastrophe, or, regardless of cause, any fire, flood, or explosion causes damage of sufficient severity and magnitude to warrant assistance to supplement State, local governments, and disaster relief organizations in alleviating damage, loss, hardship, or suffering" (p.1). The Stafford Act allows local governors to submit a formal request to the president requiring federal disaster response and recovery assistance to an emergency, major disaster, or management assistance. An affected governor must provide a written detailed request that outlines the impacts of the disaster, the effects of the preservation of life and property, and the type and amount of federal aid required; the amount of financial assistance provided to an affected area shall not be more than 75 percent of total cost of activity approved by the President (Federal Emergency Management Agency [FEMA], 2016a). Request for assistance from the federal agencies should not be a governor's first reaction, as they should work to exhaust all local resources and consider utilizing capabilities that can be provided from the Emergency Management Assistance Compact (EMAC).

The Stafford Act also allows the President two ways to assist in a major catastrophe in the absence of an official request from a state or territory government. First, the president can issue an Emergency Declaration, which provides resources prior to an incident that could help prevent a catastrophe from occurring. Second, following an incident, the President can further issue a Major Disaster Declaration in which additional federal assistance provided to response and recovery efforts (Federal Emergency Management Agency, 2016b). Prior to a declaration, federal agencies have the ability to deploy assets under their own authorities and with funds outside the President's Disaster Relief Fund under the actions of immediate response authority (Department of Homeland Security, 2013). Once a declaration is determined, the President appoints a Federal Coordinating

Officer (FCO) to perform assessments and prioritize relief efforts, establish field offices, and coordinate between local, state, (non-governmental) NGO and federal agencies (FEMA, 2016a).

3. Homeland Security Presidential Directive 5 and 8

In order to better prepare and respond to terrorist attacks or major disasters, President George W. Bush signed the Homeland Security Presidential Directive (HSPD) 5, Management of Domestic Incidents, 28 February 2003, which requires a single comprehensive approach to be created in the management of a domestic incident. To meet the objective of a comprehensive approach HSPD 5 (2003a) directed that the National Response Plan (NRP) “integrate Federal Government domestic prevention, preparedness, response, and recovery plans into one all-discipline, all-hazards plan” (p. 232). As stated in HSPD 5, the DoD will provide support to civil authorities for domestic incidents, but that the Secretary of Defense (SecDef) will also retain command of the military forces providing civil support (Government Publishing Office, 2006a). HSPD 5 also required the development of the National Incident Management System (NIMS). NIMS would provide for all levels of government to the ability to effectively and efficiently work together. The approach ensured that all agencies, be it local, state, federal, private, or NGO, the ability to share the same core concepts, principles, terminology and technologies (Government Publishing Office, 2006a).

A companion to HSPD 5 is HSPD 8, National Preparedness, 17 December 2003, which establishing readiness priorities and potential threats that will require resources to prepare, respond, and recover (Government Publishing Office, 2006b). Readiness will also encompass metrics and standards for assessments for the resources that are responding to a major disaster. To best align capabilities to prevent further suffering and timely response of forces HSPD 8 (2006b) directs the DoD will “provide to the Secretary information describing the organizations and functions within the DoD that may be utilized to provide support to civil authorities during a domestic crisis” (p. 1749). Both of the directives provide the DoD the domestic response role.

C. FEDERAL EMERGENCY MANAGEMENT AGENCY

Disasters are non-discriminatory to the impacts and level of catastrophe applied to local and state governments, and often require the assistance of federal and NGO agencies. While the federal government has provided relief and aid for over two centuries, the involvement in emergency management did not begin until April 1, 1979, with the creation of FEMA signed by President Jimmy Carter. Prior to FEMA's creation, local, state, tribal, and territory agencies coordinated directly with multiple agencies during large-scale disasters, which created complex problems with coordination and communication. Coordination between multiple agencies normally occurred through Mutual Aid Agreements (MAA) or Memorandum of Understanding (MOU) prior to an incident happening (Apte & Heath, 2011).

Under the Stafford Act, FEMA now coordinates assistance for all other supporting federal agencies in regards to emergency management. FEMA is the lead federal agency (LFA) for all disaster responses under DHS and responsible for the activation of emergency response plans with the primary mission to reduce and protect people and property from all types of hazards to include natural or man-made. The DHS and FEMA are responsible for the National Response Framework (NRF), a framework that provides doctrine to plans and executes national response to disasters and emergencies of all sizes, as displayed in Figure 1.

their construct have responsibilities, roles, resources, or capabilities for an identified function. Table 1 provides a list of all ESF's with their lead primary agency. The process of bundling resources provides a response to a core capability, but United States Government Accountability Report (GAO) 15-20 identifies the need to strengthen interagency assessments and the accountability for closing capability gaps between the LFA and FEMA (Currie, 2015). The report identifies a shortcoming in the feedback from the ESF coordinators to FEMA in identifying corrective actions during training scenarios and real-world disasters.

Table 1. Emergency Support Function and Coordinators

ESF	LFA ESF Coordinator
#1 Transportation	Dept of Transportation
#2 Communications	DHS/National Communications System
#3 Public Works and Engineering	Dept of Defense/U.S. Army Corps of Engineers (USACE)
#4 Firefighting	Dept of Agriculture/U.S. Forest Service and DHS/FEMA/U.S. Fire Administration
#5 Information and Planning	Dept of Homeland Security/FEMA
#6 Mass Care, Emergency Assistance, Temporary Housing and Human Services	Dept of Homeland Security/FEMA
#7 Logistics	General Services Administration/Dept Homeland Security/FEMA
#8 Public Health and Medical Services	Dept of Health and Human Services
#9 Search and Rescue	Dept of Homeland Security/FEMA
#10 Oil and HAZMAT Response	Environmental Protection Agency
#11 Agriculture and Natural Resources	Dept of Agriculture
#12 Energy	Dept of Energy
#13 Public Safety and Security	Dept of Justice/Bureau of Alcohol, Tobacco, Firearms, and Explosives
#14 Replaced by the National Disaster Recovery Framework	
#15 External Affairs	Dept of Homeland Security

Primary agencies are responsible for the coordination and organization of resources to support an ESF. ESF coordinators ensure that supporting agencies are prepared for activities for their particular function. Of significance, DoD is a supporting agency to 14 of 15 ESFs. DoD, United States Army Corps of Engineers (USACE) is the primary agency to ESF #3, Public Works and Engineering and maintains responsibility to manage and maintain the national waterways to include public works infrastructure.

E. DEPARTMENT OF DEFENSE ENTITIES

U.S. Northern Command (NORTHCOM) is the Geographical Combatant Commander (GCC) responsible for homeland defense and DSCA operations as established in the Unified Command Plan. NORTHCOM was created after the terrorist attacks on September 11, 2001, in October 2002. NORTHCOM is identified as the DoD representative responsible for the coordination, and planning for disaster relief for the 48 contiguous states, Alaska, the District of Columbia, U.S. Virgin Islands, and the Commonwealth of Puerto Rico. Department of Defense Directive (DoDD) 5100.01, published in 2010, identified key functions of the combatant commands and specific functions of our military departments. According to the Joint Publication 3-0, DSCA is the process of providing assistance by the DoD, to include National Guard when coordinated between the SecDef and affected states governors during a domestic emergency, law enforcement support, and other domestic activities (Joint Chiefs of Staff [JCS], 2017). While NORTHCOM has limited operational ground forces permanently assigned, they retain command and control of all Title 10 members until the affected state governor nominates a dual-status commander (DSC) and confirmed by the president or SecDef (Tussing & McCreight, 2015). In the creation of NORTHCOM, DoD did not allocate any special packages or equipment specifically designed for civil support.

1. National Guard

The National Guard is a crucial resource to the governor and, in some cases, activated as an immediate state response. Both the Air and Army National Guard brings resources and expertise in communication, search and rescue, aviation platforms, and logistics. National Guard elements activated into a state active status or National Guard in

Title 32 duty status, will be commanded and controlled by the state governor. Coordination between the SecDef and affected states governor can place National Guard forces in Title 32 status to respond to domestic emergencies. While activated the National Guard can perform law enforcement missions in accordance to the state laws. Formal agreements, such as the EMACs are created between states that allow assisting states National Guard forces to respond and provide assistance under a memorandum of assistance.

2. Federal Forces

As states National Guard forces get overwhelmed, a governor has the ability to request additional support through the president and use of regular active duty forces, known as Title 10. The president can direct the secretary of defense to utilize DoD resources for the purpose of performing response actions on public or private land where an emergency has been identified.

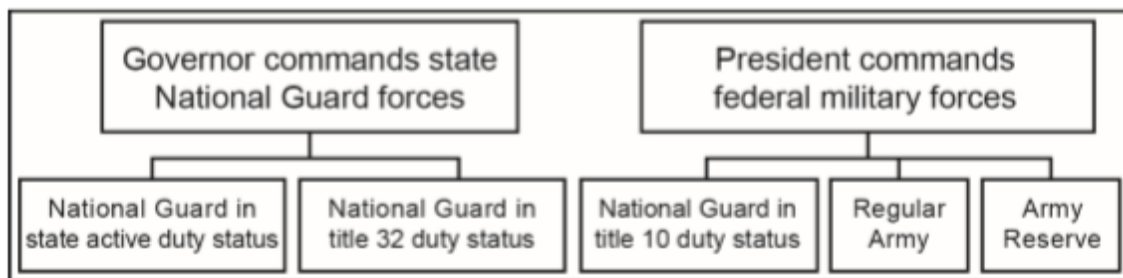


Figure 2. Example of Duty Status and Command Relationships.
Source: Department of the Army (2012).

DSCA is initiated by a request from civil authorities and is authorized by the President or Secretary of Defense. According to DoDD 3025.18 (2018), request for assistance of DoD shall be evaluated by DoD for the following areas:

- Legality (compliance with laws),
- Lethality (potential use of lethal force by or against DoD Forces),
- Risk (safety of DoD Force),

- Cost (including the source of funding and the effect on the DoD budget), Appropriateness (weather providing the requested support is in the interest of the Department),
- Readiness (impact on the Department of Defense's ability to perform its other primary missions) (pg. 4)

Immediate response authority is reserved for DoD officials to provide assistance to serious conditions while an official request is routing through higher approving authorities. Commanders operating under immediate response authority can assist for a period not to exceed 72 hours from the official request for assistance was received by the DoD. Immediate response authority does not permit federal forces to violate regulations or laws covered in the PCA or DoDI 3025.21.

3. Dual-Status Commander

While the concept of dual-status commander (DSC) has been around since 2004 through the National Defense Authorization Act (NDAA), it was initially looked as an inappropriate concept during periods of no warning or time to prepare to an event, such as a hurricane or other natural disasters (Gereski, 2006). In 2010, the DoD and Council of Governors agreed on the Joint Action Plan for Developing Unity of Effort. The application of the joint action plan designates the states as the dual-status commander with deputy commanders provided by NORTHCOM serving in a Title 10 status. The purpose of a DSC is to provide a single commander that will command both Title 32 and Title 10 forces, while receiving orders from both their federal and state chain of commands. The DSC enables the DoD to provide rapid response of federal forces to designated planned events or in major disasters within the U.S.

F. HURRICANE IMPACTS OVERVIEW

With 17 named storms that formed in the Atlantic basin, the 2017 hurricane season was one of the most active seasons in history, four of which made landfall on U.S. coastlines between August 25 and October 8. While not the deadliest hurricane season, 2017 will go down in the record books of having an impact on the number of affected

people and amount of damage and rebuilding that will be conducted for the on-going future. Overall, the 2017 hurricane season ranked as the seventh-most accumulated cycle energy (ACE), as seen in Figure 3 (McNoldy, Koltzback, & Samenow, 2017). As we plan for the 2018 hurricane season we must be plan, prepare, and pre-position the local, state, and federal resources to avoid loss of life and the destruction of property.

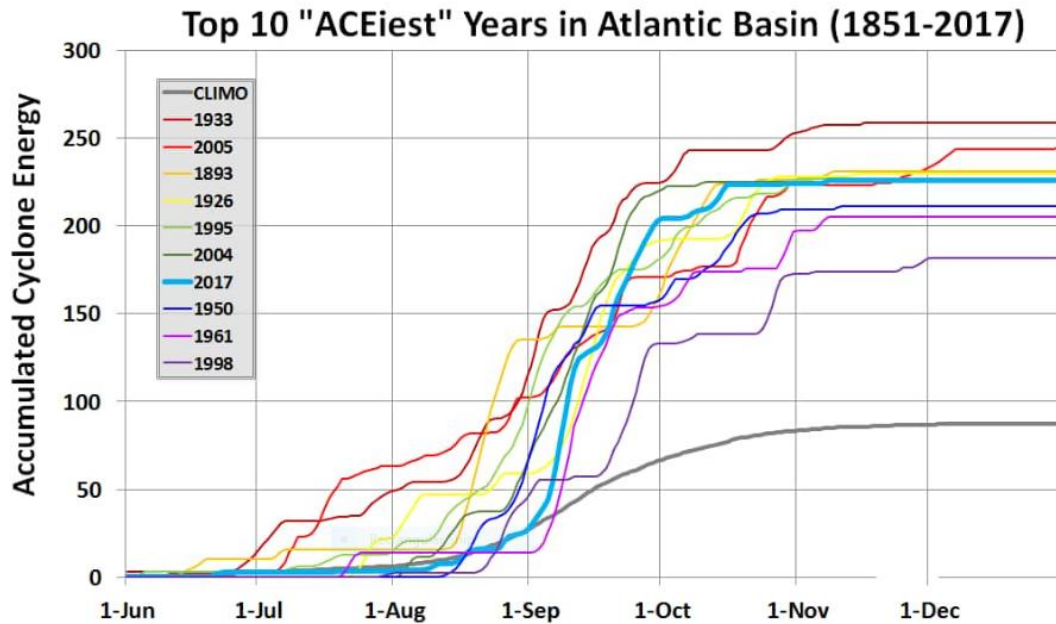


Figure 3. Top 10 “ACEiest” Years in Atlantic Basin (1851-2017).
Source: McNoldy, Koltzback, & Samenow (2017).

When analyzing the response provided to all three hurricanes, it is important to observe and identify the alerts and messages issued prior to the hurricanes making landfall. The National Hurricane Center (NHC) and National Oceanic and Atmospheric Administration (NOAA) tracking and analysis provided a detailed summary of watches, warnings, and potential effects of the storm and communicated to governments and media sources in an effort to save lives and mitigate property loss.

1. Hurricane Harvey

a. Overview

Hurricane Harvey made landfall at Rockport, Texas on 25 August 2017, at around 10:00 p.m. Central Daylight Time (CDT) (National Weather Service, 2017). With rainfall lasting over seven days, Texas received the largest amount of rainwater ever recorded in the United States, totaling more than 60 inches. The large amounts of rain caused significant damages to the Texas public infrastructure and private property, resulting in Harvey being the second-most costly hurricane in U.S. history, just behind Hurricane Katrina in 2005. The unpredictable size and path that Hurricane Harvey was predicted just days early by Governor Greg Abbott in his disaster declaration (Abbott, 2017) to the president, in the following statement, “It is not hyperbole to say that if the forecast verifies, Texas is about to experience one of the worst natural disasters in the history of the state.”(p. 3).

b. Timeline of Storm and Hurricane Warnings

Hurricane Harvey developed as Tropical Cyclone Nine on 17 August 2017, and within hours developed into a Tropical Storm with winds of 40 miles per hour (MPH), moving westward at 18 MPH developing heavy rains and wind gusts exceeding 40 MPH (National Oceanic and Atmospheric Administration [NOAA], 2017a). Rapidly moving across the Caribbean Sea, Harvey was not making any significant land impacts, but projected life threatening floods and mudslides from heavy rains. Just two days later, on 19 August 2017, Hurricane Harvey weakened to a Tropical Depression and deteriorated into a tropical wave leaving no further weather watches or warning issued for the next three days.

On 23 August 2017, As Harvey built strength over the Gulf of Mexico, Governor Greg Abbott declared a state of emergency with a disaster declaration effecting 30 counties in the state of Texas (Abbott, 2017). At 1000, 23 August 2017, hurricane and storm surge watches were issued for the Texas coast as Hurricane Harvey had been moving on a west-northwestward course as a Tropical Storm. With initial rainfall predictions expected to be 10 to 15 inches, with possible isolated amounts of 20 inches

over the Texas coast, Governor Abbott's advisors expected it to be one of the worst storms Texas had seen.

Early predictions of life threatening flooding began on 24 August 2017, as Harvey developed into a Category 1 hurricane with winds of 80 MPH and first hurricane warnings issued to Texas and expected to increase to a major hurricane by the early morning of 25 August 2017 and first warnings of isolated rainfall up to 30 to 35 inches. At approximately 0001 on 25 August 2017, Hurricane Harvey developed into a Category 2 hurricane with winds near 100 MPH. By 0700, the national weather service had issued a statement stating "preparations along the middle Texas coast should be rushed to completion this morning" (NOAA, 2017a). Seven hours later Harvey strengthens to a Category 3 hurricane with maximum sustained winds of 125 MPH and expected isolated rains over portions of Texas to exceed 40 inches.

Later on the evening of the 25th, Harvey developed into a Category 4 hurricane with sustained winds of 130 MPH and the eye of the hurricane-making landfall at approximately 2200 CDT, as illustrated in Figure 4. Already making landfall, Harvey quickly weakened to a Category 3 hurricane and on 26 August 2017, made its second landfall on Texas, and further weakened to a tropical storm. With its second interaction with land, Harvey had little movement, but continued to produce heavy rains over southeastern portions of Texas with sustained winds of 65 MPH and quickly reducing over the next few days.

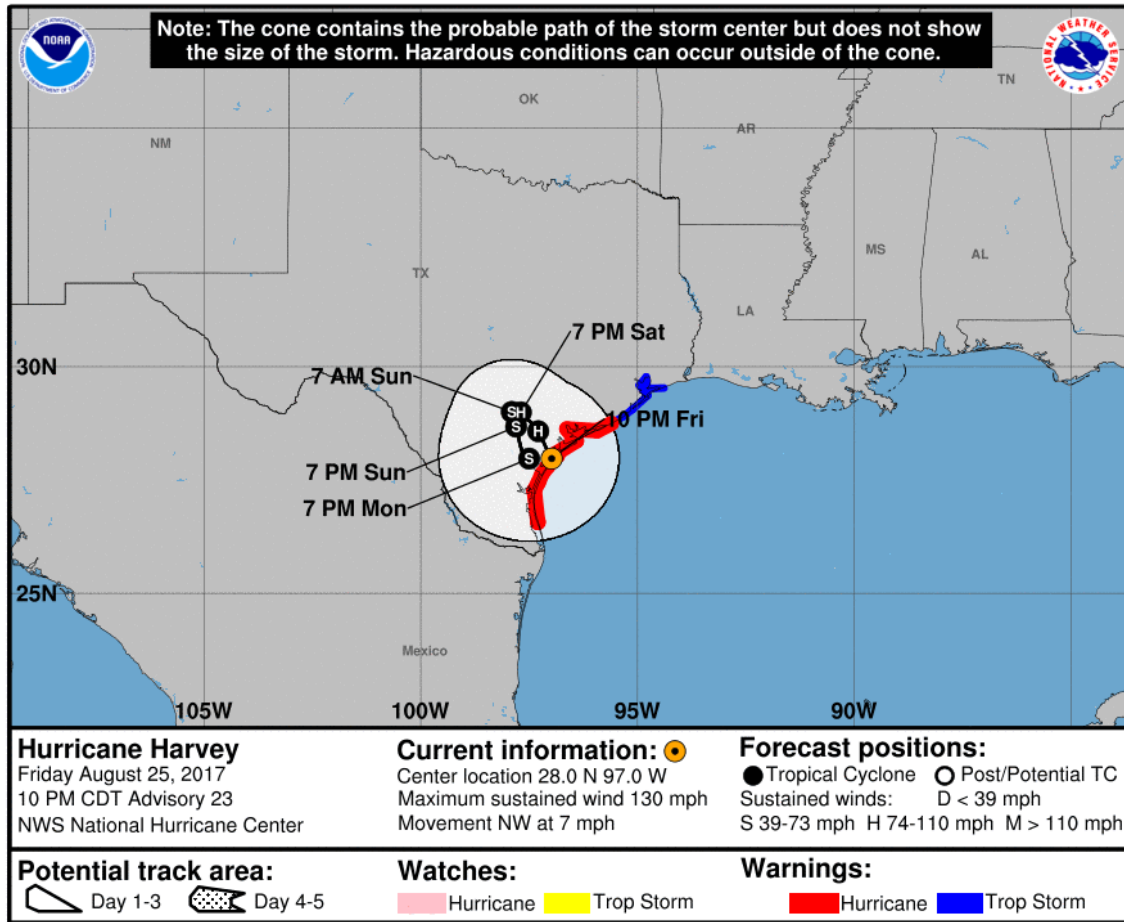


Figure 4. Hurricane Harvey Making First Landfall as a Category 4 Hurricane.
 Source: National Weather Service (2017).

Hurricane Harvey would continue to drift eastward or southeastward for the next few days and produce flash flooding in the greater Houston area reaching as much as 50 inches. At 1300, 27 August 2017, the national weather service issued the following message: “Do not attempt to travel in the affected area if you are in a safe place and do not drive into flooded roadways” (NOAA, 2017a). Harvey would eventually move back offshore on 28 August 2017 while still maintain heavy rains on the north and east side rings on areas of Houston, and the triangle of Beaumont, Port Arthur, and Orange.

Harvey would reach its final peak intensity on 29 August 2017 while it gained strength over the Western Atlantic and never moving further than 60 miles off the shore of the Texas Coast (Blake & Zelinsky, 2018). As a tropical cyclone, Harvey made final

landfall in on Louisiana on 30 August 2017, moving at a northeastward path towards portions of Tennessee Valley dissipating over Kentucky on 2 September 2017.

While Texas held the previous record for continuous rainfall of 48 inches from Tropical Storm Amelia in 1978, Texas was not prepared for the impacts that Harvey would leave behind (Blake & Zelinsky, 2018). The death toll estimated to be at least around 68 people, 33,800 people displaced, 336,000 customers without power, destroyed more than 176,000 homes, with overall damages totaling over \$125 billion (Lozano, 2017; Blake & Zelinsky, 2018; Smith, 2018). Of significance, the casualty levels were a result of seven-day rainfalls totaling more than 19 trillion gallons that occurred during Hurricane Harvey's downgrade to a Tropical Storm and eventually Tropical Depression.

2. Hurricane Irma

a. Overview

As illustrated in Figure 5, Hurricane Irma will go down in the record books as maintaining intense winds in excess of 185 MPH for 37 hours and as the second most powerful storm, only to follow Hurricane Allen's record set in 1980 of 190 MPH (Scott, 2017). While Hurricane Irma made landfall seven times our project will focus on the tracking and messages provided by the NOAA for all affected areas but will specifically focus on detailed impacts for the Commonwealth of Puerto Rico and the state of Florida.

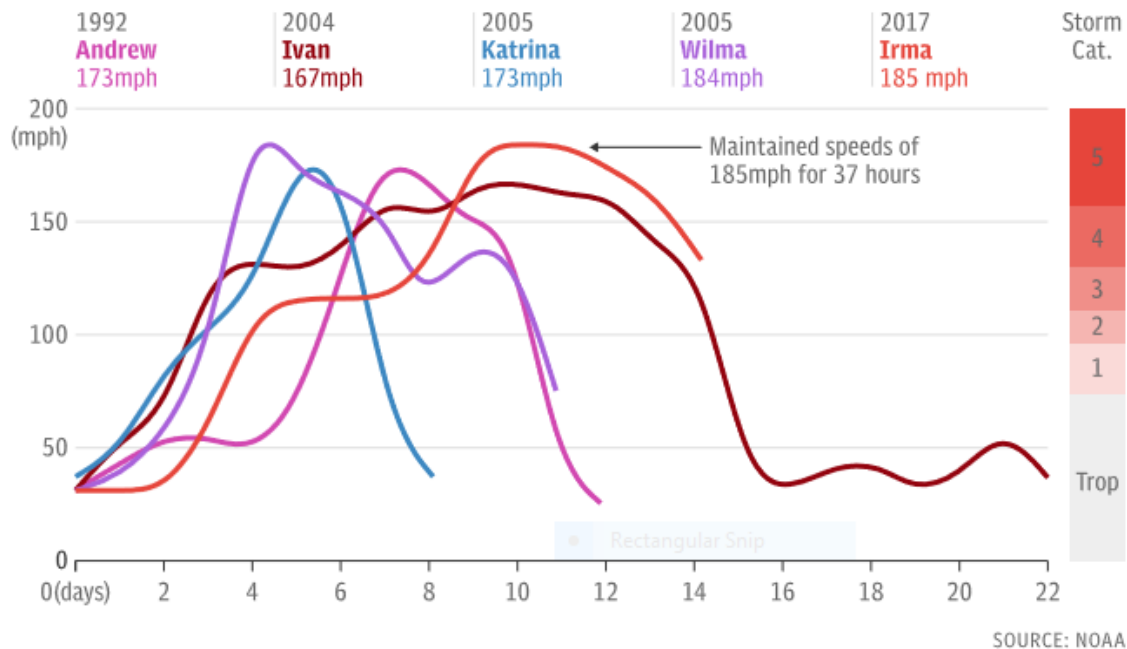


Figure 5. Major Atlantic Hurricane Strength. Source: Scott (2017).

b. Timeline of Storm and Hurricane Warnings

Hurricane Irma originated from a tropical wave formed in the eastern Atlantic Ocean and identified as a tropical storm by NOAA on 30 August 2017. Moving westward, Irma wind strengthened to speeds reaching 65 MPH and expected to reach hurricane status by 31 August 2017. Hurricane Irma formed into a Category 3 hurricane on 31 August 2017 and continued to make west-northwestward movement for two more days without making impact to land. On 3 September 2017, NOAA issued a recommendation to Puerto Rico to begin monitoring the hurricane movement through a hurricane watch on 04 September 2017. With sustained winds of 140 MPH, Irma developed into a Category 4 hurricane and turned west-southwestward, requiring the hurricane watch to be increased to a hurricane warning for Puerto Rico on the evening of 4 September 2017 (National Oceanic and Atmospheric Administration [NOAA], 2017b).

Early on 5 September 2017, Irma reached Category 5 status with winds exceeding 175 MPH and projected to make its first of seven landfalls. 6 September would prove to be Hurricane Irma’s most devastating day with three Category 5 landfall hits. Irma’s first

landfall occurred at 05:45 on 6 September 2017, causing great devastation to the island of Barbuda followed by the second landfall on St. Martin at 11:15 and finally on the island of Virgin Gorda at 16:30. On 6 September 2017, Irma began its move as a Category 5 hurricane at the northern portion of Puerto Rico, with sustained winds of 185 MPH causing flooding and area power and water outages (NOAA, 2017b). Heavy rain would continue as Irma moved away from Puerto Rico and on 7 September, portions of southern Florida and Florida Keys received their hurricane and storm watch notifying them of potential tropical storm condition by 9 September. On the evening of 7 September, South Florida and Florida Keys received their first hurricane warning.

By 8 September 2017, Hurricane Irma decreased in wind speed to a Category 4 hurricane and made its fourth landfall on Little Inagua Island in the Bahamas. On the morning of 9 September 2017, Irma strengthened back to a Category 5 with wind speeds near 160 MPH and making its fifth landfall on Cayo Romano, Cuba, at 03:00 CDT. As the day progressed, Irma would weaken back to a Category 4 and further into a Category 3 hurricane, but not before gaining additional strength over the Florida Straights and returning to a Category 4 hurricane (NOAA, 2017b).

On 10 September 2017, the eyewall of Irma reached the lower Florida Keys and by 09:10 CDT, Irma made landfall at Cudjoe Key, making its sixth landfall and the first Category 4 hurricane to landfall in Florida since Wilma in 2005 (NOAA, 2017b). By 14:00 CDT, Irma weakened to a Category 3 hurricane with winds near 120 MPH and making its final landfall at 19:30 at Marco Island, Florida producing damaging winds across Florida and eventually weakening to a Category 2 on the 11 September 2017. Irma would continue to weaken to a tropical storm by 08:00 CDT and further to a tropical cyclone with wind speeds up to 60 MPH moving into southwestern Georgia and eastern Alabama producing large amounts of rainfall.

Florida is familiar to hurricanes and the requirements to best prepare their residents through proper precautionary measures. Working with his state agencies, Florida Governor Rick Scott issued warnings to the Florida residents to make necessary plans to evacuate prior to Irma's arrival, resulting in 44 of 67 counties to issue evacuation orders to approximately 6.8 million people, the largest evacuation in U.S. history (Regan, 2017). On

4 September 2017, Governor Rick Scott declared a state of emergency four days prior to Hurricane Irma making landfall (Cangialosi, Latta, & Berg, 2018). The results of the devastation in Florida includes: damage to the power grid resulting in a loss of power to 6.7 million customers, loss of cell phone services caused by the power outages, and displacing more than 191,764.

Hurricane Irma contributed to the deaths of 84 people in Florida, 4 classified directly to the effects of the hurricane and 80 indirectly. Of note, 14 of the 80 deaths occurred in the Rehabilitation Center at Hollywood Hills with 12 deaths ruled as a homicide due to overheating. While Puerto Rico was not directly impacted by Irma, heavy rains and strong winds caused power outages and caused a loss of electricity and water supply for several days and three indirect deaths.

3. Hurricane Maria

a. Overview

On 20 September 2017, a Category 4 hurricane identified as Maria hit the small Caribbean Island of Puerto Rico. Puerto Rico measures 3,423 miles, roughly the size to the state of Connecticut, with a population of 3,725,793 (U.S. Department of Commerce, 2017). Already facing a debt crisis and a poverty level of 43.5 percent, Puerto Rico was hit by the strongest hurricane seen in over the last century (U.S. Department of Commerce, 2017). The devastation left the island with up to 64 dead, although the official death toll is feared to much higher and is a point of contention based on analysis of the daily mortality data (Hoyos & Caplan, 2017, para 1). In the days following Marias impact, the local and federal governments was criticized for being slow and not efficiently helping the effected population.

b. Timeline of Storm and Hurricane Warnings

Hurricane Maria developed its path of destruction on 16 September 2017, as a Tropical Cyclone 15 and quickly generating in a tropical storm in the evening with sustained winds of 50 MPH (National Oceanic and Atmospheric Administration [NOAA], 2017c). On 17 September 2017, Tropical Cyclone 15 built strength and evolved into a

Hurricane Maria the thirteenth hurricane of the season. Hurricane Maria developed enough strength that a hurricane watch issued for the U.S. Virgin Islands with a potential hurricane watch expected to be issued for Puerto Rico on the morning of 18 September 2017 (NOAA, 2017c). Hurricane Maria increased in strength moving toward west and north-west of the Caribbean Sea gaining strength into a Category 5 hurricane, on 18 August 2017, with sustained winds of 160 MPH with the first hurricane watch advisory issued to Puerto Rico and subsequent hurricane warnings issued to U.S. Virgin Islands and Puerto Rico (NOAA, 2017c).

On 19 August 2017, the following messages were released at 0500 and 1100, respectively, as Maria continued to gain strength with winds up to 165 MPH:

“Extremely dangerous Hurricane Maria headed for the Virgin Islands and Puerto Rico. Expected to remain a Category 4 and 5 hurricane as it approaches U.S. Virgin Islands and Puerto Rico” (NOAA, 2017c).

“Potentially catastrophic Hurricane Maria continues West-Northwestward toward Virgin Islands and Puerto Rico....preparations against life-threatening storm surge and rainfall flooding and destructive winds should be rush to completion” (NOAA, 2017c).

At 1900, 19 September 2017, Hurricane Maria is an “extremely dangerous Category 5 hurricane,” is expected to reach the southeastern side of Puerto Rico on 20 September 2017, and carry with it rain bands and tropical-storm-force winds extending outward from Maria for 150 miles (NOAA, 2017c).

On the morning of 20 September 2017, at 06:35 CDT, Hurricane Maria made landfall as a Category 4 hurricane and expected to remain dangerous through 22 September 2017 (NOAA, 2017c). While the National Ocean Service tide gauge reported a level of 5.3 feet above the average high water at Yabuca Harbor, most damage sustained would be from sustained winds of 155 MPH with gusts reaching much higher, but the windward sides of hills and mountains received more dangerous outcomes as the hurricane moved off the northern coast (NOAA, 2017c). Maria would eventually downgrade to a Category 3 hurricane while still leaving tropical storm conditions with an expected rains totaling 40 inches. The results of the devastation in Puerto Rico includes: damage to 100% of the

power distribution system, 95% of the cell phone grid, 44% left without drinking water, damage to the wastewater system, loss of key infrastructure such as roads and bridges blocked by debris and mudslides, more than 427,000 housing units destroyed, loss of 80% of planted crops, and the closure of hundreds of schools and thousands of businesses (Rossello & Defense Media Activity, 2017).

Already dealing the impacts of Hurricane Irma two weeks prior, that left 1.5 million people without power and over an estimated 1 billion dollar in damages, the U.S. citizens of Puerto Rico received warning from the governor that the infrastructure was still vulnerable (PBS NewHour, 2017). Warnings provided by the local and federal governments, encouraged people to seek shelter, which can be attributed to the low death count. In light of the warnings, local and federal agencies began preparing prior to landfall with the signing of the federal emergency declaration on 18 September 2017, the deployment of FEMA urban search and rescue team, a Department of Health and Human Services (DHHS) Disaster Medical Assistance Team, and the designation of Alejandro De La Campa as the Federal Coordinating Officer (FCO).

G. SUMMARY

In this chapter, we provided a legal foundation and historical background to domestic disaster response operations as it applies to laws and directives governing DHS and DoD. While multiple agencies are involved, in response operations, it is important to understand the DoD forces involved and the role they play when performing DSCA operations. Hurricanes Harvey, Irma, and Maria set records and impacts across multiple states requiring support from DoD forces. In the next chapter, we offer a detailed analysis of the mission assignments designated by FEMA.

III. DATA

A. POSTULATES

We collected data and categorized it subjectively based on mission assignments to examine the following postulates:

1. DoD utilization in domestic hurricane relief is less than other agencies.

After Hurricane Maria, the public questioned the level of involvement for DoD in disaster response. We established the process for federal assistance in Chapter II. Postulate #1 attempts to identify what level of participation DoD has in domestic disaster relief.

2. There are common tasks in every hurricane disaster that DoD could focus on to improve response.

Apte et al. (2013) identified that sometimes the military sends the wrong assets to aid in disaster relief. They conclude that identifying metrics would help commanders understand what personnel and materiel are best suited for the conduct of disaster response (Apte A. , Yoho, Greenfield, & Ingram, 2013). Postulate #2 attempts to identify areas of hurricane response suitable for metric development.

3. Pre-positioning has a positive effect on the quality of disaster response.

The outcomes of Hurricanes Harvey, Irma, and Maria produced different results despite each hurricane being equally devastating with little time between events. Postulate #3 attempts to find the extent in which pre-positioning may have contributed to the success or failure of the hurricane response.

B. DATA SOURCE

The Federal Emergency Management Agency (FEMA) is required by Congressional bill HR 152 Sandy Recovery Improvement Act of 2013 to publish all mission assignments issued to other government agencies (Disaster Relief Appropriations Act, 2013). This public data is published on the FEMA website daily and breaks down each

mission assignment into state, disaster number, disaster description, agency assigned, requested assistance, obligation estimate, and obligation date (2017-2019 – FEMA, 2017).

C. ASSUMPTIONS ON THE DATA

We make the following assumptions on the data.

- The FEMA public data accurately depicts the mission assignments issued to agencies.
- Work associated with the mission assignment starts on the obligation date of the mission assignment.
- All mission assignments from the public database are individual requirements and are not duplicated requests.
- Final obligation amounts will be different from the listed obligation estimate.
- Surge accounts are only used prior to an event and are no longer used for an event after landfall.

D. METHODOLOGY

The goal of our data processing was to create a timeline that describes the relationship between volume of mission assignments to the timeline of event, to show the distribution of mission assignments across government entities, and to show the types of mission assignments tasked to each agency. We based our analysis on a quantity count vice the obligation estimates due to our assumption that the obligation estimate amount would be different from the actual obligation value.

Utilizing the FEMA public data, we collate each mission assignment for Hurricanes Harvey, Irma, and Maria into Excel resulting in 1,234 mission assignments issued from 23 August to 13 December 2017. Mission assignments continue beyond 13 December 2017 for all events but are not part of the data analyzed in this thesis.

We conduct a review of each mission assignment, summarize the detailed request, and subjectively categorize each mission assignment into a FEMA Emergency Support Function (ESF) based on our interpretation of the request. Not all mission assignments explicitly state what ESF applies and some mission assignments were determined to be applicable to multiple ESFs.

FEMA gives pre-disaster mission assignments a disaster number of 7220SU to designate pre-disaster surge funding. The 7220SU number does not indicate which eventual disaster the mission assignment applies. To deal with these mission assignments, we compare the hurricane's landfall date to the obligation date to identify which event was the likely subject of the mission assignment.

We summarize the FEMA data into executive departments and independent agencies for ease of analysis. The Defense Logistics Agency, Army Corps of Engineers, and National Geospatial Agency are examples of agencies categorized as DoD.

After categorizing each mission assignment, we conduct two types of counts of mission assignments. The first is to count the total number of mission assignments to show the overall mission volume on a per day basis. The second is to count the ESF categories requested over the entire hurricane timeline. The total count based on ESF will be higher than the actual total number of mission assignments due to assigning multiple ESFs to a single mission assignment.

We verify our categorization of each mission assignment by generating a keyword list for select ESFs based on words or word groupings that would be common in the official description of each mission assignment. Some ESFs, such as Emergency Response ESF #6, do not have specific key words that would uniquely identify a mission assignment as part of that ESF. Utilizing the regular expression in R – a software language for statistics - we conduct a computer-based search of each mission description with our key word list. We then compared the assigned ESFs for each record based on our human analysis and the computer search to determine matching and un-matching pairs.

E. HURRICANE HARVEY DATA

Peak occurrences for Hurricane Harvey mission assignments occurs on the day Harvey made landfall. There were seven mission assignments issued prior to landfall that focused on ESF #3 (Public Works and Engineering) and ESF #5 (Emergency Management). Out of 130 mission assignments, 71.2% occur within two weeks of landfall. Figure 6 shows the daily issuance of mission assignments broken down to DoD and other agency designated missions represented by blue and yellow, respectively.

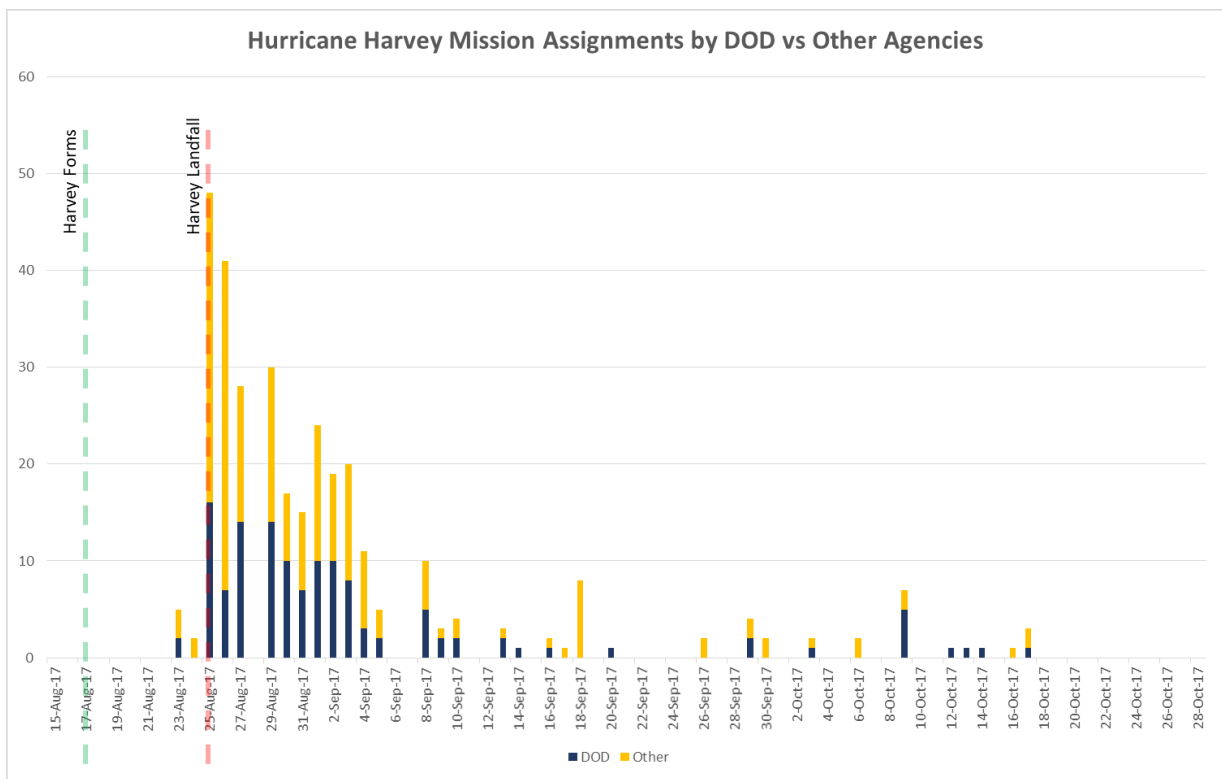


Figure 6. Hurricane Harvey Mission Assignments Aug. 2017 to Oct. 2017

Our data shows that DoD received 38% of the mission assignments, as shown in Figure 7. Of the DoD contribution, 41% comes from the Army Corps of Engineers and 59% comes from other DoD services. As shown in Figure 7, other major agencies that captured 4% or more of the mission assignments include the Department of Homeland Security, Department of Health and Human Services, Department of Commerce,

Department of Transportations, Department of Interior, Department of Justice, and U.S. Drug Administration.

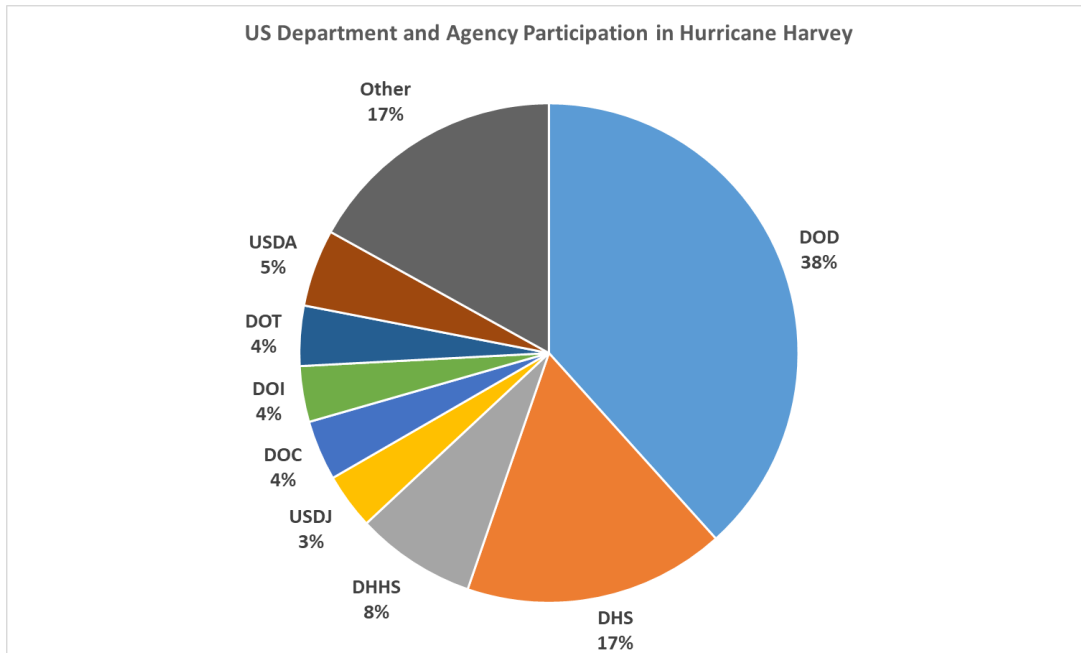


Figure 7. Agency Participation in Hurricane Harvey

FEMA issued DoD 138 mission assignments over the course of Hurricane Harvey. The DoD received more mission assignments than other agencies for Emergency Support Functions 1, 3, 7, 9, 10, and 15. DoD was significantly used (greater than 15 MAs) for ESF 5 and 6. Table 2 shows the breakdown of mission assignments by Emergency Support Function.

Table 2. Emergency Support Functions for Hurricane Harvey. Green = Majority of Tasking, Yellow = Significant Tasking (>15)

Emergency Support Function Demand Through Hurricane Harvey			
	Total	DOD	Other
#1 Transportation	15	14	1
#2 Communications	5	0	5
#3 Public Works and Engineering	66	63	3
#4 Firefighting	1	0	1
#5 Emergency Management	91	31	60
#6 Mass Care, Emergency Assistance, Housing, and Human Services	116	18	98
#7 Logistics Management and Resource Support	35	21	14
#8 Public Health and medical Services	37	9	28
#9 Search and Rescue	29	23	6
#10 Oil and Hazardous Materials Response	12	9	3
#11 Agriculture and Natural Resources	9	1	8
#12 Energy	12	4	8
#13 Public Safety and Security	25	0	25
#14 Replaced by National Disaster Recovery Framework	0	0	0
#15 External Affairs	34	19	15

F. HURRICANE IRMA DATA

Peak occurrences for Hurricane Irma mission assignments happen prior to Irma making landfall. There were 203 mission assignments issued prior to landfall that include all ESF areas. The majority of the mission assignments, 46% occur within two weeks of landfall. Figure 8 shows the daily issuance of mission assignments broken down by DoD and other agency designated missions in blue and yellow, respectively. Of the three hurricanes studied, Irma has the highest number of pre-event mission assignments.

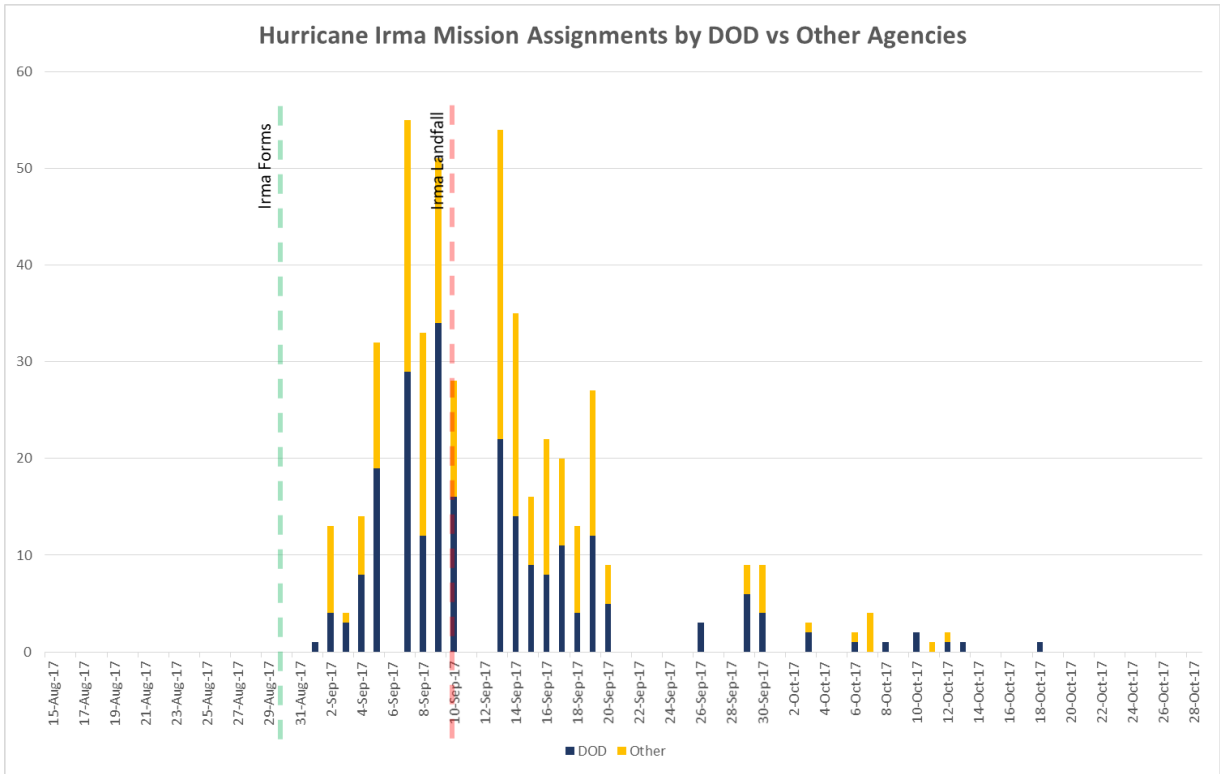


Figure 8. Hurricane Irma Mission Assignments Aug. 2017 to Oct. 2017

DoD received 49% of the mission assignments, as shown in Figure 9. Of the DoD contribution, 37% comes from the Army Corps of Engineers and 63% comes from other DoD services. As shown in Figure 9, other major agencies that captured 4% or more of the mission assignments include the Department of Homeland Security, Department of Health and Human Services, Department of Commerce, Department of Transportations, Department of Interior, Department of Justice, U.S. Drug Administration, and Environmental Protection Agency.

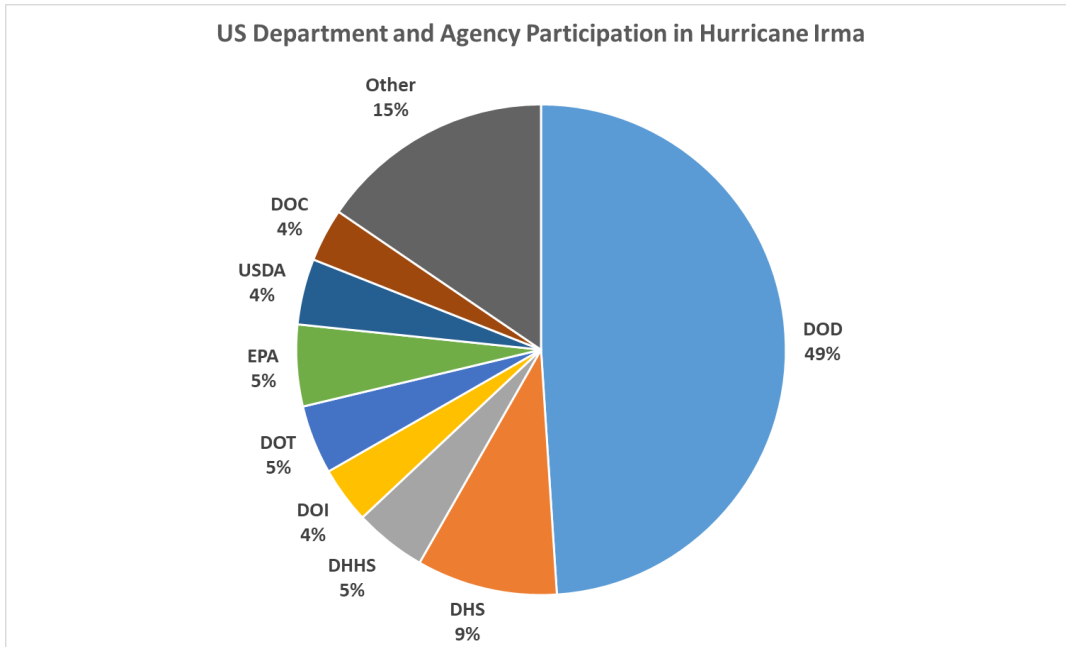


Figure 9. Agency Participation Hurricane Irma

FEMA issued DoD 238 mission assignments over the course of Hurricane Irma. DoD received more mission assignments than other agencies for Emergency Support Functions 1, 3, 5, 7, 9, 12, and 15. DoD was significantly used (greater than 15 MAs) for ESF 6 and 8. Table 3 shows the breakdown of mission assignments by Emergency Support Function.

Table 3. Emergency Support Functions for Hurricane Irma. Green = Majority of Tasking, Yellow = Significant Tasking (>15)

ESF Demand Through Hurricane Irma			
	Total	DOD	Other
#1 Transportation	32	24	8
#2 Communications	16	4	12
#3 Public Works and Engineering	111	100	11
#4 Firefighting	3	0	3
#5 Emergency Management	109	58	51
#6 Mass Care, Emergency Assistance, Housing, and Human Services	129	32	97
#7 Logistics Management and Resource Support	72	46	26
#8 Public Health and medical Services	40	19	21
#9 Search and Rescue	26	21	5
#10 Oil and Hazardous Materials Response	29	13	16
#11 Agriculture and Natural Resources	22	1	21
#12 Energy	20	10	10
#13 Public Safety and Security	23	0	23
#14 Replaced by National Disaster Recovery Framework	0	0	0
#15 External Affairs	9	8	1

G. HURRICANE MARIA DATA

Peak occurrences for Hurricane Maria mission assignments occurs the day before Maria made landfall. There were 34 mission assignments issued prior to landfall that include all ESF areas. The majority of the mission assignments, 36% occur within two weeks of landfall. Figure 10 shows the daily issuance of mission assignments broken down by DoD and other agency designated missions in blue and yellow respectively.

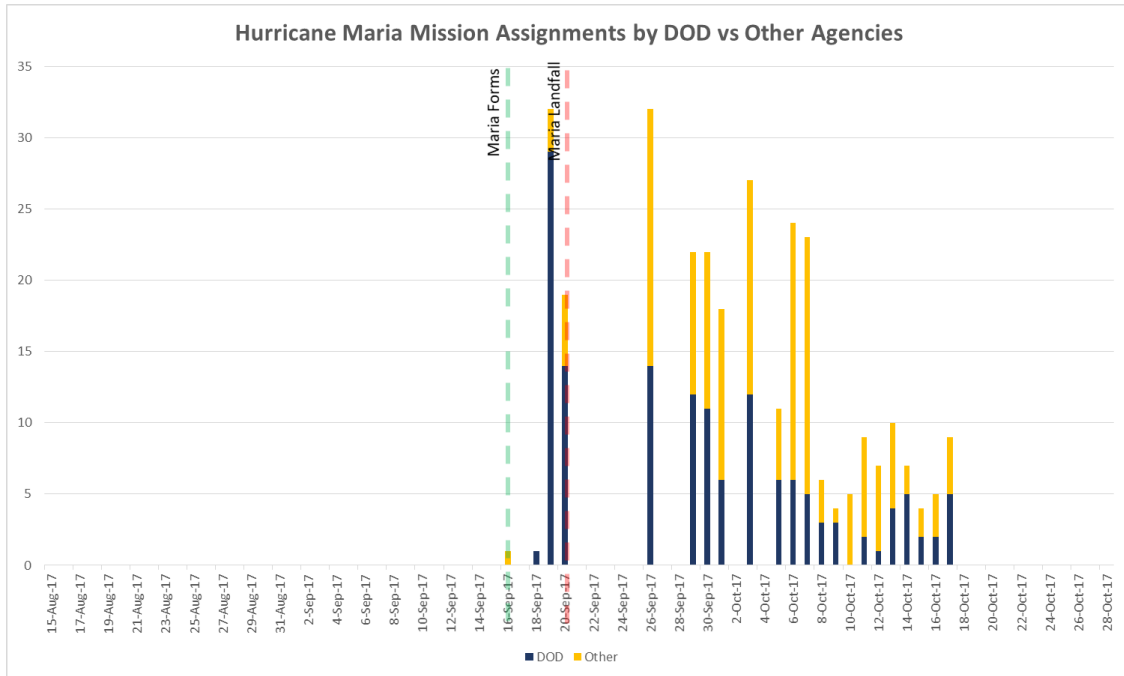


Figure 10. Hurricane Maria Mission Assignments Aug. 2017 to Oct. 2017

FEMA issued DoD 44% of the mission assignments, as shown in Figure 11. Of the DoD contribution, 30% comes from the Army Corps of Engineers and 70% comes from other DoD services. As shown in Figure 11, other major agencies that captured 4% or more of the mission assignments include the Department of Homeland Security, Department of Health and Human Services, Department of Transportations, and U.S. Drug Administration.

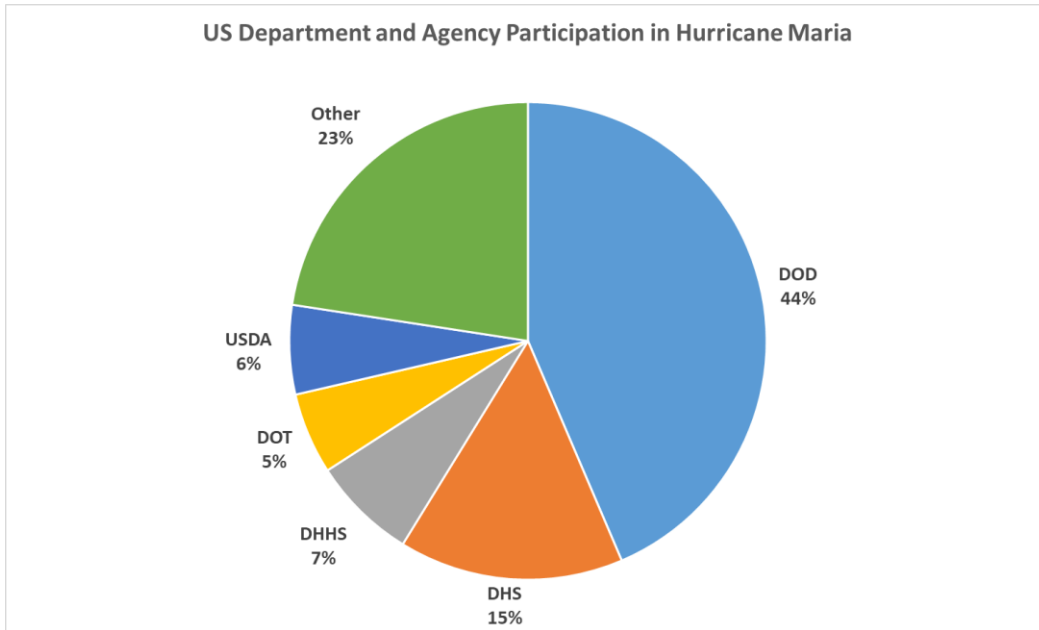


Figure 11. Agency Participation Hurricane Maria

DoD received 166 mission assignments over the course of Hurricane Maria. FEMA issued DoD more mission assignments than other agencies for Emergency Support Functions 1, 2, 3, 5, 7, 9, 12, and 15. DoD was significantly used (greater than 15 MAs) for ESF 6. Table 4 shows the breakdown of mission assignments by Emergency Support Function.

Table 4. Emergency Support Functions for Hurricane Maria. Green = Majority of Tasking, Yellow = Significant Tasking (>15)

ESF Demand Through Hurricane Maria			
	Total	DOD	Other
#1 Transportation	29	19	10
#2 Communications	16	12	4
#3 Public Works and Engineering	60	53	7
#4 Firefighting	3	0	3
#5 Emergency Management	70	39	31
#6 Mass Care, Emergency Assistance, Housing, and Human Services	136	30	106
#7 Logistics Management and Resource Support	55	40	15
#8 Public Health and medical Services	34	12	22
#9 Search and Rescue	13	11	2
#10 Oil and Hazardous Materials Response	6	2	4
#11 Agriculture and Natural Resources	14	0	14
#12 Energy	16	10	6
#13 Public Safety and Security	13	0	13
#14 Replaced by National Disaster Recovery Framework	0	0	0
#15 External Affairs	31	17	14

H. OTHER FINDINGS

All three hurricanes displayed a period shortly after landfall in which there were no mission assignments issued. For Hurricane Harvey, this occurred between August 27 and 29. The gap is more pronounced in Hurricane Irma, when it occurs from September 10 to 13, and Hurricane Maria, it occurs from September 20 to 26. This gap is indicative of the initial requirements period when first responders are working to determine what material and services are required.

Hurricane Irma received more mission assignments than Harvey or Maria. Figure 12 is a representation of mission assignment accumulation over time for all three hurricanes. Day “0” represents hurricane formation and the figure continues for 40 days. Figure 12 also shows that the rate of new mission issuance decreases to almost zero by day 30 of an event.

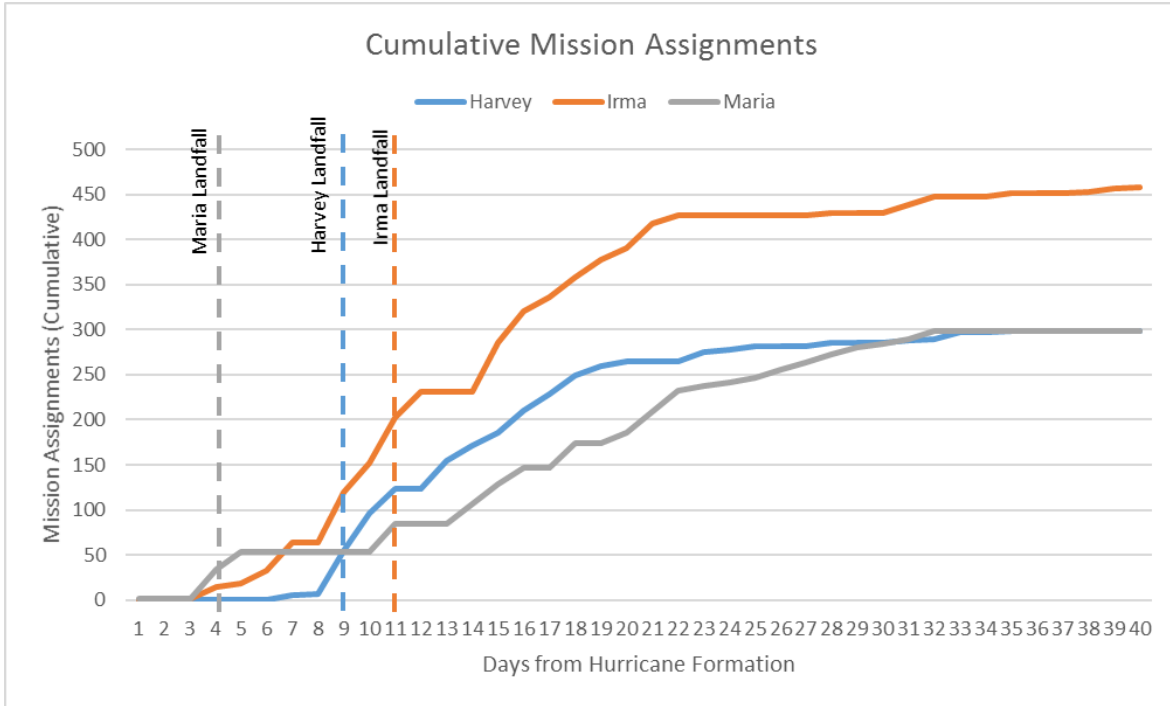


Figure 12. Cumulative Mission Assignments for Hurricane Harvey, Irma, and Maria

I. VERIFICATION OF CATEGORIZATION

We processed eight of the fifteen Emergency Support Functions using the regular expression in R with the following results.

- ESF #2 Communications: 7.5% difference
- ESF #3 Public Works and Engineering: 13.5% difference
- ESF #7 Logistics: 25.6% difference
- ESF #8 Public Health and Medical: 6.5% difference
- ESF #9 Search and Rescue: 3.4% difference
- ESF #10 Oil and HAZMAT: 2.3% difference
- ESF #12 Energy: 3.6% difference

- ESF#13 Public Safety and Security: 2.8% difference
- ESF#15 External Affairs: 5.4% difference

These differences represent mission assignments where a computer using a keyword search resulted in a different categorization than the human reviewer. This does not represent true error in the subjective categorization.

J. SUMMARY OF DATA

The publicly sourced FEMA data provides us with a closer look at mission assignments during a hurricane response. From the data generated, we identify the timeline for issuance of tasking in relation to the hurricane timeline, who receives mission assignments, and what support function the requests fulfill.

IV. ANALYSIS AND DISCUSSION

Our data shows that while the response timelines for each hurricane have their individual nuances, FEMA tasking is largely predictable for hurricanes across agencies. As we look specifically into each postulate, the anatomy of hurricane relief efforts starts to take form.

A. POSTULATE 1: DEPARTMENT OF DEFENSE UTILIZATION

Our first postulate is that utilization of the DoD is less than other agencies in domestic hurricane relief. The data does not support this conclusion. In every event, DoD was the most heavily utilized organization, drawing 38% to 49% of the mission assignments. The percentage range does include the Army Corps of Engineers, whose primary mission includes civilian infrastructure, such as maintenance of dams, waterways, and bridges (U.S. Army Corps of Engineers, 2018); however, the Corps of Engineers account for no more than 41% of the DoD mission assignments. For Hurricane Maria, the Corps of Engineers accounted for less than 30% of the DoD mission assignments.

During our categorization process of all mission assignments, we also marked down any mission assignments requested of other agencies which had a task that DoD could have accomplished. We were unable to find any tasking assigned to other agencies where DoD would have been able to accomplish the mission more effectively. There were a few mission assignments where tasking could have been assigned to DoD as well.

One was tasking for the Department of Interior (DoI) for drone utilization to conduct reconnaissance of affected areas. While the DoD has many drone assets, defense missions lower their availability. Utilization of DoI drones is more cost effective and they are more suitable for disaster relief missions. DoD did have some drone mission assignments, which indicates that the utilization of DoI drones could be an attempt to spread the workload over multiple agencies to minimize primary defense mission impacts.

Another example were missions assigned to the Department of Transportation (DoT) for ships to provide housing services for FEMA personnel responding to Hurricane Maria. The DoD could also support such a request but may not have been the most ideal to

do the mission. As explained in Apte et al. (2017), utilization of Navy ships can be costly and they are not always the ideal platform for housing services (Apte & Yoho, 2017). The U.S. Navy may also not have had an appropriate ship able to respond faster than the DoT ships.

One emergency support function that did not meet our expectation was in the area of public health and medical support. The Department of Health and Human Services appropriately received the majority of the medical mission. DoD utilization for medical support was not as much as would be expected given the expertise in field medicine. For Hurricanes Harvey and Irma, developed medical infrastructure already in place in Texas and Florida negated the need for extensive military support. However, for Hurricane Maria, we see that DoD received only 35% of the medical support mission.

B. POSTULATE 2: COMMON TASKS FOR DOD

Our second postulate was that there are common tasks assigned to the DoD which could inform training and metric focus. Our data supports this conclusion in general terms, but lacks enough detail to make conclusions on specific metrics. In all three events, FEMA utilized DoD more than any other agency for transportation, public works and engineering, logistics management and resource support, search and rescue, and external affairs.

There is evidence of DoD creating off-the-shelf support packages, such as the Distribution Expeditionary Package, which provides personnel, material handling equipment (MHE), communications, and in-transit cargo visibility to expeditionary environments. Having these packages adds modularity to disaster response, improving efficiency. With each package having a defined capacity of support, the initial assessment teams only need to determine capacity needed and not worry about the specific details to reach that capacity.

C. POSTULATE 3: EFFECT OF PRE-POSITIONING

Our third postulate was that pre-positioning directly affects the quality of disaster response. The data supports this hypothesis but not conclusively. We subjectively rank each disaster response from most to least effective: Irma, Harvey, and Maria. The data

shows a large amount of pre-positioning for Florida and very little for Harvey and Maria. What made the difference between Harvey and Maria responses was pre-existing infrastructure in Houston, which is a component of pre-position.

Due to these three events occurring in quick succession, the outcome of these events must be looked at together to understand the dynamics of the responses. Hurricane Harvey appeared small until a few days before landfall when it grew to a much larger hurricane, the first for the season. This affected the ability to respond quickly to the changing requirement. The evidence of this is the sudden uptick in surge requests right before landfall.

After the devastation of Harvey, we can see a lot of pre-positioning executed in preparation for Hurricane Irma. There is also a large amount of time between the formation of Irma and landfall, which gave planners more time to prepare. The shock of the events in Houston likely had a psychological effect that caused even more preparations in Florida leading to the best response of the three events.

Hurricane Maria formed soon after Irma made landfall and the time between Maria formation and landfall is very short. The timeline, combined with the location of Puerto Rico, made pre-positioning of assets prior to the event difficult. When Maria formed, resource utilization focused on recovery from Irma. We can attribute these factors to the outcome of response for Maria.

One could argue that pre-positioning equipment in Puerto Rico would have been counterproductive. Pre-positioned material within Puerto Rico would need to weather the storm and likely face degradation or damage. In Houston and Florida, it is easy to stage material just outside the affected area for easy access after the event utilizing pre-existing developed roads and infrastructure. In Puerto Rico, such connected infrastructure does not exist.

Apte and Yoho explain how pre-positioning is a logistics strategy needed for effective disaster relief (Apte & Yoho, 2011). The prior argument highlights the greater need for pre-planned responses for Puerto Rico given its remote location, proximity to where hurricanes form, and likelihood of having a hurricane. It would not be ideal to pre-

position material in Puerto Rico; however, pre-planning where to stage material and having the interagency agreements prepared prior to an event would greatly improve the response time for events affecting Puerto Rico.

D. LIMITATION OF THE STUDY

This research focuses on the count of mission assignment occurrences and does not account for level of effort that each mission assignment might entail. Funding or labor levels may reveal a different level of participation between the various government agencies.

This study utilizes subjective categorization of mission descriptions that may vary from how FEMA actually categorizes the missions. There is also ambiguity in many mission descriptions that simply call for general personnel support without additional information on tasks these individuals might perform. This ambiguity could lead to errors in categorization of mission assignments.

V. CONCLUSION

Hurricanes Harvey, Irma, and Maria provided a unique opportunity to assess domestic disaster relief efforts due to the short amount of time between each occurrence. Our study shows that FEMA utilizes DoD extensively in domestic disaster relief efforts and missions match DoD competencies. We identified key emergency support functions that are common across hurricane type events for DoD to focus training and support planning preparations and we were able to show the importance of preparing plans for disasters long before they form.

A. CONTRIBUTIONS OF THE STUDY

The results of this research help inform DoD planners on specific ESFs where DoD will have significant contributions and the types of pre-positioning planning that is needed to provide maximum readiness to DoD in support of disaster relief efforts.

We recommend that the DoD take a closer look at utilization within transportation, engineering, logistics, search and rescue, and external affairs to develop flyaway support packages for utilization as requirements develop. Based on our review of each mission assignment, support packages for intelligence surveillance and reconnaissance (ISR), communications, emergency water and power generation, and expeditionary engineering would be good starting points. Additional analysis of each primary support area will provide more detail to identify the benefits such support packages could bring. Once support packages are developed, defense planners can develop readiness metrics based on the support packages to identify the military's capability to respond to specific events prior to landfall.

Given the relatively remote nature of Puerto Rico and its close proximity to where hurricanes form, the DoD should be included in any response plan to streamline the activation process. Hurricane response packages could be developed and pre-staged in Jacksonville, FL and Norfolk, VA. Congress could fund limited humanitarian aid and disaster relief funds for DoD to maintain such disaster packages, which could also function as surge capabilities for traditional defense missions.

B. FUTURE RESEARCH

Future studies could take our research a step further and compare actual cost outlays as a measure of participation in disaster relief. Additional data from new hurricanes could be combined with our data set to establish a growing body of data that may eventually reach a statistically significant sample size to inform quantitative metrics for DoD planning.

We also recommend future studies that focus specifically on transportation, engineering, logistics, search and rescue, or external affairs. A more granular look at these specific areas would allow for the development of flyaway support packages and metrics for planners. Public health and medical support functions warrant a closer look into level of effort and the relationship with DHHS to evaluate if there is more DoD could do to support this ESF.

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